QUATERNARY INTERNATIONAL

The Journal of the International Union for Quaternary Research

Quaternary International is published as 13 volumes per year.

Subscription Rates 2003
Annual Institutional Subscription Rates 2003: Europe, The CIS and Japan 811 Euros. All other countries US $906. Dutch Guilder prices exclude VAT. Non-VAT registered customers in the European Community will be charged the appropriate VAT in addition to the price listed. Prices include postage and insurance and are subject to change without notice.

Orders, claims, and product enquiries: please contact the Customer Support Department at the Regional Sales Office nearest you: **New York:** Elsevier Science, PO Box 945, New York, NY 10159-0945, USA; phone: (+1) (212) 633 3730 [toll free number for North American customers: 1-888-4ES-INFO (437-4636)]; fax: (+1) (212) 633 3680; e-mail: usinfo-f@elsevier.com. **Amsterdam:** Elsevier Science, PO Box 211, 1000 AE Amsterdam, The Netherlands; phone: (+31) 20 4853757; fax: (+31) 20 4853432; e-mail: nlinfo-f@elsevier.com. **Tokyo:** Elsevier Science, 9-15 Higashi-Azabu 1-chome, Minato-ku, Tokyo 106-0044, Japan; phone: (+81) (3) 5561 5033; fax: (+81) (3) 5561 5047; e-mail: info@elsevier.co.jp. **Singapore:** Elsevier Science, 3 Killiney Road, #08-01 Winsland House I, Singapore 239519; phone: (+65) 6349 0200; fax: (+65) 6733 1510; e-mail: asiainfo@elsevier.com.sg. **Rio de Janeiro:** Elsevier Science, Rua Sete de Setembro 111/16 Andar, 20050-002 Centro, Rio de Janeiro-RJ, Brazil; phone: (+55) (21) 509 5340; fax: (+55) (21) 507 1991; e-mail: elsevier@campus.com.br [Note (Latin America): for orders, claims and help desk information, please contact the Regional Sales Office in New York as listed above.]

Author enquiries
Authors can keep a track on the progress of their accepted article, and set up email alerts informing them of changes to their manuscript's status, by using the "Track a Paper" feature of Elsevier's Author Gateway (http://authors.elsevier.com).
Full details for the electronic submission of artwork can be obtained from http://authors.elsevier.com
Contact details for questions arising after acceptance of an article, especially those relating to proofs, are provided when an article is accepted for publication.

Publication information: Quaternary International (ISSN 1040-6182). For 2003 volumes 101–113 are scheduled for publication. Subscription prices are available upon request from the Publisher or from the Regional Sales Office nearest you or from this journal's website (http://www.elsevier.com/locate/quaint). Further information is available on this journal and other Elsevier Science products through Elsevier's website: (http://www.elsevier.com). Subscriptions are accepted on a prepaid basis only and are entered on a calendar year basis. Issues are sent by standard mail (surface within Europe, air delivery outside Europe). Priority rates are available upon request. Claims for missing issues should be made within six months of the date of dispatch.

Back Issues: Back issues of all previously published volumes are available direct from Elsevier Science Offices (Oxford and New York). Complete volumes can be purchased for 1999–2002. Earlier volumes are available in high quality photo-duplicated copies. Back volumes on microfilm are available from UMI, 300 North Zeeb Road, Ann Arbor, MI 48106, USA.

Periodicals postage is paid at Rahway, New Jersey. Quaternary International (ISSN 1040-6182) is published (13 volumes) by Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK. The annual subscription in the USA is $906.
Quaternary International is circulated by Mercury International Limited, 365 Blair Road, Avenel, NJ 07001, USA.
POSTMASTER: Please send address corrections to: Quaternary International, c/o Customer Services, Elsevier Science Inc., 655 Avenue of the Americas, New York, NY 10010, USA.

Quaternary International – Instructions to Authors

The Journal of the International Union for Quaternary Research

Submission of Papers

Authors are requested to submit their original manuscript and figures with three copies to the Editor who will arrange for refereeing. Once authors have received the referee's comments, they should return their revised manuscript (one original and two complete copies, together with a computer diskette which must match the hard-copy exactly) to the Editor. Manuscripts should be submitted in English.
Submission of a paper implies that it has not been published previously, that it is not under consideration for publication elsewhere, and that if accepted it will not be published elsewhere in the same form, in English or in any other language, without the written consent of the publisher.

Manuscript Preparation

General: Manuscripts must be typewritten, double-spaced with wide margins on one side of white paper. Good quality printouts with a font size of 12 or 10 pt are required. The corresponding author should be identified (include a Fax number and E-mail address). Full postal addresses must be given for all co-authors. Authors should consult a recent issue of the journal for style if possible. An electronic copy of the paper should accompany the final version. The Editors reserve the right to adjust style to certain standards of uniformity. Authors should retain a copy of their manuscript since we cannot accept responsibility for damage or loss of papers. Original manuscript are discarded one month after publication unless the Publisher is asked to return original material after use.
Abstracts: An abstract, not exceeding 200 words, and written for Quaternary scientists of all specializations, should be provided.
Text: Follow this order when typing manuscripts: Title, Authors, Affiliations, Abstract, Keywords, Main text, Acknowledgements, Appendix, References, Vitae, Figure Captions and then Tables. Do not import the Figures or Tables into your text. The corresponding author should be identified with an asterisk and footnote. All other footnotes (except for table footnotes) should be identified with superscript Arabic numbers.
Units: Metric units should be used. If it is desirable to include Imperial units, they should appear in parentheses.
References: All publications cited in the text should be presented in a list of references following the text of the manuscript. In the text refer to the author's name (without initials) and year of publication (e.g. "Since Peterson (1993) has shown that…" or "This is in agreement with results obtained later (Kramer, 1994)". For three or more authors use the first author followed by "et al.", in the text. The list of references should be arranged alphabetically by authors' names. The manuscript should be carefully checked to ensure that the spelling of authors' names and dates are exactly the same in the text as in the reference list. References should be given in the following form:
Arts, N., 1988. Archaeology, environment and the social evolution of later band societies in a lowland area. In: Bonsall, C. (Ed.), The Mesolithic in Europe. Papers presented at the Third International Symposium. John Donald Publishers, Edinburgh, pp. 291–312.
Cahen, D., 1978. Remontage de l'industrie lithique. In: Van Noten, F. (Ed.), Les Chasseurs de Meer, Dissertationes Archaeologicae Gandenses, 18, pp. 59–72. De Tempel, Brugge.
Lundqvist, J., Mejdahl, V., 1995. Luminescence dating of the deglaciation in Northern Sweden. Quaternary International 28 (1), 193–197.
Illustrations: All illustrations should be provided in camera-ready form, suitable for reproduction (which may include reduction) without retouching. Photographs, charts and diagrams are all to be referred to as "Figure(s)" and should be numbered consecutively in the order to which they are referred. They should accompany the manuscript, but should not be included within the text. All illustrations should be clearly marked on the back with the figure number and the author's name. All figures are to have a caption. Captions should be supplied on a separate sheet.
Line drawings: Good quality printouts on white paper produced in black ink are required. All lettering, graph lines and points on graphs should be sufficiently large and bold to permit reproduction when the diagram has been reduced to a size suitable for inclusion in the journal. Dye-line prints or photocopies are not suitable for reproduction. Do not use any type of shading on computer-generated illustrations.
Photographs: Original photographs must be supplied as they are to be reproduced (e.g. black and white or colour). If necessary, a scale should be marked on the photograph. Please note that photocopies of photographs are not acceptable.
Colour: Authors will be charged for colour at current printing costs.
Tables: Tables should be numbered consecutively and given a suitable caption and each table typed on a separate sheet. Footnotes to tables should be typed below the table and should be referred to by superscript lowercase letters. No vertical rules should be used. Tables should not duplicate results presented elsewhere in the manuscript, (e.g. in graphs).

Electronic Submission

Authors should submit an electronic copy of their paper with the final version of the manuscript. The electronic copy should match the hardcopy exactly. Always keep a backup copy of the electronic file for reference and safety. Full details of electronic submission and formats can be obtained from Author Services at Elsevier Science. For authors using LaTex, the document style files, as well as the instructions "Preparing articles with LaTex" in the form of a dvi file, can be obtained free of charge from any host on the Comprehensive Tex Archive Network (CTAN) using anonymous ftp. The primary CTAN hosts are ftp.dante.de and ftp.tex.ac.uk. The Elsevier macros are in/pub/tex/macros/latex/contrib/supported/elsevier. These can also be downloaded from the Internet site: http://www.tex.ac.uk.

Proofs

Proofs will be sent to the author (first named author if no corresponding author is identified of multi-authored papers) and should be returned within 48 hours of receipt. Corrections should be restricted to typesetting errors; any others may be charged to the author. Any queries should be answered in full. Please note that authors are urged to check their proofs carefully before return, since the inclusion of late corrections cannot be guaranteed. Proofs are to be returned to the Log-in Department of the relevant Elsevier Science site.

Offprints

Twenty-five offprints will be supplied free of charge. Offprints can be ordered using the order form sent to the corresponding author after the manuscript has been accepted. Orders for reprints will incur a 50% surcharge.

Copyright

All authors must sign the "Transfer of Copyright" agreement before the article can be published. This transfer agreement enables INQUA/Elsevier Science Ltd to protect the copyrighted material for the authors, but does not relinquish the author's proprietary rights. The copyright transfer covers the exclusive rights to reproduce and distribute the article, including reprints, photographic reproductions, microfilm or any other reproductions of similar nature and translations. Includes the right to adapt the article for use in conjunction with computer systems and programs, including reproduction or publication in machine-readable form and incorporation in retrieval systems. Authors are responsible for obtaining from the copyright holder permission to reproduce any figures for which copyright exists.

Author Services

For enquiries relating to the submission of articles (including electronic submission and the preparation of electronic artwork), the status of accepted articles (using the "Track a paper" feature), author Frequently Asked Questions and any other enquiries relating to Elsevier Science, please consult http://authors.elsevier.com

PERGAMON

Quaternary International 109–110 (2003) 1–2

Preface

South America: long and winding roads for the first Americans at the Pleistocene/Holocene transition

Since 1998, the idea of discussing different topics referring to the peopling of the Southern Cone at the Pleistocene/Holocene transition was occupying our interests. Finally, and with the agreement of INQUA through the Working Group "The Archaeology of the Pleistocene/Holocene transition", a meeting was held in Argentina in December 2000 with the aims of stimulating dialogue about the existing information, and mitigating the problem of heretofore-scarce communication among those colleagues working on the archaeology of the First Americans in South America. The workshop was organized by us, with the valuable collaboration of many Argentine colleagues and friends.

This inter-INQUA congress event included presentations and discussions during two days about the theoretical and methodological framework used by specialists in different South American countries, and the status of our ideas about the assumed relationships between the first colonizers and the Quaternary megafauna. Some models for the peopling of southern South America at different geographic scales were presented. However, a very interesting point of this meeting was a 4-day field trip to the main archaeological sites related to the First Americans in southern Patagonia, where the earliest human settlements of southern South America were discussed from interdisciplinary points of view, integrating natural science and archeological analyses and evidence.

The papers compiled in this issue are only a few of a large number of contributions that were presented in the meeting. All of them not only present new data on the subject, but also new ideas that highlight the backgrounds concerning paleoenvironments, human adaptations, academic policies, and regional and continental models, as well as the state of the art in different countries.

These contributions explore significant questions such as: the beginning of the social complexity among the hunter-gatherers during the Pleistocene/Holocene transition. Dillehay's paper presents solid arguments and challenges a major temporal depth for the first semi-permanent settlements or a style-life village ("proto-households"). The area where Dillehay explores landscape and distribution of architectonical feature is the northern coast of Peru. In the same direction, Karen Stothert and collaborators discuss the structure of resources in the mangroves from Ecuador, even looking at other archaeological and paleoenvironmental markers. They analyze the social complexity through the variability of burial practices. In both papers, the background is the high availability and biodiversity of maritime and terrestrial resources in the tropical Andes, along the Pacific Coast, during the period under discussion.

Eduardo Tonni and his colleagues contribute to the regional scheme of paleoclimates in mid-latitudes during the Late Pleistocene and Holocene through faunal evidence (mammals), new radiocarbon dates, and paleoenvironmental data. Moreover, they discuss the asynchroneity of the Younger Dryas pulse in the Northern Hemisphere with those cold and arid conditions detected for the Southern Hemisphere in the Pampean Region. In this sense, this information is useful for the interpretation of the environment during human colonization times in the above-mentioned area.

As another point of view in the human occupation of the mid-latitudes in the Pampas, Nora Flegenheimer and coauthors present a detailed discussion on the First Americans' networks of tool stone and its transport in an ample region between the Uruguayan and Pampean plains. Likewise, these authors support the idea that this transport was possible since those societies would have been sharing cultural, social, environmental information, which could minimize risks for their reproduction in the long time.

R. Suárez and J. López synthesize and highlight new information on the archaeology of early inhabitants of a poorly known region, related to the main streams in the Uruguayan sector of the Río de la Plata basin, as well as the Atlantic littoral and coastal zones. María T. Civalero and Nora Franco, based on an ecological model, focus on technological organization in the southernmost Patagonia Eastern Andean slope, between two lacustrine basins, with differences of raw material availability and diversity.

Luis Borrero reanalyses the faunal context from a locality of Tierra del Fuego Island, from a site formation processes perspective. He concludes that these processes are very complex in the area, but confirms the primary association for the earlier context

PII: S1040-6182(02)00197-0

(Layer Va) of Tres Arroyos 1, dated around 10,500 BP. Thus, the paper indicates the necessity and importance of this type of study. L. Miotti and M. Salemme consider the colonization of Patagonia, and remark on the existence of some gaps for the earliest radiocarbon dates in an intermediate steppe area and discuss sample bias in some key areas.

F. Mena and colleagues present the finding of five Paleoamerican individuals, dated from at least ca. the ninth millennium BP. These skeletal remains are important not only for their completeness but also for the remarkable information about traits of biological human affiliation. From the bioanthropological view, H. Pucciarelli and colleagues present their approach to the Paleoamericans, using cranio-functional analyses. They studied samples from ancient and modern Amerindians and concluded that variations observed could be explained by a cause–effect relationship between cranial morphology and environment, confirming that these analyses are useful to explain several adaptive trends from Paleoamericans to modern Amerindians.

Robert Kelly discusses the time of entry of early people in North America and discusses the inability to locate Pre-Clovis sites, the asynchroneity of Late Pleistocene/Early Holocene dates between North and South America, the possibility of inaccurate dating of South American sites, and finally, a probable coastal migration that could have passed-by the interior of the continental northern ice mass. He concludes that at present, the apparent paradox between South and North American initial occupation data and models remains unexplained.

L. Miotti discusses the Clovis-The First model as a unidirectional explanation that disagrees with the complex archeological and environmental variability available for the Southern Cone. Finally, A. Bryan and R. Gruhn discuss and reaffirm emphatically the alternative model, in the continental scale, supporting the Pacific way of entering the American continent. Technological aspects, paleoclimatic and geomorphological indicators of the corridor, as well as radiocarbon dates, are keys in the discussion, discounting some of the main arguments of Clovis-The first model.

We are deeply indebted to the following colleagues, who carefully and patiently reviewed the contributions of this volume: Carlos Aschero, Gustavo Barrientos, Cristina Bellelli, Robert Bettinger, Robson Bonnichsen, Richard Jantz, Timothy Jull, Marcel Kornfeld, Tania Lima Andrade, Bradley Lepper, Mauricio Massone, Diana Mazzanti, Guillermo Mengoni Goñalons, Luis Orquera, Cecilia Pérez de Micou, and Jorge Rabassa. Our special thanks for Lawrence Straus, who gave us the opportunity of sharing this exciting theme with the international academic arena.

University of Comahue and University of La Plata provided facilities and vehicles for the International meeting on the Colonization of South America at the Pleistocene/Holocene Transition. INQUA, Wenner Gren Foundation, and Agencia Nacional de Promoción de Ciencia y Técnica (Argentina) financed the event.

Laura L. Miotti[a]
[a] *CONICET, Departamento Científico de Arqueología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina*
E-mail address: lmiotti@museo.fcnym.unlp.edu.ar

Mónica C. Salemme[b]
[b] *Centro Austral de Investigaciones Científicas (CADIC-CONICET), c.c. 92, V9410BFD Ushuaia, Tierra del Fuego, Argentina*
E-mail address: labcuat@satlink.com

PERGAMON

Quaternary International 109–110 (2003) 3–11

Localization and possible social aggregation in the Late Pleistocene and Early Holocene on the north coast of Perú

Tom D. Dillehay[a,*], Jack Rossen[b], Greg Maggard[a], Kary Stackelbeck[a], Patricia Netherly[a]

[a] Department of Anthropology, University of Kentucky, Lexington, KY 40506, USA
[b] Department of Anthropology, Ithaca College, Ithaca, New York, USA

Abstract

Early circular living structures made of rough field stone, radiocarbon dated between 10,800 and 8300 BP, and probably affiliated with the Paiján culture on the north coast of Perú are discussed in terms of possible proto-household economies that are localized and socially aggregated in compressed environmental zones along the lower western slopes of the Andes. The technological, settlement, and economic data recovered from several sites in the Zaña and Jequetepeque Valleys are discussed briefly. Their broader implications are presented as well.

1. Introduction

In this presentation, we are interested in examining the Late Pleistocene and Early Holocene periods from a different perspective; we want to consider how cultural developments of early complex societies in the northern Perúvian Andes were predicated on the cultural diversity and broad spectrum economies of earlier hunters and gatherers (Bryan, 1973; Ardila and Politis, 1989; Fagan, 1989; Dillehay et al., 1992; Moseley, 1992; Dillehay, 2000). We will present preliminary archeological evidence for changing conditional factors in the glacial and post-glacial environments and in hunter–gatherer economic and social systems that are relevant to broad cultural transformations taking place from approximately 10,500 to 5000 uncalibrated years ago. We will specifically focus on the regional Paiján tradition on the north coast of Perú, where we have been carrying out collaborative and interdisciplinary research over the past 25 years. Although large gaps occur in the database for the time span under consideration here, enough information exists to relate the archeological records of several cultural periods and to generate working hypotheses about long-term cultural continuity and change.

The rapid efficient adaptation of regional Late Pleistocene and Early Holocene populations to diverse environments may partially explain why some forms of incipient socio-economic complexity appeared early in South America. For instance, cultigens appeared perhaps as early as 8000 years ago at several sites in Perú (cf. Bonavia, 1991; Moseley, 1992; Pearsall, 1995; Lavallée, 2000), while pottery production was established by at least 6000 BP in parts of Colombia, Brazil, and Ecuador (Oyuela-Caycedo, 1995), mummification by 7000 BP in northern Chile (Moseley, 1992), monumental architecture by 5000 BP in Ecuador and Perú (Quilter, 1991), and so forth. What triggered these early cultural developments in diverse environments is not well understood. We suspect that it might relate to advanced hunter and gatherer societies intensifying broad-spectrum diets in lush, circumscribed areas such as low wetlands in Colombia, Ecuador and Perú, in highly compacted ecotones along the western and eastern flanks of the Andes, and in the confluences of large rivers in the eastern lowlands from Venezuela, to Paraguay, Uruguay, and northern Argentina. In each of these areas, there is growing archeological evidence to suggest that different social and historical processes were acting in Early Holocene times to form early food producing and more territorial, if not permanently settled, groups in some areas, especially in the Central Andes (Kaulicke, 1988; Dillehay, 2000; Lavallée, 2000).

One of these areas is the arid north coast of Perú, where several investigators (Moseley, 1992, Dillehay, 2000; Lavallée, 2000) have linked the significance of early cultural changes to later and more complex

*Corresponding author.
E-mail address: dilleha@uky.edu (T.D. Dillehay).

1040-6182/02/$ - see front matter © 2002 Published by Elsevier Science Ltd.
PII: S1040-6182(02)00198-2

societal developments. For instance, Moseley (1992, p. 88) states that: "In overview…Paiján points [dated ca. 10,800 and 8300] vie with fluted fishtail points as the most distinctive early projectiles on the continent. Paiján stands apart from other traditions in its circumscribed geographic focus, principally along the wide coastal plain of the north…. It is curious that this wider distribution coincides with the later distribution of large architectural monuments along the coastal desert. The earliest of these monuments were erected by preceramic fisherfolk who relied on nets and hooks, but no harpoons. Paiján was certainly ancestral to these later developments…." Although Moseley did not fully acknowledge the important contributions of contemporaneous lithic traditions (e.g. unifacial) and of generalized hunter–gatherer and later horticultural economies, he is correct in seeing Late Pleistocene and Early Holocene cultural adaptations as conditioning factors in the later rise of complex societies. To better understand these developments at the regional level in South America, we need to study long-term human and environmental interaction and the specific conditions by which local societies began to aggregate demographically and to adapt their social organization to more territorialism, or at least having focal settlements where they spent large parts of the year, in rich resource zones where they established more reliable and diverse economies.

2. Social, economic, and environmental change

The Late Pleistocene shift from high mobility of human populations to circumscribed territorialism took place in some areas of South America, in our view, within a short time after people moved into resource-rich temperate and semi-tropical environments. The abrupt deglaciation between 14,500 and 12,000 BP was a crucial event that probably enforced new and more productive environmental conditions in South America, especially the Andes (Mercer, 1972; Richardson, 1978; Rosqvist, 1995; Thompson et al., 1995; Clapperton et al., 1997). In many areas, however, for instance the eastern lowlands, glaciation was a different phenomenon in comparison to North America, with most early populations in the south moving rapidly into productive landscapes at the outset of human entry. Nonetheless, major shifts in regional environments still must have triggered corresponding shifts in human economic and settlement patterns and in the organization of foraging behavior.

Under temperate climatic conditions in the Early Holocene, large hunter–gatherer bands operating collectively and sharing resources to reduce economic risk may not have been the most productive way to exploit diverse resources (sensu Boguchi, 1999). Perhaps smaller, more flexible groups would have been more able to forage more efficiently under the new climatic conditions of the post-glacial period. In many parts of the globe, Boguchi (1999, pp. 151, 152) believes that a "transition in human organizational behavior took place during this period, beginning with the automization of Late Pleistocene foraging bands into smaller family centered units and ending with autonomous co-residential family groups with stable foci of residence." He calls these atomized units of late forager society "*proto-households*" to distinguish them from the more advanced households that developed with later agricultural societies. More specifically, Boguchi notes that:

> the most important consequence of a transition from large cooperative bands to autonomous proto-households is that the smaller proto-households could exercise initiative and resourcefulness and take risks. Clearly, the potential for failure exists as well, but the post-glacial environment may have offered so many new possibilities (and probably redundancies of resources) that for the first time the risk may have been relatively low or at least manageable. The need to share in order to mitigate risk may have suddenly diminished in a number of key parts of the world between 13,000 and 9000 years ago…. Local, autonomous proto-households freed of the sharing norms of Late Pleistocene band societies also would have been free to experiment with new methods of plant and animal use. If sharing obligations were lessened or eliminated, a late forager proto-household for the first time could feel free to maximize its exploitation and to use it the way it saw fit for its own benefit. For instance, it might exchange it for a desirable commodity. Or they could have stored the excess food and given energy to non-food foraging activities. Given the resource-rich habitats present at the end of the Pleistocene, it would have been possible for more groups to have become more territorially circumscribed and localized.
> (Boguchi, 1999, p. 152).

In our opinion, this is the kind of scenario that may help us to explain the rise of later complex societies in some areas of South America, where we know that large nomadic hunter–gatherer bands exploited selected ecozones and eventually settled down to establish productive food economies and dynamic social systems. Not known are the conditioning factors that brought about these changes in regional settings.

On the north coast of Perú, it is likely that *localization* in rich, diversified, and compressed environments is a fundamental aspect of these changes. In this setting, localization was associated with the exploitation of small, highly productive and compressed micro-environments (i.e. Pacific littoral, arid coastal plains, river bottoms, vegetated hillslopes), all within a 1–3 h walk of centrally located campsites. It is the appearance of increasingly localized and aggregated, but not necessarily larger, social systems in this kind of ecological setting that may have been the most critical aspect of the development of risk reduction, exploitation of resource-rich habitats, excess food and energy, and new social structures, all of which helped to plant the seeds of early civilization.

These changes have been difficult to detect archeologically because they may have happened rapidly, infrequently and locally, and because we do not always try to relate the cultural developments in the Late Pleistocene and Early Holocene periods to later developments. In fact, most hunter–gatherer models of advanced cultural development generally propose linkages among demographic factors, subsistence strategies, and integrative mechanisms that only seasonally aggregate larger groups of people in more permanent localities and lead to institutionalized social and economic foundations of more complex hunters and gatherers, such as alliances and exchange networks (cf. Lanning, 1970; Moseley, 1992). In addition to these factors, we believe that the reliance upon spatially restricted, highly productive, localized resources, often equated with increasing dependence on a wider food spectrum, was required to have developed more stable and formalized ties between local aggregated groups. We believe that this is the case for the north coast of Perú.

3. Social aggregation and proto-households on the north coast (?)

We do not know the settlement pattern and social group size at the outset of human habitation in the study area (Fig. 1). We have only one radiocarbon date of 11,650 BP from one excavated unifacial site, El Palto, in the upper Zaña Valley, and we have found Amotape and Talara-like unifacial sites that may date as early as 11,000 BP (Dillehay, 2000). We do know that from at least 11,000 to 10,000 BP (i.e., Younger Dryas Period when temperatures fell ca. 3 degrees) until Holocene times, there were at least three concurrent lithic industries on the north coast of Perú that are distinct in terms of fundamental technology as well as raw material used. These are the unifacial industry utilizing primarily basalts and andesites (Richardson, 1978; Malpass, 1983, 1993; Dillehay et al., 1997), the Fishtail industry utilizing at least rock quartz crystals (Politis, 1991; Briceño, 1997), and the stemmed Paiján industry utilizing quartzite, quartz, cherts, and basalts (Chauchat, 1975). The changing environmental conditions may have supported different procurement strategies, as suggested by the diverse lithic industries.

In particular, the north coast lower valleys of Zaña, Jequetepeque, Cupisnique, Chicama and Moche are rich in sites of these early cultures but particularly the Paiján culture. The best-known Paiján area is the Cupisnique and Zaña valleys. More than 300 Paiján sites have been found stretching from 10 to 35 km inland from the sea to 1000 m in elevation in these valleys. In these areas, numerous early Paiján sites are located on small hills or rising ground, commanding a general view of the surrounding country and accessing several proximal resource-rich habitats (Ossa and Moseley 1972; Ossa 1978; Chauchat, 1988; Dillehay, 2000), including the vegetated (thorn scrub with mesic forests along watercourses) lower hills of the Andes and the coastline, both within a 1–3 h walk. Most of these sites yield a wide

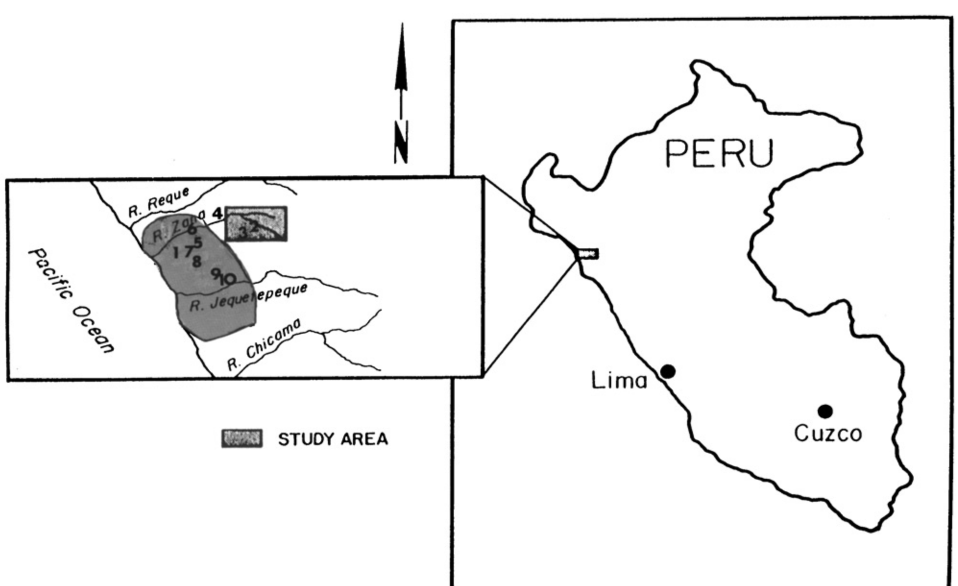


Fig. 1. Location of the Zaña and Jequetepeque valleys on the north coast of Perú, and of the sites mentioned in the text: (1) PV-19-100-7, (2) El Palto, (3) CA-09-55-2, (4) PV-19-96-1, (5) PV-19-101-11, (6) PV-19-122-1, (7) PV-19-97-8, (8) PV-19-57-2, (9) PV-470-10, (10) PV-21-431.

range of stone artifacts which suggest that they were the camping places of small groups or families. There are also a number of much larger stone tool quarry sites. These sites contain only local raw materials suggesting highly localized adaptations. There also is evidence of a very limited Paiján presence in the middle sections of these valleys, suggesting that Paiján was confined mainly to the coastal plains and adjacent foothills, that its territory overlapped with some unifacial traditions located farther upvalley, and that it initially was a general foraging adaptation focused on multiple habitats.

Chauchat believes that the Paiján industry is primarily associated with a littoral and coastal plain adaptation after the disappearance of megafauna in the region which probably occurred during deglaciation and aridity on the coast between 13,000 and 11,000 BP (Chauchat, 1975, 1978). Yet, the Paiján industry shows a good deal of variation in the lithic types found at different sites, including projectile points, various unifaces, grinding slabs, and debris (Fig. 2). Also found is the slug, or limace, which is an elongated, bipointed stone tool that has been resharpened until it is often too small to use. These different tools reflect the varied activities carried out by the local Paiján populations, who occasionally fished but focused mainly on hunting wild game and probably collecting wild plants. This last food source is indicated by the presence of macro-plant remains, milling stones, and also by the fact that some stone tools bear on their edges the characteristic sheen polish which may result from their being used to cut plants (Dillehay et al., 2001). Most Paiján stone tools are made of local quartz, quartzite, basalt, and andesite, although a few exotic cherts occur in assemblages.

For the purpose of our discussion here, we will arbitrarily divide the Paiján tradition into early and late on the basis of uncalibrated radiocarbon dates in the lower Zana and Jequetepeque Valleys. Early Paiján sites, roughly dated between 10,800 and 10,000 BP, suggest a seasonal pattern of movement, as indicated by thin, intermittent micro-stratigraphic levels in excavated sites. Charcoal from features in three excavated sites in the Zaña and Jequetepeque Valleys have been dated by radiocarbon means: CA-09-55-2 with a date of 10,360 ± 100 BP [Beta 154141], PV-19-57-2 with a date of 10,260 ± 90 BP [Beta 154128], and PV-19-96-1 with a date of 10,560 ± 60 BP [Beta 154123]. These dates correspond with those for early Paiján sites excavated by Chauchat (1975, 1988; Chauchat et al., 1998) in the Cupisnique Valley and by Ossa (1978) and Ossa and Moseley (1972) in the Moche Valley. Of the eleven sites that we have excavated in the Zaña and Jequetepeque valleys, only six contain intact cultural deposits, including the three dated ones. Many investigated early sites do not contain intact deposits because they have been deflated by fluvial and/or wind erosion. There are hearths scattered randomly across the deflated surfaces at these sites. The buried cultural deposits in the intact sites are generally between 1 and 3 cm in thickness and appear to represent shallow single occupations. There are no architectural structures associated with any of these early sites. Instead, sites are defined by lithic scatters ranging between 20 and 80 m in diameter and occasionally as much as 150 m in length, often with overlapping clusters suggestive of reuse of the site by the same group or by multigroups over time. These sites range between 2000 and 12,000 m^2 in total size.

Most of the early sites in the lower Zaña and Jequetepeque Valleys are situated along low altitude passes cutting between the coastal grasslands and the vegetated foothills or on stream terraces near large quarry localities. During different seasons of the year,

Fig. 2. Various Paiján projectile points from sites discussed in the text.

people living at these sites may have subdivided into several smaller groups, fanning out over a succession of temporary camps and special activity areas. Such a situation is suggested by the concentration of sites and surface artifacts within the passes and the adjacent mountain streams and springs. It is also suggested by other findings: the remains of migratory birds and fish and seasonally occurring plant species. A radial oscillating pattern of seasonal movement between closely juxtaposed micro-environments in the Andean foothills near the coastal plains seems to have occurred.

The late Paiján period dates between roughly 10,000 and 8300 BP. There is growing archeological evidence that late Paiján groups (and/or contemporaneous unifacial groups) were decreasing their mobility, aggregating, and establishing more permanent camps, as suggested by site location near springs in the hilly ecotone at the edge of the coastal plains, an increase in grinding stones, and the appearance of permanent living structures. Four late sites containing structures have been radiocarbon dated. These are PV-19-100-7 with a date of 8270 ± 60 BP (Beta) [154125], PV-19-101-11 with a date of 8470 ± 60 BP [Beta 154126], PV-19-122-1 with a date of 9980 ± 80 BP [Beta 154099], and PV-19-97-8 with a date of 9520 ± 130 BP [Beta 154124]. As with the early sites, no multi-component sites with deep, thick cultural deposits were located. Of the nine excavated late sites, five have intact cultural deposits that range between 5 and 15 cm in thickness. Seven of these sites are associated with permanent stone-lined architectural or residential structures ranging in diameter between 2.2 and 4 m in width (Figs. 3–5). Because Paiján points have been found on the interior surfaces and excavated from the buried floors inside these structures and because the structures are radiocarbon dated between 10,200 and 8500 BP, we believe they are associated with the Paiján tradition. The appearance of permanent living structures at these late sites suggest the appearance of small, local social systems, or *proto-households*, and more stable forms of localization.

The settlement pattern of these late sites is different from the early sites; the late sites are generally situated on the crest of large alluvial fans near springs or secondary streams in an ecotone between the lower hillslopes and the coastal plains. The late sites are also smaller and often defined by 2 to 8 house structures suggesting group sizes of perhaps 5–20 individuals. The total site areas range between 400 to 1600 m^2. In contrast, the early Paiján sites occupy areas between 2000 and 12,000 m^2 and are not associated with structures.

We wish to make it very clear that this is only a tentative chronology that could change as more excavated data are available and more radiocarbon dates are obtained from intact house floors and features. This is particularly relevant, given some difficulties with previous early sites in the region (Rossen et al., 1996). Further, it has been very difficult to associate differences in Paiján point types and other lithics with these two heuristically divided early and late phases. Possible early circular houses and structural pits are reported at several sites in coastal Ecuador, Perú, and Chile, dating as early as 9100–7000 BP years ago (Malpass and Stothert, 1992, Muñoz et al., 1993). Chauchat (1988) reports ^{14}C dates ranging from 10,380 to 8260 BP for several intact Paiján middens and hearths in the Cupisnique area. Although we found numerous Paiján open-air sites with middens and 17 sites with circular structures, only a few of the latter have intact deposits. As noted earlier, most sites are eroded and wind deflated.

Fig. 3. General view of a stone-lined residential structure in site PV-19-122-1 in the lower Zaña Valley dated at 9,980 ± 80 BP.

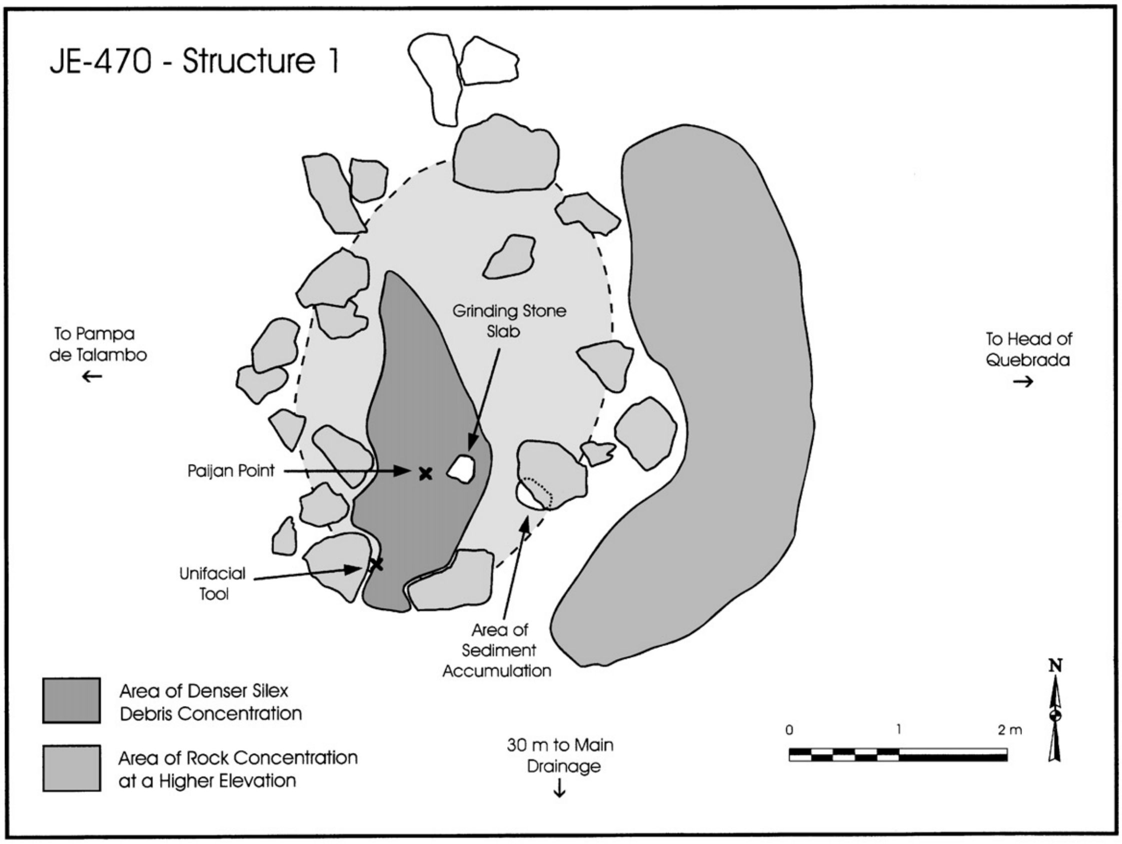


Fig. 4. Schematic drawing of a stone-lined structure associated with a Paiján point in site PV-21-470 in the Jequetepeque Valley.

In summary, we find the aggregation of smaller but perhaps more permanent late sites at the edge of the hilly ecotone near active springs and within equidistance of the coast and the vegetated hillsides indicative of a shift in social and territorial organization between 10,000 and 8300 BP. This organization was more highly localized, as indicated archeologically by (1) an intensification in the use of very localized lithic raw material and a greater degree of typological variability in the stone tool industry, which can be explained as reflecting a wider spectrum of resources; (2) an increase in the number of grinding stones and plant species found in sites; (3) a preliminary study of the species represented by animal and fish bones, plant remains, and snails, all of which are found within a 5 km radius; (4) the appearance of two to eight adjacent dwelling structures that are linear in their layout along the low crest of alluvial fans near streams, which we consider to be possible co-residential protohouseholds; (5) the presence of slightly thicker and more continuous habitational floors in the living structures that are suggestive of people occupying very specific habitats over a longer period of time; and (6) the increased presence of later sites in highly compacted and diverse micro-environments along the lower flanks of the Andes, which minimizes the spatial dispersing effect of varied resources and allows for a more efficient and reliable economy.

4. Broader implication and conclusion

For the earlier Paiján foraging societies, dated between 10,800 and 10,000 BP, greater mobility may have provided a variety of options for adjusting imbalances in scheduling, in resource availability, in population size, and in social transactions. Increased territorialism, or reduced mobility among a few selected later groups between 10,000 and 8300 BP, implies that the options afforded by mobility decreased. Alternative means may have developed to resolve similar imbalances. These may have included exploitation of a wider range of resources, food excess and storage, exchange for distant non-food items, social structure reflecting small, localized co-residential groups, and the beginnings of plant domestication (Dillehay et al., 1997, 2001). These conditions probably opened the door to further challenges presented by increased complexity in social and economic structure. They also would have permitted the accumulation of material possessions, allowed the making of a new range of artifacts, especially grinding stones, provided a stable place for

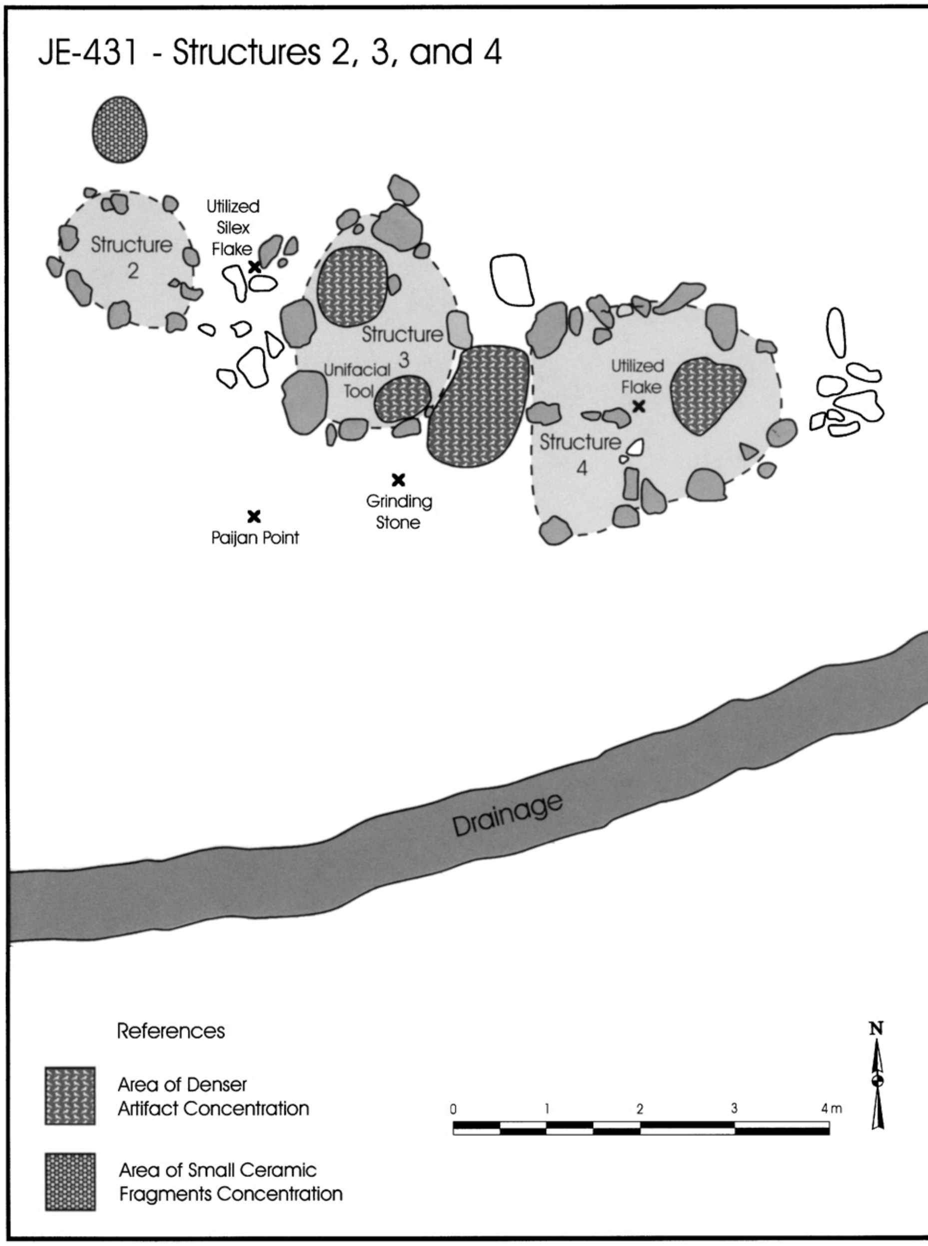


Fig. 5. Plan of three residential structures associated with an in situ Paiján point in site PV-21-431 in the Jequetepeque Valley. The ceramics outside the structure date to the Chimu period (A.D. 1100–1400) and are unrelated.

people to have social contact and exchange, and enhanced conditions for population growth and the first pulses of institutional forms that later developed into Andean civilization, including social fusion, ecological complementarity, and corporate unity. These developments began at a remarkably early date not only on the north coast but in other regions of Perú and the Andes as well, and have considerable implications for the later more complex societies that appeared between 7000 and 5000 BP.

How did these early and late cultures link together through time, space, and cultural process? The hunting and gathering societies of the terminal Pleistocene and Early Holocene did not disappear overnight. Over much of the study area the broader-based economic strategies typical of most later hunters and gatherers continued to be dominant for several millennia. Continuity in the permanent living structures and in the stone tool technology evolved in some areas, with structures becoming larger, oval and later rectangular in form during the subsequent Las Pircas and Tierra Blanca phases in the Zaña Valley (ca. 8000–5000 BP). Some of these structures are similar to those recorded at the Acha site in Chile (Muñoz et al., 1993), La Paloma and Chilca sites on the central coast of Perú (Donnan, 1984; Quilter, 1989). Although not yet dated by radiocarbon means, similar kinds of structures appear in various areas of the Jequetepeque and other north coast valleys. The tool technology shifted to more grinding stones, suggesting a greater reliance on plant foods. During this period, many Andean domesticates probably originated at different points along the eastern and western flanks of the mountains (Bonavia, 1991), where rich natural diversity occurs in narrowly stratified habitats. Eventually, large pyramids and dense permanent settlements, subsisting mainly on an agricultural economy, appeared around 4500–4000 years ago in many coastal and highland regions. Similar shifts towards increased organizational complexity and social integration were taking place in other resource-rich habitats of the Andes and probably in the eastern lowlands of the continent as well. Once we learn more about the fundamental restructuring of different foragers societies in different parts of South America, we will understand better the social and historical processes that led to the rise of complex chiefdoms and state societies in the Central Andes.

Acknowledgements

We wish to thank Laura Miotti and Monica Salemme for inviting me to participate in this conference and numerous colleagues who discussed various issues with me. We also thank the Instituto Nacional de Cultura for granting me permission to carry out research in Perú. Thanks are also extended to Walter Alva Alva, Cristóbal Campana and Duccio Bonavia for serving as project co-directors over the years.

References

Ardila, G., Politis, G., 1989. Nuevos datos para un viejo problema: Investigación y discusión en torno del poblamiento de américa del Sur. Revista del Museo del Oro (Bogotá) 23, 3–45.

Boguchi, P., 1999. The Origins of Human Society. Blackwell Publishers, Oxford.

Bonavia, D., 1991. Perú: Hombre e Historia. De Los Orígenes al Siglo XV. Edubanco, Lima.

Briceño, J., 1997. La Tradición de Puntas de Proyectil 'Cola de Pescado' en Quebrada Santa María, y el Problema del Poblamiento Temprano en los Andes Centrales. Revista Arqueológica SIAN (Trujillo) 4, 2–6.

Bryan, A.L., 1973. Paleoenvironments and cultural diversity in Late Pleistocene South America. Quaternary Research 3, 237–256.

Chauchat, C., 1975. The Paiján Complex, Pampa de Cupisnique, Perú. Ñawpa Pacha (Perú) 13, 143–146.

Chauchat, C., 1978. Additional observations on the Paijan Complex. Ñawpa Pacha (Berkeley) 16, 51–64.

Chauchat, C., 1988. Early hunter–gatherers on the Perúvian Coast. In: Keatinge, R.W. (Ed.), Peruvian Prehistory. Cambridge University Press, Cambridge, pp. 41–68.

Chauchat, C., Briceño, J., Galvez. , C., 1998. Sitios Arqueológicos de la Zona de Cupisnique y Margen Derecha del Valle de Chicama. Instituto Nacional de Cultura La Libertad-Instituto Francés de Estudios Andinos, Lima, Perú, pp. 1–169.

Clapperton, C.M., Hall, M., Mothes, P., Hole, M., Still, J.W., Helmens, K.F., Kuhry, P., Gemmell, A.M., 1997. A younger Dryas icecap in the Equatorial Andes. Quaternary Research 47, 13–28.

Dillehay, T.D., 2000. The Settlement of the Americas: A New Prehistory. Basic Books, New York.

Dillehay, T.D., Ardila, G., Politis, G., Beltrão, M.C., 1992. Earliest hunters and gatherers of South America. Journal of World Prehistory 6, 145–204.

Dillehay, T.D., Rossen, J., Netherly, P., 1997. The Nanchoc tradition: the beginnings of Andean civilization. American Scientist 85, 46–55.

Dillehay, T.D., Netherly, P., Rossen, J., 2001. Late Pleistocene and early Holocene social and economic changes on the North Coast of Perú. Paper presented at Society for American Archaeology, New Orleans.

Donnan, C., 1984. Early ceremonial architecture in the Andes. Dumbarton Oaks Research Library and Collection, Washington, DC.

Fagan, B., 1989. The Great Journey: the Peopling of Ancient America. Thames and Hudson, New York.

Kaulicke, P., 1988. Los Orígenes de la Civilización Andina. Editorial Brasa, Lima.

Lanning, E., 1970. Pleistocene man in South America. World Archaeology 2, 90–111.

Lavallée, D., 2000. The First South Americans. The University of Utah Press, Salt Lake City, UT.

Malpass, M., 1983. The preceramic occupations of the Casma Valley, Peru. Unpublished Doctoral Dissertation, Department of Anthropology, University of Wisconsin, Madison.

Malpass, M.A., 1993. The Paiján Occupations of the Casma Valley, Perú. In: Sandweiss, D. (Ed.), Investigations of Andean Past. Cornell Latin American Studies Program, Ithaca, NY, pp. 1–20.

Malpass, M., Stothert, F., 1992. Evidence for preceramic houses and household organization in Western South America. Andean Past (Ithaca, NY) 3, 137–164.

Mercer, J.H., 1972. Chilean glacial chronology 20,000 to 11,000 carbon-14 years ago. Science 176, 1118–1120.

Moseley, M.E., 1992. The Incas and their Ancestors. Thames and Hudson, London.

Muñoz, I., Arriaza, B., Aufderheide, A. (eds) 1993. En Acha-2 y Los origenes del poblamiento Humana en Arica. Ediciones de la Universidad de Tarapaca. Arica, Chile.

Ossa, J., 1978. Paiján in Early Andean prehistory: the Moche Valley, north coast of Perú. In: Bryan, A.L. (Ed.), Early Man in America from a Circum-Pacific Perspective. Department of Anthropology, University of Alberta, Edmonton, pp. 290–295.

Ossa, J., Moseley, M.E., 1972. La Cumbre: a preliminary report on research into the early lithic occupation of the Moche Valley, Perú. Ñawpa Pacha (Perú) 12, 1–16.

Oyuela-Caycedo, A., 1995. Rock versus clay: pottery technology in San Jacinto-I, Colombia. In: Barnett, W., Hoopes, J.W. (Eds.), The Emergence of Pottery: Technology and Innovation in Early Societies. Smithsonian Institution Press, Washington, DC, pp. 132–144.

Pearsall, D., 1995. Domestication and agriculture in the New World Tropics. In: Price, D., Gebauer, B. (Eds.), Last Hunters, First Farmers. School of American Research, Santa Fe, CA, pp. 157–192.

Politis, G., 1991. Fishtail projectile points in the southern cone of South America. In: Bonnischen, R., Turnmire, K. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Corvallis, pp. 287–302.

Quilter, J., 1989. Life and Death at Paloma: Society and Mortuary Practices in a Preceramic Site Perúvian Village. University of Iowa Press, Iowa City, IA.

Quilter, J., 1991. Preceramic Perú. Journal of World Prehistory 5 (4), 387–435.

Richardson III, J.B., 1978. Early man on the Perúvian North Coast, early maritime exploitation and the Pleistocene and Holocene environment. In: Bryan, A.L. (Ed.), Early Man in America from a Circum-Pacific Perspective. Department of Anthropology, University of Alberta, Edmonton, pp. 274–289.

Rosqvist, J., 1995. Proglacial lacustrine sediments from El Altar, Ecuador: evidence for late-Holocene climatic change. The Holocene 5 (7), 111–117.

Rossen, J., Dillehay, T.D., Ugent, D., 1996. Ancient cultigens or modern intrusions? Evaluating botanical remains in an Andean case study. Journal of Archaeological Science 23, 391–407.

Thompson, L.G., Mosley-Thompson, E., Davis, M.E., Lin, P.-N., Henderson, K.A., Cole-Dai, J., Bolzan, J.F., Liu, K.B., 1995. Late glacial stage and Holocene tropical ice core records from Huascaran, Perú. Science 269, 46–48.

PERGAMON

Available online at www.sciencedirect.com
SCIENCE @ DIRECT®

Quaternary International 109–110 (2003) 13–21

INQUA 1928

Against ecological reductionism: Late Pleistocene hunter-gatherers in the tropical forests of northern South America

Cristóbal Gnecco

Departamento de Antropología, Universidad del Cauca, Apartado Aereo 755, Popayan, Colombia

Abstract

Ecological reductionism has been the dominant position in the archaeology of neotropical hunter-gatherers. Traditional conceptions of the early colonists of the Americas stress their role as exploiters of the environment, highly limited by the temporal and spatial structure of resources. Yet, new ideas (and their associated "evidence") suggest that early hunter-gatherers were already impacting the environment in the neotropics through forest clearing, burning, and cultural selection of key vegetal resources; further, territoriality seems to have developed by Late Pleistocene times, well before it has been admitted. This paper discusses and supports these ideas using recent paleobotanical and archaeological data from tropical forests of northern South America. These arguments are brought to bear in the issue of the early peopling of tropical America.

1. Introduction

Ecological reductionism has been the dominant position in hunter-gatherer archaeology in the neotropics, due to the lasting influence of cultural ecology and cultural materialism. Ecology, in a reductionist perspective, is not understood as the network of total relationships within a given chrono-ecosystem but as the limitations imposed on culture by environmental variables. Ecological reductionism is an offspring of what Bargatzky (1984) has called the "adaptationist program." This program states that: (a) culture is the mean through which human beings adapt to the changing environment; (b) culture faces a pre-existent world that produces a change that the former solves, bringing the system back to a state of equilibrium; (c) if no environmental change occurs adaptation is unnecessary; that is, without external stimuli adaptation does not occur; (d) culture is essentially passive, waiting for environmental changes to start working; (e) evolution is the sum total of adaptive changes set in motion by culture with an homeostatic purpose; (f) culture and nature have to be understood as a dichotomy the former being subordinated to the latter; and (g) adaptive process are teleological, that is, they suppose cultural behaviors with a directional purpose.

Although the adaptationist program has lost strength in contemporary anthropology, especially due to the deconstruction of the nature-culture dichotomy, that is not the case in archaeology. More precisely, this program is well and alive in the archaeology of neotropical hunter-gatherers, in which adaptationism subsumes the dominant ecological reductionism. The latter, which has effectively prevented archaeological research of hunter-gatherers in tropical forests for years, has taken different forms and research agendas. To begin with, it was suggested that hunting-gathering was impossible in tropical forests until historically recorded interactions with farmers began (Milton, 1984; Bailey et al., 1989; Headland and Reid, 1989). Seasonal scarcity of carbohydrates and proteins, especially animal, was shown as preventing human occupation of tropical forests prior to agriculture (Lathrap, 1968; Myers, 1988; Bailey et al., 1989, 1991; Sponsel, 1989; Bailey and Headland, 1991). Another reductionist issue is economic specialization. Drawing from the Paleoindian data from the North American grasslands, it was traditionally believed that the early hunter-gatherers of tropical America must also have been cooperative, specialized big-game hunters living in open environments. For such big-game hunters the tropical forests would not have been attractive (see Willey, 1971) because their animal biomass would be too low to sustain their focal, specialized economic strategy. If early hunter-gatherers in the Americas were specialized hunters, and if

E-mail address: cgnecco@unicauca.edu.co (C. Gnecco).

1040-6182/03/$ - see front matter © 2003 Published by Elsevier Science Ltd.
doi:10.1016/S1040-6182(02)00199-4

hunter-gatherers were not suited for a forest living, then their presence in forest environments was casted off as an empirical and theoretical oddity. This reductionist blindness produced curious results. By far the most twisted, manipulated, intentional, and yet instructive reductionist argument is that dealing with the early crossing of the Isthmus of Panama. The tropical forest "barrier" currently existing between Panama and Colombia forced archaeologists to come up with ideas for explaining the early colonization and occupation of South America. Sauer's (1944) and Lothrop's (1961) old suggestion of an open corridor along the Pacific coast through which southbound hunter-gatherers passed is well known, and it proved hard to die (e.g., Lynch, 1978) until paleobotanical evidence indicated otherwise (Bartlett and Barghoorn, 1973; Piperno, 1990; Colinvaux and Bush, 1991; Piperno et al., 1991a).

Recent developments in archaeology and ethnology have strongly questioned ecological reductionism in hunter-gatherer studies. Further, ecological reductionism has also been questioned from a general theoretical perspective. The passivity it accords to an ontologized culture (*sensu* Fabian, 1983) is giving way to a more dynamic consideration, by virtue of which culture is no longer the submissive subject of nature and human beings no longer the submissive subjects of culture. Culture is now seen as the active medium through which societies build their world around, and human beings use it, manipulate it, create it, and negotiate it daily. Culture is not deployed only when people need to adapt to changing conditions; culture is deployed constantly, exhibited, transformed.

I also take a stand against ecological reductionism from the viewpoint of hunter-gatherer occupations of tropical forests in southern Colombia around the time of the Pleistocene–Holocene boundary. I will explore and criticize two reductionist issues central to the archaeology of tropical hunter-gatherers: the stereotype of hunting-gathering as an explotative, nontransformative strategy; and the conception of mobility as a direct function of resource distribution. The evidence I will discuss comes from two sites recently investigated in southern Colombia: Peña Roja, in the middle Caquetá river valley, in the Amazon Basin; and San Isidro, in the upper Cauca river valley, in an interandean valley (Fig. 1). The former has been dated to 9100–9300 BP [9125±250 BP (GX-17395); 9160±90 BP (B-52963); and 9250±140 BP (B-52964)], and the latter to around 10 000 BP [9530±100 BP (B-65877), 10 050±100 BP (B-65878), and 10 030±60 BP (B-93275)].

Both occupations occurred in what can be termed tropical forests, although I am not arguing that their composition was in any way identical to that of modern counterparts; moreover, available evidence suggests that the composition of late Pleistocene and early Holocene tropical forests in the neotropics was indeed very different (cf. Gnecco, 1995). This evidence must be added to well-known, mounting archaeological data documenting pre-agricultural hunter-gatherer occupations in neotropical forests: in Panama (Ranere and Cooke, 1991); Venezuela (Barse, 1990); Colombia (Gnecco and Mora, 1997); and Brazil (Roosevelt et al., 1996). Those occupations do not belong to specialized big-game hunters but to generalized hunter-gatherers; further, archaeological and paleobotanical data indicate humanly induced forest disturbance and resource manipulation and intervention since the late Pleistocene (Piperno, 1990; Piperno et al., 1991a; Gnecco and Mora, 1997).

2. Against essentialism in the archaeology of tropical hunter-gatherers

Ecological reductionism has required an essentialist metaphysics, which has dominated the archaeological conception of tropical hunter-gatherers. That is, the concept "hunter-gatherer" has been taken as a discrete, incontingent class of economic organization. Thus, hunter-gatherers would be to the passive exploitation of the environment what farmers to its active transformation. Such essentialism has been greatly fueled by the idea that the early hunter-gatherers of the Americas were megamammal hunters. Thus, hunter-gatherers were not considered as selective manipulators and modifiers of wild resources, as recent evidence indicates. As a result, the term "hunter-gatherers" is frankly imprecise (cf. Ingold, 1991; Kelly, 1995) to refer to people who not only gathered and hunted but who also altered to their benefit the natural productivity of resources.

Evidence from Peña Roja and San Isidro suggests human impact and modification of the ecosystem as early as 10 000 BP. Pollen data from San Isidro includes secondary vegetation, as herbaceous plants and weeds-Gramineae, Cyperaceae and two colonizer species of open spaces, *Plantago* sp. and *Trema* sp., among a majority of mature or primary forest species. This suggests the existence on the site or its surroundings of an open or partially open space during the time of human occupation; the prevalence of mature forest species, however, shows that the documented phenomena was not a total forest clearing or deforestation but the existence of a space open enough for allowing the growth of pioneer species. I cannot say whether this open space was naturally or humanly created, but it is not coincidental that this palynological evidence happened to come from an archaeological site. The analysis of pollen from San Isidro highlights another important issue: the association of current allopatric species. Although this can be explained arguing that the vegetal formation in which the site was located at the time of its

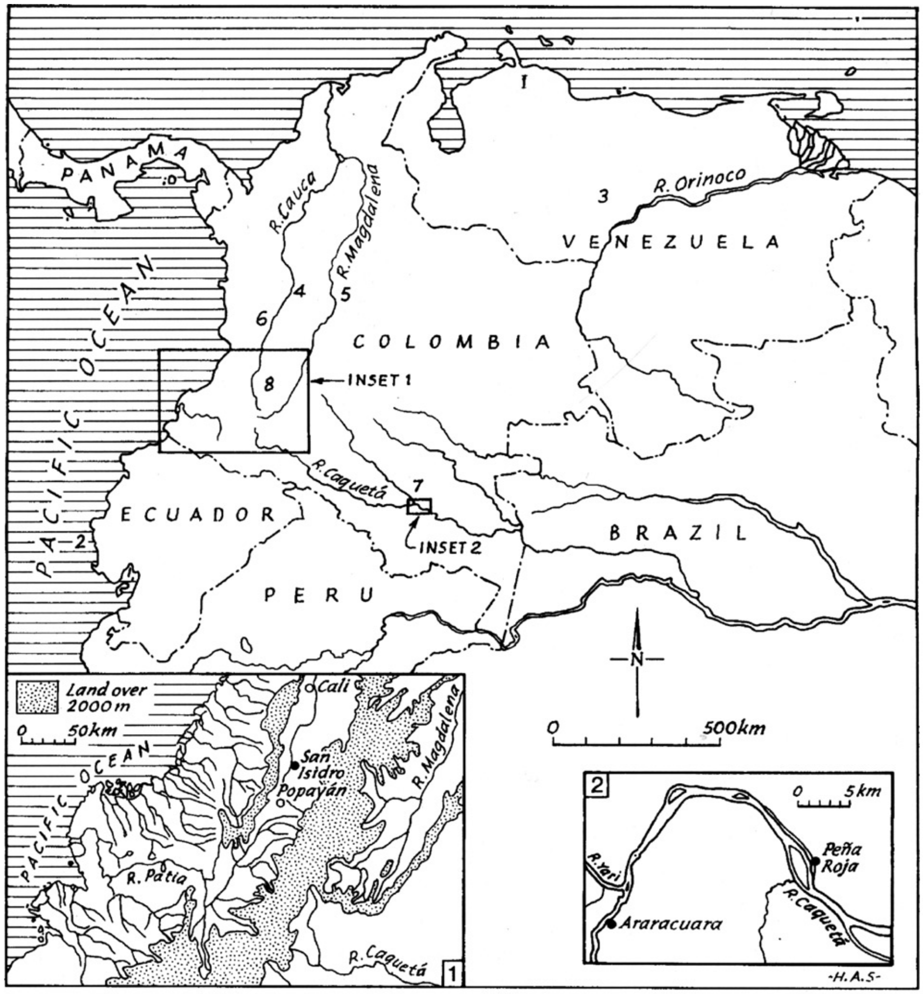


Fig. 1. Map of Colombia showing the location of San Isidro and Peña Roja (from Gnecco and Mora, 1997).

occupation around the Pleistocene/Holocene boundary has no modern analogs, it is also possible to say that the useful species from the lowlands represented in the pollen sample, especially *Virola*, may have been transported, and perhaps also cultivated, from their original habitat. The nonnatural association of certain species, not necessarily cultigens, could indicate human manipulation of the environment.

I have explored this argument at length in Gnecco (1995), where I argue that Pleistocene climatic oscillations (especially from 13 000 years ago onwards) did not cause the displacement of whole vegetational belts along the altitudinal gradient in the tropics, as it has been traditionally held, but minor responses at the level of single species or groups of species. This argument is based on the ideas of Graham (1990, p. 57), who favors the individualistic model (biomes are nor highly co-evolved systems but collections of species randomly distributed along environmental gradients) over the community model (biomes are stable assemblages of species, tightly bound and highly co-evolved, that react uniformly on the face of environmental fluctuations) in order to account for the existence of disharmonious distributions of Pleistocene mammal species in North America.

The dominance of *Lagenaria sp.* remains in the macro-botanical collection from San Isidro (92%) and of palm remains in the collection from Peña Roja (>99%) could simply represent dietary preferences or high natural availability, as in the "resource islands" reported by Posey (1984, p. 117) for the Amazon, but could also indicate humanly induced concentration of preferred resources. In this sense, it is worth recalling that one of the most salient characteristics of tropical forests is high species diversity and low number of individuals per species (see Meltzer and Smith, 1986), along with their temporal and spatial homogeneous distribution. Therefore, one maximization mechanism prior to domestication and fully established agriculture was the artificial concentration of useful, otherwise dispersed plants. The artificial concentration of favored species may have required planting and tending, including forest clearing, weeding and/or maintenance of naturally opened spaces, much in the way contemporaneous Amazonian groups do, from hunter-gatherers (Gutiérrez, 1996; Politis, 1996) to farmers (Posey, 1984).

Politis (1996) has shown that the mobility strategy of the Nukak from the Colombian Amazon creates resource patches (wild orchards) encouraging the concentration of useful species, guaranteeing resource supplies in the long run. Mobility transforms the natural composition of ecosystems: wild orchards, which are periodically visited and used, increase productivity by creating artificial concentrations of useful plant species. Similarly, Amazonian farmers plant and tend forest clearings that are subsequently abandoned; however, they are really not abandoned but left unattended to permit and encourage the colonization of a number of useful species such as medicinal and edible perennials with large roots and stems (Posey, 1983, 1984; Piperno, 1989). Posey (1984, 1993) has called them forest fields, and has coined (Posey, 1983) the term nomadic agriculture for this efficient management strategy for the maximization of wild resources. The main characteristic of wild orchards and forest fields is that they require little, if any, tending once created (Posey, 1993). But forest clearing and/or tending not only favored useful plant species but also animals (see Posey, 1983, 1984; Cooke and Piperno, 1993); the use of a higher animal biomass resulting from human intervention of tropical forests has been called garden hunting by Linares (1976). I believe that the evidence from Peña Roja and San Isidro points in this direction.

Archaeological evidence can be coupled with paleobotanical evidence to strength the argument of early anthropogenic ecosystems. In the sedimentary sequence of lake La Yeguada, in Panama, an anthropic horizon suddenly appears by 11 000 BP, characterized by burning, intensifying in the following millenium (Piperno et al., 1991a, b). The contemporaneous increase in colonizing species supports the interpretation that burning was associated with intentional clearing and maintenance of the forest (Piperno, 1990; Cooke and Piperno, 1993). In this regard is worth noting that the ethnographic record of protoagriculturalists (Keeley, 1995) indicates that burning of natural vegetation in order to stimulate the growth of useful species, mostly pioneers, is very characteristic of peoples involved in the cultural intensification of resources.

But neotropical hunter-gatherers may have been doing more than just forest clearing and plant tending. *Persea* seeds (Fig. 2) from San Isidro (longest, 6 cm), among the almost 4000 carbonized macro-botanical remains recovered from the archaeological deposit, are very likely from a cultivar, as they are larger than average for a wild population (see Smith, 1966, 1969); the same can be said of three *Erythrina edulis* specimes

Fig. 2. *Persea americana* charred seed from San Isidro.

Fig. 3. *E. edulis* charred seed from San Isidro.

(Fig. 3). *Maranta* phytoliths found in grinding tools from San Isidro (Fig. 4) may well belong to a known cultivar, perhaps *M. arundinacea*. Although the

Fig. 4. Edge-ground tool from San Isidro, from which *Marantha residues* were recovered.

domesticated history of this almost forgotten rhizome is not totally clear, Piperno (Piperno, 1995; Piperno et al., 1991b) believes that it was domesticated some 8600 years ago in Panama. Thus, the neotropical hunter-gatherers of the Pleistocene/Holocene boundary were not only using but also managing and improving the productivity of forest resources. In this form, the essentialism of an ecological-reductionist perspective of hunter-gatherers is seriously impaired.

3. Against mobility as a function of resource distribution

Binford (1980) suggested that mobility in hunter-gatherers is almost exclusively contingent to resource distribution. But mobility, even in the case of the late Pleistocene colonists of the Americas, may have been affected by different factors. Neotropical hunter-gatherers from northern South America were already impacting and altering the ecosystem with practices such as forest clearing, selective planting and domestication. Rindos (1984) coined the concept "agrilocality" to refer to groups responsible for specialized domestication and that show regular spatio-temporal patterns that allow for the emergence and development of agroecology. These patterns are linked to territoriality and, thus, with restricted mobility and with focalization in resource use; both factors are responsible for the transformation of the structure of most ecosystems. This possibility departs from the traditional idea that saw early hunter-gatherers as just users of resources, especially animal resources, who had a negligible impact upon ecosystems. Yet, from the point of view of territoriality the emergence of agrilocalities appears, alternatively, as its consequence and as its cause: as its consequence because restricted mobility and the development of territoriality would have forced it due to pressure on the resource base, and as its cause because it is possible that certain social demands, such as sectional competition, demanded strategies to maximize resources beyond their natural productivity, resulting in zonal settlements that made previous mobility patterns obsolete.

The stereotype of mobile hunters faces arguments such as territoriality and its associated aspects (e.g., social competition and the emergence of alternative strategies of occupation) and with the suggestion that the exploitation of focal resources, as in the southern coast of Peru (Keefer et al., 1998; Sandweiss et al., 1998), and the alteration and manipulation of vegetal and animal resources (as in San Isidro) may have occurred from the very beginning of initial colonization and occupation and not as an incidental result of the crisis of previous patterns. Thus, prehispanic tropical forest hunter-gatherers in northern South America may have been moving in a highly occupied space; a humanized space. But the existence of territoriality in early hunter-gatherers is problematic for the reductionist view, which reflects a "nomadic" conception of hunter-gatherers in vogue in world archaeology for the last 30 years. One of the main characteristics of that "nomadism" is the lack of territoriality, because if the best strategy to deal with variability in resource distribution is the movement between regions, then territorial defense would militate against survival (cf. Kelly, 1995, pp. 14–15).

Territoriality can be glimpsed at San Isidro through several lines of evidence. The degrees of curation (*sensu* Shott, 1996) of a lithic assemblage are informative of mobility: high mobility demands high curation. Highly curated assemblages (i.e., assemblages with artifacts that are only abandoned when their potential utility has been lasted) have been explained with three basic arguments: transport of artifacts between sites in anticipation of their continued use (Binford, 1973, 1977); time budgeting (Torrence, 1983); and limitations in raw material availability (Bamforth, 1986) due to absolute scarcity of cultural behaviors restricting access to the sources. Bamforth (1986, p. 39) identified four variables of tool manufacture and use that have been associated with curation: portability; versatility; reshaping; and recycling. Those variables can be examined in the lithic assemblage from San Isidro in order to determine its degree of curation; Table 1 presents the figures obtained

Table 1
Variables of curation in the lithic assemblage from San Isidro (*P*: portability; *V*: versatility; RJ: rejuvenation; RC: recycling)

P (%)	V (%)	RJ (%)	RC (%)
97	5	0.8	0.4

for each variable. Although portability is a very relative criterion I used 20 g and less than 10 cm in the maximum dimension as the limit between portability and nonportability (that is, between easy and not-so-easy portability). Those figures seem adequate for the kind of hunter-gatherers this paper deals with, i.e., with no animal or vehicular transportation.

To begin with, the majority of the tools from San Isidro does not exceed 10 cm in their longest dimension and few tools weigh more than 10 g. The tools exceeding these figures (grinding and knapping tools) could not have fulfilled their role weighing less—and, therefore, measuring less—than they do. Moreover, their use must have occurred in specific locations (as in the places where plant material needing processing was collected or where raw material was knapped); thus, it is very unlikely that they were transported from place to place. Evidence of versatility comes from multifunctional tools (4.2% of the sum total of artifacts); the generalized morphology of these specimens permits their use in, at least, two different functions, although some tools were used in three or more functions. Some bifaces were also used in more than one function: although their form suggests that they were used as projectiles, use-wear analysis revealed that some were used in different functions, such as butchering and scraping. In San Isidro the percentages of rejuvenation and recycling are truly modest: only three broken bifaces were recycled, while rejuvenation could only be determined in one biface, rejuvenated while still hafted, and perhaps in five retouched but unused tools. Other possible evidence of rejuvenation, abrupt and invasive retouch, will be explored shortly. Thus, even excepting the always problematic variable of portability, the results presented in Table 1 clearly indicate low curation.

One implication of Bamforth's (1986) idea on the relationship between high curation and raw material scarcity is obvious: artifacts made on scarce materials would be more curated than artifacts made on abundant materials. In order to evaluate this implication the assemblage from San Isidro was discriminated by raw materials—scarce (obsidian) and abundant (chert)—according to the following criteria: versatility, recycling and retouch; the latter was taken to represent the degree of reshaping and was divided in three analytical categories (unretouched, marginal retouch, and invasive retouch). The result (Table 2) shows that there is no clear segregation in raw materials: artifacts made with chert and obsidian (the most popular raw materials used at the site) experienced a similar degree of curation. But this is only true in absolute terms, because if we consider it in relative terms the relation in San Isidro between obsidian and chert artifacts is 1:10; then, the relations between the variables analyzed in Table 2, 1:3 for versatility and 1:2.4 for recycling, indicate that the artifacts made with obsidian were more curated than those made with chert. Thus, although the degree of curation in the assemblage is low, the artifacts made with the scarce raw material experienced higher curation. To this fact we must add that the use of obsidian was maximized, a fact evident in the relationship between artifacts and debris (1:74 for obsidian tools and 1:49 for chert tools) and in the size of debitage (only 5% of the debitage is more than 1 cm in length); that was not the case with chert, though, whose use was clearly wasteful. Regarding diversity, the analysis of the ethnographic record of hunter-gatherers (Shott, 1996) indicates that as mobility diminishes diversity in tool function increases. Thus, a high diversity in tool function in the San Isidro assemblage, coupled with low curation and higher curation of scarce materials, point to a case of restricted mobility and territoriality.

Table 2
Artifacts from San Isidro discriminated by raw material availability. *V*: versatility; RC: recycling; RT: retouch (1: unretouched; 2: marginal retouch; 3: invasive retouch)

	V	RC	RT		
			1	2	3
Obsidian (scarce)	7	—	14	24	10
Chert (abundant)	21	3	119	226	24

Raw material procurement also points to territoriality. Data from northern South America and Panama shows reliance on local sources, even sources that are extremely difficult to locate, such as the very small, buried obsidian flows in the valley of Popayán (in SW Colombia), underscoring a detailed territorial knowledge. A good example of how local raw material dominated in tool manufacture is the case for two stemmed bifaces found in surface in La Elvira, in Colombia (Gnecco, 2000), and in Imbabura, in Ecuador (Mayer-Oakes, 1986), some 400 km to the south. These presumed late Pleistocene age bifaces, truly large specimens about 18 cm long, are virtually identical; not only the two share the same form but also technological features such as platform preparation. Both were manufactured with high-quality obsidian, yet both were made with obsidian procured in local sources, as determined by Neutron Activation Analysis (Gnecco, 2000).

Regarding diversity, Shott (1996, pp. 20–27) found in his analysis of the ethnographic record of hunter-gatherers that as mobility diminishes diversity in tool function increases. Thus, I can suggest that the high diversity in tool function in the San Isidro assemblage, coupled with low curation and higher curation of scarce materials, also point to a case of restricted mobility.

4. Discussion: early peopling of tropical America

Late Pleistocene bands in tropical America must have been initially small in order to cope with the heterogeneous distribution of resources, a fact that could have been balanced with their manipulation and cultural selection. More importantly than site redundancy, an early pattern of agrilocality (*sensu* Rindos, 1984, p. 176) begins to emerge in the area, indicating human manipulation and transformation of the ecosystem, alien to rapid colonizers moving swiftly through different environments. Evidence from the neotropics indicates early human management of vegetal and, likely, animal resources by 11 000 BP, including forest clearing or utilization and maintenance of natural openings by burning, and the cultural selection of useful species through protection and planting. The arguments presented in this paper document hunter-gatherers living in neotropical forests by Late Pleistocene and Early Holocene times; manipulating and altering the natural distribution of resources; exercising some kind of territoriality; and not interacting with farmers (which were still to come!!). Therefore, this paper challenges ecological reductionism. The question, therefore, is not if hunter-gatherers ever existed in tropical forests without farmers; the question is how they lived in those ecosystems.

Bailey and Headland (1991, p. 268) predicted that "if foragers were living in tropical rain forest before the introduction of agriculture, they may well have had to be much more mobile than the African Pygmies, Agta, Batek, Penan, and other central-place foragers found in most areas of tropical rain forest today." I do not believe this was necessary if resources were maximized through manipulation, planting, tending, and uprooting from their natural habitats. The mobility of hunter-gatherers can be affected, limited and distorted by forms of competition and territorial control and by alternative ways of minimizing risk, as planting and tending. In other words, it may well be that the most important variables for understanding hunter-gatherer mobility are not natural but cultural: mobility as a function of the control over resources, not of the way they are distributed. Kelly (1983) noted that in those areas where is not necessary to exercise control over resources access to them is what conditions mobility. But neither Kelly nor Binford explored what happened in those cases in which it is necessary to control resources, as in conditions of sectorization and territorial competition; that is, in conditions in which mobility depends not of resource distribution but of cultural restrictions limiting their access.

Method of group fissioning is basic to understand colonizing strategies in an empty continent. Following Beaton (1991) we can envision two types of colonizing strategist: transient explorers and estate settlers. Transient explorers were highly mobile and directional, independent from the founding group, and exploited diverse ecological settings; although daring, they were also subjected to several risks, only one of which is endemism, especially tropical, as explored by Dillehay (1991). Others are contingent to the exploitation of unknown or notwell-known resources. Ranere (1980) and Kelly and Todd (1988) have stated that most risks were avoided if the strategy was technology oriented instead of place oriented, that is, if the first colonists relied on known, relatively similar faunal assemblages across different ecosystems, rather than on the most varied, regionally specific vegetal resources.

The technology-oriented argument is in agreement with the currently more favored idea that sees Clovis as exploiting several, different megapatches instead of exploiting similar or continuos megapatches (e.g., Haynes, 1980; Bryan, 1991; Stanford, 1991). This model implies that initial colonists spread very rapidly over immense stretches of land, through varying megapatches with different but equivalent faunal assemblages, both in terms of net quantity and predictability (such as the Great Plains and tropical forests of various kinds), following an unknown but extremely compelling drive, and irrespectively of ecosystemic differences. Accepting that the first colonists of North and Central America were technology oriented instead of place oriented, we cannot explain with the same argument the colonization of tropical South America, where animal biomass is low and where foragers rely heavily on vegetal resources and high, but tethered mobility geared to well known, bounded and large territories. Politis (1996,p. 157) has shown that the high mobility of the Nukak from the Colombian Amazon is strategically articulated to the creation of resource patches encouraging the concentration of useful species, guaranteeing resource supplies in the long run. But this high mobility is tethered to a specific territory.

Is it that North America had peculiar conditions that forced Clovis bands to be highly mobile and rapid colonizers of an entire continent? Or is that only North and Central America had those conditions? If we hold to this unlikely scenario, then the first South American colonists behaved rather differently. Is is that the crossing of the Panama isthmus was like a cultural Rubicon: once crossed everything was different?

Estate settlers were less mobile and certainly not directional, keeping ties with the founding group; risk was minimized by these ties and by a conservative colonizing strategy that dictated the exploitation of identical or similar environments to those from where they come. In other words, they would be exploiters and colonizers of megapatches, and would be place-oriented (*sensu* Kelly and Todd, 1988). These settlers were cautious, minimizing risks while maximizing survival probability (Beaton, 1991).

Thus, the early peopling of tropical America can be seen as a slow colonizing process instead of a rapid migration, starting well before Clovis times. Further, to the use of predominantly local raw materials we must also add modification of the landscape and intervention in the natural cycle of plant resources, as in La Yeguada and San Isidro, indicating a place-oriented strategy leading to territoriality. However, late Pleistocene territoriality, in departing from the Clovis on-the-move model, would be hard to deal with, especially because Binford's (1980) suggestion that mobility in hunter-gatherers is almost exclusively contingent to resource distribution is deeply rooted in our theoretical baggage. But Binford's idea, being resource dependent, is overtly deterministic. Mobility, even in the case of the late Pleistocene colonists of the Americas, may have been affected by different factors, some of them cultural; in fact, if the mobility strategies of the lake La Yeguada and San Isidro hunter-gatherers affected resource distribution through its manipulation, it can posited that they exercised some kind of territoriality.

Acknowledgements

I thank Laura Miotti and Mónica Salemme for inviting me to participate in this issue. The ideas presented in this paper were drawn from a paper I wrote with Santiago Mora, "Archaeological hunter-gatherers in tropical forests: a view from Colombia," which will appear this year in the book "Under the Canopy: Archaeological Studies on the Hunter-Gatherer Colonization of the Tropical Forest Belt," edited by Julio Mercader and to be published by Rutgers University Press.

References

Bailey, R.C., Headland, T.N., 1991. The tropical rain forest: is it a productive environment for human foragers? Human Ecology 19, 261–285.

Bailey, R.C., Head, G., Jenike, M., Owen, B., Rechtman, R., Zechentes, E., 1989. Hunting and gathering in tropical rain forest: is it possible? American Anthropologist 91, 59–82.

Bailey, R.C., Jenike, M., Rechtman, R., 1991. Reply to Colinvaux and Bush. American Anthropologist 93, 160–162.

Bamforth, D.B., 1986. Technological efficiency and tool curation. American Antiquity 51, 38–50.

Bargatzky, Th., 1984. Culture, environment, and the ills of adaptationism. Current Anthropology 25, 399–415.

Barse, W.P., 1990. Preceramic occupations in the Orinoco river valley. Science 250, 1388–1390.

Bartlett, A.S., Barghoorn, E.S., 1973. Phytogeographic history of the Isthmus of Panama during the past 12000 years (a history of vegetation, climate, and sea-level change). In: Graham, A. (Ed.), Vegetation and Vegetational History of Northern Latin America. Elsevier, New York, pp. 203–299.

Beaton, J.M., 1991. Colonizing continents: some problems from Australia and the Americas. In: Dillehay, T.D., Meltzer, D.J. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, FL, pp. 209–230.

Binford, L.R., 1973. Interassemblage variability-the Mousterian and the functional argument. In: Renfrew, C. (Ed.), The Explanation of Culture Change. Duckworth, London, pp. 227–254.

Binford, L.R., 1977. Forty-seven trips. In: Wright, R.V. (Ed.), Stone Tools as Cultural Markers. Australian Institute of Aboriginal Studies, Canberra, pp. 24–36.

Binford, L.R., 1980. Willow smoke and dog's tails: hunter-gatherer settlement systems and archaeological site formation. American Antiquity 45, 1–17.

Bryan, A.L., 1991. The fluted point tradition in the Americas: one of several adaptations to late Pleistocene American environments. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans. Oregon State University, Corvallis, pp. 15–33.

Colinvaux, P., Bush, M.B., 1991. The rain-forest ecosystem as a resource for hunting and gathering. American Anthropologist 93, 153–162.

Cooke, R., Piperno, D.R., 1993. Native American adaptations to the tropical forests of Central and South America before the European colonization. In: Hladik, C.M., Hladik, A., Linares, O.F., Pagezy, H., Semple, A., Hadley, M. (Eds.), Tropical Forests, People and Food. Unesco-Parthenon, Paris, pp. 25–36.

Dillehay, T.D., 1991. Disease ecology and initial human migration. In: Dillehay, T.D., Meltzer, D.J. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, FL, pp. 231–264.

Fabian, J., 1983. Time and the Other. Columbia University Press, New York.

Gnecco, C., 1995. Paleoambientes, modelos individualistas y modelos colectivos en el norte de Suramérica. Gaceta Arqueológica Andina 24, 5–11.

Gnecco, C., 2000. Ocupación Temprana de Bosques Tropicales de Montaña. Universidad del Cauca, Popayán.

Gnecco, C., Mora, S., 1997. Early occupations of the tropical forest of northern South America by hunter-gatherers. Antiquity 71, 683–690.

Graham, R.W., 1990. Evolution of new ecosystems at the end of the Pleistocene. In: Agenbroad, L.D., Mead, J.I., Nelson, L.W. (Eds.), Megafauna and Man: Discovery of America's Heartland, The Mammoth Site of Hot Springs Scientific Papers, Vol. 1. Hot Springs, South Dakota, pp. 54–60.

Gutiérrez, R., 1996. Los Nukak y el uso de los recursos. Diversa 2, 4–7.

Haynes, C.V., 1980. The Clovis culture. Canadian Journal of Anthropology 1, 115–121.

Headland, T.N., Reid, L.A., 1989. Hunter-gatherers and their neighbors from prehistory to the present. Current Anthropology 30, 43–66.

Ingold, T., 1991. Notes on the foraging mode of production. In: Ingold, T., Riches, D., Woodburn, J. (Eds.), Hunters Gatherers: History, Evolution and Social Change, Vol. 1. Berg, New York, pp. 269–285.

Keefer, D.K., de France, S.D., Moseley, M.E., Richardson, J.B., Satterlee, D.R., Day-Lewis, A., 1998. Early maritime economy and El Niño events at quebrada Tacahuay. Science 281, 1833–1835.

Keeley, L.H., 1995. Protoagricultural practices among hunter-gatherers: a cross-cultural survey. In: Douglas Price, T., Gebauer, A.B.

(Eds.), Last Hunters, First Farmers: New Perspectives on the Prehistoric Transition to Agriculture. School of American Research, Santa Fe, NM, pp. 243–272.
Kelly, R.L., 1983. Hunter-gatherer mobility strategies. Journal of Anthropological Research 39, 277–306.
Kelly, R.L., 1995. The Foraging Spectrum: diversity in hunter-gatherer lifeways. Smithsonian Institute, Washington.
Kelly, R.L., Todd, L.C., 1988. Coming into the country: early Paleoindian hunting and mobility. American Antiquity 53, 231–244.
Lathrap, D.W., 1968. The "hunting" economies of the tropical forest zone of South America: an attempt at historical perspective. In: Lee, R.B., Devore, I. (Eds.), Man the Hunter. Aldine, New York, pp. 23–29.
Linares, O.F., 1976. Garden hunting in the American tropics. Human Ecology 4, 331–349.
Lothrop, S.K., 1961. Early migrations to Central and South America: an anthropological problem in the light of other sciences. Journal of the Royal Anthropological Institute 91, 97–123.
Lynch, Th.F., 1978. The South American Paleoindians. In: Jennings, J. (Ed.), Ancient Native Americans. W.H. Freeman and Co, San Francisco, pp. 455–489.
Mayer-Oakes, W.J. 1986. El Inga: a Paleoindian Site in the Sierra of Northern Ecuador. Transactions of the American Philosophical Society 76(4).
Meltzer, D.J., Smith, B.D., 1986. Paleoindian and early Archaic subsistence strategies in eastern North America. In: Neusius, S.W., Foraging (Eds.), Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands. Center for Archaeological Investigations Occasional Paper No. 6, Southern Illinois University, Carbondale, pp. 2–31.
Milton, K., 1984. Protein and carbohydrate resources of the Maku Indians of Northwestern Amazonia. American Anthropologist 86, 7–27.
Myers, T., 1988. Una visión de la prehistoria de la Amazonia superior. In: I Seminario de Investigaciones Sociales en Amazonia. CETA (Centre for Theological Studies on the Amazon), Iquitos, pp. 37–87.
Piperno, D.R., 1989. Non-affluent foragers: resource availability, seasonal shortages, and the emergence of agriculture in Panamanian tropical forests. In: Harris, D.R., Hillman, G.C. (Eds.), Foraging and Farming: The Evolution of Plant Exploitation. Unwin Hyman, London, pp. 538–554.
Piperno, D.R., 1990. Paleoenvironments and human occupation in late-glacial panamá. Quaternary Research 33, 108–116.
Piperno, D.R., 1995. Plant microfossils and their application in the New World tropics. In: Stahl, P.W. (Ed.), Archaeology in the Lowland American Tropics. Cambridge University Press, Cambridge, MA, pp. 130–153.
Piperno, D.R., Bush, M.B., Colinvaux, P.A., 1991a. Paleoecological perspectives on human adaptation in Panama I. The Pleistocene. Geoarchaeology 6, 201–226.
Piperno, D.R., Bush, M.B., Colinvaux, P.A., 1991b. Paleoecological perspectives on human adaptation in central Panama II. The Holocene. Geoarchaeology 6, 227–250.
Politis, G.G., 1996. Moving to produce: nukak mobility and settlement patterns in Amazonia. World Archaeology 27, 492–511.
Posey, D.A., 1983. Indigenous knowledge and development; an ideological bridge to the future. Ciencia e Cultura 35, 877–894.
Posey, D.A., 1984. A preliminary report on diversified management of tropical forests by the Kayapó Indians of the Brazilian Amazon. Advances in Economic Botany 1, 112–126.
Posey, D.A., 1993. The importance of semi-domesticated species in post-contact Amazonia: effects of the Kayapó Indians on the dispersal of flora and fauna. In: Hladik, C.M., Hladik, A., Linares, O.F., Pagezy, H., Semple, A., Hadley, M. (Eds.), Tropical Forests, People and Food. Unesco-Parthenon, Paris, pp. 63–71.
Ranere, A.J., 1980. Human movement into tropical America at the end of the Pleistocene. In: Harten, L.B., Warren, C.N, Touhy, D.R. (Eds.), Anthropological Papers in Memory of Earl H. Swanson. Jr. Idaho State University Press, Pocatello, pp. 41–47.
Ranere, A.J., Cooke, R., 1991. Paleoindian occupation in the Central American tropics. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Oregon State University, Corvallis, pp. 237–253.
Rindos, D., 1984. The Origins of Agriculture: An Evolutionary Perspective. Academic Press, San Diego.
Roosevelt, A.C., Lima, M., Lopes, C., Michab, M., Mercier, N., Valladas, H., Feathers, J., Barnett, W., Imazio, M., Henderson, A., Sliva, J., Chernoff, B., Reese, D.S., Holman, J.A., Toth, N., Schick, K., 1996. Paleoindian cave dwellers in the Amazon: the peopling of the Americas. Science 272, 373–384.
Sandweiss, D.H., McInnis, H., Burger, R.L., Cano, A., Ojeda, B., Paredes, R., Sandweiss, M.C., Glascock, M.D., 1998. Quebrada Jaguay: early South American maritime adaptations. Science 281, 1830–1832.
Sauer, C., 1944. A geographic sketch of early man in America. The Geographical Review 34, 529–573.
Shott, M.J., 1996. An exegesis of the curation concept. Journal of Anthropological Research 52, 259–280.
Smith, C.E., 1966. Archaeological evidence for selection in avocado. Economic Botany 20, 169–175.
Smith, C.E., 1969. Additional notes on pre-conquest avocados in Mexico. Economic Botany 23, 135–140.
Sponsel, L.E., 1989. Farming and foraging: a necessary complementarity in Amazonia? In: Kent, S. (Ed.), Farmers as Hunters: the Implications of Sedentism. Cambridge University Press, Cambridge, MA, pp. 37–45.
Stanford, D., 1991. Clovis origins and adaptations: an introductory perspective. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Oregon State University, Corvallis, pp. 1–13.
Torrence, R., 1983. Time budgeting and hunter-gatherer technology. In: Bailey, G. (Ed.), Pleistocene Hunters and Gatherers in Europe. Cambridge University Press, Cambridge, MA, pp. 11–22.
Willey, G.R., 1971. An Introduction to American Archaeology, Vol. 2,. Prentice-Hall, Englewood Cliffs, NJ.

PERGAMON

Quaternary International 109–110 (2003) 23–43

Terminal Pleistocene/Early Holocene human adaptation in coastal Ecuador: the Las Vegas evidence

Karen E. Stothert[a,*], Dolores R. Piperno[b], Thomas C. Andres[c]

[a] Center for Archaeological Research, The University of Texas at San Antonio, San Antonio, TX, USA
[b] Smithsonian Tropical Research Institute, Balboa, Panama
[c] Cornell University, Ithaca, NY, USA

Abstract

Preceramic sites located on the Santa Elena Peninsula in southwestern Ecuador and occupied in the Terminal Pleistocene and during the Early Holocene (10,800–6600 BP) have produced evidence of a durable Las Vegas adaptation focused on marine, estuarine and terrestrial resources. The Las Vegas people were among the earliest cultivators in America who participated in the domestication of useful plant species and progressively intensified their efforts in both fishing and horticulture.

1. Introduction

The earliest known inhabitants of the coast of Ecuador were the preceramic Las Vegas people who occupied sites located on uplifted Pleistocene terraces on the Santa Elena Peninsula (Fig. 1) between 10,800 and 6600 years ago (uncalibrated radiocarbon dates are used throughout). In this paper we review and update the interpretation of the paleoenvironments of the peninsula, describe the preceramic use of marine, estuarine and terrestrial resources, and report on new research which supports the idea that the Las Vegas people domesticated and adopted cultigens including squash and gourds (*Cucurbita* spp.) at the beginning of the Early Holocene period (10,000–7000 BP). The Las Vegas people were among other occupants of the Pacific littoral of South America who developed coastal adaptations at the end of the Pleistocene (Richardson, 1973, 1978, 1981; Llagostera, 1979; Sandweiss et al., 1989, 1996a, b, 1999a, b; Stothert and Quilter, 1991), but as early as the beginning of the Early Holocene Las Vegas people initiated an enduring pattern of plant cultivation.

2. Peopling the coast of Ecuador

The study of the origins and routes of dispersal of Paleoindians in South America is ongoing and controversial. The derivation of the first inhabitants of Ecuador cannot be specified, but it is clear that people were living in the highlands and along the southwest Ecuadorian littoral between 11,000 and 10,000 BP (Temme, 1982; Salazar, 1983; Stothert, 1985, 1988). The earliest denizens of the coast might have arrived by sea (Holm, 1986, 1987; see also Fladmark, 1978, and Sandweiss and Richardson, 2000).

If people entered Santa Elena in the Late Pleistocene, whether by land or by sea, they would have found a patchwork of biomes and an array of animals. The species identified in the Late Pleistocene fossil assemblages from Santa Elena (remains probably less than 25,000 years old) and from the Talara region of northern Peru (remains about 14,000 years old) include the following: mastodons, horse, camelids, deer, ground sloth, armadillo, capybara, opossum, fox, wolf, puma, saber-tooth tiger, snakes, lizards, turtles, crocodiles, gulls, ducks, doves, falcons, owls, vultures and condors (Hoffstetter, 1952; Edmund, 1965). The fossil evidence suggests that these terrestrial environments were relatively open grasslands with gallery vegetation along the river courses. Apparently there was sufficient moisture to maintain a high water table, standing pools of water, and vegetation along the drainage courses, but

*Corresponding author.
E-mail addresses: maur2stoth@earthlink.net (K.E. Stothert), pipernod@stri.org (D.R. Piperno), tom@Andres.com (T.C. Andres).

1040-6182/02/$ - see front matter © 2003 Elsevier Ltd and INQUA. All rights reserved.
PII: S1040-6182(02)00200-8

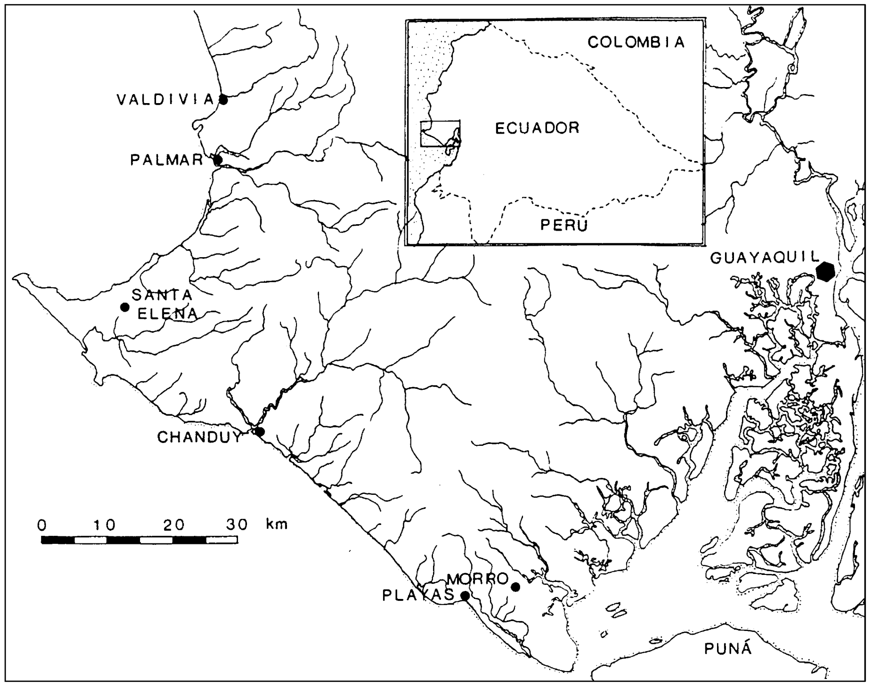


Fig. 1. Map of southwestern Ecuador showing the Santa Elena Peninsula, modern towns (small black dots), the city of Guayaquil (black hexagon), and the seasonal rivers of the peninsula.

insufficient to support forests between the temporal rivers (Lemon and Churcher, 1961). Along the littoral, people would have found a teeming sea, as well as lagoons, bays and estuaries where fresh water pooled seasonally (Lemon and Churcher, 1961; Edmund, 1965; Campbell, 1973, 1982; Richardson, 1978, 1998a, b; Portais, 1983; Usselmann, 1989). The Late Pleistocene environments were affected by tectonic uplift (Sheppard, 1937; Edmund, 1965), changes in sea level (Fairbridge, 1960), and climate changes occurring on a global scale (Sherratt, 1997).

In coastal Ecuador no association between fossil bones and diagnostic human artifacts has been described, and no credible Late Pleistocene cultural deposits are known (Stothert, 1983). The discovery of a few stone projectile points with no archaeological context is the only evidence that the Santa Elena Peninsula was occupied by Paleoindian hunters, but human predators are likely to have been attracted to the Ice Age herbivores before those animals became extinct in the Terminal Pleistocene Period.

3. The preceramic culture of the Santa Elena Peninsula

In contrast to the lack of information about Late Pleistocene peoples in coastal Ecuador, the Early Holocene Las Vegas way of life is known from a wide variety of evidence found in 32 sites on the Santa Elena Peninsula (Fig. 2). The reconstruction of this preceramic adaptation is based principally upon evidence from the Las Vegas type site, Site 80 (CT M5 A3-80, formerly OGSE-80, 2°13′S; 80°52′W), which is characterized by deep midden that accumulated for almost 4000 years (Stothert, 1976, 1977, 1979, 1985, 1987, 1988; Ubelaker, 1980, 1988; Malpass and Stothert, 1992). Today the site is located about 3 km from the Bay of Santa Elena.

The Las Vegas type site is found in the coastal zone, defined as the land lying between the Ecuadorian Andean massif and the sea. This diverse region measures between 70 and 200 km in width and some 700 km from north to south, and is characterized by wet tropical forest in the north and dry forests and open habitats in the south. A pattern of seasonal rainfall is characteristic of most of the coast, which results in a mosaic of compressed terrestrial zones with variable agricultural potential. Today the Santa Elena Peninsula is a biologically complex, dry, tropical ecotone, sometimes called the “abnormal appendage” of southwest Ecuador (Wolf, 1975 [1892]). The chronological framework for interpreting Las Vegas evidence is based upon numerous radiocarbon dates (Table 1) which inspire confidence because they form a coherent series, they agree well with independent stratigraphic interpretations, and because the assays were made at different laboratories using shell, charcoal, human bone, and by directly dating microfossil samples using AMS techniques.

Three radiocarbon dates associated with sparse cultural materials in the deepest levels of Site 80 are the only evidence of a pre-Las Vegas occupation

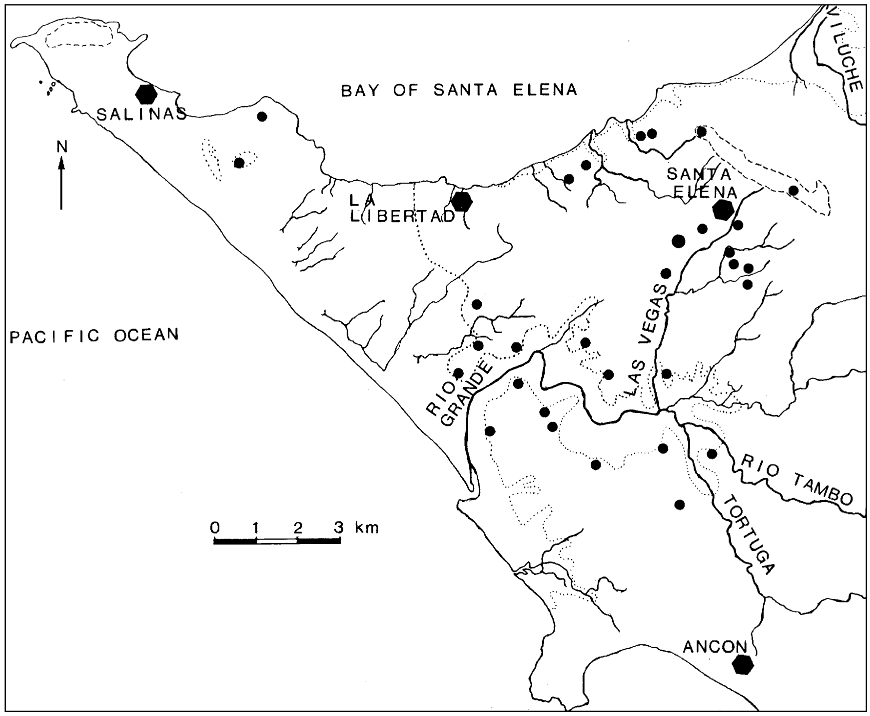


Fig. 2. Map of the western portion of the Santa Elena Peninsula showing the distribution of Las Vegas preceramic sites, the modern drainage pattern, the modern 10-m contour line (dotted line), modern towns (hexagons), Las Vegas Site 80 (larger dot near the town of Santa Elena), and 30 other Las Vegas camp sites (small dots).

between 10,800 and 10,000 years ago (Stothert, 1988, pp. 618–619). The subsequent Las Vegas occupation lasted from about 10,000–6600 BP. On the basis of a stratigraphic break in the midden at Site 80, the preceramic occupation was divided into an Early Las Vegas phase (10,000–8000 BP) and a Late Las Vegas phase (8000–6600 BP).

Las Vegas settlement strategies are poorly known and Las Vegas patterns of residential mobility have not been modeled adequately. Nevertheless, people may have occupied Site 80 either continuously or re-occupied it repeatedly from the terminal Pleistocene until about 6600 BP. In the Late Las Vegas Period this possible base camp may also have served as a ceremonial center where its residents undertook elaborate funeral activities, which are understood as evidence of social intensification and growing economic complexity. Other sites, consisting of shallow deposits of preceramic midden dated to both the Early and Late Las Vegas periods, suggest that the preceramic people also occupied temporal campsites near the western tip of the peninsula (Fig. 2) while they exploited marine and land resources (Stothert, 1988, pp. 225–236).

4. Reassessing Las Vegas paleoenvironments

There is no paleoecological evidence from the Santa Elena Peninsula which would permit a fine-grained paleoenvironmental reconstruction for the region. However, numerous studies have demonstrated that the Late Pleistocene period in tropical America was characterized by drier and cooler climates and vegetation and faunal communities that differed substantially from conditions seen today (Piperno and Pearsall, 1998, Chapter 2). It is likely that the people of Santa Elena, like other Terminal Pleistocene peoples, were confronted with fluctuating environmental conditions and changing resource availability, which were influential factors in the development of food production. Although we lack direct evidence, it seems likely that the Las Vegas people manipulated the vegetation (including burning and clearing native vegetation before cultivation) and significantly altered their environment in the Early Holocene, as has been demonstrated for other tropical regions including Panama and in the Amazon (Stahl, 1996, pp. 113–114; Piperno and Pearsall, 1998; Athens and Ward, 1999).

After a review of recent literature, Stahl (1996, p. 118) concluded that "[a]t any given time and place, environmentally and/or anthropogenically induced alteration set both the numbers of different kinds of species and their respective proportions into a continuous flux." He further emphasized that the "Holocene record suggests a dynamic ecological history that impacted plants, animals, and native human populations on a hemispheric scale" (1996:109). Specifically, the end of the Pleistocene was characterized by "gradual and oscillating climatic

Table 1
Thirty-two radiocarbon dates and calibrated ranges from Las Vegas cultural contexts (Stothert, 1988, p. 56, Table 3.1; 1988, p. 231, Table 12.2; Piperno and Pearsall, 1998, p. 186, Table 4.1)

	Site number	Measured radiocarbon age (BP)	Material assayed	Conventional radiocarbon age	95% probability dendrocalibrated age range in years BP (2-sigma)[a]
Rejected dates	80	15,850±400	C	15,850±400	20,160–17,750
	80	12,130±70	P[b]	12,130±70	Circa Cal 15,260–13,830
Pre-Las Vegas	80	10,840±410	C	10,840±410	Circa Cal 13,820–11,350
	80	10,300±240	C	10,300±240	12,950–11,210
	80	10,100±130	S	10,510±130	Circa Cal 12,310–10,850
Early Las Vegas	80	9800±100	S	10,210±100	Circa Cal 11,620–10,640
	80	9740±60	P[b]	9740±60	Circa Cal 11,220–10,890
	80	9550±120	S	9960±120	Circa Cal 11,310–10,300
	201	9460±100	S	9870±100	Circa Cal 11,150–10,290
	80	9080±60	P[b]	9080±60	Circa Cal 10,370–10,170
	80	8920±120 [9330±120]	S	9330±120	Circa Cal 10,540–9560
	80	8810±395	C	8810±400	Circa Cal 11,090–8990
	80	8600±200	S	9010±200	10,290–8980
	78	8600±100	S	9010±100	Circa Cal 9930–9080
	80	8250±120	HB	8350±120	9540–9020
	80	8170±70	S	8580±70	Circa Cal 9410–8890
	38B	8100±130	S	8510±130	Circa Cal 9590–8770
Late Las Vegas	80	7960±60	P[b]	7960±60	9010–8610
	67	7480±70	S	7890±70	8460–8180
	66	7390±60	S	7800±70	8380–8120
	202	7780±90	S	8190±90	8940–8430
	80	7710±240	HB	7810±240	9290–8160
	80	7600±100	S	8010±100	8700–8290
	80	7440±100	S	7850±100	8500–8110
	38A	7250±150	S	7660±150	8400–7810
	80	7170±60	P[b]	7170±60	Circa Cal 8110–7860
	80	7150±70	S	7560±70	8160–7870
	203	6900±80	S	7310±80	7930–7610
	80	6750±150	HB	6850±150	7960–7440
	80	6600±150	HB	6700±150	7820–7310
Post-Las Vegas	213	5830±80	S	6240±80	6860–6490
	80	5780±60	P[b]	5780±60	6710–6430

Dated material includes phytoliths (P), shell (S), human bone (HB), and charcoal (C). Beta Analytic provided the Beta/Pretoria calibrations (Stuiver and van der Plicht, 1998; Stuiver et al., 1998; Talma and Vogel, 1993).
[a] In the case of each date that has multiple ranges, caused by the highly variable correlation between radiocarbon years and calendar years, the set of ranges has been collapsed into a single range [circa Cal xxxx–yyyy] for purposes of this discussion.
[b] AMS date.

amelioration'' after which there were ''greater seasonal extremes in temperature and moisture'' that resulted in substantial change in the communities of plants and animals: ''[I]n this scenario, local richness and evenness of any biota would be in a state of constant spatial and temporal flux as each component acted and reacted according to its own ecological needs depending upon changing circumstances'' (1996:110).

Regrettably the Las Vegas midden deposits are too compressed to allow the documentation of climate processes and oscillations, but it is widely believed that these processes created long- and short-term environmental variations throughout the Early and Middle Holocene (Piperno and Pearsall, 1998, pp. 90–107). Plant and animal remains from the Vegas type site indicate the ancient Las Vegas environments varied across only a limited range, from thorn scrub to seasonally dry forest. This suggests that there was a persistent pattern of seasonal rainfall and a marked dry season in the region. Our current understanding of past environments will be summarized here in four discussions.

4.1. The Vegas littoral

In southwest Ecuador today marine resources are attractive due to their great diversity, the availability of a large biomass, and the absence of pronounced seasonality. These waters today are only slightly less rich in terms of carbon, phytoplankton, and zooplankton than those of coastal Peru (United Nations, 1972, maps 1.1, 1.2; Rand McNally Corporation, 1977, p. 86). The overall productivity of the marine biotopes of Ecuador is not drastically affected during periodic El Niño disturbances. While marine resources are irregularly distributed because of coastal morphology and the localized contribution of nutrients from river systems, the same species are available in differing proportions along the southwestern coast. The most attractive areas for prehistoric fishermen and modern artisanal fishermen are the shallow bays, shoals, lagoons, estuaries and mangrove formations (including the great ones of Esmeraldas and Gulf of Guayaquil). Most fishing communities are and were oriented to these resource areas. The Bay of Santa Elena continues to be productive for both commercial and artisanal fishing.

Conditions in the sea and along the littoral of Santa Elena were probably very different in the past. The change in fish fauna between the Early and Late Las Vegas phases might have been due to changes in the position of the Humboldt Current, geomorphological alterations of the coast and associated ecological changes, or to technological, social or economic innovations among the Vegas fisherpeople.

Recent research has shown that in the Early Holocene ocean currents in the Pacific operated differently than they do today (Sandweiss, 1996a; Sandweiss et al., 1996). The warm Equatorial Counter Current apparently penetrated as far as 9° south latitude along the coast of Peru, and the boundary between the tropical Panamic faunal province and temperate Peruvian province (characterized by cold water upwelling) moved to a position some 800 km south of the Santa Elena Peninsula (Rollins et al., 1986; Sandweiss et al., 1996). While the more southerly position of the warm current resulted in dramatic changes in the distribution of marine faunal species in Peru, it seems to have altered the tropical pattern in Santa Elena to a much lesser extent. The same species exploited by the Early and Late Las Vegas people are still available off Santa Elena today.

Another factor that determines the distribution and extent of littoral resources is eustatic change in sea level. Recent research has supported Fairbridge's contention that marine transgression was marked by reversals and changes in tempo, so we believe that Vegas people were confronted with a dynamic littoral, but the relationship between the sea and the land at particular geographical locations at various dates in the past cannot be reconstructed with surety. Although the Fairbridge curve, which models changes in historical sea level, is repeated in modern text books (Bird, 1993, p. 15), there is controversy about the deformations in the earth's crust which caused local variations in sea levels. Morner's plot of sea level changes (since about 20,000 years ago) from sites around the globe against "present geoid position" shows considerable non-conformity, which he attributes to regional geoid deformation (Morner, 1983, 2000; Donnelly, 2001). Nevertheless, Fig. 3 represents one attempt to model Early Holocene sea level change using bathymetric soundings from the modern sea floor off the Santa Elena Peninsula (INOCAR, 1980 [1989]) and information about change in sea level (Fairbrige, 1961; Bird, 1993).

About 10,000 years ago mean sea level was depressed 30 m below its modern level (Table 2). In this case, an additional 600 km^2 of land might have been exposed. Taking into account a modest rate of tectonic uplift, the extent of exposed continental shelf would have been around 500 km^2.

In Fig. 3, Site 80 might have been located as much as 13 km from the coast (Table 3), or perhaps a kilometer or two closer if the land were 5 m lower at that time. Depending upon local topography, the exposed areas of the continental shelf might have been characterized by wetlands, lagoons, and mangrove swamps.

According to Fairbridge's research on sea level change (Fairbridge, 1960, 1961, 1962), there was rapid upsurge between 10,000 and 9000 years BP, then, in the 9th millennium BP, the sea level may have reached about 16 m below its modern mean, only to fall again to below 20 m below present level by 8000 BP. The amplitude of short-term oscillations was greater in this period than in the Middle Holocene Period (7000–3000 BP). More recent research has supported the Fairbridge curve (Bird, 1993, p. 15). Fairbanks (1989) has strengthened the evidence for two episodes of marine surge, one between 14,000 and 12,000 BP, followed by a period of stable conditions, then a significant "melt-water pulse" between 10,000 and 7000 BP.

Around 8000 BP the fluctuating sea level might have been near the 20 m isobath. In this case, Site 80 could have been about 12 km from the north shore of the peninsula, and the people may have enjoyed some 360 km^2 of land, estuaries and mangrove formations that are today submerged on the continental shelf. By 7000 years ago, when sea level was depressed only 10 m, Site 80 would have been only 5.5 km from the north shore, and the amount of exposed continental shelf was reduced to only 63 km^2 (see black area in Fig. 3).

As the sea level rose and fluctuated in Santa Elena, people would have witnessed the creation and destruction of mangrove swamps, as well as the alteration of river courses, water tables, salt marshes, lagoons, and

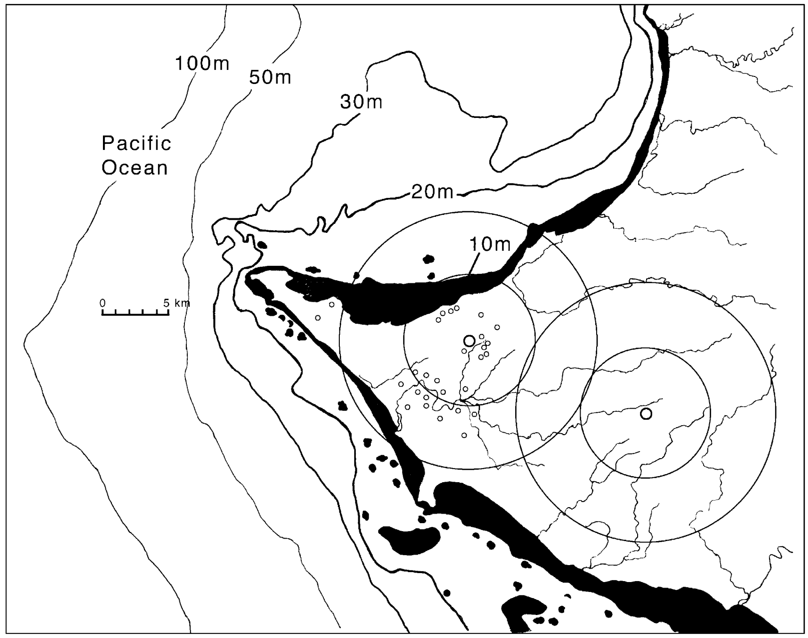


Fig. 3. Map of the changing coastline of the Santa Elena Peninsula as inferred from bathymetric readings of the modern sea bottom. When sea level was depressed 30 m, the paleocoastline may have approximated the 30 m isobath, and the continental shelf between that contour line and the present coast may have been dry land. The area between the 10 m isobath and the present coastline is marked in black. Thirty small Las Vegas camp sites are indicated by small circles, and Sites 80 and 67 are represented by larger circles. The catchment areas of these two large sites are represented by overlapping concentric circles 10 and 20 km in diameter.

Table 2
Extent of additional terrestrial zone exposed in the littoral of the Santa Elena Peninsula in the Early Holocene when world sea level was depressed (see Fig. 3)

Years before present (uncal. 14C years)	Sea level in meters below present level[a]	Amount of additional land exposed compared to today (in km^2)	Level of land (in meters) with respect to modern level	Difference in elevation (in meters) between modern shore line and sea level	Amount of land exposed given steady tectonic uplift of the land (in km^2)
10,000 BP	−30	600	−5	25	498
8000 BP	−20	450	−4	16	360
7000 BP	−10	97	−3.5	6.5	63
5000 BP	−5 to 0	20 to 0	−2.5	2.5 to 0	10
Present	0		0	0	—

If tectonic uplift occurred in coastal Ecuador at a steady rate of 0.5 vertical meters per 1000 years (as suggested for Peru by Richardson, 1998a, p. 4; Sandweiss et al., 1989, pp. 49, 53, then the distance between the modern shore and the paleocoastline might have been reduced as indicated.

[a] These levels are subject to both temporal and spatial fluctuations. For instance, in coastal Peru at 7000 BP the sea level may have been some 20 m below present sea level (Sandweiss and Richardson, 2000, p. 181).

estuaries (Bird, 1993; Oyuela-Caycedo and Rodriguez Ramírez, 1995). One authority states that "[p]resumably life in lower river valleys was precarious until the rise in sea level decelerated at about 4000 BC [6000 BP]" (Donnelly, 2001).

Evidence recovered from a deep sea core from off the coast of Ecuador, which probably reflects conditions in the Gulf of Guayaquil, suggests that mangrove formations reached their maximum development between 12,000 and 7000 years ago (Heusser and Shackleton, 1994, p. 223). In fact, mangrove clams (*Anadara tuberculosa*) dominated the molluscan assemblages of the Early Las Vegas Period, but were less well-represented in Late Las Vegas assemblages after 8000 BP (Table 4). These numbers may track the changing extent of mangrove formations on the peninsula.

It has been suggested that a specialized adaptation to the vast and highly productive mangrove formations of the Late Pleistocene/Early Holocene developed in the Gulf of Guayaquil (Spath, 1980), but this hypothesis is poorly supported because any archaeological sites located in or near the former mangrove swamps were later submerged during continuing marine transgression. Our inventory of Vegas sites lacks any specialized Vegas extraction camps that might have been located nearer the former littoral. The Las Vegas base camps, apparently lying inland from the sea, may represent only the terrestrial aspect of the ancient subsistence system. This interpretation has been suggested also by investigators in Peru who also deal with the more inland camps of preceramic people who also exploited the sea, perhaps seasonally (Richardson, 1998b, p. 3; Chauchat, 1992).

Returning to the issue of tectonic uplift. A conservative estimate of uplift falls in the range of 0.1–0.5 m per 1000 years (Clapperton, 1993, p. 71; Richardson, 1998a, p. 4, citing Sandweiss et al., 1989, pp. 49, 53), but it is also true that Santa Elena lies in a "subduction coast" where uplift is notoriously variable, "rising at different rates and by different amounts than neighboring sections; [and] differential vertical movements may occur even within a segment [of the coast] because of deep fractures" (Clapperton, 1993, p. 618). More troubling still is that Santa Elena rests within a degree of the Carnegie Ridge, an aseismic sub-marine ridge responsible for the extraordinary "flights of Quaternary marine terraces" observed along the coast. The height of the terraces in Ecuador and northern Peru is indicative of "rapid tectonic uplift compared to other parts of the Pacific coast where the terraces are lower" (Clapperton, 1993, p. 618). Some estimates suggest that uplift in the Northern Andes approximated 150 m in 70,000 years (Clapperton, 1993, p. 37), which is a rate of more than 2.0 m per 1000 years. Because of uncertainty about local tectonic changes, the conformation of the coastline in Vegas times remains a mystery.

The most important implication of this modeling of the Early Holocene littoral is that the ancient configuration of coastal resources was constantly changing. Estuaries and extensive mangrove formations would have been repeatedly created and destroyed, and all the evidence of these events has been scoured away or now lies underwater. The Santa Elena Peninsula lies within the tropical belt where the formation of mangrove swamps depends upon local geomorphology. Persistently rising sea level may have created the conditions that allowed mangroves to reach their greatest extent on the Santa Elena Peninsula in Vegas times. The mangrove formations which characterized Santa Elena early in the 20th century were destroyed altogether by bulldozers and dams (Ferdon, 1981; Stothert, 1988, pp. 243–244).

Even without specifying which physiographic changes took place precisely when, it is clear that plant and animal communities living along beaches, rocky points, and in bays and estuaries would have been affected by both sea level fluctuations and tectonic uplift. Similarly,

Table 3
Estimated distance from Las Vegas Site 80 to the seashore of Santa Elena at various moments during its occupation

Years before present (BP)	Sea level in meters below present sea level	Estimated minimum distance from Site 80 to north shore of peninsula (km)	Estimated minimum distance from Site 80 to south shore of peninsula (km)
10,000	−30	13	14.5
9000	−15	10	13
8000	−20	12	11
7000	−10	5.5	9
6000	−2	4	10
5000	0	3.5	10

Geographical relationships calculated from modern isobaths and by assuming depressed sea levels in the Early and Middle Holocene Periods (Fairbridge, 1961; Bird, 1993, p. 15). Tectonic uplift is ignored.

Table 4
Analysis of molluscan remains identified in excavated units from Las Vegas Site 80. Based upon a calculation of Minimum Number of Individuals in each sample, the occurrence of each category of mollusk is represented as a percentage of the entire sample

Las Vegas Phase	Level in unit F-H/8-11	Rock-Living species	Estuarine/Mangrove species	*Anadara tuberculosa*	Total[a]
Range of occurrence of species in three Late Las Vegas contexts	65–80 cm 80–90 cm 90–100 cm	5.3–8.6%	13.3–13.8%	57–70%	78.9–89.1%[a]
Range of Occurrences of species in 4 Early Las Vegas contexts	100–110 cm 110–120 cm 120–130 cm 130–140 cm	0.8–1.5%	5.5–8.3%	81–87%	89.9–94.9%[a]

The category of rock living species includes *Astrea* sp., *Fisurella* sp., and *Turbo saxosis.* The estuarine and mangrove species include *Cerithidea pulchra, Tagelus rufus*, and *Thais kiosquiformes.* The mangrove clam *Anadara tuberculosa* is described separately. Data taken from Stothert (1988, Chapter 9).

[a]Other mollusks not listed make up only 5.1–10.1% of the Early Las Vegas assemblages. In contrast, other species make up 10.9–21.1% of the Late Las Vegas samples.

in the terrestrial zone, changes in water table, in river gradients, and sedimentation rates can be inferred.

The long-term settlement of some sites in western Santa Elena may reflect the formation and persistence of productive embayments, estuaries and mangroves during the period of dramatic marine emergence (Bird, 1993, p. 15). Cultural change in the archaeological record may reflect human responses to the instability of highly productive estuarine resources, particularly mangrove swamps (Oyuela-Caycedo and Rodriguez, 1995).

4.2. Terrestrial animals and Vegas environments

The remains of terrestrial animal species found in midden deposits at Site 80 are the basis for the reconstruction of the Las Vegas environment and climate regime (Table 5). Regrettably neither the paleoenvironmental reconstructions based on Pleistocene fossils, nor the interpretation of the Las Vegas remains is sufficiently fine-grained to identify climate oscillations and environmental shifts, even those that may have lasted a few centuries or more. The Vegas bioindicators were recovered from "time-averaged assemblages [which] could easily mask environmental variability, particularly in sensitive ecotonal areas like southwestern Ecuador" (Stahl, 1991, p. 356).

Assemblages of terrestrial vertebrate animals that accumulated for over 3000 years in Las Vegas midden deposits showed only species that are found today in the sub-humid and arid environments of southwestern Ecuador. In Vegas times, the region was probably a semi-arid ecotone: as the Vegas people moved just short distances across the landscape they would have found distinct plant and animal communities, but little wet forest. Despite a potential for radical environmental change (caused by shifts in global climate), species characteristic of moist tropical forests are missing from the Vegas fauna, so we conclude that moister conditions were never established.

In summary, the bones of terrestrial animals suggest that conditions were always sub-humid on the western peninsula. Similarly, the remains of fish and shellfish which accumulated in the Vegas midden showed that the same marine species that are present today were important in Vegas times (although today mangrove clams are locally extinct).

4.3. Plant remains and Las Vegas conditions

Today precipitation on the peninsula is concentrated in one short season, followed by eight relatively dry months. This climate pattern does not necessarily create desert-like conditions. The modern desert characteristic of the western portion of the peninsula is the result of deforestation and other human interventions. Ferdon (1981) argued that geomorphological forces in Santa Elena caused environmental change in the past, and Spath (1980) working near the Gulf of Guayaquil has concluded that the differences between the preceramic period environment and the modern environment can be attributed to human degradation of the plant communities and not to climate change. Pearsall (1979, pp. 55–64, 1988) reconstructed the environments of the Valdivia and Machalilla periods and concluded that the climate patterns and currents of the western peninsula during between 5000 and 3500 BP were similar to the present day.

Past environments, unaffected by recent depredation, would have been more attractive to people with or without a moisture budget more generous than today's. Based on contemporary observations of more humid conditions in areas to the north and east of Santa Elena, we can imagine a scenario in which the peninsula received greater rainfall, but the evidence from Las Vegas sites shows that tropical forest conditions were never produced in the immediate vicinity of the Las Vegas sites. Documented shifts in the position of the Intertropical Convergence Zone (from north of the Equator toward the south) might have increased the amount of rainfall southwestern Ecuador, and global phenomena such as mid-Holocene warming and eustatic rises in sea level might have affected the moisture budget in Santa Elena. However, the Las Vegas remains have lead to the conclusion that the Early Holocene environment of the peninsula was seasonally arid.

Missing from the Las Vegas sediments are palm phytoliths which are found commonly in archaeological soils in moist tropical habitats. In contrast, the abundance of grass and shrub phytoliths in Las Vegas soil samples is additional evidence that the ancient environment was dry. The western part of the peninsula probably was characterized by thorn scrub and wooded savanna vegetation in the Early Holocene (Piperno and Pearsall, 1998, Chapters 2 and 4, Figs. 4.1a, b).

4.4. Climate change

The paleoclimatic history of northwestern South America is based on several pollen cores and on global climate models. It is not sure that general climate models accurately describe conditions in local areas, such as Santa Elena, because paleoclimatic patterns have been regionally very differentiated since about 12,000 years ago (Markgraf, 1993, pp. 377, 381, 357–358). Nevertheless, one general paleoclimate history for lowland South America states that conditions "…at 12,000 yr BP were cold and dry, in a continuation of the glacial mode. By 9000 yr BP moisture levels had reached or even surpassed modern levels, but temperatures were probably still lower than today. After 8500 yr BP moisture

Table 5
Composite list of animal species identified in both Early and Late Las Vegas faunal assemblages excavated from Site 80[a]

Family or species	Common name, Spanish	Common name, English	Habitat
Fish			
Carcharhinidae	Tiburón	Sharks	Off and in shore
Mustelus sp.	tollo, cazón de leche	Requiem shark	—
Dasyatidae	Raya	Stingrays	In shore
Ariidae	Bagre	Sea catfish	Estuaries and in shore
Bagre sp.	Bagre	Sea catfish	Estuaries and in shore
Centropomus sp.	Robalo	Snook, robalo	Off shore
Serranidae	Guato, cherna	Sea basses, groupers	Estuaries and in shore
Batrachoides sp.	Bruja	Toadfish	rocks
Scombridae	Atún, bonito, sierra	Tunas , mackerels	Off and in shore
Caranx sp.	Jurel, caballa	Jack, yellow caranx	Estuaries and in shore
Chaetodipterus sp.	Leonora, chavela	Spadefish	Rocks
Mugil sp.	Liza	Mullet	Estuaries and in shore
Trachinotus sp.	Pámpano	Pompano	Beach
Lutjanus sp.	Pargo	Snapper	Estuaries and in shore
Diapterus sp.	Mojarra, palometa	Mojarra	Beach
Orthopristis sp.	Teniente, presidents	Grunt, pigfish	—
Isacia sp.	—	Grunt	—
Micropogonias sp.	Corvina , roncador	Croaker	In shore
Odontoscion sp.	—	Drum, croaker	—
Scianidae	Corvina, chogorro	Drum, croaker	Estuaries and in shore
Conodon sp.	Limona	Drum, Barret grunt	Beach
Paralonchurus sp.	Rayado , ratón	Drum, croaker	Beach
Sciaena sp.	Corvina, roncador	Drum	—
Sphaeroides sp.	Tamborín, tambulero	Swellfish, puffer	Beach
Cynoscion sp.	Corvina	Weakfish	In shore
Amphibians			
Ranidae	Rana	Frog	Cosmopolitan
Bufonidae	Sapo	Toad	Cosmopolitan
Anuran	Rana, sapo	Toads, frogs	Cosmopolitan
Reptiles			
Cheloniidae	Tortuga	Sea turtles	Sea
Emydidae	Tortuga	Box and water turtles	—
Dicrodon sp.	Lagarto	Lizard	Thorn-scrub
Boa sp.	Boa	Boa constrictor	Cosmopolitan
Drymarchon sp.	Culebra	Indigo snake	Cosmopolitan
Birds			
Psittacidae	Loro	Parrots	Cosmopolitan
Mammals			
Didelphus sp.	Zarigueya/zorro	Opossum	Cosmopolitan
Sylvilagus sp.	Conejo	Rabbit	Cosmopolitan
Mustela sp.	Chucuri	Weasel	Cosmopolitan
Dusicyon sp.	Lobo de selva	Fox	Cosmopolitan
Mazama sp.	Chivicabra, mazama	Brocket deer	Cosmop/mangrove
Odocoileus virginianus	Venado	White-tailed deer	Cosmopolitan
Tayassu sp.	Saíno, javelina	Peccary	Cosmop/thorn scrub
Cricetinae	Ratas, ratón de campo	Rats and mice	—
Sigmond sp.	Rata	Cotton rat	—
Proechimys sp.	Rata	Spiny rat	—
Other rodents	Roedores	Rodents	—
Tamandua t.	Oso mielero, tamandua	Anteater	Cosmopolitan
Sciuriade	Ardilla	Squirrel	Cosmopolitan
Canidae	Perro, lobo	Dog/wolf	—
Felis sp.	Tigrillo (?)	Cat	—
Marine mammal	Mamífero marine	Marine mammal	Sea, beaches
Crustaceans			
Decapods	Cangrejo	Crab	Rocks and mangroves

Table 5 (*continued*)

Family or species	Common name, Spanish	Common name, English	Habitat
Mollusks			
Anadara tuberculosa	Concha prieta	Clam	Abundant in mangrove
Anadara grandis	Pata de burro	—	Sand banks/low tide line
Astreae buschii	Colón	—	Rocks in tidal zone
Cerithidea pulchra	Churo, jeringaolorra	—	Mangrove/high tide line
Chione subimbricata	Concha	—	Bays and swamps
Chiton plates			Rocks
Fissurella sp.	Conchalagua	—	Rocks in tidal zone
Hexaplex regius	Churo zambo	Royal murex	Tidal zone
Lyropecten subnodosus	Concha de abanico	—	Shallow and deep waters
Argopecten circularis	pinganilla	—	Shallow and deep waters
Malea ringens	Churo	Grinning tun	Sand banks and rocks in tidal zone
Melongena patula	Caracol	—	Shallow and deep waters
Modiolus capax	Mejillón	Mussel	—
Natica sp.	Caracol	—	Deep waters
Ostrea columbiensis	Ostion	Oyster	Abundant in mangrove
Pinna rugosa/Atrina maura	—	—	Sand banks and bays
Pinctada mazatlanica	Concha de perla	Pearl oyster	Shallow waters
Pteria sterna	Concha de perla	Pearl oyster	Shallow waters and tidal zone
Pitar catharius	—	—	Deep sea
Protothaca ecuatoriana	Concha	—	Tidal zone
Tagelus dombeii	Michulla	Razor clam	Tidal zone, mangrove
Thais kiosquiformes	churo	—	Tidal zone, mangrove
Trachycardium sp.	Concha	Cockle	Shallow and deep waters
Turbo saxosus	Guerere soñador	—	Rocks in tidal zone
Strophocheilus sp.	Caracol de monte	Tree snail	Trees and bushes

[a] Data from Byrd (1976), Chase (1988), Stothert (1988), and Wing (1988); see also Cobo and Massay (1969), Patzelt (1978), and Keen (1971).

levels fell, reaching a minimum at 6000 yr BP" (Markgraf, 1993, p. 364).

Because there is little evidence for ancient climatic conditions in southwestern Ecuador during the Late Pleistocene and Early Holocene (Sarma, 1974; Spath, 1980; Stothert, 1987; Stahl, 1991), late glacial moisture patterns in Santa Elena can not be inferred directly, but it seems likely that less precipitation fell in the Late Pleistocene than in the Early Holocene. Temperatures were probably significantly reduced as well, as has been shown for elsewhere in tropical America (Colinvaux et al., 1996; Piperno and Pearsall, 1998).

Today the aridity of the Santa Elena Peninsula is attributed to the action of the cold Peru (Humboldt) Current. If this cold current had a more southerly position in the Early Holocene (Sandweiss, 1996a), and if the warm Equatorial Counter Current permanently bathed the peninsula, then the region may have experienced more rainfall, even without the effects of the ENSO phenomenon, which seems to have occurred much less frequently before 5000 years ago (Sandweiss et al., 1996).

Despite the possibility of a wetter regime in the Early Holocene (as predicted by the general paleoclimatic model), the Las Vegas environment inferred from midden remains was shaped by a pattern of low rainfall or seasonal precipitation. The plant and animal communities found near the Cape of Santa Elena in the 3000 year-long Las Vegas period apparently are the same ones found in sub-humid and semi-arid southwest Ecuador today. Even if there was greater precipitation in the Early Holocene epoch, nevertheless, palms, bamboo, monkeys and other canopy animals were never present.

Because the Southern Hemisphere in general experienced decreased seasonality in the Early Holocene (Markgraf, 1993, p. 379; Piperno and Pearsall, 1998), it is possible that precipitation in Las Vegas times was more evenly spread throughout the year (as compared to the Middle and Late Holocene periods after 7000 BP). Markgraf suggests that in South America only after 8500 years BP was there an increase in "seasonally dry periods" (1993:364). Dry southwesterly winds in the Early Holocene might have increased evaporation (Svenson, 1946) which prevented the formation of moist forests in southwestern Ecuador, but it seems likely that plant cultivation was always possible on a small scale in Santa Elena. While this activity could have been limited by low annual rainfall, it might have been favored by a more robust water table and lower rates of evaporation than observed today.

While environmental conditions in both the Early and Late Las Vegas periods seem to have been within the range of modern ones, this does not mean that they were unchanging. On the continental scale there is growing evidence that past climate regimes were different from present ones, and scientists are now convinced that Neotropical environments were unstable in the Late Pleistocene and Early Holocene periods (Markgraf, 1993; Piperno, 1994, p. 638; Piperno and Pearsall, 1998; Athens and Ward, 1999). According to Markgraf (1993, p. 364), "[b]etween 10,000 and 8500 yr BP those records with sufficient paleoenvironmental detail show a rapid stepwise succession of vegetation types, replacing the Late Pleistocene grasslands.... This succession suggests a stepwise warming and increase in precipitation."

Pollen data from a site on the Galapagos Islands off Ecuador shows that toward the middle of the Early Holocene there was an environmental transition, from grassland with a few savanna trees and extensive marshes at 9000 BP to a grassland with more savanna trees and much reduced marshland at 6000 BP (Markgraf, 1993, p. 365, Fig. 143). Subsequently people may have witnessed intervals of "moisture stress" beginning as early as 8000 BP and continuing after 6000 BP (Markgraf, 1993, p. 377). In other words, in South America after 8500 years BP there may have been an increase in "seasonally dry periods" (1993:364).

Temporal and regional details are missing for the Santa Elena Peninsula, but if there was a drying trend late in the Early Holocene, this would have increased the attractiveness of risk-averting subsistence strategies, including plant cultivation and fishing. It is intriguing that ecologists expect to find "the wild ancestors of many important crop plants" in environments with dry seasons, such as those of ancient Santa Elena in Vegas times. These are the probable areas of origin of plant husbandry (Piperno and Pearsall, 1998, pp. 46; 50–52).

5. Las Vegas settlements and adaptation

The 32 known Vegas settlements (Fig. 3) reflect the adaptation of a group of people who harvested a wide variety of species from several sub environments on the western peninsula and in the Bay of Santa Elena. These Vegas sites are found today between 10 and 60 m above modern sea level. In the Early Holocene they must have been located on low hills overlooking the courses of seasonal or permanent rivers. In Vegas times the distance from these camps to littoral resource areas must have been greater.

The locations of the two larger Vegas sites, Sites 80 and 67/66, and of all the smaller sites (Fig. 3) indicate that both terrestrial and marine resources were attractive: these sites offer access to river bottom, to inland terrestrial environments, including higher hills east of Site 80, and to the diverse biomes of the littoral which, in the Early Holocene, may have lain between 5 and 20 km from Site 80, and even further from Site 67/66 (Fig. 3). Permanent residence in these settlements may have been desirable because of the juxtaposition of tropical marine and terrestrial resources. However, given the mosaic of resources available within the 10 km catchment zone of these settlements (Fig. 3), it seems possible that people might have moved freely from camp to camp depending upon the season or upon personal preferences. At this time it is not possible to weight the relative importance of resources in the Vegas subsistence system at any moment in time.

In the Early Las Vegas Period the local community may have consisted of tiny, independent household groups: the only known Vegas is a shelter less than 2 m in diameter (Stothert, 1988; Malpass and Stothert, 1992). Perhaps the basic social unit of production, distribution and consumption was the small, relatively self-sufficient family, flexibly organized for carrying out a wide variety of subsistence tasks using a few generalized tools and facilities. It is possible that this basic economic unit changed in Late Las Vegas times, and that people grew less mobile and more committed to plant cultivation.

When Lanning originally defined Vegas he suggested that there were "riverside camp sites" and "shell middens along the shore and near ancient estuaries" (Lanning, 1967, p. 13). Subsequently no true "shell midden" sites have been identified. Site 38 (located just east of modern Salinas and occupied as early as 8000 BP) might have been located closer to the shore and the mangrove swamps than Site 80, but the accumulated midden showed about the same density of shell remains as seen at Site 80 (Stothert n.d. [1971]).

While marine and estuarine resources contributed significantly to the diet of the Vegas people, it is now clear that plant cultivation also was a key aspect of their way of life. Newly excavated Site 67/66 (Fig. 3), located 15 km further inland from Site 80, has been interpreted as another base camp where Vegas people resided and buried their dead (Stothert, 2000).

Although the length of occupation of Site 67/66 has not been estimated, the first two radiocarbon dates confirm that midden accumulated there at the beginning of the Late Las Vegas Period (Table 1). Based on preliminary observations, it seems that the density of molluscan remains may be lower at Site 67/66 than at Site 80, and the ratio of deer bone to fish bone may be higher. Initial analysis of sediments from Site 67/66 show that squash (*Cucurbita* spp.) was being consumed there. Midden contents support the idea that this was a habitation site, but both Site 80 and 67/66 are distinguished from all the smaller Vegas settlements by the presence of graves. The recovery of human remains in both primary and secondary burials at both Site 80 and Site 67 is evidence of burial ceremonialism which may have been a mechanism by which members of the Vegas community achieved greater social integration or expressed their claims to resources and territory (Stothert, 1985, 1988, 2000).

These two sites indicate a Late Las Vegas pattern: families apparently occupied base camps located some kilometers inland near small seasonal rivers whose valleys served as a conduit for people moving between littoral extraction camps and inland areas. People may have settled in these base camps seasonally in order to cultivate crops and undertake celebrations that involved members of the larger community. People may or may not have exploited marine/estuarine resources on a daily basis, but they did carry seafood to these inland sites at intervals.

6. Evidence of change

A remarkable pattern of change has been described from the study of Las Vegas zooarchaeological and paleobotanical evidence.

6.1. Faunal remains

Remains from Las Vegas midden indicate that the ancient people exploited 25 categories of marine fish, one marine mammal, crab, a wide variety of mollusks, several species of reptiles and amphibians, scant bird, and 15 categories of terrestrial mammals (Table 5). More important is that when a comparison is made between the Early Las Vegas midden levels (9800–8000 BP) and the Late Las Vegas levels (8000 and 7150 BP), a pattern of change is revealed.

Table 6 shows that the relative contribution of fish increased significantly in the Late Las Vegas period as sea level fluctuated and approached its modern level. Although fish may not have contributed more calories to the diet than terrestrial vertebrates in either of the Las Vegas phases, the evidence indicates a change in the valuation of fishing and an intensification in some fishing activities which might have involved technological change, or reorganization of labor or increased labor investment. All the Las Vegas fish could have been taken with hooks in near-shore waters or estuaries (Byrd, 1976; Chase, 1988), although netting, trapping, and the use of fish poison are possible alternative strategies for harvesting these resources. The Las Vegas artifacts that were preserved do not offer clues about either fishing or hunting techniques: neither fishhooks nor projectile points were found. It seems likely that rafts and canoes were in use by Las Vegas people for fishing and travel: the faunal species identified could have been taken by fishermen who lacked skill in offshore navigation, but logically that skill could have developed over time (Stothert, 1977).

A comparison of the Early and Late Vegas faunal remains also shows that terrestrial animal exploitation changed by species (Stothert, 1988). The Early Las Vegas people consumed both large mammals (principally deer), smaller ones (rodents and opossum), and fish, but in Late Vegas times while the same larger mammals were exploited, the smaller ones were sought less frequently, and, at the same time, people took more fish, including more small fish.

An analysis of shellfish remains from the midden at Site 80 shows a contrast between the Early and Late Las Vegas levels (Table 4). While the Early Vegas folks brought home principally *Anadara* clams from the mangrove swamps, the later peoples consumed a wider variety of shellfish from rocks and other habitats. Shell artifacts were recovered from Late Vegas tombs, but no Early Vegas period graves were investigated and no shell artifacts were reported. The apparent change in shellfish exploitation may have tracked fluctuations in the estuarine/mangrove resources caused by sea level change. Feedback from other subsystems such as technology, short-term climate oscillations, the need to cope with population growth, or the expansion of other socio-ceremonial activities also might have inspired the ancient Vegans to intensify their use of certain animal resources at the expense of others.

One aspect of the Late Las Vegas diet was reconstructed by estimating the amount of edible biomass (expressed in calories) represented by the number of individuals of each animal species identified in a small sample of fauna remains (Byrd, 1976, p. Table 30; Stothert, 1988, pp. 199–201). This reconstruction was based only on vertebrate sources, whereas the ancient

Table 6
Comparison of the occurrence of bony remains of fish and mammals (expressed as a ratio of fish to mammals) from Early and Late Las Vegas deposits at Site 80

	Early Las Vegas contexts	Late Las Vegas contexts
Minimum number of individuals (fish/mammals)	30.5/55.2 = 0.55	48.4/38.5 = 1.26
Number of elements (fish/mammals)	11.2/22.2 = 0.50	22.2/21.4 = 1.04

Calculations are based on both the minimum number of individuals and number of elements identified in combined samples. Data from Chase (1988) and Stothert (1988, p. 194, Table 9.2).

people surely consumed large quantities of terrestrial and marine plants, as well as terrestrial and marine invertebrates, like insects, grubs, shrimp, and octopus, whose remains are not preserved in Las Vegas soils. The dietary estimate suggests the relative contribution of terrestrial mammals, marine fish and shellfish to subsistence over as much as 1000 years in the Late Las Vegas period.

In the sample studied, terrestrial animals (primarily deer) accounted for about 54% of the calories consumed from animal sources, fish contributed about 35%, and mangrove clams contributed about 11%. The proportion of shellfish may be over-estimated because of the excellent preservation of shell, while the quantity of small fish is probably underestimated in the calculations because the tiny bones which passed through the 0.5 cm screen have not been analyzed.

In summary, the study of faunal remains suggests that the Las Vegas people, living in villages inland from the sea in an area of tropical ecotone with little seasonal variation in the availability of animal resources, probably exploited a wide variety of terrestrial and marine species and enjoyed a constant supply of animal protein. In the Late Vegas period fishing practices apparently were intensified, and at that time half of all food from animal sources was sought in the marine and estuarine environments, while the other half came from the terrestrial zone. The human skeletal remains showed that people were healthy, free of anemia, and relatively long-lived (Ubelaker, 1980, 1988; Stothert, 1985, 1988).

6.2. *Paleobotanical remains*

Today, the seasonally dry tropical forest and savannas have a variety of useful and edible plants which probably were important to Vegas people (Svenson, 1946; Valverde et al., 1979; Lindao and Stothert, 1994), but poor preservation of plant remains initially frustrated the reconstruction of the vegetal aspects of Las Vegas subsistence (Stothert, 1985, 1988).

New evidence from the study of plant microfossils has altered strikingly our understanding of the Las Vegas adaptation, and now confirms that since early in the Holocene Las Vegas people were involved in plant cultivation. This result corresponds to the predictions of David Harris (1972), who argued that early populations in tropical ecotonal regions of northwestern South America would be among the earliest American horticulturists. It is also clear that several domesticated root plants were developed from wild ancestors native to the seasonally dry Neotropics, and that the cultivation and storage of maize and other seed crops is favored in regions, such as Santa Elena, with distinct and long dry seasons (Pearsall and Piperno, 1990, p. 335).

6.2.1. *Phytolith chronology*

The study of change in the use of plants in the Las Vegas period has been made possible by the development of methods for identifying plants from the microscopic silica bodies which originally formed in their cells and which are preserved in archaeological sediments (Piperno, 1988a, 1998). Not only may some ancient plants be identified to genus or species, but recently AMS dating procedures have been employed to assess directly the age of decoctions of phytoliths extracted from archaeological soils (Mulholland and Prior, 1993). This approach has verified that the Las Vegas phytoliths were deposited in the preceramic period and are of preceramic age. Furthermore, the Vegas phytolith assemblages have dates similar to those from samples of bone, shell and charcoal from the same midden contexts.

6.2.2. *Plant use in Vegas times*

Even though bottle gourd (*Lagenaria siceraria*) produces very few phytoliths, silica bodies from this plant are present at Site 80 in archaeological deposits dated as early as 9000 BP. They continue to appear in later levels (Piperno, 1988a, 1988b; Piperno and Pearsall, 1998).

Phytoliths from the seeds of *Calathea allouia* have also been identified. This is a tropical root crop, called leren, which is grown today in northern South America and the Antilles, and which probably was introduced into coastal Ecuador. Its diagnostic phytoliths appeared first in a 9000 BP level at Site 80, and they are common in later levels. The economic importance of this plant in Vegas times is unknown, but the occurrence of a few edge-ground cobbles and other simple, stone grinding tools is evidence that the Las Vegas people, like other preceramic groups, were processing tropical root foods (Ranere, 1972, 1976; Piperno and Pearsall, 1998, p. 283).

Vegas soil from all levels showed a high concentration of phytoliths from the epidermal cells of grass. Samples from the pre-7960 BP deposits show only phytoliths from wild grasses but maize phytoliths (*Zea mays*) were identified in soils from Late Las Vegas levels and some features (Pearsall and Piperno, 1990). Two samples containing phytoliths identified as those of maize yielded uncorrected dates of 7170 and 5780 BP. Maize apparently was not a staple in Las Vegas times, but the inhabitants of Site 80 began cultivating a primitive variety shortly before 6600 BP. No later preceramic sediments have been recovered from Site 80. The cultivation and storage of maize and other seed crops is favored in regions with distinct and long dry seasons (Piperno and Pearsall, 1998, p. 335).

Primitive maize, which is easily transported, would have been well adapted to the seasonally dry habitats of coastal Pacific Central America and the interior Cauca and Magdalena valleys of Colombia. People may have carried seeds out of West Mexico and dispersed them into northern South America along this route. There probably existed a network of interacting preceramic peoples who, in Vegas times, passed useful plants from hand to hand (Stothert, 1977, 1985, 1988).

The Las Vegans also may have cultivated beans, cotton, peanuts, and other tropical root crops like manioc, arrowroot, achira (*Cana edulis*), and perhaps species of *Xanthosoma* and *Dioscorea.* No direct evidence for these crops was recovered from Vegas sites, but several of these cultigens were positively identified, from both phytoliths and macrofossil remains, in later (Early Formative period) contexts in coastal Ecuador (Pearsall, 1979, 1988; Damp et al., 1981; Damp, 1990; Damp and Pearsall, 1994). Manioc and other tropical food species are difficult to identify, but manioc starch grains have recently been recovered from plant grinding stones dating to ca. 7000 BP at the Aguadulce Rock Shelter in Panama, evidence of its early domestication and spread from its domestication hearth in South America (Piperno et al., 2000a, b). Other evidence of domesticated squash, leren and bottle gourd were found in association with abundant remains of palm fruits at the Peña Roja site in eastern Colombia, in contexts dating to 8090±60 BP (Gnecco and Mora, 1997; Piperno and Pearsall, 1998, pp. 303–04).

6.2.3. *The domestication of squash (*Cucurbita* spp.)*

Recently botanical, paleobotanical and archaeological evidence has been employed to reconstruct the origin and development of domesticated squash (Andres, 1990; Andres and Piperno, 1995; Piperno et al., 2000a, b; Stothert et al., 2001). An analysis of the size of modern *Cucurbita* phytoliths has allowed Piperno to distinguish domesticated from wild squashes (Piperno and Pearsall, 1998, p. 191, Table 4.2; Stothert and Piperno, 2000, Table 5). Modern-day wild squashes have short phytoliths, while domesticated species have longer ones. The phytoliths of *Cucurbita ecuadorensis* are intermediate in size between those of wild species and domesticated species (*C. moschata* and *C. ficifolia*), a result supporting the semi-domesticated status of *C. ecuadorensis* (Nee, 1990).

Furthermore, it has been shown that as squash fruit and seeds increase in size, so do the phytoliths recovered from the remains of their fruit rinds (Figs. 4 and 5; Piperno and Pearsall, 1998, Chapter 4). This means that there is a method for assessing the size of ancient *Cucurbita* fruit and seeds directly from phytolith measurements (Piperno and Pearsall, 1998, Fig. 4.7a).

Cucurbita phytoliths are ubiquitous in preceramic midden at Site 80. Samples of phytoliths from the oldest midden deposits were dated by associated shell and charcoal, while the later phytolith assemblages were dated directly. The study of these samples demonstrates that the size of the phytoliths increased regularly through time (Table 7).

In brief, soil samples dating before 10,000 BP yielded a population of *Cucurbita* phytoliths whose measured

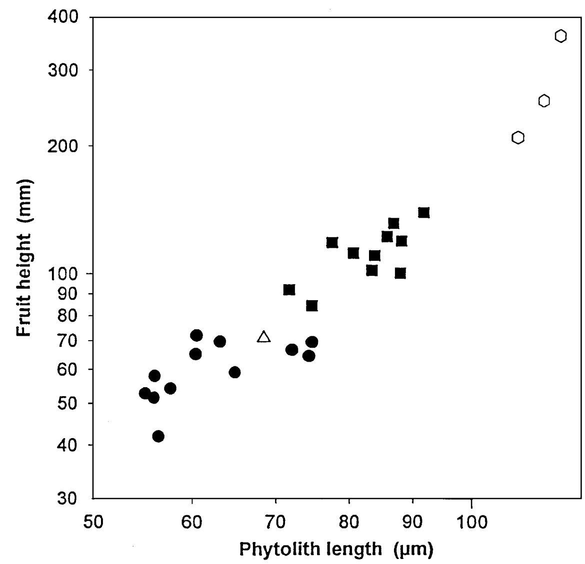


Fig. 4. The relationship between phytolith length (microns) and fruit height (millimeters) in modern species of *Cucurbita.* Black circles are wild *C. argyrosperma* ssp. *sororia* from Panama; open triangle is wild *C. pepo* ssp. *texana*; black squares are semi-domesticated *C. ecuadorensis*; and open hexagons are domesticated *C. ficifolia* (data from Piperno and Pearsall, 1998, p. 194, Fig. 4.7a).

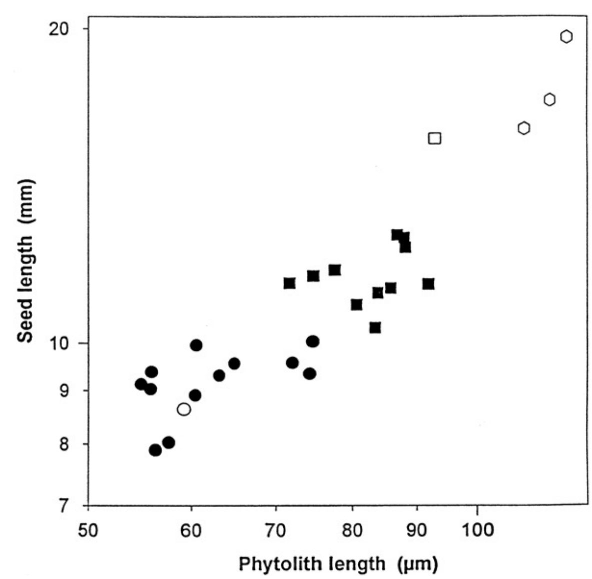


Fig. 5. The relationship between phytolith length (microns) and seed length (millimeters) in modern species of *Cucurbita.* Black circles are wild *C. argyrosperma* ssp. *sororia* from Panama; open circle is wild *C. foetidissima*; black squares are semi-domesticated *C. ecuadorensis*; open square is domesticated *C. moschata*; and open hexagons are domesticated *C. ficifolia* (data from Piperno and Pearsall, 1998, p. 195, Fig. 4.7b).

Table 7
Mean lengths and thicknesses of assemblages of squash phytoliths (*Cucurbita*) from dated archaeological contexts in Las Vegas Site 80. The pre-10,000 BP context was dated by associated shell and charcoal, but all the other contexts were dated by AMS dates from phytoliths

14C Phytolith age in years BP	Mean length in microns	Range	Number of length measurements in sample	Mean thickness in microns	Range	Number of thickness measurements in sample
5780 ± 60 Feature 1, 112 cm	96	72–120	8	74	56–88	4
7170 ± 60 GH8–9, 105–110 cm	94	64–116	12	78	64–95	6
7960 ± 60 G10–11, 130–140 cm	78	56–108	52	63	40–76	41
9080 ± 60 E8–9, 110–120 cm	86	56–120	66	68	42–93	32
9740 ± 60 F8–9, 110–120 cm	72	48–108	51	55	36–76	45
> 10,000 Feature 95, 200 cm	64	52–92	9	55	41–80	3

For calibrations see Table 1. Data from (Piperno and Pearsall, 1998, p. 186, Table 4.1; and Piperno et al., 2000a, b, p. 206, Table 5).

mean was small: it is very likely that the fruit and seed size had not been subject to significant selection by human beings. These probably were wild squashes.

The phytoliths from a context dated 9740 BP showed a greater mean length than those of the pre-10,000 BP deposit, although phytolith thickness did not increase. These phytoliths were within the size range of some modern, wild species, and were slightly smaller than those of modern *C. ecuadorensis.*

The assemblage of phytoliths with a direct phytolith date of 9080 BP yielded a mean length more than 20% greater than that of the next older sample, and the recorded phytolith thicknesses were significantly greater. Data suggest that the squashes of the early 9th millennium BP had fruits and seeds larger than those of any wild species that have been investigated. The ancient fruits likely were from a genetically and morphologically altered form of *Cucurbita*, and they likely measured at least 12 cm long.

The sediment sample dated 7960 BP showed phytoliths which were substantially larger than those in the 9740 BP context, but the means were not as high as the 9080 BP sample. In fact, the mean fell within the range of modern *C. ecuadorensis.* More than one type of squash may have been under domestication at Site 80 at this time.

The microfossil sample directly dated to 7170 ± 60 BP contained both maize phytoliths and an assemblage of squash phytoliths with the greatest mean length of any Vegas assemblage. The mean phytolith size overlapped that of modern *C. moschata.* The Late Las Vegas fruits may have been around 16 cm long, which is double the size of the 9700 year old squashes from the site. *Cucurbita* phytoliths of this size also occur in the later sample dated 5780 ± 60 BP.

In summary, the pattern of change in the size of squash phytoliths from these contexts appears to document the progressive domestication of the plant. These data support the argument that domestication was underway by 9000 BP in Santa Elena, and provide evidence for independent domestication of squash species in lowland tropical South America during the earliest Holocene (Piperno and Pearsall, 1998, Chapter 4). Recently Smith (1997) also has shown that early domesticated *Cucurbita* seeds were present in Mexico by 8990 ± 60 BP.

6.2.4. Starch grains

There have been several fruitless attempts to use trace elements in human bone samples to assess the diet and plant intake of the Late Las Vegas people (Stothert, 1988, pp. 219–224; Van der Merwe et al., 1993), but a new approach to the reconstruction of ancient diet has resulted in evidence that supports the hypothesis of early cultivation in coastal Ecuador. Starch grain analysis provides information about the presence in ancient sites of elusive root crops and other starchy plants like maize. This technique depends upon the fact that the starch grains found in roots, tubers and seeds may be preserved in archaeological contexts, and that the form of these grains, which is under genetic control, permits the identification of tropical cultivars such as manioc, maize, and arrowroot.

Paleobotanists are now recovering starch grains from the working surfaces of stone tools and from the teeth of prehistoric skeletons (Piperno and Holst, 1998; Piperno et al., 2000b, 2001). Both starch grains and phytoliths recovered from the plaque of teeth sampled from Late Las Vegas contexts have been identified as follows: 6 phytoliths are indistinguishable from those of maize glumes, 6 grains of starch compare favorably in size and morphology to grains from seeds of modern varieties of maize, and two other grains correspond to roots and tubers. This evidence supports the argument that maize was used by the Late Vegans by 7000 years ago.

7. Marine resources and early agriculture

In the Early Holocene the people of the Santa Elena Peninsula developed a pattern of broad-spectrum collecting, focused on both terrestrial and marine resources. This subsistence strategy may have compensated them for the loss of Pleistocene resources (such as giant Ice Age animals), and provided them with a subsistence system that adequately buffered the local community against instability and fluctuations in the environment. Relatively sedentary settlement may have been favored because of the economic benefits of exploiting both predictable terrestrial and marine/estuarine resources. The Las Vegas people became progressively more committed to exploiting the rich marine/estuarine fish resources while also feeding themselves with products from their gardens.

Innovating a subsistence strategy that included the cultivation of plants in the early stages of domestication, and others more fully domesticated, proved to be a successful and enduring adjustment in a complex tropical, coastal ecosystem. One can argue that the Las Vegas preceramic people were the innovators of the successful farming and fishing adaptation which was characteristic of the succeeding Formative period and which was the basis for life in all subsequent peoples in coastal Ecuador. Later coastal people developed more complex social arrangements upon the foundation of this mixed economic strategy (Stothert, 1992): ultimately they combined several maritime activities (fishing, shell fish harvesting, seafaring and trading) with terrestrial pursuits (especially agriculture, forest product extraction, mining, and craft production). This adaptation has been durable and well-suited to an unstable environment in a region where agriculture is risky.

The Las Vegas case demonstrates that as early as 9000 BP both seed plants (*Cucurbita* sp. and *Lagenaria siceraria*) and root crops (*Calathea allouid*) were cultivated in local gardens. By 7000 BP the Las Vegas farmers had domesticated or acquired more productive species of squash, and added primitive maize to their list of cultivars. These Late Las Vegans who practiced both intensified fishing and an evolved form of gardening, also undertook some social changes, including the development of elaborate communal burial activities.

One of the intriguing issues in the study of Las Vegas is what motivated the evolution of the Las Vegas adaptation. In one scenario, change may be viewed as a mechanism for adjusting to environmental alterations. Given the probability that there were significant environmental fluctuations in the Early Holocene in Santa Elena, it is likely that short-term changes in the climate and biogeography of the Santa Elena Peninsula were factors that shaped the Las Vegas adaptation. For instance, the evolution of shell fishing between the early and late Las Vegas phases may reflect the replacement of mangrove formations by lagoons, beaches and rocky points. However, in order to test this explanation, and in order to model change successfully, geomorphological and paleoenvironmental studies designed to reconstruct the paleoenvironments of the peninsula are required. We need to know how cultural and environmental changes were correlated in order to improve the Las Vegas case study.

Other interpretations are attractive, too. People may have chosen to reallocate the labor of men or women for a variety of reasons not directly related to the loss of mangrove formations or climate instability. Other incentives to change may have included the perceived benefits of new technologies or the rise of social demands, which might have been satisfied by investing more food and other products in building alliances, engaging in reciprocity and undertaking regional and extra-regional exchange. Plants figure widely into human exchange activities (Hastorf, 1998).

Another intriguing issue in the study of the Las Vegas adaptation is modeling plant cultivation in the early and mid-Holocene periods. The Vegas case contributes an important corpus of data to the study of the origin of horticulture in the Neotropics. The Vegas data support the model that cultivation originated as foragers, familiar with a wide variety of species within a few kilometers of their stable settlements, manipulated complex tropical ecosystems (Harris, 1972). Harris predicted that the most "propitious areas" for early cultivation in the tropics "may have been marginal transitional zones, or ecotones, between major ecosystems" (1972:184), and he also suggested that sedentary foraging people would be most likely to undertake cultivation. On the Santa Elena Peninsula, the Las Vegas people, who developed horticulture in the Early Holocene, lived in just the kind of zone described by Harris and apparently occupied some relatively stable settlements.

Harris also suggested that early cultivation in the tropics was vegeculture, focused on tropical root crops, which are starch-rich cultigens. Because the wild ancestors of plants like manioc, leren and some species of *Xanthosoma* were adapted to seasonally arid regions, they would have been domesticated in tropical zones with marked dry seasons. The Vegas data support this interpretation.

In their comprehensive model of the origin of cultivation in the tropics, Piperno and Pearsall (1998, Chapters 1, 2 and 4; see also Piperno, 1989) argue that broad-spectrum collecting developed as people found more energetically efficient adjustments to the changing resource patterns of the Late Pleistocene and early post-Pleistocene periods. In particular, because people operated in an ecosystem poor in starchy wild plants, they would have found it desirable to inject more calories into their diet. Evidence from several regions, including southwest Ecuador, supports the idea that plant cultivation was a low-cost subsistence strategy innovated in seasonally dry tropical forest areas. Contrary to popular belief, in tropical forested biomes plant cultivation is a more energetically efficient subsistence activity than wild plant collecting. Not surprisingly, horticulture developed in Central and South America before 9000 BP, during a period when there was much more environmental instability than was experienced by people later in the Middle Holocene (Piperno, 1994, p. 638).

The Las Vegas economy evolved as people intensified their investment in fishing and added a progressively greater number of cultigens to their subsistence system. This may indicate that the Vegans found ways to pool their labor in order to improve their economic returns.

Late Las Vegas people, compared to their ancestors, consumed more fish, trapped fewer small animals, hunted large animals, and cultivated improved squash, maize, and root crops (like leren). Perhaps Late Vegas Period men hunted deer as before, but also parties of kinsmen developed ways of fishing together, improving the productivity of their lines and nets. Women may have gardened in the bottom land along the Las Vegas River (Hastorf, 1998; Bruhns and Stothert, 1999), an activity viewed as more productive than only foraging in the bush for wild plants and small animals. If Las Vegas women traditionally were responsible for collecting plants and small animals, and if they were also the farmers, then their growing specialization in cultivation in the Late Las Vegas phase may explain the decrease in the utilization of small animals in that period.

Late Las Vegas burial ceremonialism indicates that people invested more time and effort in community social activities. One imagines that groups of families developed integrative mechanisms, including the mortuary rituals inferred from the Vegas graves, which might have helped them to share food on a regular or irregular basis and to field larger work groups.

Ceremonial gatherings imply both the consumption of special foods and the giving of food as gifts (Hastorf, 1998). Growing food and producing quantities of fish in order to share is another way that people insure themselves against resource fluctuation. Food sharing is an important strategy for minimizing risk (Rossen, 1991; Piperno and Pearsall, 1998). The intensification of both fishing and farming may have underwritten the development of ceremonial activities, alliance building, and reciprocal exchange. In fact, spreading one's social net more widely would have been a risk-management strategy, which accounts for the strong pattern of interconnectedness observable among ancient Native American peoples.

The Las Vegas research demonstrates that some of the earliest horticulture in America took place among people who also fished for a living. While on the one hand the exploitation of the productive resources of the sea and mangrove estuaries may have favored stable settlement, by the same token gardening may have increased the availability of vegetable food, permitting people to live at the shore and enjoy the exquisite fruits of the sea. The Early Holocene people worked out a system in which the exploitation of several sub environments was the basis of a successful adaptation that persisted for more than 3000 years despite changing coastlines and fluctuating climates. This mixed economy allowed the Las Vegas people to tap the rich resources of the sea and the land, to adapt successfully to the instability of the resources of the littoral and the changing terrestrial conditions of the "abnormal appendage" of southwestern Ecuador.

The Late Las Vegas way of life can be seen as a pre-adaption for the development of fully agricultural, village life. By 5000 years ago, peoples who cultivated a wide variety of useful domesticated plants were ubiquitous in the tropical regions of America. Some of them also fished.

Acknowledgements

An earlier version of this paper was presented in the Symposium on Terminal Pleistocene/Early Holocene Maritime Adaptations along the Pacific Coast of the Americas at the 63rd Annual Meeting of the Society for American Archeology, Seattle (1998). The Las Vegas research was sponsored by the Museo Antropológico, Banco Central del Ecuador (Guayaquil). Additional support came from CEPE (now PetroEcuador). The field work was also supported by grants from Sigma Xi, The Scientific Research Society, and from the Faculty Research Council of Fordham University. Writing was made possible in part by the Comisión para el Intercambio Educativo entre los Estados Unidos y el Ecuador (Fulbright Commission). We are grateful to a multitude of individuals who made great contributions to the reconstruction of the Las Vegas Culture during two decades of research: the late Olaf Holm, former director of the Museo Antropológico; Julio Jaramillo, former superintendent of CEPE; Stanley Moss, former manager of REPRETROL; Hernán Crespo Toral, former director of the Museos del Banco Central (Quito); Bob Norris, formerly of Anglo-Ecuadorian Oilfields; Rita Schichhold de Molina; Vicente Molina; Neil Maurer; Roberto Lindao Quimí; Medardo Vera;

Marcial Vera; Enrique Vera; Alberto Vera; Agustín Suárez; Iván Cruz Cevallos; Paula Rogasner; Ann Mester; Mathilde Temme; Rosa Izquierdo; Eugenia Rodriguez; Petrova Ashby; Marcelo Villaba; Carlos Andrés Molina; Robert Mix, Susana Burgos, Nadia Vivanco and Ana Maritza Freire. The research on Las Vegas microfossils was supported by the Smithsonian Tropical Research Institute (STRI) and a grant to STRI from the Andrew W. Mellon Foundation. We are grateful to the National Herbarium in Washington, DC, for Cucurbitaceae specimens, and to Irene Holst and Digna Matías for technical support. Among the other scientists who have collaborated in the Las Vegas research are Douglas Ubelaker, Elizabeth Wing, Thomas Chase, Robert Kautz, Samuel Velastro, Ralph Rowlett, James Vogt, Antoinette Brown, Deborah Pearsall, and Maureen Kavanagh. Many thanks to Luis Orquera and Jim Zeidler for useful advice, and to Darden Hood of Beta Analytic for help with the calibration of radiocarbon dates.

References

Andres, T.C., 1990. Biosystematics, theories on the origin, and breeding potential of *Cucurbita ficifolia*. In: Bates, D.M., Robinson, R.W., Jeffrey, C. (Eds.), Biology and Utilization of the Cucurbitaceae. Cornell University Press, Ithaca, NY, pp. 102–119.

Andres, T., Piperno, D.R., 1995. New Evidence on the Past and Present Distribution of *Cucurbita* in Panama. Paper Presented at the Annual Meeting of the Society for Economic Botany. Cornell University, Ithaca, NY.

Athens, J.S., Ward, J.V., 1999. The Late quaternary of the Western Amazon: climate, vegetation and humans. Antiquity 73, 287–302.

Bird, E.C.F., 1993. Submerging Coasts: the effects of a rising sea level on coastal environments. Wiley, Chichester, UK.

Bruhns, K.O., Stothert, K.E., 1999. Women in Ancient America. University of Oklahoma Press, Norman.

Byrd, K.M., 1976. Changing Animal Utilization Patterns and Their Implications: Southwest Ecuador (6500 BC to AD 1400). Ph.D. Dissertation, Department of Anthropology, University of Florida, Gainesville.

Campbell, K.E., 1973. The Pleistocene Avifauna of the Talara Tar-Seeps, Northwestern Peru. Ph.D. Dissertation, University of Florida, Gainesville.

Campbell, K.E., 1982. Late Pleistocene events along the coastal plain of northwestern Peru. In: Prance, G. (Ed.), Biological Diversification in the Tropics. Columbia University Press, New York, pp. 423–440.

Chase, T., 1988. Restos Faúnicos (con introducción de Elizabeth Wing). In: Stothert, K., La Prehistoria Temprana de la Península de Santa Elena, Ecuador: La Cultura Las Vegas, Miscelánea Antropológica Ecuatoriana, Serie Monográfica 10. Museums of the Central Bank of Ecuador, Guayaquil, pp. 171–178.

Chauchat, C., 1992. Préhistoire de la Côte du Pérou: Le Paijanien de Cupisnique. Cahiers du Quaternaire No. 18. Centre National de la Recherche Scientifique, Centre Regional de Publication de Bordeaux, Bordeaux, France.

Clapperton, C., 1993. Quaternary Geology and Geomorphology of South America. Elsevier Science Publishers, Amsterdam.

Cobo, M., Massay, S., 1969. Lista de los peces marinos del Ecuador. Boletín Científico y Técnico 2 (1). Instituto Nacional de Pesca del Ecuador, Guayaquil.

Colinvaux, P.A., Liu, K-B., De Oliveira, P., Bush, M.B., Miller, M.C., Steinitz-Kannan, M., 1996. Temperature depression in the lowland tropics in Glacial times. Climatic Change 32, 19–33.

Damp, J.E., 1990. Altomayo: Investigaciones Arqueológicas en el Bajo Rio Verde. Boletín Arqueológico. ARAS (Arqueólogos Asociados) 1, 38–43.

Damp, J.E., Pearsall, D.M., 1994. Early cotton from coastal Ecuador. Economic Botany 48 (2), 163–165.

Damp, J., Pearsall, D., Kaplan, L., 1981. Beans for Valdivia. Science 212, 811–812.

Donnelly, I., 2001. Scientific Summary Chronological Index Ignatius Donnelly and the End of the World. Web Site: http://www.stanford.edu/~meehan/donnellyr/sealevel.html.

Edmund, A.G., 1965. A Late Pleistocene Fauna from the Santa Elena Peninsula, Ecuador. Life Sciences Contribution 63. Royal Ontario Museum, University of Toronto Press, Toronto.

Fairbanks, R.G., 1989. A 17,000-year Glacio-Eustatic sea level record: influence of glacial melting rates on the younger dryas event and deep-ocean circulation. Nature 342, 637–642.

Fairbridge, R.W., 1960. The changing level of the sea. Scientific American 202, 70–79.

Fairbridge, R.W., 1961. Eustatic changes in sea level. In: Ahrens, L.H., Press, F., Rankania, K., Runchorn, S.K. (Eds.), Physics and Chemistry of the Earth, Vol. 4. Pergamon Press, New York, pp. 99–185.

Fairbridge, R.W., 1962. World sea level and climatic changes. Quaternaria 6, 111–134.

Ferdon, E.N., 1981. Holocene mangrove formations on the Santa Elena Peninsula, Ecuador: pluvial indicators or ecological response to physiographic changes? American Antiquity 46, 619–625.

Fladmark, K.R., 1978. The feasibility of the northwest coast as a migration route for early man. In: Bryan, A.L. (Ed.), Early Man in America from a Circum-Pacific Perspective, Occasional Papers 1. Department of Anthropology, Archaeological Researches International, University of Alberta, Edmonton, Canada, pp. 119–128.

Gnecco, C., Mora, S., 1997. Late Pleistocene/Early Holocene tropical forest occupations at San Isidro and Peña Roja, Colombia. Antiquity 71, 683–690.

Harris, D., 1972. The origins of agriculture in the tropics. American Scientist 60, 180–193.

Hastorf, C., 1998. The cultural life of early domestic plant use. Antiquity 72, 773–782.

Heusser, L.E., Shackleton, N.J., 1994. Tropical climate variation on the pacific slopes of the Ecuadorian Andes based on a 25,000-year pollen record from deep-sea sediment core Tri 163-31B. Quaternary Research 42, 222–225.

Hoffstetter, R., 1952. Les Mammiferes Pleistocenes de la Republique de l'Ecuateur. Memoires de la Societe Geologique de France, Paris 66, 1–391.

Holm, O., 1986 . Navegación Precolombina I. Revista del Institute de Historia Marítima. Armada del Ecuador 1, 7–13.

Holm, O., 1987. Navegación Precolombina II. Revista del Instituto de Historia Marítima Armada del Ecuador 2, 97–108.

INOCAR, 1980. Map I.O.A. 105, Bahía de Santa Elena (Isla Salango-Chanduy), República del Ecuador, América del Sur. Levantamiento hidrográfico efectuado por el Instituto Oceanográfico de la Armada (INOCAR) en 1979. Linea de costa según Restitución Aerofotogramétrica efectuada por el Instituto Geográfico Militar en 1965. Primera Edición, Agosto 1980. Instituto Geográfico Militar (for the Instituto Oceanográfico de la Armada), Ecuador (revised 1989).

Keen, A.M., 1971. Sea shells of tropical West America: marine Mollusks from Baja California to Peru, 2nd Edition. Stanford University Press, Stanford.

Lanning, E.P., 1967. Archaeological investigations on the Santa Elena Peninsula, Ecuador. Report to the National Science Foundation on

Research Carried out under Grant GS-402, 1964–65 (Unpublished report).
Llagostera, A., 1979. 9700 years of maritime subsistence on the Pacific: an analysis by means of bioindicators in the North of Chile. American Antiquity 44, 309–324.
Lemon, R.R.H., Churcher, C.S., 1961. Pleistocene geology and paleontology of the Talara Region, Northwest Peru. American Journal of Science 259, 410–429.
Lindao, Quimi, R., Stothert, K.E., 1994. El Uso Vernáculo de los Arboles y Plantas en la Península de Santa Elena. Fundación Pro-Pueblo de la Cemento Nacional, and Subdirección Programas Culturales, Banco Central del Ecuador. Guayaquil.
Malpass, M., Stothert, K.E., 1992. Preceramic Houses and Household Organization along the Western Coast of South America, Vol. 3. Andean Past, Latin American Studies Program, Cornell University, pp. 137–164.
Markgraf, V., 1993. Climatic history of Central and South America since 18000 yr BP: comparison of pollen records and model simulations. In: Wright Jr., H.E., Kutzbach, J.E., Webb III, T., Ruddiman, W.F. (Eds.), Global Climates since the Last Glacial Maximum. University of Minnesota Press, Minneapolis, pp. 357–385.
Morner, N.-A., 1983. Sea levels. In: Gardner, R., Scoging, H. (Eds.), Mega-Geomorphology. Oxford University Press, Oxford, pp. 73–91.
Morner, N.-A., 2000. Research Topics (RT) 14. Web Site: http://www.pog.su.se/sea/07_research_topics/rt14.htm.
Mulholland, S.C., Prior, C., 1993. AMS radiocarbon dating of phytoliths. In: Pearsall, D.M. Piperno, D.R. (Eds.), Current Research in Phytolith Analysis: Applications in Archaeology and Paleoecology, MASCA Research papers in Science and Archaeology, Vol. 10. MASCA, The University Museum of Archaeology and Anthropology, University of Pennsylvania, Philadelphia, pp. 21–23.
Nee, M., 1990. The domestication of Cucurbita (Cucurbitaceae). Economic Botany 44 (3, Suppl.), 56–58.
Oyuela-Caycedo, A., Rodriguez Ramirez, C., 1995. La formación de concheros en la costa norte de sur America. Revista de Antropología y Arqueología 11, 73–123.
Patzelt, E., 1978. Fauna del Ecuador. Editorial Las Casas. Quito, Ecuador.
Pearsall, D.M., 1979. Application of ethnobotanical techniques to the problem of subsistence in the Ecuadorian formative. Doctoral dissertation, University of Illinois, Champaign-Urbana.
Pearsall, D.M., 1988. La Producción de Alimentos en Real Alto: La Aplicación de las Técnicas Etnobotánicas al Problema de la Subsistencia en el Período Formative Ecuatoriano. Escula Politécnica del Litoral y Corporación Editora Nacional, Quito.
Pearsall, D.M., Piperno, D.R., 1990. Antiquity of maize cultivation in Ecuador: summary and reevaluation of the evidence. American Antiquity 55 (2), 324–337.
Piperno, D.R., 1988a. Phytolith Analysis: An Archaeological and Geological Perspective. Academic Press, San Diego.
Piperno, D.R., 1988b. Primer Informe Sobre los Fitolitos de las Plantas del OGSE-80 y la Evidencia del Cultivo de Maiz en el Ecuador. In: Stothert, K., La Prehistoria Temprana de la Peninsula de Santa Elena, Ecuador: La Cultura Las Vegas, pp. 203–214. Miscelanea Antropológica Ecuatoriana, Serie Monográfica 10. Museums of the Central Bank of Ecuador, Guayaquil.
Piperno, D.R., 1989. Non-affluent foragers: resource availability, seasonal shortages, and the emergence of agriculture in Panamanian tropical forests. In: Harris, D.R., Hillman, G. (Eds.), Foraging and Farming: The Evolution of Plant Domestication. Unwin Hyman, London, pp. 538–554.
Piperno, D.R., 1994. On the emergence of agriculture in the New World. Current Anthropology 35, 637–639.
Piperno, D.R., 1998. Paleoethnobotany from microfossils in the Neotropics: new insights into ancient plant use and agricultural origins. Journal of World Prehistory 12, 393–449.
Piperno, D.R., Holst, I., 1998. The presence of starch grains on prehistoric stone tools from the humid neotropics: indications of early tuber use and agriculture in Panama. Journal of Archaeological Science 25, 765–776.
Piperno, D.R., Pearsall, D.M., 1998. The Origins of Agriculture in the Lowland Neotropics. Academic Press, San Diego.
Piperno, D.R., Andres, T.C., Stothert, K.E., 2000a. Phytoliths in Cucurbita and other Neotropical Cucurbitaceae and their occurrence in early archaeological sites from the Lowland American Tropics. Journal of Archeological Science 27, 193–208.
Piperno, D.R., Ranere, A.J., Holst, I., Hansell, P., 2000b. Starch grains reveal early root crop horticulture in the Panamanian tropical forest. Nature 407, 894–897.
Piperno, D.R., Holst, I., Ranere, A.J., Hansell, P., Stothert, K.E., 2001. The occurrence of genetically controlled phytoliths from maize cobs and starch grains from maize kernels on archaeological stone tools and human teeth, and in archaeological sediments from Southern Central America and Northern South America. The Phytolitharien 13, 1–7.
Portais, M., 1983. De los Cazadores Recolectores Hacia el Sistema Colonial de Dominio del Espacio. In: Deler, J.P., Gomez, N., Portais, M. (Eds.), El Manejo del Espacio en el Ecuador: Etapas Claves Geografía Básica del Ecuador, Tomo I, Geografía Histórica. Centro Ecuatoriano de Investigación Geográfica and. Institute Panamericano de Geografía e Historia, Quito, pp. 11–101.
Rand McNally Corporation, 1977. The Rand McNally Atlas of the Oceans. Rand McNally Corporation, New York.
Ranere, A.J., 1972. Early Human Adaptations to New World Tropical Forests: the View from Panama. Doctoral dissertation, University of California, Davis.
Ranere, A.J., 1976. The Preceramic of Panama: The View from the Interior. In: Robinson, L.S. (Ed.), Proceedings of the First Puerto Rican Symposium on Archaeology, Fundación Arqueológica, Antropológica e Histórica de Puerto Rico, San Juan.
Richardson III, J.B., 1973. The preceramic sequence and the Pleistocene and post-Pleistocene climate of Northwest Peru. In: Lathrap, D., Douglas, J. (Eds.), Variation in Anthropology. Illinois Archaeological Survey, Urbana, IL, pp. 199–211.
Richardson III, J.B., 1978. Early man on the Peruvian North Coast, early maritime exploitation and the Pleistocene and Holocene environment. In: Bryan, A.L. (Ed.), Early Man in America from a Circum-Pacific Perspective, Occasional Papers No. 1. Department of Anthropology, University of Alberta, Edmonton, pp. 274–289.
Richardson III, J.B., 1981. Modeling the development of early complex economies on the coast of Peru: a preliminary statement. Annals of the Carnegie Museum 50, 139–150.
Richardson III, J.B., 1998a. From mastodons and mangroves to desert: Late Pleistocene to mid-Holocene climate changes and cultural adaptations on the Peruvian North Coast. Paper presented at the FERCO International Conference on Climate and Culture at 3000 BC. University of Maine, Orono, 1998.
Richardson III, J.B., 1998b. Looking in the right places: pre-5000 BP. Maritime Adaptations in Peru and the Changing Environment. Revista de Arqueología Americana 15, 34–56.
Rollins, H.B., Richardson III, J.B., Sandweiss, D.H., 1986. The birth of El Niño: geoarchaeological evidence and implications. Geoarchaeology 1, 3–15.
Rossen, J., 1991. Ecotones and low-risk intensification: the middle preceramic occupation of Nanchoc, Northern Peru. Doctoral dissertation, University of Kentucky.
Salazar, E., 1983. El Hombre Temprano en el Ecuador. In: Ayala Mora, E. (Ed.), Nueval Historia del Ecuador, 1: Epoca Aborigen,

Corporación Editora Nacional and Editorial Grijalbo Ecuatoriana, Quito, pp. 73–128.

Sandweiss, D.H., 1996a. Environmental change and its consequences for human society on the central Andean coast: a malacological perspective. In: Reitz, E.J., Newsom, L.A., Scudder, S.J. (Eds.), Case Studies in Environmental Archaeology. Plenum Press, New York, pp. 127–146.

Sandweiss, D.H., 1996b. The development of fishing specialization on the central Andean coast. In: Plew, M.G. (Ed.), Prehistoric Hunter-Gatherer Fishing Strategies. Department of Anthropology, Boise State University, Boise, ID, pp. 41–63.

Sandweiss, D.H., Cano, A., Ojeda, B., Roque, J., 1999. Pescadores Paleoindios del Perú. Investigación y Ciéncia (Octubre), pp. 55–61.

Sandweiss, D.H., Keefer, D.K., Richardson III, J.B., 1999. First Americans and the sea. Discovering Archaeology 1, 59–65.

Sandweiss, D.H., Richardson III., J.B., 2000 Las Fundaciones Precerámicas de la Etapa Formativa en la Costa Peruana. In: Ledergerber-Crespo, P. (Ed.), Formativo Sudamericano, Una Revaluación, Segunda Edición. Ediciones Abya-Yala, Quito, pp. 179–188.

Sandweiss, D.H., Richardson III, J.B., Reitz, E.J., Hsu, J.T., Feldman, R.A., 1989. Early maritime adaptations in the Andes: preliminary studies at the Ring Site, Peru. In: Rice, D.S., Stanish, C., Scarr, P.R. (Eds.), Ecology, Settlement, and History in the Osmore Drainage, Peru, Vol. 545(i). British Archaeological Reports International Series, Oxford, UK, pp. 35–84.

Sandweiss, D.H., Richardson III, J.B., Reitz, E.J., Rollins, H.B., Maasch, K.A., 1996. Geoarchaeological Evidence from Peru for a 5000 Years BP. Onset of El Niño. Science 273, 1531–1533.

Sarma, A.V.N., 1974. Holocene paleoecology of south coastal Ecuador. Proceedings of the American Philosophical Society 118, 93–134.

Sheppard, G., 1937. The Geology of South-Western Ecuador. Thomas Murby, London.

Sherratt, A., 1997. Climatic cycles and behavioural revolutions: the emergence of modern humans and the beginning of farming. Antiquity 71, 271–287.

Smith, B., 1997. The initial domestication of *Cucurbita pepo* in the Americas 10,000 years ago. Science 276, 932–934.

Spath, C.D., 1980. The El Encanto focus: a post-Pleistocene maritime adaptation to expanding littoral resources. Doctoral Dissertation, University of Illinois.

Stahl, P.W., 1991. Arid landscapes and environmental transformations in ancient southwestern Ecuador. World Archaeology 22, 346–359.

Stahl, P.W., 1996. Holocene biodiversity: an archaeological perspective from the Americas. Annual Review of Anthropology 25, 105–126.

Stothert, K.E., 1971. (n.d.).Unpublished Field Notes, Santa Elena, 1971.

Stothert, K.E., 1976. The early prehistory of the Santa Elena Peninsula, Ecuador: continuities between the preceramic and ceramic cultures. Actas del XLI Congreso International de Americanistas, Mexico, Mexico, 1974, Vol. 2, pp. 88–98.

Stothert, K.E., 1977. Preceramic adaptation and trade in the intermediate area. Paper Presented in the Symposium on the Andean Preceramic, Annual Meeting of the American Anthropological Association, Houston.

Stothert, K.E., 1979. La Prehistoria Temprana de la Península de Santa Elena, Ecuador: una interpretación preliminar. Vínculos Revista de Antropología del Museo Nacional de Costa Rica, San José 5 (2), 73–87.

Stothert, K.E., 1983. Review of the early preceramic complexes of the Santa Elena Peninsula, Ecuador. American Antiquity 48, 122–127.

Stothert, K.E., 1985. The preceramic Las Vegas culture of coastal Ecuador. American Antiquity 50, 613–637.

Stothert, K.E., 1987. Interpreting a gap in the prehistoric chronology of the arid Santa Elena Peninsula, Ecuador. In: McKinnon, N.A., Stuart, G.S.L. (Eds.), Man and the Mid-Holocene Climatic Optimum: Proceedings of the Seventeenth Annual Conference of the Archaeological Association of the University of Calgary. The University of Calgary Archaeological Association, Calgary, Alberta, pp. 131–141.

Stothert, K.E., 1988. La Prehistoria Temprana de la Península de Santa Elena, Ecuador: La Cultura Las Vegas. With contributions by Chase, T., Piperno, D., Wing, E., Ubelaker, D. Miscelanea Antropológica Ecuatoriana, Serie Monográfica 10. Museums of the Central Bank of Ecuador, Guayaquil.

Stothert, K.E., 1992. Early Economies of Coastal Ecuador and the Foundations of Andean Civilization. Andean Past, Vol. 3. Latin American Studies Program, Cornell University, pp. 43–54.

Stothert, K.E., 2000. Investigación Arqueológica en Sitios Precerámicos en la Península de Santa Elena: Informe Preliminar. Report submitted to the Sub-Dirección Regional, Instituto Nacional de Patrimonio Cultural, Guayaquil, Ecuador, August, 2000.

Stothert, K.E., Piperno, D.R., 2000. La cultura las vegas de los amantes de sumpa y el contexto del origen del cultivo de plantas domesticadas. Miscelánea Antropológica Ecuatoriana 9, 51–71.

Stothert, K.E., Quilter, J., 1991. Archaic adaptations of the Andean region, 9000–5000 BP. Revista de Arqueología Americana/Journal of American Archaeology/Revue d'Archéologie Américaine. Institute Panamericano de Geografía e Historia, Organization of American States, Mexico 4, 25–53.

Stothert, K.E., Piperno, D.R., Andres, T.C., 2001. New evidence of early Holocene agriculture from the coast of Ecuador: a multidisciplinary approach. Culture and Agriculture, 2001, 24 (2), in preparation.

Stuiver, M., van der Plicht, H., 1998. Editorial comment. Radiocarbon 40 (3), xii–xiii.

Stuiver, M., et al., 1998. INTCAL98 radiocarbon age calibration. Radiocarbon 40 (3), 1041–1083.

Svenson, H.K., 1946. Vegetation of the coast of Ecuador and the Peru and its relations to the Galapagos Islands. American Journal of Botany 33, 394–498.

Talma, A.S., Vogel, J.C., 1993. A simplified approach to calibrating C14 dates. Radiocarbon 35 (2), 317–322.

Temme, M., 1982. Excavaciones en el Sitio Precerámico de Cubilán (Ecuador). Miscelánea Antropológica Ecuatoriana 2, 135–164.

Ubelaker, D.H., 1980. Human skeletal remains from site OGSE-80, a preceramic site on the Santa Elena Peninsula, Coastal Ecuador. Journal of the Washington Academy of Science 70 (1), 3–24.

Ubelaker, D.H., 1988. Restos de Esqueletos Humanos del Sitio OGSE-80. In: Stothert, K.E., La Prehistoria Temprana de la Peninsula de Santa Elena, Ecuador: La Cultura Las Vegas, Miscelanea Antropológica Ecuatoriana, Serie Monográfica 10. Museums of the Central Bank of Ecuador, Guayaquil, pp. 105–132.

United Nations, 1972. Atlas of the Living Resources of the Seas. Food and Agriculture Organization of the United Nations, Department of Fisheries, Rome (maps 1.1 and 1.2).

Usselmann, P., 1989. Evolución del Clima y Sus Consecuencias a lo Largo del Litoral Pacífico de los Andes Centrales desde el Fin de la Ultima Glaciación. In: Bouchard, J.F., Guinea, M. (Eds.), Relaciones Interculturales en el Area Ecuatorial del Pacífico Durante la Epoca Precolombina, British Archaeological Research International Series 503, Oxford, pp. 237–246.

Valverde, F. de M., De Tazán, G.R., García Rizzo, C., 1979. Cubierta Vegetal de la Peninsula de Santa Elena. Escuela de Biología, Departamento de Botánica, Facultad de Ciencias Naturales, Universidad de Guayaaquil, Publicación No. 2.

Van der Merwe, N.J., Lee-Thorp, J.A., Raymond, J.S., 1993. Light, stable isotopes and the subsistence base of formative cultures at Valdivia, Ecuador. In: Lambert, J.B., Grupe, G. (Eds.), Prehistoric Human Bone: Archaeology at the Molecular Level. Springer, Berlin, pp. 63–97.

Wing, E., 1988. *Dusicyon sechurae* en contextos arqueológicos tempranos. In: Stothert, K., La Prehistoria Temprana de la Península de Santa Elena, Ecuador: La Cultura Las Vegas, Miscelánea Antropológica Ecuatoriana, Serie Monográfica 10. Museums of the Central Bank of Ecuador, Guayaquil, pp. 179–185.

Wolf, T., 1975 [1892]. Geografía y Geología del Ecuador. Editorial Casa de la Cultura Ecuatoriana, Quito.

PERGAMON

Quaternary International 109–110 (2003) 45–48

New radiocarbon chronology for the Guerrero Member of the Luján Formation (Buenos Aires, Argentina): palaeoclimatic significance

Eduardo P. Tonni[a,*], Roberto A. Huarte[b], Jorge E. Carbonari[b], Anibal J. Figini[b]

[a] Departamento Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, 1900-La Plata, Argentina
[b] LATYR-CIG, Facultad de Ciencias Naturales y Museo, Paseo del Bosque s/n, 1900-La Plata, Argentina

Abstract

New radiocarbon dating performed on materials from the Guerrero Member of the Luján Formation considerably enlarges the time period previously assigned to this unit. New data suggest that deposition began about the Last Glacial Maximum (ca. 21 ka BP) and continued until at least ca. 10 ka BP. During this period several climatic and biological events occurred, among the latter the last processes leading to the extinction of Pleistocene megafauna.

1. Introduction

The Guerrero Member (GM) of the Luján Formation (LF) was defined and characterized by Fidalgo et al. (1973). These authors described this unit as sub-aquatic in origin, composed of fine sand to silty sand, brown to yellowish brown at the base, transitional to silty sand and sandy silt, yellowish green to grayish green, up to 4 or 5 m thick. Subsequently, Dillon and Rabassa (1985) separated the brownish silty sand of the base as another member and named it La Chumbiada Member (CHM). The LF is composed of three members, from oldest to youngest: La Chumbiada, Guerrero and Río Salado (RSM) members. The first two represent the upper Pleistocene and the last member, the Holocene.

The CHM and GM are well represented in the east of the pampean region of Argentina. They contain a significant and varied mammalian fauna, which includes the last records in South America of species with masses larger than a ton. These units as a whole represent the Lujanian, which is biostratigraphically based on the *Equus (Amerhippus) neogeus* Biozone. *E. (Amerhippus) neogeus* is recorded in the area since the beginning of the upper Pleistocene (around 130 ka BP, see Cione and Tonni, 1999). Both members were correlated by Tonni and Fidalgo (1978) with the "Pleniglacial phase" of a glacial cycle. Subsequently, Tonni et al. (1999) correlated the Guerrero Member with the Last Glacial Maximum (LGM).

Several radiocarbon dates of the GM made on calcium carbonate of sediment and fresh water mollusc valves (Carbonari et al. 1992; Figini et al. 1995, 1998) represent the period 21–17 ka BP. In this paper, new dates from bone collagen of extinct mega-mammals, which enlarge this time to more recent ages (ca. 10 ka BP), are reported. Consequently, faunal associations from the GM of the LF are not approximately synchronous as previously supposed, and the span of time comprised by the deposit of this unit involves several changes of climatic conditions that may explain the supposed non-analogous associations. In addition, part of the events that led to the extinction of the Pleistocenic megafauna occurred during this time.

2. Radiocarbon dates

Fig. 1 shows the sample area with the location of the sites. Fig. 2 provides a schematic profile with the recognized units and the location of the samples with their dates.

Exposures located on the flood plain of Arroyo Tapalqué (Olavarría, Buenos Aires Province) were sampled for radiocarbon dating in the GM of the LF. Carbonari et al. (1992) reported three dates performed on shells of *Heleobia parchappei*, collected from

*Corresponding author.
E-mail addresses: eptonni@museo.fcnym.unlp.edu.ar (E.P. Tonni), afigini@museo.fcnym.unlp.edu.ar (A.J. Figini).

1040-6182/02/$ - see front matter © 2002 Elsevier Ltd and INQUA. All rights reserved.
PII: S 1 0 4 0 - 6 1 8 2 (0 2) 0 0 2 0 1 - X

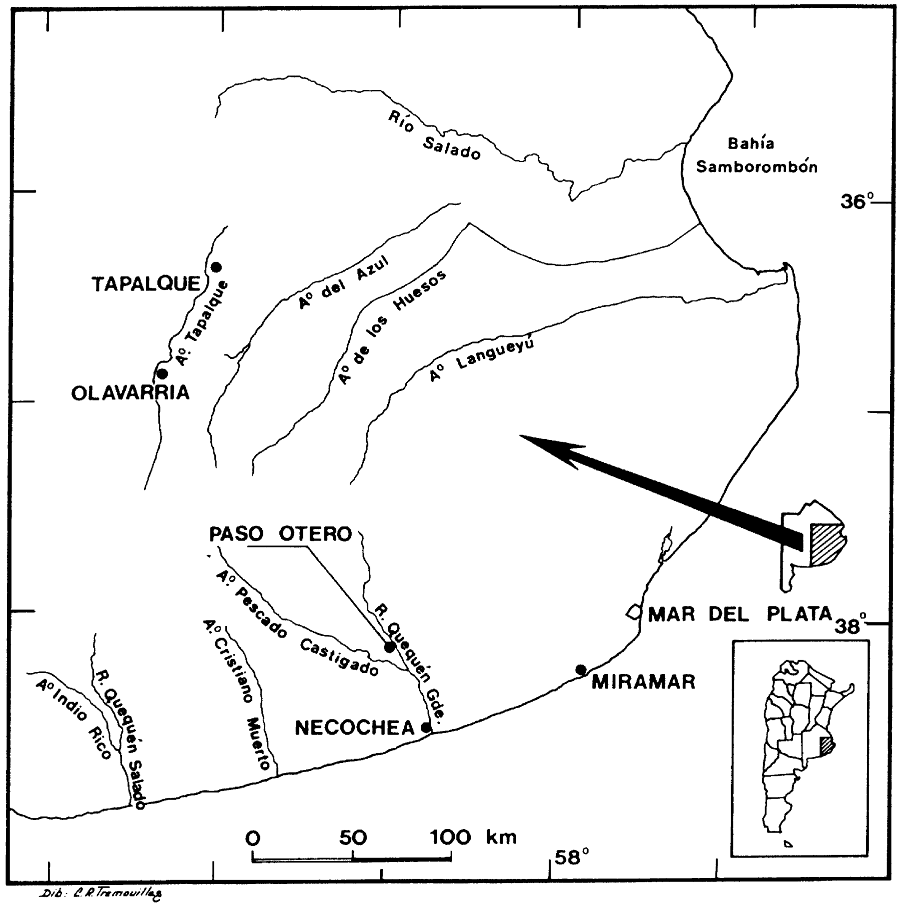


Fig. 1. Location map.

lenticular concentrations or scattered in the lower and upper sectors of the GM, with the following results: 17680 ± 400 years ^{14}C BP (LP-272); 18280 ± 220 years ^{14}C BP (LP-296); and 18600 ± 400 years ^{14}C BP (LP-292).

Figini et al. (1995) cited two other dates performed on shells of *Heleobia parchappei* and on calcium carbonate rounded clasts from the GM, with the following results: 21040 ± 450 years ^{14}C BP (LP-396) and 29850 ± 1370 years ^{14}C BP (LP-621), respectively. Figini et al. (1998) reported another date on dusty calcium carbonate scattered in the sediment of GM, which yielded 17020 ± 160 years ^{14}C BP (LP-955).

Bone material was pretreated using the collagen extraction method of Longin (1971), with slight modifications. The dating of ^{14}C was done at Laboratorio de Tritio y Radiocarbono (LATYR, La Plata), by synthesis of samples to benzene. The ^{14}C activity of synthesized benzene was measured using liquid scintillation counting (LSC) on a Packard Tri-Carb in low ^{40}K, borosilicate glass vials. Age calculations are based on the Libby half-life of 5568 yr and reported in ^{14}C years before 1950. Errors quoted refer only to the standard deviation ($\pm$ 1σ) calculated from a statistical analysis of sample, background, and standard count rates. None of the ^{14}C ages were corrected by ^{13}C or for any "reservoir effect".

The studied samples yielded ^{14}C ages consistent with stratigraphic position. The age of sample LP-621, though consistent with the stratigraphic position, is discarded because the dated calcium carbonate pebbles (29850 ± 1370 years ^{14}C BP) may have been influenced by older carbonates from the "pampean sediments" (Fidalgo et al., 1975), which are overlain disconformably by the sediments of the LF.

The GM bears a rich and varied mammal fauna. However, dates on bone collagen are scarce because of the poor preservation of bony material. Generally, when the amount of bone collagen is less than 1%, radiocarbon dating should not be done (Hedges and van Klinken, 1992; Stafford et al., 1987). Dating of bone remains with such low percentages of protein yields ages which may not be representative of the age of death of the specimen, giving anomalous results, such as that reported by (Rossello et al., 1999) with respect to the age of the GM (see discussion in Cione et al., 2001). Collagen of bone remains undergoes alterations during diagenesis, including unexpected combinations, humification of part of the adsorption of exogenous humic

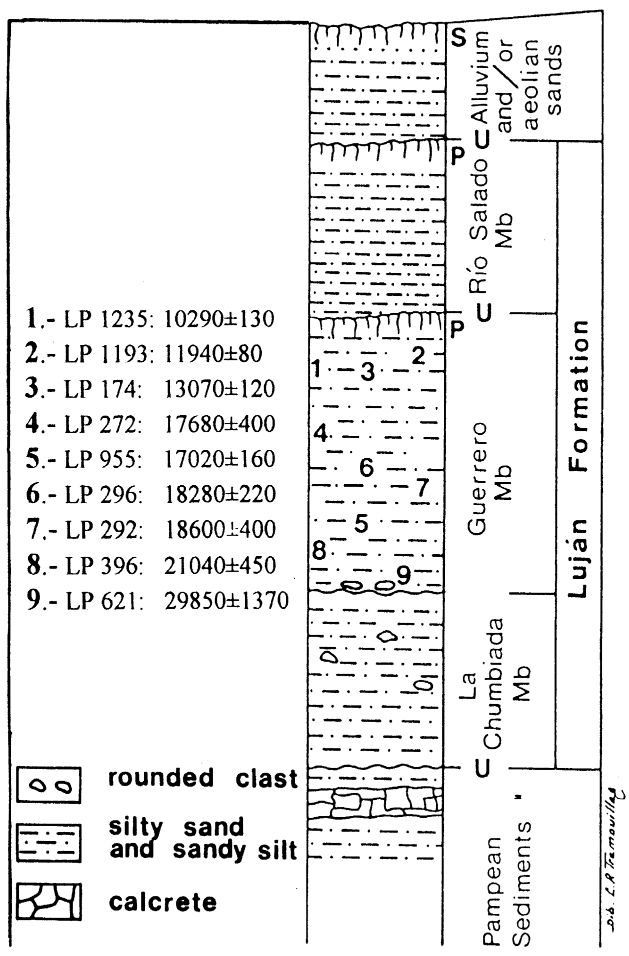


Fig. 2. Schematic profile with the recognized units and the location of the radiocarbonic samples at the Guerrero Member. u: unconformity; p: paleosol; s: soil.

materials, and hydrolysis with preferential loss of some amino acids (De Niro and Weiner, 1988). These alterations may modify the original composition of the carbons in collagen, rejuvenating or increasing the age of the sample.

Hitherto, only three dates of bone remains with protein content ca. 4% could be made, all from the GM but at three different sites (Fig. 1): Salto de Piedra (LP-1193) in Arroyo Tapalqué (36°56′54″ S, 60°22′10″ W); Campo de Arce (LP-174) in Río Quequén Chico (59°S, 38°02′W); and Zanjón Seco (LP-1235) in Río Quequén Grande (38°11′48″ S, 59°06′56″W). Results were as following: 11940 ± 80 yr ^{14}C BP (LP-1193; Mylodontidae rib); 13070 ± 120 yr ^{14}C BP (LP-174; clavicle, phalanx, rib and caudal vertebra of *Megatherium americanum*); 10290 ± 130 yr ^{14}C BP [LP-1235; and cervical vertebra and proximal portion of tibia of *Equus* (*Amerhippus*) *neogeus*].

These younger ages obtained from bone collagen differ notably from the older ages yielded by other materials (i.e. shells and calcium carbonate), but are stratigraphically consistent. Figini et al. (1995) quantified the "reservoir effect" in fresh water molluscs, calculating it as 1100 ± 140 yr BP. Even subtracting this "reservoir effect" of the dates obtained in the valves, these are significantly older that the ones obtained from bone collagen.

An effort to obtain collagen in enough quantity and quality to date bones stratigraphically associated with older samples failed. It is likely that bone remains that yielded these younger ages are better preserved. Physical and chemical conditions of the sediments may have intensively degraded the older bones.

3. Climatic variation during the deposition of the Guerrero Member

The new radiocarbon dates indicate that the deposit of the GM of the LF comprises at least the span of time between 21 and 10 ka BP. This period involves two-thirds of the Isotopic Stage 2 and the beginning of the Isotopic Stage 1, during which several climatic events occurred (Clapperton, 1993). The last glacial advance occurred in the central Andes around 20 ka BP, approximately coeval with the LGM (Baker et al., 2001). Afterwards there was a relatively rapid increase of temperature (around 16 ka; Clapperton, 1993; Petit et al., 1999, and literature cited therein). At 14 ka, a well-defined stadial occurred in the Andes of Peru and in southern Chile, coincidentally with similar global conditions (Clapperton, 1993; Petit et al., 1999). Around 11 ka, a new glacial advance developed in the Northern Hemisphere (Younger Dryas, see Labeyrie, 2000). This event is also recorded, at least at the north of the Andean region of South America, in central Brazil (Ledru, 1993) and in southernmost South America (McCulloch et al., 2000).

Climatic variations such as those mentioned have not been precisely determined in the pampean region of Argentina. Some palynological data (Prieto, 1996; Quattrocchio and Borromei, 1998) support arid conditions for the interval prior to 10.5–10 ka BP. The intensive aeolian sedimentation verified for this period, as well as the record of mammals adapted to arid conditions, also agree with this palynological information (Tonni et al., 1999). In summary, despite the lack of precise indicators of temperature fluctuations, the arid event prior to 10 ka is suggested to be coincident with the Younger Dryas global event.

The faunal evidence suggests arid conditions during the whole deposition of the GM of the LF. This aridity coincided at certain times with lower temperatures than the present ones, as indicated by the presence of Patagonian fauna (Tonni et al., 1999).

Up to now, the period comprised by the deposition of the GM was considered shorter and related to the LGM, and no accurate stratigraphic, sedimentological or paleontological studies have been performed. Consequently, it cannot be determined with which cold period the Patagonian fauna is associated (i.e. the LGM, some stadial following the LGM, or the Younger Dryas). It may also be possible that some indicators of warmer conditions (i.e. *Lundomys molitor*, see Pardiñas and Lezcano, 1995), belong to real non- analogous associations or reflect artificial homogenization of the record. Consequently, new and detailed studies are essential in order to obtain useful and reliable information to test hypotheses concerning the disappearance from the trophic level of mammals larger than one ton, which inhabited southern South America from the Late Miocene up to ca. 8 ka BP.

Acknowledgements

We thank Timothy Jull and Jorge Rabassa for the critical review of this manuscript. This study was made possible with financial support from the Agencia Nacional de Promoción Científica y Tecnológica, Consejo Nacional de Investigaciones Científicas y Técnicas (grant PIP 4697/96), Comisión de Investigaciones Científicas de la Provincia de Buenos Aires, and Universidad Nacional de La Plata. However, the authors alone are responsible for the opinions expressed in this paper including errors and omissions.

References

Baker, P.A., Seltzer, G.O., Fritz, S.C., Dunbar, R., Grove, M.J., Tapia, P.N., Cross, S.L., Rowe, H.D., Broda, J.P., 2001. The history of south american tropical precipitation for the past 25,000 years. Science 291, 640–643.

Carbonari, J.E., Huarte, R., Figini, A.J., 1992. Miembro guerrero, formación lujan (pleistoceno, pcia. Buenos Aires) edades 14C. Terceras Jornadas Geológicas Bonaerenses, Actas 1, 1992, 245–247.

Cione, A.L., Figini, A.J., Tonni, E.P., 2001. Did the megafauna range to 4300 BP in South America? Radiocarbon 43 (1), 69–75.

Cione, A.L., Tonni, E.P., 1999. Biostratigraphy and chronological scale of uppermost Cenozoic in the pampean area, Argentina. In: Tonni, E.P., Cione, A.L. (Eds.), Quaternary Vertebrate Paleontology in South America, Quaternary of South America and Antarctic Peninsula, Vol.12, pp.23–51.

Clapperton, C., 1993. Quaternary Geology and Geomorphology of South America. Elsevier, Amsterdam, 779 pp.

De Niro, M.J., Weiner, S., 1988. A chemical, enzymatic and spectroscopic characterization of "collagen" and other organic fractions from prehistoric bones. Geochimica et Cosmochimica Acta 52, 2197–2206.

Dillon C. , A., Rabassa, J., 1985. Miembro La Chumbiada, Formación Luján (Pleistoceno, provincia de Buenos Aires): Una nueva unidad estratigráfica del valle del Río Salado. Primeras Jornadas Geológicas Bonaerenses, Resúmenes, 27 pp.

Fidalgo, F., de Francesco, F.O., Colado, U.R., 1973. Geología superficial en las hojas castelli, j. M. Cobo y Monasterio (provincia de Buenos Aires). V Congreso Geológico Argentino, Actas 4, 27–39.

Fidalgo, F., De Francesco, F.O., Pascual R., 1975. Geología superficial de la llanura bonaerense. In: Relatorio Geología de la Provincia de Buenos Aires, VI Congreso Geológico Argentino Asoc. Geológica Argentina, Buenos Aires, pp. 103–138.

Figini, A.J., Fidalgo, F., Huarte, R., Carbonari, J.E., Gentile, R., 1995. Cronología Radiocarbónica de los sedimentos de la Fm Luján en Arroyo Tapalqué, Provincia de Buenos Aires. IV Jornadas Geológicas y Geofísicas Bonaerenses. Actas 1, 119–126.

Figini, A.J., Huarte, R., Carbonari, J.E., Tonni, E.P., 1998. Edades C-14 en un perfil del Arroyo Tapalqué, provincia de Buenos Aires, Argentina. Contribución a la cronología de acontecimientos faunístico-ambientales. X Congreso Latinoamericano de Geología y VI Congreso Nacional de Geología Económica, Actas I, pp.27–31.

Hedges, R.E.M., van Klinken, G.J., 1992. A review of current approaches in the pretreatment of bone for radiocarbon dating by AMS. Radiocarbon 34 (3), 279–291.

Labeyrie, L., 2000. Glacial climate instability. Science 290, 1905–1907.

Ledru, M.P., 1993. Late quaternary environmental and climatic changes in Central Brazil. Quaternary Research 39, 90–98.

Longin, R., 1971. New method of collagen extraction for radiocarbon dating. Nature 230, 241–242.

McCulloch, R.D., Bentley, M.J., Purves, R.S., Hulton, N.R.J., Sugden, D.E., Clapperton, C.M., 2000. Climatic inferences from glacial and palaeoecological evidence at the last glacial termination, southern South America. Journal of Quaternary Science 14, 409–417.

Pardiñas, U.F.J., Lezcano, M., 1995. Cricètidos (mammalia, rodentia) del pleistoceno tardío del nordeste de la provincia de buenos aires (Argentina). Aspectos sistemáticos y paleoambientales. Ameghiniana 32 (3), 249–265.

Petit, J.R., Jouzel, J., Raynaud, D., Barkov, N.I., Barnola, J.-M., Basile, I., Benders, M., Chappellaz, J., Davis, M., Delaygue, G., Delmotte, M., Kotkyakov, V.M., Legrand, M., Lipenkov, V.Y., Lorius, C., Pépin, L., Ritz, C., Saltzman, E., Stievenard, M., 1999. Climate and atmospheric history of the past 420,000 years from the vostok ice core, Antarctica. Nature 399, 429–436.

Prieto, A.R., 1996. Late quaternary vegetational and climatic changes in the pampa grassland of argentina. Quaternary Research 45, 73–88.

Quattrocchio, M.E., Borromei, A.M., 1998. Paleovegetational and paleoclimatic changes during the late Quaternary in southwestern buenos aires province and southern Tierra del fuego (Argentina). Palynology 22, 67–82.

Rossello, E.A, Bor-Ming, J., Liu, T.K, Petrocelli, J.L., 1999. New 4300 yr ^{14}C age of glyptodonts at Luján river (Buenos Aires, Argentina) and its implications. Actas del Segundo Simposio Sudamericano de Geología Isotópica 1, 105–110.

Stafford Jr., T.W, Jull, A.J.T., Brendel, K., Duhamel, R.C., Donahue, D., 1987. Study of bone radiocarbon dating accuracy at the University of Arizona NSF accelerator facility for radioisotope analysis. Radiocarbon 29 (1), 24–44.

Tonni, E.P., Cione, A.L., Figini, A.J., 1999. Predominance of arid climates indicated by mammals in the pampas of Argentina during the late Pleistocene and Holocene. Palaeogeography, Palaeoclimatology, Palaeoecology 147, 257–281.

Tonni, E.P., Fidalgo, F., 1978. Consideraciones sobre los cambios climáticos durante el Pleistoceno tardío—reciente en la provincia de Buenos Aires. Aspectos ecológicos y zoogeográficos relacionados. Ameghiniana 15 (1–2), 235–253.

PERGAMON

Quaternary International 109–110 (2003) 49–64

Long distance tool stone transport in the Argentine Pampas

Nora Flegenheimer[a,*], Cristina Bayón[b], Miguel Valente[b], Jorge Baeza[c], Jorge Femenías[d]

[a] CONICET- Museo Municip. de Necochea, CC 275, 7630 Necochea, Argentina
[b] Universidad Nacional del Sur, 12 de octubre y San Juan, 8000 Bahía Blanca, Argentina
[c] Facultad Humanidades y Ciencias de la Educación, Uruguay
[d] Museo Arqueológico de Canelones, Uruguay

Abstract

Tools manufactured from a characteristic reddish siliceous rock are present in low frequencies in most early Pampean assemblages in Argentina. They are bifacial tools, including fishtail projectile points, bipolar products, and flakes. They have been found in both excavated assemblages dated between 10,000 and 11,000 BP, and in surface sites. Surface collections from Uruguay also include fishtail projectile points manufactured on this rock.

Petrographic analyses were carried out to determine stone provenance. Archaeological artifacts from the Argentine Pampas, and macroscopically similar nodules obtained from secondary deposits in Uruguay were analyzed. The rock used for the artifacts is composed of a siliceous very fine homogeneous mass that is nearly isotropic, and is characterized by recognizable remains of organisms, including silicified gastropods. The samples obtained from deposits in central and southern Uruguay have similar microscopic characteristics. Many of these deposits were exploited as indigenous quarries.

Therefore, this reddish rock was transported from Uruguay to the Argentine Pampas by societies who inhabited the region during the Pleistocene/Holocene transition. Within this context, we discuss the social meaning of this long distance tool stone transport and propose that it was a result of human interaction networks.

1. Introduction

Studies on human occupations in the Argentine Pampas region during the Pleistocene/Holocene transition have proliferated during the last two decades. Through this advance in research, a richer and more complex image of the early Pampean inhabitants is emerging. One of the subjects receiving attention is tool stone selection and use. Selection and use of tool stone has been analyzed mainly from information gathered at localities in the Tandilia Range (Bayón et al., 1999; Flegenheimer and Bayón, 1999; Valverde, 2000; Mazzanti, 2001). The more frequently used rocks in these early assemblages are immediately available and local. However, other rocks were infrequently utilized as well. In this paper, we will focus on a tool stone which is present less frequently in the early regional assemblages and which has been assigned to a long distance origin. Implications for this tool stone transport will also be analyzed.

The study of raw material provenance associated with the Pleistocene/Holocene transition time period throughout the Americas is currently an active issue of research. Lithic studies have matured enough to take advantage of the interpretative potential of provenance studies in the analysis of social decisions regarding different realms including strictly economic issues, social relationships, or even symbolic behavior.

In about 40 early sites of late Pleistocene-early Holocene age described for the Southern cone, acquisition of tool stone is also mostly immediately available and local. However, exceptionally long distance transport of bifaces and obsidians has been reported (Crivelli et al., 1996; Borrero and Franco, 1997; Borrero, 1999; Mena et al., 2000). This pattern differs from that described for North America during the same age where long distance transport of large proportions of the assemblages is common and has been used to infer group movement (for example, Goodyear, 1989; Meltzer, 1989; Anderson, 1990; Tankersley, 1991).

In Argentina several recent studies on long distance tool stone transport are based on obsidian. These studies are mostly centered in the Northwestern and

*Corresponding author. Tel./fax: 54-2262-436539.
E-mail address: noraf@teletel.com.ar (N. Flegenheimer).

PII: S1040-6182(02)00202-1

Patagonian regions, involving both hunter-gatherer and agricultural societies. In the Northwest an important number of distribution studies are the basis for discussing lithic production systems, direct access, social interaction networks and the role of exchanged domestic goods (Escola et al., 1994; Lazzari, 1997; Scattolin and Lazzari, 1997). In Patagonia, both regional circulation and long distance transport of obsidian have been recorded and studied within the framework of the organization of lithic technology (Civalero, 1999; Molinari and Espinosa, 1999; Stern, 1999, 2000; Stern and Franco, 2000).

Lithic resources in the province of Buenos Aires, in the Argentine Pampa, are highly localized. Therefore, people necessarily had to transport tool stone within the region throughout the entire span of hunter-gatherer occupation. Rocks have been transported for hundreds of kilometers employing different strategies of tool stone management (González de Bonaveri et al., 1998; Martínez, 1999). Orthoquartzites from the Tandilia range were the main rocks transported, while other secondary rocks have been transported from Tandilia, Ventania, the coast, or unidentified sources. As well, in some late Holocene assemblages a few artifacts of exotic raw materials have been recorded and interpreted as resulting from long distance transport. These cases are orthoquartzites from Tandilia in the La Pampa province (Berón, 1999), and obsidian and crysocola of unknown origin in the Interserrana and Salado Areas (Crivelli et al., 1987-88; González de Bonaveri, 2001).

Here, we will describe a case of long distance transport for early occupations of the Pampean region based on artifacts manufactured using a reddish siliceous rock. We have tried to find a potential source for this rock while working on the lithic resource base in Buenos Aires. During surveys in the Tandilia ranges, a rock with some macroscopic similarities was identified in a conglomerate of Precambrian age (Barna and Kain, 1994). After microscopic analysis, this rock was found to be very different from the archaeological tool stone. We now know that the archaeological raw materials are younger, as they contain fossils of early Tertiary age. Thus, the previous attempt to assign a source location to this rock was erroneous.

The observation of fishtail points from Uruguay flaked on a macroscopically identical rock prompted us to look further north for its origin. We therefore carried out a field survey, and recognized a reddish siliceous rock outcropping in Uruguay where it is abundant in quarries and workshops.

A sample of tool stones collected at Uruguayan quarries was subjected to petrographic analysis. Results were then compared with the results obtained on the archaeological artifacts from the province of Buenos Aires and their significance for the early occupation of the region is evaluated.

2. Early assemblages in the Argentine Pampa Region

The early peopling in the Pampean Region has been recorded in the Tandilia ranges and the plains. Sites corresponding to the Pleistocene–Holocene transition with and without faunal remains have been excavated (Politis and Madrid, 2001) (Fig. 1). At the moment 14 sites present early dates. Only six of these have yielded fishtail projectile points, and five have some preservation of bone remains and yield both extinct and modern fauna (Fig. 2). These sites exhibit great intersite variability, and lithic assemblages differ from one site to another, indicating differences in activities carried out and possibly also with respect to the social actors who occupied them.

As mentioned, tool stone source location has been an important subject of current research in the province of Buenos Aires. At these early sites, the most frequently used tool stone acquisition is local and immediately available, respectively found within a radius of 40–10 km from the site or less than 10 km (Flegenheimer et al., 1999). Among the other rocks utilized in small proportions, silicified dolomite originates at identified sources in the Tandilia Ranges and metaquartzites originate at the Ventania Ranges. The reddish siliceous rock stands out among the infrequently used rocks due to its characteristic color and texture.

We will here use as a case study the excavated early assemblages from localities Cerro La China (Sites 1, 2 and 3) and Cerro El Sombrero (Abrigo 1 and Cima) in the Tandilia Range. Artifacts recovered as surface remains at Cerro El Sombrero also are considered. The earliest occupations at these localities have been dated to about 10,000–11,000 yr BP (Flegenheimer and Zárate, 1997). The following is a general description of the assemblages, highlighting aspects relevant for this research.

Tool types commonly represented at the sites include: fishtail or Fell's Cave Stemmed projectile points, side and transverse scrapers, gravers, knives, denticulates, endscrapers, scraper planes, notches, burins, and a wide range of retouched flake tools which are typologically unidentified. These collections currently include 112 fishtail points and preforms (Flegenheimer, 1999). Pecked and ground complete and fragmented tools were also recovered, corresponding to small spheroids, as well as a discose stone that exhibits an engraving.

Most of the artifacts have been flaked on rocks from the Tandilia range. Among these rocks, the most frequent are highly selected local orthoquartzites of the Sierras Bayas Group (Fig. 3) from 30 to 60 km to the west of the sites. The Sierras Bayas Group stones were chosen for their quality and color (Flegenheimer and Bayón, 1999). In smaller proportions, immediately available poor quality orthoquartzites of the Balcarce Formation and quartz were also used. Both are found in

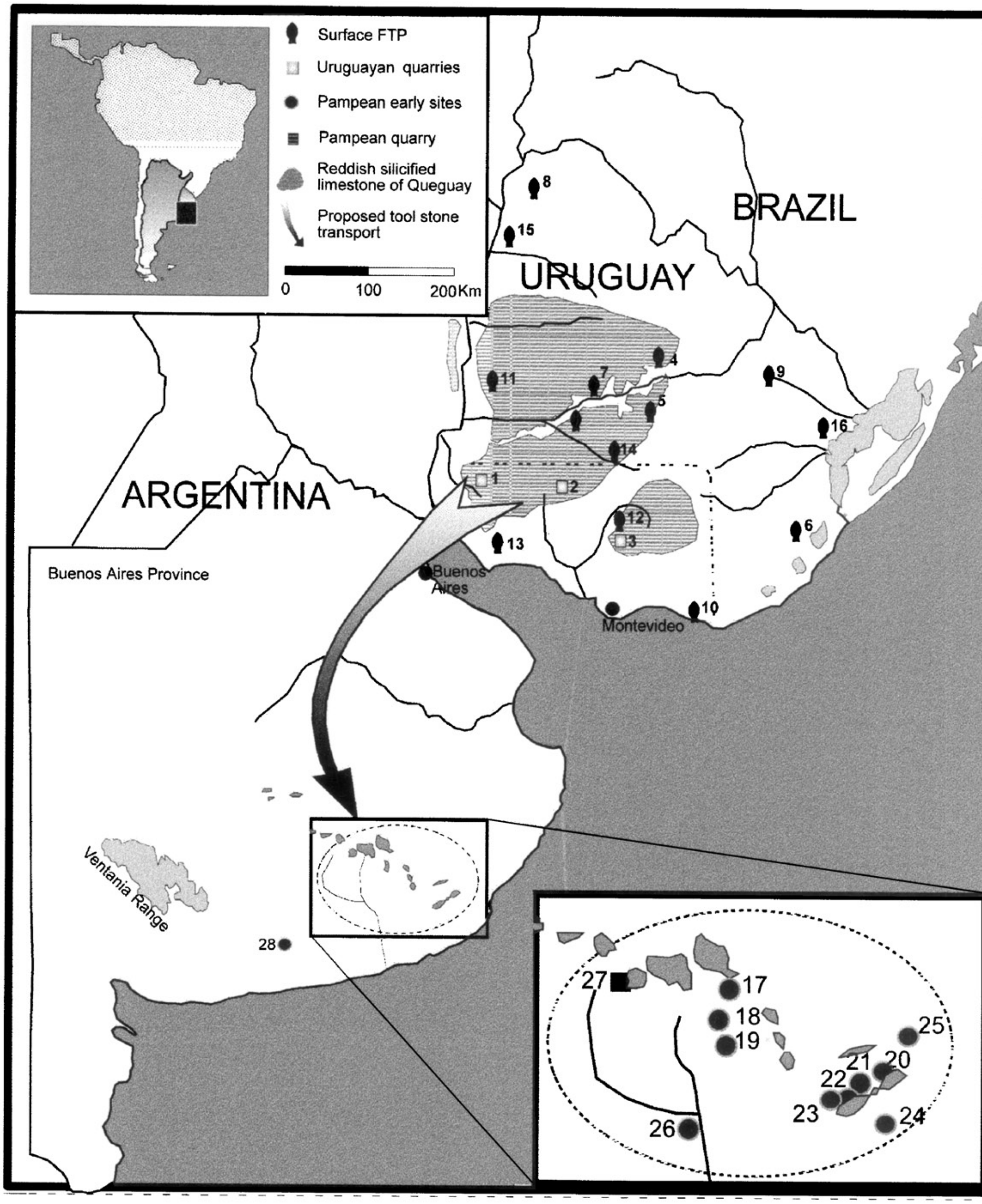


Fig. 1. Map of study area showing early Argentine Pampa sites, surface fishtail points from Uruguay and tool stone provenance. Quarries of reddish silicified limestone of Queguay: (1) Punta Arroyo San Martín, Soriano. (2) Estancia Fagalde. (3) Paso de Berget, Río Santa Lucía, Canelones, Florida. Surface fishtail projectile points from Uruguay: (4) and (5) Río Negro Medio (Tacuarembó and Durazno Departments): 41 points. (6) Rocha Department: 8 points. (7) Río Negro Department: 5 points. (8) Artigas Department: 5 points. (9) Cerro Largo Department: 4 points. (10) Maldonado Department: 4 points. (11) Paysandú Department: 3 points. (12) Canelones Department: 2 points. (13) Colonia Department: 2 points. (14) Flores Department: 2 points. (15) Salto Grande Department, 2 points. (16) Treinta y tres Department: 1 point. Early sites in the Argentine Pampa: (17) Cerro El Sombrero, Cima and Abrigo 1. (18) Cerro La China 1, 2 and 3. (19) Los Helechos. (20) Alero Los Pinos. (21) Burucuyá. (22) Cueva Tixi. (23) Cueva El Abra. (24) La Amalia, site 2. (25) La Brava. (26) Paso Otero 5. (28) Arroyo Seco, site 2. Quarries of Sierras Bayas Group Orthoquartzite: (27) Arroyo Diamante.

a radius of 10 km from the sites. These two orthoquartzites, of different flaking quality, follow different production trajectories. Local orthoquartzites, which comprise the main tool stone, were used to manufacture both unifacial and bifacial artifacts. Although the sites are not too far from the sources, a concern for tool stone optimization is evident. The raw material was transported as cores, blanks and probably tools. The initial

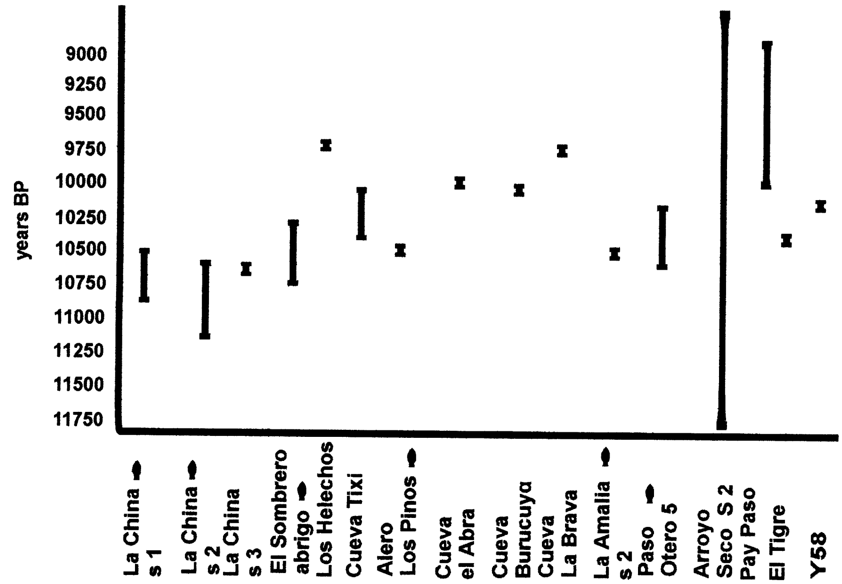


Fig. 2. Dates of early sites in Buenos Aires and Uruguay. Dates considered as doubtful by the authors were eliminated. The presence of fishtail points at the sites is indicated.

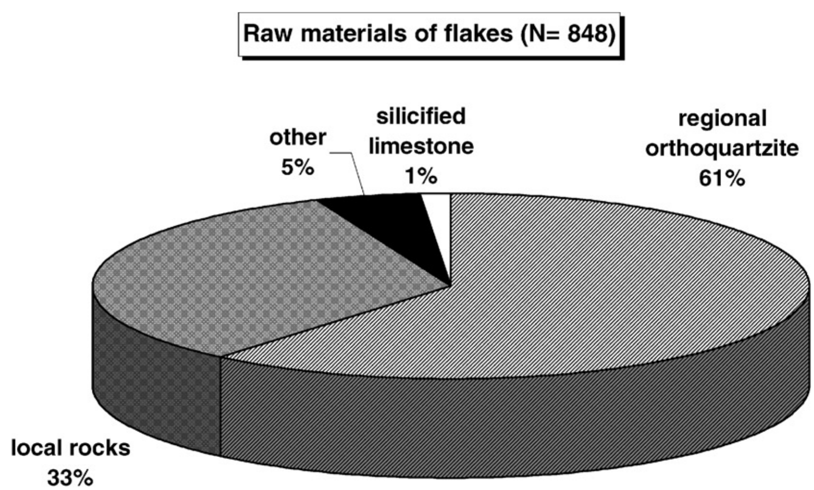
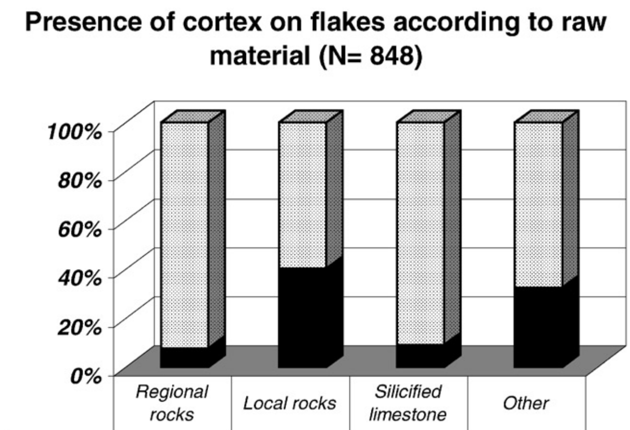


Fig. 3. Flakes from Cerro La China (S 1, 2 and 3) and Cerro El Sombrero (Abrigo 1) according to their raw materials.

reduction must have occurred elsewhere as there are few cortical flakes on these local rocks. Non-bipolar cores are characteristically small, worn out and sometimes have even been flaked on an anvil to make the most use of the raw material. Also, the transport of bifaces has been inferred and bifacial thinning flakes have been eventually used as blanks (Flegenheimer, 2001). Bipolar flaking has been applied as a way of making use of small pieces of rock or of recycling tools. Maintenance and recycling of fishtail projectile points has been reported. All this does not mean that the whole assemblages are worn out: complete tools and medium sized flakes have also been discarded. Immediately available rocks were used expediently on most occasions, as artifacts are mainly unifacial, large or medium sized, commonly with cortex and cores presenting a few random flake scars. An example of these different trajectories of immediately available and local tool stone can be inferred from the different frequency of cortex in the flakes (Fig. 4). In these assemblages, the ratios of bifacial artifacts vary from site to site between 50% and 4%, and that of bipolar cores between 50% and 0%. Table 1 shows artifacts flaked on the reddish siliceous rock from sites at Cerro La China and Cerro El Sombrero.

Of the 13 artifacts with retouches on the reddish siliceous rock, most (10) are biface fragments or bifacial tools, and one is a bipolar fragment, which could correspond to a recycled tool (Fig. 5). Only two of the artifacts are small unifacial tools. Flakes are very scarce, currently amounting to 20, and have been recovered at



	Regional rocks	Local rocks	Silicified limestone	Other
no cortex	479	166	10	27
cortex	40	112	1	13

Fig. 4. Presence of dorsal cortex on flakes from Cerro La China (S 1, 2 and 3) and Cerro El Sombrero (Abrigo 1) according to raw materials.

Cerro La China S3, Cerro El Sombrero Abrigo 1 and Cima. Flakes from Cima are not included in Figs. 3, 4 and 6, as total flake count has not been completed. All the flakes recovered are small thinning or resharpening flakes, and most are bifacial thinning flakes.

This group of artifacts is very different from the overall assemblage recovered at these sites where unifacial tools predominate. Flakes corresponding to both initial and final reduction have been recovered, but bifacial reduction flakes only amount to 8% of the sample (Fig. 6). Clearly, artifacts on the reddish siliceous rock represent a distinct production trajectory. *Chaînes operatoires* on this rock are among the longest ones registered. Most artifacts have undergone bifacial production and many are recycled. Also, no initial production flakes have been found and cortex is very scarce. No cores of reddish siliceous rocks were recovered, but the presence of a fragment of a large biface indicates that bifaces might have been used as cores. Tools developed on bifacial reduction flakes using this lithology have not been reported. Three tools from Cerro El Sombrero-Cima display heat damage, but we think this is not due to thermal treatment. They are either surface remains or were found in shallow deposits. As fires are currently common at the site, they might have produced damage on these artifacts.

Artifacts on reddish siliceous rocks have also been reported at other early sites in the region. At Paso Otero 5, dated to 10,190 and 10,450 yr BP, a fishtail point flaked on the same reddish siliceous rock was found associated with extinct Pleistocene megafauna (Martínez, 2001). Mazzanti (1999) mentions yellow, reddish, green, brown and translucid siliceous rocks at Tixi, Los Pinos, Cueva Burucuyá and Cueva la Brava from occupation levels dated between about 9000 and 10,500 yr BP. According to Mazzanti (pers. com. 1999), reddish varieties could be similar to those described in this paper. Furthermore, a surface fishtail point on the same rock has been reported from San Cayetano (Politis, 1991; Fig. 2C). All these sites lie within a distance of 150 km from Cerro la China and Cerro El Sombrero.

Recently, a complete biface on this rock was found among other artifacts in a surface site in a plowed field about 35 km to the east of the studied sites. It is similar to the fragment found at Cerro la China Site 1, and is useful in providing an idea of what the fragment found at Cerro La China Site 1 might have looked like (Fig. 5A and F).

3. Fishtail points from Uruguay

In Uruguay, early dated assemblages are still scarce and few sites correspond to the Pleistocene–Holocene transition (MEC, 1989; Hilbert, 1991; Austral, 1994; Suárez Sainz, 2000). This probably is result of the history of research in the region, as surface fishtail projectile points are commonly found throughout the country (Fig. 1). Also, another assemblage has been considered to represent a very early occupation only on morphological grounds (Bórmida, 1964; Taddei, 1964). Therefore, our information consists mostly of reported surface finds of fishtail projectile points (Figueira, 1892; Cordero, 1960; Schobinger, 1972; Meneghin, 1977; Bosch et al., 1980; Politis, 1991; Suárez Sainz, 2000; Nami, 2001) and unpublished finds located in amateur collections. Also, we have observed that most large archaeological collections contain at least a few specimens (Museo Colonia, Collection Oliveira at Museo Nacional de Antropología, Collection Taddei at Museo Municipal de Canelones). Up to the moment, a total of 82 surface fishtail points have been recorded, and at least 23 have been flaked on the reddish or pink siliceous rock (Fig. 7). The localization for the majority of these points is known, and most have been found in the central part of the country, in the Río Negro basin (Fig. 1).

The fishtail points in both the Argentine Pampas and Uruguayan collections exhibit most of the characteristic traits of the type as described by Bird (1969). Most have been manufactured using flake blanks of approximately the same thickness as the finished product. Some have been fluted either on one face or both. Marginal grinding of the stem edges and base are very characteristic.

Other authors have described morphological and technical characteristics of fishtail projectile points found in different regions of South America. The points exhibit similarities throughout the continent, including basal thinning and fluting as has already been discussed (for example, Mayer-Oakes, 1986; Gnecco, 1994; Nami, 1997, 2001; Politis, 1991). Regarding fluting, both the

Table 1
Artifacts on reddish siliceous rock from Cerro El Sombrero and Cerro La China

Site	Number/ collection	Type	State	Length	Width	Thickness	Surface	Comment
La China S1	35/381	Biface	Transverse fracture	45	61	9	Red luster	Plano-convex section, nearly complete bifacial reduction
	35/ 120	Biface fragment	Several fractures	38	11	6	Red luster	Probably recycled, could correspond to 381
	35/119	Retouched flake	Complete	16	27	7	Red luster	With small portion of cortex
La China S3	35/3/20	Bipolar product splintered piece	Complete	18	20	10	Red luster	Could be recycled artifact
	35/3/969	Retouched flake	Complete	26	24	6	Red luster	With small portion of cortex
	35/3/1800	Bifacial blank?	Transverse fracture	36	36	10	Pink opaque	Crudely flaked
El Sombrero cima-excavation	S12/303/3	Bifacial scraper	Complete	32	18	7	White-red luster	Totally retouched, possibly recycled biface
	S12/204/13	Bifacial fragment	Several fractures	18	17	4	Red luster	Strong heat damage
El Sombrero Cima-surface	No. 153	Bifacial blank	Transverse fracture	34	18	9	Pink luster	Slight heat damage
	No.127	Recycled point	Transverse stem fracture	29	21	7	Yellow/pink, luster	Slight heat damage. Recycled as concave distal edge and straight lateral edge
	No. 151	Bifacial tool	Transverse	17	11	4	Red luster	
	No. 150	Bifacial tool	Complete	22	19	4	Pink luster	Heat damage. Probably recycled tool
	Collection Noseda	Bifacial tool	Transverse fracture	16	22		Red luster	Rounded point tip?

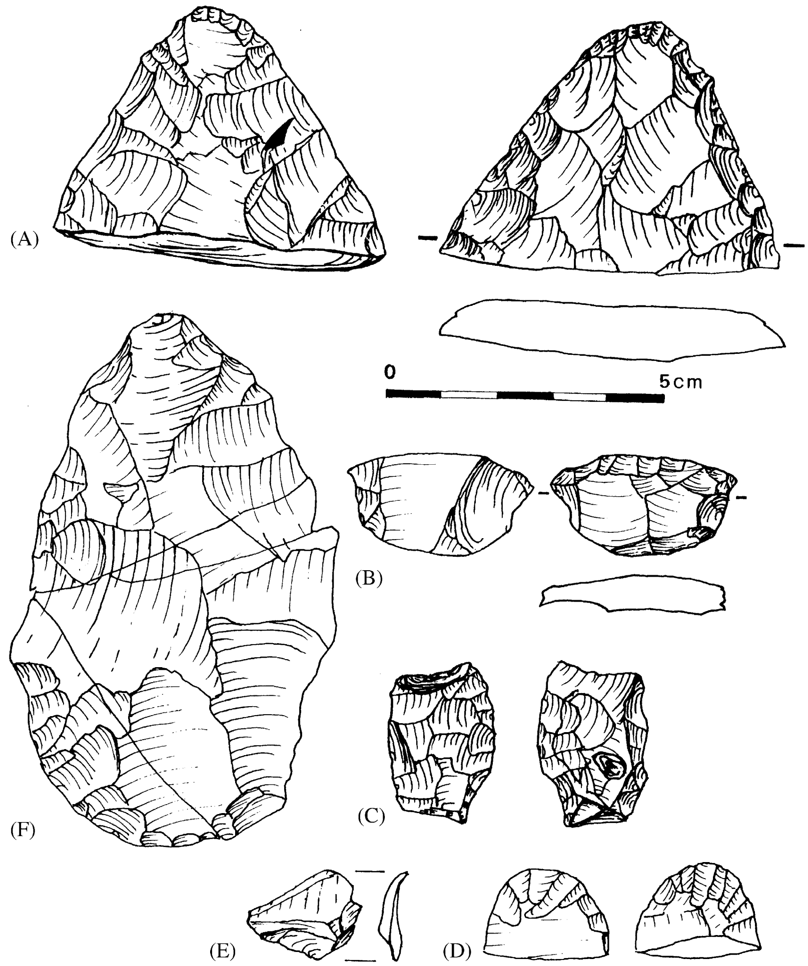
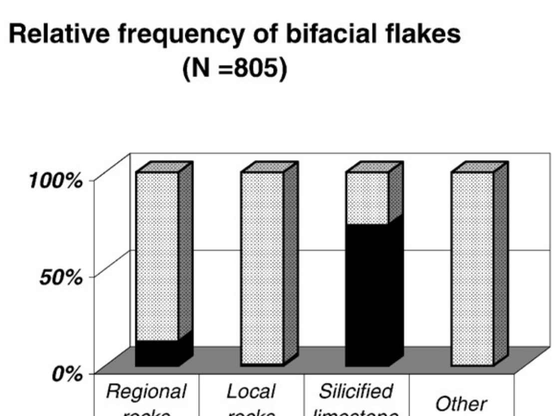


Fig. 5. Artifacts from Buenos Aires sites on reddish silicified limestone of Queguay: (A) Fragmented biface from Cerro La China1. No.35/1/381. (B) Bifacial scraper from Cerro El Sombrero, Cima. No. S12/303/3. (C) Probable recycled fishtail point from Cerro El Sombrero, Cima with heat damage. Surface No.127. (D) Fragmented bifacial artifact from Cerro El Sombrero Cima. Surface, Collection Noseda. (E) Bifacial thinning flake from Cerro El Sombrero, Abrigo. No.C.10/87. (F) Biface found in surface site in the Tandilia Ranges.



	Regional rocks	Local rocks	Silicified limestone	Other
flakes	428	263	3	40
Bifacial flakes	62	2	8	0

Fig. 6. Relative frequency of bifacial thinning flakes at Cerro La China (S 1, 2 and 3) and Cerro El Sombrero (Abrigo 1).

Argentine Pampa and Uruguayan collections include performs and those with fluting are especially useful for discussing platform preparation and flaking technique. In a very few specimens, we have observed that the platforms are not always centered (Fig. 8C and D). Thus, in specimens with fluting on both faces, such as the preform illustrated in Fig. 7D, channel flakes are not symmetrical but slightly offset, producing a thicker central portion in the stem. With this strategy, an extreme thinning of the section is avoided. This trait was first observed on a preform from Cerro El Sombrero by B. Bradley (pers. com., 1997). The detail in the asymmetrical placement of platform preparation for fluting is present in both regions. At the moment we do not have quantitative data from other regions in South America, and do not know the distribution of this manufacturing trait. Also, the existence of complete bifacial production on large bifaces is being discussed as

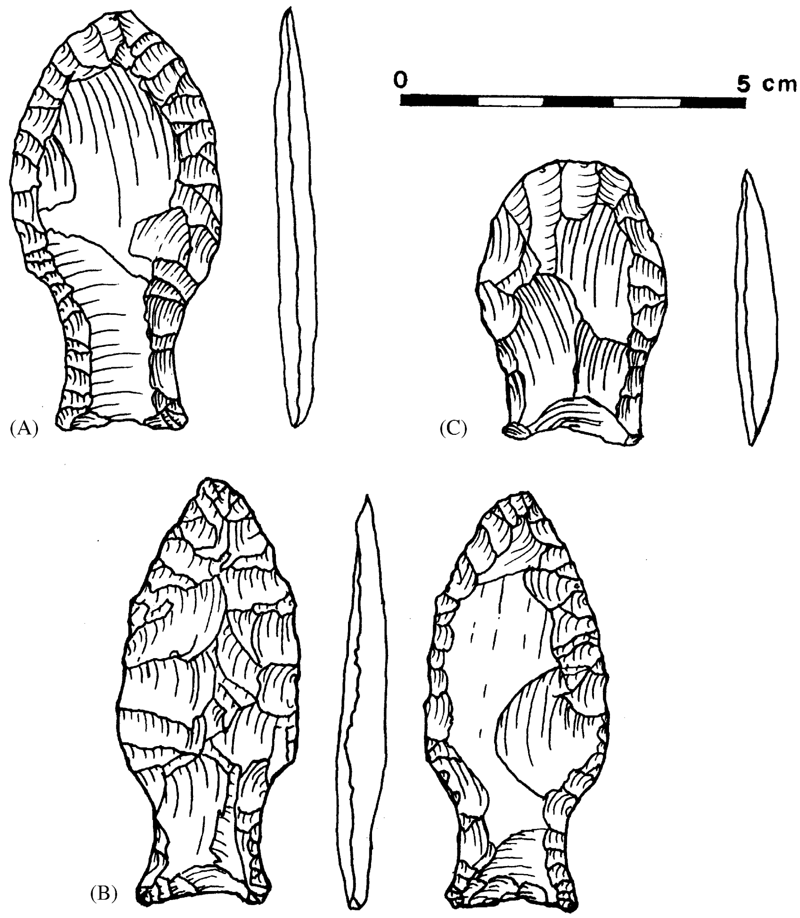


Fig. 7. Fishtail points on reddish silcrete from Uruguay. (A) Fishtail point from Río Negro,Uruguay, Collection Vera de Claret (redrawn from Fig. 16 in Bosch et al. 1980). (B) Resharpened fishtail point from Laguna Blanca, Uruguay, Collection Oliveras (redrawn from Fig. 18 in Bosch et al. 1980). (C) Fishtail point found at Ea. Fagalde, published as No. 32 by Bosch et al. (1980).

a manufacturing process for both regions. Large points in the Pampas possibly were manufactured from bifaces (Flegenheimer, 2001), and a similar idea has been proposed in Uruguay (cf. Nami, 2001; Suárez Sainz, 2001). In Uruguay, the presence of unifacial fishtail points also has been recorded, and in Buenos Aires scarcely retouched points have been found (Fig. 8A and B). In both regions, the manufacturing technology used to produce fishtail projectile points was very flexible, and several *chaînes operatoires* were being used at the same time.

4. Reddish siliceous rock: macroscopic and petrographic descriptions

The following descriptions refer to geological and archaeological samples. The geological samples described were obtained from quarries in secondary deposits in Southern Uruguay and from outcrops at Meseta del Fresco, La Pampa province. The archaeological samples are two flakes from Cerro El Sombrero-Cima, Buenos Aires province. In all cases we include both a macro and microscopic description. Finally, the samples are compared and similarities assessed (see Table 2).

4.1. Samples from El Fresco Formation, La Pampa province

These samples were collected by Berón (1999). According to their mineralogic composition, these rocks can be classified as silicified limestones. They are characterized by a brecciated structure with angular to subrounded fragments, the presence of structures of organic origin, spherulithic quartz, quartz/chalcedony microgeodes, and the replacement of carbonates by silica (Fig. 9). Melchor and Casadío (1997) describe the presence of similar characteristics in silicified peloidal grainstone belonging to facies V of the Eocene El Fresco Formation in the Province of La Pampa. Due to the

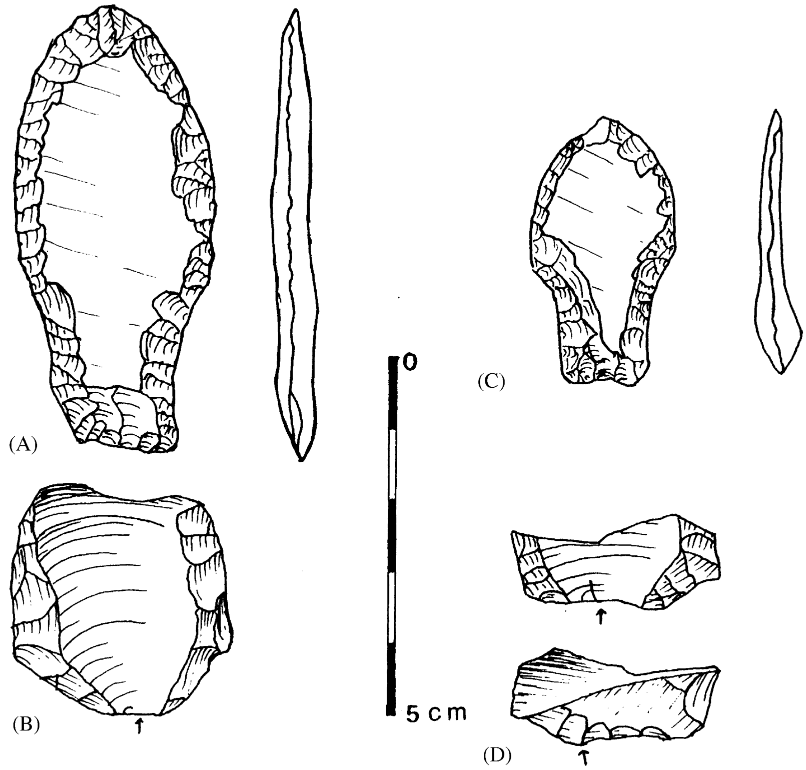


Fig. 8. Fishtail points from Uruguay and the Argentine Pampa. (A) Scarcely retouched unifacial point from Uruguay (redrawn from Fig. 17 in Bosch et al. 1980). (B) Scarcely retouched point from Cerro El Sombrero, Abrigo 1, No. C 7/134. (C) Broken fluted preform of fishtail point. Note asymmetrical placement of flute from Paso del Puerto, Collection Taddei, Museo Arqueológico de Canelones. (D) Broken fluted preform of fishtail point. Note asymmetrical placement of platform for second fluting from Cerro El Sombrero, Cima, No. S12/401/2.

similarities mentioned above we assume the samples collected by Berón correspond to this Formation.

4.2. Geological samples from Uruguay, collected at quarries

The samples exhibit a complete replacement of the original material by silica, which has not allowed the preservation of evidence regarding the original rock composition. They also include valve fragments, circular structures assigned to gyrogonites of charophytes (Fig. 10A), quartz/chalcedony microgeodes, and detrital grains. Therefore these samples can be considered as sedimentary silicified limestone.

The macro and microscopic characteristics of the samples correspond to those of the silicified limestones of the Queguay (Calizas del Queguay), related to the Mercedes and Asencio Formations (Bossi et al., 1975; Martínez et al., 1997). The age of these deposits has been the subject of discussion, and different authors assign them either to the Upper Cretaceous (Bossi and Navarro, 1991) or to the Paleocene (Martínez et al., 1997) based on their fossil content. Similar deposits are also mentioned in the province of Entre Ríos and Corrientes, Argentina (Gentili and Rimoldi, 1979).

4.3. Samples from archaeological sites of the Argentine Pampa region

These samples can be considered as silicified limestone, exhibiting the complete replacement of original material by silica and the presence of quartz/chalcedony microgeodes, circular structures assigned to gyrogonites of charophytes (Fig. 10B), valve fragments, and structures assigned to gastropod transversal sections (Fig. 11).

When comparing the archaeological samples with those obtained from El Fresco, La Pampa, the presence of specimens of gyrogonites of charophytes is particularly diagnostic (Fig. 10A and B). These fossils are neither reported nor have been observed in the samples from El Fresco. The presence of quartz grains with wavy extinction would have their provenance in the metamorphic area of Uruguay, and would not be found in the area of El Fresco. Macroscopic observation of both the Uruguayan and the archaeological raw materials indicates a close match. The different varieties recovered (pink, red, opaque, lustrous) at Cerro La China and Cerro El Sombrero are all present in the Uruguayan sources.

We consider that the results of this comparison should be tested through the analysis of more samples

Table 2
Petrographic description of tool stone samples from El Fresco, Uruguay and archaeological flakes from Buenos Aires. Diagnostic similarities from Uruguayan and archaeological samples are highlighted

Samples	**Geological sample from El Fresco formation, La Pampa province**	**Geological sample from Queguay formation, Southern Uruguay. Secondary deposits**	**Archaeological flakes from Cerro El Sombrero, Cima**
Macroscopic description			
Color	Brownish red to pink or gray	Brownish red , pink or dark gray	Red, brownish red to pink
Fracture	Perfect conchoidal fracture, locally irregular	Very good to perfect conchoidal fracture	Perfect conchoidal fracture
Luster	Greasy luster	Greasy luster	Greasy luster
Structure	Brecciated structure	Homogeneous structure	Partially brecciated structure
Organic remains	Fragments of silicified mollusk valves	Fragments of silicified gastropod valves, circular structures up to 0.7 mm	Fragments of silicified mollusk valves, circular structures up to 0.5 mm
Observations	Quartz/chalcedony microgeodes, presence of boxworks with Fe-oxides, inclusion of lithic? detritic grains	Quartz/chalcedony microgeodes, dark stains related to oxides form dendritic structures	Discolored zones associated to boxworks. Quartz/chalcedony microgeodes
Microscopic description			
Texture	Microcrystalline	Microcrystalline	Cryptocrystalline to microcrystalline
Structure	Fine brecciated, lithic fragments? Quartz/chalcedony microgeode, spherulithic quartz	Homogeneous, quartz/chalcedony Microgeodes	Siliceous very fine homogeneous mass, quartz/chalcedony microgeodes
Replacement mineralogy	Strong silicification, mosaic structure and fibrous chalcedony. Hematite?	Strong silicification, mosaic and fibrous chalcedony	Mosaic aggregate of very fine chalcedony, or partially, opal in process of recrystallization
Organic remains	Unidentified mollusk valves	Unidentified mollusk valves (gastropods). **Complete specimens of gyrogonites of charophytes**	Unidentified mollusk valves (gastropods). **Complete specimens of gyrogonites of charophytes**
Original rock	Micritic or microsparitic calcite	Do not observe	Do not observe
Observations	Feldspar and quartz detritic grains. Hematite?	Quartz detritic grains and feldspar present wavy extinction	Quartz detritic grains present wavy extinction
Classification			
	Silicified limestone	Silicified limestone?	Silicified limestone?

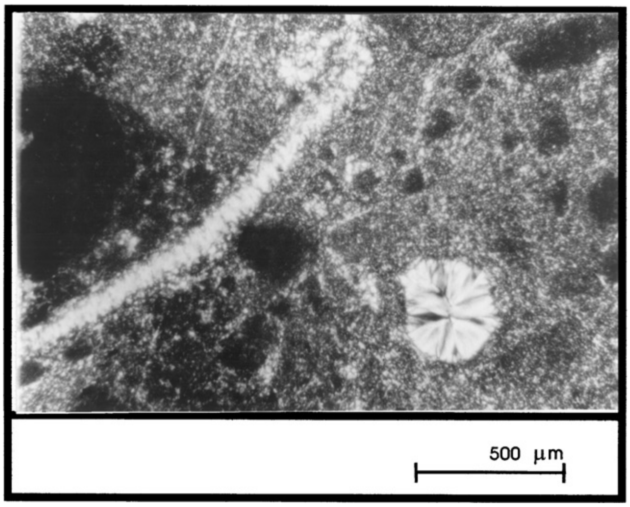


Fig. 9. Geological sample from El Fresco: valve fragment and spherulithic quartz, 5 × magnification.

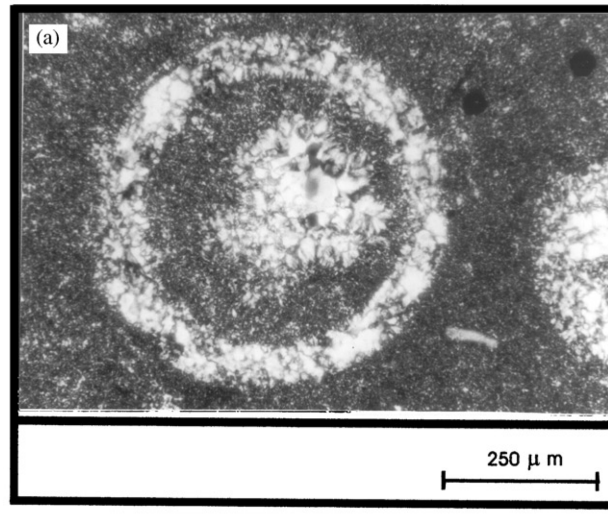
from geological sources, especially from the El Fresco area in La Pampa province and the outcrops from Entre Ríos and Corrientes provinces. However, no early archaeological sites have been reported from these provinces.

5. Reddish silicified limestone quarries in Uruguay

The reddish silicified limestone is commonly found in primary and secondary deposits in Western, Central (Río Negro basin), Southern (Santa Lucía basin) and Northeastern Uruguay (Baeza, 1987). These rocks have been described as silicified limestones with intense silicification processes, which sometimes produce limestones and silcretes, including gastropod fossils. In the local archaeological literature this tool stone has been described as "caliza silicificada" or "carneolita", similar to chert.

We visited three localities where this reddish silicified limestone is available and a fourth in which it was used as a tool stone. At localities where it is available, the source includes both flakeable and non-flakeable rocks, as well as several colors of silicified limestone. All these localities are associated with prehistoric workshops.

At Paso de Sena, this tool stone is one of several rocks included in the alluvial sediments of the Arroyo Miguelete. A complete fishtail projectile point on a translucent siliceous rock was collected from the site (Collection Mr. N. Berton), which includes a variety of other artifacts. In another locality with several workshops (Balneario Punta del San Martín), the reddish rock crops out, and constitutes one of the components of a conglomerate. The densest workshop we visited is at a third locality, Estancia Fagalde (situated at Route No. 3, km 154). Here the silicified limestone exhibits several



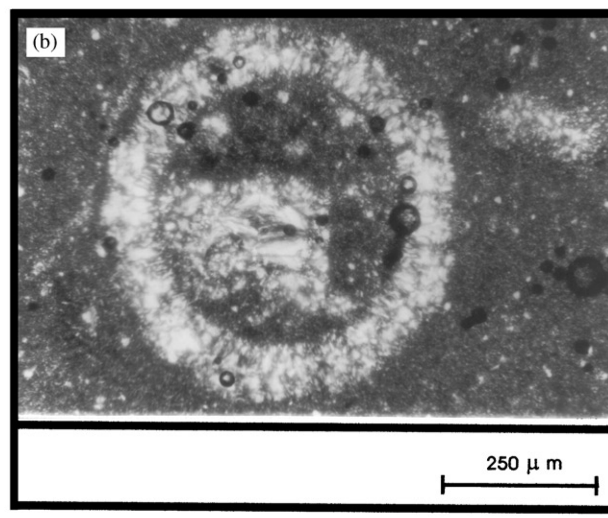


Fig. 10. Thin sections of archaeological and geological samples, 10 × magnification. Note close similarities between both samples. (a) Archaeological flake from Cerro El Sombrero, Cima. The circular structure corresponds to a gyrogonite of a carophyte. (b) Geological sample obtained at Uruguayan quarries. The circular structure corresponds to a gyrogonite of a carophyte.

colors, andis one of a number of rock types included as clasts in a conglomerate. A fishtail point on a pink variety of this tool stone was recovered at the site and has been deposited at the Museo Municipal de Canelones (Fig. 7C). The fourth locality (Arroyo Piedras Blancas), is a surface site where we observed a variety of flaked artifacts. Some of the tools and cores are on red and pink varieties of the silicified limestone.

At the quarries and associated workshops, we observed clasts with opaque external surfaces or with a characteristic luster. Many are covered by a calcareous cortex. At all sites the sizes of the clasts vary between very small (unflakeable) up to 50 cm in length. Their quality as a tool stone depends mostly on the quantity of

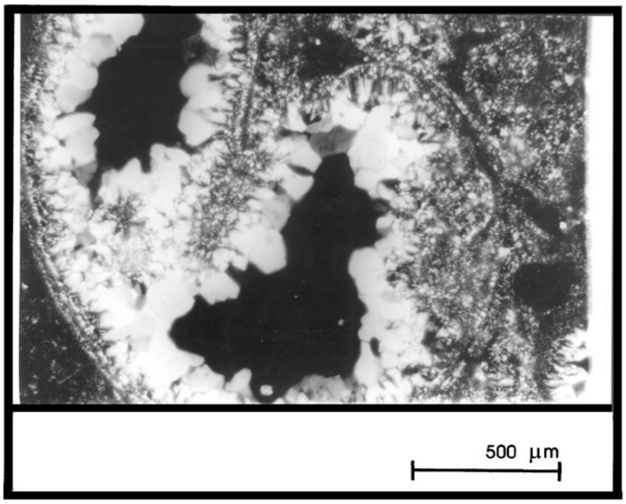


Fig. 11. Archaeological flake from Cerro El Sombrero, Cima which exhibits a transversal section of a gastropod replaced by quartz, magnification 5×.

inclusions and fissures and on the degree of weathering. Artifacts and debitage are manufactured on all the available tool stone varieties, and the reddish silicified limestone was abundant and easy to collect at these sites. Although, fishtail points had been previously collected at two of these sites, in our short visit we did not find evidence to assign any of these three workshops to an early age.

6. Discussion

In summary, the reddish silicified limestone tools are scarce but exist in most early archaeological assemblages in the Argentine Pampas. They reflect a curated strategy, and are mainly bifacial tools including fishtail projectile points. This is demonstrated both by the tools, which are bifacial, and by the flakes, which are scarce and small. The evidence presented indicates that the raw material must have been transported as retouched artifacts or blanks. We think that many of the transported artifacts were bifaces, which could have served several functions (Kelly, 1988). We have found both bifaces and fragments of bifaces recycled as other tool types such as scrapers. Although we do not have evidence of the use of bifaces as cores, such use is expected. Tools also show a strategy of maximization of raw material: some are recycled or worn out and no large debitage is found.

In this paper we propose southern Uruguay as the source area for the reddish silicified limestone based upon the petrographic characteristics of the rock and the presence of fishtail projectile points in both regions. Petrography of archaeological samples from the province of Buenos Aires indicates a strong similarity with raw material obtained in quarries in Uruguay. As well, fishtail points, with technical characteristics similar to the ones from Buenos Aires, are frequent in surface collections from Uruguay. Therefore the provenance of this tool stone from Uruguay is sustained by two different lines of evidence, one based on petrographic and the other on archaeological data. Applying these same criteria, the other sources have been eliminated as possible sources of raw material (Meseta del Fresco in La Pampa province, the outcrops in Entre Ríos and Corrientes provinces and the conglomerate in Tandilia in Buenos Aires province).

We therefore propose that the "reddish siliceous rock" found in the early Argentine Pampa contexts can be assigned to the same type of rock that the archaeologists in Uruguay call "caliza silicificada", "carneolita", or silicified limestone. As this name is too inclusive, we suggest the rock in our case can be identified as "reddish silicified limestone of Queguay".

The distance between Southern Uruguay and the early sites in Buenos Aires is about 400–500 km and the area is characterized as plains. Therefore, the only geographical barriers that the people who transported the tools would have encountered are rivers. The widest of these, the Río de la Plata, presented conditions very different from the present during the Pleistocene/Holocene transition. About 11,000 years ago the marine coast was located several kilometers further to the east. Therefore, the Río de La Plata, which today is a wide estuary, was limited to a channel discharging eastwards from the present inlet, very close to the headlands of the continental slope. From 11,000 to 6000 years ago the sea advanced progressively towards the present level (Urien and Ottmann, 1971; Cavallotto et al., 1999). Consequently, the question arises whether this river was waded or crossed by navigation during the Pleistocene/Holocene transition. Recently, the possibility of water craft use by early American populations during this time is being considered (Lepper, 2000).

Finally, what does this tool stone transport mean from a prehistoric perspective? Four possibilities can be considered:

- An initial group of colonizers moving from the north into the Argentine Pampa brought part of their toolkit with them;
- one group of people inhabited a large territory including both the Argentine Pampa and Southern Uruguay, discarding artifacts during their periodic movements;
- different groups living respectively in the Argentine Pampa and Uruguay had sporadic contact, during which artifacts occasionally circulated; or
- different groups of people living respectively in the Argentine Pampa and Uruguay maintained regular social relations through which goods circulated.

Ideally in the first case, we would expect older dates for the sites with fishtail points in Uruguay. Sites with these assemblages have not been found in stratigraphic context, but some sites, mentioned above, with dates corresponding to the Pleistocene–Holocene transition have been reported (see Fig. 2). The currently available dates from early occupations in both regions are the same. However, even if we had more dates, the current accuracy of radiocarbon assays would not allow for sufficient detail to solve this issue. As recently described (Fiedel, 1999), in radiocarbon dating there is a methodological uncertainty for ages between 12,500 to 10,000 BP, due to plateaus and jumps in the calibration curve. In addition, depending on the rhythm of colonization, an expansion over 400–500 km could have been accomplished in a short time, and might be ‘‘invisible’’ to archaeological and radiometric dating methods.

We would also expect to find whole assemblages or a great portion of them developed on a variety of raw materials transported from Uruguay. We would not expect a tool type selection: rather, both unifacial and bifacial tools should be represented. Such is not the case, as raw materials have been transported very selectively and tool types are restricted. Although the case of transport presented in this paper could be similar to the situation described by Borrero and Franco (1997), resulting from exploration of new territories, we want to emphasize two differences. On the one hand, in previous papers we have suggested that the early Argentine Pampa sites do not correspond to the very first occupation of the territory, due to the highly selective use of the landscape and lithic resources (Flegenheimer et al., 1999). On the other hand, Borrero and Franco (1997) proposed their model for Patagonia, an area with plentiful raw materials. This is not the case in the province of Buenos Aires. This argument is also relevant for discussion of the second possibility.

In discussing the possibility of a large territory throughout which only one group of people moved between Uruguay and the Argentine Pampa, we must take into account its lithic resource base. The existence of exotic tool stone varieties has been discussed by Meltzer (1989) who has emphasized the difficulty of recognizing the difference between exchange and direct access, except for very particular cases. In most situations, interpretation confronts problems of equifinality. In our case, the group would have occupied a large territory, within which it had periodic direct access to areas with different raw material availability. This territory would include the area of Uruguay south of Río Negro, which presents a great richness, variety and availability of flakeable tool stone. Once one crosses the Río de la Plata, the area of the Salado basin in Argentina is completely devoid of lithic resources. This plain extends for some 400 km until the Tandilia ranges, where at least one rock of good quality for flaking is found (Sierras Bayas orthoquartzites). Under these circumstances, one would expect that people moving around within their territory transported complete and portable toolkits from Uruguay, the area of the best, more abundant and varied raw materials, and discarded them once they were worn out, near the Tandilia quarries. Also, the better rocks within the territory would have been preferred as a tool stone for the more standardized and longer use-life instruments. Neither of these expected results occurs. Artifacts corresponding to the whole toolkit have not been discarded in Tandilia, nor were a great variety of rocks transported, nor are large proportions of the long-use life instruments developed on the reddish silicified limestone of Queguay.

The third possibility implies the existence of different groups that had sporadic contacts. As we mentioned above, the availability of good quality raw materials in Southern Uruguay is high. One can find various rock types, and the silicified limestone is present in several colors. If the rock traveled as a result of isolated encounters, one would expect different rock types and colors from Uruguay in pampean assemblages, without any evidence for selection. However, our case, with about 1% of the assemblages on a peculiar tool stone of only red or pink color, selected among other possible rocks at the quarries, indicates that a certain regularity in the encounters must have existed. Also, for this selection to exist the information about the existence of distant valued goods must be shared within the group. So, this third possibility has a very low probability as the reddish silicified limestone has been found in most early sites excavated up to the moment.

Therefore, we think that the last possibility, involving different small groups inhabiting different territories but sharing information and goods, is the most probable. Soffer (1991), working on East European Upper Paleolithic groups, developed the idea that the presence of exotic materials used to fashion items of personal adornment can be interpreted as resulting from regional interaction networks. In the case of exotic lithics, she proposes that either they were obtained by individuals in the course of long distance visits, or through regional interaction networks in groups with limited residential mobility. Also, the existence of social systems of interregional interaction has been discussed by Gamble (1994) based upon several archaeological traits: shared information, repeated association of utilitarian and non-utilitarian artifacts of similar design of widespread geographical distribution, and raw material transport. In South America, Dillehay (2000) has suggested that exchange network systems developed between 11,000 and 10,000 years ago, and that within them, both ideas and cultural styles traveled for long distances. Here we present a case for the long distance transport of goods, previously missing from the South American information (Dillehay, 2000). The relevance of Paleoindian interaction and mating networks as a means of maintaining reproductive viability of small groups has been recently stressed (Anderson and Gillman, 2001). The importance of these networks in organizing the subsequent, more densely populated human landscape is mentioned, when they probably were useful to keep people apart most of the time or cooperate when necessary.

In our case, apart from recording transport of raw material between both regions, we have also observed technological similarities. The reduction sequences of fishtail points at Cerro El Sombrero and Cerro La China are similar to those observed in collections from Uruguay. For example, many fishtail points are manufactured from flake blanks, stem abrasion is a common trait, and fluting is present in low proportions. We have even observed a peculiar feature in both regions regarding the placement of the nipple for flute extraction, which is not centered. Furthermore, in the two regions flexible manufacturing sequences were in use, and these sequences are the result of both simple and complex *chaînes operatoires*. Elsewhere, we have discussed that the presence of non-utilitarian artifacts associated with these points, such as the discoidal stones, reinforce the existence of shared designs and technical knowledge (Bayón and Flegenheimer, 2000). Nami (1997) has also proposed that technical information was transmitted among different groups with fishtail points, based on cases from Southern Patagonia.

We think that other non-technical information also was shared among the same people. In the Argentine Pampa collection not all the points had the same function (Politis, 1998). Points exhibit tremendous size differences, as well as the variability mentioned above in the manufacturing process. Due to the variable sizes, we cannot infer the same function for all "fishtail points", yet they possess a similar morphology. We therefore think that shape had a social meaning (Bayón and Flegenheimer, 2000) which was shared in both regions and even further beyond.

We therefore propose that the long distance transport we have described must be considered within the framework of social interaction networks. Several main questions arise as issues for a future agenda. The first are spatial concerns: do other early South American contexts exhibit indicators of open social networks as well? Can we recognize the existence of exotic rocks, coming from the Pampas, in Uruguay where the lithic resource base is abundant and varied? Another question is time related: how did these open social systems evolve? When did they change to more territorial systems?

Acknowledgements

This research was funded by grants PIP 0390/98 and UNS-SECYT 24/I062. We would like to thank Diana Mazzanti and Mónica Berón for allowing us to use their information. The Fagalde family, Mr. Berton and Mr. Barragán generously allowed access to their lands and collections. We also acknowledge all other owners of private collections who have permitted their study throughout the years. Fig. 7C is redrawn from original supplied by Mr. Meneghin. We wish to thank our reviewers Marcel Kornfeld and Willy Mengoni Goñalons and our colleagues Gustavo Martínez, Cristina Scattolin, Gustavo Barrientos, Federico Isla and Marcelo Zárate who have all provided useful suggestions and Clive Gamble for his encouragement. Joan López Pueyredón reviewed our English.

References

Anderson, D., 1990. The paleoindian colonization of Eastern North America: a view from the Southeastern United States. Research in Economic Anthropology 5 (Suppl.), 163–216.

Anderson, D., Gillman, C., 2001. Paleoindian interaction and mating networks: reply to Moore and Moseley. American Antiquity 66 (3), 530–535.

Austral, A., 1994. La campaña de en el sitio Paypaso, Río Quarai, Departamento de Artigas, República Oriental del Uruguay. Proceedings XI Congreso Nacional de Arqueología Argentina, San Rafael, p. 355.

Baeza, J., 1987. El aprovechamiento de las materias primas líticas en grupos prehistóricos. Proceedings of the Primeras Jornadas de Ciencias Antropológicas en el Uruguay, Montevideo, pp. 9–13.

Barna, A., Kain, S., 1994. Una fuente potencial de aprovisionamiento lítico en el Cerro El Sombrero. Partido de Lobería (Pcia. de Buenos Aires). Revista del Museo de Historia Natural de San Rafael XIV, 206–208.

Bayón, C., Flegenheimer, N., 2000. Tendencias en el Estudio del Material Lítico. Paper Presented at the Segunda Reunión Internacional de Teoría Arqueológica en América del Sur. Olavarría Ms, unpublished.

Bayón, C., Flegenheimer, N., Valente, M., Pupio, A., 1999. Dime cómo eres y te diré de dónde vienes: la procedencia de rocas cuarcíticas en la Región Pampeana. Relaciones de la Sociedad Argentina de Antropología XXIV, 187–235.

Berón, M., 1999. Contacto, intercambio, Relaciones Interétnicas e implicancias arqueológicas. Soplando en el viento. Actas de las III Jornadas de Arqueología de la Patagonia, Neuquén-Buenos Aires, pp. 287–302.

Bird, J., 1969. A comparisson of South Chilean and Ecuadorian "Fishtail" projectile points. Kroeber Anthropological Society Papers 40, 52–71.

Bórmida, M., 1964. Las industrias líticas pre-cerámicas del Arroyo Catalán Chico y del Río Cuareim. Revista di Scienze Preistoriche 19 (Fasc.1-4), 195–232.

Borrero, L., 1999. The prehistoric exploration and colonization of fuego-patagonia. Journal of World Archaeology 13 (3), 321–351.

Borrero, L., Franco, N., 1997. Early patagonian hunter-gatherers: subsistence and technology. Journal of Anthropological Research 53, 219–239.

Bosch, A., Femenías, J., Olivera, A., 1980. Dispersión de las Puntas de Proyectil Pisciformes en el Uruguay. Paper Presented at Tercer

Congreso Nacional de Arqueología y Cuarto Encuentro de Arqueología del Litoral, Centro de Estudios Arqueológicos, Montevideo, pp. 245–261.
Bossi, J., Navarro, R., 1991. Geología del Uruguay. Departamento de publicaciones de la Universidad de la República, Montevideo, 966pp.
Bossi, J., Ferrando, L., Fernández, A., Elizalde, G., Morales, H., Ledesma, J., Carballo, E., Medina, E., Ford, I., Montaña, J., 1975. Carta Geológica del Uruguay. Dirección de Suelos y Fertilizantes M.A.P., Montevideo, p. 32.
Cavallotto, J.L., Violante, R., Parker, G., 1999. Historia evolutiva del Río de la Plata durante el Holoceno. Proceedings of XIV Congreso Geológico Argentino, Salta, pp. 508–511.
Civalero, M.T., 1999. Obsidiana en Santa Cruz, una problemática a resolver . Soplando en el viento, Actas III Jornadas de Arqueología de Patagonia: Neuquen- Buenos Aires, pp. 155–164.
Cordero, S., 1960 Los charrúas. Editorial Mentor, Montevideo, 333pp.
Crivelli, M.E., Silveira, M., Eugenio, E., Escola, P., Fernández, M., Franco, N., 1987–88. El Sitio Fortín Necochea (partido de General Lamadrid, provincia de Buenos Aires). Estado actual de los trabajos. Paleoetnológica IV, 39–53.
Crivelli, M.E., Pardiñas, U., Fernández, M., Bogazzi, M., Chauvin, A., Fernández, U., Lezcano, M., 1996. La Cueva Epullán Grande (Prov. de Neuquén). Praehistoria 2, 155–265.
Dillehay, T., 2000. The Settlement of the Americas: A New Prehistory. Basic Books, New York.
Escola, P., Vazquez, C., Momo, F., 1994. Análisis de procedencia de artefactos de obsidiana: vías metodológicas de acercamiento al intercambio. Revista del Museo de Historia Natural de San Rafael XIII (1/4) I parte, 307–311.
Fiedel, S., 1999,. Older than we thought: implications of corrected dates for Paleoindians. American Antiquity 64 (1), 95–115.
Figueira, J., 1892. Los Primitivos Habitantes del Uruguay. El Uruguay en la Exposición Histórica Americana de Madrid, Montevideo, pp.121–219.
Flegenheimer, N., 1999. Vista una, vistas todas? Las "colas de pescado" de la Cima de Cerro El Sombrero. Paper presented at the XIII Congreso Nacional de Arqueología Argentina Córdoba, pp. 353–354.
Flegenheimer, N., 2001. Biface transport in the Pampean Region, Argentina. Current Research in the Pleistocene 18, 21–22.
Flegenheimer, N., Bayón, C., 1999. Abastecimiento de rocas en sitios pampeanos tempranos: recolectando colores. In: Aschero, C., Korstanje, A., Vuoto, P. (Eds.), En los Tres Reinos: Prácticas de Recolección en el Cono Sur de América. Ediciones Magna Publicaciones, Tucumán, pp. 95–107.
Flegenheimer, N., Zárate, M., 1997. Considerations on radiocarbon and calibrated dates from Cerro La China and Cerro El Sombrero, Argentina. Current Research in the Pleistocene 14, 27–28.
Flegenheimer, N., Amick, D., Bayón, C., 1999. Early Strategies of Raw Material acquisition and use in the Southern Cone. Paper Presented at the 62nd SAA Annual meeting, Nashville, 2–6 April.
Gamble, C., 1994. Timewalkers: the prehistory of global colonization. Harvard University Press, Cambridge, MA.
Gentili, C., Rimoldi, H., 1979. Mesopotamia. Segundo Simposio de Geología Regional Argentina 1, 200–201.
Gnecco, C., 1994. Fluting technology in South America. Lithic Technology 19 (1), 35–42.
González de Bonaveri, M.I., 2001. Uso del espacio y circulación de bienes en la cuenca inferior del Salado. Arqueología 10, in press.
González de Bonaveri, I., Frère, M., Bayón, C., Flegenheimer, N., 1998. La organización de la tecnología lítica en la cuenca del Salado (Buenos Aires, Argentina). Arqueología 8, 57–69.
Goodyear, A., 1989. A Hypothesis for the use of cryptocrystalline raw materials among Paleo-Indian groups of North America. In: Ellis, C., Lothrop, J. (Eds.), Eastern Paleoindian Lithic Resource Use. Westerview Press, Boulder, CO, pp. 1–10.
Hilbert, K., 1991. Aspectos de la Arqueología en el Uruguay. In: Ava Materialien, Vol. 44. Verlag Philipp Von Zabern-Mainz Am Rhein, Germany.
Kelly, R., 1988. The three sides of a biface. American Antiquity 53 (4), 717–734.
Lazzari, M., 1997. La economía más allá de la subsistencia: intercambio y producción lítica en el Aconquija. Arqueología 7, 9–50.
Lepper, B., 2000. Beyond "Clovis and Beyond", Current Research in the Pleistocene, Center for the Study of the First Americans, Texas A & M University, College Station, Texas Vol 17, pp. vii–ix.
Martínez, G., 1999. Tecnología, subsistencia y asentamientos en el curso medio del Río Quequén Grande: un enfoque arqueológico. Unpublished Ph.D. Thesis, La Plata, p.406.
Martínez, G., 2001. Análisis preliminar del sitio Paso Otero 5 (Área Interserrana Bonaerense). Implicancias para las ocupaciones tempranas de la Región Pampeana. Cuadernos del Instituto Nacional de Antropología y Pensamiento Latinoamericano, Vol. 19, Buenos Aires, in press.
Martínez, S., Veroslavsky, G., Verde, M., 1997. Primer registro del paleoceno en el uruguay: paleosuelos calcáreos fosilíferos en la cuenca de Santa Lucía. Revista Brasileira de Geociências 27 (3), 295–302.
Mayer-Oakes, W., 1986. El Inga A Paleo-Indian Site in the Sierra Of Northern Ecuador. Transactions of American Philosophical Society 76 (4), 1–235.
Mazzanti, D., 1999. Ocupaciones Humanas Tempranas en Sierra La Vigilancia y Laguna La Brava, Tandilia Oriental, provincia de Buenos Aires. Proceedings of XII Congreso Nacional de Arqueología Argentina, Vol. III, 22–26 september 1997, Laplata, pp. 149–155.
Mazzanti, D., 2001. Human settlements in caves and rockshelters during the Pleistocene–Holocene in the Eastern of Tandilia Range, Pampean Region, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: from where the South Winds blow. CSFA and A-M Texas University Press, Texas, in press.
Melchor, R., Casadío, S., 1997. Hoja Geológica 3766–III La Reforma, Provincia de La Pampa. Secretaría de Minería de la Nación, Buenos Aires, pp. 1–57.
MEC (Ministerio de Educación y Cultura), 1989. Misión de Rescate Arqueológico de Salto Grande, Vol. 2, First part, Montevideo, Uruguay p. 609.
Meltzer, D.J., 1989. Was Stone Exchanged among Eastern North American Paleoindians? In: Ellis, Ch., Lothrop, J. (Eds.), Eastern Paleoindian lithic resource use. Westview Press, Boulder, pp. 11–39.
Mena, F., Lucero, V., Reyes, O., Trejo, V., Velásquez, H., 2000. Cazadores tempranos y Tardíos en la cueva Baño Nuevo 1, margen occidental de la estepa centropatagónica (XI Región de Aisen, Chile). Anales del Instituto de la Patagonia Serie Cs. Hs. 28, 173–195.
Meneghin, U., 1977. Nuevas Investigaciones en los yacimientos del "Cerro de Los Burros". Timón Press, Montevideo, Uruguay.
Molinari, R., Espinosa, S., 1999. Brilla tu, diamante "loco". Soplando en el viento, Actas III Jornadas de Arqueología de Patagonia, Neuquén-Buenos Aires, pp.189–198.
Nami, H., 1997. Investigaciones actualísticas para discutir aspectos técnicos de los Cazadores-recolectores del Tardiglacial: El problema Clovis-Cueva Fell. Anales del Instituto de la Patagonia 25, 151–186.
Nami, H., 2001. Consideraciones tecnológicas preliminares sobre los artefactos líticos de Cerro de los Burros (Maldonado, Uruguay).

Comunicaciones Antropológicas Museos Nacionales de Historia Nacional y Antropología 21, 1–24.
Politis, G., 1991. Fishtail projectile points in the southern cone of South America: an overview. In: Bonnichsen, R. (Ed.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, University of Maine, Orono, pp. 287–301.
Politis, G., 1998. Arqueología de la infancia: una perspectiva etnoarqueológica. Trabajos de Prehistoria 55 (2), 5–19.
Politis, G., Madrid, P., 2001. Arqueología Pampeana: Estado actual y Perspectivas. In: Berberián E, Nielsen, A. (Eds.), Historia Argentina Prehispánica. Vol. II, Editorial Brujas, pp. 737–814.
Scattolin, M.C., Lazzari, M., 1997. Tramando redes: obsidianas al oeste del aconquija. Estudios Atacameños 14, 189–209.
Schobinger, J., 1972. Nuevos hallazgos de puntas cola de pescado, y consideraciones en torno al origen y dispersión de la cultura de cazadores superiores Toldense (Fell 1) en Suramérica. Atti del XL Congresso Internazionale degli Americanisti. Roma-Genova, Rome, pp. 33–50.
Soffer, O., 1991. Lithics and lifeways-the diversity in raw material procurement and settlement systems on the Upper Paleolithic East European Plain. In: Montet-White, A., Holen, S. (Eds.), Raw Material Economies among Prehistoric Hunter-Gatherers. Lawrence, Kansas, pp. 221–234.
Stern, C., 1999. Black obsidian from Central- South Patagonia; Chemical characteristics, sources and regional distribution of artefacts. Soplando en el viento, Actas III Jornadas de Arqueología de Patagonia, Neuquen-Buenos Aires, pp. 221–234.
Stern, C., 2000. Fuentes de los artefactos de obsidiana en los sitios arqueológicos de la cuevas de Pali Aike, Fell, y Cañadón La Leona, en Patagonia Austral. Anales del Instituto de la Patagonia, Serie Cs Hs 28, 251–263.
Stern, C., Franco, N., 2000. Obsidiana gris verdosa veteada de la cuenca superior del río santa cruz, extremo sur de patagonia. Anales Inst. Patagonia, Serie Cs Hs 28, 265–273.
Suárez Sainz, R., 2000. Paleoindian occupations in Uruguay. Current Research in the Pleistocene 17, 78–80.
Suárez Sainz, R., 2001. Paleoindian components of Northern Uruguay: new data for early human occupations of the Late Pleistocene and Early Holocene. In: CSFA(Ed.), Ancient evidences for Paleo South Americans: from where the South Winds Blow. Texas A-M University Press, Texas, in press.
Taddei, A., 1964. Un yacimiento precerámico en el Uruguay. Baessler-Archiv, Neue Folge, Vol. XII. Berlin, pp. 317–372.
Tankersley, K., 1991. A geoarchaeological investigation of distribution and exchange in the raw material economies of clovis groups in Eastern North America. In: Montet-White, A., Holen, S. (Eds.), Raw Material Economies among Prehistoric Hunter-Gatherers. Lawrence, Kansas, pp. 285–304.
Urien, C.M., Ottmann, F., 1971. Histoire du Rio de la Plata au Quaternaire. Quaternaria 14, 51–59.
Valverde, F., 2000.Variabilidad de recursos líticos en dos sitios paleoindios de las sierras de Tandilia oriental, Provincia de Buenos Aires. Paper Presented at the II Congreso de Arqueología de la Región Pampeana, Mar del Plata, p. 43.

PERGAMON

Quaternary International 109–110 (2003) 65–76

Archaeology of the Pleistocene–Holocene transition in Uruguay: an overview

Rafael Suárez[a,*], José M. López[b]

[a] Comisión Nacional de Arqueología, Misiones 1227, CP 11.000, Montevideo, Uruguay
[b] Facultad de Humanidades y Ciencias de la Educación, Magallanes 1577 Montevideo, Uruguay

Abstract

In Uruguay, evidence of early human occupation comes from different archaeological regions, including the Basin of Uruguay and Cuareim Rivers, Basin of Negro mid River, and the Atlantic littoral. This paper presents a synthesis and overview of the poorly known archaeology of the Pleistocene/Holocene transition of Uruguay, including archaeological, sedimentological and palaeontological information related to the early human occupation. In this region, the ancient human settlements occurred in various environmental settings including riverbanks, hilltops, and maritime landscapes. New Fell type or "*fishtail*" projectile points and preliminary results of the current research in Pay Paso locality are presented. Evidence from Pay Paso site 1 indicates that during Early Holocene, the shore of the Cuareim River was a paleosurface that was occupied by early human groups. A new and previously unpublished type of projectile point from early hunter-gatherers (ca. 9300–9100 yr BP) was recovered from excavation of Pay Paso site 1. Finally, some comments and observations about culture material and lithic technology for early people of Uruguay are explored.

1. Introduction

Research into human occupation for the Pleistocene–Holocene transition in several countries of South America has made remarkable progress during the last decade, concerning theoretical (e.g. Gnecco, 1990; Nami, 1998; Politis, 1999), technological (e.g. Nami, 1987; Flegenheimer and Zárate, 1989; Flegenheimer, 1991; Politis, 1991; Gnecco, 1994; Nami, 1997, 2000, 2001; Suárez, 2001a, c), and stratigraphical, faunistical, environmental and chronological aspects (e.g. Nami, 1987; Zárate and Flegenheimer, 1991; Miotti, 1995, 1996; Paunero, 1995–96; Politis et al., 1995; Dillehay, 1997; Flegenheimer and Zárate, 1997; Martinez, 1997; Mazzanti, 1997; Borrero et al., 1998; Borrero, 1999; García et al., 1999; Gnecco, 1999, 2000; Massone, 1999; Miotti and Salemme, 1999; Alberdi et al., 2001). In Uruguay (30–35°S to 58–54°W), research on early archaeological localities is in its initial stage. However, the expectations and potential to carry out research concerning different aspects of South American ancient settlers are important. There are interesting aspects to consider in the recording and archaeological context of the Pleistocene–Holocene transition in Uruguay, including sites radiocarbon dated with a chronological range between 11.2 and 8.6 kyr BP (Table 1)(MEC, 1989a; Hilbert, 1991; Suárez, 2000b). Dozens of Fell Cave type points have been recovered on the surface (also called "*fishtail projectile points*", *Fell's Cave Stemmed*), as well as fluted and unfluted bifacial preforms of projectile points (Suárez, 2000b).

During recent years, an increasing amount of new data concerning the archaeology of the Pleistocene/Holocene transition has been obtained from Uruguay, including sedimentological (Piñeiro et al., 1999), chronological, paleoenvironmental, and stratigraphical aspects (Suárez, 2000b). Quarries supplying raw material for the lithic technology of early hunter-gatherers were identified (Suárez, 1999). Research has also focused on knowledge and correlation of physical properties of several silicified sandstone and agates from quarries and archaeological lithic samples based on petrographic thin section analysis, coming from excavation contexts dated during the Pleistocene–Holocene transition. (Suárez and Piñeiro, 2001).

Current evidence about early human occupations suggests two Paleoindian periods for Uruguay, an early Paleoindian ca. 11,000–10,000 yr BP, and the late

*Corresponding author.
E-mail addresses: suarezra@hotmail.com (R. Suárez), peppino9@hotmail.com (J.M. López).

1040-6182/03/$ - see front matter
PII: S1040-6182(02)00203-3

Table 1
Early archaeological sites dated by ^{14}C in Uruguay (30–31°S to 57–58 W)

Site name	^{14}C date yr BP	Material dated/Method	Lab. number	Archaeological material	References
Y58	11,200±500	Charcoal standard	Gif 4412	1 core, bifacial flakes?	MEC, (1989a, p. 459)
K87	10,420±90	Charcoal standard	Kn 2531	Biface, grinding stone, flakes	Hilbert (1991, p. 15)
Pay Paso 1	9890±75	Charcoal standard	Rt 1445	Remains debitage, projectile point	Austral (1994, p. 365)
Pay Paso 1	9280±200	Charcoal standard	Uru 248	Projectile point, flakes, unifacial tools	Suárez (2000b)
Pay Paso 1	9120±40	Charcoal AMS	Beta 156973	Projectile point, flakes unifacial tools	Suárez (2000b)
Pay Paso 1	8570±150	Charcoal standard	Uru 246	Flakes, unifacial tools	Suárez (2000b)

Paleoindian ca. 9900–9100 yr BP (Suárez, 2001d, e). This paper aims to organize, present and discuss a series of data and new information about human presence in Uruguay during the Late Pleistocene and Early Holocene.

2. Early archaeological locations of Uruguay

The early archaeological sites known in Uruguay are all subaerial and are situated close to important streams (Negro, Uruguay, and Cuareim rivers) or their tributaries, such as Arroyo del Tigre (Suárez, 2001e). In the Atlantic littoral, early sites are located in a parabolic sand dune (López, 1995) and on hilltops, such as Cerro Los Burros see (Meneghin, 1977, 2000; Nami, 2001; Fig. 2).

2.1. Uruguay mid-river basin

The archaeological locality *Isla de Arriba*, situated by the Uruguay River (Fig. 3(1)), is a multicomponent site. Its rich geoarchaeological stratigraphy gave a hint of important aspects of prehistoric human occupation in the Uruguay River area. The IX excavation of site Y58, at the SW of the island, was done after lithic artifacts were recovered at 5.60 m depth during a survey. Two teams worked there during the "*Mision de Rescate Arqueológico de Salto Grande*" in 1976–78, the French group lead by N. Guidon and the North American group lead by W. Hurt. The stratigraphic sequence studied reached 6.60 m depth. The archaeological stratigraphy revealed four cultural levels (in this paper the oldest one is discussed), separated by dense sterile layers. A "series of inferior lithic level" was recovered at 5.37 m depth, formed by three assemblages of flaking remains. At 5.69 m depth, a radiocarbon date of 11,200±500 BP (Gif4412) was obtained. At 6.02 m below the oldest sample dated, a core of very silicified sandstone was recovered (MEC, 1989b, pp. 459–460). Recent lithic analysis carried out by Suárez on this assemblage (curated at the "*Museo Nacional de Antropología*") recovered in the first lithic level, has revealed some interesting data about technological aspects of these remains (at present, they are the earliest found in Uruguay). The pieces of this level form three assemblages ($n = 48$) chalcedony and jasper flaking remains (red, semi-translucent and coffee colour). It was possible to recognize that the bigger remains, some flakes 47 mm long, 23 mm wide, and 3–5 mm thick in the three assemblages, correspond to the final stages of bifacial reduction. Among the technological features, the flakes show lip platforms prepared with small retouches and abrasion. The flaking was obtained through direct percussion and pressure, in both cases with soft billet hammers.

At *Arroyo del Tigre* (Fig. 3(3)), there are several archaeological sites (k82, k86, K87, k10 and k103) along the left bank of Uruguay River, close to the mouth of Arroyo del Tigre (MEC, 1989a). Site K87 was researched by the German team of "*Misión de Rescate Arqueológico de Salto Grande*" (conducted by P. Hilbert), who excavated an area of 40 m^2 in the 1970s. It is a multicomponent site, and a carbon sample both stratigraphically and contextually directly related to remains of flaking, a biface fragment and a grinding stone (30 cm long, 21 cm wide and 3 cm thick) was dated at 10,420±90 (Kn 2531)(MEC, 1989b, p. 60; Hilbert, 1991, p. 15). The K87 site is strategically situated in what is at present an excellent fishing resort, and before construction of the Salto Grande dam was a natural crossing of the Uruguay River.

Los Pinos is a multicomponent open air site, situated on the left bank of the Uruguay River, in NW Uruguay (Fig. 3(5)), a few kilometers from the mouth of the Cuareim River. It is a stratified multicomponent site. The earliest cultural level is at 2.5 m depth in a brown clay layer. Above this unit, there is a volcanic ash, overlain by a black sediment showing a more recent mid-Holocene occupation. In this site, two samples of Fell Cave points (Figs. 4b and c and Figs. 6a and b) were recovered on the surface.

In a superficial site of the Uruguay River, close to the mouth of Arroyo Boicuá, a Fell projectile point was recorded (Cordero, 1960, p. 61; Fig. 4s). This site is located some 40 km north of Y58 site and 30 km south of K87 site (see Fig. 3).

2.2. Cuareim river basin: Pay Paso locality

Pay Paso site 1 was investigated by Antonio Austral (1980, 1994, 1995), and Suárez has recently restarted activities there. It is on the Uruguayan bank of the lower stream of Cuareim River, 15 km from Bella Unión town (Fig. 3(6)).

The archaeological research in Pay Paso (30°16′S–57°27′W) along the Cuareim River (Uruguay–Brazil–Argentine border; Fig. 3(6)) shows the potential for regional archaeological research to investigate the most recent Paleoindian occupations in the north of Uruguay at the beginning of the Holocene. The Pay Paso locality has seven sites with similar stratigraphical and sedimentological features, which result from complex geomorphological processes. The research in this archaeological area is in its initial phase, with 60 m^2 excavated at Pay Paso site 1. The lower archaeological level possesses vertical development between 7 and 18 cm and is at 5.70–5.90 m depth. In the lower archaeological level, charcoal samples were recently ^{14}C dated at 9280 $\pm$ 200 BP (Uru 248), 9120 $\pm$ 40 BP (Beta 156973), and 8570 $\pm$ 150 yr BP (Uru 246)(Suárez, 2000b). The greenish sedimentary matrix where the cultural remains are found was formed by fluvial (sand, slime, clay) and aeolian sedimentation (loess and volcanic ash). In this archaeological level, a red–orange longer combustion structure (basin-shaped hearth) was identified, containing fragments of charcoal as well as ash from combustion. This structure is 1.05 m $\times$ 0.60 m in area, and 0.30 m in depth. The sediment around this structure was strongly compacted. The archaeological level shows flaking remains ($n = 468$) of silicified sandstone, chalcedony and agate, 12 unifacial tools, and abundant charcoal. In addition, a bifacial projectile point of Pay Paso type (Fig. 4A) was recovered, manufactured in grey–greenish silicified sandstone. The archaeological context where this projectile point was recovered yielded two radiocarbon dates at 9280 $\pm$ 200 BP (Uru 248, conventional method) and 9120 $\pm$ 40 BP (Beta 156973, AMS). In Pay Paso sites 2 and 3, and other sites in the archaeological region of the Uruguay–Cuareim rivers, we recognized 9 points from private collections from surface contexts, with similar technomorphological features to the one recovered at Pay Paso 1 (Suárez, 2001d).

3. The Uruguayan Atlantic littoral

The Uruguayan Atlantic littoral has distinctive characteristics deriving from changes in the sea level during the Late Pleistocene–Early Holocene (Martin and Suguio, 1989; Martin et al., 1997). Also affecting the littoral were the River Plate estuary flowing into the Atlantic Ocean, the coastal lagoons, and the convergence of the Falkland and Brazilian marine currents in the area.

The Uruguayan coast constitutes a geological coastal plain, where several landscape elements such as coastal lagoons, lowlands, mid-plains, and the seashore itself, with rocky inlets and islands, can be recognized. Circa 17,000 yr BP, as indicated by landmarks between 50 and 30 m below sea level, an ancient delta-shaped drainage system was recognized, with the sea rising to minus 23 m around 11,000 BP (OEA, 1971; Ayup, 1991).

Subsequently, after a recessional phase around 6000 yr BP that left behind sand bars and the lagoon system, the sea rose to more than 5 m above its present day level, about 5500 yr BP (González, 1989). Finally, after a drastic recession that lowered sea level between 12 and 17 m below present day figures, the sea rose to a maximum of 2 m and then stabilized at its present position about 2500 yr BP (OEA, 1971; Ayup, 1991; Bracco, 1995).

It has been possible to find evidence supporting this model of environmental evolution in several archaeological sites. At *La Coronilla*, for instance, human occupation seems to be restricted to soil forming sand levels (Capdepont, 1999), and in *Cabo Polonio*, an important sand deposit corresponding to an arid phase covers an archaeological level (Iriarte, 1996). In the *La Esmeralda* site, some artificial shellfish gatherings seem to be associated with a regression in the sea level (Bracco et al., 1999). From an archaeological perspective, the existence of ancient drainage channels near the present day coastline, seem to suggest that some sites near the sea, such as *Cabo Polonio* and *Cerro Buena Vista*, could have had similar locations before 7000 yr BP.

In Cabo Polonio and Balizas/Buena Vista (Fig. 2(3c)), there are some Fell points recovered on the surface. On both sites there are also extensive surficial sites, palaeosoils and stratified deposits. Cabo Polonio is a stratified site with four eolian layers with different degrees of soil formation (I, II, III, IV) and with archaeological material. A mid-Holocene radiocarbon date of 4360 $\pm$ 170 BP (URU 005) was obtained for the contact between layers III and IV (López, 1994–95). The greatest hope for obtaining evidence of early occupation is focused on layer IV, which has been assigned a relative age of more than 4400 yr BP. The recovered material consists of sea mammal remains associated with milky quartz flakes.

Cerro Los Burros site is located in on a hilltop south of Las Animas Range (Fig. 2(3a)). Excavations by Meneghin (1977) produced two fragments of Fell points. No radiocarbon dating was possible. Recent re-analysis of the Meneghin collection suggests that Cerro Los Burros was visited by early human groups during the Pleistocene/Holocene transition (Nami, 2001).

In the Solís Grande riverbank (Fig. 2(3b)), an extraordinarily sized "*fishtail*" spear point was collected on the surface (Fig. 5). It shows a good spacing scar flake and some diagonal flaking. Made of blood reddish silicified limestone, it is 107.7 mm long, 48.4 mm wide, and 10 mm thick and weighs 51.8 g. It shows a dark patina all over its surface. The tip of the point is cracked, indicating that it originally was more than 110 mm long. The tip, the corner of the stem and the edges of the blade have been slightly damaged in modern times.

4. The Uruguayan central area

This region of rolling plains and ridges of hills is drained by rivers and springs with woodlands and extensive marshlands along the riverbanks. Large beaches and lagoons are found in the meanders of these rivers containing extensive surface archaeological sites (e.g. *Las Veras*, *Paso del Puerto* Fig. 2(2a, d)).

The basin of the Negro mid River has the greatest density in the country of Fell Cave type points (Bosh et al., 1974; Hilbert, 1991; Suárez, 2000a, b, 2001f). In this region appear some weapons practically identical in shape and size to others reported from Fell's Cave which is more than 2,500 km distant, at the southernmost point of the continent (see Fig. 1). In the basin of Negro

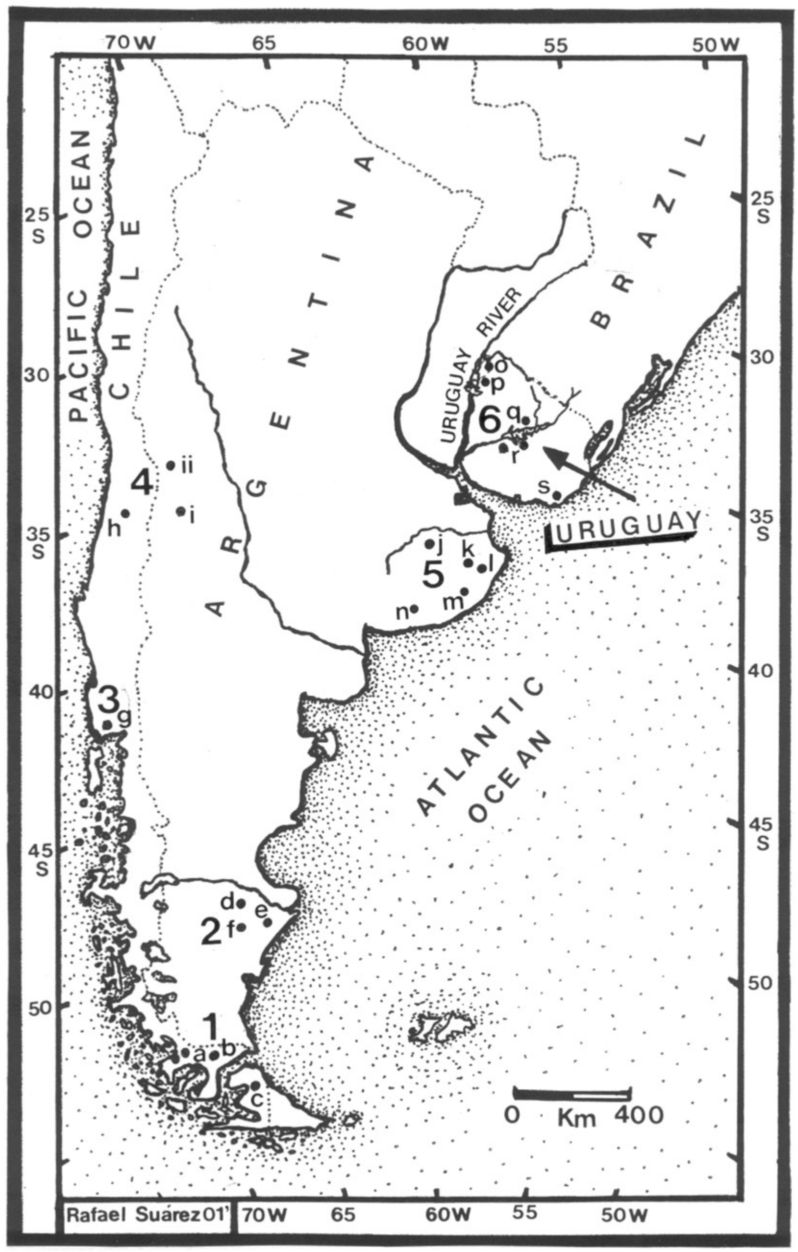


Fig. 1. Geographic locations of Pleistocene/Holocene transition archaeological regions in the South Cone context: 1. Southern Patagonia and Tierra del Fuego (Chile): (a) Cueva del Medio and Lago Sofia 1, (b) Fell and Palli Aike Caves, (c) Tres Arroyos 1 rockshelter; 2. Patagonia Central Plateau (Argentina): (d) Los Toldos Cave 3, (e) Piedra Museo, rockshelter AEP-1, (f) Cerro Tres Tetas; 3. (g) Monte Verde (Chile); 4. Central Chile and Central Andes of Argentina: (h) Tagua Tagua Basin (Chile), (i) Indio Cave, (ii) Aguada de la Cueva rockshelter; 5. Pampas (Argentina): (j) La Moderna, (k) Cerro El Sombrero and Cerro La China, (l) Tixi Cave, (m) Paso Otero 5, (n) Arroyo Seco; 6. Uruguayan archaeological regions: (p) Basin of Uruguay mid-River, (o) Basin of Cuareim River, (q–r) Basin of Negro mid-River, (s) Atlantic littoral.

mid-River, fluted Fell points have been recovered (Suárez, 2000a, p. 80; Fig. 1c). These points show a fluting technique very similar to other points recovered in extra-regional sites: in the Argentinian Pampa at the Cerro El Sombrero site (Flegenheimer and Zárate, 1989, p. 12; Fig. 1b), in the Central Patagonian Plateau at Piedra Museo AEP1 (Miotti, 1996, p. 36; Fig. 5A), and in Ecuador at the El Inga site (Bird, 1969, p. 67; Fig. 1d and h). Other "*fishtail*" points have undergone a long process of resharpening and are at the end of their useful lives (Suárez, 2000a, p. 80; Fig. 1b).

5. Weapons technology of early human groups, Pleistocene/Holocene transition in Uruguay

The abundance of "*fishtail*" projectile points in surface contexts in Uruguay have been noted by several authors (e.g. Cordero, 1960; Bird, 1969; Bosh et al., 1974; Meneghin, 1977, 2000; Politis, 1991; Suárez, 1999, 2000a, b, 2001c, d, f; Nami, 2001). In the centre, north, and south of the country, there is a great variety and abundance of lithic cryptocrystalline raw material, excellent for flaking. These archaeological regions show great concentrations of highly siliceous lithic resources, which can be obtained either by quarrying, primary outcrops or form secondary quarries (Suárez, 2000a). Northern Uruguay presents outcrops of geological formations among which the Arapey Formation (volcanic rocks) is significant. It supplied Paleoindian knappers with geodes of chalcedony and translucent agate. As well, vast shoals and clastic dams of silicified sandstone, jasper and opal were used to manufacture toolkits (Suárez, 1999).

The projectile point recovered from the low level of Pay Paso site 1 dated ca. 9300–9100 yr BP allows the identification of a new unusual and unpublished type of hunting weapon for Early Holocene in Uruguay, Pay Paso points (Fig. 4A). The Pay Paso points present some features which make them similar in some aspects of the flaking technique to the Fell points, for example, the base thinning in both faces of the stem by means of short finishing retouches (Suárez, 2001d).

In Uruguay the "*fishtail*" projectile points show designs which indicate the following considerations, especially regarding the shape of the stem and shoulders. These comments are based on observations of "*fishtail*" points ($n = 23$) from Northern and Central Uruguay, most of which were probably used for hunting (some show impact and fracture damages). These weapons can be fluted and unfluted on the base. They have complete bifacial thinning in some cases (Suárez, 2001c, e) and in others they are shaped starting from a flake. The final shaping (pressure flaking) can be marginal or laminar (Nami, 1997).

Two large groups can be distinguished: (a) in some cases "*fishtail*" points have very pronounced shoulders (angle of shoulder blade stem 90–110°, see Figs. 5 and 6a) with defined stem concave edges strongly expanded with concave base and abrasion on both edges of the stem or concave lowcut base; (b) another group of "fishtail" points show insinuated and rounded shoulders (angle of shoulder blade stem between 140° and 160°; Fig. 6b). The edges of the stem are concave with abrasion and the concave base is hinted or straight in some cases. Rather than stylistic differences, these morphological variations shown by the "*fishtail*" projectile points are probably due more to the long use and resharpening or rejuvenation process that these complex bifacial artifacts were submitted to (Suárez, 2001c, d; see discussion).

Another remarkable feature of the "*fishtail*" point groups of Uruguay, with shoulder angle between 90° and 110°, is that they are of large size (between 95 and 107.7 mm long and 30.5–51.8 g weight)(see Fig. 5). These "*fishtail*" points can be defined as spear points, were made starting from a large oval perform, and should have undergone initial, primary and secondary bifacial thinning (stages 1–4 sensu Callahan, 1979; Suárez, 2001a, c).

At an extra-regional scale in the Argentinean Patagonia as well as in the Pampas, both, fishtail points with very pronounced shoulders and large size have been recorded (see Flegenheimer and Zárate, 1989, p. 12; Fig. 1b; Miotti, 1996, p. 36, Fig. 5a), as well as examples with insinuated or rounded shoulders (see Bird, 1969, Fig. 2(2,3,4) and Fig. 5(d,i,j,m–p)). They are very similar in their technological and morphological aspects to those of Uruguay (see Bird, 1969, Fig. 4(m); Suárez, 2000a, Fig. 1a–c)(Figs. 3–6).

6. Paleoenvironment during Pleistocene and early Holocene in Uruguay

6.1. Sedimentary aspects

In the north of Uruguay, in the departments of Artigas, Salto and Tacuarembó, the Sopas Formation crops out (Antón, 1975). This silty clay is stratigraphically situated in the subsoil of basaltic alluvial plains. It is pale brown, and in its upper part, concentrations of $CaCO_3$ (Antón, 1975, p. 9) can be recognized. Between Sopas Fm and the recent alluvial formations, volcanic ash horizons frequently crop out as a white or light grey silty sediment 0.30 m thick.

Antón (1975, p. 10) and Bombin (1976, p. 60) correlate the Sopas Fm with the Touro Paso Formation of southern Brazil. The base of the Touro Paso Fm is between 15 and 14 ky BP (Antón, 1975, p. 10). ^{14}C dating carried out on burned wood from the Touro Paso

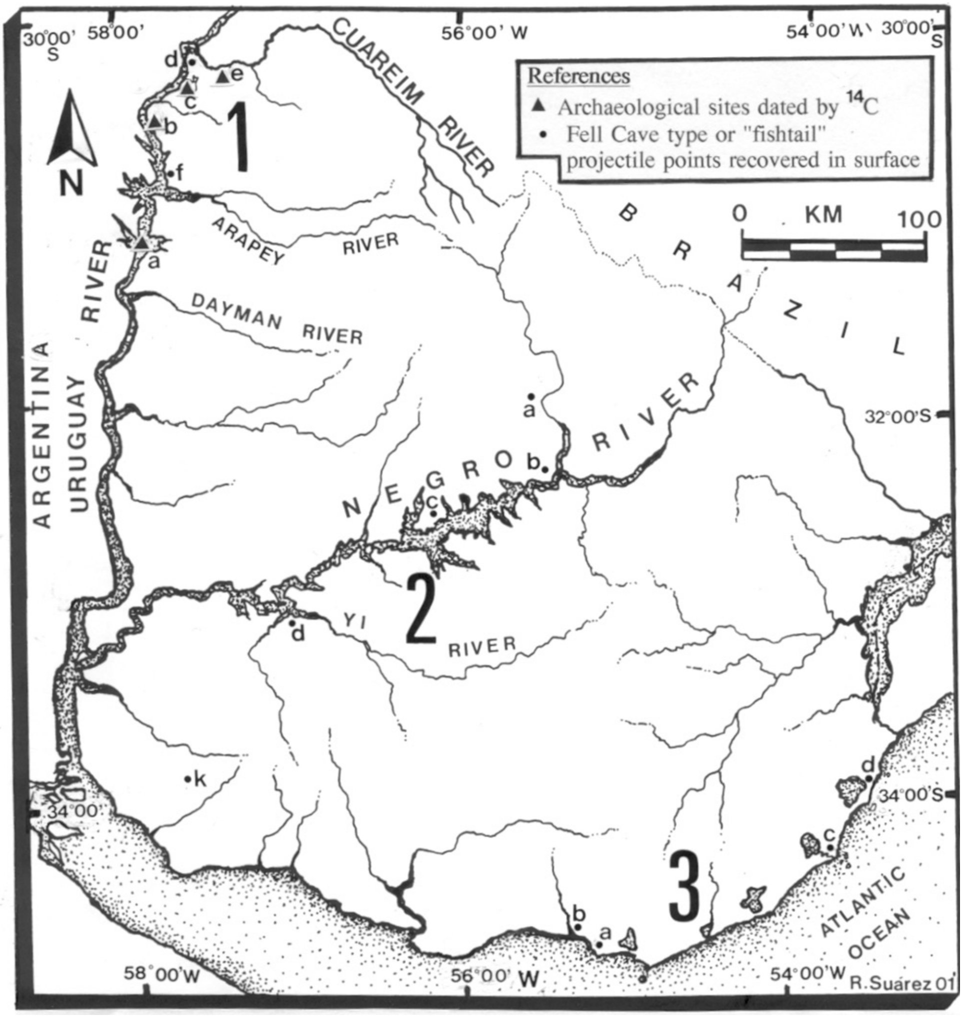


Fig. 2. Main early archaeological localities of Uruguay: 1. Northern, Uruguay–Cuareim Rivers, (a) Isla de Arriba Y58 site, (b) Arroyo del Tigre K87 site, (c) Calpica D03 site, (d) Los Pinos site, (e) Pay Paso locality sites 1–4, (f) Arroyo Boicuá; 2. Río Negro mid-Basin, (a) Las Veras lagoon, (b, c) sites on the Negro River shore, (d) Paso del Puerto site; 3. Atlantic littoral, (a) Cerro Los Burros, (b) Solís Grande River, (c) Cabo Polonio/Balizas/Buena Vista, (d) Santa Teresa, Southwest, (k) Paso Sena locality.

Fm. provided a date of 11,040 $\pm$ 190 BP (I 9628)(Bombin, 1976, p. 81).

Recent ^{14}C dates carried out on wood and mollusc shells from the Sopas Fm have questioned the assumed relationship between the formations. A set of six dates from Sopas Fm place it in a temporal rank between 43 and 45 ky BP, placing this formation in a geological time prior to that previously thought (Ubilla and Perea, 1999, p. 84).

The Dolores Fm is formed by clay-silt sediments with varied content of sand and gravel (Goso, 1972; Antón and Goso, 1974; Preciozzi et al., 1985). The Dolores Fm has a continental origin, and the depositional environment of this unit indicates that sediments occurred in a continental area with semiarid climate interspersed with more humid periods (Preciozzi et al., 1985). Due to a series of fauna associations and an apparent chronological similarity, the ''*Miembro Guerrero*'' of the Lujan Fm (Pampa Argentina) is correlated with the Dolores Fm of Uruguay (Ubilla and Perea, 1999, p. 84).

A sedimentary sequence at the Pleistocene/Holocene boundary, in the archaeological region of the Uruguay–Cuareim Rivers, has recently been described (Piñeiro et al., 1999, pp. 19–20). The base of the sequence is marked by coarse alluvium. Its lower limit is an erosional unconformity with the Cretaceous rocks of Arapey Fm, frequently exhibiting basalt with silicified sandstone. Its geometry is tabular with a horizontal upper contact, with large concentrations filled (in some cases) with calcium carbonate. The texture is sand-clay, with slight variations associated with occasional cut-and-fill structures and low angle cross stratification. A layer of volcanic ash slightly more than 1 m below the upper contact is dated at ca. 9000 BP (MEC 1989b). A horizon of $CaCO_3$ is developed between the ash and upper contact (Piñeiro et al., 1999, p. 19).

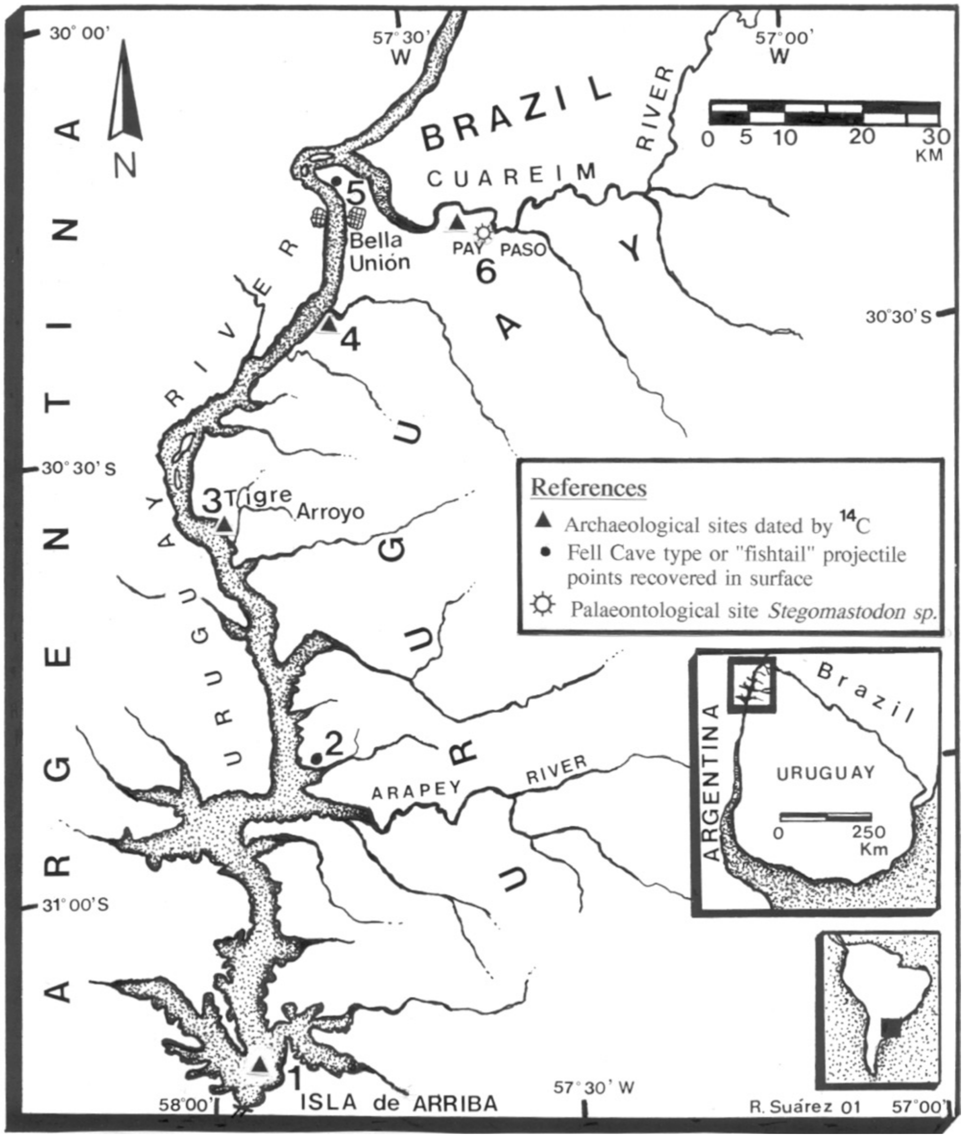


Fig. 3. Detail and location of the Uruguay–Cuareim Rivers archaeological region: 1—Isla de Arriba, Y58 site (dated 11,200 ± 500 BP); 2—Arroyo Boicuá; 3—Arroyo del Tigre, K87 site (dated 10,420 ± 90 BP); 4—Calpica, D03 site (dated 9320 ± 150 BP); 5—Los Pinos site; 6—Pay Paso locality (sites 1–4)(site 1 dated: 9890 ± 75 BP, 9280 ± 200 BP, 9120 ± 40 BP, 8570 ± 150 BP).

Excavation 1 at Pay Paso site 1, at the same level as the archaeological material shows strong (white) precipitations of calcium carbonate reflecting post-depositional processes. These carbonates form subhorizontal veins, both simple and branched, from 2.5 to 20 mm. In other cases, carbonate refills small vertical cracks resulting from contractions of clay. Concretional structures (rhizoconcretions) with circular cross-sections corresponding to radicule ducts (carbonated roots), as seen in the intersection of the threads, are also present. The carbonate veins adhere to the lithic material in some cases. This site has an important study potential, as it is possible to investigate mechanisms of formation and evolution of the landscape, and the paleoenvironmental and cultural aspects of human occupation during the transition. The carbonate structures, as well the presence of rhizoconcretions and carbonated threads at the same level than the archaeological material, and fire hearths identified in the lower level of the site (dated between 9300 and 8600 yr BP), indicated that during the Early Holocene there was a Paleosurface on the banks of the Cuareim River which was occupied by early hunter-gatherers (Suárez, 2001d).

6.2. Megafauna record of Uruguay

A noticeable feature of the Sopas Fm is the presence of abundant remains of vertebrates (megafauna)

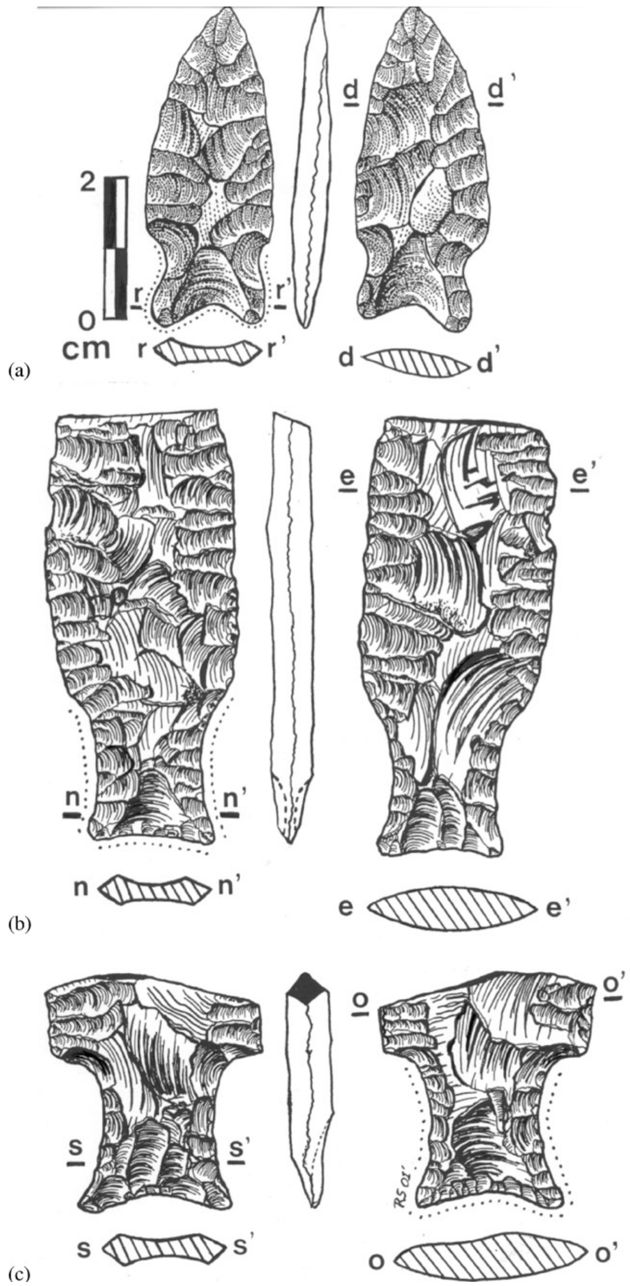


Fig. 4. Projectile points of early hunter-gatherers late Pleistocene and early Holocene of Uruguay: (A) Pay Paso type, found in the lower archaeological level of Pay Paso site 1, dated ca. 9300–9100 yr BP (grey–greenish very silicified sandstone); (B) Classic Fell Cave type or "fishtail" point, from Los Pinos site—Uruguay middle River, yellowish jasper; (C) Variant of Fell Cave type or "fishtail" point from Los Pinos site—Uruguay middle River, reddish blood chalcedony. The dotted line represents abrasion in the edges of the stem.

and organic remains, which include the following taxa: Dasypodidae, Glyptodontidae, Megatheriidae, Mylodontidae, Felidae, Macraucheniidae, Toxodontidae, Equidae, Camelidae and Cervidae (Ubilla, 1996; Ubilla and Perea, 1999, p. 78). In the area of *Pay Paso site* 4, about 7 km east of site 1 (Fig. 3(6)), bones of a *Stegomastodon* sp. (Personal communication, Tonni) a young nursing animal, were recovered in situ at the bottom of a ravine at an approximate depth of 6.70 m. The recovered bones are a molar tooth, a vertebra, fragments of a rib and a complete tibia.

Other species of megamammals identified in Uruguay (Sopas and Dolores Formations) and southern Brazil (Touro Paso Formation) include: *Hemiauchenia paradoxa*, *Scelidotherium leptocephalum*, *Glossotherium robustum*, *Pampatherium humboldti*, *Toxodon platensis*, *Glyptodon clavipes*, *Hippidion principale*, *Equus* (*Amerhippus*) *neogeus*, *Megatherium americanum*, *Smilodon populator*, *Macrauchenia patachonica*, *Morenelaphus brachyceros*, *Morenelaphus lujanensis*, *Paraceros fragilis*, and *Antifer ultra* (Bombin, 1976, pp. 48–51; Ubilla and Perea, 1999, p. 78). Although they are not associated with cultural remains, these finds imply that remains of extinct fauna have been preserved in the area and potentially could be found at archaeological sites.

7. Discussion and conclusion

The design of projectile points of the early hunter-gatherers for the Late Pleistocene and Early Holocene in Uruguay shows variability in stylistic aspects between the Fell and Pay Paso types. Recent technological observations made on some lithic assemblage recorded in early archaeological sites in Northern Uruguay (Suárez, 2000b, 2001a, b, c), suggest that early inhabitants possessed in their material culture large fluted and unfluted bifaces; preforms of Fell points between 78 and 130.1 mm made of chalcedony, agate, jasper, silicified limestone and sandstone (Suárez, 2001b, c, d); bifacial knives of Arapey translucent agate, longer than 110 mm and showing extraordinary flaking technique, excellent flake spacing and overshot flaking (outre passé)(Suárez, 2001d); and large "*fishtail*" spear points between 95 and 107.7 mm made using blood reddish chalcedony, jasper and silicified limestone (Suárez, 2000b, 2001a, b). In Uruguay there are four of these "*fishtail*" spear points with sizes between 95 and 107.7 mm. These large "*fishtail*" Paleoindian hunters' weapons were used as spear points. When fractured and damaged in hunting activities, they probably could have been recycled to be used in another techno-functional hunting complex. Perhaps some "*fishtail*" points originally designed by Paleoindian knappers to be used as spear points that were damaged or fractured during hunting activities could have been used later as dart points of atlatl.

With reference to paleoenviromental aspects which occurred during Late Pleistocene when Uruguayan colonization occurred, the climatic conditions were more arid and cooler than present conditions. Human exploration and colonization of Uruguay was made in

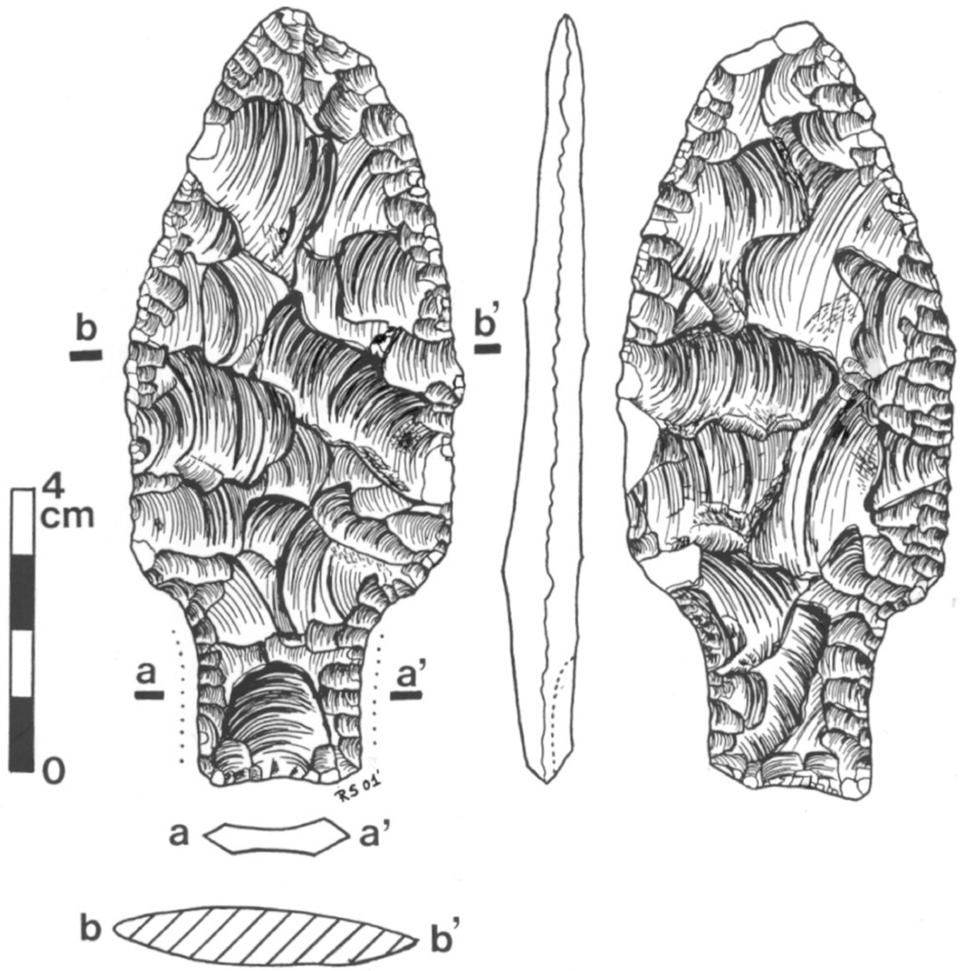


Fig. 5. "*Fishtail*" spear point from South of Uruguay, collected on the surface (Solis Grande River). Exhibits good flake scar spacing and some diagonal flaking, manufactured on reddish blood silicified limestone. Note the basal thinning in one face and lateral thinning on reverse face of the stem. This spear was finished starting of a large biface. The break at the tip, slightly damaged on the stem corner and edges of the blade are modern. The dotted line represents abrasion in the edges of the stem.

different environments, including the Basin of Uruguay and Negro Rivers, and the hilltops and littoral dunes of the Atlantic Region. Fell points were recorded in all these regions.

The known data for Uruguay, though fragmentary, situate the first evidence of human exploration and colonization at the end of last glacial period. This evidence is coherent with extra-regional data recovered in detail from various archaeological sites (Nami, 1987; Flegenheimer, 1991; Nuñez et al., 1994; Miotti, 1996; Dillehay, 1997). Only two Late Pleistocene sites in Uruguay have been investigated: site Y58 at Isla de Arriba and site K87 at Arroyo del Tigre, both located on the Uruguay mid-River. Although the chronological data are not abundant, both sites can be dated between 11,200 and 10,500 yr BP. Recent lithic analysis of the lowest stratigraphic level of Y58 site indicate that this material corresponds either to the final stages of bifacial reduction (stage 4) and/or resharpening of projectile points, that occurred during an ephemeral occupation (Suárez, 2000b, 2001b).

Current research (Northern Uruguay) determined the presence of six unpublished Fell projectile points (Suárez, 1999, 2000b, 2001c, e) found at different archaeological locations situated between 30 and 40 km from the Y58 and K87 sites. These new data complete and strengthen the chronological and stratigraphical evidence previously known which indicated human presence along the Uruguay River towards the Latest Pleistocene. The Early Paleoindian (exploration period, sensu Borrero, 1999; Miotti and Salemme, 1999) thus appears in this region as one of the characteristics of early human occupations in Uruguay (ca. 11,200–10,500 BP). As well, the present studies in Pay Paso site 1 (Cuareim river) enable to suggest a new component for Uruguay in late Paleoindian times (ca. 9900–9100 BP)(colonization period, sensu; Borrero, 1999; Miotti and Salemme, 1999)(Suárez, 2001d).

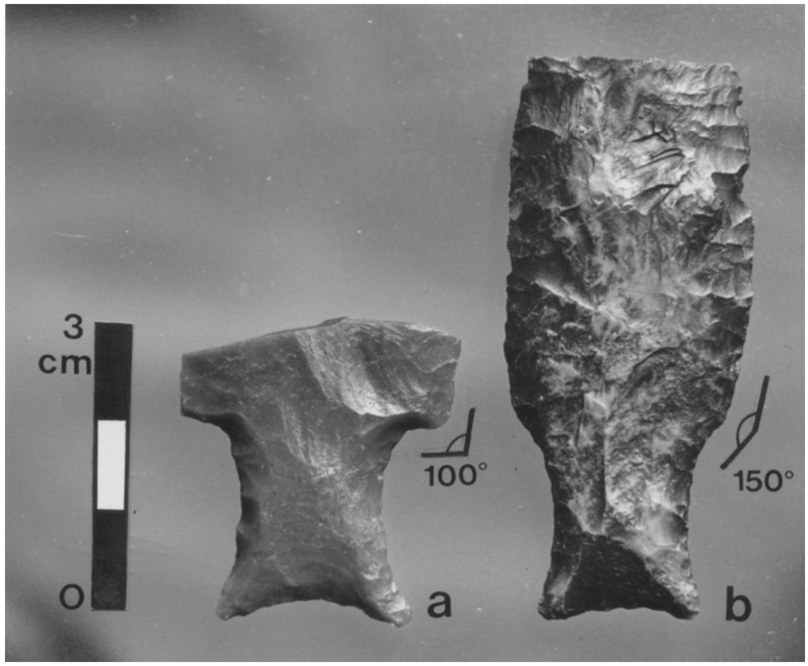


Fig. 6. Two variants of Fell Cave type or "*fishtail*" projectile points from Uruguay middle River, Los Pinos site: (a) note the very pronounced angle shoulder blade stem of 100°, manufactured on reddish chalcedony; (b) note the insinuated angle shoulder blade stem of 150°, manufactured on yellowish jasper. Both the projectile points show impact and fracture damages probably broken during hunting activities.

Acknowledgements

The research in the North of Uruguay (Uruguay and Cuareim rivers) is financed by CONICYT, Fondo Clemente Estable project No. 5093; Comisión Nacional de Arqueología (M.E.C.). The authors express their thanks to the reviewers Mauricio Massone and Cecilia B. Perez Micou for their constructive comments and suggestions. Finally, the authors want to thank Laura Miotti and Mónica Salemme for the invitation to include this paper in the present volume.

References

Alberdi, M., Miotti, L., Prado, J., 2001. *Hippidion saldiasi* Roth, 1899 (Equidae, Perissodactyla) at the Piedra Museo Site (Santa Cruz, Argentina): its implication for the regional economy and environmental reconstruction. Journal of Archaelogical Science 28, 411–419.

Antón, D., 1975. Evolución Geomorfólogica del Norte del Uruguay. Ministerio de Agriculutra y Pesa, Montevideo, pp. 1–22.

Antón, D., Goso, H., 1974. Estado actual de los conocimientos sobre el Cuaternario en el Uruguay. XXVII Congreso Brasiliero de Geología 3, 151–157.

Austral, A. (1980). Informe sobre la II Campaña Arqueológica al Río Cuareim. Paypaso 1980. VIII Congreso Nacional de Arqueología uruguaya:3–7 AVA. Colonia del Sacramento.

Austral, A. (1994). La camapaña de 1989 en el sitio Pay Paso, Río Quarai, Dpto. Artigas, Rep. Oriental del Uruguay. Revista del Museo de Historia Natural de San Rafael (Actas y Memorias del Congreso Nacional de Arqueología Argentina) XIV (1/4), 365.

Austral, A. (1995). Los cazadores del sitio estratificado Pay Paso hace 10,000 años. In: Consens, M., López, J.M., Curbelo, C. (Eds.), *Arqueología en el Uruguay*. Montevideo, pp. 212–218.

Ayup, R. (1991). Avaliacao das mudancas do nivel do mar durante Holoceno na Plataforma continental adjacente ao Río de la Plata. Ph.D. Dissertation. Universidade Federal do Río Grande do Sul.

Bird, J., 1969. A comparison of south Chilean and Ecuatorial "fishtail" projectile points. The Kroeber Anthropological Society Papers, California 40, 52–71.

Bombin, M., 1976. Modelo Paleoecológico Evolutivo para o Neoquaternario da Regiao da Campaha oeste do Río Grande do Sul (Brasil) A formacao Touro Passo, seu conteudo fossilifero e a Pedogenese Pos- deposicional. Cominicacoes do Museo de Ciencias da PUCRGS Porto Alegre 15, 1–90.

Borrero, L.A., 1999. The prehistoric exploration and colonization of Fuego-Patagonia. Journal of World Prehistory 13 (3), 321–355.

Borrero, L., Zárate, M., Miotti, L., Massone, M., 1998. The Pleistocene–Holocene transition and human occupation in the southern cone. Quaternary International 48, 191–199.

Bosh, A., Femenías, J., Olivera, A., 1974. Dispersión de las puntas de proyectil líticas pisciformes en el Uruguay. III Congreso Nacional de Arqueología C.E.A.

Bracco, R., 1995. Cronología de la Laguna de Castillos. Causas geológicas del paisaje rochense. Probides, Rocha Uruguay, pp. 14–17.

Bracco, R., Panario, D., Ures, C., 1999. Dataciones 14C y efecto reservorio para el litoral del Uruguay. I Jornadas del Cenozoico en Uruguay. Facultad de Ciencias. Montevideo.

Callahan, E., 1979. The basics of biface knapping in the eastern fluted point tradition: a manual for flintknappers and lithic analysis. Archaeology of Eastern North America 7 (1), 1–180.

Capdepont, I., 1999. Contexto geomorfológico de Punta La Coronilla. Unpublished. FC. Montevideo.

Cordero, S., 1960. Los Charuás. Mentor, Montevideo.

Dillehay, T., 1997. Monte Verde. A Late Pleistocene Settlement in Chile, Vol. 2. Smithsonian Institution Press, Washington, DC.

Flegenheimer, N., 1991. Bifacialidad y piedra pulida en los sitios pampeanos tempranos. X Congreso Nacional de Arqueología Argentina. Catamarca, pp. 64–78.

Flegenheimer, N., Zárate, M., 1989. Paleoindian occupations at Cerro El Sombrero locality, Buenos Aires province, Argentina. Current Research in the Pleistocene 6, 12–13.

Flegenheimer, N., Zárate, M., 1997. Consideration on radiocarbon and calibrated dates from Cerro la China and Cerro el Sombrero, Argentina. Current Research in the Pleistocene 14, 27–28.

García, A., Zárate, M., Paez, M., 1999. The Pleistocene/Holocene transition and human occupation in the Central Andes of Argentina: Aguada de la Cueva locality. Quaternary International 53/54, 43–52.

González, M., 1989. Informe geomorfológico del sitio arqueológico CH2DO1, San Miguel. CRALM, Ministerio de Educación y Cultura, Montevideo.

Goso, H., 1972. Cuaternario Uruguayo. P.E.L.S. Montevideo.

Gnecco, C., 1990. El Paradigma Paleoindio en Suramerica. Revista de Antropología y Arqueología VI (1), 37–77.

Gnecco, C., 1994. Fluting technology in South America. Lithic Technology, Tulsa 19 (1), 32–45.

Gnecco, C., 1999. An archaeological perspective of the Pleistocene/Holocene boundary in northern South America. Quaternary International (53/54), 3–9.

Gnecco, C., 2000. Ocupación Temprana de Bosques Tropicales de Montaña. Universidad del Cauca, Colombia.

Hilbert, K., 1991. Aspectos de la Arqueología en el Uruguay. Verlang Philipp Von Zabern. Mainz Am Rhein.

Iriarte, J., 1996. Análisis sedimentario de los depósitos del sitio arqueológico de Cabo Polonio. FC, Montevideo, unpublished.

López, J.M., 1994–95. Cabo polonio, sitio arqueológico del litoral Atlántico uruguayo. Revista de Arqueología Sao Paulo 8 (2), 239–267.

López, J.M., 1995. In: Consens, M., López, J., Curbelo, C. (Eds.), El fosil que no guía y la formación de los sitios costeros. Arqueología en Uruguay, Montevideo, pp. 92–105.

Martin, P., Suguio, K., 1989. International Symposium on Global Change in South America. Special Publication (2), Sao Paulo, pp. 8–12.

Martin, P., Suguio, K., Dominguez, J., Flexor, J., 1997. Geología do Quaternario Costeriro de litoral Norte de Rio de Janiero e do Spiritu Santo. CPRM/FAPEST, Sao Paulo.

Martinez, G., 1997. A preliminar report on Paso Otero 5, a late Pleistocene site in the Pampean Region of Argentina. Current Research in the Pleistocene 14, 53–55.

Massone, M., 1999. Aproximación metodológica al estudio de las ocupaciones tempranas de cazadores recolectores en la región de Magallanes. III Jornadas de Arqueología de la Patagonia, Soplando en el viento, pp. 99–112.

Mazzanti, D., 1997. Excavaciones arqueologicas en el sitio Cueva Tixi, Buenos Aires, Argentina. Latin American Antiquity 8 (1), 55–62.

MEC (Ministerio de Educación y Cultura), 1989a. Misión de Rescate Arqueológico de Salto Grande, Montevideo 2, 609.

MEC (Ministerio de Educación y Cultura), 1989b. Misión de Rescate Arqueológico de Salto Grande, Montevideo, 3.

Meneghin, U. (Ed.), 1977. Nuevas investigaciones en los yacimientos del "Cerro de los Burros". Montevideo.

Meneghin, U., 2000. Artefactos líticos elaborados por picado y abrasión del Cerro de los Burros (Yacimiento II), Uruguay. Comunicaciones Antropologicas del Museo de História Natural de Montevideo 20, 1–24.

Miotti, L., 1995. Piedra Museo Locality: an special place in the new world. Current Research in the Pleistocene 12, 34–40.

Miotti, L., 1996. Piedra Mueso (Santa Cruz), Nuevos datos para la ocupación Pleistocénica en Patagonia. II Jornadas de Arqueología de la Patagonia, Centro Nacional Patagónico, pp. 27–38.

Miotti, L., Salemme, M., 1999. Biodiversity, taxonomic richness and specialists-generalists during late Pleistocene/early Holocene times in Pampa and Patagonia (Argentina, Sothern South America). Quaternary International 53/54, 53–68.

Nami, H., 1987. Cueva del Medio: Perspectivas Arqueológicas para la Patagonia Austral. Anales del Instituto de la Patagonia, Serie Cs.Sc. 17, 73–106.

Nami, H., 1997. Investigaciones actualísticas para discutir aspectos técnicos de los cazadores-recolectores del Tardiglacial: El problema Clovis-Cueva Fell. Anales Instituto Patagonia. Ser. Cs.Hs., Punta Arenas Chile 25, 151–185.

Nami, H., 1998. Cazadores-recolectores del Pleistoceno Final: Algunas reflexiones y comentarios teóricos. II Congreso Argentino de Americanistas II, 493–516.

Nami, H., 2000. Technological comments on some Paleoindian lithic artifacts from Ilaló, Ecuador. Current Research in the Pleistocene 17, 104–107.

Nami, H., 2001. Consideraciones tecnológicas preliminares sobre artefactos líticos de Cerro de los Burros (Maldonado, Uruguay). Comunicaciones Antropologicas, Montevideo III (21), 1–23.

Nuñez, L., Varela, J., Casamiquela, R., Schippacasse, V., Niemeyer, H., Villagran, C., 1994. Cuenca de Taguatagua en Chile: el ambiente del Pleistoceno superior y ocupaciones humanas. Revista Chilena de Historia Natural 64 (4), 503–519.

OEA, 1971. Informe sobre el estado de las playas. Montevideo.

Paunero, R., 1995–96. Noticia sobre nuevas fechas radiocarbonicas del sitio Cueva 1, C3 T. Santa Cruz, Argentina. Anales de Arqueología y Etnología, Universidad Nacional de Cuyo 50–51, 189–199.

Piñeiro, G., Suárez, R., Gascue, R., 1999. Transición Pleistoceno–Holoceno en los sitios arqueológicos del río Uruguay Medio: Sedimentos asociados. I Jornadas del Cenozoico en Uruguay. Facultad de Ciencias, pp. 19–20.

Politis, G., 1991. Fishtail projectile points in the southern cone of South America: an overview. In: Bonnichsen, R., Turnmire, K. (Eds.), Clovis: Origins and Adaptations, pp. 287–301.

Politis, G., 1999. La estructura sobre el debate del Poblamiento de América. Boletin de Arqueología Santa Fe de Bogotá Colombibia II, 25–51. Center for the study of first Americans (Oregon State University Press).

Politis, G., Prado, J., Beukens, R., 1995. The human impact in Pleistocene–Holocene extinctions in South America: the Pampean case. In: Johnson, E. (Ed.), Ancient Peoples and Landscapes. Museum of Texas Tech University, Lubbock-Texas.

Preciozzi, F., Spoturno, J., Marizotto, W., Rossi, P., 1985. Carta geológica del Uruguay a escala 1:500.000. Editor DI.NA.MI.GE.

Suárez, R., 1999. Cazadores recolectores en la transición Pleistoceno–Holoceno del norte uruguayo: Fuentes de abastecimiento de materias primas y tecnología lítica. I Jornadas del Cenozoico en Uruguay: 27–28. Facultad de Ciencias.

Suárez, R., 2000a. Paleoindian occupations in Uruguay. Current Research in the Pleistocene 17, 79–81.

Suárez, R., 2000b. Evidence of human occupation during the transition Pleistocene–Holocene in the north of Uruguay: Paleoindian sites, "fishtail" projectile points and new radiocarbon dates for the archaeological region of Uruguay–Cuareim rivers. Abstracts: 35, International Workshop of INQUA, The colonization of South America during the Pleistocene/Holocene transition. La Plata 4–9 December, Argentina.

Suárez, R., 2001a. Manufactura y replicas de puntas de proyectil Fell I de Uruguay: Primeros datos desde la arqueología experimental. Abstracts: 55, X Congreso Nacional de Arqueología Uruguaya. Montevideo.

Suárez, R., 2001b. Arqueología de los primeros americanos en Uruguay: Componentes Paleoindios del río Uruguay-Cuareim. Abstract: 57–58, X Congreso Nacional de Arqueología Uruguaya. Montevideo.

Suárez, R., 2001c. Technomorphological observations on fishtail projectile points and bifacial artifacts from Northern Uruguay. Current Research in the Pleistocene,Vol. 18, 56–58.

Suárez, R., 2001d. Paleoindian components of Northern Uruguay. New data for early human occupations of the Late Pleistocene and Early Holocene. Voices of South America. Special edition Current Research in the Pleistocene, Vol. 18, 56–58.

Suárez, R., 2001e. Investigaciones Paleoindias en Uruguay: Estado actual del conocimiento y recientes investigaciones en la localidad arqueológica Pay Paso (río Cuareim, dpto. Artigas). Del Mar a los Salitrales. Diez mil años de Historia Indígena en el Umbral del Tercer Milenio Mar del Plata, Argentina, 311–326.

Suárez, R., 2001f. De los constructores de Cerritos al Paleoindio: Tecnología lítica en la región del a° Yaguarí 12.000 años de ocupación. Arqueología uruguaya hacia fin del milenio Tomo I, 255–270.

Suárez, R., Piñeiro, G., 2001. La cantera taller del Arroyo Catalán Chico: nuevos aportes a un viejo problema de la arqueología Uruguaya. Del Mar a los Salitrales. Diez mil años de Historia Indígena en el Umbral del Tercer Milenio Mar del Plata, Argentina, 263–278.

Ubilla, M., 1996. Paleozoología del Cuaternario continental de la cuenca Norte del Uruguay: Biogeografía, Cronología y aspectos climáticos-ambientales. Ph.D. Dissertation PEDECIBA UdelaR. Montevideo.

Ubilla, M., Perea, D., 1999. In: Rabassa, J., Salemme, M. (Eds.), Quaternary Vertebrates of Uruguay: A Biostratigraphic, Biogeographic and Climatic Overview. Balkema, Rotterdam. Quaternary of South America and Antarctic Peninsula 12, 75–90.

Zárate, M., Flegenheimer, 1991. Geoarchaeology of the Cerro La China Locality (Buenos Aires, Argentina): Site 2 and 3. Geoarchaeology 3 (6), 273–294.

PERGAMON

Quaternary International 109–110 (2003) 77–86

Early human occupations in Western Santa Cruz Province, Southernmost South America

Maria Teresa Civalero[a,*], Nora Viviana Franco[b]

[a] CONICET—INAPL. 3 de Febrero 1378, Buenos Aires 1426, Argentina
[b] Departamento de Investigaciones Prehistóricas y Arqueológicas (IMHICIHU, CONICET), Universidad de Buenos Aires. Saavedra 15, 5to. Piso, Buenos Aires 1083, Argentina

Abstract

This paper discusses basic tendencies in the characteristics of the early archaeological record corresponding to human occupation near the eastern flank of the Andean range, at the southern end of South America. Lithic artifacts are analyzed within an organization of technology perspective and are discussed according to Borrero's ecological model of the peopling of Patagonia. The characteristics of the lithic artifacts along with raw material provenience at the oldest levels at sites Cerro Casa de Piedra 7 and Chorrillo Malo 2, match our expectations for an exploration or early colonization phase in the peopling of the space. In addition, the range of variation of tools is similar to that present at early sites located to the east of the area. Some differences at these sites are already evident. Among these are the higher tool deposition rates at sites located close to Pampa del Asador, a known source of black obsidian that was used by early inhabitants of Patagonia. This poses some new questions that should be addressed regionally, taking into account the regional availability of lithic resources.

1. Introduction

This paper discusses the characteristics of the early lithic archaeological record corresponding to human occupation near the eastern flank of the Andean range, southern end of South America. Lithic artifacts are analyzed within an organization of technology theoretical framework (Nelson, 1991), and are discussed according to Borrero's ecological model of the peopling of Patagonia. This model considers phases of exploration, colonization and effective occupation of the space (Borrero, 1989–1990, 1994–1995).

The analysis is preliminary and looks for basic tendencies. It uses the available evidence from two sites: Cerro Casa de Piedra 7, at ca. 47°S, and Chorrillo Malo 2, at ca. 50°S. Both sites are located less than 25 km east of the Andean range (see Fig. 1), and have sequences with initial dates of occupation ca. 9700 ^{14}C yr BP. These are the earliest dates attesting at the areas analyzed. The main food resource recovered at both sites is guanaco (*Lama guanicoe*).

The principal difference in location between these two sites is their altitude above sea level, being 900 m a.s.l. for Cerro Casa de Piedra 7, and ca. 200 m a.s.l. for Chorrillo Malo 2. Both sites are located in modern ecotonal environments. At Cerro Casa de Piedra precipitation ranges between 200 and 400 mm per year (Mancini et al., in press), while at Chorrillo Malo 2 it is around 250 mm per year (Furque, 1973).

2. Theoretical framework

The initial peopling and occupation of Patagonia took place in an environment of climatic instability. Changes of temperature and precipitation were important during the Pleistocene/Holocene transition and the Holocene, including cold pulses between 14,000 and 10,000 yr BP (Markgraf, 1991; Clapperton, 1993; Heusser, 1993), 5000 and 4000 yr BP (Clapperton, 1993), and between the 12th and 19th centuries (Villalba, 1993, 1994), in correlation with the "Little Ice Age" (Mercer, 1968, 1970).

Comparing pollen samples to modern analogs, Mancini (1998) suggests that before 11,000 yr BP a steppe dominated by *Ephedra* indicates extreme arid

*Corresponding author.
E-mail addresses: mtcivalero@fibertel.com.ar (M.T. Civalero), nvfranco@escape.com.ar (N.V. Franco).

1040-6182/02/$ - see front matter © 2002 Elsevier Ltd and INQUA. All rights reserved.
PII: S1040-6182(02)00204-5

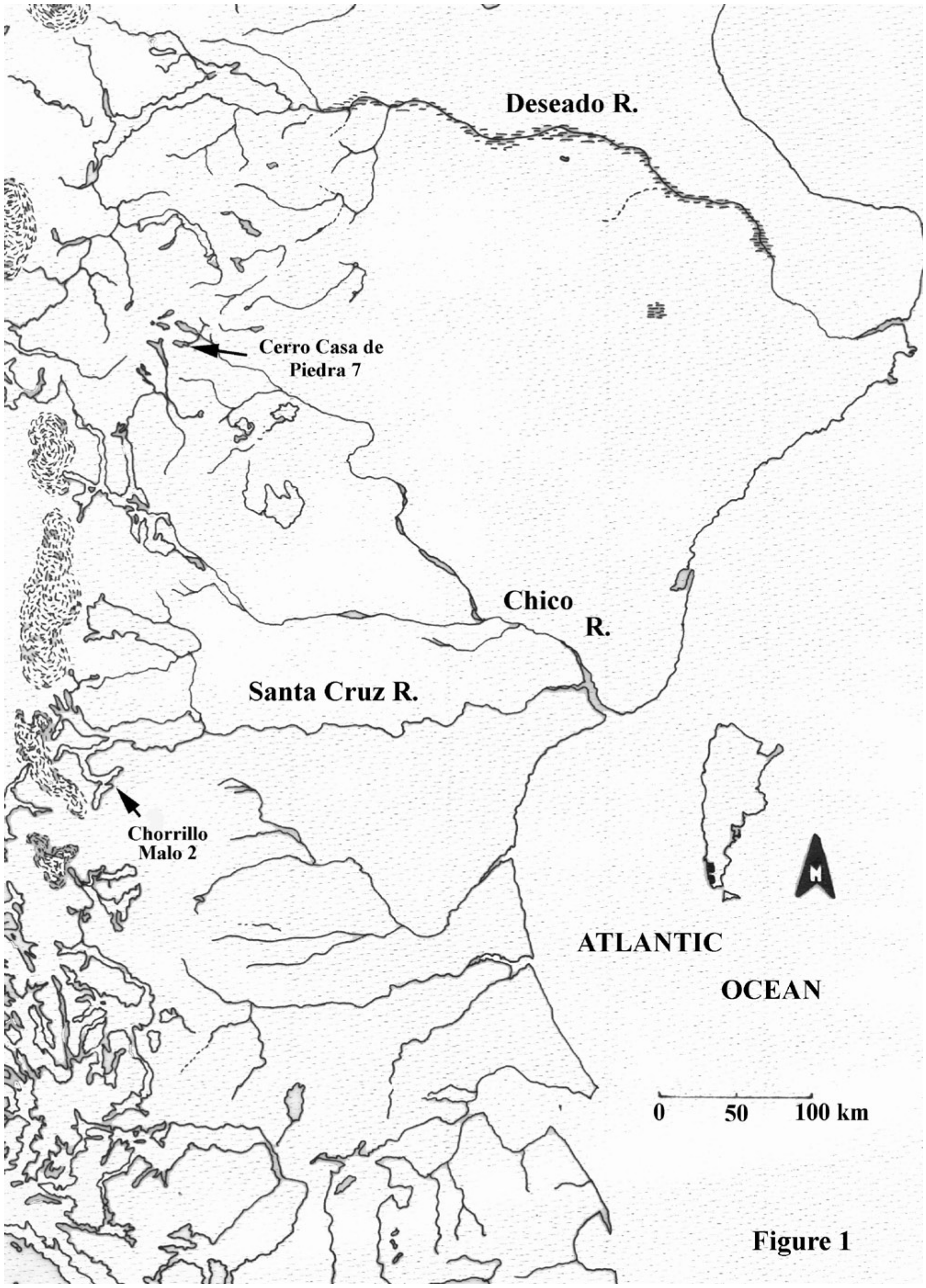


Fig. 1.

conditions in Southern Patagonia. Between 11,000 and ca. 10,000 yr BP this steppe is replaced by a grass steppe, suggesting an increase in effective moisture, probably related to an increase in precipitation to about 200 mm per year under cold conditions (Mancini, 1998; Páez et al., 1999). This grass steppe should have extended widely throughout Patagonia at least as far north as 47°S (Páez et al., 1999). The existence of a wet and cold climate is indicated by an expansion in *Nothofagus* forest between 50–55°S, as well as the increased lake levels of Cardiel Lake, about 150 km SE from Parque Nacional Perito Moreno, between 9800 and 7700 yr BP (Stine and Stine, 1990). Winters were probably slightly warmer and summers slightly cooler than today (Markgraf, 1991). In addition, Mancini (1998) suggests an increase of the temperature between 9000 and 6500 yr BP. These changes would have affected human life, especially in areas located close to the Andean range, as the ones we are dealing with.

We believe that human populations implement different kinds of strategies to facilitate their use of the environment (Nelson, 1991), and that these strategies are reflected in the archaeological record. In assessing these strategies one needs to take into account costs and benefits associated with the exploitation of a given set of subsistence resources, including toolstone. The costs and benefits will also be related to human mobility and lithic reduction strategies (Binford, 1980; Torrence, 1983, 1989; Bleed, 1986; Hayden, 1986; Lurie, 1989; Nami, 1992).

To understand human strategies of use of the environment, it is extremely important to know the regional structure of lithic resources (sensu Ericson, 1984). To classify the raw material availability, we follow Meltzer (1989), who uses ethnographical information, and differentiates between immediately available, local (until distances of 40 km), and non-local raw material (more than 40 km). We consider as immediately available, toolstone located at distances of less than 5 km from the site. In addition, among local toolstone, we believe it is useful to distinguish between those raw materials available close to the site (less than 10 km) and those located between 10 and 40 km. Artifacts are analyzed following Aschero's classification (1983), which is widely used by archaeologists working at Patagonia.

Borrero (1989, 1994–1995) has proposed an ecological model of the peopling of Patagonia, with phases of exploration, colonization and effective occupation of the space (Borrero, 1989–1990, 1994–1995), and has generated archaeological expectations for each one of them. We will focus our discussion in the expectations for lithic artifacts. We expect human populations to pursue different kinds of strategies during each one of Borrero's phases.

According to Borrero (1989), exploration corresponds to the initial dispersion of human populations into uninhabited spaces, implying movements of individuals or groups following the natural routes of less resistance. For this interval, low populations densities are expected. Accordingly, the expected recovery of sites corresponding to this phase is low. In addition, it is important to point out that there may or may not be continuity in the human occupation of a given area. If a population went extinct or abandoned the area, a new process of exploration can take place (Borrero, 1994–1995).

Most of the sites related to early human occupation of Patagonia are located in caves or rockshelters. We recognize that these sites represent only a limited set of the human activities at the time. Because of this, we know that we are dealing with only a part of past human behavior.

Borrero and Franco (1997) generated a series of expectations related to the entering of a population into a new space. Following principles associated with the design of tools and taking into account raw material availability, they expect similarities in the strategies prioritized: (1) an abundance of expediently shaped artifacts, adequate for immediate use, made of immediately available raw material (sensu Meltzer, 1989); (2) curated artifacts in lower frequencies, mostly broken and discarded when exhausted, made of exotic rocks; (3) the presence of resharpening debitage or debitage associated with the final shaping of transported artifacts, such as bifacial preforms, made of exotic rocks (Borrero and Franco, 1997:223). Taking this into account, they expect the transportation of finished tools or preforms, and perhaps cores made of exotic stone. They would be part of the curated personal gear. Following Kuhn (1992) we believe that the number and classes or artifacts transported would vary in relation to the frequencies of moves and with the distances travelled, among others.

In addition, Borrero and Franco (1997) do not believe that exploration can be accomplished in short periods, say days or even weeks (Nami, 1994). Accordingly, we believe exploration can last long periods of time. From a systemic point of view, we expect that early inhabitants would have used the closest rocks locally available (i.e., 10 km) and that these artifacts would have been expediently shaped. In addition, and in cases where available raw material is of excellent or very good quality, we expect their transportation to other areas. This means that, from an archaeological point of view, we expect the presence of tools expediently shaped on immediately or closely available toolstone. Their frequency should be a function of the length of the stay at the area. Cores with variable quantities of flakes removed from them also indicate that their exploitation is also a function of the length of the stay. In the case of toolstone of excellent quality immediately or closely available, we expect the presence of bifacial artifacts discarded because of flaws, fractures or knapping mistakes, and bifacial reduction flakes corresponding to different stages of manufacture.

3. Cerro Casa de Piedra

Cerro Casa de Piedra is mainly a volcanic rhyolitic hill, located at 47°57′S and 72°05′W, within Parque Nacional Perito Moreno (Fig. 1). The hill has several caves and rockshelters looking northwards. The oldest radiocarbon dates are from cave 7. During the early occupations the rocky roof sheltered ca. 223 m^2 of ground. Around ca. 3400 yr BP rockfall episodes sealed the west wing of the site (Civalero and Aschero, in press).

Cave 7 has 19 occupational levels, dated between ca. 9700 and 3400 ^{14}C yr BP. It was available at least by 10,500 years BP, as the dung of large herbivores (S. Vizcaíno and M. Merino, pers. comm.) dated at that time was recovered in the interior. This chronology may well be extended back in time in the near future,

Table 1
Cerro Casa de Piedra 7. Oldest deposits

Provenience	Raw material	Tool presence	Debitage		Core presence
			Presence	Size (mm)	
Immediately available (less than 5 km)	Rhyolites from cave wall	No	Yes	35.1–60	No
	1. Rhyolite (ca. 5 km)	Yes	Yes	10.1–90	Yes
Local	2. Chalcedony (ca. 5 km)	Yes	No	No	Yes
(5–40 km)	3. Siliceous rock of good quality (ca. 5 km)	No	Yes	5.1–30	No
	4. Basalt (ca. 25 km)	Yes	Yes	5.1–65	Yes
Non-local	1. Black obsidian (40 km)	Yes	Yes	5.1–40	Yes
(more than 40 km)	2. Siliceous rock of very good quality (ca. 100 km)	Yes	Yes	5.1–30	Yes

when the recent findings from the top of stratigraphic unit 18 are dated. From the lowest deposits, 5.75 m^2 were excavated.

The cave is located 6 km ESE of Burmeister Lake. Nowadays, the site is in a transitional environment between *Nothofagus* forest (*Nothofagus pumilio*) and the shrub steppe. This ecotone is composed of shrub steppe and scattered spots of *Nothofagus* forest. Mancini et al. (in press) suggest the development of floral/vegetational scatters of *Nothofagus* forest, grass and shrub steppe before 6500 yr BP. Future studies of fossil pollen analysis will allow the reconstruction of the vegetation history before 7000 yr BP.

According to González's geomorphological studies (1992), the Belgrano and Burmeister lakes could be relict stages of a deep lake basin, which would have reached a level 100 m above the modern Belgrano Lake (800 m a.s.l.). This paleolake would have had different transgression pulses. We still do not know the level of the paleolake at the time period we are analyzing. However, it is important to mention that sites with the earliest dates in the area are located above 900 m a.s.l. (Civalero and Aschero, in press).

We will focus here on the lithic information coming from the earliest levels of occupation, which span levels 15–18. Level 15 has a date of 9730 ± 100 yr BP obtained from wood (BETA 59925). Wood from level 16 was dated at 8920 ± 200 yr BP (UGA7383). Level 17 has two dates, one from wood yielded 9640 ± 190 yr BP (UGA7384) and the other one from charcoal dated at 9100 ± 150 yr BP (LP364) (Civalero and Aschero, in press).

Due to the cold and dry conditions inside the cave, guanaco skin/hide and vein threads, vegetal fiber, bones with periosteum, and wooden artifacts were preserved. Some guanaco bones display cut marks (M. De Nigris, pers. comm.). Huemul bones (*Hippocamelus bisulcus*) were also recovered at these levels (Aschero, pers. comm.).

There are different raw materials available in the area. River gravels and rhyolite from the wall of the cave are immediately available. Chalcedony, rhyolite and siliceous rocks of good quality are locally available, all of them coming from within ca. 5 km of the cave. Siliceous rocks of good quality and rhyolite are abundant, while chalcedony is present at low frequencies. Basalt comes from distances about 25 km from the cave. Among the non-local raw materials are three varieties of black obsidian from Pampa del Asador, located 40 km from the site (Stern, 1999). Siliceous rocks of very good quality are present at the Pinturas River area (Aschero, pers. comm. 1999), at a distance of ca. 100 km (lineal distance).

The artifact sample includes 12 cores, most of them made of non-local raw material (black obsidian and siliceous rocks) (Table 1). Fifty-eight percent were recycled and used as blanks for tools (Civalero, in press). Because of this, we consider them exhausted, which meets our expectations for an exploratory phase of occupation of a space. There are also cores made of local raw material. Most of them are exhausted, which probably reflects extended stays at the site.

Thirty-five tools were found, most of them made of non-local raw material of excellent quality: obsidian and siliceous rocks. According to Stern (1999), most of the obsidian from this site is similar to one of the varieties available at Pampa del Asador, ca. 40 km from the site. The high frequency of non-local toolstone is contrary to our expectations. However, this could be related to the proximity of this obsidian source. Most of the tools are fractured (63.16%) (Civalero, in press), which can be related to the length of stay at the site.

A high percentage of tools made of non-local rocks have more than one retouched edge (47.37% of the sample). This meets our expectations of economy of non-local raw material. The high frequency of tools with more than one retouched edge made of local raw material (38.46%) can also be related to the length of stay at the site.

Most of the tools are unifacially retouched and made on large and thick flakes. There are few classes, including endscrapers and scrapers. There are also flakes with natural edges with macroscopically continuous damage. The bifacial technique is restricted to triangular projectile points and bifaces made of non-local black obsidian. Some of the projectile points were resharpened.

If we compare the thickness of tools recovered at the lower levels with the ones of the youngest ones, dated ca. 3400 yr BP, we find that:

- The arithmetic mean of tool thickness is 13.41 mm (±5.51) at lower levels, while at the upper levels the mean is 6.43 mm (±2.19). The coefficient of variation at lower levels is 0.41, while at upper levels is 0.34.
- At the lower levels, the end-scrapers have an arithmetic mean thickness of 12.94 mm (±5.67). At the upper levels, this kind of tool has an arithmetic mean thickness of 6.80 mm (±2.24). The coefficient of variation at lower levels is 0.44, while at upper levels it is 0.33.
- At the lower levels, the side-scrapers and knives have a thickness mean of 14.00 mm (±5.46). At the upper levels, the mean thickness is 5.88 mm (±2.06). Coefficient of variation at lower levels is 0.39, while at upper levels it is 0.35.

These data show that tools are thicker at older levels, and also that there is a higher standardization of end-scrapers at the upper levels. This would tend to support more expedient usage in the lower deposits, which is consistent with our expectations for an exploratory phase of occupation of a space. A sample of 204 non-retouched flakes or debitage (sensu Andredfsky, 1998) was analyzed with the following results:

- Most of the non-retouched flakes are made of non-local raw material (59.60% of the sample). Most of them are internal ones. The presence of primary and secondary flakes and of cortex was noted mainly in black obsidian. Bifacial reduction flakes of this raw material were recovered. Both obsidian and siliceous resharpening flakes are present. Among the local raw materials, most of the flakes come from areas close to the site (rhyolite and local varieties of siliceous rocks coming from distances of ca. 5 km). Flakes made of local basalt from distances of 25 km have also been recovered. One flake was recovered of raw material coming from the wall of the cave (rhyolite).
- The debitage size ranges from 5 to 90 mm. The largest sizes correspond to local rhyolite (between 10.1 and 90 mm) and basalt (from 5.1 to 65 mm), and immediately available rock of the wall of the cave (between 35.1 and 60 mm). The smallest sizes correspond to non-local raw material. Obsidian displays sizes between 5.1 and 40 mm, with most between 5.1 and 10 mm. Siliceous rocks have sizes between 5.1 and 30 mm, with most between 5.1 and 10 mm.

The stratigraphic position of the artifacts would tend to suggest that they correspond to the initial occupation at the site. In addition, the dates obtained are the earliest ones in this area. The presence of unifacially retouched tools made on large and thick flakes on toolstone closely available and the variation in the thickness of the tools would tend to suggest that most of the artifacts were expediently shaped. This fact, along with the presence of exhausted cores and high frequency of broken tools made of non-local toolstone, and the presence of few classes of tools are consistent with our expectations for an exploration phase of occupation of the space. However, the frequency of tools made of non-local raw material is higher than expected. This could be related to longer stays at the site, to higher frequencies of reoccupation and/or to the proximity of the obsidian source.

The presence of cores, along with exterior flakes of non-local black obsidian, point to the transport of nodules or cores with cortex, suggesting small sizes of nodules at the source. Espinosa and Goñi (1999) point out that the majority of obsidian nodules at this source are no more than 10 cm in diameter. According to geochemical analysis, this source had been exploited and raw material circulated throughout central and South Patagonia since at least 9700 yr BP (Stern et al. 1995a, b; Stern, 1999). Because of this, it is possible that the size of the nodules was bigger at the late Pleistocene-early Holocene transition. In addition, the proximity of this black obsidian source could have probably influenced hunter-gatherers' strategies.

As we already mentioned, 35 tools were recovered at the lower part of the deposit. This means a deposition rate of 0.55 tools every hundred years per square meter. This rate is very similar to the oldest deposit of Cueva de las Manos (0.52 tools every hundred years per square meter), and higher than the one found at Arroyo Feo (0.10). Both sites are located near the Pinturas River in the headwaters of the Deseado hydrographic system, at the east of the area (Gradin et al., 1976; Aguerre, 1977, 1981–1982; Borrero and Franco, 1997; Alonso et al., 1984–1985). The oldest deposits at these sites are dated at ca. 9300 and 9400 yr BP, respectively.

4. Chorrillo Malo 2

Chorrillo Malo 2 is a rockshelter oriented to the south, located at 50°30′S and 72°40′W, at ca. 200 m a.s.l. It is close to Lakes Argentino and Roca, and at the foot of the Baguales range (Fig. 1). Data from a basal peat close to Brazo Rico suggests that the area was deglaciated around 10,000 yr BP (Mancini, 1998; Stern, 1990). By that time, the Moreno glacier was at about the same location as it is today (Mercer, 1968), at ca. 25 km from the site.

A 2 × 1 m test pit was excavated. At the lowest part of the deposit, and due to the presence of a big rock, the excavated area was reduced to 1 m × 1 m. The test pit reached almost 1.70 m depth, where the presence of glacial till was recorded (Belardi et al., 1995; Favier Dubois, 1995). The lowest part of the stratigraphic sequence has dates between ca. 9700 to 6200 yr BP (Franco and Borrero, in press).

The oldest radiocarbon dates correspond to 150–155 cm from the surface: 9740 ± 50 yr BP (GX-25279, AMS) and 9690 ± 80 yr BP (CAMS 71152, AMS), both on guanaco bones with cut marks and lateral blows. The date of 6170 ± 50 yr BP (CAMS 71153, AMS), 115–120 cm from the surface, was obtained on a guanaco bone with cut marks.

Another date of 4520 ± 70 yr BP (Beta 82292) was obtained from a mixture of several guanaco bones between 140 and 145 cm from the surface. According to Franco and Borrero (in press), taking into account the rocky nature of the deposit, it was a mistake to submit this sample, consisting of several bones that may represent different ages. Because of this reason, this date will not be taken into account for the analysis. Palynological analysis from the oldest deposits shows the presence of a gramineous steppe, with Poaceae, Cyperaceae and Fabaceae. A change to Asteraceae, Tubuliflorae, *Mulinum* and Solanaceae shrubs is noted above 140–145 cm depth (Mancini, 1999).

Raw materials immediately available include green, beige and grey varieties of dacite, dacitic porphyry and a variety of basalt. Local rocks include a different basalt of very good quality, two different varieties of chalcedony, jasper, tridymite, and a grey–green banded obsidian (Franco, 2002). A distinction should be made between those raw materials available very close to the site (i.e. less than 10 km), such as a variety of basalt (from ca. 9 km), and those coming from longer distances, such as translucent chalcedony and white opal (from distances of 15 km), and tridymite (from 32 km). The provenience of a variety of chalcedony (variety 2) and opal is unknown, but according to geological observations, these raw materials probably come from sedimentary deposits located beneath volcanic ones (Aragon, pers. comm.), at distances of ca. 29 km of the site. In the case of grey–green banded obsidian, its provenience is also unknown, but the frequency of artifacts made of this rock along with the similarities of ages between them and basalts from the Baguales range, suggest that they came from this area (Stern and Franco, 2000), at a distance of ca. 18 km.

Only one artifact was recovered below the level dated to ca. 9700 yr BP. It is a black obsidian interior debitage. According to XRF and neutron activation analysis, this raw material is one of the varieties from the Pampa del Asador source, more than 260 km to the north (Stern, pers. comm.). We believe that this obsidian was part of the transported tool-kit of early populations, i.e., it corresponds to the personal curated gear of early inhabitants.

Forty-five artifacts were recovered in the lower part of the deposit—dated between 9700 and 6100 yr BP. They include (see Table 2) one tool expediently manufactured on immediately available green dacite. It is a short and thick bifacially retouched point with macroscopical traces of damage. Its length is 60 mm, its width is 73 mm, and its thickness is 20 mm.

Table 2
Chorrillo Malo 2. Oldest deposits

Provenience	Raw material	Tool presence	Debitage		Core presence
			Presence	Size (mm)	
Immediately available (less than 5 km)	1. Green dacite	Yes	Yes	5.1–80	No
	2. Grey dacite	No	Yes	5.1–35	No
	3. Dacitic porphyry	No	Yes	60.1–65	No
	4. Basalt (variety 1)	No	Yes	10.1–30	No
Local (5–40 km)	1. Basalt (variety 2) (ca. 9 km)	No	Yes	10.1–15	No
	2. Chalcedony (variety 1) (ca. 15 km)	No	Yes	10.1–15	No
	3. Grey–green banded obsidian (ca. 18 km)	No	Yes	5.1–10	No
	4. Chalcedony (variety 2) (ca. 29 km)	No	Yes	15.1–20	No
	5. Opal (ca. 29 km)	No	Yes	10.1–15	No
	6. Tridymite (ca. 33 km)	No	Yes	No data	No
Non-local (more than 40 km)	Black obsidian (more than 260 km)	No	Yes	No data	No

References.

Also present are non-retouched flakes or debitage, including:

- Interior flakes made of immediately available green and grey dacite, and basalt (variety 1). The only external flake is made of immediately available dacitic porphyry. It has a prominent bulb of percussion, and probably represents an initial stage of manufacture. Artifacts made of immediately available raw material make up 82.22% of the sample.
- The largest sizes of complete flakes are represented by immediately available green dacite (sizes between 5.1 and 80 mm). Local raw materials have smaller sizes (less than 20 mm).
- The most abundant artifacts are flakes of grey dacite (37.78% of the sample). Most of the artifacts are tertiary flakes. A bifacial reduction flake was recovered. It size is less than 20 mm, and probably corresponds to a late stage of manufacture of bifaces. In addition, resharpening flakes were recovered of this raw material. Taking into account that this raw material is one of the best available in close proximity to the site, these findings meet our expectations.
- There is also a core rejuvenation flake made of the variety of basalt available very close to the site (variety 2). This suggests the transport of cores of this very good quality raw material.
- Among the raw materials available at longer distances, we can mention the presence of the two varieties of chalcedony, opal, tridymite and grey–green banded obsidian. They have sizes of less than 20 mm. An opal resharpening flake was recovered. These findings meet our expectations.

As we already mentioned, these materials were recovered above a glacial till deposit. Because of this, we consider that they probably represent the initial occupation of the area. Do the characteristics of the artifacts correspond to an exploratory moment? The black obsidian artifact recovered below the 9700 yr BP level was probably part of the curated personal gear of the early inhabitants of the area. This obsidian comes from the Pampa del Asador area, located more than 260 km to the north, suggesting that this source must have been known some time before.

Non-retouched flakes or debitage dated between 9700 and 6100 year BP correspond to the expectations generated for an exploratory moment of peopling of the space. The only tool recovered was expediently shaped of immediately available green dacite. The only exterior flake was made of immediately available dacitic porphyry, and artifacts made of immediately available raw material are the largest. Bifacial reduction and resharpening flakes are present on raw materials of excellent quality closely available. The existence of a core rejuvenation flake made of very good quality locally available basalt, suggests the transport of cores of this raw material. These characteristics can be attributed to an exploratory moment. We are conscious of the problems of equifinality that are widespread in archaeology. However, and taking into account the stratigraphical position of the artifacts above a glacial till, we believe they represent an early exploratory phase of occupation of the space.

As we already mentioned, only one tool was recovered in this part of the stratigraphic sequence. This means a deposition rate of 0.02 tools every hundred years per square meter. This depositation rate is very similar to the one obtained at Los Toldos cave 3 (0.06 tools every hundred years per square meter), located northeast to the site, at the central Plateau, and dated ca. 12,000 BP (see Cardich et al., 1973; Borrero and Franco, 1997; Borrero, 1999).

What can we say about the tools? Unfortunately, only one tool was recovered at these levels. However, it was expediently shaped from immediately available green dacite, and is very thick, which agrees with our expectations. Tools were recovered immediately above this level. Tools dated between ca. 6100 and 3800 yr BP can be compared with the ones recovered at the youngest deposits at the site (Franco, 2002). At levels dated between 6100 and 3800 yr BP:

- 60% of the tools are complete. They are made on large, thick flakes of local and immediately available raw material and are unifacially retouched.
- Tool thickness ranges from 3 to 50 mm, with a mean 21.25 mm ($\pm$16.10), which implies substantial variation within the sample (coefficient of variation = 0,76).
- There is a predominance of tools with long edges (side-scrapers and knives). Only two end-scrapers have been recovered. The arithmetic mean for thickness in the case of side-scrapers and knives is 12.20 mm ($\pm$9.76), with a coefficient of variation of 0.80. This again shows substantial variation in the thickness in these tools.
- The deposition rate is 0.22 tools every hundred years per square meter (Franco, 2002).

At the youngest deposits at the site:

- 20.84% of the tools are complete. They are made on smaller and thinner flakes than those in the older levels.
- Tool thickness ranges from 4 to 15 mm.
- The mean of thickness of side-scrapers and knives is 9.61 mm ($\pm$3.48), displaying less variation than is registered at the older deposits (coefficient of variation = 0.36).
- The arithmetic mean for end-scrapers thickness is 8.69 mm ($\pm$2.12), and the coefficient of variation is 0.34.

Cores recovered at the deposit dated between 6100 and 3800 yr BP are made of immediately available raw material and have few flakes removed from them, while in the youngest deposit they are smaller and exhausted.

The characteristics of the artifacts recovered at the levels between 6100 and 3800 yr BP are consistent with an initial exploration phase of occupation of space. However, the tool deposition rate (0.22 tools every hundred years per square meter) and percentage of broken tools (79.16%) are higher, suggesting extended stays at the site that would correspond to an exploration or early colonization phase. In this case, it remains to be explained if the exploration phase lasted so long (at least 3000 years), or if the characteristics of the tools can be explained because of some other reason (i.e. a problem of equifinality). Future work at the site and the area will help to evaluate this. However, it should be mentioned that the area was not effectively settled until 3800 yr BP After this date more sites are present in the area, both at the steppe and forest, and at low (ca. 200 m a.s.l.) and high altitudes (ca. 1000 m a.s.l.) (Borrero and Franco, 2000).

5. General tendencies

The two sites whose early lithic artifacts were analyzed are located less than 25 km from the Andes, their main difference in location being their elevation. Another important difference is their distance to the main source of varieties of black obsidian found in Southern Patagonia, Pampa del Asador. While Cerro Casa de Piedra 7 is located 40 km away, Chorrillo Malo 2 is more than 260 km away. Black obsidian coming from this source was used by early inhabitants at both sites and was probably part of the curated transported gear, suggesting that the source was already known some time prior to 9700 yr BP. The recovery of cores at Cerro Casa de Piedra 7 points to their transport as cores or nodules, at least for distances up to 40 km.

The assemblages analyzed match our expectations for an exploratory or early colonization phase of occupation of a space. However, there are some differences between them, such as the higher percentage of non-local toolstone and the higher degree of fragmentation for local raw materials at Cerro Casa de Piedra 7. The former can be explained because of the proximity to Pampa del Asador. The higher degree of fragmentation for local artifacts could be related to longer stays at this site, which is consistent with the depositional rate of tools (0.55 tools per square meter each 100 years) (Table 3).

The characteristics of artifacts from early levels of Chorrillo Malo 2, along with their stratigraphical position, match our expectations for an exploration phase. Black obsidian from Pampa del Asador area was transported by early inhabitants and discarded at the site.

Table 3
Tool deposition rates

Site	Tools/100 years/m^2
Cerro Casa de Piedra 7	0.55
Cueva de las Manos[a]	0.52
Arroyo Feo[a]	0.10
Chorrillo Malo 2	0.02
Los Toldos cave 3[a]	0.06

[a] From Borrero and Franco (1997).

The characteristics of lithic artifacts recovered at both sites are consistent with our expectations for an early exploration or early colonization phase of occupation of the space. The range of variation of the thickness of these tools is similar to that present at early deposits at sites located to the east such as Cueva de las Manos, Los Toldos and El Ceibo at the Atlantic slope, and Cueva Lago Sofía at the Pacific slope (Cardich and Flegenheimer, 1978; Mansur-Franchomme, 1983; Borrero and Franco, 1997). In addition, large end-scrapers and large and thick side-scrapers have also been recovered at Piedra Museo, Cueva Fell and Arroyo Feo (Aguerre, 1981–1982; Bird, 1988; Miotti, 1996; Borrero and Franco, 1997). Humans were locally producing and discarding tools, the frequency of curated artifacts being generally low, except in the case of Cerro Casa de Piedra 7. With the exception of Los Toldos, there is always evidence of bifacial reduction and of transport of bifacial artifacts preforms (Franco and Borrero, 1997). However, more data are needed in order to assess possible variations on them, including not only information about lithic tools, but also on debitage and raw material availability and accessibility (Haury, 1995).

Some differences are already evident. Among these, we should mention the higher rates of tool deposition at Cerro Casa de Piedra 7 (0.55 tools per square meter each 100 years), Cueva de Las Manos (0.52 tools) and Arroyo Feo (0.10 tools) compared to Los Toldos cave 3 (0.06) and Chorrillo Malo 2 (0.02 tools) (Table 3). This could suggest the existence of higher densities of population at the first ones and/or a higher frequency of reoccupation. This can be related to different factors. Among them, we could mention their proximity to the obsidian source. It remains to be explained, however, why the deposition rate at the oldest deposits of Arroyo Feo is lower than those of Cerro Casa de Piedra 7 and Cueva de las Manos.

We believe by this time human populations were living in low densities in Patagonia (Borrero, 1994–1995). Black obsidian distribution suggests the existence of wide ranges of raw material and human circulation, which is consistent with Borrero's (1994–1995) suggestion on the basis of ecological data.

There are still several unanswered questions. Why were densities higher at Cueva de Las Manos and Cerro Casa de Piedra 7? Is this difference related to the proximity to the black obsidian source? In other words, was the nearby presence of first quality rocks important in the intensity of the occupation? Was the initial colonization faster at this area? We are aware that this problem should be addressed regionally. More studies are necessary and a detailed knowledge of the regional availability of lithic resources is needed.

Acknowledgements

We are grateful to Robert Bettinger, Luis Borrero, Carlos Aschero and Gabriela Guráieb for their useful comments on the manuscript, and to all the people who took part in the excavations. We wish to thank Parques Nacionales, Universidad Nacional de la Patagonia Austral, Subsecretaría de Turismo y Ministerio de Acción Social de la provincia de Santa Cruz, and Estancia Chorrillo Malo. We also are grateful to Dr. Tom Brow, from the Center for Accelerator Mass Spectometry, Lawrence Livermore National Laboratory, and to Dr. Scott Stine for dates CAMS 71152 and 71153, and to Dr. Charles Stern (University of Colorado-Boulder) and Eugenio Aragón (CIG-UNLP-CONICET).

The works were financed by CONICET (projects "Variabilidad Temporal y Espacial en Sociedades Cazadoras-recolectoras del Ámbito Cordillerano Patagónico", "Arqueología del Area Río Belgrano-Lago Posadas, Provincia de Santa Cruz" and "Magallania II"), Secretaría de Cultura de la Nación through the Instituto Nacional de Antropología y Pensamiento Latinoamericano, Agencia Nacional de Promoción Científica y Técnica (PICT 97 No. 04-00000-00807) and Universidad de Buenos Aires (UBACyT Fi 141, F133 and F017).

References

Aguerre, A.M., 1977. A propósito de un nuevo fechado radiocarbónico para la "Cueva de las Manos" (Alto Río Pinturas-Pcia Santa Cruz). Relaciones de la Sociedad Argentina de Antropología (NS) 11, 129–158.

Aguerre, A.M., 1981–1982. Los niveles inferiores de la Cueva Grande (Arroyo Feo), Area Río Pinturas, Pcia. Santa Cruz. Relaciones de la Sociedad Argentina de Antropología 14 (2), 211–239.

Alonso, F., Gradin, C.J., Aschero, C.A., Aguerre, A.M., 1984–1985. Algunas consideraciones sobre recientes dataciones radiocarbónicas para el área del río Pinturas, pcia. de Santa Crux. Relaciones de la Sociedad Argentina de Antropología (NS) 16, 275–285.

Andredfsky, Jr., W., 1998. Lithics. Macroscopic Approaches to Analysis. Cambridge Manuals in Archaeology, Cambridge.

Aschero, C.A., 1983. Ensayo para una Clasificación Morfológica de los Artefactos Líticos. Unpublished report to the Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires.

Belardi, J.B., Franco, N.V., Borrero, L.A., 1995. Informe de las tareas realizadas en el sitio Chorrillo Malo 2 (área de Lago Roca, Lago Argentino). Unpublished report for Administración de Parques Nacionales, Buenos Aires.

Binford, L.R., 1980. Willow smoke and dog's tails: hunter-gatherer settlement systems and archaeological site formation. American Antiquity 45, 4–20.

Bird, J., 1988. In: Hyslop, J. (Ed.), Travels and Archaeology in South Chile. University of Iowa Press, Iowa City.

Bleed, P., 1986. The optimal design of hunting weapons: maintainability or reliability. American Antiquity 51 (4), 737–747.

Borrero, L.A., 1989. Replanteo de la Arqueología Patagónica. Interciencia 14 (3), 107–135.

Borrero, L.A., 1989–1990. Evolución cultural divergente en la Patagonia Austral. Anales del Instituto de la Patagonia (Ser. Cs. Soc.) 19, 133–139.

Borrero, L.A., 1994–1995. Arqueología de la Patagonia. Palimpsesto. Revista de Arqueología 4, 9–69.

Borrero, L.A., 1999. The prehistoric exploration and colonization of Fuego-Patagonia. Journal of World Prehistory 13 (3), 321–355.

Borrero, L.A., Franco, N.V., 1997. Early Patagonian hunter-gatherers: subsistence and technology. Journal of Anthropological Research 53, 219–239.

Borrero, L.A., Franco, N.V., 2000. Cuenca superior del río Santa Cruz: perspectivas temporales. In: Universidad Nacional de la Patagonia Austral (Ed.), Desde el País de los Gigantes. Perspectivas arqueológicas en Patagonia, Vol. II. Río Gallegos, Argentina, pp. 345-356.

Cardich, A., Flegenheimer, N., 1978. Descripción y tipología de las industrias líticas más antiguas de Los Toldos. Relaciones de la Sociedad Argentina de Antropología 12 (N.S.), 85–123.

Cardich, A., Cardich, L., Hajduk, A., 1973. Secuencia Arqueológica y Cronología Radiocarbónica de la Cueva 3 de Los Toldos. Relaciones de la Sociedad Argentina de Antropología 7 (N.S.), 85–123.

Civalero, M.T., in press. Circulación, Aprovechamiento de Recursos Líticos y Estrategias de Diseño en el Sur Patagónico. Arqueología 10.

Civalero, M.T., Aschero, C.A., in press. Early Occupations at Cerro Casa de Piedra 7, Santa Cruz Province, Patagonia Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From where the South Winds Blow. Center for the Studies of the First American (CSFA) and Texas A&M University Press, Texas.

Clapperton, C., 1993. Quaternary Geology and Geomorphology of South America. Elsevier Science Publishers, Amsterdam.

Ericson, J.E., 1984. Toward the analysis of lithic reduction systems. In: Ericson, J.E., Purdy, B. (Eds.), Prehistoric Quarries and Lithic Production. Cambridge University Press, Cambridge, pp. 11–22.

Espinosa, S., Goñi, R., 1999. Viven!: Una fuente de obsidiana en la provincia de Santa Cruz. In: Instituto Nacional de Antropología y Pensamiento Latinoamericano and Facultad de Humanidades, Universidad Nacional del Comahue (Eds.), Soplando en el Viento. Actas de las III Jornadas de Arqueología de la Patagonia. Neuquén-Buenos Aires, pp. 177–198.

Favier Dubois, C., 1995. Aproximación geoarqueológica a los estudios de formación de sitio. Análisis de casos en Fuego-Patagonia. Tesis de licenciatura, Universidad de Buenos Aires.

Franco, N.V. 2002. Estrategias de utilización de recursos líticos en la cuenca superior del río Santa Cruz. Ph.D. Thesis, University of Buenos Aires.

Franco, N.V., Borrero, L.A., in press. Chorrillo Malo 2: initial peopling of the upper Santa Cruz basin, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From where the South Winds Blow. Center for the Studies of the First American (CSFA) and Texas A&M University Press, Texas.

Furque, G., 1973. Descripción geológica de la hoja 58b, Lago Argentino, Provincia de Santa Cruz. Carta Geológica de la hoja 58 b, Lago Argentino. Boletín 140, Servicio Nacional Minero Geológico, Buenos Aires, 70pp.

González, M.A., 1992. Paleoambientes del Pleistoceno Tardío/Holoceno Temprano en la Cuenca de los Lagos Belgrano y Burmeister (47°40′/48′ Sur, 72°30′Oeste), Santa Cruz. Informes Técnicos Fundación Carl C. zon Caldenius 9, 1–7.

Gradin, C.J., Aschero, C., Aguerre, A., 1976. Investigaciones Arqueológicas en la Cueva de las Manos, Estancia Alto Río Pinturas, Pcia. de Santa Cruz. Relaciones de la Sociedad Argentina de Antropología 10, 201–270.

Haury, C.E., 1995. Defining lithic procurement technology. In: Church, T. (Ed.), Lithic Resource Studies: A Sourcebook for Archaeologists. Lithic Technology, Special Publication No. 3. Department of Anthropology, University of Tulsa, Tulsa, Oklahoma, pp. 26–31.

Hayden, B., 1986. Resource models of inter-assemblage variability. Lithic Technology 15, 82–89.

Heusser, C.J., 1993. Late-glacial of Southern South America. Quaternary Science Reviews 12, 345–350.

Kuhn, S.L., 1992. On planning and curated technologies in the Middle Paleolithic. Journal of Anthropological Research 48 (3), 185–214.

Lurie, R., 1989. Lithic technology and mobility strategies: the Koster site middle archaic. In: Torrence, R. (Ed.), Time, Energy and Stone Tools. Cambridge University Press, Cambridge, pp. 46–56.

Mancini, M.V., 1998. Vegetational changes during the Holocene in Extra-Andean Patagonia, Santa Cruz Province, Argentina. Palaeogeography, Palaeoclimatology, Palaeoecology 138, 207–219.

Mancini, M.V. 1999. Cambios de la vegetación y del clima durante los últimos 5000 años en el área del lago Argentino, Santa Cruz. In: X Simposio Argentino de Paleobotáncia y Palinología, Asociación Paleontológica Argentina. Publicación Especial, Vol. 6. Buenos Aires, pp. 49–53.

Mancini, M.V., Páez, M., Prieto, A.R., in press. Vegetational history during the last 7000 years in the Steppe-forest ecotone, Santa Cruz, Argentina. In: Volkheimer, W., Smolka, S. (Eds.), Southern Hemisphere Paleo and Neoclimates. Methods and Concepts. Cambridge University Press, Cambridge.

Mansur–Franchomme, M.E., 1983. Traces d'Utilisation et Technologie Lithique: Exemples de la Patagonia. Ph.D. dissertation, University of Bordeaux, France.

Markgraf, V., 1991. Younger dryas in Southern South America? Boreas 20, 63–69.

Meltzer, D., 1989. Was Stone Exchanged among Eastern North American Paleoindians? In: Ellis, C.J., Lothrop, J. (Eds.), Eastern Paleoindian Lithic Resource Use. Westview Press, Boulder, pp. 11–39.

Mercer, J., 1968. Variations of some Patagonian Glaciers since the Late-Glacial: I. American Journal of Science 266, 91–109.

Mercer, J., 1970. Variations of some Patagonian Glaciers since the Late Glacial: II. American Journal of Science 269, 1–25.

Miotti, L., 1996. Piedra Museo, Nuevos Datos para la Ocupación Pleistocénica en Patagonia. In: Gómez Otero, J. (Ed.), Arqueología. Sólo Patagonia. Centro Nacional Patagónico-Consejo Nacional de Investigaciones Científicas y Técnicas. Puerto Madryn, Argentina, pp. 93–101.

Nami, H.G., 1992. El subsistema tecnológico de la confección de instrumentos líticos y la explotación de los recursos del ambiente: una nueva vía de aproximación. Shincal 2, 33–53.

Nami, H.G., 1994. Paleoindio, Cazadores-Recolectores y Tecnología Lítica en el Extremo sur de Sudamérica continental. In Lanata, J.L., Borrero, L.A. (comp) Arqueología de Cazadores-Recolectores: Límites, Casos y Aperturas. Arqueología Contemporánea, Vol. 5 (Special Edition). Buenos Aires, pp. 89–103.

Nelson, M.C., 1991. The study of technological organization. In: Schiffer, M. (Ed.), Archaeological Method and Theory, Vol. 13. University of Arizona Press, Tucson, pp. 57–100.

Páez, M.M., Prieto, A.R., Manczini, M.V., 1999. Fossil pollen from Los Toldos locality: a record of the late-glacial transition in the extra-Andean Patagonia. Quaternary International 53/54, 69–75.

Stern, C.R., 1990. Tephrochronology of Southernmost Patagonia. National Geographic Research 6, 110–126.

Stern, C.R., 1999. Black obsidian from central-south Patagonia; chemical characteristics, sources and regional distribution of artifacts. In: Instituto Nacional de Antropología y Pensamiento Latinoamericano and Facultad de Humanidades de la Universidad Nacional del Comahue (Eds.), Soplando en el Viento. Actas de las III Jornadas de Arqueología de la Patagonia. Neuquén-Buenos Aires, Argentina, pp. 221–234.

Stern, C.R., Franco, N.V., 2000. Obsidiana gris verdosa veteada de la cuenca superior del río Santa Cruz, extremo sur de Patagonia. Anales del Instituto de la Patagonia (Serie Cs. Hs.) 28, 265–273.

Stern, Ch., Mena, F., Aschero, C.A., Goñi, R., 1995a. Obsidiana negra de los sitios arqueológicos en la Precordillera Andina de Patagonia Central. Anales del Instituto de la Patagonia (Ser. Cs. Soc.) 23, 111–118.

Stern, Ch., Prieto, A., Franco, N.V., 1995b. Obsidiana negra en los sitios cazadores-recolectores terrestres en Patagonia austral. Anales del Instituto de la Patagonia (Ser. Cs. Soc.) 23, 105–109.

Stine, G., Stine, M., 1990. A record from Lake Cardiel of climate change in Southern South America. Nature 345, 705–708.

Torrence, R., 1983. Time budgeting and hunter-gatherer technology. In: Bailey, G. (Ed.), Pleistocene hunter-gatherers in Europe. Cambridge University Press, Cambridge, pp. 11–22.

Torrence, R., 1989. Tools as optimal solutions. In: Torrence, R. (Ed.), Time, Energy and Stone Tools. Cambridge University Press, Cambridge, pp. 1–6.

Villalba, R., 1993. Fluctuaciones climáticas en latitudes medias de América del Sur durante los últimos 1000 años, sus relaciones con la Oscilación del Sur. Paper presented at the Workshop El Cuaternario de Chile, Universidad de Chile, Santiago.

Villalba, R., 1994. Tree-ring and glacial evidence for the Medieval warm epoch and the Little Ice Age in Southern South America. Climatic Change 26, 193–197.

PERGAMON

Quaternary International 109–110 (2003) 87–93

Taphonomy of the Tres Arroyos 1 Rockshelter, Tierra del Fuego, Chile

Luis Alberto Borrero

Instituto Multidisciplinario de Historia y Ciencias Humanas, CONICET, Saavedra 15-Piso 5, 1083 ACA Buenos Aires, Argentina

Received 17 October 2002; accepted 17 October 2002

Abstract

A discussion concerning the main formation processes implied in the accumulation of Layer Va at Tres Arroyos 1 Rockshelter, Tierra del Fuego, Chile, is presented. This site was intensively studied by an interdisciplinary team led by Mauricio Massone, and produced evidence of human occupation dated around 10 500 yr BP. This evidence includes remains of extant as well as extinct fauna in physical association with lithic artifacts and hearths. A taphonomic analysis of the bones is used to assess the different formation processes involved in the accumulation of Layer Va bone assemblage. Several processes, especially bioturbation were identified, and should be taken into account in order to explain the formation of the layer.

1. Introduction

For decades, the Late Pleistocene record of Tierra del Fuego was close to nonexistent. This was due to both lack of research as well as scarcity of deposits of the appropriate age. The earliest archaeological site, Marazzi, was imperfectly dated ca. 9000 yr BP (Laming-Emperaire, 1968; Laming-Emperaire et al., 1972). Without a detailed publication, neither the content nor the age of the lower deposits of Marazzi were clear. Recently the original collection was re-studied (Morello Repetto, 2000) and the site was reexcavated (Morello Repetto et al., 1999). No evidence of extinct fauna was found. It was only with the discovery of the Tres Arroyos site at the Cerro de los Onas locality, that the Pleistocene record of the island of Tierra del Fuego began to be known (Massone, 1983). This paper will be focused in the preliminary analysis of the faunal remains recovered at this shelter, particularly from Layer Va, dated ca. 10 500 yr BP Layers Vb and VI, also containing Pleistocene fauna, will only be treated for comparative purposes.

2. The Tres Arroyos 1 Rockshelter

Tres Arroyos 1 (TA1) is a small rockshelter of about 70 m^2. It is formed on the Carmen Sylva Formation, located at 92 m a.s.l. (Massone et al., 1993). It is one of the many sites discovered within the Cerro de los Onas locality (53° 23′ S; 68°47′ W) where Mauricio Massone, from the Biblioteca Nacional, Santiago de Chile, directed two research projects. The site was partially excavated between 1981 and 1986 and between 1996 and 1998.

2.1. Stratigraphy

On the surface there was a deposit of sheep dung up to 10 cm thick. This was followed by Layers I–IV, all dated in the Late Holocene (Table 1). Layer IV, dated c. 1300 yr BP rests above Layer Va, which is Late Pleistocene. Thus, most of the Holocene is not represented at the site. Sediments from Layer Va are constituted by a dark silt-clay, with a cineritic component, with a thickness between 21 and 29 cm. Late Pleistocene human occupation was found here, including five hearths, as well as 841 lithic artifacts, red pigment, a few bone artifacts and hundreds of bones (Massone et al., 1998).

Layer Vb, which is immediately below, is similar but more compact and presents discrete concentrations of tephra. The tephra was determined to be the result of an explosive eruption of the Reclus volcano, located some 400 km north-west, in what today is the continent. This tephra is regionally dated c. 12 000 yr BP (Stern, 1992). In Layer Vb a few artifacts were found, but it is difficult to sustain that they represent an in situ occupation.

E-mail address: laborrero@hotmail.com, prep@conicet.gov.ar (L.A. Borrero).

1040-6182/03/$ - see front matter © 2003 Elsevier Ltd and INQUA. All rights reserved.
PII: S1040-6182(02)00205-7

Table 1
Radiocarbon dates from Tres Arroyos 1

Layer	Age	Laboratory	Material
I	135±85	Monaco	Charcoal
III	700±70	Dic. 2731	Charcoal
III	10 575±65	OxA-9245	Tooth, *D. avus*
IV	1340±50	Beta 30903	Guanaco bone
Va	10 240±110	Dic-2732	Camelid bone
Vb	10 420±100	Dic-2733	Camelid bone
Va	11 880±250	Beta-20219	Undetermined burnt bones
Va	10 600±90	Beta-101023 (AMS)	Charcoal
Va	10 580±50	Beta-113171 (AMS)	Charcoal
Va	1120±40	Beta-101054 (AMS)	*L. guanicoe* bone fragments
Va	10 630±70	OxA-9246 (AMS)	Mandible (Ramus) *Vicugna sp.* (see Prieto and Canto, 1997)
Va	10 685±70	OxA-9247 (AMS)	Equidae bone
Va	10 130±210	OxA-9666 (AMS)	Charcoal
Va	11 085±70	OxA-9248 (AMS)	Metatarsal, panther
VI	12 540±70	Beta-123152 (AMS)	Equidae bone

They probably migrated from Layer Va. At the base of the sedimentary succession Layer VI was defined. It is different from Va and Vb in that it includes more sand and less clay (Jackson and Arroyo, 1998). No evidences of human occupation were found, and it is defined as a paleontological layer.

2.2. Bone assemblage

Late Pleistocene faunal remains from Layers V and VI at Tres Arroyos (Table 2) are both abundant and important. Many of those remains were found in physical association with the archaeological findings at Layer Va. For that reason they were used to discuss the subsistence of the first inhabitants of Tierra del Fuego (Massone et al., 1993). However, there are several reasons to suggest that not all those remains were originally deposited in Layer Va.

Taphonomic work at the Cerro de los Onas locality show the importance of several processes, which suggest the necessity of producing a more detailed analysis of the remains found at TA1. These processes include trampling by sheep (Seguel, 1993, p. 157), the deposition of modern carcasses of sheep and guanaco (*Lama guanicoe*), probably related to winter stress (Seguel and Martínez, 1997; Borrero, 1997a), and the action of small rodents (Seguel, 1993; Martin, 1997). Also, several rocks partially closing the entrance of the cave were deposited relatively recently. This suggests the existence of a period when the rockshelter was more open (Borrero, 1997a).

Moreover, the discovery of rabbit bones (*Oryctolagus cuniculus*) in the cave, including their presence in the Pleistocene layers, suggested that mixing of sediments and particles was taking place (Martin and Borrero, 1999). Since European rabbits were introduced to the island in the 1930s and the 1950s, it was clear that the only way to explain the association of rabbit and Pleistocene fauna bones was related with perturbation, most probably bioturbation produced by the rabbits themselves. Several holes identified during the excavation were initially attributed to *Ctenomys* sp. (Massone et al., 1993), but are better explained as rabbit burrows (Martin and Borrero, 1999). Their size, content and other properties were well within the range of known rabbit burrows, including several excavated in Northern Tierra del Fuego (Martin and Borrero, 1999). On one hand, this provides a mechanism for the introduction of rabbit bones into the lower deposits, and on the other it suggests that other remains may have vertically migrated as well.

Table 2
Major taxa present at Tres Arroyos 1, Layer Va (rodents are not included) (Data from Massone et al., 1997; Prieto, 1999)

Taxon	MNI
Mylodon darwini	1
Hippidion saldiasi	2
L. guanicoe	4
Lama sp.	4
Vicugna sp.	1
Panthera onca mesembrina	1
D. avus	Present
P. culpaeus	Present

Another bone accumulation was found in the talus of Tres Arroyos, TA 14 (30) (Prieto et al., 1997; Constantinescu and Contreras, 1998). The faunal remains found there will not be analyzed here. However, they are relevant in assessing the importance of some processes in Cerro de los Onas. At least two horizons were recognized. The upper one is dated 2280±60 yr BP (Beta-101055), and the lower 12 280±110 yr BP (Beta-101056 AMS). Within the upper layer complete guanaco bones were found that differ in color, weathering and degree of fragmentation from the rest of the assemblage. A sample of those guanaco bones was dated and resulted in a "Modern" date (LP-883), demonstrating the existence of bone migration. Together with the evidence for the importance for rabbit burrows, they alert us to the complexity involved in the interpretation of these bone assemblages. Conditions for contamination of ancient deposits with modern bones are very important at Cerro de los Onas, highlighting the necessity of taphonomic analysis.

In this study, I will be assessing the integrity of the faunal assemblage from Layer Va, since it includes the artifacts that are currently used to understand the Late Pleistocene peopling of Tierra del Fuego. I am using a sample of faunal remains recovered between 1981 and 1986, as well as studies produced by several members of the team conducted by Mauricio Massone. Particularly important are a report by Mengoni Goñalons (1987) who analyzed the first faunal sample from Layer V, and the unpublished reports of Prieto (1997, 1999) on the remains obtained between 1996 and 1998. This is a first approximation to the taphonomy of the site, and it is an exploratory study that will try to indicate major directions for research concerning the formation of the deposits. At least part of the collection still needs taxonomic study (see Mengoni Goñalons, 1987; Latorre, 1998; Prieto and Canto, 1997), and surely new patterns will emerge when this work is completed. Also, more contextual work is needed, including the spatial distribution of bones and lithics (see Jackson, 1999).

Several variables were recorded in the bones from Layer Va, including the presence of carnivore marks (see Borrero et al., 1997), presence of rodent marks, root marks, weathering (Behrensmeyer, 1978), completeness, fusion (absent, semifused, fused), presence of manganese, staining, chemical alteration, peeling, presence of cut or percussion marks, thermal alteration and attrition. Some of these variables were used to assess the stability of the bones (Guichón et al., 2000). Only some of those records are used in this paper. The study of these properties on bones recovered between 1981 and 1986 was, in many cases, made difficult by changes in the bone surface produced by the curation procedures.

3. Results

One of the properties of this assemblage is that it is highly fragmented. Moreover, the only complete elements are teeth, phalanges, dermal ossicles and articulations. The fractures look old, without changes in colour, staining or weathering that may indicate differences in exposition.

Table 3 presents some of the results of this study. It is clear that manganese oxidation is an important process at TA1, with at least ten horse bones (55%), 68 guanaco bones (78%) and 49 *Lama* sp. bones (71%) presenting manganese. In contrast, only two of the ground sloth bones display manganese, but it is also present at 12 of the Mammalia bones that show the bone structure of large edentates (60%). Among the carnivores, eight of the 13 fox bones (see Table 4) as well as a panther metatarsal display manganese. Only one bird bone shows manganese (3.5%). It must be noted that there is no manganese in the bones from Layer VI. This contrast probably indicates the existence of water in contact with the bones from Layer Va. Prieto (1999) observed different taphonomic histories on two conjoinable fragments of a Camelidae mandible, with deposition of calcium carbonate on one fragment and manganese on the other.

Importantly, there is very little evidence of weathering (see also Mengoni Goñalons, 1987). Three horse (16%), seven guanaco (8%) and 14 *Lama* sp. (20%) bones display limited weathering, always "1" on the Behrensmeyer (1978) scale. On a sample of 136 unidentified

Table 4
Taphonomic processes identified on fox remains from Layer Va (Arroyo, 1998)

Taphonomic marker	Percentage
Cut marks	2.3
Burnt	0.7
Fractures	2.3
Weathering	10.8
Manganese	59.7
Carnivore marks	6.2
Rodent marks	0.7
Gastric acids	0.7
Root marks	10

Table 3
Taphonomic properties identified at Tres Arroyos 1, Layer Va

	N	Manganese	*W*	Carnivore marks	Cut marks	Root marks	Thermal alteration
Hippidion saldiasi	18	10	3	3	—	1	—
L. guanicoe	87	68	7	11	2	1	—
Lama sp.	69	49	14	2	2	2	4
Mylodon darwini	38	2	—	—	—	—	1
Mammalia	181	112	11	6	1	1	10

fragments of Mammalia bones only nine display weathering (6.6%), in all cases having a Behrensmeyer value of "1". Only one bird bone presents minimal evidence of weathering (3.5%) and none was found on the 13 fox bones. Considering that the rockshelter is open and highly exposed, this means that the bone assemblage was swiftly covered by sediment.

Other taphonomic processes appear to be less important. There is evidence of root marks in only five bones, all of them located near the mouth of the cave (Prieto, 1999). There are several cases of volcanic sediment adhered to the surface of the bones (Prieto, 1997), suggesting a long period of contact within that sediment matrix.

Apparently, the attractive of the bones from Layer Va to carnivores was low, or carnivores were not abundant at the time that this assemblage was exposed. Mengoni Goñalons (1987) published a detailed description of carnivore marks on a first phalanx and a mandible of *Lama* sp. and an humerus and a rib of *Equidae*, all from Layer Va. Prieto (1999) observed 13 examples of bones with punctures. Two of them, on a Camelidae tibia and a horse thoracic vertebrae, are similar to those produced by large felines (Prieto, 1997). In the sample that I have studied, of 393 bones, there are carnivore marks on three horse bones, eleven guanaco bones and two *Lama* sp. bones, the majority of which are punctures. Also six bones attributed to Mammalia have different kinds of carnivore marks, including punctures and pitting. There is one case of a probable puncture and one case of pitting on bird bones.

Several carnivore remains were found at Layer Va. These include two phalanges and one complete metatarsal of a panther (*Panthera onca mesembrina*), the latter with exostosis. It is dated 11 085±70 yr BP (Table 1). There are also 13 fox bones, four of which are complete (one incisive, one molar, one rib and one thoracic vertebrae). The rest were highly fragmented. The presence of cut marks suggest some relationship with humans. The fox remains includes at least one *Dusicyon avus* mandible (Mengoni Goñalons, 1987, p. 64). It was difficult to distinguish between *D. avus* and *Pseudalopex culpaeus* in the post-cranial material (Arroyo, 1998, 1999; see also Latorre, 1998). *D. avus*, a medium-sized fox is the only representative of the Pleistocene fauna that apparently goes extinct during the Late Holocene in Southern extra-andean Patagonia (Miotti and Berman, 1988) and Pampa (Tonni and Politis, 1981). However, it must be emphasized that it is not yet clear if this is a true extinction or a case of transformation. It is only in TA 1 that the remains of this fox were directly dated. Effectively, the mandible was found within Layer III, which is radiocarbon dated c. 1300 yr BP. However, a radiocarbon date made on the bone itself produced a result of 10 575±65 (OxA-9245) (Table 1). The activity of rodents may explain the upward migration of this mandible (Massone, 1987; Martin, 1997).

Five of the fox remains have carnivore marks. Particularly interesting is the case of one calcaneum (N° 17074-484) which displays cut marks, carnivore punctures and rodent marks. Unfortunately it was not possible to identify an order of access of these agents (Arroyo, 1998). The presence of at least three small bones that present evidence of gastric acids can also be added to the list of carnivore related remains (Prieto, 1999).

In general the evidence for the action of carnivores on the bones from Layer Va is not numerically important. This is interesting given the presence of fox and panther remains, only some of which display evidence of being introduced, or at least processed by humans.

The gnawing action of small rodents also was not important. Prieto (1999) found two cases of rodent marks in his study of the 1996–1998 collections, and Arroyo (1998) found one example on the fox bone collection. This is interesting given the presence of rodent remains in the deposits, including both *Ctenomys* sp. and Cricetidae (Pardiñas and Martin, in prep.). It appears that vertical migration of elements is the main process caused by rabbits. In addition to the upward movement of the *D. avus* mandible, we have evidence of what appears to be the downward movement of guanaco bones. Effectively, small guanaco bone fragments recovered at Layer Va were dated 1120±40 yr BP, a date that makes more sense in Layer IV, immediately above, dated 1340±50 yr BP (Table 1), which is a dense midden of guanaco bone fragments (Muñoz, 1997).

The evidence of cut marks is usually the most important to assess the degree of human activity on a bone assemblage. Mengoni Goñalons (1987) published a description of cut marks on a tibia diaphysis and a distal fragment of a rib of *Equidae* as well as on a *D. avus* mandible. Prieto (1999) recognized a total of six cut marks and the presence of bone flakes and percussion scars, and Massone et al. (1997) observed one case of lithic particles encrusted in one guanaco long bone. The bones with cut marks include two examples on guanaco (Prieto, 1997), two on *Lama* sp. and one on Mammalia (which also presents percussion marks). In addition to the percussion marks observed on the Mammalia specimen, they were also recorded in four *Lama* sp. long bones. Mengoni Goñalons (1987) described examples of percussion marks on an *Equidae* tibia diaphysis and a humerus of *Lama* sp.

The diaphysis and epyphises of a right humerus of *Chloephaga sp*. presents cut marks along the perimeter of the diaphysis, suggesting the production of bone beads (Massone, 1988). A fragment of cilindric bead 15.3 mm in diameter on a large bird bone was also recorded (Massone et al., 1997).

Given that most of the cut marks and percussion marks are recorded on extant fauna, the existence of a bone artifact made on a horse rib is remarkable (Prieto, 1999; Alberdi and Prieto, 2000). This evidence constitute, together with the cut marks on two bones recorded by Mengoni Goñalons, the most clear proof of human involvement with horses. None of the ground sloth bone display anthropic marks. However, most of them are dermal ossicles. Undetermined fragments of Mollusca were also found. They do not display any evidence of human activity.

In summary, cut marks are not abundant in the TA 1 bone assemblage. This is a significant result, given the good preservation of this collection. If humans were important agents of accumulation, then it must be concluded that processing of the animals at the site was not intensive.

In this sense, it must be recalled that all these bones with cut marks and percussion marks were recovered within or near five well-defined, basin-shaped hearths which present consistent dates of about 10 500 yr BP. Indeed, there are evidences of thermal alteration in specimens of *Lama* sp., Mammalia, and one ground sloth rib. Moreover, the radiocarbon dates clearly indicate that there is contemporaneity between Pleistocene fauna and humans at Layer Va. Given the low involvement of carnivores, it certainly looks plausible that the Pleistocene fauna was indeed deposited by humans. The bones are too broken to see them as the result of a natural accumulation of animals dying at the shelter. The presence of a few panther bones may suggest a carnivore accumulation, but the carnivore marks are not abundant and no evidences comparable with those recognized at panther den sites were found (Borrero et al., 1997).

In contrast, it is not easy to understand the mechanisms behind the faunal accumulation of Layer Vb. Four flakes were found in a tunnel within Layer Vb (Jackson and Arroyo, 1998), which was attributed to the action of rabbits (F.M. Martin, pers. comm.). The faunal composition is similar, but the degree of fragmentation is even higher in Layer Vb. Moreover, all the bones in Layer Vb are coated with the sediment (Prieto, 1999).

Bones in Layer VI are in better condition than those from Va and Vb. They are less fragmented, and only some display manganese (Jackson and Arroyo, 1998; Pardiñas and Martin, in prep.). Jackson and Arroyo carefully excavated Layer Vb and VI at Square D, and concluded that deposition in those layers was not anthropic. They suggest that TA1 was probably a trap for animals before the arrival of humans (Jackson and Arroyo, 1998), an explanation that applies better to Layer VI.

4. Conclusions

Taking into account the many indications of vertical migration of bone, it is necessary to make a distinction between the bones that were recovered in Pleistocene deposits and those which are of Pleistocene age. Independent chronology, together with the analysis of several taphonomic variables and spatial distribution is the minimum required in order to assess the penecontemporaneity of artifacts and bones. Radiocarbon is the only safe way to assign ages to particular elements. The problem of "dating for association," in other words the problem of assigning dates to bones and artifacts accordingly with their presence within dated deposits (Borrero, 1997b), is aggravated in TA 1 due to the presence of important processes of bioturbation. We have presented evidence for the vertical movement of elements, like the *D. avus* mandible found at Layer III but Late Pleistocene in age, or the dating of c. 1300 yr BP on guanaco bones recovered at Layer Va. Summing up, the list of species that can be securely attributed to the Late Pleistocene at TA1 is well supported by the radiocarbon data (Table 1). However, the list of elements is less secure. Even in the cases in which the age of a bone can be defended as Late Pleistocene, humans may not be the main agents contributing to the accumulation.

One of the reasons to be careful in the assessing of the age of specific elements of megafauna is their bearing in the discussion of the Pleistocene extinctions. Hypothesis of human overkill and climatic change compete to explain the timing of the extinctions in Fuego-Patagonia. The scanty evidence of interaction of humans and megafauna at TA1 cannot be used to sustain the case for human overkill (cf. Martin and Steadman, 1999). On the other hand, the existence of a Younger Dryas episode or a cold pulse in the Southern Hemisphere is the best scenario for climatically derived extinctions. However, it is very difficult to analyze the chronological relationships between human occupations, last appearances of megafauna and the climatic signals. In general, they appear to be at least partially coincident, and that the process of human colonization and megafaunal extinction of southern South America took place under very cold conditions. Tres Arroyos 1 is one example of this, in which there is coincidence between the arrival of humans, the extinction of megafauna and the existence of a cold reversal. Under those conditions, and given the present state of knowledge concerning the use of megafauna, opportunistic exploitation of Pleistocene mammals is the best available explanation for the recorded archaeological patterns (Borrero, 1997b). Either scavenging or hunting are indicated in different cases. The former could have been the case specifically for ground sloth and other megaherbivores. In summary, we still do not know what caused the demise of so many species at the end of the Pleistocene, but taphonomic analysis together with an improved chronological framework and revised systematics are helping in the selection of the samples which are useful to discuss these issues.

Acknowledgements

The project was funded by an FONDECYT Grant to Mauricio Massone (Nr. 1960027). I thank to all the members of the Project "Hombre Temprano y paleoambiente en Tierra del Fuego," particularly to Alfredo Prieto and Fabiana M. Martin who also work in the taphonomy of the Cerro de los Onas locality. I am very grateful to Pedro Cárdenas who help me to deal with the bones stored at the Instituto de la Patagonia, and to Mateo Martinic for his support to this study. My taphonomic work was also partially funded by PIP-4596/96 ("Magallania II", CONICET).

References

Alberdi, M.T., Prieto, A., 2000. Hippidion (Mammalia, Perissodactyla) de las cuevas de las provincias de Magallanes y Tierra del Fuego. Anales del Instituto de la Patagonia 28, 147–171.

Arroyo, M., 1998. Restos óseos de Canidae en Cerro de los Onas, resultados preliminares para los sitios TA-1 y TA-14 (30). Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Segundo año, Chile.

Arroyo, M., 1999. Análisis morfométrico de M1 de Canidae de Tres Arroyos. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe Final, Tercer año, Chile.

Behrensmeyer, A.K., 1978. Taphonomic and ecologic information from bone weathering. Paleobiology 4 (2), 150–162.

Borrero, L.A., 1997a. Tafonomía en Cerro de los Onas. Informe Campaña Noviembre 1996. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año, Chile.

Borrero, L.A., 1997b. La extinción de la megafauna en la Patagonia. Anales del Instituto de la Patagonia 25, 89–102.

Borrero, L.A., Martín, F.M., Prieto, A., 1997. La cueva Lago Sofía 4, Ultima Esperanza: una madriguera felina del Pleistoceno tardío. Anales del Instituto de la Patagonia (Serie Ciencias Humanas) 25, 103–122.

Constantinescu, F., Contreras, L., 1998. TA-14 (30): evidencias de una ocupación tardía … y otra temprana? Hombre Temprano y Paleoambiente en Tierra del Fuego. Proyecto FONDECYT No. 1960027. Informe de Avance, Segundo Año, Chile.

Guichón, R.A., Muñoz, A.S., Borrero, L.A., 2000. Datos para una tafonomía de restos óseos humanos en Bahía San Sebastián, Tierra del Fuego. Relaciones de la Sociedad Argentina de Antropología 25, 297–311.

Jackson, D., 1999. Los instrumentos líticos de los primeros cazadores de Tierra del Fuego. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe Final, Tercer año, Chile.

Jackson, D., Arroyo, M., 1998. Excavaciones de los niveles Vb y VI de la Cuadrícula D de TA-1. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Segundo año, Chile.

Laming-Emperaire, A., 1968. Le site Marassi en Terre de Feu. Rehue 1, 133–143.

Laming-Emperaire, A., Lavallée, D., Humbert, R., 1972. Le site de Marazzi en Terre de Feu. Objets et Mondes 12, 225–244.

Latorre, C., 1998. Paleontología de mamíferos del Alero Tres Arroyos 1, Tierra del Fuego, XII Región, Chile. Anales del Instituto de la Patagonia (Serie Ciencias Naturales) 26, 77–89.

Martín, F.M., 1997. Cerro de los Onas: Análisis de roedores de Tres Arroyos 1 (TA1). Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año.

Martín, F.M., Borrero, L.A., 1999. Los pequeños mamíferos de Tres Arroyos 1, Tierra del Fuego, Chile. El caso de los conejos. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe Final, Tercer año, Chile.

Martin, P.S., Steadman, D.W., 1999. Prehistoric Extinctions on Islands and Continents. Extinctions in Near Time. In: MacPhee, R.D.E. (Ed.), Causes, Contexts, and Consequences. Kluwer Academic/Plenum Publishers, New York, pp. 17–55.

Massone, M., 1983. 10400 años de colonización humana en Tierra del Fuego. Infórmese III (14), 24–32.

Massone, M., 1987. Los cazadores paleoindios de Tres Arroyos (Tierra Del Fuego). Anales del Instituto de la Patagonia (Serie Ciencias Sociales) 17, 47–60.

Massone, M., 1988. Artefactos óseos del yacimiento arqueológico Tres Arroyos (Tierra del Fuego). Anales del Instituto de la Patagonia 18, 107–112.

Massone, M., Jackson, D., Prieto, A., 1993. Perspectiva arqueológica de los Selk'nam. Centro de Investigaciones Diego Barros Arana, Santiago.

Masssone, M., Cárdenas, G., Constantinescu, F., Cárdenas, P., Sánchez, R., 1997. Estudios estratigráficos en la Cueva Tres Arroyos 1, Tierra del Fuego. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año, Chile.

Massone, M., Prieto, A., Jackson, D., Cárdenas, G., Arroyo, M., Cárdenas, P., 1998. Los cazadores tempranos y sus fogatas: una nueva historia para la cueva Tres Arroyos 1, Tierra del Fuego. Boletín de la Sociedad Chilena de Arqueología 26, 11–18.

Mengoni Goñalons, G.L., 1987. Modificaciones culturales y animales en los huesos de los niveles inferiores del sitio Tres Arroyos 1 (Tierra del Fuego, Chile). Anales del Instituto de la Patagonia (Serie Ciencias Sociales) 17, 61–66.

Miotti, L., Berman, D., 1988. Mamíferos del Holoceno tardío de Punta Bustamante. Resúmenes de las V Jornadas de Paleontología de Vertebrados 68–69.

Morello Repetto, F., 2000. Treinta años después, una primera aproximación a la Colección Marazzi (Museo Regional, Punta Arenas). Desde el País de los Gigantes. In: Perspectivas arqueológicas en Patagonia. Universidad Nacional de la Patagonia Austral, Río Gallegos, pp. 481–497.

Morello Repetto, F., Contreras, L., San Román, M., 1999. La localidad de Marazzi y el sitio arqueológico Marazzi 1, una reevaluación. Anales del Instituto de la Patagonia (Serie Ciencias Humanas) 27, 183–197.

Muñoz, A.S., 1997. Explotación y procesamiento de ungulados en Patagonia meridional y Tierra del Fuego. Anales del Instituto de la Patagonia 25, 201–222.

Pardiñas, F.J.U., Martín, F.M., Los restos de roedores recuperados en Tres Arroyos 1, in preparation.

Prieto, A., 1997. Arqueofauna del Nivel Va de Tres Arroyos. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año, Chile.

Prieto, A., 1999. Arqueofauna del Nivel Va de Tres Arroyos 1 (Año 3). Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe Final, Tercer año, Chile.

Prieto, A., Canto, J., 1997. Presencia de un lamoide atípico en Cueva Lago Sofía (Ultima Esperanza) y Tres Arroyos (Tierra del Fuego), Región de Magallanes, Chile. Anales del Instituto de la Patagonia (Serie Ciencias Humanas) 25, 147–150.

Prieto, A., Martín, F.M., Arroyo, M., 1997. Excavaciones del sitio TA-14 (30) NE (FONDECYT 1960027). Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año, Chile.

Seguel, R., 1993. Estudios de conservación sobre el patrimonio arqueológico de Tierra del Fuego. XII Región. Perspectiva arqueológica de los Selk'nam. Centro de Investigaciones Diego Barros Arana, Santiago.

Seguel, R., Martínez, I., 1997. Condiciones de preservación del sitio arqueológico de Tres Arroyos, Tierra del Fuego. Proyecto Fondecyt No. 1960027, Hombre temprano y paleoambiente en Tierra del Fuego. Informe de Avance, Primer año, Chile.

Stern, C., 1992. Tefrocronología de Magallanes: Nuevos datos e implicaciones. Anales del Instituto de la Patagonia 21, 129–141.

Tonni, E.P., Politis, G., 1981. Un gran cánido del Holoceno de la Provincia de Buenos Aires y el registro prehistórico de Canis (Canis) familiaris en las áreas pampeana y patagónica. Ameghiniana 18, 251–265.

PERGAMON

Quaternary International 109–110 (2003) 95–111

When Patagonia was colonized: people mobility at high latitudes during Pleistocene/Holocene transition

L. Miotti[a,*], M.C. Salemme[b]

[a] CONICET, Departamento de Arqueología, Museo de La Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina
[b] CADIC-CONICET, C.C. 92. V9410BFD Ushuaia, Tierra del Fuego, Argentina

Abstract

The Pleistocene–Holocene transition was a critical time for the dispersal of human societies all over South America. People looking for places to settle had to accept high environmental variability during the colonizing process. The case studied for this paper is Patagonia (Southern South America), where the oldest dates (ca. 13–10.5 ka BP) have been obtained for the peopling in the Deseado River Basin and Magellan Basin, as well. However, two archaeological sites yielded similar dates on the western side of the Andes (Monte Verde and Tagua Tagua).

Following archaeological and palaeoenvironmental data (palynological, faunal, sedimentological and glaciological information), as well as radiocarbon datings, a hypothesis about the colonization of Patagonia is presented. Analysing the ways and time of colonization for this region, it is remarkable the coincidence of these ages in the centre of the steppe and close to the Magellan Strait, even in the present Tierra del Fuego island, though the eastern Andean foothills seems to be occupied at least two millennia later. It is proposed that independent peopling entries would have occurred both through the Atlantic and Pacific facades, and that the Andean foothills were colonized much later, only when the available spaces allowed it.

1. Introduction

The Pleistocene–Holocene transition was a critical time for the dispersal of human societies all over Patagonian. People looking for places to settle, even temporarily, had to accept high environmental variability at the beginning of the colonizing process (Borrero, 1996, 1999; Borrero et al., 1998; Miotti [1989]1998; Miotti and Salemme, 1999).

Analysing the map of Patagonia and reviewing those radiocarbon dates known for this period (Table 1, Fig. 1), a remarkable concentration appears in the Deseado Central plateau, in the south-central area of Patagonian Region, and in the Magellan Basin, including Tierra del Fuego which before 9000 BP was part of continental Patagonia through two narrow proglacial lakes or meltwater channels; after this age, Magellan Strait opened (Clapperton, 1992; Clapperton et al., 1995; Rabassa et al., 2000). As can be seen, dates for the earliest occupational events in extra-Andean Patagonia and the Magellan basin spread between ca. 13,000 and 10,500 yr BP. On the other side, in the eastern Andean foothills, the earliest human occupations are not older than 9500 yr BP, even most of them oscillate between ca. 8000–7000 BP (Aschero et al., 1992; Gradín and Aguerre, 1994; Aschero, 1996; Civalero and Aschero, 2002; Franco and Borrero, 2001; Civalero and Franco, 2003). Likewise, the absence of early sites in Central Patagonia is recognizable. On the western side of the Patagonian Andes, a third spot with clear evidence of early radiocarbon dates occurs in Chilean Araucanía, where dates between 13 and 10.5 ka BP (Dillehay, 1997) relate Monte Verde site with the hypothesis of the peopling through the Pacific rim (Bryan, 1978; Bonnichsen and Steele, 2000; Bryan and Gruhn, 2003; Miotti, 2003). Then, there is a high concentration of the oldest dates farther south in Patagonia, mainly in three areas: Deseado Central Plateau, in the eastern steppe of the Cordillera; Magellan basin; and the region of the Pacific rim at the western slope Andean Cordillera.

In this sense, the colonization during the Pleistocene/Holocene transition in Southern South America could be correlated with the American process of human

*Corresponding author.
E-mail addresses: lmiotti@museo.fcnym.unlp.edu.ar (L. Miotti), labcuat@satlink.com (M.C. Salemme).

1040-6182/03/$ - see front matter © 2003 Elsevier Ltd and INQUA. All rights reserved.
PII: S1040-6182(02)00206-9

Table 1
Radiocarbon dates for Pleistocene–Holocene Transition of Patagonian Archaeological Sites

Localities	Yr ^{14}C BP	Lab. no.	References
Central Deseado Massif			
Los Toldos			Cardich et al. (1973)
Nivel 11 (Layer 11b)	12,600±650	FRA 98	
Toldense (Layer 9)	8750±480	FRA 97	
Piedra Museo AEP-1	12,890±90	AA-20125	Miotti et al. (1999)
First Occupation U6	11,000±65	AA-27950	Miotti et al. (2002)
	10,925±65	OxA8528	
Transition U6/U5	10,390±70	OxA8527	
Bottom U5	10,470±60	OxA9249	
Second occupation U5/U4	10,470±65	GRA9837	
	10,400±80	AA-8428	
Top U4	9710±105	LP859	
	9230±105	LP949	
Cerro Tres Tetas	11,560±140	LP525	Paunero (2000)
	11,100±150	OxA9244	
	10,915±65	AA22233	
	10,850±150	LP781	
	10,260±110	LP800	
Cueva Casa del Minero	10,999±55	AA37207	Paunero (2001)
	10,967±55	AA37208	
La Mesada	9090±40	Beta 135963	Paunero (2001)
El Ceibo	Ca. 9500		Cardich (pers.comm)
La Martita	8050±90	CSIC-506	Aguerre (1987)
	7940±260	CSIC-506	
Andean Foothills			
Cueva de Las Manos	9320±90	CSIC-138	Gradín and Aguerre (1994)
	9300±90	CSIC-385	
Arroyo Feo	9410±70	CSIC-514	Gradín and Aguerre (1994)
	9330±80	CSIC-396	
	8610±70	CSIC-515	
Casa de Piedra 7	9730±100		
	9100±150	NR*	Aschero (1996)
	8300±115	NR	
		NR	
Chorrillo Malo	9740+50	GX-25279	Franco and Borrero (2001)
	9690+80	CAMS 71152	
Baño Nuevo 1	11,480±70	CAMS-32685	Mena et al. (2003)
	8850±50	CAMS-36633	
	8880±50	CAMS-36634	
Magellan Basin			
Fell I	11,000±170	I-3988	Borrero (1999)
	10,080±160	I-5146	
	10,720±300	W-915	
Fell III			
Cueva del Medio	10,930±230	Beta-39081	Borrero (1999)
	10,550±120	GrN-14911	
	10,310±70	GrN-14913	
	9770±70	Beta-40281	
	9595±115	PITT-0344	

Table 1 (*continued*)

Localities	Yr ^{14}C BP	Lab. no.	References
Cueva Lago Sofía 1	11,570±60	PITT-0684	Borrero (1999)
Alero Marazzi	9590±210	GIF-1034	Morello (2000)
Tres Arroyos	10,280±110	Dic. 2732	Massone (2001)
	10,420±100	Dic. 2733	
	11,880±250	Beta 20219	
	10,600±90	Beta 101023	
	10,580±50	Beta 113171	
	10,575±65	OxA-9245	
	10,630±70	OxA-9246	
	10,685±70	OxA-9247	
	11,085±70	OxA-9248	
	10,130±210	OxA-9666	
Central Patagonia			
Campo Moncada 2	5080±100	AC 666	Bellelli (1988)
	4885±135	AC 1110	Pérez de Micou et al. (1992)
Northern Patagonia			
Monte Verde II component			Dillehay (1997) Table 3.1, pp. 43–44 for lab. Codes
MV-6 Layer	12,780±240–11,920±120		
MV-5 Layer	11,800±80–10,860±130		
El Trébol Cave	Ca. 8000–10,000	Without ^{14}C date	Hajduk et al. (2002)
Cueva del Manzano, Arroyo Corral	Ca. 10,000	Without ^{14}C date	Hajduk (1998)
Cuyín Manzano	9920±85	KN-1,432	Ceballos (1982; p. 31)
Traful 1	9285±105	GX-1711G	Crivelli Montero et al. (1993)
	9430±230	INGEIS 2676	
Cueva Epuyán	9970±100	LP-213	Crivelli et al. (1996)
Casa de Piedra	8620±190	I–12,067	Gradín (1984; p. 42)
	7560±230	I–12,159	
	6080±190	I–12,067	

dispersal, the ways of adaptations and the environmental stress during that period, and beyond it. Discontinuity in the occupation could be attributed to changing climates by that time (that is changes or extinction in fauna and flora, disappearance of some animal or vegetal species and increasing of others, as well), or simply by the delay in the occupations of some regions, but it could also be related to a sampling bias (Borrero, 1999). However, early explorations in the eastern Patagonian Andes could have failed due to the rigorousness of those environments (it would have been a periglacial zone during Late Glacial times, so space was inappropriate for human settlements), probably even worse at that time because of the continentality of the area by the end of the Pleistocene; thus, the archaeological record could be of very low visibility or even perhaps, inexistent.

The scope of this contribution is to review the archaeological evidence, radiocarbon datings and palaeoenvironmental records available for the first stages in the peopling of Patagonia. The main questions to be answered are: Did the first colonizers disperse to the interior of the continent from both ocean rims? Did they take several routes, involving the ocean rims and hinterlands? or did they take the hinterland as a main path and then disperse towards the maritime coasts, taking into account that the coasts were farther east by that time and the evidence can be submerged?

2. What is the Pleistocene/Holocene transition?

At least two volumes of "Quaternary International" (1998, 1999) were devoted to this transition and the

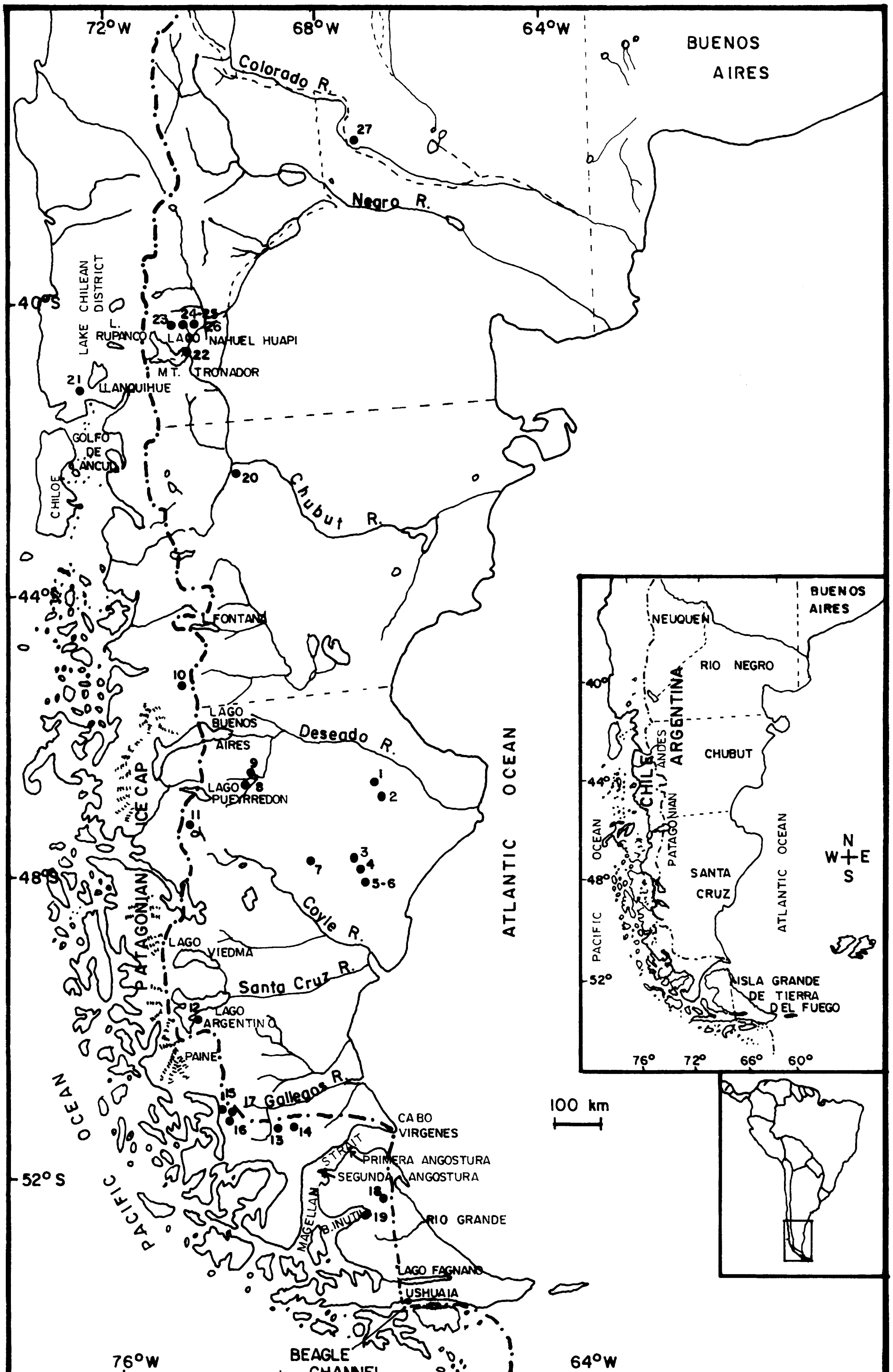


Fig. 1. Location of archaeological sites mentioned in the text. (1) Los Toldos, (2) Piedra Museo, (3) El Ceibo, (4) Cerro Tres Tetas, (5) and (6). La María: Minero Cave and La Mesada; (7). La Martita, (8) Cueva de la Manos Pintadas, (9) Arroyo Feo, (10) Baño Nuevo, (11) Casa de Piedra 7, (12) Chorrillo Malo, (13) Fell Cave, (14) Palli Aike Cave, (15) Cueva del Medio, (16) Lago Sofía 1, (17). Mylodon Cave, (18) Tres Arroyos, (19) Marazzi, (20) Piedra Parada: Campo Moncada 2, (21) Monte Verde, (22) El Trébol, (23) Arroyo Corral, Cueva del Manzano, (24) Cuyín Manzano, (25) Traful Cave, (26) Epuyán Grande, (27) Casa de Piedra.

human population of the world. According to the marine oxygen isotopic record, the Pleistocene/Holocene Transition involves the few millennia that spanned the end of the Late Glacial (Oxygen Isotope Stage 2) and the early Postglacial (before the Optimum Climatic, Oxygen Isotope Stage 1), equivalent to the 13–8 ky BP period (Rabassa and Clapperton, 1990; Straus and Eriksen, 1998). In agreement with the geological sciences (glaciology and sedimentology especially), this period involves un-stable climatic conditions, which produced dramatic changes in the biota and landscapes. The glaciers began to recede and climate warmed. Even during this climatic tendency, at least two events of new glacial advances were detected throughout the world.

Patagonia is one of the regions of the Southern Cone where two main cooling episodes seem to have occurred, likely related to the Older and Younger Dryas episodes of the Northern Hemisphere, respectively (Coronato et al., 1999), even though without a strictly radiocarbon dating correspondence with those (Heusser, 1998; Tonni et al., 1999, among others). In fact, Quaternarists concur in the existence of different cooling episodes because of minor glacier advances for the period 11–1 ka BP. Therefore, this must be taken into account in analysing why some habitats could have been colonized before others.

We share this idea of a period of progressive climatic amelioration, which has been the period when people spread around the South American hemi-continent. After the analyses of radiocarbon dates and their geographical and temporal distribution, we reinforce the idea that the ways for human colonization in southernmost Patagonia would have been long and winding roads for the first Americans.

3. The role of palaeoenvironments in Patagonia (Southern Hemisphere high latitudes) for human settlements

3.1. The conditions for peopling at the late glacial palaeoenvironments

The Last Glacial Maximum in Southernmost South America has been considered as a period in which global climatic conditions underwent significant and recurrent changes, especially during the Late Glacial between 16 and 10 ^{14}C ka BP (Fig. 2; Coronato et al., 1999). Tundra environments were then dominant in Southernmost South America, progressively evolving during ice recession and changing progressively to forested areas in the Andean Cordillera (Heusser, 1998; Heusser et al., 1999) or steppe expansion in the eastern plains. Shrub steppe or herbaceous steppe depended on variations in temperatures and precipitations during Late Glacial and Early Holocene times (Páez et al., 1999, 2001; Borromei, 2002).

A time delay of 2–3 ka on similar stages of vegetation recovery after deglaciation is estimated from North to South, and even from West to East. Probably, this delay was due to the greater climatic continentality in the inland areas (Roig et al., 1993, 1995), taking into account the major extent of the landmass in the hemi-continent during this time (Tonni et al., 1999; E. Tonni, pers. comm., 2002). Changes in vertebrate fauna have also been recorded from the palaeontological and archaeological record for this period, in Patagonia and Pampa as well (Tonni and Cione, 1999; Miotti and Salemme, 1999, among others).

3.1.1. The environmental history after 15–14 ka ^{14}C BP advance

Evidence along the Andes Range suggests that mountain glaciers readvanced at ca. 15–14 ^{14}C ka BP (Fig. 2). This is coincident with Broecker and Denton's (1990) observations for the Northern Hemisphere, where the ice margins would have advanced within 100 and 200 km from their Isotopic Stage 2 boundary. For the purpose of this paper, the Chilean Lake District results an area of special focus because of the interesting regional geological and palaeoenvironmental data that could support archaeological information on the early peopling along the western Andean slope.

Llanquihue III Drift (Porter, 1981; Mercer, 1984) reflects the advance of a piedmont glacier that occupied Lake Llanquihue, Reloncaví Sound and the Gulf of Ancud ca. 15–14 ka ^{14}C BP. In Puerto Varas, the radiocarbon age of organic matter contained in lake bottom strata suggests that the glacial advance took place between 15 and 14.5 ^{14}C ky BP, peaking around 13 ky BP (Porter, 1981). However, the area where the Monte Verde site is located (Fig. 1) would have been free of ice immediately afterwards, since the earliest occupations have been dated between 13.2 and 11 ky BP (see Table 1 and Fig. 3a; Dillehay, 1997). At the same latitude, but on the eastern Andean slope, a glacial advance of similar extension and age has not been demonstrated yet (Rabassa and Evenson, 1996). Therefore, palaeolimnological studies suggest that regional deglaciation conditions were maintained and propose that after the Last Glacial Maximum (Fig. 2), a great palaeolake would have covered the present basins of Lake Nahuel Huapi and Lake Mascardi generating the present lacustrine system ca. 14–13 ^{14}C ky BP (del Valle et al., 1996). Later on, between 11,400 and 10,200 BP, a new glacial readvance has been dated in the proglacial Lake Mascardi (Ariztegui et al., 1997).

In agreement with this data, recent archaeological information from El Trébol Cave in the surroundings of Lake Nahuel Huapi (Hajduk et al., 2002; Fig. 1) indicates that this forested and lacustrian area could

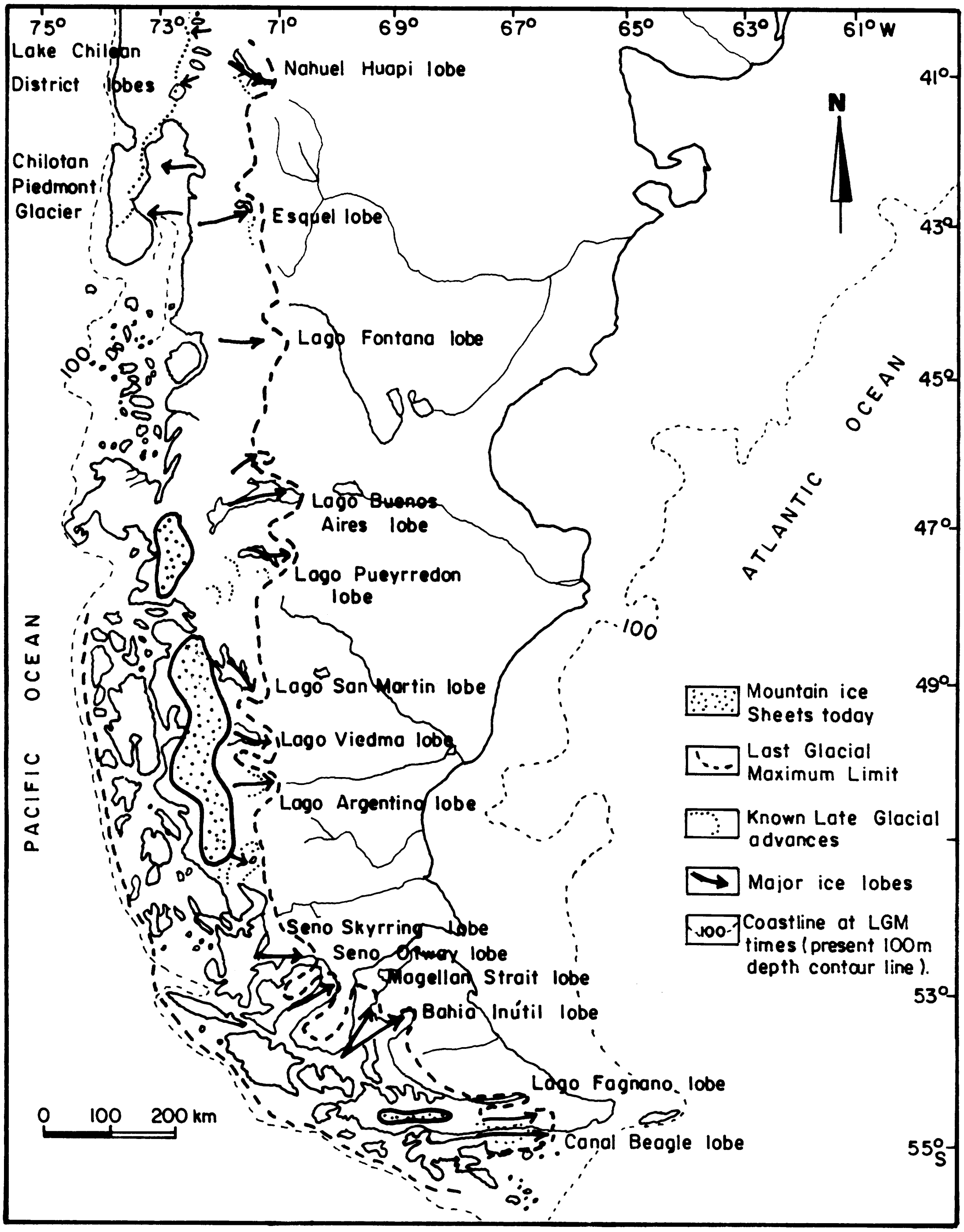


Fig. 2. Map of Last Glacial Maximum and Late Glacial in Fuego-Patagonia (after Coronato et al., 1999)

have been occupied by humans ca. 8–10 ky BP. This could imply an ice-free territory with available land masses and water sources in Northern Patagonia 2000 yr later than on the Pacific slope. However, eastwards but at the same latitude, in the steppe area, three caves yielded radiocarbon dates ca. 10,000 yr BP: Cuyín Manzano (Ceballos, 1982), Traful 1 and Cueva Epullán (Crivelli et al., 1993, 1996) (see Fig. 1 and Table 1, Northern Patagonia). In the Arroyo Corral valley, east of Bariloche, the archaeological site Cueva del Manzano has yielded several occupational levels dating from the Holocene. As well, in the basal levels (approximately 3.10 m in depth) some bone remains of extinct fauna were recorded associated with a few cultural remains (Hadjuk, 1998), but unfortunately there are no radiocarbon dates yet.

In the Southern Patagonian Andes, evidence of the Lanquihue III glacial advance was also found.

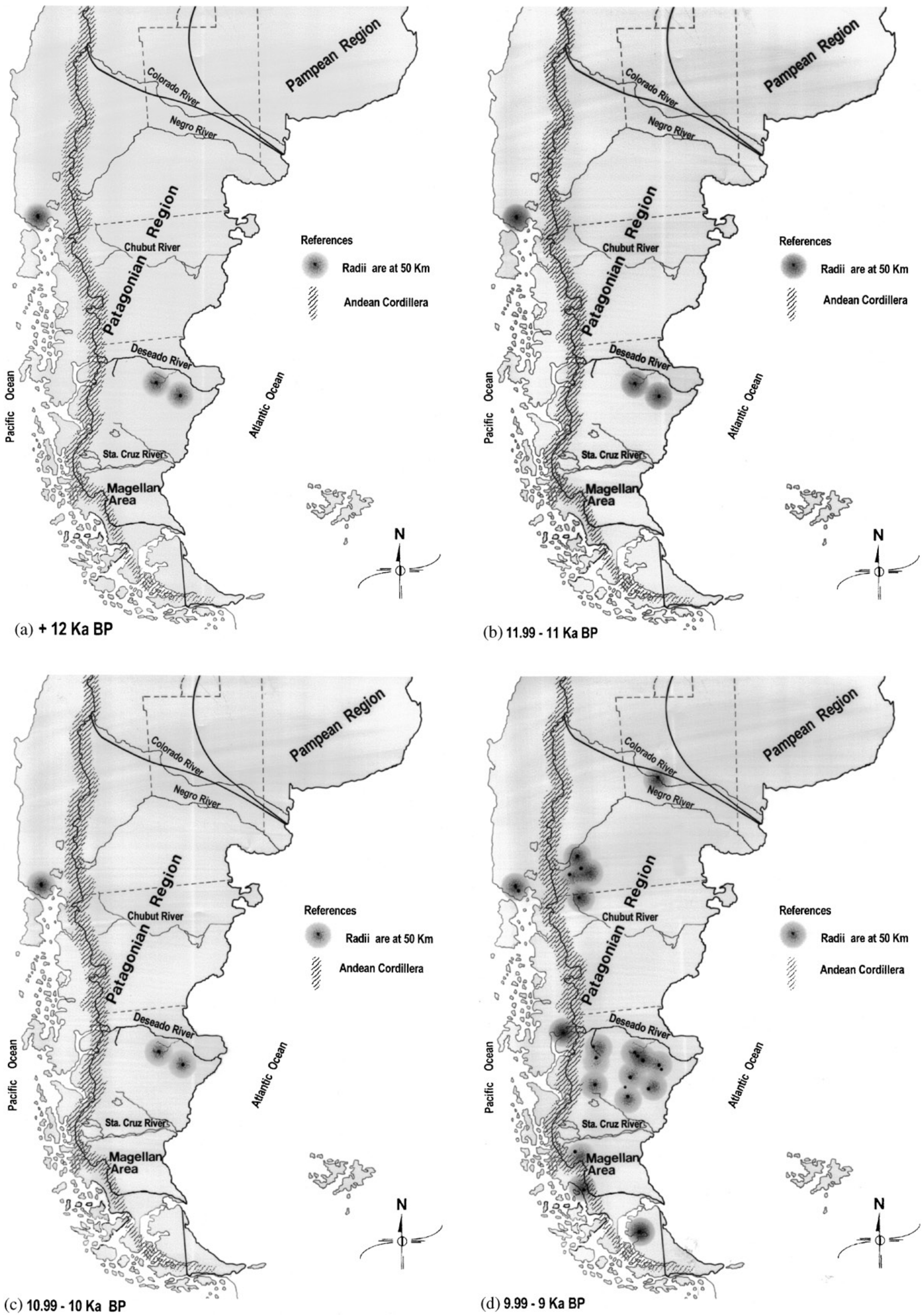


Fig. 3. Radiocarbon dispersion over Patagonia for the Pleistocene–Holocene transition. Radii represent 50 km (sensu Tolan-Smith, 1998). (a) 13–12 millenium, explored landscapes for beginning of colonization in Atlantic and Pacific façades. (b) 11,99–11 millenium, colonized landscapes. (c) 10,99–10 millenium, effective human colonization. (d) 999–9 millenium, consolidation territorial phase: human groups move towards both sides of Andean Cordillera and probably from north to south.

Southeast of the South Patagonian Icefield, radiocarbon ages have been obtained at the base of peat bogs inside the morainic arcs. They gave a minimum age for the ice recession at 11.3 ^{14}C ky BP (Clapperton, 1993; Clapperton et al., 1995). Westward, in the Chilean channels, radiocarbon ages of 12,960 and 11,590 yr BP have been obtained at the base of peat bogs (Ashworth et al., 1991). These dates indicate the presence of low altitude valley-glaciers after the LGM (Fig. 2). As well as farther north, this evidence could be an indicator of available landscapes for humans and biota to settle in. Some of these radiocarbon dates correlate with others from archaeological sites such as Cueva del Medio, Lago Sofía 1 (Fig. 1), and even Mylodon Cave, in spite of the taphonomic history related to the latter.

3.2. 12–10 ^{14}C ka BP: time for human colonization?

In spite of the fact that a warming trend after 14,000 BP has been demonstrated not only in pollen profiles, but also in the analysis of beetle fauna (Hoganson and Ashworth, 1993) and in the glacial features (Clapperton et al., 1995), a period of atmospheric cooling towards the end of the Late Glacial in southernmost South America is a matter of conjecture according to Clapperton (1993), but it has been recognized in some areas.

In that sense, several palynological studies in the Northern and Southern Patagonian Andes depict cold–wet climatic conditions between 11 and 10 ^{14}C ka (Heusser and Rabassa, 1987; Heusser, 1994), whereas, as has already been mentioned, the studies on fossil beetles (Ashworth et al., 1991; Hoganson and Ashworth, 1993) and Markgraf's (1991, 1993) palynological work suggest instead that the climate has remained relatively warm since 12.8 ^{14}C ka BP, interpreting those short-term vegetational changes as a response to local climatic events. Bennett et al. (2000, p. 325) argue that "there was no cooling and that the Younger Dryas Chronozone (YDC) was a period of continuing forest development and increasing diversity" based on palynological, sedimentological and chronological records from sediments of small lakes at 44–47°S, in southern Chile.

"The *Nothofagus* forest appears poorly represented until 13,000 BP, when the association *Nothofagus*–*Empetrum*–*Gunnera*–Gramineae–Cyperaceae is dominant in Tierra del Fuego. At lat. 50°S, Markgraf (1993) observed an expansion of the forest within the grassland environment starting at 12.5 ^{14}C ka BP and replacing peatlands" (Coronato et al., 1999, p. 84). By that time, evergreen *Nothofagus* became a closed forest at 41°S, in the Southern Chilean Lake District (Heusser et al., 1999), meaning similar conditions to the present ones and coincident with early human occupations along the western Andean slope.

Scarce palynological studies have been done in the Patagonian steppe environment. The pollen record from Los Toldos Locality (caves 2 and 3; Fig. 1, Table 1), in the Extra-andean plains, showed a shrub steppe with a high proportion of *Ephedra* estimated between 12.6 and 11 ka BP, while cold conditions and the increase in precipitations are reflected in pollen records of the grass steppe between 11 and 10 ka BP (Páez et al., 1999, 2001). Therefore, this recent palynological work in Los Toldos Locality is based only on one radiocarbon date from the lowest level, 12.6 ka BP (see Table 1; Fig. 3a); this is not reliable today (Borrero, 1996), because it was performed with dispersed charcoal particles of two artificial archaeological levels (11a and 11b, Cardich et al., 1973), which in fact join cultural and faunal materials corresponding, likely, to different occupational levels. The other radiocarbon date, 8750 yr BP (Table 1), dates another context, which does not contain extinct fauna. As Páez et al. (1999) estimated, after 10 ka BP, the shrub steppe began to dominate again the plains, replacing the grasses of the end of the Pleistocene.

In the case of La Martita (Fig. 1, Table 1), an environmental change is detected around 8 ka BP from a palynological and faunal point of view. Remains of a species related to body waters (*Lutra* sp.) like streams, lagoons or lakes, have been registered in the Lower Component of this site (Aguerre, 1982; Table 1). In fact, this carnivore presently inhabits Cordilleran lakes but its presence is not recorded in the plateau. However, the record of *Lutra* in the steppe could be related to a basin with much more water than it has at present, where there is a salt lake. Thus, a more humid pulse ca. 8 ka BP can be inferred (Miotti [1989]1998) though it cannot be estimated how long it lasted, since the other ^{14}C dates provide a chronology for Middle Holocene occupations.

The archaeofaunal context from Los Toldos level 11 and Piedra Museo Unit 6 (12.8–11 ka BP, see Table 1) are very similar, and in both cases they are indicative of grassland environments. However, in the radiocarbon dating of Los Toldos, part of the dated material comes from level 11b where the faunal component is different from that of level 11a (Miotti [1989]1998). It is impossible to check if the change in environmental conditions to a gramineous steppe in this sector of central Plateau is consistent with the proposed radiocarbon dating. Studies of finer details and new radiocarbon datings are needed in Los Toldos Locality, because its average dating makes it difficult to precisely ascertain its antiquity.

The pollen analysis in Piedra Museo has a much better radiocarbon control. A similar faunal composition to that of Los Toldos level 11, for the lowest level of AEP-1, dated at 12,890 ^{14}C yr BP (see Table 1; Fig. 3a) also indicates an increase of grass by that time. Though this date has already been discussed in

Miotti et al. (2002), it is reliable for the beginning of the rockshelter occupation. The other dates, one of them performed on a bone of *Hippidion saldiasi*, are located around 11 ka BP (Fig. 3b). This equid is one of the three species recorded at those initial levels that indicate an open grassland environment. It is associated with *Lama gracilis* and *Rhea americana*, these being also grazing species. In the pollen profile, two environmental changes are observed. The first one, ca. 11 ka BP, was probably due to an increase of effective moisture and cold conditions while the second one, ca. 9.5 ka BP, was interpreted "as an increase in temperature and precipitation varying within modern ranges" (Borromei, 2002).

Similar dates around 11 ka BP for the initial occupations were obtained in two sites located at the southern border of the Central Plateau, Cerro Tres Tetas and Cueva Casa del Minero (Paunero, 2000, 2001; see Table 1, Figs 1 and 3a–c), where some extinct species were also recorded.

Therefore, the interdisciplinary studies in this central basin in Southern Patagonia would indicate an increase of humidity and/or a temperature elevation, which could point to improved hydrological efficiency due to a decrease of evaporation for the period 11.5–11 ka BP. An amelioration in the conditions at least in this sector of the Deseado river Basin, during the end of Oxygen Isotope Stage 2 is thus inferred. The evidence indicates that this basin could have concentrated more humidity, and as a moist place could have been an appropriate refuge for fauna and people (Miotti et al., 1999; Miotti and Salemme, 2001; Zárate et al., 2000; Borromei, 2002), while the surroundings, especially the higher sectors, could have been more arid, in agreement with the conditions in an extraglaciated area during a glacier advance.

Considering the geological features, in certain valleys of the Patagonian Andes, morainic arcs have been identified occupying an intermediate position between those representing the Last Glacial Maximum and those corresponding to the Neoglacial events. In several tributary valleys of Lake Nahuel Huapi (Fig. 2), Rabassa (1983) recognized several morainic arcs, younger than 14 ^{14}C ka BP, located downstream from well-identified Neoglacial moraines. Farther south, at Lago Argentino (Fig. 2), the moraines of Punta Bandera and Lago Rico occupy a similar intermediate position. Deglaciation there would have begun ca. 10,400 yr BP (Strelin and Malagnino, 2000), although three readvances would have occurred ca. 8500, 8000–7000 and 5800–5500 (Wenzens, 1999). Considering that these are only minimum ages, it is possible that the oldest ones belong to the Late Glacial (Strelin et al., 2002). This data could be coincident with later human occupations in this sector of the Andean foothills (Civalero and Franco, 2003; Figs. 1 and 3c–d, Table 1).

In the southern margin of the Beagle Channel, near Isla Gable, a radiocarbon age of 12,700 ^{14}C yr BP was obtained at the base of Caleta Róbalo peat bog. Puerto Harberton peat bog gave ages of 14.6 and 13.1 ka BP at its base (Heusser, 1994). This has been interpreted as a minimum age for ice recession. Radiocarbon dates of basal peat on the Pista de Ski Drift and at the Punta Pingüinos Cliff have been used to establish its chronological limits between 11.7 and 10.8 ka BP (Rabassa et al., 2000). Palynological analysis from Pista de Ski and Ushuaia 2 peat bogs, indicates cold climates during the Late Glacial and Younger Dryas (Heusser, 1998) for this latitude. Palaeotemperature analysis from marine waters from Ushuaia Bay demonstrates several cool periods during the Holocene, as well (Obelic et al., 1998). Some records of charcoal particles in several pollen profiles from different peat bogs allowed Heusser (1994, 1998) to infer human activities related with fire management by the end of the Pleistocene in these high latitudes, when forest was not completely developed. However, there is still no archaeological evidence available to prove the hypothesis of an early colonization in the Beagle Channel, the earliest dates being ca. 6800 BP (Orquera and Piana, 1999).

Volcanic ashes detected in different Patagonian and Magellan sites are other important evidence to be taken into account. These tephras have been dated from several sources and yielded datings that in cases could be related to occupations or the disappearance of occupations in caves all over Patagonia, especially during the end of Early and Middle Holocene.

Thus, Auer's Tephra I (Auer, 1974) probably correlates with the Reclus volcano eruption estimated around 12,480 BP, though Auer dated it in 9380 and 8905 BP in Tierra del Fuego. The ashes of this eruption could be correlated with the ash level identified at Tres Arroyos site, in northern Tierra del Fuego (Figs. 1 and 3a–c, Table 1) where an early occupational level has been recorded (Stern, 1992; Massone, 1999). However, another ash erupted from the Reclus volcano has been observed in a core from Represa Porvenir (in Chilean Tierra del Fuego) and dated between 14,150 and 14,990 yr BP (Stern, 1990, 1992). The Reclus volcano is the source of Late Glacial tephras in Tierra del Fuego and southern South America, but it must be considered that they do not correspond to a single synchronous event. Other evidence of volcanism has been detected in pollen profiles from the Southern District Lake in Chile (Heusser et al., 1999), and in several archaeological sites, mainly caves in Patagonia. These ash layers sometimes seal occupational events corresponding to the Pleistocene/Holocene transition.

In spite of the fact that volcanic processes have been mainly related to the Andean Ranges, they could have been an important factor together with the cooling episode equivalent to the Younger Dryas to explain our hypothesis that the Patagonian Cordillera area was not available for humans around the Pleistocene/Holocene transition, while the plateaus and coastal areas were free. A recurrent phenomenon by 9 ka BP appears in most of the caves in the regions: roof collapses, which have generated true seals of previous human occupations and are coincident with actual occupational hiatuses. These shelters were recurrently occupied later.

3.3. What happened after 10.0 ^{14}C ka BP?

The alpine environments of the Fuegian Andes were occupied by valley lakes, formed by a general recession after 10 ^{14}C ka BP during the first millenium of the Holocene (10–9 ka ^{14}C BP) (Coronato, 1995). These conditions probably existed in other areas of the Patagonian Andes, but their development was related to local palaeoglaciological and geomorphological characteristics. The palaeoenvironmental conditions during deglaciation were transitional between forest/steppe and open forest, with high levels of non-arboreal components (Markgraf, 1993), in the mountain areas and foothills. According to Heusser (1994), the forest community begins to develop as isolated groups in the grassy steppe. These transitional conditions may have lasted until the Middle Holocene, when forest essentially took over (Heusser and Rabassa, 1995) in the northern area of Tierra del Fuego. In the steppe area, variations could have been passed from shrub steppe to grass steppe and viceversa, depending on the increase or decrease of precipitations and temperature. Instead, some periglaciated areas were available for human occupations by 9 ka BP, as the records in Chorrillo Malo, close to Lago Argentino and Casa de Piedra 7, in the area of Lago Posadas have shown (Civalero and Franco, 2003; Franco and Borrero, 2001; Figs. 1 and 3; Table 1). Probably this period corresponds to a climatic amelioration, which in the steppe areas of Patagonia was recorded as a grass steppe (Miotti and Salemme, 2001; Paunero, 2001; Borromei, 2002). There, it could also coincide with the beginning of sea level rise and, consequently, with a continentality decrease.

During the Middle Holocene, the environmental conditions inferred from palynological studies indicate a strong climatic amelioration between at least 8.5 and 6.5 ^{14}C ka BP, both in the Northern Patagonian Andes (in the Chilean Lake District) and in the Fuegian Andes, where the mean annual temperatures increased at least 2°C above present conditions (Heusser, 1989a, b). Based on pollen analysis in the area of Río Pinturas (North-western Santa Cruz, Fig. 1) dry conditions and an increase of temperature have been suggested from 7.3 to 2.5 ^{14}C yr ka BP, with higher moisture during the interval 6.5–5.5 ^{14}C yr ka BP (Gradín and Aguerre, 1994). However, it seems to be certain that after 8.5 ka BP, during the Consolidation Territorial Phase (Miotti and Salemme, 1999), the environment was able to support a larger population, as the sites dated in this period have proved.

The most significative palaeoclimatic and geomorphological event that took place during this period was the Holocene marine transgression (from ca. 8–7 to 4.5 ka BP), as it has been already mentioned. It probably submerged the evidence of other early sites from the Colonization Phase. However, some other events, like volcanic eruptions, occurred during the Holocene and have been recorded in archaeological caves and open air sites, as well.

4. Archaeological record and ^{14}C datings of Patagonian sites during the Pleistocene/Holocene transition

For the purpose of this contribution, the archaeological record of the mentioned sites is not included herein due to space limitations, but the appropriate references are quoted in Table 1. It is assumed that all the contexts from sites listed have similarities, as well as differences, from a technological viewpoint, associated archaeofaunas, radiocarbon dates, strategic places of settlements, inferred functions, and ecological and taphonomic histories. According to this, a great archaeological and environmental variability is remarkable, particularly considering a huge topographic feature as the Andean Cordillera. We assume that the Andes are and would have been then an important barrier not only for plant and fauna communities, but also for human populations exploring and colonizing new habitats during and/or after the last glaciation. The human responses could have been different on both sides of the Andes.

In this sense, we approach the study of human dispersal and colonization in the Patagonian region in temporal blocks of 1000 yr that involve the radiocarbon datings with two standard deviations (Table 1), using as spatial units areas of 10 km^2. This methodology was employed by Tolan-Smith (1998) to explain the process of colonization, abandonment, and resettlement of the British Isles.

Only those records of the Pleistocene/Holocene transition have been taken into account, even though many of the sites have longer chronological sequences. However, some records of the Middle Holocene have been included in the table to discuss the absence of early dates in key areas of Eastern Patagonia.

5. Piedra Museo rockshelters and the neighbourings

The rockshelter AEP-1, Piedra Museo Locality (Fig. 1), is situated in the central plateau of Santa Cruz

Province, Argentina, at lat. 47°53′42″S and long. 67°52′04″W. Archaeological materials were recovered from Pleistocene and Holocene stratigraphic layers. The faunal and cultural remains, as well as the rock art have allowed to interpret the palaeoenvironmental evolution of this endorheic basin, the taphonomy, the subsistence systems, and the use of the Patagonian region by the earliest hunter–gatherer populations.

Two strata have been defined in the site. The upper one is an aeolian unit (U1) and the second stratum is a palaeosol containing five units (from the top to the bottom, U2 to U6) (Zárate et al., 2000). Two occupational events were confirmed through radiocarbon dating (Table 1). Unit 6, dated between 12,890 ± 90 ^{14}C yr BP and 10,925 ± 65 yr BP ^{14}C yr BP (Fig. 3a–c), illustrates the initial Pleistocene occupation in southernmost Patagonia. Unit 4/5, dated between 10,400 ± 80 ^{14}C yr BP and 9230 ± 105 ^{14}C yr BP (Fig. 3c–d), represents the stage of effective colonization of the region. The Holocene context of Unit 2 was dated at 7670 ± 110 ^{14}C yr BP, and is related to the stage of territorial consolidation of the local hunter–gatherer societies; it is not discussed here.

From a zooarchaeological point of view, a greater biodiversity was identified in U6 as compared to U4/5. Unit 6 includes a higher proportion of extinct taxa. Likewise, there are differences between U5 and U4. There are more extinct species in U5 than in U4. Species as *Hippidion saldiasi*, *Lama (V.) gracilis*, *Rhea americana*, *Mylodon* sp., *Lama guanicoe* and medium-sized birds are present in those three units in different percentages (Miotti et al., 1999; Miotti and Salemme, 2001), There are no extinct species in Unit 2, where *Lama guanicoe* dominates the spectra. The disappearance of taxa from U6 to U4 has been interpreted as a differential extinction of the Pleistocene fauna, based on the comparative studies of other archaeological contexts from the Patagonian region, of similar antiquity (Miotti and Salemme, 2001).

Remains of U6 and U4/5 have been identified related to chronologically separated different depositional events, as suggested through radiocarbon dating, different depths below the surface of the site, and changes in the sedimentology of the units. Both depositional zones contain archaeological remains that are interpreted as hunting events corresponding to two different occasions in the human colonization of the region. AEP-1 is the first site in Extra-Andean Patagonian region of Argentina where fluted projectile points, namely fishtail projectile points (FPP), were found in this oldest major component, associated with that high-resolution faunal assemblage and bone instruments. According to the faunal assemblage, stratigraphic position, and radiocarbon dating, U2 represents the latest occupation in the site, during the Holocene.

"Piedra Museo has been interpreted as a special place where colonizers took advantage of an opportunistic strategy, probably hunting prey around the nearby lagoon or profiting there from dead animals, partially butchering them in the closer rockshelter, but transporting pieces to another place, not discovered yet. Lithic raw materials were obtained within a local range, not farther than 20 km away. A forager strategy governed hunter–gatherers' lives until different environmental conditions developed, such as the increasing evolutionary success of gregarious species (camelids and rheids), and the decrease of fresh water sources; as well, the increase in population provided new characteristics" (Miotti and Salemme, 2001).

5.1. *The regional level: an inter-site analysis*

From a regional point of view, Piedra Museo is seen as part of a complex network, a similar sociocultural system, together with El Ceibo, Los Toldos, 3 T and La María localities, at least, for the Colonization Phase (Miotti, in press). This main nucleus with the oldest occupational events in the Deseado Basin (Figs. 3a–c) could be related also with very old rock art, corresponding to the Late Pleistocene (Cardich et al., 1973; Cardich, 1987; Miotti, 2003; Miotti and Carden, 2001). Thus, a differential use of the space has been postulated, which is much more evident later on, during the Territorial Consolidation Phase, as is shown in the Upper Component at AEP-1 during the Middle Holocene.

A similar locus of kill and butchering as Piedra Museo occurs only in other locality in the Southern Cone, associated with FPPs and mastodon bones from a hunting event; the Tagua Tagua site, in Central Chile (Núñez et al., 1994). In addition, the technological organization in the early component at AEP-1 could be related to the Nivel 11 and the Initial Toldense "industries" from Los Toldos and El Ceibo localities (*sensu* Cardich, 1987; Fig. 1). Informal tools of Piedra Museo are technologically equivalent to those of Nivel 11 in Los Toldos. Meanwhile the formal tools could be the equivalent to those Cardich defined as Toldense industry (Miotti, in press, 2003; Miotti and Cattáneo, 2002). Although in Los Toldos and El Ceibo caves FPPs have not been recorded in stratigraphic contexts, and in spite of the fact that "Cardich … mentions a surface find near the El Ceibo site, but no measurements, illustrations, or morphological information are provided" (Politis, 1991, p. 290), the lithic technology of all the other artifacts seems to be similar. Likewise, extinct species of megamammals were associated in both site contexts. In addition, in Los Toldos Cave 3, *Rhea americana* has been found in association with the Toldense (Cardich and Miotti, 1983; Tambussi and Tonni, 1985; Salemme and Miotti, 1987), confirming that the "big ñandú" was present up to ca. 9.0 ka BP, on the central plateau of Santa Cruz, and left its niche there to restrict its corology farther north, in more grazy areas, like the Pampas.

The Magellan Basin has been an appropriate area for human installation at earliest times. Other sites identified as kill sites, kill and butchering sites, or multiple activities sites are located there, on the Chilean side (Fig. 1, Fell Cave, Palli Aike Cave, Cerro Sota, Cueva del Medio I and III, Lago Sofía 1 and Mylodon Cave). Extinct species are associated in all of these contexts, except *Rhea americana,* which is absent. The lithic technology is represented by unifacial and bifacial technology, although fishtail projectile points are absent from Mylodon Cave. The occupations at these sites were also dated between 12 and 8.5 ka BP (Miotti and Salemme, 1999, 2001).

Thus, a similar environmental panorama could be found in different areas in Patagonia by the time of the Initial Colonization Phase. The archaeological associations suggest that hunter–gatherers were moving camps recurrently following "forager" strategies. Colonizers co-inhabited the area with the last megamammals, under a strong environmental stress at the end of the Pleistocene and the beginning of the Holocene in the Southernmost South America. In any case, those societies learned how to live under such conditions, using generalized strategies and building up their own social environments.

The situation seems to be something different, though sharing the idea of colonization, in the Andean foothills and northwestern sector of Santa Cruz province. No extinct fauna was recorded, but technology, raw materials and other resources were comparable at this stage, although the radiocarbon dates indicate a later entry to this area (see Table 1, Fig. 3c–d), as well as in Northern Patagonia (Fig. 3b).

In contrast, once the Transition finished after 8.5 ka BP and during the Territorial Consolidation Phase, people became "collectors", with a more specialized strategy that focused upon one or two main resources; and in this interval, the resources were brought back to a residential base camp. This could be due, at least partially, based on the increase in seasonality, and because of a decrease in continentality after sea level rise.

"According to the idea of one of us (Miotti, 1996), it is thought that the social landscape of the region was changing during the Holocene, and the relationships among the hunter/gatherer groups during the Territorial Consolidation Phase were supported by alliances and exchange" (Miotti and Salemme, 2001). Anyway, the group mobility continues as high as at the end of the Pleistocene, even though the increasing density of population. The plasticity of these societies plus a high technology, the communication network, and the existence of vacant ecological niches facilitated and favored the success of territorial occupation.

6. Discussion

The Southern Hemisphere is the most maritime portion of the Earth (Miotti [1989]1998, 2003). Therefore, the marine wind circulation and the location of cyclons and anticyclons are different from that of the Northern Hemisphere, which shows larger continental masses.

However, during the Pleistocene/Holocene transition the continentality of all the Southern Hemisphere was maintained, in agreement with the lower sea level. The question is how did this continentality influenced or acted on the peopling of South America?

According to this, the plains that extend to the Atlantic coast would have been farther east than the present coastline, and probably nearby the isobath of 100 m (Fig. 2). In this sense, the present estuary of Río de la Plata would have been an emerged land, with a stream that drained along the present Uruguayan coastline, presently the thalweg line. If these were the landforms at that time, the hypothesis sustained by Flegenheimer et al. (2003) on the tool stone transport from Uruguay to the Pampean Plains could have been possible. A similar situation would have occurred with the inlets of the main fluvial streams of the Atlantic façade in Patagonia, such as the rivers Colorado, Negro, Chubut, Deseado, Santa Cruz, Gallegos and Chico (Miotti, 2003).

The Magellan Strait is a similar case, due to its Late Pleistocene configuration, as a result of a strong process of deglaciation during the Early Holocene (Clapperton, 1992; Coronato et al., 1999). Between 12–10 ka BP, sea level was still perhaps 60 m below its present position, and therefore a sort of a "land bridge" existed between the sites Primera and Segunda Angostura. The conditions in this valley, occupied by a braided stream and shallow channels of meltwater discharge, would probably have allowed the displacement of human groups from continental Patagonia to the present Tierra del Fuego island, when they settled in the Tres Arroyos rockshelter (Massone, 1999, 2001). Moreover, and considering the Pacific rim hypothesis (Bryan, 1978; 1995; Shutler, 1983; Fladmark, 1983; Erlandson, 2001; Bonnichsen and Steele, 2000; Bryan and Gruhn, 2003; Miotti, 2003), it could be stated that Northern Tierra del Fuego could have been peopled from the west, as well, considering the possibility of groups sailing along the Southern Pacific coasts.

In this ancient landscape, the consequent displacement of the Pacific anticyclone northwards and eastwards would have been one of the main consequences and cold and dry winds of the glaciated areas in the

Andes would have been strongly active. Thus, several areas in the eastern Andean foothills would not have been available by the end of the Pleistocene for human occupation, while the successful settlements might have occurred in farther areas to the east.

If this scenario would be accepted, then the area of Central Plateau in the present Santa Cruz province would have been one of the best candidates for the beginning of human colonization (Miotti, in press). Thus, the question is how the reconstruction of human colonization can be performed for this area, if Central Patagonia (between the Negro and Deseado rivers) does not show evidence for this period? (see Figs 3a–d, Table 1).

Some answers may be offered:

(a) People arrived through the Atlantic rim, submerged today, and began with the exploration of the hinterland, going up the large rivers that drain to the Atlantic Ocean, with the success of colonization in the Central Plateau, due to a great resource availability. This model comes from that one formulated by Beaton (1991) comparing the human colonization in the last two continents to be peopled: Oceania and America. Beaton remarks that Australia has characteristics more similar to those from the South American continent than those from the North American continent. Then, this author proposes that coasts were colonized first and then people enter the hinterlands through the natural ways such as drainage basins.

Following this idea, as well as Erlandson's (2001) one, humans could have entered the Southern South American continent along a Pacific rim, as demonstrated through the Tagua–Tagua, Monte Verde or Baño Nuevo 1 sites on the Chilean side (Fig. 1, Table 1), and along an Atlantic rim, entering the Chubut or the Negro river valleys. However, there is no evidence of early territorial recognitions and/or settings in them. Then, what did happen? Were the resources not enough? Were the conditions to penetrate the hinterland more difficult than farther south? Or, finally, is there a sampling bias in the archaeological survey? (See Fig. 3a–d).

As far as the available published works allow us to interpret, the best answer up to this moment is an important bias in the sampling. In fact, archaeological excavations in the Chubut valley occurred at Piedra Parada locality (Fig. 1, Table 1), where a cave was excavated (Aschero et al., 1983; Bellelli, 1988; Pérez de Micou et al., 1992) and dated around 5 ka BP. However, the excavation went down only to a landslide, likely causing the collapse of the roof. Therefore, it is probable other evidence might be under this collapse, as occurred in many other caves in Patagonia, for example a section of the rockshelter AEP-1, in Piedra Museo.

In spite of the fact that other occupations might be found, the information indicates that the earliest occupation in the Chubut Valley (Piedra Parada 1) dates from 5080 ± 100 BP (AC 666) (Bellelli, 1988; Pérez de Micou et al., 1992). On the other hand, after a test pit in La Rural site in Cerro del Castillo area (Belardi, 1991), the information from both areas, approximately at a distance ca. 100 km, has been compared chronologically although they share only a Late Holocene temporal block. However, Ratto and Belardi (1996) estimated, without any further discussion, that the first occupations in the Chubut valley occurred no earlier than 5000 yr BP.

(b) Up to now, the references indicate that at least the Central Plateau of Santa Cruz could have been a comfortable area to colonize, in order to find shelter, nourishment, raw materials (stone and pigments), water sources, and ways of communications, such as the ravines and presently ephemeral streams that would have flowed during the early postglacial. But it appears that similar conditions could have been available in the Chubut or Río Negro valleys. Thus, our hypothesis is that the lack of data is due to sampling bias in those areas, at least for earliest human occupations.

In fact, in Northern Patagonia, the area of Lake Nahuel Huapi would have been free of ice already by ca. 14 ka BP, as suggested by the existence of a proglacial lake and by the archaeological evidence (Hajduk, 1998; Hajduk et al., 2002; Fig. 1, Table 1), although no radiocarbon dates are yet available in these sites. However, this is an indicator that the area could not have been colonized before that time, as effectively occurred on the western side of the Andes (Monte Verde, Fig. 3a–c, or Baño Nuevo 1, Fig. 3d).

(c) Notwithstanding, farther south the Eastern Andean foothills and piedmont landscape probably would have been available later than similar environments of the Pacific slope, if it is accepted that the earliest radiocarbon dates are ca. 9800 yr BP (see Table 1, Fig. 3d). Moreover, the contexts from one side and the other of the Cordillera were similar, and on the western side have been dated between 13 and 10 ka BP. Thus, it is possible that the intermountain corridors would have been ice-free since glaciers were only constrained to the higher valleys. These corridors were low and easy to traverse, and people could have crossed them, although the Andean ranges are a true physical and ecological barrier. For example, proboscideans recorded in Monte Verde and Tagua–Tagua sites were never recorded in Patagonia. Along the Eastern Andes, the proboscideans were registered from Colombia, up to the Argentinean Pampean Region. Moreover, the species identified in the west façade of the Andes (from Colombia south to South Chile) are different genera to those found in the eastern side (Alberdi and Prado, 1995; Miotti and Suárez, 2001).

(d) The volcanic activity (ash layers, roof collapses) is an important indicator in the Andean areas and the extra-Andean regions, as well. Its evidence has been confirmed in different sites where volcanic events could have marked abandonment of some sites and/or areas even temporarily, or at least, changes in the distribution of fauna and flora that also could have influenced human settlement patterns and mobility.

(e) According to Heusser (1998), Markgraf (1993) and more recently Bennett et al. (2000), pulses of colder climates have been recorded during the Late Glacial and the beginning of Postglacial times, probably related to minor glacial readvances, sometimes confined to the cirques and high valleys (Rabassa and Coronato, 2002). However, dates are not completely coincident for the huge extension of Patagonia, from lat. 41° to 54°S and from long. 64° to 72°W, considering both the Argentine and Chilean sides. Besides the receding ice masses, patterns of air masses circulation and the influence of ocean currents might have acted in the regulation of the climates that the first groups of humans found in different sectors of the ample Patagonia region.

7. Conclusions

As can be seen in Table 1 and Fig. 3, some areas in Patagonia yielded datings no earlier than 10 ka BP, such as the westernmost area, in the Upper section of Deseado and Santa Cruz rivers, and Northern Patagonia, between Chubut and Colorado rivers. Moreover, human occupations before 5 ka BP have not been recorded in Central Patagonia. In the meanwhile, the southern central plains of the Deseado River and the Magellan Basin localities have proved that the colonization of this territory took place as early as ca. 12 ka BP. Moreover, if the hypothesis of independent population entries through both Atlantic and Pacific rims is confirmed, it can be assumed that sites with the older occupations on the Atlantic façade should be located today under the epicontinental Argentinean sea, considering the sea level rise since the LGM and especially during the Middle Holocene (see the hypothetical coastline for the LGM in Fig. 2).

A different effect could have occurred along the western Andean slope, where fauna and vegetation were intimately related to glacial phenomena, the lack of continentality effect and the possibility of human groups exploring (?) and colonizing the continent from the Pacific side (Fladmark 1983; Bryan and Gruhn 2000; Bonnichsen and Steele 2000; Gruhn, 2000; Miotti, 2003; Bryan and Gruhn, 2003). These ideas support the hypothesis of independent migrations of colonization, even simultaneously on both sides of the Andes, which would explain the available radiocarbon datings of the Fell, Tres Arroyos, Cueva del Medio, Lago Sofía and, farther north, Monte Verde sites (Figs 1 and 3a–c).

On the same line of reasoning, Tagua Tagua must be mentioned (Núñez et al., 1994). Though this site is farther north, in Central Chile, and out of the area of interest for this paper, the results of the research and the interpretation of data (radiocarbon dated ca. 11,400 BP, extinct fauna associated to living species, unifacial and bifacial technology, etc.) are consistent with the hypothesis of the Pacific Rim as one of the ways for peopling the Southernmost Sector of America. Likewise, it reinforces the hypothesis that first colonizers, before 11 ka BP would have been populations that entered Southern America through different ways; anyway, they should have developed aquatic adaptations, in all cases, preferably, close to fresh water sources like lagoons, lakes or creek).

In any case, those groups (explorers and/or colonizers) occupied the spaces knowing perfectly the territory they inhabited or they looked for. In this sense, the archaeologists usually have detected those occupations that represent a final stage of the colonization. They have considered the whole space according to its function, as sacred places, domestic places and places of transit. Nonetheless, we believe that many apparent problems are related to the low archaeological visibility for the sites of exploration, which could be undetected yet.

Acknowledgements

An anonymous reviewer made useful comments to a previous draft; Jorge Rabassa revised the English translation and also made interesting observations. Fig. 3 was prepared with the valuable help of Soledad Sartori.. However, the authors are the only responsible for the ideas written herein.

References

Aguerre, A., 1982. Informe preliminar de las excavaciones en la Cueva 4 de La Martita—Departamento Magallanes–Provincia de Santa Cruz. VII°Congreso Nacional de Arqueología Argentina, San Luis, oral communication.

Alberdi, M.T., Prado, J.L., 1995. Los Mastodontes de América del Sur. In: Alberdi, M.T., Gabriello, L., Tonni, E.P. (Eds.), Evolución Biológica y Climática de la Región Pampeana Durante los Últimos Cinco Millones de Años. Museo Nacional de Ciencias Naturales de Madrid, Madrid, pp. 293–308 (Chapter 13).

Ariztegui, D., Bianchi, M.M., Masaferro, J., Lafargue, E., Niessen, F., 1997. Interhemispheric synchrony of late-glacial climatic instability as recorded in proglacial Lake Mascardi, Argentina. Journal of Quaternary Science 12, 333–338.

Aschero, C.A., 1996. El área Río Belgrano-Lago Posadas (Santa Cruz): Problemas y estado de problemas. In: Gómez Otero, J. (Ed.), Arqueología. Sólo Patagonia. Centro Nacional Patagónico, Puerto Madryn, pp. 17–26.

Aschero, C.A., Bellelli, C., Fischer, A., Nacuzzi, L., Oneto, M., Pérez de Micou, C., 1983. Arqueología del Chubut. El valle de Piedra

Parada. Gobierno de la Provincia de Chubut Serie Humanidades 1. Dirección de Impresiones Oficiales, Rawson, Argentina.

Aschero, C.A., Bellelli, C., Civalero de Biset, M.T., Goñi, R., Guráieb, A.G., Molinari, R., 1992. Cronología y tecnología en el Parque Nacional Perito Moreno (PNPM): continuidad o reemplazos? Arqueología 2, 89–105 (Universidad de Buenos Aires).

Ashworth, A.C., Markgraf, V., Villagrán, C., 1991. Late quaternary climatic history of the Chilean channels based on fossil pollen records and beetle analyses, with an analyses of modern vegetation and pollen rain. Journal of Quaternary Science 6, 279–291.

Auer, V., 1974. The isorhythmicity subsequent to the Fuego-Patagonian and Fennoscandian ocean level transgressions of the latest glaciation. Annales Academiae Scientiarum Fennicae Series A III 115, 1–188 (Helsinki).

Beaton, J.M., 1991. Colonizing continents: some problems from Australia and the Americas. In: Dillehay, T., Meltzer, D. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, USA, pp. 209–230.

Belardi, J.B., 1991. Relevamiento arqueológico del área Cerro Castillo, Departamento de Gastre, Provincia de Chubut. Tesis de Licenciatura, Facultad de Filosofía y Letras, Universidad de Buenos Aires, unpublished.

Bellelli, C., 1988. Recursos minerales: su estrategia de aprovisionamiento en los niveles tempranos de Campo Moncada 2 (Valle de Piedra Parada, río Chubut). In: Arqueología Contemporánea Argentina. Ediciones Búsqueda, Buenos Aires, pp. 147–176.

Bennett, K.D., Haberle, S.G., Lumley, S.H., 2000. The last Glacial–Holocene transition in Southern Chile. Science 290, 325–328.

Bonnichsen, R., Steele, D.G., 2000. The Pacific Rim Hypothesis: climate forcing and colonizers from Southeast Asia. In: Miotti, L., Salemme, M., Cattáneo, G.R., Paunero, R. (Eds.), International Workshop of INQUA "The colonization of South America during the Pleistocene/Holocene Transition", Book of Abstracts, Vol. 13. La Plata, Argentina.

Borrero, L., 1996. The Pleistocene–Holocene transition in Southern South America. In: Straus, L., Eriksen, B., Erlandson, J., Yesner, D. (Eds), Humans at the End of the Ice Age. Plenum Press, New York, London, pp. 339–354 (Chapter 17).

Borrero, L., 1999. Human dispersal and climatic conditions during the Late Pleistocene times in Fuego-Patagonia. Quaternary International 53/54, 93–99.

Borrero, L., Zárate, M., Miotti, L., Massone, M., 1998. The Pleistocene–Holocene transition and human occupations in the Southern Cone of South America. Quaternary International 49/50, 191–199.

Borromei, A.M., 2002. Palynology at Piedra Museo locality, Santa Cruz Province, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow, Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Broecker, W.S., Denton, G.H., 1990. The role of ocean–atmosphere reorganizations in glacial cycles. Quaternary Science Reviews 9, 305–341.

Bryan, A. (Ed.), 1978. Early Man in America from a Circum Pacific Perspective. Department of Anthropology, University of Alberta, Canada.

Bryan, A., 1995. Disproof of commonly held assumptions relevant to the peopling of the Americas. Current Research in the Pleistocene 12, 6–9 (Center for the Study of First Americans, Oregon State University, Corvallis, Oregon).

Bryan, A., Gruhn, R., 2003. Some difficulties in modeling the original peopling of the Americas. Quaternary International. (PII: S1040-6182(02)00211-2).

Cardich, A., 1987. Arqueología de Los Toldos y El Ceibo (provincia de Santa Cruz, Argentina). In: Núñez, L., Meggers, B. (Eds.), Investigaciones paleoindias al sur de la línea ecuatorial. Estudios Atacameños Santiago, Chile, Vol. 8, pp. 98–117.

Cardich, A., Miotti, L., 1983. Recursos faunísticos en la economía de los cazadores-recolectores de Los Toldos (provincia de Santa Cruz, Argentina). Revista Relaciones XV, 147–157 Sociedad Argentina de Antropología, Buenos Aires.

Cardich, A., Cardich, L., Hadjuk, A., 1973. Secuencia arqueológica y cronología radiocarbónica de la cueva 3 de Los Toldos (Santa Cruz Argentina). Relaciones Sociedad Argentina de Antropología VII, 87–122 (Buenos Aires).

Ceballos, R., 1982. El sitio Cuyín Manzano. Estudios y Documentos No. 9, Centro de Investigaciones Científicas, Secretaría de Planeamiento, Río Negro, 66 pp.

Civalero, M.T., Aschero, C.A., 2002. Early occupations at Cerro Casa de Piedra 7, Santa Cruz Province, Patagonia, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow, Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Civalero, M.T., Franco, N., 2003. Early human occupations at the West of Santa Cruz Province, Southern end of South America. Quaternary International. (PII: S1040-6182(02)00204-5).

Clapperton, Ch., 1992. La última Glaciación y Deglaciación en el Estrecho de Magallanes, implicaciones para el poblamiento de Tierra del Fuego. Anales del Instituto de la Patagonia Ser. Cs. de la Tierra 21, 113/128 Punta Arenas, Chile.

Clapperton, Ch., 1993. Quaternary Geology and Geomorphology of South America. Elsevier, Amsterdam, 779pp.

Clapperton, Ch., Sudgen, D., Kaufman, D., McCullogh, R., 1995. The last glaciation in Central Magellan Strait, Southernmost Chile. Quaternary Research 44, 133–148.

Coronato, A., 1995. The last Pleistocene glaciation in tributary valleys of the Beagle Channel. Quaternary of South America & Antarctic Peninsula 9, 153–172 (Balkema Publishers, Rotterdam).

Coronato, A., Salemme, M., Rabassa, J., 1999. Palaeoenvironmental conditions during the early peopling of Southernmost South America (Late Glacial-Early Holocene, 14–8 ka BP). Quaternary International 53/54, 77–92.

Crivelli Montero, E., Cursio, D., Silveira, M., 1993. La estratigrafía de la Cueva Traful 1 (provincia del Neuquén). Praehistoria 1, 9–60 (CONICET, Buenos Aires).

Crivelli Montero, E., Pardiñas, U., Férnandez, M., 1996. Introducción, procesamiento y almacenamiento de macro vegetales en la Cueva Epullán Grande. In: Gómez Otero, J. (Ed.), Arqueología. Sólo Patagonia. Centro Nacional Patagónico, Puerto Madryn, pp. 49–58.

del Valle, R., Lirio, J., Nuñez, H., Tatur, A., Rinaldi, C., Amos, J., 1996. Reconstrucción paleoambiental Pleistoceno–Holoceno en latitudes medias al este de los Andes. XIII Congreso Geológico Argentino, Actas, Buenos Aires, Vol. IV, pp. 85–102.

Dillehay, T., 1997. Monte Verde: A Late Pleistocene Settlement in Chile. Vol 2, The Archaeological Context and Interpretation. Smithsonian Press, Washington, pp.1060.

Erlandson, J.M., 2001. The archaeology of aquatic adaptations: paradigms for a new millennium. Journal of Archaeological Research 9 (4), 287–350.

Fladmark, K., 1983. Times and places: environmental correlates of mid to late Wisconsinan human population expansion in North America. In: Shutler, R. (Ed.), Early Man in the New World. Sage Publishing, Beverly Hills, CA, pp. 13–24.

Flegenheimer, N., Bayón, C., Valente, M., Baeza, J., Femenías, J., 2003. Long distance tool stone transport in the Argentine Pampas. Quaternary International. (PII: S1040-6182(02)00202-1).

Franco, N.V., Borrero, L.A., 2001. Chorrillo Malo 2: initial peopling of the upper Santa Cruz basin, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South

Americans: From Where the South Winds Blow. Center for the Study of First Americans, Oregon State University, and Texas A&M University Press, College Station, TX.

Gradín, C., 1984. Investigaciones arqueológicas en Casa de Piedra. Ministerio de Educación y Cultura, Provincia de La Pampa, 149pp.

Gradín, C., Aguerre, A., (Dirs.), 1994. Contribución a la Arqueología del Río Pinturas, Provincia de Santa Cruz. Búsqueda-Ayllu, Concepción del Uruguay, Argentina, p. 375.

Gruhn, R., 2000. South Americans in the models of the most ancient American Prehistory. In: Miotti, L., Salemme, M., Cattáneo, R., Paunero, R. (Eds.), Book of Abstracts, Taller Internacional "La Colonización del Sur de América durante la Transición Pleistoceno/Holoceno", La Plata—Santa Cruz, pp. 19. Oral Communication, m.s.

Hajduk, A., 1998. Parada: Cueva en Valle de Arroyo Corral. In: Guía de Campo de la Xa. Reunión de Campo de Geología del Cuaternario, San Carlos de Bariloche, 29 al 31 de Octubre de 1998, p. 7.

Hajduk, A., Albornoz, A., Lezcano, M., 2002. El "Mylodon" en el patio de atrás. Informe preliminar sobre los trabajos en el Sitio El Trébol, ejido urbano de San Carlos de Bariloche provincia de Río Negro. Jornadas de Arqueología de la Patagonia Resúmenes de Ponencias V, 37–38 (Buenos Aires).

Heusser, C.J., 1989a. Late Quaternary vegetation and climate of Southern Tierra del Fuego. Quaternary Research 31, 396–406.

Heusser, C.J., 1989b. Southern westerlies during the Last Glacial Maximum. Quaternary Research 31, 423–425.

Heusser, C.J., 1994. Quaternary paleoecology of Fuego-Patagonia. Rev. IG. Sao Paulo 15 (1–2), 7–26 (Sao Paulo, Brazil).

Heusser, C., 1998. Deglacial paleoclimate of the American sector of the Southern Ocean: Late Glacial–Holocene records from the latitude of Canal Beagle (55°S) Argentine Tierra del Fuego. Palaeogeography, Palaeoclimatology, Palaeoecology 141, 277–301.

Heusser, C.J., Rabassa, J., 1987. Cold climate episode of Younger Dryas age in Tierra del Fuego. Nature 328, 609–611.

Heusser, C.J., Rabassa, J., 1995. Late Holocene forest steppe interaction at Cabo San Pablo, Isla Grande de Tierra del Fuego, Argentina. Quaternary of South America and Antarctic Peninsula 9, 179–188 Revista del Instituto Geologico (Balkema Publishers, Rotterdam).

Heusser, C., Heusser, L., Lowell, Th., 1999. Paleoecology of the Southern Chilean Lake District-isla Grande de Chilé during Middle–Late Llanquihue glaciation and deglaciation. Geografiska Annaler 81 (A), 231–284.

Hoganson, J., Ashworth, A., 1993. The magnitude and the rapidity of the climate change marking the end of the Pleistocene in mid–latitudes of South America. Palaeogeography, Palaeoclimatology, Palaeoecology 101, 263–270.

Markgraf, V., 1991. Younger Dryas in South America? Boreas 20, 63–69.

Markgraf, V., 1993. Paleoenvironments and paleoclimates in Tierra del Fuego and Southernmost Patagonia, South America. Palaeogeography, Palaeoclimatology, Palaeoecology 102, 53–68.

Massone, M., 1999. Aproximación metodológica al estudio de las ocupaciones tempranas de cazadores terrestres en la Región de Magallanes. In: Soplando en el Viento, Actas III Jornadas de Arqueología de la Patagonia, Neuquen, Buenos Aires, pp. 99–112.

Massone, M., 2001. Fell 1 Hunters' Fire hearths in Magallanes Area by the End of the Pleistocene. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Mena, F., Reyes, O., Stafford Jr., Th.W., Southon, J., 2003. Early Human remains from Baño Nuevo-1 Cave (Central Patagonian Andes, Chile). Quaternary International. (PII: S1040-6182(02)00207-0).

Mercer, J.H., 1984. Late Cainozoic glacier variation in South America south of the Ecuador. In: Vogel, J.C. (Ed.), Late Cainozoic Paleoclimates of the Southern Hemisphere. Balkema Publishers, Rotterdam, pp. 45–53.

Miotti, L., [1989] 1998. Zooarqueología de la Meseta Central y Costa de Santa Cruz. Un enfoque de las estrategias adaptativas aborígenes y los paleoambientes. Revista del Museo de Historia Natural de San Rafael, T. X (1/4), 306 (San Rafael, Mendoza).

Miotti, L., 1996. Piedra Museo (Santa Cruz): nuevos datos para el debate de la ocupación Pleistocénica en Patagonia. In: Gómez Otero, J. (Ed.), Arqueología, sólo Patagonia. Publicaciones Secretaría Cultura de Chubut y CONICET, Puerto Madryn, pp. 27–38.

Miotti, L., in press. Quandary: the Clovis Phenomenon, The First Americans, and the view from Patagonia. In: Lepper, B. (Ed.), New Directions in First American Studies, Center for the Study of First Americans, Oregon State University, and Texas A&M University Press, College Station, TX.

Miotti, L., 2003. Patagonia: a paradox for building images of the first Americans during Pleistocene/Holocene transition. Quaternary International. (PII: S1040-6182(02)00210-0).

Miotti, L., Carden, N., 2001. Sobre las relaciones entre el arte rupestre y las arqueofaunas en el Nesocratón del Deseado. XIV Congreso Nacional de Arqueología, Libro de Resúmenes. Rosario, 17 al 21 de setiembre de 2001, pp. 387–388.

Miotti, L., Cattáneo, G.R., 2002. Variation in the strategies of lithic production and faunal exploitation during the Pleistocene/Holocene transition at Piedra Museo and surrounding region. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Miotti, L., Salemme, M., 1999. Biodiversity, taxonomic richness and specialists-generalists during late Pleistocene/early Holocene times in Pampa and Patagonia (Argentina, Southern South America). Quaternary International 53/54, 53–68.

Miotti, L., Salemme, M., 2001. Hunting and Butchering events at the Pleistocene/Holocene transition in Piedra Museo: and example of adaptation strategies of the first colonizers. In: Bonnichsen, R. (Ed.), Paleoamerican Origins: Beyond Clovis, Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Miotti, L., Suárez, R., 2001. Variabilidad tecnológica y recursos faunísticos durante la transición Pleistoceno/Holoceno en dos regiones del Cono Sur. Paper presented at El Poblamiento Temprano de América X Congreso Nacional de Arqueología Uruguaya. Libro de Resúmenes, Montevideo, Uruguay, pp. 59.

Miotti, L., Vázquez, M., Hermo, D., 1999. Piedra Museo: un yamnagoo pleistocénico de los colonizadores de la meseta de Santa Cruz. El estudio de la arqueofauna. In: Soplando en el Viento. Actas III Jornadas de Arqueología de la Patagonia, Neuquen, Buenos Aires, pp. 113–135.

Miotti, L., Salemme, M., Rabassa, J., 2002. Radiocarbon chronology at Piedra Museo Locality. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Morello Repetto, F., 2000. 30 años después, una primera aproximación a la Colección Marazzi (Museo Regional, Punta Arenas). In: Desde el País de los Gigantes. Perspectivas arqueológicas en Patagonia Vol. II, Universidad Nacional de la Patagonia Austral, pp. 481–498.

Núñez, L., Varela, J., Casamiquela, R., Schiappacasse, V., Niemeyer, H., Villagrán, C., 1994. Cuenca de Tagua Tagua en Chile: el ambiente del Pleistoceno superior y ocupaciones humanas. Revista Chilena de Historia Natural 67, 503–519 (Chile).

Obelic, B., Alvarez, A., Argullós, J., Piana, E.L., 1998. Determination of water palaeotemperature in the Beagle Channel (Argentina) during the last 6000 years through stable isotope composition of *Mytilus edulis* shells. Quaternary of South America and Antarctic Peninsula 11, 47–71 (Balkema Publishers, Rotterdam).

Orquera, L.A., Piana, E.L., 1999. Arqueología de la región del Canal Beagle (Tierra del Fuego, República Argentina). Sociedad Argentina de Antropología, Buenos Aires, 46pp.

Páez, M.M., Prieto, A.R., Mancini, M.V., 1999. Fossil pollen from Los Toldos locality: a record of the Late-Glacial transition in the Extra-Andean Patagonia. Quaternary International 53/54, 69–76.

Páez, M., Zárate, M., Mancini, M.V., Prieto, A., 2001. Paleoenvironments during the Pleistocene–Holocene transition in Southern South America, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Paunero, R.S., 2000. Localidad Arqueológica Cerro Tres Tetas Locality. In: Miotti, L., Paunero, R., Salemme, M., Cattáneo, R. Guía de Campo de la Visita a las Localidades Arqueológicas, Taller Internacional "La Colonización del Sur de América durante la Transición Pleistoceno/Holoceno". La Plata, Santa Cruz, pp. 89–100

Paunero, R.S., 2001. The presence of a Pleistocenic colonizing culture in La Maria archaeological locality: Casa del Minero 1, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of First Americans, and Texas A&M University Press, College Station, TX.

Pérez de Micou, C., Bellelli, C., Aschero, C.A., 1992. Vestigios minerales y vegetales en la determinación de explotación de un sitio. In: Borrero, L.A., Lanata, J.L. (Eds.), Análisis espacial en la arqueología patagónica. Ediciones Ayllu, Buenos Aires, pp.57–86.

Politis, G., 1991. Fishtail projectile points in the Southern Cone of South America. In: Bonnichsen, R., Turnmine, K. (Eds.), Clovis: origins and adaptations. Center for the Study of First Americans, University of Maine, Orono, pp. 287–303.

Porter, S.C., 1981. Pleistocene glaciation in the southern Lake District of Chile. Quaternary Research 16, 263–292.

Rabassa, J., 1983. INQUA Commission on Lithology and Genesis of Quaternary deposits: South American regional meeting, Argentina 1982. In: Evenson, E.B., Schlüchter, Ch., Rabassa, J. (Eds.), Till and Related Deposits. Balkema Publishers, Rotterdam, pp. 445–451.

Rabassa, J., Clapperton, C., 1990. Quaternary glaciations of the Southern Andes. Quaternary Science Reviews 9, 153–174.

Rabassa, J., Coronato, A., 2002. Glaciaciones del Cenozoico tardío. In: Haller, M. (Ed.), Geología y Recursos Naturales de Santa Cruz, Relatorio del Congreso Geológico Argentino, El Calafate. Buenos Aires, pp. 303–316.

Rabassa, J., Coronato, A., Bujalesky, G., Salemme, M., Roig, C., Meglioli, A., Heusser, C., Gordillo, S., Roig, F., Borromei, A., Quattrocchio, M., 2000. Quaternary of Tierra del Fuego, Southernmost South America: an updated review. Quaternary International 68-71, 217–240.

Rabassa, J., Evenson, E., 1996. Reinterpretación de la estratigrafía glaciaria de la región de San Carlos de Bariloche. XIII Congreso Geológico Argentino Actas IV, 327.

Ratto, N., Belardi, J.B., 1996. Selección y uso de materias primas líticas en la región de Cerro Castillo (provincias de Chubut y Río Negro). In: Gómez Otero, J. (Ed.), Arqueología. Sólo Patagonia. Centro Nacional Patagónico, Puerto Madryn, pp. 411–422.

Roig, C.E., Coronato, A.M., Heusser, C.J., Rabassa, J., 1993. Respuestas geomorfológicas a las variaciones climáticas durante el Pleistoceno Tardío-Holoceno en los Andes Fueguinos, Argentina. 5ta. Reunión Anual del IGCP-281 "Climas Cuaternarios de América del Sur", Resúmenes, 4, Santiago de Chile.

Roig, C.E., Heusser, C.J., Rabassa, J., 1995. Late Quaternary palaeoenvironmental reconstruction in Tierra del Fuego: Part 1. Pollen Data. Terra Nostra, XIV INQUA Congress, Abstracts, Volume 231, Berlin.

Salemme, M., Miotti, L., 1987. Zooarchaeology and palaeoenvironments: some examples from Patagonian and Pampean regions (Argentina). Quaternary of South America & Antarctic Peninsula 5, 33–57 (Balkema Publishers, Rotterdam).

Shutler, R. (Ed.), 1983. Early Man in the New World. Sage Publishing, Beverly Hills, CA.

Stern, Ch., 1990. Tephrochronology of Southernmost Patagonia. National Geographic Research 6, 110–126.

Stern, Ch., 1992. Tefrocronología de Magallanes: nuevos datos e implicaciones. Anales del Instituto de la Patagonia 21, 129–141 (Punta Arenas, Chile).

Straus, L.G., Eriksen, B.V., 1998. Preface. As the world warmed: human adaptations across the Pleistocene/Holocene boundary. Quaternary International 49/50, 1–2.

Strelin, J., Malagnino, E., 2000. The late-glacial history of Lago Argentino, Argentina and age of Puerto Banderas Moraines. Quaternary Research 54, 339–347.

Strelin, J., Malagnino, E., Sone, T., Casassa, G., Iturraspe, R., Mori, J., Torielli, C., 2002. Cronología neoglacial del extremos sur de Sudamérica, Arco de Scotia y Península Antártica. Actas del XV Congreso Geológico Argentino. El Calafate. CD-ROM edition.

Tambussi, C.P., Tonni, E.P., 1985. Aves del sitio arqueológico Los Toldos, cañadón de las Cuevas, Provincia de Santa Cruz (República Argentina). Ameghiniana 22 (1-2), 69–74, Buenos Aires.

Tolan-Smith, Ch., 1998. Radiocarbon chronology and the lateglacial and early postglacial resettlement of the British Isles. Quaternary International 49/50, 21–27.

Tonni, E.P., Cione, A.L., 1999. Biostratigraphy and chronological scale of uppermost cenozoic in the Pampean area, Argentina. Quaternary of South America and Antarctic Peninsula 12, 23–52 (Balkema Publishers, Rotterdam).

Tonni, E.P., Cione, A.L., Figini, J.A., 1999. Predominance of arid climates indicated by mammals in the Pampas of Argentina during the Late Pleistocene and Holocene. Palaeogeography, Palaeoclimatology, Palaeoecology 147, 257–281.

Wenzens, G., 1999. Fluctuations of outlet and valley glaciers in the Southern Andes (Argentina) during the past 13,000 years. Quaternary Research 51, 238–247.

Zárate, M., Blasi, A., Rabassa, J., 2000. Geoarqueología de la Localidad de Piedra Museo. In: Miotti, L., Paunero, R., Salemme, M., Cattáneo, R. Guía de Campo de la Visita a las Localidades Arqueológicas, Taller Internacional "La Colonización del Sur de América durante la Transición Pleistoceno/Holoceno", La Plata, Santa Cruz, pp. 56–64.

PERGAMON

Quaternary International 109–110 (2003) 113–121

Early human remains from Baño Nuevo-1 cave, central Patagonian Andes, Chile

Francisco Mena L[a,*], Omar Reyes B[a], Thomas W. Stafford Jr.[b], John Southon[c]

[a] Museo Chileno de Arte Precolombino, Bandera, Santiago de Chile 361, Chile
[b] Stafford Research Laboratories, Inc. 5401 Western Avenue, Suite C, Boulder, CO 80301, USA
[c] Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA 94451, USA

Received 17 October 2002; accepted 17 October 2002

Abstract

The notable sparseness of human skeletal remains is a characteristic trait of early American prehistory and, therefore, this aspect of the archaeological record is seldom considered in its discussion. In this context, the finding of remains from five individuals dated to the 9th millenium BP on the re-excavations at Baño Nuevo Cave (Andean Central Patagonia, Chile) is particularly interesting. They may not appear excessively old, but several radiocarbon dates (two of them done through AMS directly on the bone of one of the individuals) place them among the very few well-dated early human skeletons throughout the Americas. The small sample size militates against any interpretation of biological affiliation (to say nothing of population movements) and we can only affirm that these people belonged to a generalized "mongoloid stock", different from historically known Patagonian populations. After a brief presentation of the skeletal evidence and the bone dating methods, we evaluate the relevance of this context with respect to the sparse osteological record of humans in the Americas on the Pleistocene/Holocene transition.

1. Introduction

Baño Nuevo-1 cave, a site located in the Chilean region of Aisen close to the border with Argentina in Central Patagonia (750 m a.s.l. 45°17′S; 71°32′W, Fig. 1) was first excavated by Felipe Bate in 1972. As a result of those works, Bate claimed to have found the remains of several human occupations, the earliest ones dating to right after the retreat of a proglacial lake, in association with extinct horse and *Mylodon* (Bate, 1979). With the purpose of evaluating these claims, recovering a new collection (the one excavated in 1972 being lost after the 1973 military coup and Bate's flight from the country) and obtaining absolute dates, Mena, with support from an FONDECYT (Chilean Scientific Research Fund) research grant (1950106), undertook a re-excavation of the Baño Nuevo-1 cave in January 1996.

The removal of an additional 7 m^3 volume of sediments has revealed at least two clearly defined archaeological floors (Figs. 2 and 3). The upper level (layers 1 and 2; Fig. 3), associated with a 2830 ± 70 BP ^{14}C date on charcoal (Beta-90894), calibrated to 1045–900 BC at 1σ, presents a rich assemblage of guanaco and canid bones, a blade technology and some evidence of cordage. The lower level (layers 4 and 5; Fig. 3), on the other hand, encompasses several dates on charcoal from a well-defined hearth between 9200 ± 80 BP (Beta-90888) calibrated to 8330–8300 BP or 8280–8090 BP at 1σ and 8530 ± 160 BP (Beta-90892) calibrated to 7640–7445 BP at 1σ, and shares many characteristics with the upper levels, although there is an emphasis on flake technology instead of blades. Several *Mylodon* ossicles have been found in this layer and in the sterile layer underneath, one of them dated to 11 480 ± 50 BP (CAMS-32685). Contrary to Bate (1979), we cannot affirm that there was any coexistence among Pleistocene megafauna and human occupants of the site, although it is beyond any doubt that the latter were at the cave around 9000 BP, either in contemporaneity (but not necessarily in association) with *Mylodon* or slightly after its extinction.

In this paper, we want to focus on the finding of the remains of five human individuals, two of them fairly complete adult skeletons (individuals 2 and 3) and three

*Corresponding author.
E-mail addresses: fmena@museoprecolombino.cl (F. Mena L), omarreyesbaez@vtr.net (O. Reyes B).

1040-6182/03/$ - see front matter
PII: S1040-6182(02)00207-0

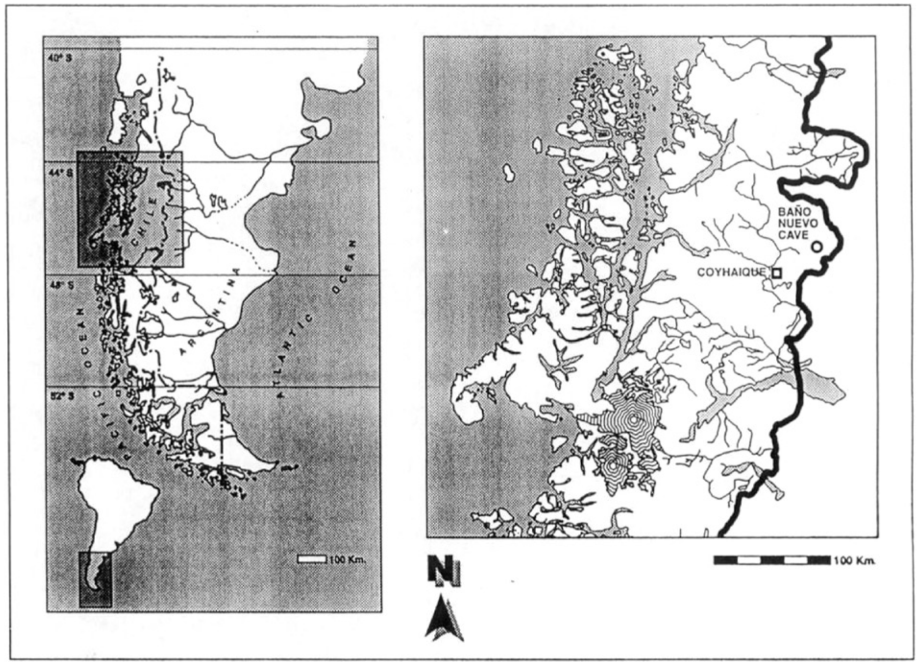


Fig. 1. Location of Baño Nuevo-1 cave in the Chilean region of Aisen, close to the Argentine border.

Fig. 2. Section and plan of Baño Nuevo-1 cave with indication of excavated surfaces.

highly fragmented juveniles (individuals 1, 4 and 5). Although some of these data have been reported before (Mena and Reyes, 1998, 2001; Mena et al., 1998, 2000), this is a first attempt to integrate the dating and bioanthropological aspects of the research.

Although some of the juvenile skeletons may be related to the lower cultural level, there is no doubt that this is the case with respect to the better preserved adult remains. A fragment of charcoal found between two cervical vertebrae of individual 2 yielded an AMS ^{14}C date of 8890 ± 90 BP (Beta-90889) and another fragment of charcoal close to individual 3 has been dated to 8530 ± 160 BP (Beta-90892). However, stratigraphic relationships suggested that individual 3 was buried before individual 2, and the conflict between this interpretation and the dating analysis led to suspicions

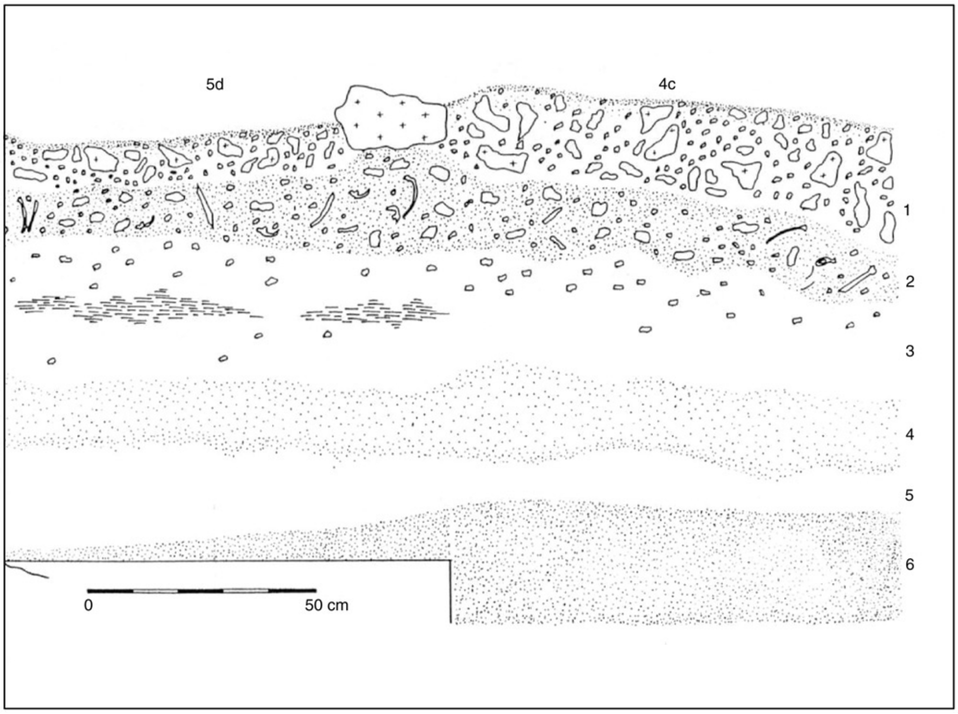


Fig. 3. Stratigraphic profile of the site (Early component layers 5 and 4, 10 000–8000 BP Late component layers 2, 3000–1000 BP).

with respect to the contextual association between the skeletons and the surrounding sediments, including charcoal grains, that could well have been removed during the burial of the corpses. Two recent AMS ^{14}C dates directly on the human bone of individual 2 have helped to settle the issue, dating the skeleton to 8850 ± 50 BP (CAMS-36663) and 8880 ± 50 BP (CAMS-36634), and thus establishing these as the earliest human remains so far found in Patagonia. In the following sections, we discuss these skeletons and the dating procedure on individual 2, leading to a discussion of early human remains in America.

2. Site context

The Baño Nuevo-1 cave is carved on the base of one of several isolated basaltic buttes emerging from a large plain created by Pleistocene glacial erosion and pro-glacial lakes on the eastern Andean slopes of Central Patagonia. The site is located some 80 km northeast of the modern city of Coyhaique in the Aisen region of Chile, on a large sheep ranch of the same name (Estancia Baño Nuevo). The area is characterized by a dry continental climate (average annual precipitation 400 mm mainly as snow; average annual maximum temperature 7°C) that nurtures a xerophytic steppe vegetation dominated by *Stipa* grasses. Although there are some isolated stands of *Nothofagus* trees on the eastern slopes of major buttes (thus protected from the strong westerlies), the cave is not likely to have ever been in a forest environment, and prehistoric subsistence and mobility patterns may have been heavily tied to the eastern, open plains Patagonian steppe.

Although paleo-palynological studies have not yet been done at the area, a general comparison with other valleys in the region rules out the effects of relatively recent (XIX or XX centuries) forest fires. If rainfall patterns are conditioned by topographic features such as the Andean mountains to the west, we may predict that Baño Nuevo has been a dry area for a long time. This condition also backs the estimated association of prehistoric population to an eastern, steppe-plains tradition, rather than to a Pacific canoe tradition. The record of rock paintings (that are a common trait of eastern Central Patagonian archaeological record and are virtually unknown in the Western archipelagos) and obsidian (with one piece attributed by geochemical analyses to a source in present-day northwestern Santa Cruz, Argentina; Stern, 1996) add further support to this interpretation. A single projectile point found at the site does not clearly belong to these early levels and, if so, does not present any diagnostic stylistic trait to propose such a relationship.

3. The early skeletal sample

The skeleton directly dated by AMS ^{14}C analysis (individual 2) is in a generally good state of preservation

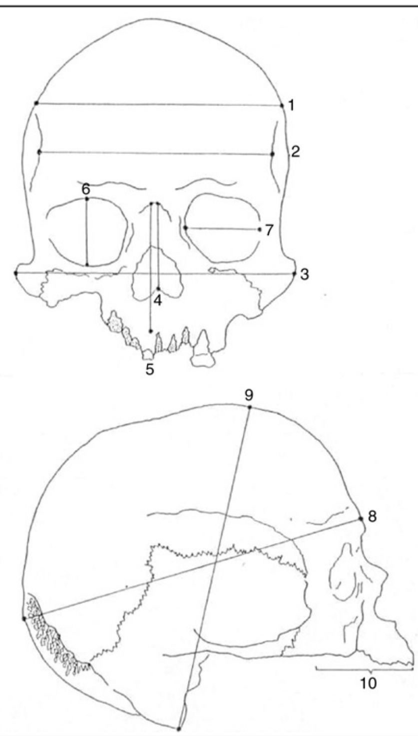
(Reyes, 1998). It was found in excavation unit 7E, at a depth of between 80 and 130 cm from the present-day surface, in a flexed position as if placed on a rocky inflection of the wall with the right side of the body leaning against the eastern wall of the cave, facing west. The present underground location is solely due to the deposition of soil and debris against the cave walls (low section) throughout the millenia since the body was placed. Originally, some shallow digging may have been done, but the corpse was basically placed at ground level in a natural niche in the cave wall and covered with stones and dirt as a kind of mound, reminescent of those known as *chenke* among historical Tehuelche Indians in Patagonia.

Except for the pelvis (that lay directly on the basal rock and, thus, may have been exposed to particular humidity and chemical conditions), the main part of the right scapulae and a few phalanges (mainly from the left hand, that lay close to the pelvis on top of the basal rock) the skeleton is complete, although the leg bones are fragmented (and, thus, could not be used for stature estimates) and most of the ribs and vertebrae are heavily eroded and fragmented. Only two maxillary teeth are lacking from the recovered skeleton.

The bones correspond to a male aged around 20–25 years old. Although the pelvis was largely lost, the sex was defined on the basis of a large supraorbital ridge, a large mastoid processes and a quadrangular and robust chin. The age has been estimated on the basis of the eruption and wear of the third molar (Hillson, 1996; Ubelaker, 1996) and the still not fully closed basilar suture and other cranial sutures (Meindl and Lovejoy, 1985). Epyphiseal lines are still clearly visible on the proximal humerus and tibia, and the distal radius, ulna and femur. Using regression formulas for total height estimation from maximal humeral length (Trotter and Glesser, 1958), the individual's stature has been calculated to 162 ± 4 cm tall.

The cranium presents several discrete traits attributable to a Mongoloid type, such as sagital keeling, complex main sutures, pronounced zygomaxilar tuberosity, angular zygomaxilar suture and elliptical external auditory meatus (Gill and Rhine, 1990). Incisor shovelling (Hinkes, 1990) relates this individual to a general Sinodont pattern prevalent among modern Northeast Asian and Amerindian populations (Turner, 1986). The cranial vault is high and elongated and could be described as "dolicoid". The face is smaller and more gracile than the "typical", historical Patagonian pattern (Fig. 4). An analysis of the few postcranial traits that are supposedly diagnostic of population affiliation (Gilbert and Gill, 1990) does not contradict the above determination.

Although bones from individual 3 (Fig. 5) have not been directly dated, the date on associated charcoal and the stratigraphic relationships to individual 2 suggest that they may be roughly contemporary. In any case, they seem to correspond to a rather uniform funerary



1	Maximum cranial breadth	141 mm
2	Minimum frontal breadth	103 mm
3	Bizygomatic diameter	139 mm
4	Nasal height	42 mm
5	Upper facial height	63 mm
6	Orbital height	40 mm
7	Orbital breadth	32 mm
8	Maximum cranial length	194 mm
9	Basion-Bregma height	142 mm
10	Maxilo-Alveolar length	51 mm

Fig. 4. Cranium of Individual ♯2, with standard measurements.

Fig. 5. Skeletal remains of Ind. #3 (adult female); cranium removal due to post-depositional disturbance.

pattern (both are in the same anatomical position leaning against the eastern rocky wall, both are associated with fox (*Pseudalopex culpaeus)* remains; Trejo and Jackson, 1998). Although the cranium from individual 3 was not in place and has not been located in the excavation, the postcranial skeletal features are comparable to those from individual 2 and suggest that both individuals correspond to a common physical type and population. On the basis of measurements of the preserved long bones (Genovés, 1967; Trotter and Glesser, 1958), the individual stature is estimated at 154 ± 3.5 cm. Since the remains belong to an adult female individual, this value also falls within a reasonable range of stature for the same population that comprised individual 2, given expected sexual dimorphism.

The age of this individual has been estimated on the basis of morphological changes in the pubic symphisis and the ileon articular surface (Meindl et al., 1985) to about 50 years, but the morphological changes observed on the sternal edge of the fourth rib point to a somewhat younger age (stage I *sensu* Loth and Iscan, 1989). We have decided to attribute to this individual an age of between 42 and 45 years. The pelvis was, fortunately, well preserved, allowing the clear identification of individual 3 as a female individual.

Although two of the juvenile individuals have shovel shaped incisors that point to a common Mongoloid stock, their remains are too sparse and damaged to be clearly assigned to this early population. However, stratigraphic association and some common funerary traits suggest that they may well be of the same age. Individual 1 shares with both adult burials the close association with fox remains, and with 3 the deposition of a bundle of plant material on the chest cavity. Individuals 4 and 5 share with both adult burials the fact of laying close to the rocky wall. Anatomical position may differ because of differential preservation and/or different cultural ways of handling juvenile versus adult corpses. Their age was determined by deciduous teeth eruption (Ubelaker, 1996) to be less than 6 months old. These specimens could not be sexed.

4. Dating procedures

Two human bones from individual 2 were used for direct AMS radiocarbon dating, a rib fragment (NSRL-3485) and a long bone fragment (NSRL-3486). In addition, the same dating procedure was applied to a *Mylodon* dermal ossicle (NSRL-3320) from the base of layer 5. The physical appearances of the *Mylodon* and human bones were distinctly different. The *Mylodon* dermal ossicle was white to extremely pale yellow, hard, very difficult to break and with a semi-waxy surface similar to modern bone. The human bone fragments

Table 1
AMS radiocarbon dates on fossil bone from Baño Nuevo Cave, Chile. All dates were measured on the XAD-purified gelatin hydrolyzate chemical fraction. CAMS- is the abbreviation for the Center for Accelerator Mass Spectrometry at the Lawrence Livermore National Laboratory, California. The mg carbon dated signifies the mass of graphitized carbon used for dating. NSRL- is the laboratory number assigned in the INSTAAR radiocarbon laboratory

Sample No.	Description	Mg C dated	Fm $\pm$ 1SD	14C AGE, YR $\pm$ 1 SD	LLNL No.
NSRL-3320	Mylodon dermal ossicle: h-17	1.16 mg	0.2396 $\pm$ 0.0057	11 480 $\pm$ 70	CAMS-32685
NSRL-3485	Human rib fragment: Cuad. 7E, Capa 4, 90–110 cm.	0.96 mg	0.3323 $\pm$ 0.0020	8850 $\pm$ 50	CAMS-36633
NSRL-3486	Human long bone fragment Cuad. /E, Capa 4, 90–110 cm.	0.81 mg	0.3313 $\pm$ 0.0020	8880 $\pm$ 50	CAMS-36634

Table 2
Physical observations and chemical yields for the chemical pretreatment of three fossil bones from Baño Nuevo Cave, Chile

Sample No.	Mg bone used for decalcification	Mg decalcified collagen after KOH	% Yield after HCI/KOH	% Collagen pseudomorph	Mg collagen used for gelatin extraction	% Collagen soluble as gelatin	% Overall resemblance to modern bone(%)
NSRL-3320	890.5	106.9	12.0	99	108	100	90
NSRL-3485	982.1	21.7	2.2	60	14.3	66	60
NSRL-3486	996.3	5.1	0.5	15	1.2	24	40

were brown to light brown, matte texture, soft and easily broken. Slightly less than a gram of cleaned bone was pretreated chemically from each specimen.

Sample pretreatment chemistry followed Stafford et al. (1991) with some improvements. The sequence of chemical purification steps was decalcified in cold (4°C) 0.2 N HCl, washing with cold 0.5% KOH, gelatin extraction by heating the protein for 10–30 min in pH2 water at 110°C, hydrolysis of the gelatin into amino acids with 6 N HCl for 24 h at 110°C and finally purification of the hydrolyzate through XAD resin. Approximately 6 mg or less of XAD-pretreated amino acids were transferred to a 6 mm quartz tube and dried under vacuum. Copper oxide, silver and copper reagents were added, the tube was evacuated and the sample was combusted for 3 h at 820°C. After purifying the CO_2, it was converted into graphite, which was analysed at the Lawrence Livermore National Laboratory Center for Accelerator Mass Spectrometry (CAMS).

The chemical and physical behaviour of the protein was recorded after each step to assess how well contaminants were being removed and to estimate the degree of chemical preservation for the bone protein collagen. The pretreatment results and yields are summarized in Table 1 and those of the chemical pretreatment sequence in Table 2.

Overall, the *Mylodon* ossicle was extremely well preserved chemically and had 85–90% of the chemical and physical characters of a modern bone. In contrast, the human bones were substantially less well preserved (60% and 50%, respectively) than the fossil sloth, despite the human bones' younger geologic age. The chemical properties of the human bones were still well within those acceptable for dating fossil bone (Stafford et al., 1988) and the agreement of the two radiocarbon dates to within 30 years is evidence that the ages are accurate.

The calibration of these dates is complicated by two factors. First, both lie on a plateau in the tree ring calibration curve, so that relatively precise ^{14}C dates calibrate to a much larger range of calendar years. Second, this particular plateau corresponds to the end of the late Glacial-Holocene German pine chronology and the start of the master German oak sequence. A tentative 1993 matching between these two chronologies (Becker, 1993) has recently been revised (Bjorck et al., 1996; Goslar et al., 1995). Based on the Bjorck et al. (1996) chronologies, radiocarbon dates of 8850 $\pm$ 50 and 8880 $\pm$ 50 calibrate to age ranges of approximately 7750–8150 BC and 7900–8200 BC, respectively, at one sigma. However, the process of cross-linking the oak and pine sequences is ongoing, and further shifts of several decades are considered likely (Becker, 1997).

5. Discussion

The direct AMS ^{14}C dating of individual 2 from Baño Nuevo-1 cave positively points to it as the earliest human skeletal remains known from the Patagonian area, and strongly suggests comparable early Holocene ages for other human remains in the site. The human remains from Pali Aike and Cerro Sota caves in southern Patagonia, excavated by Bird in 1936 and long held to be evidence of Paleoindian burials (Bird, 1983; Munizaga, 1976), are now suspect. The Cerro Sota remains have been directly redated to around 3700 BP (Hedges et al., 1992) and the association with extinct Pleistocene fauna has come to be regarded in this case as a poor chronological indicator. Since the funerary pattern and megafaunal associations at Cerro Sota are similar to the ones observed at Pali Aike (though not the skeletal morphology, see Munizaga, 1976), they have been judged contemporary. Therefore, since the Pali Aike remains have not been directly dated, the reanalysis of Cerro Sota also throws doubts on the long-assumed high antiquity of the former. However, both sites may not be as similar as we have tended to think. The practice of skeletal cremation and the use of red ochre, supposedly shared at Cerro Sota and Pali Aike, are both in question and, at least in the case of Cerro Sota, fire damage to human bones is clearly accidental and postdates the intentional burial (Aspillaga, pers. com., 1997). If remains from Pali Aike do in fact reveal evidence of intentional cremation following death (and they have not been adequately restudied), the observed craniometrical differences may in fact point to a different, and perhaps earlier, population (Aspillaga et al., 1992). At this moment, however, direct evidence of an antiquity comparable to that from the Baño Nuevo individual 2 is lacking. Besides, Baño Nuevo reveals that funerary patterns may not be useful as a widespread temporal signature and points to an extraordinary continuity in burial practices, at least in this part of Patagonia, where *chenke* burial may have early Holocene antecedents.

Few skeletal remains have been adequately studied in Patagonia and still fewer are rigourously dated. Still, with the above questionable exceptions, the earliest skeletal remains so far available for discussion in Patagonia before the Baño Nuevo-1 findings came from Mata Molle in the Argentinian province of Neuquén (Fernández, 1983).

The human remains from Baño Nuevo-1 in fact are among the earliest known from the South American continent. Sparse and fragmented remains from Meadowcroft, Pennsylvania (lower IIa level) may date from ~11 300 BP (Sciulli, 1982). Two juvenial crania from Anzick, Montana, previously supposed to be evidence of a collective burial (Lahren and Bonnichsen, 1974), were dated to events separated by two millenia: 10 680 ± 50 BP and 8600 ± 90 BP (Stafford, 1994). Although a few recent North American finds (i.e. Kennewick, Wash. (see Chatters, 1997; Morell, 1998); Hourglass Cave, Colorado, (see Mosch and Watson, 1997); Buhl, Idaho (see Green et al., 1998); Prince of Wales Island, Alaska, see Field, 1996) are rendering dates in the 10th or 11th millenia BP many of these sites (e.g. Marmes, Wash.; Mostin, Calif., Midland, Tx.) have not been well evaluated, and all human bones claimed to be earlier than 11 000 BP are under heavy scrutiny (Stafford et al., 1990; Taylor et al., 1985). Further south, early human skeletal samples are very rare and only the Acha-2 burial in far northern Chile (8970 ± 255 BP (Muñoz et al., 1993, pp. 47–62)), one of the skeletons recovered at Arroyo Seco 2 (8558 ± 316 BP; currently under discussion (see Politis and Madrid, 2001)), the burial from Huentelauquén-2 (8080 ± 70 BP (Costa et al., 1997)) and a few remains dated by associated charcoal (i.e. Cerro Mangote, Panama, (see McGimsey, 1956; Ranere, 1981); Las Vegas, coastal Ecuador (see Stothert, 1988; Ubelaker, 1980); La Paloma, Peru (see Quilter, 1989; Benfer, 1990); Paiján, Peru, (see Chauchat and Lacombe, 1984); Piuquenes, Chile (see Stehberg, 1997) and Cuchipuy, Chile (see Kaltwasser et al., 1980) are likely to date from a time period comparable to the one represented by the Baño Nuevo material reported here. One of the skeletons from Piuquenes cave has been recently directly dated to 8990 ± 40 BP (Beta 151285; Aspillaga, pers. comm., 2002).

The early Baño Nuevo-1 skeletal remains are interesting not only for their age and, granting that the sample is preciously limited, we cannot avoid pointing to some observations that impinge on general theories on early human migrations in America. It is interesting to mention, for instance, that although some "classical Mongoloid traits" are present, individual 2 from Baño Nuevo does not fully correspond to the tall, broad-faced parameters more common in recent Patagonian populations (Lahr, 1995). The relatively low stature and small, gracile face, are traits more commonly associated to western, more "Andean" populations, and may relate to a more recent "Archaic" population wave that reached the southern Andes some 10 000 or 9000 years ago (as reflected, for instance, at Cuchipuy and Chinchorro; (Aspillaga, pers. com., 1998)). If so, the ~8870 years old remains from individual 2 at Baño Nuevo-1 (perhaps as much as a millenium older, if we average the calibrated dates) may represent part of the broad range of variation related to the hybridation of these "Andean" populations with an earlier, perhaps non-mongoloid eastern stock, in an area geographically and environmentally transitional between the Andean and Patagonian areas. This hypothesis is currently being evaluated by means of DNA analyses.

Acknowledgements

We want to thank the Baño Nuevo excavation team that included Victor Lucero and Valentina Trejo besides the two main authors. Thanks to Eugenio Aspillaga, Mario Castro, Florence Constantinescu (Depto. de Antropología, Universidad de Chile) and Luis Cornejo (Museo Chileno de Arte Precolombino) for their valuable commentaries and advice.

References

Aspillaga, E., Castro, M., Paredes, C., 1992. Early human remains from patagonia: Cerro Sota, Palli Aike and Cañadón Leona. American Journal of Physical Anthropology 14 (Suppl.), 45 (Annual Meeting Issue).

Bate, L.F., 1979. Las investigaciones sobre los cazadores tempranos en Chile austral. Trapananda 1 (2), 14–23.

Becker, B., 1993. An 11000-year German oak and pine dendrochronology for radiocarbon calibration. Radiocarbon 35, 201–213.

Becker, B., 1997. Unpublished data presented at the 16th international ^{14}C Conference, Groningen, The Netherlands, June 16–20.

Benfer, R.A., 1990. The preceramic period site of Paloma, Peru: bioindications of improving adaptation to sedentism. Latin American Antiquity 1, 284–318.

Bird, J., 1983. Enterratorios paleoindios con creamación en las cuevas de Pali Aike y Cerro Sota en Chile meridional. Anales del Instituto de la Patagonia 14, 55–65.

Bjorck, S., Kromer, B., Johnsen, S., Bennike, O., Hammarlund, D., Lemdahl, G., Possnert, G., Rasmussen, T.L., Wolfharth, B., Hammer, C.U., Spurk, M., 1996. Synchronized terrestrial-atmospheric deglacial records around the North Atlantic. Science 274, 1155–1160.

Chatters, J., 1997. Encounter with an ancestor. Anthropology Newsletter 38 (1), 9–10.

Chauchat, C., Lacombe, J.P., 1984. El Hombre de Paiján: el más antiguo peruano? Gaceta Arqueológica Andina 11, 4–6.

Costa, A., Quevedo, S., Aspillaga, E., 1997. Sepultamiento arcaico costero: sitio Huentelauquén 2. Resúmenes XIV Congreso Nacional de Arqueología Chilena, Copiapó, pp. 23–22.

Fernández, J., 1983. Cronología y posición estratigráfica del llamado "hombre fósil" de Mata Molle. Historia Natural 3 (7), 57–72.

Field, T., 1996. Human remains found in Alaska reported to be 9730 years old. SAA Bulletin 14 (5), 5.

Genovés, S., 1967. Proportionality of the long bones and their relation to stature among mesoamericans. American Journal of Physical Anthropology 26 (1), 67–77.

Gilbert, R., Gill, G., 1990. A metric technique for identifying American Indian femora. In: Gill, G., Rhine, S. (Eds.), Skeletal Attribution of Race; Methods for Forensic Anthropology. University of New Mexico, Albuquerque, pp. 97–99.

Gill, W.G., Rhine, S., 1990. Skeletal Attribution of Race. Methods for Forensic Anthropology. University of New Mexico, Albuquerque.

Goslar, T., Arnold, M., Tisnerat-Laborde, N., Czernik, J., Wichowski, K., 1995. High concentration of atmospheric ^{14}C during the Younger Dryas cold episode. Nature 377, 414–417.

Green, T.B., Cochran, T., Fenton, J., Woods, G., Titmus, L., Tieszen, M.A., Davies, S., Miller, S., 1998. The Buhl burial: a paleoindian woman from southern Idaho. American Antiquity 63 (3), 437–456.

Hedges, R.E.M., Housley, R.A., Bronk, C.R., Van Klinken, G.J., 1992. Radiocarbon dates from the Oxford AMS System: Archaeometry datelist 15. Archaeometry 34, 337–357.

Hillson, S., 1996. Dental Anthropology. Cambridge University Press, Cambridge, MA.

Hinkes, M., 1990. Shovel shaped incisors in human identification. In: Gill, G., Rhine, S. (Eds.), Skeletal Attribution of Race; Methods for Forensic Anthropology. University of New Mexico, Albuquerque, pp. 21–26.

Kaltwasser, J., Medina, A., Munizaga, J., 1980. Cementerio del periodo Arcaico en Cuchipuy. Revista Chilena de Antropología 3, 109–123.

Lahr, M.M., 1995. Patterns of modern human diversification: implications for Amerindian origins. Yearbook of Physical Anthropology 38, 163–198.

Lahren, L., Bonnichsen, R., 1974. Bone foreshafts from a Clovis burial in Southwestern Montana. Science 186, 147–150.

Loth, S.R., Iscan, M.Y., 1989. Morphological assessments of age in the adult: the thoracic region. In: Iscan (Ed.), Age Markers in the Human Skeleton. Charles Thomas Publishers, Springfield, pp. 105–135.

McGimsey, C.R., 1956. Cerro Mangote: a preceramic site in Panama. American Antiquity 22, 151–161.

Meindl, R.S., Lovejoy, C.O., 1985. Ectocranean suture closure: a revised method for the determination of skeletal age at death and blind test of its accuracy. American Journal of Physical Anthropology 68, 57–66.

Meindl, R.S., Lovejoy, C.O., Mensforth, R.P., 1985. A revised method of age determination using the Os Pubis, with a review and tests of accuracy of other current methods of pubic symphyseal ring. American Journal of Physical Anthropology 68, 29–45.

Mena, F., Reyes, O., 1998. Esqueletos humanos del Arcaico Temprano en el margen occidental de la estepa centropatagónica (Cueva Baño Nuevo; XI Región). Boletín de la Sociedad Chilena de Arqueología 25, 19–24.

Mena, F., Reyes, O., 2001. Montículos y cuevas funerarias en Patagonia: una visión desde cueva baño Nuevo, XI Región. Chungara 33 (1), 21–30.

Mena, F., Stafford Jr., T., Southon, J., 1998. Direct AMS radiocarbon dating on human bones from Baño Nuevo, Central Patagonian Andes, Chile. Current Research in the Pleistocene 15, 71–72.

Mena, F., Lucero, V., Reyes, O., Trejo, V., Velásquez, H., 2000. Cazadores tempranos y tardíos en la Cueva Baño Nuevo-1, margen occidental de la estepa centropatagónica (XI Región de Aisén, Chile). Anales del Instituto de la Patagonia 28, 173–195.

Morell, V., 1998. Kennewick man's trials continue. Science 280, 190–191.

Mosch, C., Watson, P.J., 1997. The ancient explorer of Hourglass Cave. Evolutionary Anthropology 111–115.

Munizaga, J., 1976. Paleoindio en Sudamérica (Restos óseos humanos de las cuevas de Palli Aike y Cerro Sota, Provincia de Magallanes, Chile). Volumen Homenaje al Dr. Gustavo Le Paige; Universidad del Norte, pp. 19–30.

Muñoz, I., Arriaza, B., Aufderheide, A., 1993. El poblamiento Chinchorro: nuevos indicadores bioantropológicos y discusión en torno a su organización social. In: Muñoz, I., Arriaza, B., Aufderheide, A. (Eds.), Acha-2 y los Orígenes del Poblamiento Humano en Arica, Universidad de Tarapacá, Arica.

Politis, G., Madrid, P., 2001. Arqueología pampeana: estado actual y perspectivas. In: Berberian, E., Nielsen, A. (Eds.), Historia Argentina Prehispánica, Vol. II. Editorial Brujas, Córdoba, pp. 737–814.

Quilter, J., 1989. Life and Death at Paloma. University of Iowa Press, Iowa City.

Ranere, A., 1981. The re-excavation and reinterpretation of Cerro Mangote: a preceramic shell midden in central Panama. Department of Anthropology, Temple University, unpublished MS on file.

Reyes, O., 1998. Restos óseos humanos de cueva Baño Nuevo-1 (Alto Ñirehuao, Región de Aysén): descripción general y análisis paleopatológico de los individuos 2 y 3. Depto. Antropología, Universidad de Chile, unpublished Práctica profesional.

Sciulli, P., 1982. Human remains from Meadowcroft Rockshelter, Washington county, Southwestern Pennsylvania. In: Carlisle, Adovasio, J. (Eds.), Meadowcroft: Collected Papers on the Archaeology of Meadowcroft Rockshelter and the Cross Creek

Drainage. Department of Anthropology, University of Pittsburgh, pp. 175–185.

Stafford, Th., 1994. Accelerator C-14 dating of human fossil skeletons: assessing accuracy and results on new world specimens. In: Bonnichsen, R., Steele, G. (Eds.), Method and Theory for Investigating the Peopling of the Americas. Center for the Study of the First Americans, Corvallis, Oregon, pp. 45–55.

Stafford, Th., Brendel, K., Duhamel, R., 1988. Radiocarbon, ^{13}C and ^{15}N analysis of fossil bone: removal of humates with XAD-2 resin. Geochemica et Cosmochimica Acta 52, 2257–2267.

Stafford, Th., Hare, P.E., Currie, L., Jull, A., Donahue, D., 1990. Accuracy of North American human skeleton ages. Quaternary Research 34, 111–120.

Stafford, Th., Hare, P.E., Currie, L., Jull, A., Donahue, D., 1991. Accelerator radiocarbon dating at the molecular level. Journal of Archaeological Science 18, 35–72.

Stehberg, R., 1997. El hombre y su medio en el período Holoceno temprano (5000–10000 AP): Caverna Piuquenes, Cordillera andina de Chile Central. Resúmenes XIV Congreso Nacional de Arqueología Chilena, Copiapó, p. 114.

Stern, Ch., 1996. Black obsidian from Central-South Patagonia; chemical characteristics, possible sources and regional distribution of artifacts. Soplando en el Viento, Actas III Jornadas de Arqueología de la Patagonia. San Carlos de Bariloche, Argentina.

Stothert, K., 1988. Cultura Las Vegas: La prehistoria temprana de la peninsula de Santa Elena. Ecuador Miscelánea Antropológica Ecuatoriana; Serie Monográfica No. 10.

Taylor, R., Payen, L.A., Prior, C.A., Slota Jr., P.J., Gillespie, R., Gowlett, J.A., Hedges, R.E., Tull, A.J., Zabel, T.H., Donahue, D.J., Burger, R., 1985. Major revisions in the Pleistocene age assignments for North American human skeletons by C-14 accelerator mass spectrometry: none older than 11000 C-14 years BP. American Antiquity 50, 136–140.

Trejo, V., Jackson, D., 1998. Cánidos patagónicos: identificación taxonómica de mandíbulas y molares del sitio arqueológico Baño Nuevo-1 (alto Ñirehuao, XI Región). Anales del Instituto de la Patagonia 26, 181–194.

Trotter, N., Glesser, G., 1958. A re-evaluation of estimations of stature based on measurements of stature taken during life and of long bones after death. American Journal of Physical Anthropology 16 (1), 79–123.

Turner, Ch., 1986. The first Americans: the dental evidence. National Geographic Research 2, 37–46.

Ubelaker, D., 1980. Human skeletal remains from site: OGSE-80: a preceramic site on the Santa Elena Peninsula, Coastal Ecuador. Journal of the Washington Academy of Sciences 70 (1), 3–24.

Ubelaker, D., 1996. Human Skeletal Remains. Manuals on Archaeology, No. 2. Smithsonian Institution, Washington.

PERGAMON

Quaternary International 109–110 (2003) 123–132

Early peopling and evolutionary diversification in America

Héctor M. Pucciarelli[a,b,*], Marina L. Sardi[a], José C. Jimenez López[c], Carlos Serrano Sanchez[d]

[a] *División Antropología del Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina*

[b] *Consejo Nacional de Investigaciones Científicas y Técnicas, Avda. Rivadauia 1917, 1033 Buenos Aires, Argentina*

[c] *Instituto Nacional de Antropología e Historia (INAH), Mexico DF, Mexico*

[d] *Instituto de Investigaciones Antropológicas, Mexico DF, Mexico*

Abstract

Several cranial-functional studies were made to compare the major (neurocranium and face) and minor (anteroneural, midneural, posteroneural, otic, optic, respiratory, masticatory, and alveolar) cranial components in different human populations. In the present study, samples from Paleoamericans and ancient and modern Amerindians from Valley of Mexico, Lagoa Santa, Tierra del Fuego Island, and Minas Gerais (Botocudos) were compared. The aim was to test the hypotheses that (1) "There are non-significant differences in the functional cranial components of different Paleoamerican crania, since they proceeded from a single dispersive effect" and that (2) "The biological variability of Paleoamerican and Amerindian functional cranial components was produced by random diversification evoked—after migration—by stochastic evolution". Its acceptance will hold the criterion of temporal discontinuity between "megapopulations", with a high incidence of migration and genetic drift. Its rejection will mean that Paleoamericans were not a morphologically homogeneous substratum, and that further populations could have—at least in part—originated from one or several central nuclei highly diversified by non-stochastic processes, like selection and adaptation. Multivariate (discriminant analysis and hierarchical clusters) were employed to get a general sample distribution. Univariate between-group standardized sD^2 distances were calculated to measure absolute and relative within-component differences. Statistical analyses were performed by the SYSTAT 9 program. Results lead us to reject both null hypotheses, suggesting that: (1) some cranial-functional differences were evident between both Paleoamerican samples, and (2) that several adaptative trends from Paleoamericans to modern Amerindians, and between Amerindians, might have occurred. It was concluded that adaptation could explain a fraction of the non-detectable cranial variation by the non-functional craniometric methods not explained by the "migration-drift" model for the American diversification.

1. Introduction

Several attempts to explain the origin and diversity of South-American human populations were made. Until the mid-20th century, the explanations were, except for Ameghino's valuable efforts, based purely on migration. In essence, a "migratory wave" for each morphological type had been considered. The origin and number of such waves varied in function of the number of observable morphological types, which were seldom influenced by the subjectivism of the observer. The intermediate types were explained by miscegenation among contemporary waves. Such an extremely diffusionist paradigm was replaced about 1950 by the point of view that migration is just one evolutionary mechanism. Genetic drift was the other one. Later, non-stochastic processes such as adaptation were proposed by Lahr (1995) and Hernández et al. (1997), among other authors.We believe that such a complex process as the peopling of a continent through, at least, a hundred centuries, is only explainable by multiple factors, such as migration, genetic drift, and adaptation. From the 1980s onwards, several explanatory hypotheses about human settlement in the Americas were proposed. They were based on one (Bonatto and Salzano, 1997a, b; Merriwether et al., 1995; Szathmáry, 1981, 1984), three (Greenberg et al., 1986; Lahr, 1995; Turner, 1987, 1992), and four (Neves and Pucciarelli, 1990, 1991, 1998; Neves et al., 1999a, b; Powell and Neves, 1999; Steele

*Corresponding author. Division Antropologia del Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina.

E-mail address: hmpucci@fcv.unlp.edu.ar (H.M. Pucciarelli).

1040-6182/02/$ - see front matter
doi:10.1016/S1040-6182(02)00208-2

and Powell, 1992, 1993) possible migrations. Now, the problem should be analyzed from two perspectives. One of them is to reconsider the number of population components rather than the number of migratory waves, and the other one is to introduce adaptation as an actual differentiation process in the Americas.

The first topic came from an interesting question. At the end of the 1980s, the Three-Migration Model (TMM), based on dental, genetic, and linguistic traits, was generally accepted for the American peopling. The TMM postulated three population waves, one for Eskimos, another for Na-Dene and a third one, in fact the first, for the remaining Amerindians. The Four-Migration Model (FMM) was built on the TMM basis, since the fourth wave was added to explain the first American settlement, that of the Paleoamericans, about 12,000–8000 years ago. Further linguistic, non-metric, mtDNA, and "Y" chromosome studies made between Na-Dene and American Eskimos (Ossenberg, 1976; Szathmáry and Ossenberg, 1978; Szathmáry, 1979; 1993) did not indicate that both groups were actually different. Consequently, the TMM was seriously constrained, by reducing from three to two the number of migratory waves, and the FMM became the TMM. A more rational model, however, would be the Two-Component settlement System (TCS). This model avoided the untesteable concept of "wave" in favor of the more tangible concept of "component", since, on the one hand, in more than one migratory wave the Amerindians could people the continent, and, on the other hand, different peoples could come forth from a single migration. A component, in the TCS, may be one, two, or several populations that, sharing similarity in morphology and antiquity, compound a true megapopulation, independent of the number of migratory waves supposed to happen. The system is the autochthonous American people and the components are the Paleoamericans (12,000–8000 BP), the ancient (8000–500 BP), and modern (<500 BP) Amerindians. The first ones were non-Mongoloid people, morphologically near the South-Africans and Australians, and some of them might have survived to the present. The second ones were Mongoloids, or with mongolized cranial and facial structures. They came from North Asia and constituted great part of the extinct and extant Amerindian populations.

The second component is the main subject of the present study, which points to the fact that the autochthonous American variability may be due, at least in part, to non-stochastic evolutionary processes. It is possible that, given the knowledge about the population density of the Paleoamerican times, they may have evolved and, if not banished by the Amerindians, survived up to modern times. Functional cranial studies made on American skulls allowed us to conclude that, beyond the mere taxonomic implications drawn from the classical craniometrical methods, the evolutionary adaption played an important role in the American diversifying processes (Pucciarelli et al., 1999). Such studies are based on the Functional Cranial theory, proposed by van der Klaauw for the mammalians (Klaauw, 1948–52), and by Moss and Young (1960) for the human skull. In substance, the Klaawesian theory considers the skull as formed by several skeletal units, relatively independent, and suitably differentiated by their support and protection functions to the head soft tissues and organs (Dressino and Pucciarelli, 1999; Pucciarelli et al., 1990, 1999).

The aim of the present study was to examine the null hypotheses that (1) "There are non-significant differences in the craniofacial structure of Paleoamerican crania, whether they proceeded from a single dispersive effect"; and that (2) "The biological variability of Paleoamerican and Amerindian functional cranial components was produced by random diversification evoked (after migration) by stochastic evolution". The acceptance of the two hypotheses will hold the criterion of temporal discontinuity between the megapopulations, with high incidence of migration drift. Their rejection will mean that, on the one hand, Paleoamericans were not a morphologically homogeneous substratum, and that, on the other hand, further populations could be, at least in part, originated from one or several central nuclei highly diversified by non-stochastic processes, like selection and adaptation.

2. Material and methods

Sixty male skulls from hunter–gatherer populations were employed. They came from Mexico, Brazil, and Argentina. Mexican crania belonged to four Paleoamericans (*Valley*), nine Archaic Amerindians (*Tlatilco*), and six modern Amerindians (*Tlatelolco*), all belonging to the Instituto Nacional de Antropología e Historia (INAH, Mexico DF). The South American samples were ten Paleoamericans (*Lagoa Santa*) belonging to the Harold Walter collection (Minas Gerais Museum, Brazil), eleven Amerindians, belonging to the Minas Gerais (*Botocudos*) (Rio de Janeiro Museum, Brazil), and ten Amerindians coming from the southernmost part of Argentina (*Fuegians*) (La Plata Museum, Argentina). The limited reliable radiocarbon data are enough to assure, on average, antiquities of 10,000 BP for Valley (Tlapacoya), 9000 BP for Lagoa Santa, (Lapa Vermelha, Santana do Riacho), and at least 5000 BP for the Mexican Archaics (Texcal, Tepexpan).

The 30 variables belonging to the functional craniometrical method, i.e., a length (L_x), a width (W_x), and a height (H_x) for each major (neurocranium and face), and minor neurocranial (anteroneural, midneural, posteroneural, and otic), and facial (optic, respiratory, masticatory, and alveolar) functional components, were measured (see Tables 1 and 2 for description). Ten volumetric indices (VI_x), for estimating the absolute size of the components, were built as the geometric mean from the three orthogonal dimensions measured into each component. Nine morphometric indices (MI_x) were also built for measuring shape in terms of relative size differences between minor functional components, and with respect to the major component to which they belong. The VI_x is calculated as

$$VI_x = \sqrt[3]{(L_x W_x H_x)}$$

The volumetric indices (VI) calculated for the neurocranium were: the neurocranial (NVI), anteroneural (ANVI), midneural (MNVI), posteroneural (PNVI), and otic (OTVI) ones. For the face, the facial (FVI), optic (OVI), respiratory (RVI), masticatory (MVI), and alveolar (AVI) ones were employed.

The morphometric indices are useful to describe shape changes of the functional components, in terms of relative size variation with respect to the remaining ones involved in the major component to which they belong

$$MI_x = 100 VI_x / VI_t$$

where

$$\text{Neurocranial } VI_t = ANVI + MNVI + PNVI + OTVI$$
$$\text{Facial } VI_t = OVI + RVI + MVI + AVI$$

Table 1
Variables employed in this study

Number	Symbol	Name	Description	Instrument	Mode[a]
01	NL	Neurocranial length	Nasion-Opisthocranium	Poech Caliper	Projected
02	NW	Neurocranial width	Eurion-Eurion	Curved Branch Caliper	Direct
03	NH	Neurocranial height	Basion-Vertex	Poech Caliper	Projected
04	FL	Facial length	Inner Prosthion-Vomerobasilar	Poech Caliper	Projected
05	FW	Facial width	Zygion-Zygion	Curved Branch Caliper	Direct
06	FH	Facial height	Nasion-Prosthion	Poech Caliper	Projected
07	ANL	Anteroneural length	Glabella-Bregma	Poech Caliper	Projected
08	ANW	Anteroneural width	Pterion-Pterion	Poech Caliper	Direct
09	ANH	Anteroneural height	Bregma-Vomerobasilar	Poech Caliper	Projected
10	MNL	Midneural length	Bregma-Lambda	Poech Caliper	Projected
11	MNW	Midneural width	Same as NW	Curved Branch Caliper	Direct
12	MNH	Midneural height	Basion-Bregma	Poech Caliper	Projected
13	PNL	Posteroneural length	Opistion-Opisthocranium	Poech Caliper	Projected
14	PNW	Posteroneural width	Asterion-Asterion	Curved Branch Caliper	Direct
15	PNH	Posteroneural height	Lambda-Opistion	Poech Caliper	Projected
16	OTL	Otic length	Timpanic bone posterior inferior end-mid point of inner end of the petrous bone	Vernier Caliper	Direct
17	OTW	Otic width	External auditive width	Needle Caliper	Direct
18	OTH	Otic height	External auditive height	Needle Caliper	Direct
19	OL	Optic length	Dacrion-intersfenoidal foramen	Orbitometer	Direct
20	OW	Optic width	Dacrion-Ectoconquio	Poech Caliper	Projected
21	OH	Optic height	Mid-Supraorbitary point-Mid-Infraorbitary point	Poech Caliper	Projected
22	RL	Respiratory length	Subnasal-Posterior nasal espine	Poech Caliper	Projected
23	RW	Respiratory width	Maximum nasal width	Vernier Caliper	Direct
24	RH	Respiratory height	Nasion-Subnasal	Poech Caliper	Projected
25	ML	Masticatory length	Lower border zygomatic synchondrosis-posterior border of the glenoid cavity	Vernier Caliper	Direct
26	MW	Masticatory width	Anterior sulcus of the sphenotemporal crest-lower point of the zygotemporal synchondrosis	Needle Caliper	Projected
27	MH	Masticatory height	Lower border of the zygotemporal synchondrosis- upper temporal line at the coronal intersection	Poech Caliper	Projected
28	AL	Alveolar length	External Prosthion-posterior alveolar border	Vernier Caliper	Direct
29	AW	Alveolar width	From left to right second-third molars width	Vernier Caliper	Direct
30	AH	Alveolar height	Palatal deep at midsaggital/second-third molars width	Palatometer	Direct

[a] For the projected measurements, the skull must be placed laterally on a 1 m squared $50 \times 50\,cm^2$ white cardboard, for reaching an acceptable parallelism with the caliper bar and/or its branches. Positioning must be done rotating carefully the skull up to reach and Auricular-Infraorbitary equalization (Frankfurt line). Previously, the correct anterior-posterior and vertical placement of the skull must be done with, respectively, the equalization of the Prosthion and Inion points with respect to the horizontal plane, and of the palatal first molars perpendicularly to this plane. Frankfurt orientation can be facilitated by a nylon thread placed not more than 1 cm above the skull, and subtended parallel to one of the cardboard lines. The thread must be took away after the correct placement was reached and before measurement starts. Direct measurements may be made out of the Frankfurt orientation. It is recommended to be first all projected and then all direct measurements or vice-versa.

Table 2
Indices employed in this study

Symbol	Formula	Description
Major components		Neurocranial volumetric index
NVI	$NVI = \sqrt[3]{NL\,NW\,NH}$	Facial volumetric index
FVI	$FVI = \sqrt[3]{FL\,FW\,FH}$	Neurofacial index (morphometric)
NFI	$NFI = NVI/FVI$	
Minor components		
ANVI	$ANVI = \sqrt[3]{ANL\,ANW\,ANH}$	Anteroneural volumetric index
MNVI	$MNVI = \sqrt[3]{MNL\,MNW\,MNH}$	Midneural volumetric index
PNVI	$PNVI = \sqrt[3]{PNL\,PNW\,PNH}$	Posteroneural volumetric index
OTVI	$OTVI = \sqrt[3]{OTL\,OTW\,OTH}$	Otic volumetric index
OVI	$OVI = \sqrt[3]{OL\,OW\,OH}$	Optic volumetric index
RVI	$RVI = \sqrt[3]{RL\,RW\,RH}$	Respiratory volumetric index
MVI	$MVI = \sqrt[3]{ML\,MW\,MH}$	Masticatory volumetric index
AVI	$AVI = \sqrt[3]{AL\,AW\,AH}$	Alveolar volumetric index
ANMI	$ANMI = 100ANVI/(ANVI + MNVI + PNVI + OTVI)$	Anteroneural morphometric index
MNMI	$MNMI = 100MNVI/(ANVI + MNVI + PNVI + OTVI)$	Midneural morphometric index
PNMI	$PNMI = 100PNVI/(ANVI + MNVI + PNVI + OTVI)$	Posteroneural morphometric index
OTMI	$OTMI = 100OTVI/(ANVI + MNVI + PNVI + OTVI)$	Otic morphometric index
OMI	$OMI = 100OVI/(OVI + RVI + MVI + AVI)$	Optic morphometric index
RMI	$RMI = 100RVI/(OVI + RVI + MVI + AVI)$	Respiratory morphometric index
MMI	$MMI = 100MVI/(OVI + RVI + MVI + AVI)$	Masticatory morphometric index
AMI	$AMI = 100AVI/(OVI + RVI + MVI + AVI)$	Alveolar morphometric index

For the neurocranium, the anteroneural (ANMI), midneural (MNMI), posteroneural (PNMI), and otic (OTMI) indices were employed. For the face, the optic (OMI), respiratory (RMI), masticatory (MMI), and alveolar (AMI) ones, were used.

The morphometric index employed for the major components was the neural–facial (NFI) one, which relates both major components

$$NFI = NVI/FVI$$

The NFI measures how many times the size of the neurocranium is involved in a unit of facial size. An $NFI = 2.0$ means that two times of neurocranium per unit of facial size is contained. The higher the NFI value, the greater the "encephalization" degree. In human crania, it depends, in fact, much more on the facial than on the neurocranial size variation, since face variation is highly related to the overall size -stature- variation (Tables 1 and 2).

The multivariate statistics employed were hierarchical clusters based on the canonical scores from the minor component variables, given by the between-group discriminant analysis. Clusters were built with average linkage type and euclidean distances, after scaling (z) and size (double-z) standardizations (Figs. 1 and 2). The univariate statistics involved the one-sample non-parametric Kolmogorov–Smirnov test, and the χ^2 proportion comparison for testing, respectively, the frequency distribution properties, and the signification of the differences in component proportions. The intensity and signification of the between-group comparisons were obtained by univariate Mahalanobis D^2 distances. The distances obtained from each between-group comparison were standardized (sD^2) as percentual fractions in the major and minor components. For example, an $sD^2 = -16.0$ obtained for the AMI in the Valley–Lagoa Santa comparison means that the free-sized alveolar component in Lagoa Santa was 16% greater than in Valley. Samples were compared following a sequential antiquity order in which the same sample was compared twice, in a consecutive way.

Different comparisons had different meanings. Fig. 3 shows the differences between Paleoamerican functional components. Fig. 4 shows the results of the South-American comparison sequence. Fig. 5 shows the results of the Mexico Valley cranial functional comparison. The statistical work was performed by the SYSTAT 9 program. The work was carried out at the División Antropología of the Museo de La Plata (Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina).

3. Results

The free of scaling hierarchical cluster made with the discriminant scores from the minor component variables (Fig. 1) showed two subclusters separated by the greatest distance ($d = 4.7$). One for Tlatilco, Tlatelolco, and Valley, and the other for Lagoa Santa, Botocudos, and Fuegians. Valley was more separated from Tlatilco and Tlatelolco ($d = 3.8$) than Botocudos and Fuegians

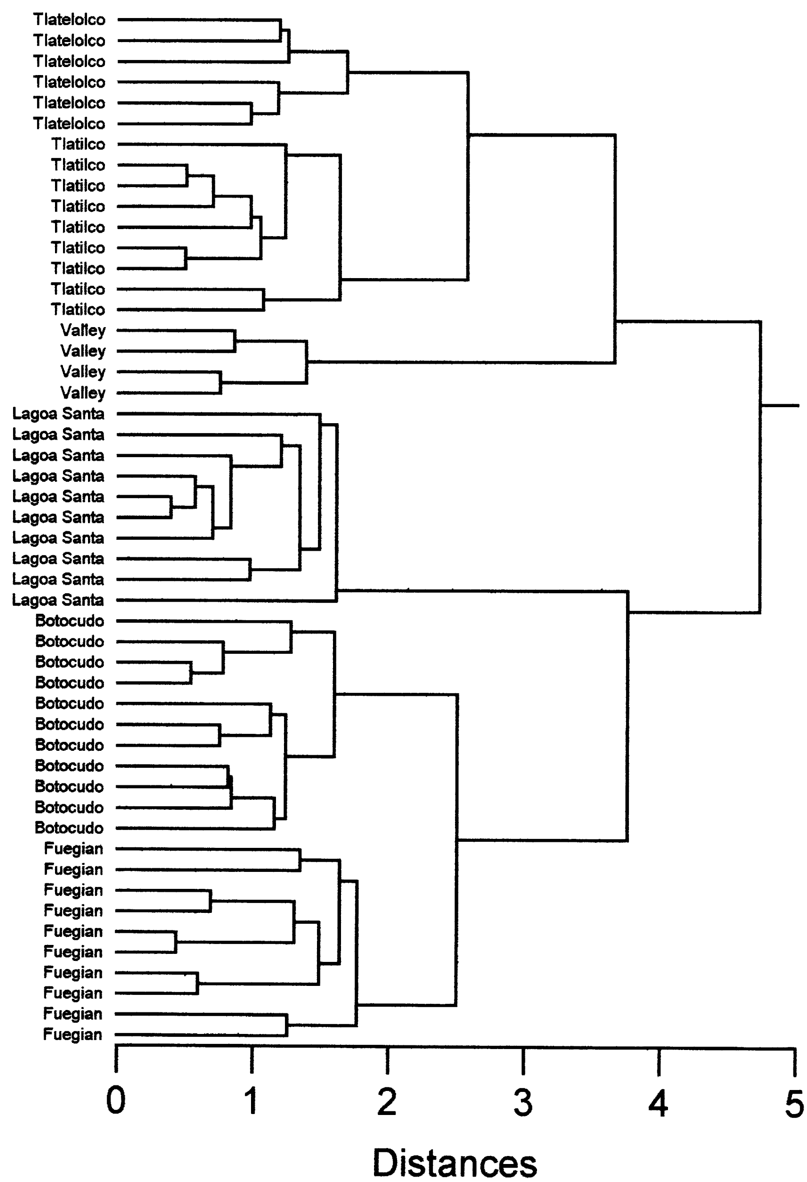


Fig. 1. Cluster built from the canonical discriminant scores of the "simple z" standardized (size plus shape) minor component variables.

did between themselves ($d = 2.5$). Lagoa Santa was more separated from Botocudos and Fuegians ($d = 3.8$) than the latters did between them ($d = 2.5$). The hierarchical cluster made with the discriminant scores from the free of size minor component variables (Fig. 2) showed a slight shortening of the distances, but no change in the sample distributions.

The behavior of the functional cranial components is shown in Fig. 3 for comparison between Paleoamericans. Valley had greater neurocranial (18%), and much greater facial (60%) component sizes, while the neural–facial index (−22%) was greater in the latters. The respiratory and masticatory components were greater in Lagoa Santa than in Valley (−40%, and −10%, respectively), while the alveolar one was greater in Valley (30%) than in Lagoa Santa.The remaining components (20%) were non-significant

The South-American cranial differences are shown in Fig. 4. In the Lagoa Santa–Botocudo comparison, while the face (−56%) was greater in the first population, the neural–facial index (40%) was greater in the other one, the neurocranial index being non-significant (−4%). The otic (−50%), and the masticatory (−30%) components were greater in Botocudos, while the remaining components (20%) were non-significant (Fig. 4a). Fuegians were greater than Botocudos in the facial component (−45%), while the remaining major indices (55%) were non-significant. The posteroneural component was greater in Fuegians (−18%), while the otic one was greater in Botocudos (20%), the remaining ones

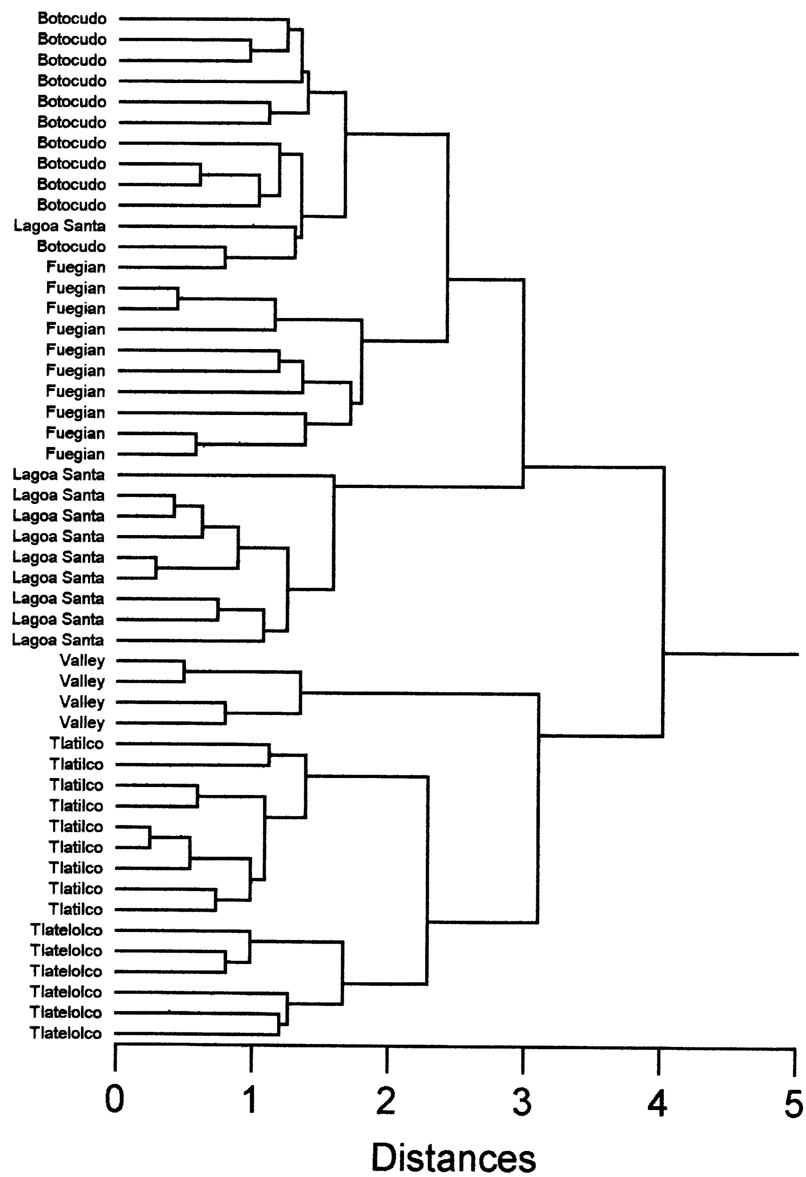


Fig. 2. Cluster built from the canonical discriminant scores of the "double z" standardized (only shape) minor component variables.

being (62%) non-significant (Fig. 4b). Fuegians were greater than Lagoa Santa in the neurocranial (10%), and facial (60%) components; while Lagoa Santa was greater in the neural–facial index (−30%). Two minor components were greater in Lagoa Santa: the optic (−22%), and the respiratory (−20%), while the masticatory one (37%) was greater in Fuegians, the remaining (21%) components being non-significant (Fig. 4c).

The cranial differences in Mexico Valley are shown in Fig. 5. In Valley–Tlatilco comparison, the facial component was greater in the former (60%), while the neural–facial index (−23%) was greater in the latter. The neurocranial component (17%) was non-significant. The respiratory component (−52%) was greater in Tlatilco, while the alveolar one (29%) was greater in Valley. The remaining ones (19%) were non-significant (Fig. 5a). The neurocranial and the facial components were greater (60% and 39%, respectively) in Tlatilco than in Tlatelolco, while the neural–facial index being non-significant (−1%). Tlatelolco was greater than Tlatilco in the posteroneural component (−49%), while the remaining ones (51%) were non-significant (Fig. 5b). The Tlatelolco–Valley comparison showed a greater neurocranium (−38%) and face (−52%) in the latter, while the neural–facial index was greater in Tlatelolco (10%). The posteroneural (20%) and respiratory (50%) components were greater in Tlatelolco, while the alveolar (−20%) one was greater in Valley. The remaining minor components (10%) were non-significant (Fig. 5c).

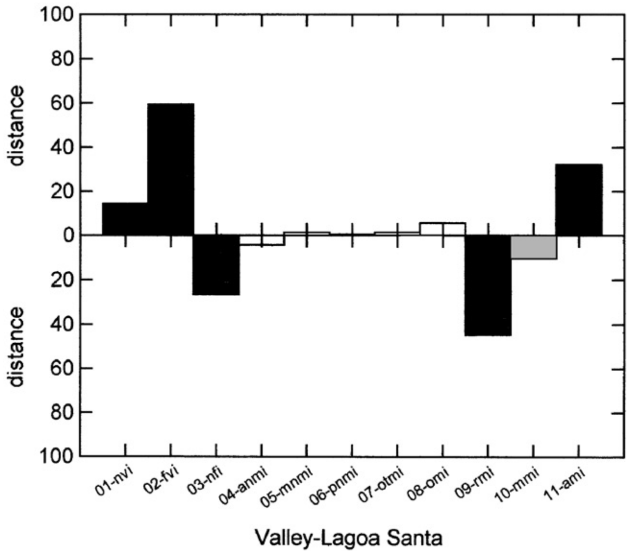


Fig. 3. Inter-populational sD^2 distances between Lagoa Santa and Valley samples, based on both major-component volumetric (neurocranial and facial) indices, the morphometric neural–facial index, and for the morphometric indices from the minor functional cranial components. Bars above zero: Lagoa Santa greater than Valley. Bars below zero: Valley greater than Lagoa Santa. White bars: non-significant sD^2 differences ($p > 0.05$). Gray bars: significant sD^2 differences ($p < 0.05$). Black bars: highly significant sD^2 differences ($p < 0.01$).

4. Discussion

4.1. First hypothesis

If the first hypothesis was true, then the functional component differences between Valley and Lagoa Santa should be null or nearly null. This was not supported by the results. First, gross size plus shape (Fig. 1) and shape (Fig. 2) differences can be drawn from the topologies given by the clusters, in which Lagoa Santa remained separated from Valley by the greatest distances. Second, the major component bars (Fig. 3) showed greater neurocranial and facial sizes for Valley, and a greater neural–facial index for Lagoa Santa. These results meant that the increment in size of Valley was followed by a shape effect in terms of neurocranial content per unit of facial volume. Such neural–facial disruption was expressed by the lack of the neurocranial minor-component variation, and by the significantly incremented respiratory and masticatory components in Lagoa Santa, as well as, the significantly incremented alveolar component in Valley. These facts may indicate, at least, three different adaptative trends: one associated to cold stress (respiratory), another associated to the masticatory stress, and the third marked by the statural decrement of Lagoa Santa people with respect to Valley, possibly linked to both cold and nutritional stresses.

The neural–facial structure found in Lagoa Santa agreed with the small facial size found by Steele and Powell (1994) in Paleoindians of North America. Lagoa Santa crania had an apparently greater encephalized skull (NFI = 1.96) than Valley (NFI = 1.73). In fact, we should think of a lower facialization, since the face is always more variable than the neurocranium in most of the human cranial comparisons. Due to all these considerations, the first hypothesis was rejected.

4.2. Second hypothesis

If the second hypothesis was true, then randomly distributed significances in all minor functional components—"mosaic distribution"—with similar probability values about the mean value ($p = 0.34$) would be expected. Since significant deviations actually appeared, a non-randomly distributed differentiation may be accepted. Proportions actually varied from $p = 0.29$ (otic) to 0.57 (respiratory) with highly significant ($\chi^2_p < 0.01$) differences, suggesting that several adaptative trends may be identified in Meso and/or South-America.

Botocudos were differentiated from Lagoa Santa by their decreased encephalization, and incremented facial, otic, and masticatory components. The facial increment was the only trend persistent in Fuegians; while the neural–facial index and the masticatory component were stopped, the otic one was reversed, in an apparently stasis period. The otic increment in Botocudos may be an exclusive attribute of this population, while the posteroneural increment was one of the Fuegians. Both were apparently not connected to any adaptative trend. With the Fuegian–Lagoa Santa comparison, almost all trends—increments in overall and facial size, and in the masticatory development, decreases in the neural–facial ratio and in the respiratory component, seen in the comparisons against Valley and Botocudos, were confirmed. The optic reduction seemed to be an exclusive Fuegian adaptation, probably due to protection against the cold and windy climate of the southernmost region of the continent.

Tlatilco was differentiated from Valley by its increased encephalization and respiratory gauge, and by its decreased facial size and alveolar development. Tlatelolco suffered, with respect to Tlatilco, a decrease of the overall size, and an increment of the posteroneural development, the rest of the components being invariable. Thus, the same stasis found in Botocudo–Fuegians was supposed for Tlatelolco–Valley. Such comparison showed that almost all trends—decrease in overall and facial sizes and in the alveolar component, and increments in the neural–facial ratio and in the respiratory development—seen in their comparisons against Lagoa Santa and Tlatelolco were confirmed. The posteroneural increment seemed to be an exclusive

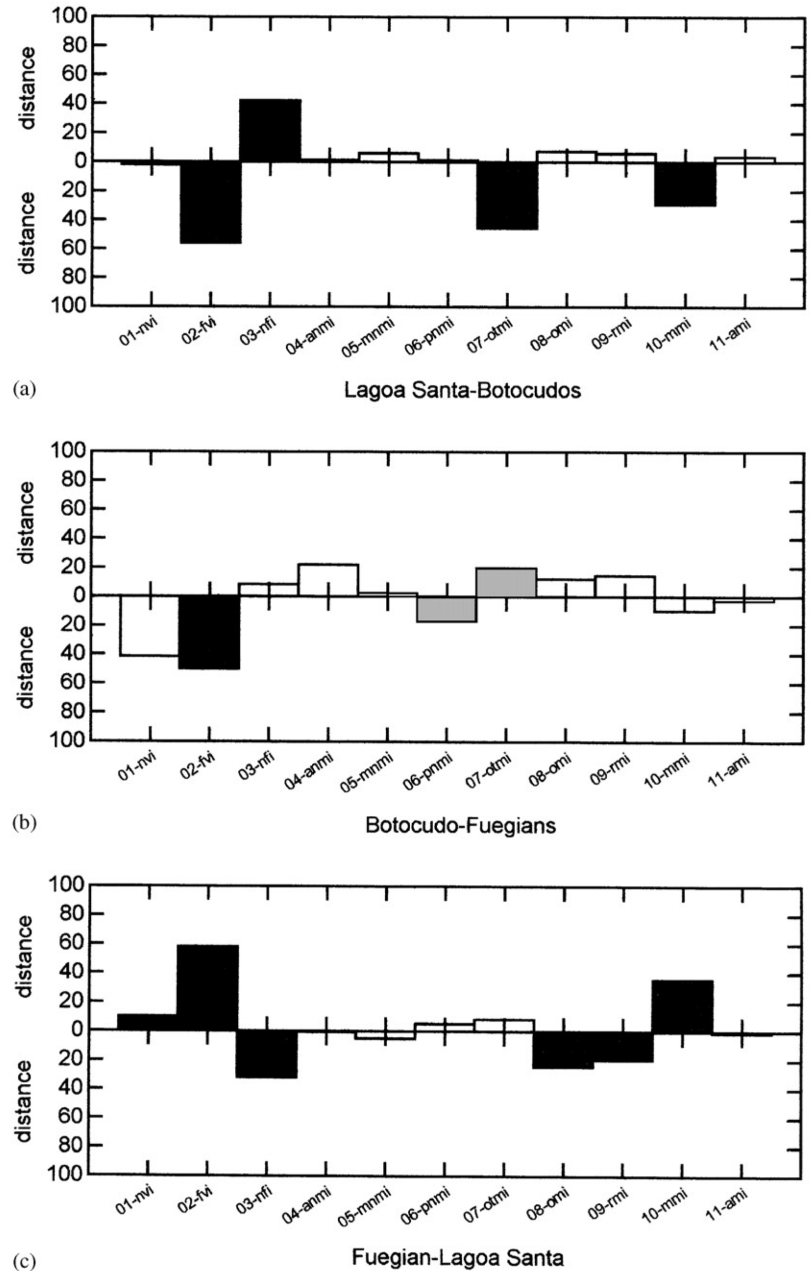


Fig. 4. Inter-populational sD^2 distances between the South-American samples, based on both major-component volumetric (neurocranial and facial) indices, the morphometric neural–facial index, and for the morphometric indices from the minor functional cranial components. Bars above zero: first sample greater than the second. Bars below zero: second sample greater than the first. White bars: non-significant differences sD^2 ($p > 0.05$). Gray bars: significant sD^2 differences ($p < 0.05$). Black bars: highly significant sD^2 differences ($p < 0.01$).

Tlatelolco variation, apparently not connected with an adaptative trend.

The second hypothesis had to be rejected, since most of the functional component variability found was more probably explained by directional adaptative trends than by non-directional hazardous differentiations. The Valley–Lagoa Santa differences agreed with the diversity found between other Paleoamericans by Powell and Neves (1999), Barrientos et al. (2001), and Jantz and Owsley (2001). The progressive size reduction trend found in Mesoamerica in function of time, agreed with Lahr's idea of grasilization as an evolutive mechanism in the modern American man (Lahr, 1995). The progressive robusticity found for the South-American samples agreed with the same author about an eventual Fuegian retention of ancestral patterns (Lahr, 1996). We did not agree, however, in that grasilization was all that happened in the Americas, since when cranial components were compared in sequence, several adaptative explanations could be given.

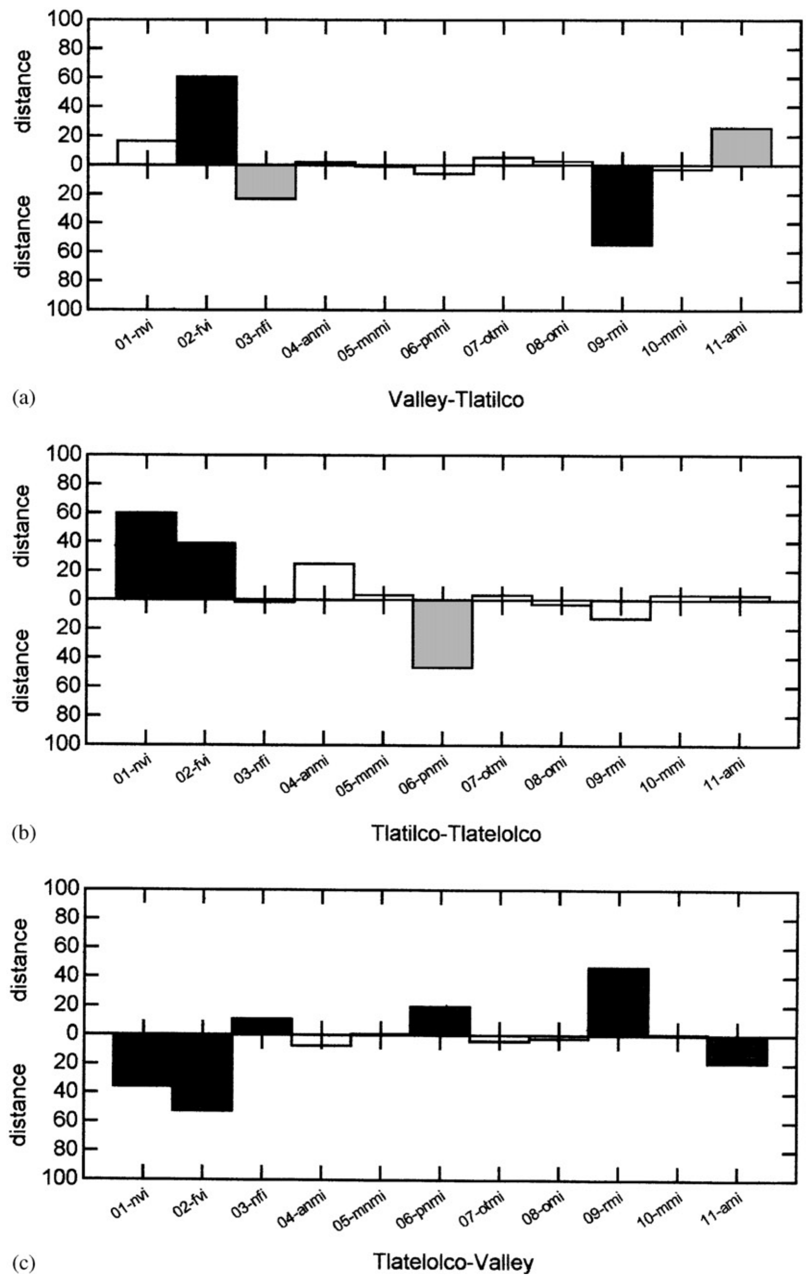


Fig. 5. Inter-populational sD^2 distances between the Mexico Valley samples, based on both major-component volumetric (neurocranial and facial) indices, the morphometric neural–facial index, and for the morphometric indices from the minor functional cranial components. Bars above zero: first sample greater than the second. Bars below zero: second sample greater than the first. White bars: non-significant sD^2 differences Gray instead ($p > 0.05$), gray bars: significant sD^2 differences ($p < 0.05$). Black bars: highly significant sD^2 differences ($p < 0.01$).

5. Conclusions

Rejection of the null hypotheses shows that many non-fortuitous cranial variations actually happened from the early Holocene to modern times in the Americas. A cause–effect relationship between cranial morphology and environment may be evidenced by the Cranial Functional analysis. Since the early American settlement, several selective-adaptative processes—together with migration and genetic drift—would explain some non-detected craniofacial variation of the American *Homo sapiens*, when classical craniometrical methods were applied.

Acknowledgements

The authors are grateful to Dr. Mark G. Hubbe for kindly providing us with the Botocudos data; and to Ing. Ernesto A. Calderón and to Mrs. María C. Muñe, for their highly valuable help in the technical assistance, and to Mrs. Damiana C. Pucciarelli for the language correction of the manuscript. This study was partially supported by a grant from the Universidad Nacional de La Plata.

References

Barrientos, G., Pucciarelli, H.M., Politis, G.G., Pérez, S.I., Sardi, M., 2001. The craniofacial morphology of the early/middle Holocene human populations from the Pampean region (República Argentina): getting a new insight into the morphological variability of early Americans, unpublished paper.

Bonatto, S.L., Salzano, F.M., 1997a. A single and early migration for the peopling of the Americas supported by mitochondrial DNA sequence data. Proceedings of the National Academy of Sciences 94, 1866–1871.

Bonatto, S.L., Salzano, F.M., 1997b. Diversity and age of the four major mtDNA haplogroups, and their implications for the peopling of the New World. American Journal of Human Genetics 61, 1413–1423.

Dressino, V., Pucciarelli, H.M., 1999. Growth of functional cranial components in *Saimiri sciureus boliviensis* (Cebidae). A longitudinal study. Growth, Development & Aging 63 (3), 111–127.

Greenberg, J.H., Turner, C.G., Zegura, S.L., 1986. The settlement of the Americas: a comparison of the linguistic, dental and genetic evidence. Current Anthropology 27 (5), 477–495.

Hernández, M., Lalueza-Fox, C., García-Moro, C., 1997. Fuegian cranial morphology: the adaptation to a cold, harsh environment. American Journal of Physical Anthropology 103, 103–117.

Jantz, R.L., Owsley, D.W., 2001. Variation among early North American crania. American Journal of Physical Anthropology 114, 146–155.

Klaauw, C.J.van der, 1948–52. Size and position of the functional components of the skull. Archivs of the Neetherland Zoology 9, 1–559.

Lahr, M.M., 1995. Patterns of modern human diversification: implications for Amerindian origins. Yearbook of Physical Anthropology 38, 163–198.

Lahr, M.M., 1996. The Evolution of Modern Human Diversity. Cambridge University Press, Cambridge.

Merriwether, D.A., Rothhammer, F., Ferrel, R.E., 1995. Distribution of the four founding lineage haplotypes in native Americans suggest a single wave of migration for the New World. American Journal of Physical Anthropology 98, 411–443.

Moss, M.L., Young, R.W., 1960. A functional approach to craniology. American Journal of Physical Anthropology 18, 281–292.

Neves, W.A., Pucciarelli, H.M., 1990. The origin of the first Americans: an analysis based on the cranial morphology of early South American human remains. American Journal of Physical Anthropology 81, 274.

Neves, W.A., Pucciarelli, H.M., 1991. Morphological affinities of the first Americans: an exploratory analysis based on early South American human remains. Journal of Human Evolution 21, 261–273.

Neves, W.A., Pucciarelli, H.M., 1998. The Zhoukoudien Upper Cave skull 101 as seen from the Americas. Journal of Human Evolution 34, 219–222.

Neves, W.A., Powell, J.F., Ozolins, E.G., 1999a. Extra-continental morphological affinities of Lapa Vermelha IV, Hominid 1: a multivariate analysis with progressive numbers of variables. Homo 50, 263–282.

Neves, W.A., Munford, D., Zanini, M.C., Pucciarelli, H.M., 1999b. Cranial morphological variation in South America and the colonization of the New World: towards a four migration model? Ciencia e Cultura 51, 151–165.

Ossenberg, N.S., 1976. Within and between race distances in population studies based on discrete traits of the human skull. American Journal of Physical Anthropology 45, 701–716.

Powell, J.F., Neves, W.A., 1999. Craniofacial morphology of the first Americans: pattern and process in the peopling of the New World. Yearbook of Physical Anthropology 42, 153–188.

Pucciarelli, H.M., Dressino, V., Niveiro, M.H., 1990. Changes in skull components of the squirrel monkey evoked by growth and nutrition: An experimental study. American Journal of Physical Anthropology 81, 535–543.

Pucciarelli, H.M., Sardi, M.L., Luis, M.A., Lustig, A.L., Ponce, P.V., Zanini, M.C., Neves, W.A., 1999. Posición de los araucanos en un contexto Asiático-Europeo. I: Metodología craneofuncional. Revista Argentina de Antropología Biológica 2 (1), 163–186.

Steele, D.G., Powell, J.F., 1992. Peopling of the Americas: paleobiological evidence. Human Biology 64, 303–336.

Steele, D.G., Powell, J.F., 1993. Paleobiology of the first Americans. Evolutionary Anthropology 2, 138–146.

Steele, D.G., Powell, J.F., 1994. Paleobiological evidence of the peopling of the Americas: a morphometric view. In: Bonnichsen, R., Steele, D.G. (Eds.), Method and Theory for Investigating the Peopling of the Americas. Center for the Study of the First Americans, University of Oregon, Corvallis, pp. 141–163.

Szathmáry, E.J.E., 1979. Blood groups of Siberians, Eskimos, subarctic and Northwest Coast Indians: the problem of origin and genetic relationships. In: Laughlin, W.S., Harper, A.B. (Eds.), The First Americans: Origins, Affinities and Adaptations. Gustav Fischer, New York, pp. 185–209.

Szathmáry, E.J.E., 1981. Genetic markers in Siberian and northern North American populations. Yearbook of Physical Anthropology 24, 37–73.

Szathmáry, E.J.E., 1984. Peopling of northern North American: clues from genetic studies. Acta Anthropogenetica 8, 79–109.

Szathmáry, E.J.E., 1993. Genetics of aboriginal North Americans. Evolutionary Anthroplogy 1, 202–220.

Szathmáry, E.J.E., Ossenberg, N.S., 1978. Are the biological differences between North American Indians and Eskimos truly profound? Current Anthropology 19, 673–701.

Turner, C.G., 1987. Late Pleistocene and Holocene population history of East Asia based on dental variation. American Journal of Physical Anthropology 73, 305–321.

Turner, C.G., 1992. Microevolution of East Asian and European populations: a dental perspective. In: Akazawa, T., Aoki, K., Kimura, T. (Eds.), The Evolution and Dispersal of Modern Humans in Asia. Hokusen-sha, Tokyo, pp. 414–438.

PERGAMON

Quaternary International 109–110 (2003) 133–145

Maybe we do know when people first came to North America; and what does it mean if we do?

Robert L. Kelly

Department of Anthropology, University of Wyoming, Laramie, Wyoming 82071, USA

Abstract

The history of research in North America suggests that we already know when people arrived in the continental US: about 11,500 ^{14}C yr BP. Research also suggests that people were in the southern cone of South America by a comparable age, if not earlier. If the New World was colonized by Late Pleistocene migrants from Asia via the Bering Strait, then the earliest sites should be in North not South America. Several possibilities might account for this apparent paradox: (a) the inability to locate pre-11,500 ^{14}C yr BP sites in North America, (b) asynchroneity of late Pleistocene/early Holocene ^{14}C dates between North and South America, (c) inaccurate dating of South American sites, or (d) a coastal migration that by-passed interior North America. All these possibilities currently appear unlikely, and the paradox resists explanation at this date.

1. Introduction

Some years ago David Meltzer asked "Why don't we know when the first people came to North America?" His answer was "it is entirely possible that we already do" (Meltzer, 1989; p. 483). It is from this statement that I take my title.

All archaeologists will agree that people were in North America by at least 11,800 ^{14}C yr BP (uncalibrated ^{14}C dates are used throughout this paper). This is the earliest date on the "Nenana complex" in Alaska (Hamilton and Goebel, 1999; Dixon, 2001). In the continental US, the earliest unquestioned evidence for the presence of humans is the Clovis complex, with dates from 11,500 or 11,300 to about 10,900 ^{14}C yr BP. The standard 'text book' model is that arctic-adapted hunters entered North America by passing through the ice-free corridor that was open by about 12,300 ^{14}C yr BP between the Cordilleran and Laurentian ice sheets that covered northern North America. This population then allegedly grew in size and moved rapidly across the Americas. In some instances these Clovis hunters are seen as exclusive hunters of megafauna (e.g., Martin, 1967), but in other reconstructions they have a more varied diet (Meltzer and Smith, 1986; Kelly and Todd, 1988).

There have always been challenges to this model, North American sites purported to be more ancient than Clovis. Especially compelling evidence has come, however, from South America. Best known to a North American audience is the site of Monte Verde in southern Chile, which appears to date to 12,000–12,500 ^{14}C yr BP (Dillehay, 1989, 1997). This is only one of a number of South American sites that raise the possibility that people were in the western hemisphere before the population who manufactured Clovis spear-points, and that realization suggests that the 'textbook' Clovis-first model may be incorrect.

It is clear that the ancestors of living Native peoples of the western hemisphere came from Asia, and it is clear that there were several times in the late Pleistocene when they could have crossed over to North America. The question is when did they first do so? An ancillary question is whether some migrants came from other places, such as Europe. In my opinion, the current evidence for a non-Asian origin of Native Americans is weak. But the question here is not so much where they came from but what is the earliest evidence of their appearance. We can never know *with certainty* that we have found the earliest remains in North America because there may always be something that we have not found. But we can generate some idea of the *probability* that we have found the earliest remains. I argue that the probability is very high that we have found the earliest

E-mail address: rlkelly@uwyo.edu (R.L. Kelly).

1040-6182/02/$ - see front matter © 2002 Published by Elsevier Science Ltd.
PII: S1040-6182(02)00209-4

occupation of North America. But research also suggests that the earliest occupation of the southern cone of South America is at least nearly as early as that of North America, if not even earlier. If the New World was colonized by Late Pleistocene migrants from Asia via the Bering Strait, then the earliest sites should be in North not South America. Several possibilities might account for this apparent paradox: (a) the inability to locate pre-11,500 ^{14}C yr BP sites in North America, (b) asynchroneity of late Pleistocene/early Holocene ^{14}C dates between North and South America, (c) inaccurate dating of South American sites, or (d) a coastal migration that by-passed interior North America.

2. Dating the late Pleistocene colonization of North America

One way to estimate the probability of whether we have found the earliest occupation of North America is to look at how long it took archaeologists to establish the age of a human presence on the continent. Take the year 1900 as a starting point. A number of tantalizing sites had been discovered in the late 19th and early 20th centuries but it is the Folsom site in new Mexico that is widely regarded as the 'smoking gun' of a Pleistocene presence in North America.

The Folsom site was discovered in 1908 by the African–American cowboy, George McJunkin. He unfortunately did not live to see its excavation in the late 1920s, when an artifact of undoubtedly human manufacture (a Folsom spearpoint) was found in unambiguous association with the remains of extinct fauna (*Bison antiquus*), and its age guessed (not too badly) at about 10,000 yr. During the 1930s other sites of comparable age or slightly older were found (perhaps due to the erosion that accompanied the Dust Bowl years), including the Clovis locality at Blackwater Draw in New Mexico. These sites' ages were later confirmed by radiocarbon dating in the 1950s (see history of research in Meltzer, 1993). We now have quite a few Clovis and Folsom sites, and thousands of fluted points have been found on the surface throughout the US (Anderson and Faught, 2000; Anderson and Gillam, 2000). So, the minimal age of the colonization of North America was established in the 1920s by a site first found in 1908; by the 1930s we had convincing evidence of a Clovis occupation.

In the past 50 yr many sites have been offered as evidence of a pre-Clovis occupation in North America, although most have been discarded by even ardent proponents of pre-Clovis. The question arises: have North American archaeologists looked hard enough? A decade ago, Jelinek (1992) offered a way to answer this question.

Jelinek pointed out that establishing the antiquity of human occupation of a continent has much to do with the intensity of archaeological research on that continent. In the year 1900 American archaeologists did not know how long people had been in North America in large part because there were so few archaeologists and thus so few field investigations. So, to answer the question of whether North American archaeologists have looked hard enough let us compare North America to two other places that also face questions about the timing of initial human colonization: Australia and western Beringia.

In Australia, the earliest sites in 1960 dated to 9000 ^{14}C yr BP; by the 1970s, sites accidentally discovered at Lake Mungo pushed the colonization of Australia to 35,000 ^{14}C yr BP (see history in Mulvaney and Kamminga, 1999). Subsequent finds pushed the continent's prehistory back to at least 38,000 yr. Today we know of over 150 Pleistocene sites in Australia (Mulvaney and Kamminga, 1999). Controversial work in northern and southwestern Australia, as well as new dating of the Lake Mungo skeletal remains may push the continent's prehistory back to 50,000 or 60,000 yr (see Thorne et al., 1999; Turney et al., 2001). In brief, Australia has an established prehistory of at least 40,000 yr.

To the Australian case, we can add that of western Beringia. East of the Lena River, ^{14}C dating of excavated deposits established a progression of early sites: Ushki-1 at 14,000 ^{14}C yr BP in the 1960s, Berelekh at 12,200 ^{14}C yr BP in the 1970s, and Verkhen–Troitskaia, at 18,000 ^{14}C yr BP in the 1970s (Goebel, 1999; Goebel and Slobodin, 1999). There are some claims of still earlier sites but what is important is that western Beringia has an established prehistory of at least 18,000 yr.

In sum, archaeologists in Australia and western Beringia have established prehistories that are older than that of North America. This is interesting because the US has seen far more intensive archaeological research than either of these other places. Cultural heritage laws in the US and Australia have ensured a large amount of archaeological fieldwork in the past 35 yr. But more has occurred in the US than in Australia because there are more people in the US (270 million) compared to Australia (19 million) and thus more construction activities that legally require archaeological research. There are no such heritage laws at work in western Beringia.

There are also more archaeologists in the US than in Australia or western Beringia. The Society for American Archaeology has about 7000 members (and a recent survey suggests that there could be 10,000 practicing archaeologists in the US) while the Australian Archaeological Association has only 430 (and there are probably not more than about 500 practicing archaeologists in Australia; Colin Pardoe, personal communication, 2000). For western Beringia, there are fewer than a dozen active archaeologists (Goebel and Slobodin, 1999, p. 106) working in an area the size of Alaska.

Since the US has seen far more intensive archaeological scrutiny than either Australia or Beringia, it is likely that we have found the earliest remains in North America. Recently, Adams et al. (2001) have made a similar argument by comparing the age distribution of archaeological sites from the US, Europe and Australia. From this comparison they conclude that it is extremely unlikely that humans were in the continental US before the last Glacial Maximum. Obviously, I would take their data further and suggest that there is most likely no occupation preceding Clovis.

Some archaeologists claim there is a bias against pre-Clovis sites such that they go uninvestigated or their claims are shouted down (e.g., Adovasio, 1993). This is simply not true. Possible pre-Clovis sites receive substantial attention in North America and numerous volumes report the results of these projects (e.g., Bonnichson and Turnmire, 1999). For example, more funds have probably been spent, and more attention focused on Meadowcroft Shelter (specifically, its pre-10,000 ^{14}C yr BP deposits) than on any other rockshelter in North America. The National Geographic Society sponsors excavations at several possible pre-Clovis, for example, Cactus Hill and the Burnham Bison site. Private funds—several million dollars—support other projects.

Others say that we have not looked hard enough, that we have not excavated deep enough, or that we have looked in the wrong places (e.g., Butzer, 1988; Adovasio, 1993). Perhaps, but several professional archaeologists have devoted their lives to searching for evidence of pre-Clovis. And the US has seen sufficient earth-moving activities for paleontologists to amass a large database of pre-Clovis-aged Pleistocene faunal locations (see, e.g., FAUNMAP; Graham et al., 1996). If we have located many animal remains that are older than Clovis, then we have obviously dug into plenty of pre-Clovis aged sediments: why have we not located more pre-Clovis archaeological sites? There are, of course, a number of contenders; but virtually all of these (see below) have serious questions about their stratigraphy, their dating, or the evidence for human presence (as at those sites containing no stone tools but only faunal remains with fractures said to be of human origin). So we might rephrase the original question: why cannot North Americans find pre-11,500 ^{14}C yr BP age sites of unquestionable evidence like the Australians and Russians?

Before proceeding, we should note that linguists and geneticists have also registered in on the question of when people first colonized North America. Using existing linguistic and genetic diversity and some assumptions about rates of linguistic and genetic change some geneticists and linguists argue for dates of colonization that range from 11,000 to 70,000 ^{14}C yr BP (Greenberg et al., 1986; Turner, 1986; Greenberg, 1987; Gruhn, 1988; Nichols, 1990; Shields et al., 1993; Szathmáry, 1993; Torroni et al., 1993a, b, 1994; Bonatto and Salzano, 1997; Stone and Stoneking, 1998; Renfrew, 2000). Even spirited proponents of a pre-Clovis archaeology cannot support the older range of these dates. This suggests that some of the assumptions of linguistic and genetic 'clocks', or the relation of linguistic and genetic diversity to dates of colonization, as opposed to genetic or linguistic divergence, are wrong or misunderstood. Nichols (1990), for example, argues that the "unmistakable testimony" of the linguistic evidence is that the New World has been inhabited for some 35,000 yr, but Kaufman and Golla (2000) argue that linguistic comparative methods are not useful beyond about 6000–8000 yr (although they also argue that linguistic isolates in the Americas such as Zuni and Kutenai argue for an occupation in excess of 10,000 yr). Also, genetic analyses reach colonization times that are often widely divergent and that are thus compatible with many colonization scenarios (Szathmáry, 1993) or have such large error ranges that they are essentially useless for dating colonization (Fiedel, 2000). In sum, while linguistic and genetic data can shed light on the process of colonization, the question of when colonization occurred must ultimately be settled by archaeological data.

And in fact, archaeologists have offered many sites as evidence of a pre-Clovis occupation in North America (reviewed in Fiedel, 2000), but there are only two or three serious contenders. Meadowcroft is the best known (see Adovasio et al., 1999 and references cited therein). Although Haynes suggested that groundwater may have contaminated the lowest ^{14}C samples, research into the micromorphology of the stratigraphy indicates this is unlikely (Goldberg and Arpin, 1999). Still, questions about the stratigraphy, the locations of artifacts and the dated material relative to the many alleged features and the layers of rooffall have not been answered (Kelly, 1987). Two other recent candidates are Cactus Hill, in Virginia (McAvoy and McAvoy, 1997; McAvoy, 2000), and Topper, in South Carolina (Goodyear, 2001). Neither site has yet been published in detail. Cactus Hill is a sand dune that contains a fluted point occupation dated to 10,920 $\pm$ 250 ^{14}C yr BP. About 10 cm beneath this lies 1–3 layers of debitage suggestive of a blade industry. The unit bearing the pre-Clovis artifacts is dated to 15,000–17,000 ^{14}C yr BP and in places is found between bands of what are thought to be illuviated clays suggesting rapid burial and no subsequent disturbance. The sedimentation rate between the two units is only 0.002 cm per year (much slower than the apparent rate below and above this layer). Although there is the possibility that artifacts have moved downward in the dune, the Clovis artifacts are of local quartzite and cherts, and largely bifacial, while the pre-Clovis material is made of local quartzite and appears to be primarily blades.

Topper is a sandy deposit that overlies a silty clay terrace. There is a possible Clovis layer, although this is based on the lithic technology suggested by the flakes rather than the presence of fluted points or ^{14}C dates. Beneath this, and separated by a rather thick layer of sterile clay, is found a low density of very small flakes—some argued to be microblades or burin spalls—associated with some larger unworked cobbles. Goodyear (2001) has found it difficult to establish the age of the earliest remains at the site. Radiocarbon dates on the alleged pre-Clovis level are very young, and the optically stimulated luminescence dates, up to 37,000 BP, are difficult to interpret, as they are underlain by ^{14}C dates of 20,000 ^{14}C yr BP. As at Cactus Hill, however, there is a difference in the raw material of the alleged Clovis and pre-Clovis artifacts.

Stanford and Bradley (2000) have resurrected an old idea that these sites are evidence of a Solutrean population that migrated from Europe and that eventually gave rise to Clovis. They make this argument based on what they see as numerous similarities between Solutrean and Clovis stone-working technology. Their argument has not been published in detail, yet already Sellet (1998) and Straus (2000) have both demonstrated that the alleged connections between these two stone-working traditions are more apparent than real, and most likely a product of independent invention rather than migration. Perhaps then, Meadowcroft and Cactus Hill are sites left behind by an unsuccessful colonizing population, one that went extinct long before Clovis hunters roamed the continent (Meltzer, 1995). This might explain the lack of any archaeological sites between Clovis and sites that date to 14,000–16,000 ^{14}C yr BP, and it might also account for why these sites contain an apparently microblade or blade technology, similar to that present in Beringia in the late Pleistocene. But it seems unlikely that a migration from Siberia left remains that have only been found in eastern North America, and not somewhere in the western or central US, since they must have passed through there.

Meltzer (1989) argues that it only takes one site to break the Clovis barrier. I disagree. If the Folsom site had not been followed up by numerous other discoveries, the site today would be an interesting footnote to North American prehistory, nothing more. I would assume that if people were in North America 14,000 or 16,000 yr ago, that we would have, for the reasons given above, found many more sites that date to older than 11,500 BP. So, one or two sites, like Meadowcroft or Cactus Hill, may not be enough to rewrite prehistory.

We should continue to look for and investigate potential pre-Clovis sites with vigor. But compared to other world areas, we have looked very hard. For me this suggests that maybe we do know when people first came to North America—and, for the continental US that appears to be the Clovis complex at 11,500 ^{14}C yr BP.

3. South America

But then there is South America. A reasonable guess is that North America has seen a far greater intensity of field research than South America. And yet a growing list of South American sites seem to be as old, if not older, than Clovis (Fig. 1). Monte Verde is the best known of these sites (Dillehay, 1989, 1997), but there are others (see Dillehay, 1999, 2000; Dillehay et al., 1992; Kipnis, 1998). If the first inhabitants of North America came from Asia, then they had to pass through North America before arriving in South America. How do we explain the presence of people in South America at the same time or prior to their appearance in North America?

There are several possible explanations. There could, of course, be a pre-Clovis occupation in North America that we have not yet found. As should be clear, I think that the probability of this is small. There is also the possibility that South America was initially populated by a migration from somewhere other than northeastern Asia, from across the Pacific, perhaps. This has been suggested by several archaeologists (reviewed in Borrero, 1999b) but there is no good evidence to support it. Three other ideas are perhaps more worthy of attention.

3.1. Radiocarbon date synchroneity

It is worth considering whether late Pleistocene ^{14}C dates from the northern and southern hemispheres are systematically out of sync with each other. For the Holocene, we know that ^{14}C dates are only 30–40 yr out of sync, and no modern reservoir effect seems to account for the early dates at Monte Verde (Taylor et al., 1999). But is it possible that the unique late Pleistocene climate acted in such a way to create a larger difference in the ^{14}C ages of similar calendar-aged material in the northern and southern hemispheres?

It is well known that radiocarbon dates of the late Pleistocene are tricky because they require significant calibration to be converted to calendar years and where a rapid (<100 yr) rise in atmospheric ^{14}C results in a radiocarbon 'plateau' during the Younger Dryas. I do not mean to imply that the "problem" could only lie in the southern hemisphere—it may be that Clovis dates are systematically too young. But radiocarbon

Fig. 1. A selection of pre-10,000 ^{14}C BP South American sites.

calibration curves are established from northern hemisphere data sources. Are they accurate for late-Pleistocene-aged material in the southern hemisphere?

We might look to the timing of the Younger Dryas (YD) as a test of the synchroneity of the hemispheres. The timing of the YD is argued by some to be nearly instantaneous over the globe (e.g., Alley, 2000), but some southern hemisphere data show that the Antarctic Cold Reversal began some 1000 yr before the YD (see also Shen et al., 1998; Bennett et al., 2000; Markgraf et al., 2000; Moreno, 2000; Rodbell and Seltzer, 2000; Shi et al., 2000). However, the proxy data are conflicting, difficult to interpret and afflicted by the imprecision of ^{14}C dating of materials more than 9000 calendar years in age (Osborn et al., 1996; Seltzer and Lachneit, 1998; Borrero, 1999a, b; Geyh et al., 1999; Pendall et al., 2001). Analysis of Antarctica's Taylor Dome ice core suggests that we should expect regional differences in the expression of climate changes due to patterns of oceanic circulation and (unlike other Antarctic ice cores) that the northern and southern hemispheres have been in phase since at least the last glacial maximum (Grootes et al., 2001). This ice-core study, however, is not based on ^{14}C dates. Do studies based on ^{14}C dates reflect regional differences in climate, dates that are out-of-sync, or just inadequate chronological control?

Although several factors may be involved in producing the YD climatic change (Broecker, 1997; Boyle, 2000; Goslar et al., 2000; Renssen et al., 2000) it is fairly clear that it entailed changes in the thermohaline circulation of the oceans. Fluctuations in the ^{14}C content of the atmosphere during the Holocene are linked to fluctuations in solar activity, but the large fluctuations in glacial and immediately post-glacial time may also be linked to changing rates of deep ocean ventilation. If so—and it is not clear if ocean ventilation during the YD was different from today (Goslar et al., 2000)—it could have produced more localized atmospheric conditions that could put ^{14}C calibrations out of sync. At 11,900 ^{14}C yr BP, for example, Antarctic surface waters were twice as old (800 yr) as they are today, suggesting that in the late Pleistocene greater ocean upwelling in the southern hemisphere could have brought old deep water to the surface (see Sikes et al., 2000). Coupled with increased vigor of the southern hemisphere's westerlies relative to the Holocene (but see Hesse and McTainsh, 1999; Boyle, 2000) or perhaps just latitudinal seasonal stabilization (at perhaps 43–45°S;

Markgraf and Kenny, cited in Benn and Clapperton, 2000) changes in ocean upwelling could have created an atmosphere over southern South America that was, relative to the northern hemisphere, depleted of ^{14}C.

Although it seems logical to suppose that atmospheric mixing would have reduced the differences between the hemispheres to the current 30–40 yr discrepancy (a discrepancy brought about by the hemispheres' differences in the ocean-to-land ratio), we do not know if mixing rates have remained constant over time. The factors that produce the north–south change in ^{14}C are complex and not fully understood, but the gradient becomes greater at high latitudes and the ocean poleward of 50°S seems to be a critical area (Braziunas et al., 1995). There may be a need for regional calibration curves. Studies have, for example, produced different estimates of atmospheric ^{14}C during the early YD in the northern hemisphere (Goslar et al., 2000). And a recent European study shows a late Holocene 22 yr offset between areas as close as Germany and Turkey produced by the differential production of ^{14}C in the atmosphere and seasonal differences in carbon uptake by different plant species (Kromer et al., 2001).

For a lack of synchroneity between the two hemispheres to account for the discrepancy between the earliest dates of South America—those dating the 12,500 ^{14}C yr BP occupation at Monte Verde—we need to find a factor that pushes Clovis dates back some 1500 ^{14}C yr or more, or that pushes the Monte Verde dates forward some 1500 or more years, or some combination. Given that the oceanic reservoir effect along the Beagle Channel in Tierra del Fuego is only +620 yr at 6000 ^{14}C yr BP (Albero et al., 1986), it may not be that the correction factor lies solely in the Southern Hemisphere, and it seems unlikely that a late Pleistocene north-to-south ^{14}C gradient could be of sufficient magnitude to produce the necessary northern–southern hemisphere discrepancy to account for 'early' South American dates (Stuiver, pers. comm., 2000). But given the large discrepancy between calendar and radiocarbon ages for materials that are in excess of 9000 calendar years in age, the very rapid rise in atmospheric ^{14}C at the beginning of the YD, the presence of a frustrating plateau in calendar ages relative to ^{14}C ages approximately during the YD (see Fiedel, 1999), and the conflicting climatic evidence from the southern hemisphere, we should perhaps be cautious of other ^{14}C oddities of the late Pleistocene/early Holocene. The most direct way to determine if this is a problem is through construction of (a) ^{14}C calibration curve(s) for South America.

3.2. Are South American dates accurate?

There is the possibility that there are problems with the early sites in southern South America. Certainly some of the pre-11,000 ^{14}C BP candidates suffered from the same stratigraphic, contamination and interpretive difficulties as did North American ones (see Lynch, 1990). But recent excavations have been far more careful and thorough. Space does not permit a thorough review of the radiocarbon evidence from South America. Instead, my purpose here is to suggest that even taking some possible sources of error into account, there still appears to be an occupation in South America that is *at least* contemporaneous with late Clovis.

A number of sites in South America's southern cone other than Monte Verde have produced some very early dates. From its basal layer, Cueva 3 at Los Toldos produced a date of 12,600±500 ^{14}C yr BP (Cardich et al., 1973), but its large error, the fact that its association with artifacts is uncertain and the fact that it is a standard date made from several pieces of carbon cast some doubt on its utility (Borrero and Franco, 1997). Piedra Museo has an even older date of 12,890±90 on its lowest level (Miotti, 1992, 1995; Miotti and Cattáneo, 1997). However, other dates on the site, including one on a cut-marked horse bone, place the earliest level's age closer to 11,000 ^{14}C yr BP (Miotti, pers. comm., 2000). Likewise, at other sites, a range of dates come from the earliest occupational surfaces, including samples from the same hearth (Borrero et al., 1998; Massone, 2000). At Cueva del Medio, for example, one hearth produced dates from 12,390 ± 80 to 10,350 ± 130 ^{14}C yr BP (Nami and Nakamura, 1995). The lowest level at Cueva 1 at Cerro Tres Tetas, which varies in thickness from 6 to 38 cm, contains a date of 10,260 ± 110 ^{14}C yr BP at the top, and dates of 10,850 ± 150 ^{14}C yr BP, 11,100 ± 150 ^{14}C yr BP, and 11,560 ± 140 ^{14}C yr BP for the lower portion (Paunero, 2000). A similar situation exists at Cueva de los Mineros (Rafael Paunero, pers. comm., 2000). This is, incidentally, no different from many North American paleoindian sites; the Paleo Crossing site in Ohio, for example, contains dates from 9230 to 13,100 ^{14}C yr BP (Brose, 1992). Removing the outliers and averaging, Brose (1992) dates the site to 10,000 ^{14}C yr BP. At Brazilian sites the pre-10,000 ^{14}C yr BP dates are afflicted by large standard deviations (Kipnis, 1998) that suggest contamination. At Lapa do Boquete, for example, the pre-10,000 ^{14}C yr BP dates have error ranges from 140 to 500 yr. At Caverna da Pedra Pintada the arrival of humans is said to be marked by "a cluster of four dates between 11,145±145 and 10,875±295" (Roosevelt et al., 1996, p. 380). The sizeable errors associated with these dates places the initial occupation (using 2σ ranges) anywhere from 11,465 to 10,285: an unacceptably large range for the problem at hand. What might explain situations like these?

Recently, a redating of a number of the early sites in Argentina with samples restricted to humanly modified bone and identified plant species (to eliminate the old wood problem), and using two labs has failed to produce dates that are equivalent to the earliest dates already in hand, with the exception of Arroyo Seco 2, where bone dates of 12,070 ± 140 and 12,240 ± 110 ^{14}C yr BP confirm previous ~12,000 ^{14}C yr BP bone dates (Steele et al., 2001; Politis et al., 2001). In most cases, however, the sites date to no more than about 11,000 ^{14}C yr BP (Tres Tetas Cueva 1, Piedra Museo), or 10,800 ^{14}C yr BP and younger (Cueva 1 del Lago Sofia, Tres Arroyos; 10,400 ^{14}C yr BP, in the case of Paso Otero 5). Possibly, the first occupants of the region used some wood or bone that had been lying on the surface for a long period of time—since no humans had previously been present to burn the material. Thus, an 'old wood' or 'old bone' problem (especially in dry caves) could appear to increase the age of initial occupation significantly. But multiple dates on strata and hearths can make this problem visible (as at Cueva del Medio, where Nami had wisely rejected the pre-12,000 ^{14}C yr BP date).

Nonetheless, even taking a possible 'old wood' or contamination problem into account the current evidence suggests that people were present in Patagonia and Tierra del Fuego at a very early date, by at least 11,000 ^{14}C yr BP, if not earlier. Other sites produce equally old dates—Quereo I in central Chile, for example, has dates of 11,600 ± 190 and 11,400 ± 145 ^{14}C yr BP on wood (Núñez, 2000). And, at present, no good explanation has been offered as to why the dates from Monte Verde, averaging 12,000–12,500 ^{14}C yr BP, should be discounted. Thus, at the moment we appear to be left with an initial occupation of South America that appears to be *at least* contemporaneous with the earliest occupation in North America, if not earlier. How might we account for this?

4. The coastal route

The current suggestion is that a coastal migration route might account for the early dates in South America. It was long assumed that the 1200-km long ice free 'corridor' in central Canada between the Cordilleran and Laurentide ice sheets was the migratory route of the first peoples to the western hemisphere. The corridor was probably closed by ice from 18,000 to at least 12,300 ^{14}C yr BP (Meltzer, 1995; Jackson and Duk-Rodin, 1996; Haynes, 2001), and was probably not really passable until 11,600 ^{14}C yr BP—just before the appearance of Clovis. People would have had to move very quickly through the corridor as well as the Great Plains to be at the Aubrey site in northern Texas at 11,590 ^{14}C yr BP (Ferring, 1990, 1994). This is not impossible, but even when open the corridor was probably biologically dead and difficult to traverse (Fladmark, 1979, 1983; Aoki, 1993; Mandryk, 1993; Anderson and Gillam, 2000; Fiedel, 2000). There is virtually no evidence of late Pleistocene human activity in the corridor except at the southernmost end (Carlson, 1991) but only a small number of small sites (with a low probability of discovery) would be expected if passage through the corridor was quick.

An alternative migratory pathway is along the western coast of North America (Fladmark, 1979). Once thought impassable due to glaciers, new data suggest that it was largely ice-free by at least 16,000 ^{14}C yr BP (Fladmark, 1979; Bednarik, 1989; Dixon, 1993, 1999; Gruhn, 1994), and completely ice-free—and capable of supporting bears—by 13,000 ^{14}C yr BP (see Josenhans et al., 1997; Dixon, 1999; Fedje and Christenson, 1999; Mandryk et al., 2001). Thus, humans could have entered the New World by moving along the western coast, and sometime later turned to the east and moved into the interior of North and South America.

Unfortunately, this is a difficult hypothesis to check for the late Pleistocene rise in sea level covered the coast except in a few areas that saw uplift at the same time. There are some early sites along the western coast—on Prince of Wales island of the Alaskan panhandle, on the Channel Islands off southern California, and along the Peruvian Coast (Sandweiss et al., 1998; Keefer et al., 1998; Josenhans et al., 1997; Dixon et al., 1997; Erlandson, 1994, 1998; Erlandson et al., 1996) but these date from 9000 to at most 11,000 ^{14}C yr BP (and perhaps not older than 10,700 ^{14}C yr BP). In southern California, cation ratio and AMS dates on rock varnish coating artifacts and organics trapped in the varnish have produced dates as old as 16,000 ^{14}C yr BP (Whitley and Dorn, 1993), but these techniques are controversial. In order for them to explain Monte Verde and the other early sites in southern South America sites need to pre-date 12,500 ^{14}C yr BP. Given that the coastal migration hypothesis will be difficult to verify directly, as an alternative we might ask what are its implications for the archaeology of the interior of North America?

It is possible that if people entered the New World along the coast, that they could have simply kept with an adaptation that they knew until they eventually reached southern South America some 12,500 yr ago. Such a migration could have been driven by local resource depletion by simply lowering the rate of return from hunting and gathering food around the current camp relative to the return rate that could be achieved by moving on to virgin coast. Lawrence Todd and I argued some years ago that Clovis hunters who entered North America with an arctic hunting adaptation would have moved rapidly throughout the continent. Key to this argument was the assumption that naive prey—animals that had never encountered human predators before—could have been easily hunted, but would have rapidly adapted to human predators, thus making movement to unexplored territory—with naive fauna—a more economical strategy than remaining in the current territory (see also Kelly and Todd, 1988; Kelly, 1995, 1996, 1999). Research demonstrates that when bear and wolves are introduced to populations of elk and moose which have not experienced predation for several generations that the predators have far higher success rates than those who have lived with their prey populations for several generations (Berger et al., 2001). These studies also show that prey become wary very quickly, within a generation. Human hunter–gatherer colonists would have been in a situation similar to that of carnivores introduced to a naive prey population. Given the knowledge that uninhabited land lay before them (and the first colonists must have suspected this) they would have quickly learned that moving into new territory was a better option than remaining where they were if they wished to continue to maximize their hunting efforts.

For comparison, consider the case of the colonization of the Canadian Arctic. The high arctic was first occupied by the Arctic Small Tool Tradition about 4500 yr ago. Radiocarbon dates on the Arctic Small Tool Tradition from its far western and eastern edges are statistically indistinguishable (McGhee, 1996), indicating a very rapid occupation. The Arctic Small Tool Tradition people were primarily muskox hunters, relying much less on marine resources (unlike the later Inuit). Muskox's defense strategy—in which males form a circle around the females and young, their horns and bony heads pointing outward—was a successful strategy against wolves, but it was foolish against human hunters. The search for driftwood as a fuel source may also have been partly responsible for the rapid movement (Arctic Small Tool Tradition people apparently did not use oil lamps).

But a late Pleistocene adaptation along the western coast of North America would probably not have focused on mammals, and firewood would not have been so critical as along the Arctic coast. My best guess is that a temperate marine adaptation would not have resulted in rapid migration because marine environments replenish themselves more rapidly than terrestrial environments (this is one reason why hunter–gatherers living along coasts are sedentary) and because the 'naivety' factor would not be relevant for foragers relying on shellfish and fish.

It is possible that the initial colonizers of the New World, occupying an empty niche and being highly residentially mobile, had high rates of population growth, as Surovell (2000a) has argued. If ethnographic data are used as a guide, less mobile coastal peoples would have had high growth rates as well (Kelly, 1995). As a coastal population grew to the point where it had begun to deplete resources, it would eventually send daughter populations to the south (see Surovell, 2000b).

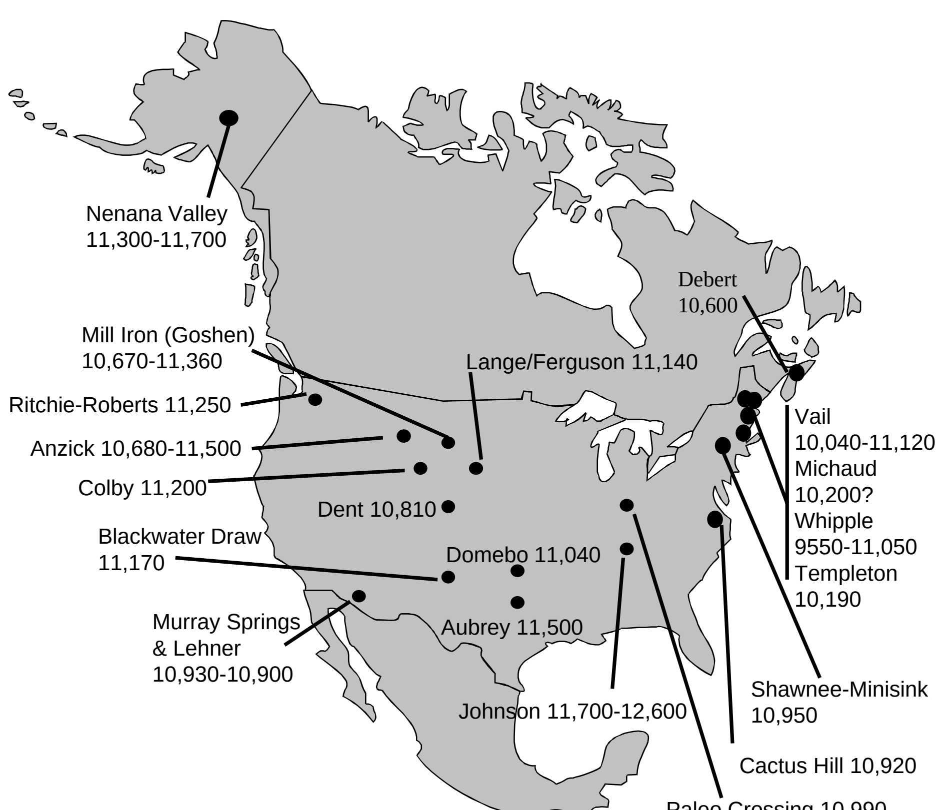


Fig. 2. Dated Clovis (including Goshen) and Nenana localities in North America.

But population-induced depletion takes time. Studies of changes in diet for the Holocene period in California show that dietary changes due to resource depletion took hundreds of years (Broughton, 1994). If the population growth model is correct, for people to have reached southern Chile by 12,500 ^{14}C yr BP they must have been along the coast of California at a considerably earlier date, perhaps 1000 or more years earlier. And if that is true, then as demographic growth along the population front sent daughter populations south, those populations who remained behind would have sent future excess population into the interior of North America (Surovell, 2000b). By the time people reached southern Chile, they should also have been in the interior of North America.

Such a migratory scenario would result in a geographic pattern in which the earliest dates of human occupation would be in the western US, and the later ones in the east (Fig. 2). The latest dates on Clovis are in the east, and the earliest dates tend to be in the interior. But the error inherent in radiocarbon dates, the short time span of Clovis, the small sample of dates and the lack of dates from far western North America make it difficult to use these data at the moment. The Ritchie-Roberts Clovis date is based on the presence of a volcanic tephra of known age on the surface on which the Clovis points were laid. Hence, it is a maximal date. There are some proposed pre-Clovis sites in western North America (reviewed in Bryan and Tuohy, 1999) that may be evidence of an eastward migration from a pre-Clovis occupation along the west coast. But all these sites have serious problems with their stratigraphy or dates (Beck and Jones, 1997; Fiedel, 2000). These include Fort Rock Cave (13,200 $\pm$ 720 ^{14}C yr BP on carbon; but this date's large error and its dubious association with cultural materials renders it suspicious), Wilson Butte Cave (14,500–15,000 ^{14}C yr BP, but these are questionable bone apatite dates), Smith Creek Cave (11,680–12,150 ^{14}C yr BP on wood, charcoal and camelid hair; but the layer also has a 10,420 ^{14}C yr BP date on cordage), Clark's Flat in California (a paleosol with dates of 9170 and 11,720 ^{14}C yr BP), and the Cooper's Ferry site (11,370–12,020 ^{14}C yr BP). Without good dates on western Clovis we are left wondering if the earliest dates for Clovis are truly in the center of the US, or if Clovis is earlier in the western US.

5. Conclusion

The lengthy history of archaeological research in North America when compared to that of Australia and Beringia strongly argues that we have found the earliest evidence of human occupation in North America–Clovis. In light of the argument developed here, it seems likely that South American archaeologists have also found the earliest or nearly the earliest evidence of human occupation there, too, and that evidence points to an occupation that is at least contemporary with that of North America.

What are the implications of these facts? One possibility is that there is some unknown factor that has left late Pleistocene ^{14}C dates significantly unsynchronized between North and South America. At present, however, there is no hard evidence for this.

An alternative is that a coastal migration accounts for the earlier dates in South America. However, this hypothesis is difficult to test since the late Pleistocene coast is nearly completely underwater at present. Still, I would expect a pre-Clovis coastal migration to have been driven largely by population growth, for that growth to have occurred long before ^{14}C dates place people in southern South America, and, consequently, for that population growth to have resulted in a significant population in the interior of North America long before Clovis. The evidence for a pre-Clovis occupation in North America, however, is weak. We lack consensus on the earliest ages of western sites, and, oddly, have virtually no dates on Clovis west of the Rocky Mountains (with the exception of Lehner and Murray Springs in southern Arizona). There is no reason to think that the ca. 11,000 ^{14}C yr BP South American dates, or the early dates from Monte Verde, are wildly erroneous, yet also no direct evidence that a coastal migration can account for them. I think we do know when people arrived in North America, but what this means for understanding the colonization process is not clear.

Acknowledgements

I thank Laura Miotti for inviting me to contribute to this effort. I also thank her, Roxana Cattáneo, Gustavo Politis, Nora Flegenheimer and Juan Flegenheimer for making it possible to visit Argentine sites. I thank Luis Borrero, Roxana Cattáneo, Tom Dillehay, Stuart Fiedel, Nora Flegenheimer, Marcel Kornfeld, Gustavo Politis, Lawrence Straus, Todd Surovell and an anonymous reviewer for their comments on this manuscript and/or a previous version presented at the INQUA conference in Argentina. I alone am responsible for any errors.

References

Adams, J.M., Foote, G.R., Otte, M., 2001. Could pre-last glacial maximum humans have existed in North America undetected? An interregional approach to the question. Current Anthropology 42, 563–566.

Adovasio, J.M., 1993. The ones that will not go away: a biased view of pre-clovis populations in the new world. In: Soffer, O. (Ed.), From

Kostenki to Clovis: Upper Paleolithic to Clovis Adaptations. Plenum, New York, pp. 199–218.
Adovasio, J.M., Pedler, D., Donahue, J., Stuckenrath, R., 1999. No vestige of a beginning nor prospect of an end: two decades of debate on meadowcroft rockshelter. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Ice Age Peoples of North America: Environments, Origins, and Adaptations of the First Americans. Oregon State University Press, Corvallis, pp. 416–431.
Albero, M.C., Angiolini, F.E., Piana, E.L., 1986. Discordant ages related to reservoir effect of associated archaeological remains from the tunel site, beagle channel, argentine republic. Radiocarbon 28, 748–753.
Alley, R.B., 2000. The younger Dryas cold interval as viewed from Central Greenland. Quaternary Science Reviews 19, 213–236.
Anderson, D., Faught, M., 2000. Paleoindian artefact distributions: evidence and implications. Antiquity 74, 507–513.
Anderson, D.G., Gillam, J.C., 2000. Paleoindian colonization of the Americas: implications from an examination of physiography, demography, and artifact distribution. American Antiquity 65, 43–66.
Aoki, K., 1993. Modeling the dispersal of the first Americas through an inhospitable ice-free corridor. Anthropological Science 101, 79–89.
Beck, C., Jones, G.T., 1997. The terminal pleistocene/Early Holocene archaeology of the Great Basin. Journal of World Prehistory 11, 161–236.
Bednarik, R.G., 1989. On the Pleistocene settlement of South America. Antiquity 63, 101–111.
Benn, D.I., Clapperton, C.M., 2000. Glacial sediment-landform associations and paleoclimate during the last glaciation, Strait of Magellan, Chile. Quaternary Research 54, 13–23.
Bennett, K.D., Haberle, S.G., Lumley, S.H., 2000. The last glacial-Holocene transition in Southern Chile. Science 290, 325–328.
Berger, J., Swenson, J.E., Persson, I.L., 2001. Recolonizing carnivores and naive prey: conservation lessons from Pleistocene extinctions. Science 291, 1036–1039.
Bonatto, S.L., Salzano, F.M., 1997. Diversity and age of the four major mtDNA haplogroups, and their implications for the peopling of the New World. American Journal of Human Genetics 61, 1413–1423.
Bonnichsen, R., Turnmire, K., 1999. Ice-Age Peoples of North America: Environments, Origins, and Adaptations. Oregon State University Press, Corvallis, OR.
Borrero, L.A., 1999a. Human dispersal and climatic conditions during Late Pleistocene times in Fuego-Patagonia. Quaternary International 53/54, 93–99.
Borrero, L.A., 1999b. The prehistoric exploration and colonization of Fuego-Patagonia. Journal of World Prehistory 13, 321–355.
Borrero, L.A., Franco, N.V., 1997. Early Patagonian hunter–gatherers: subsistence and technology. Journal of Anthropological Research 53, 219–239.
Borrero, L.A., Zarate, M., Miotti, L., Massone, M., 1998. The Pleistocene/Holocene transition and human occupations in the southern cone of South America. Quaternary International 49, 191–199.
Boyle, E.A., 2000. Is ocean thermohaline circulation linked to abrupt stadial/interstadial transitions? Quaternary Science Reviews 19, 255–272.
Braziunas, T.F., Fung, I.Y., Stuiver, M., 1995. The preindustrial atmospheric $^{14}CO_2$ latitudinal gradient as related to exchanges among atmospheric, oceanic, and terrestrial reservoirs. Global Biogeochemical Cycles 9, 565–584.
Broecker, W., 1997. Paleocean circulation during the last deglaciation: a bipolar seesaw? Paleoceanography 13, 119–121.
Brose, D., 1992. Archaeological investigations at the 12,000 year Old Paleo crossing site. Paper presented at the Ohio Archaeological Council's First Discovery of America Conference, 21 November 1992, Columbus.
Broughton, J., 1994. Late Holocene resource intensification in the Sacramento Valley, California: the vertebrate evidence. Journal of Archaeological Science 21, 501–514.
Bryan, A.L., Tuohy, D.R., 1999. Prehistory of the Great Basin/Snake River Plain to about 8500 years ago. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Ice-Age Peoples of North America: Environments, Origins, and Adaptations. Oregon State University Press, Corvallis, OR, pp. 249–263.
Butzer, K., 1988. A "marginality" model to explain major spatial and temporal gaps in the Old and New World Pleistocene settlement records. Geoarchaeology 3, 193–203.
Cardich, A., Cardich, L., Hajduk, A., 1973. Secuencia Arqueológica y Cronología Radiocarbónica de la Cueva 3 de los toldos. Relaciones de la Sociedad Argentina de Antropología 7, 85–123.
Carlson, R.L., 1991. Clovis from the perspective of the ice-free corridor. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Corvallis, OR, pp. 81-90.
Dillehay, T., 1989. Monte Verde: A Late Pleistocene Site in Chile. Volume 1: Palaeoenvironment and Site Context. Smithsonian Institution Press, Washington, DC.
Dillehay, T., 1997. Monte Verde: A Late Pleistocene Site in Chile. Volume 2: The Archaeological Context and Interpretation. Smithsonian Institution Press, Washington, D.C.
Dillehay, T., 1999. The late Pleistocene cultures of South America. Evolutionary Anthropology 7, 206–216.
Dillehay, T., 2000. The Settlement of the Americas: A New Perspective. Basic Books, New York.
Dillehay, T., Calderon, G., Politis, G., Beltrao, M., 1992. Earliest hunters and gatherers of South America. Journal of World Prehistory 6, 145–204.
Dixon, E.J., 1993. The Quest for the Origins of the First Americans. University of New Mexico Press, Albuquerque.
Dixon, E.J., 1999. Bones, Boats, and Bison. University of New Mexico Press, Albuquerque.
Dixon, E.J., 2001. Human colonization of the Americas: timing, technology, and process. Quaternary Science Reviews 20, 277–299.
Dixon, E.J., Heaton, T.H., Fifield, T.E., Hamilton, T.D., Putnam, D.E., Grady, F., 1997. Late Quaternary regional geoarchaeology of southeast Alaska Karst: a progress report. Geoarchaeology 12, 689–712.
Erlandson, J.M., 1994. Early Hunter–Gatherers of the California Coast. Plenum, New York.
Erlandson, J.M., 1998. Paleocoastal Occupations of Daisy Cave, San Miguel Island, California. Paper presented at the 63rd Annual Meeting of the Society for American Archaeology, Seattle.
Erlandson, J., Tveskov, M., Kennett, D., Ingram, L., 1996. Further evidence for a terminal Pleistocene occupation of Daisy Cave, San Miguel Island, California. Current Research in the Pleistocene 13, 13–15.
Fedje, D.W., Christenson, T., 1999. Modeling paleoshorelines and locating early Holocene coastal sites in Haida Gwaii. American Antiquity 64, 635–652.
Ferring, R., 1990. The 1989 investigations at the Aubrey Clovis Site, Texas. Current Research in the Pleistocene 7, 10–12.
Ferring, R., 1994. The role of geoarchaeology in paleoindian research. In: Bonnichsen, R., Steele, D.G. (Eds.), Method and Theory for Investigating the Peopling of the Americas. Center for the Study of the First Americans, Corvallis, Oregon, pp. 57–72.
Fiedel, S.J., 1999. Older than we thought: implications of corrected dates for paleoindians. American Antiquity 64, 95–115.
Fiedel, S.J., 2000. The peopling of the New World; present evidence, new theories and future directions. Journal of Archaeological Research 8, 39–103.

Fladmark, K., 1979. Routes: alternative migration corridors for early man in North America. American Antiquity 44, 55–69.

Fladmark, K., 1983. Times and places: environmental correlates of mid-to-late Wisconsinan human population expansion in the North America. In: Shutler, R. (Ed.), Early Man in the New World. Sage, Beverly Hills, CA, pp. 13–42.

Geyh, M.A., Grosjean, M., Núñez, L., Schotterer, U., 1999. Radiocarbon reservoir effect and the timing of the late-glacial/early Holocene humid phase in the Atacama Desert (Northern Chile). Quaternary Research 52, 143–153.

Goebel, T., 1999. Pleistocene human colonization of Siberia and Peopling of the Americas: an ecological approach. Evolutionary Anthropology 8, 208–227.

Goebel, T., Slobodin, S.B., 1999. The colonization of Western Beringia: technology, ecology, and adaptations. In: Bonnichsen, R., Turnmire, T.L. (Eds.), Ice Age Peoples of North America: Environments, Origins and Adaptations of the First Americans. Oregon State University Press, Corvallis, OR, pp. 104–155.

Goldberg, P., Arpin, T.L., 1999. Micromorphological analysis of sediments from Meadowcroft Rockshelter, Pennsylvania: implications for radiocarbon dating. Journal of Field Archaeology 26, 325–342.

Goodyear, A., 2001. Recent Investigations at Topper, a Pleistocene Age Site on the Savannah River in South Carolina. Paper presented at the 66th Annual Meeting of the Society for American Archaeology, New Orleans.

Goslar, T., Arnold, M., Tisnerat-Laborde, N., Czernik, J., Wickowski, K., 2000. Variations of younger Dryas atmospheric radiocarbon explicable without ocean circulation changes. Nature 4043, 877–880.

Graham, R.W., Lundelius, E.L., Graham, M.A., Schroeder, E.K., Toomey III, R.S., Anderson, E., Barnosky, A.D., Burns, J.A., Churcher, C.S., Grayson, D.K., Guthrie, R.D., Harington, C.R., Jefferson, G.T., Martin, L.D., McDonald, H.G., Morlan, R.E., Semken Jr., H.A., Webb, S.D., Werdelin, L., Wilson, M.C., 1996. Spatial response of mammals to late Quaternary environmental fluctuations. Science 272, 1601–1606.

Greenberg, J.H., 1987. Language in the Americas. Stanford University Press, Stanford.

Greenberg, J.H., Turner II, C.G., Zegura, Z.L., 1986. The settlement of the Americas: a comparison of the linguistic, dental, and genetic evidence. Current Anthropology 27, 477–497.

Grootes, P.M., Steig, E.J., Stuiver, M., Waddington, E.D., Morse, D.L., 2001. The Taylor Dome Antarctic ^{18}O record and globally synchronous changes in climate. Quaternary Research 56, 289–298.

Gruhn, R., 1988. Linguistic evidence in support of the coastal route of earliest entry into the new world. Man 23, 77–100.

Gruhn, R., 1994. The Pacific Coast route of initial entry: an overview. In: Bonnichsen, R., Steele, D.G. (Eds.), Method and Theory for Investigating the Peopling of the Americas. Center for the Study of the First Americans, Corvallis, Oregon, pp. 249–256.

Hamilton, T.D., Goebel, T., 1999. Late Pleistocene peopling of Alaska. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Ice Age Peoples of North America: Environments, Origins and Adaptations of the First Americans. Oregon State University Press, Corvallis, Oregon, pp. 156–199.

Haynes, C.V., 2001. Clovis, pre-Clovis, climate change, and extinction. Manuscript in possession of the author.

Hesse, P.P., McTainsh, G.H., 1999. Last glacial maximum to early Holocene wind strength in the mid-latitudes of the Southern Hemisphere from Aeolian dust in the Tasman Sea. Quaternary Research 52, 343–349.

Jackson, L.E., Duk-Rodkin, A., 1996. Quaternary geology of the ice-free corridor: glacial controls on the peopling of the New World. In: Akazawa, T., Szathmáry, E.J.E. (Eds.), Prehistoric Mongoloid Dispersals. Oxford University Press, Tokyo, pp. 214–227.

Jelinek, A., 1992. Perspectives from the Old World on the habitation of the New. American Antiquity 57, 345–348.

Josenhans, H., Fedje, D., Pienitz, R., Southon, J., 1997. Early humans and rapidly changing Holocene sea levels in the Queen Charlotte Islands–Hecate Strait, British Columbia, Canada. Science 277, 71–74.

Kaufman, T., Golla, V., 2000. Language groupings in the New World: their reliability and usability in cross-disciplinary studies. In: Renfrew, C. (Ed.), America Past, America Present: Genes and Language in the Americas and beyond. McDonald Institute for Archeological Research, Oxford, pp. 47–57.

Keefer, D.K., deFrance, S.D., Moseley, M.E., Richardson III, J.B., Satterlee, D.R., Day-Lewis, A., 1998. Early maritime economy and El Niño events at Quebrada Tacahuay, Peru. Science 281, 1833–1835.

Kelly, R.L., 1987. A comment on the pre-Clovis deposits at Meadowcroft Rockshelter. Quaternary Research 27, 332–334.

Kelly, R.L., 1995. The Foraging Spectrum. Smithsonian Institution Press, Washington, DC.

Kelly, R.L., 1996. Ethnographic Analogy and Migration to the Western Hemisphere. In: Akazawa, T., Szathmáry, E.J.E. (Eds.), Prehistoric Dispersals of Mongoloid Peoples. Oxford University Press, Tokyo, pp. 228–240.

Kelly, R.L., 1999. Hunter–gatherer foraging and colonization of the Western Hemisphere. Anthropologie 37 (1), 143–153.

Kelly, R.L., Todd, L.C., 1988. Coming into the country: early paleoindian hunting and mobility. American Antiquity 53, 231–244.

Kipnis, R., 1998. Early hunter–gatherers in the Americas: perspectives from Central Brazil. Antiquity 72, 581–592.

Kromer, B., Manning, S.W., Kuniholm, P.I., Newton, M.W., Spirk, M., Levin, I., 2001. Regional $^{14}CO_2$ offsets in the troposphere: magnitude, mechanisms, and consequences. Science 294, 2529–2532.

Lynch, T.F., 1990. Glacial-age man in South America? a critical review. American Antiquity 55, 12–36.

Mandryk, C.A.S., 1993. Hunter–gatherer social costs and the nonviability of submarginal environments. Journal of Anthropological Research 49, 39–71.

Mandryk, C.A.S., Josenhans, H., Fedje, D.W., Mathewes, R.W., 2001. Late Quaternary paleoenvironments of Northwestern North America: implications for inland versus coastal migration routes. Quaternary Science Reviews 20, 301–314.

Markgraf, V., Baumgartner, T.R., Bradbury, J.P., Diaz, H.F., Dunbar, R.B., Luckman, B.H., Seltzer, G.O., Swetnam, T.W., Villalba, R., 2000. Paleoclimate reconstruction along the pole-equator-pole transect of the Americas (PEP 1). Quaternary Science Reviews 19, 125–140.

Martin, P.S., 1967. Pleistocene overkill. In: Martin, P.S., Wright, H.E. (Eds.), Pleistocene Extinctions: The Search for a Cause. Yale University Press, New Haven, pp. 75–120.

Massone, M., 2000. The hearths of Fell 1 cultural modality in Magallanes: characteristics and contextual associations. Paper presented at the International Workshop of INQUA The Colonization of South American During the Pleistocene/Holocene Transition, December 4–9, 2000, La Plata, Argentina.

McAvoy, J.M., 2000. Radiocarbon age range and stratigraphic context of artifact clusters in pre-fluted point levels at Cactus Hill, Sussex Co., Virginia. Paper presented at the 65th Annual meeting of the Society for American Archaeology, Philadelphia.

McAvoy, J.M., McAvoy, L., 1997. Archaeological Investigations of Site 44SX202, cactus Hill, Sussex County Virginia. Virginia Department of Historic Resources Research Report Series 8, Richmond.

McGhee, R., 1996. Ancient People of the Arctic. University of British Columbia Press, Vancouver, BC.

Meltzer, D.J., 1989. Why don't we know when the first people came to America? American Antiquity 54, 471–490.

Meltzer, D.J., 1993. Search for the First Americans. Smithsonian Institution Press, Washington, DC.

Meltzer, D.J., 1995. Clocking the first Americans. Annual Review of Anthropology 24, 21–45.

Meltzer, D.J, Smith, B.D., 1986. Paleoindian and Early Archaic subsistence strategies in Eastern North America. In: Neusius, S.W. (Ed.), Foraging, Collecting and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands. Center for Archaeological Research Occasional Paper No. 6, Southern Illinois University, Carbondale, Illinois, pp. 3-31.

Miotti, L.L., 1992. Paleoindian occupation at Piedra Museo Locality, Santa Cruz Province, Argentina. Current Research in the Pleistocene 9, 30–32.

Miotti, L.L., 1995. Piedra Museo locality: a special place in the New World. Current Research in the Pleistocene 12, 36–38.

Miotti, L.L., Cattáneo, R., 1997. Bifacial/unifacial technology at 13,000 years ago in Southern Patagonia. Current Research in the Pleistocene 14, 62–64.

Moreno, P.I., 2000. Climate, fire and vegetation between about 13,000 and 9200 ^{14}C B.P. in the Chilean Lake District. Quaternary Research 54, 81–89.

Mulvaney, J., Kamminga, J., 1999. Prehistory of Australia. Smithsonian Institution Press, Washington, DC.

Nami, H.G., Nakamura, T., 1995. Cronología radiocarbónica con AMS sobre muestras de hueso procedentes del sitio Cueva del Medio. Anales del Instituto de la Patagonia 23, 125–133.

Nichols, J., 1990. Linguistic diversity and the first settlement of the New World. Language 66, 475–521.

Núñez, L., 2000. Early Human Occupation in Quereo I (North Central Chile). Paper presented at the International Workshop of INQUA The Colonization of South American During the Pleistocene/Holocene Transition, December 4–9, 2000, La Plata, Argentina.

Osborn, G., Clapperton, C., Davis, P.T., Reasoner, M., Rodbell, D.T., Seltzer, G.O., Zielinski, G., 1996. Potential glacial evidence for the younger Dryas event in the Cordillera of North and South America. Quaternary Science Reviews 14, 823–832.

Paunero, S., 2000. Notas sobre nuevas fechas radiocarbónicas del sitio Cueva 1, C 3 T., Santa Cruz, Argentina. Anales de Arqueología y Ethnología. Universidad Nacional de Cuyo, Mendoza, in press.

Pendall, E., Margraf, V., White, J.W.C., Drier, M., 2001. Multiproxy record of late Pleistocene–Holocene climate and vegetation changes from a Peat Bog in Patagonia. Quaternary Research 55, 168–178.

Politis, G., Johnson, E., Gutierrez, M.A., 2001. Survival of the Pleistocene Fauna: new radiocarbon dates on organic sediments from La Moderna (Pampean Region, Argentina). Current Research in the Pleistocene, in press.

Renssen, H., van Geel, B., van der Plicht, J., Magny, M., 2000. Reduced solar activity as a trigger for the start of the younger Dryas. Quaternary International 68/71, 373–383.

Renfrew, C., 2000. America Past, America Present: Genes and Language in the Americas and beyond. McDonald Institute for Archeological Research, Oxford.

Rodbell, D.T., Seltzer, G.O., 2000. Rapid ice margin fluctuations during the younger Dryas in the Tropical Andes. Quaternary Research 54, 328–338.

Roosevelt, A.C., Lima da Costa, M., Lopes Machado, C., Michab, M., Mercier, N., Valladas, H., Feathers, J., Barnett, W., Imazio da Silveira, M., Henderson, A., Silva, J., Chernoff, B., Reese, D.S., Holman, J.A., Toth, N., Schick, K., 1996. Paleoindian cave dwellers in the Amazon: the peopling of the Americas. Science 272, 373–384.

Sandweiss, D.L., McInnis, H., Burger, R.L., Cano, A., Ojeda, B., Paredes, R., del Carmen Sandweiss, M., Glascock, M.D., 1998. Quebrada Jaguay: early South American maritime adaptations. Science 281, 1830–1832.

Sellet, F., 1998. The french connection: investigating a possible Clovis-Solutrean link. Current Research in the Pleistocene 15, 67–68.

Seltzer, G., Lachneit, M., 1998. Late glacial and Holocene glaciation in Central and South American: Results of the PEP I transect. Abstract of poster presented at the Pages Open Science Meeting, Past Global Changes and Their Implications for the Future, University of London, April, 1998. http://www.pages.unibe.ch/products/reports98.html.

Shen, C., Liu, T., Yi, W., Sun, Y., Jiang, M., Beer, J., Bonani, G., 1998. ^{14}C dating of Antarctic lake deposits and paleoclimatic changes. Abstract of poster presented at the Pages Open Science Meeting, Past Global Changes and Their Implications for the Future, University of London, April, 1998. http://www.pages.unibe.ch/products/reports98.html.

Shi, N., Dupont, H.J., Beug, J., Schneider, R., 2000. Correlation between vegetation in southwestern Africa and oceanic upwelling in the past 21,000 years. Quaternary Research 54, 72–80.

Shields, G.F., Schmiechen, A.M., Frazier, B.L., Redd, A., Voevoda, M.I., Reed, J.K., Ward, R.H., 1993. mtDNA sequences suggest a recent evolutionary divergence for Beringian and Northern North American populations. American Journal of Human Genetics 53, 549–562.

Sikes, E., Samson, C.R., Guilderson, T.P., Howard, W.R., 2000. Old radiocarbon dates in the southwest Pacific ocean during the last glacial period and deglaciation. Nature 405, 555–559.

Stanford, D., Bradley, B., 2000. The Solutrean Solution. Discovering Archaeology 21 (1), 54–55.

Steele, J., Politis, G., Pettitt, P., 2001. AMS radiocarbon Dating of the Earliest Paleoindian Occupation of the Southern Cone of South America. Paper presented at the 66th Annual Meeting of the Society for American Archaeology, New Orleans.

Stone, A.C., Stoneking, M., 1998. mtDNA analysis of a prehistoric Oneota population: implications for the peopling of the New World. American Journal of Human Genetics 62, 1153–1170.

Straus, L.G., 2000. Solutrean settlement of North America? A review of reality. American Antiquity 65, 219–226.

Surovell, T., 2000a. Early paleoindian women, children, mobility and fertility. American Antiquity 65, 493–508.

Surovell, T., 2000b. Can a Coastal Migration Explain Monte Verde? Paper presented at the 65th Annual Meeting of the Society for American Archaeology, Philadelphia.

Szathmáry, E.J.E., 1993. mtDNA and the peopling of the Americas. American Journal of Human Genetics 53, 793–799.

Taylor, R.E., Haynes Jr., C.V., Kirner, D.L., Southon, J.R., 1999. Analysis of modern organics at Monte Verde, Chile: no evidence for a local reservoir effect. American Antiquity 64, 455–460.

Thorne, A., Grün, R., Mortimer, G., Spooner, N.A., Simpson, J.J., McCulloch, M.M., Taylor, L., Curnoe, D., 1999. Australia's earliest human remains: age of the lake Mungo 3 skeleton. Journal of Human Evolution 36, 591–612.

Torroni, A., Schurr, T.G., Cabell, M.F., Brown, M.D., Neel, J.V., Larsen, M., Smith, D.F., Vullo, C.N., Wallace, D.C., 1993a. Asian affinities and continental radiation of the four founding Native American mtDNAs. American Journal of Human Genetics 53, 563–590.

Torroni, A., Sukerik, R.I., Schurr, T.G., Starikovskaya, Y.B., Cabell, M.F., Crawford, M.H., Comuzzie, A.G., Wallace, D.C., 1993b. mtDNA variation of aboriginal Siberians reveals distinct genetic affinities with Native American. American Journal of Human Genetics 53, 591–608.

Torroni, A., Neel, J.V., Barrantes, R., Schurr, T.G., Wallace, D.C., 1994. Mitochrondrial DNA "clock" for the amerinds and its implications for timing their entry into North America. Proceedings of the National Academy of Sciences 91, 1158–1162.

Turner, C., 1986. Dentochronological separation estimates for Pacific Rim populations. Science 232, 1140–1142.

Turney, C.S.M., Bird, M.I., Fifield, L.K., Roberts, R.G., Smith, M., Dortch, C.E., Grün, R., Lawson, E., Ayliffe, L.K., Miller, G.H., Dortch, J., Cresswell, R.G., 2001. Early human occupation at Devil's Lair, Southwestern Australia 50,000 years ago. Quaternary Research 55, 3–13.

Whitley, D.S., Dorn, R., 1993. New perspectives on the Clovis vs. pre-Clovis controversy. American Antiquity 58, 626–647.

PERGAMON

Quaternary International 109–110 (2003) 147–173

Patagonia: a paradox for building images of the first Americans during the Pleistocene/Holocene Transition

Laura L. Miotti

Departmento Científico de Arqueología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina

"Y no es esto pura imaginación: La naturaleza está pintada aquí en (Patagonia) colores bien reales. Tal es la contienda en que se embarca el colono, llena de grandes e inesperadas vicisitudes, y que requiere la mayor vigilancia y la más sutil estrategia de su parte." - William Hudson: "Días de Ocio en la Patagonia", 1997: 82. Ed. El Elefante Blanco, Bs.As.

Abstract

South America appears as a paradox for building the images of the New World's human colonization. It is a paradox, because according to the models of the Peopling of America, it was the last part of the continent to be occupied by humans, but in spite of that sites as old as or older than the "Clovis" sites from North America, started to be discovered since the last century. It is a laboratory, because the amount of the Pleistocene archaeological sites is as great as their variability. In this way, since the last two decades, the hemi-continent is placed in a privileged situation for questioning and reconstructing theories concerning the first Americans, and also for answering questions as when did they arrive, how did they arrive, what strategies (social, ecological and economic) did they develop for the colonization of such different environments, which were their ideas for achieving this colonization, and how does their use of space and resources reflect in the archaeological record. The model "Clovis the first", brings an image of unidirectional migration of the first people, from the great North American plains to southern Patagonia. For a decade, this model showed itself insufficient for explaining the great archaeological variability of America and especially for referring those South American contexts directly to a Clovis migration. The new findings in South America are creating more anomalies for this model, which predicts that the arrival of Pleistocene hunter–gatherers should be around 10,000 years in Patagonia. The object of this paper is to discuss these models in view of South American archaeological evidence, and thus propose answers for removing the paradox. The axes which are considered are: the geographical and chronological distribution of the main localities of Patagonia and South America; the function of the sites within regional mobility systems; the use of subsistence resources; the differences in the circulation of lithic raw materials; and the different taphonomical histories. These characteristics will be compared with models of social network among mobile peoples and American paleolandscapes at the Pleistocene/Holocene transition and a new alternative route of peopling in South America will be presented. In this sense, the data of Patagonia are highly relevant.

1. Introduction

South America appears a paradox and at the same time, a very well equipped laboratory for building images of the New World's human colonization. Paradox, because according to the models of the American peopling, it was the last sector of the continent occupied by humans, and despite that assumption, sites with the same antiquity or older than the North American ones, have been discovered since the last century. Laboratory, because although there are plenty of Pleistocene archaeological sites in the Southern Cone, the last two decades place this hemi-continent in a privileged situation for dismounting and rearranging the previous ideas about who the first Americans were, when they came, how they came, what strategies they developed in the colonization of such different environments, what ideas they had to achieve this colonization, and how their ways of using space and resources are manifested in the archaeological record.

Southern Patagonia does not escape from this dual characteristic, with critical and challenging sites for the standard models. In this sense, it has been identified since the 16th century, as a landscape where the social and natural changes were extremely slow or did not occur, so that the first chroniclers, as well as the 19th

E-mail address: miotti@netverk.com.ar (L.L. Miotti).

1040-6182/02/$ - see front matter
PII: S1040-6182(02)00210-0

century naturalists, Darwin among them, described the hunter–gatherers of Patagonia as ‘‘*the last living exponents of Stone Age*’’ or as ‘‘*the missing link*’’. Caves such as Fell (Bird, 1938, 1988) and Los Toldos since the Toldense occupation (de Aparicio, 1933/35; Menghin, 1952) and then the ‘‘Unifacial Nivel 11 Industry’’ (Cardich et al., 1973), have been frequently taken as strong referents that sustain the Clovis migration model from the great North American plains (Martin, 1973; Haynes, 1984; Lynch, 1990; Dincauze, 1993, among the main defenders of the model). However, in the case of the ‘‘Nivel 11 Industry’’, the defenders of ‘‘Clovis: The First Americans’’ paradigm reject it plainly (see Lynch, 1991, p. 350). This model considers the manifestations involved in the mentioned ‘‘cultural complex’’ or ‘‘Megafauna Hunter’s Horizon’’ as the oldest and most reliable evidence of the human occupation in the New World (Haynes, 1967, 1974, 1984; Martin, 1973, 1984; Lynch, 1990, 1991; Dincauze, 1993, among others). However, and although from other perspectives this model appeared insufficient to explain the great archaeological variability of North and South America (Adovasio et al., 1978; Bryan, 1978, 1986, 1995; Fladmark, 1983; Dillehay, 1984, 1997; Gruhn, 1986, 1989; Borrero, 1990, 1996; Frison, 1990; Ardila Calderón and Politis, 1991; Bonnichsen, 1991; Stanford, 1991; Adovasio, 1993; Meltzer, 1993; Núñez Atencio et al., 1994, Gnecco, 1995, 1998; Roosevelt et al., 1996; Driver, 1998; Aldenderfer, 1999), and especially to refer those contexts with stemmed projectile points, known as ‘‘fishtail points’’ (FTP) directly to Clovis migration from the Great North American Plains to the Magellan Strait (Borrero, 1983; Miotti, 1990, 1994, in press; Miotti and Cattáneo, 1997a; Politis, 1991; Nami, 1997), during the last 10 years new finds from the Patagonian and other South American contexts have generated anomalies to the mentioned model, whose expectations of Pleistocene hunter–gatherer contexts, should place them around 10,000 years age in the Patagonian region. Sites such as Monte Verde (Dillehay, 1997); Tres Arroyos (Massone, 1984; Borrero et al., 1998); Cueva Lago Sofía I (Prieto, 1991); Cerro Tres Tetas Cueva I (C1C3T) (Paunero, 1993–94, 1996) and Piedra Museo (Miotti, 1992, 1993, 1994, 1996, in press; Miotti et al., 1999a, b; Miotti and Cattáneo, 1997a) challenge this position, since all these, in addition to having radiocarbon dates which equal and even exceed the oldest dates considered for Clovis in North America (ca. 11.6–10.8 ky BP, according to Bonnichsen, 1991) (Table 1), differ from it mainly in the function inferred for them within the regional mobility systems, in the different associated faunistic species, in the different availability of lithic raw material, and of course, in the different taphonomic histories of each site. However, they share the reliability of representing first or initial colonization contexts of American hunter–gatherers (Miotti [1989] 1998, 1994; Miotti and Salemme, 1999, in press) assigned to the Exploration stage (Borrero, 1990), and the same author later considered that the peopling processes involved three different phases: exploration, colonization, and full occupation (Borrero, 1995).

An intermediate position to the Clovis paradigm is used by Morrow and Morrow (1999, p. 215), who state that ‘‘*All data make us conclude that the South American fishtail points evolved from the fluted projectile points*’’. They also suggest that previous Clovis populations could have existed, but both populations did not compete with each other because of the different subsistence strategies, allowing the Clovis groups to reach the south of the continent without human or environmental interruptions.

> *While we are proposing that the spread of fluted point technology across North and South America resulted from the expansion of a migratory human population, this does not necessarily invoke the often challenged ‘Clovis First’ model of the peopling of the New World … Even if people did inhabit parts of North and South America prior to Clovis times, their populations were probably small and perhaps localized. As such, pre-Clovis groups may have presented no serious impediment to the spread of Clovis bands and their descendants, especially if these antecedent populations practiced a generalized subsistence economy and Clovis and Clovis-derived groups focused on large mammal hunting so that the two populations were not in direct competition with each other* (Morrow and Morrow, 1999, p. 228).

In this article the authors, not critically analyzing the archaeological variability, even more strongly marked for the South American contexts, state that the Clovis points were only used for hunting megafauna. However, according to information over more than the last decade, there are Clovis contexts that fall within the temporal rank of the late Pleistocene/early Holocene with not only megamammals, but also medium and small mammals, and even birds, reptiles, and amphibians (Frison, 1990; Bonnichsen, 1991; Goebel et al., 1991; Stanford, 1991; Driver, 1996, 1998). The same happens in South America, where fishtail points (FTP) do not necessary appear with megafauna (Table 1b, Fig. 1; Miotti, 1992, 1996; Nami and Menegaz, 1991; Martínez, 1997) but instead are associated with faunistic assemblages where the most abundant species are guanaco (South American camelid), big flightless birds (South American ostrich), with megamammals appearing in lesser proportions (Miotti et al., 1988; Politis et al., 1995; Miotti and Salemme, 1999). In other South American cases, as shown in Table 1b, sites such as Taima–Taima, Alice Boër, Monte Verde, and Lago Sofía 1 C3T, are associated with megafauna, but the projectile points are not fishtailed, or they lack points.

Table 1
Radiocarbon dates and contextual characteristics of the main sites quoted in the text

Name of the site	No. in map	^{14}C datings in kyr BP	Main tools and technology	Associated fauna	Inferred activities	Contextual evaluation
(A) *Main North American sites clovis age*						
Bluefish cave	1	16–13	Burils, bifaces, (Pre-Clovis)	Extinct and present fauna	Primary processing	Cinq-Mars (1979)
Batza Tenna (Nennana complex)	2	11.6–11	Non-fluted points, Clovis aged blades	Caribou	Several kinds of sites	Clark (1991)
Nennana complex	3	11.7–10.6	Tear-shaped bifaces, without microblades	Caribou	Several kinds of sites	Goebel et al. (1991)
Dry Creek, Denali Complex	4	11–10.5	Knives, points, microblades	bison, horse, mammoth and caribou	Campsites	Clark (1991)
Walker Road, Broken Mammoth and Mesa site	5	11.8–11	Knives, points and instruments over big nodular flakes	waterfowl remains, fish, otter, beaver in mixed economies (aquatic/terrestrial)	Specific activity sites and campsites	Goebel et al. (1991), Goebel (1999)
Cactus Hill	6	15–10.3	Similar to the Cantabrian Solutrean, with blades. Fluted Clovis points	?	?	Goodyear (1999), Johnson (1997)[a]
Meadowcroft	7	17–14.5	Bifaces, flakes, Preclovis/ Clovis fluted points	Present Fauna	Campsites	Adovasio (1993)
Lubbock lake	8	11–10	Hammers, anvils, Pre-Clovis flakes	Mammoth, horse, bison, camel	Processing	Johnson (1991)
Charlie Lake Cave	9	10.8–10.1	Fluted points, Flakes with marginal retouch and instruments on cores	Bisons, medium fowl and small mammals	Bison hunting event	Carlson (1991), Driver (1996, 1998)
Clovis, Lubbock	10	11.5–11	Fluted points, knives and scrapers	Extinct and present fauna	Multiple activities	Johnson (1991)
Blackwater draw	11	11.2–10.5	Clovis fluted points, knives	Bison, Horse, Mammoths, Camels	Base Camp	Johnson (1991)
Lindenmeier	12	10.8	Folsom fluted points, side scrapers	Extinct bison	Idem previous	Johnson (1991) and ref. quoted there
Guila Naquitz	14	10.8–8.8	Points, side scrapers	Present fauna	Seasonal Camp.	Flannery (1983)
Lago Alajuela	15	No ^{14}C dating	Clovis points and FTP. Low resolution site	Without association	Surface Workshop	Bryan (1978)
Los Tapiales-	16	No ^{14}C dating	Clovis fluted points	Without assignation	Workshop-Camp	Bird and Cooke (1979)
(B) *South American sites*						
Taima–Taima	1	13.2	"El Jobo" points, bifaces and flakes retouched	Mastodons	Killing site	Bryan (1978)
Early Vegas	2	10.8–8	Flakes	Present fauna	Burial camp	Stothert (1985)
El Inga	3	9.5–9.3	FTP, burils, blades and flakes	Without association	Multiple activities	Mayer Oakes (1986)
El Abra	4	12.4–7.2	Used flakes	Horses, mastodon	Workshop-Camp	Correal Urrego (1986)
Tibito	5	11.7 (only one date)	Scrapers on cores, flakes, etc.	Extinct Mega fauna	Killing and processing site	Correal Urrego (1986)
San Isidro and Peña Roja	6	10	Grinding tools useful plants	Allopatric palms, mate	Agrilocality	Gnecco (1998)

Table 1 (*continued*)

Name of the site	No. in map	^{14}C datings in kyr BP	Main tools and technology	Associated fauna	Inferred activities	Contextual evaluation
Pedra Pintada	7	11	Stemmed points	Present fauna	Multiple activities	Roosevelt et al. (1996)
Pedra Furada	8	33–17	Flakes–scrapers	Without association	Non-assigned	Guidon (1986), Guidon and Delebrias (1986)
Touro Passos	9	23.3–10.4	Choppers, flakes	Worn bones from extinct fauna	Non-formulated	Prous and Fogaça (1999)
Go Ja 01 Paranaiba	10	10.7–9.1	Flakes	Without association	Camp	Prous and Fogaça (1999)
Lagoa Santa	11	14.5–12	Flakes and choppers	Present and extinct fauna	Human burials	Prous and Fogaça (1999)
Alice Boer	12	14.2–10.7	Eared points	Without association	Non-assigned	Gruhn (1989)
Cerca Grande	13	10.4–9.7	Flakes, scrapers, point, axe	Not quoted	Human burials	Prous and Fogaça (1999)
Lapa Vermhela IV	14	11.7–10.2	Human female bones	Scelidotherio Bones, coprolites	Human burial	Prous and Fogaça (1999)
Talara	15	11.2–10.2	Unifacial tool tradition	N/d	camps	Aldenderfer (1999)
La Cumbre, Quirihuac, Pampa de los Fósiles	16		Flakes, plants, Unifacial tool tradition	Extinct megafauna	camps	Richardson III (1978), Chauchat (1988)
Cumbe	17	10, 5	Small Flakes used Heart?	Cervids and rodents	N/D	Cardich (1991)
Quebrada Tacahuay	18	10–8	Lanceolated points Hearths, midden	fish, shellfish, and seabird remains	Camp	Aldenderfer (1999)
Quebrada de los Burros	19	10–9.5	Hearth, midden	Marine mollusks	Midden of campsite	Lavallée et al. (1999)
Telarmachay	20	12–8	Lanceolated points	Deers and camels	Base camp	Lavallée (1985)
Lauricocha 1	21	9.5–8	Puntas lanceoladas raspadores, etc.	Deers and camels	Multiple activities and burials	Cardich (1980)
Pachamachay	22	11.8	Bifacial technology	Present fauna	campsite	Rick (1988)
San Lorenzo-Tuina	23	11–8	Lanceolated points choppers, etc.	Deers, camels, rodents	Camp and seasonal workshop	Santoro (1989)
Quebrada Seca III	24	10.4	Bifaces, choppers	Present fauna	Brief camp	Aschero (1988)
Tagua–Tagua	25	11.8	Fishtail points and unifacial technology	Guanacos, mastodons	Killing site	Núñez et al. (1994)
Agua de La Cueva	26	10.2–9.2	Unifacial	guanacos	Seasonal camps	García (1995)
Monte Verde	27	13.2–11	Unifacial and bifacial technology, lanceolated points	Mastodons and "Paleo-lama"	Village camp	Dillehay (1984, 1997)
Arroyo Malo 3	28	10	Flakes, hearts	Present fauna	Seasonal camp	Neme (2001)
Gruta del Indio Lower level	29	+8.5	Flakes, bifaces, hearts.	Present and exticnct fauna	Campsite	Lagiglia and García (1999)
Arroyo del Tigre	30	11.2–10.4	Flakes and bifaces	N/D	Multiple activities, workshop	Suárez and López Mass (this volume)
Pay Paso 1	31	10–8.6	Unifacial tools, abundant charcoal, FTPs	Extinct and present	Multiple activities, workshop	Suárez and López Mass (this volume)
Cerro La China 2	32	11.1–10.6	FTP, awls, core, flakes	Without association	Activities related to hunting	Flegenheimer (1987, 1994)

Cerro La China 1	33	10.8–10.5	FTP, different stages of confection, use and resharpening	Glyptodont	Multiple activities	Flegenheimer (1987, 1994)
Cerro La China 3	34	10.6	Artifacts with marginal retouch, no points, great typological diversity	Without association	Multiple activities, workshop	Flegenheimer (1987, 1994)
Co. El Sombrero cima y Abrigo 1	35	10.7–8	Bifacial technology, FTP, cores, ochre,	Without fauna data	Equipment Watching site, cache	Flegenheimer (1987, 1994)
Los Pinos	36	10.5–8.8	Flake technology, FTP	Local and extinct fauna	Workshop and camp	Mazzanti (1997a, b, 1999)
Cueva Tixi	37	10.4–10	Flake technology, FTP	Local and extinct	Workshop and camp	Mazzanti (1997a, b)
Paso Otero 5	38	10.2–9.5	Flake technology, FTP	Armadillos, Horse, guanaco	Killing and butchering	Martínez (1997)
Arroyo Seco 2	39	9–8.5	Flakes, bifaces	Extinct and present	Camp, burial site.	Politis et al. (1995)
La Moderna	40	10–7.5	Flakes and natural edges knives	Gliptodonts, and guanaco	Kill site	Politis and Gutiérrez (1998)
Piedra Museo AEP1	41	12.9–9.3	FTP and associated bifacial thinning flakes, unifacial tools on large flakes	Extinct and present	Primary processing	Miotti (1992, 1996)
Los Toldos Cueva 3, Nivel 11	42	12.6 (only one date)	Knives, side-scraper	Extinct and present	Residential camp site	Cardich et al. (1973)
Cueva 1 Cerro Tres Tetas (C1 C3T)	43	11.6–10.3	Unifacial technology on large flakes	Guanacos	Without data	Paunero (1993/94, 1996)
Cueva Casa del Minero 1	44	11–10	Unifacial tools on large flakes and slimed bifacial flakes used	*Hemiauchenia Paradoxa, Lama gracilis and present fauna*		Paunero, in press
Los Toldos C3, "Toldense Industry"	45	8.7 for the end of the occupation	Bifacial points, flake technology	Extinct and present	Locus of limited activities	Cardich et al. (1973)
Rio Pinturas I: Arroyo Feo, de las Manos caves	46	9.3–8.5	Bifacial and triangular points, flakes, rock art.	Guanaco and present fauna	Multiple activities	Gradín (1980)
CCP7	47	9.7–9.1	Rock art, flakes, combustion structures	Guanaco and present fauna	Domestic activities	Aschero (1996), Civalero and Franco (2003)
Chorrillo Malo	48	9.2	Expeditive tools	Present fauna	N/d	Civalero and Franco (2003)
Cva del Medio	49	10.5–10.2	FTP, hearths, flake technology	Extinct and present	Base camp	Nami (1987)
Fell, Pali Aike	50	11–10	FTP, hearths, flake technology	Extinct and present	Camp, burial	Bird (1988)
Cva. Lago Sofía 1	51	11.5	Without points, flakes	Extinct and present	Without data	Prieto (1991)
Tres Arroyos	52	11.9–10.3	Points, scrapers, bipolar technology	Extinct and present	Base camp	Massone (1984)

[a] Part of this information was taken from the article "The First Americans". From News Week, 26/4/1999.

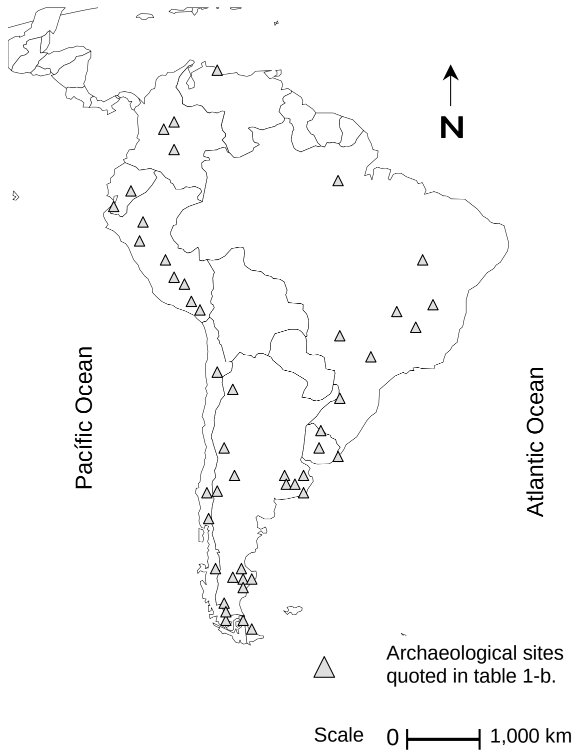


Fig. 1. Map of South America and the main archaeological sites quoted in Table 1b.

Based on these statements on the questions up to the moment, the goals of this article are firstly, to introduce a summary of our own works in the Central Plateau of Santa Cruz; and secondly, to discuss the latest archaeological regional models about the peopling in Patagonia during the Pleistocene/Holocene transition (ca. 13–8.5 ky BP) Finally, these data are compared with information from the other Pleistocene sites in the Southern Cone in order to build an alternative more complex model about human space occupation.

2. Piedra Museo and the region of gullies and residual basins of the Deseado Massif

The research that we have carried out since 1988 in Santa Cruz Central Plateau, specifically in the sector known as Deseado Nesocratón or Massif (Figs. 1 and 2), is generating reliable information about the spatial chronological structure of the human occupation in Patagonia, as well as about the Pleistocene peopling of the continent. This allows us to review the answers to questions such as which, when and where the occupation and colonization was produced critically. The Deseado Massif was until recently accepted as just one more sector of the homogeneous and arid steppe, according to the distribution and quality of resources and to the area's human settlement. The available information that comes from archaeology, ecology and paleoenvironments has introduced a different panorama since such homogeneity is only apparent. It may be in this part of the Patagonian Plateau where the geomorphologic differences, as well as the differences in resource structures, and in the natural landmarks, so important for the late Pleistocene and early Holocene successful colonization of space, are more conspicuous than today.

From a geological point of view, the Massif is a structural block which differs from the Andean block, from the southern Magellan Basin, from Comodoro Rivadavia Basin, and even from the steppe area between the rivers Chalía and Santa Cruz, which is an ecotone between the Deseado Massif, to the north, and the volcanic basin of rivers Chico and Gallegos, to the south (Panza, 1982; Panza and Genini, 1998; Miotti, [1989] 1998 and the geological bibliography quoted there). In this way, the volcanic landscape of hills, plateaus, valleys and endorheic basins with lagoons, with good and abundant lithic raw materials; places for sightseeing and wide panoramic views; vegetation; rockshelters and concentration of fresh water for the development of an important fauna including mammals and birds with gregarious behavior such as camelids (*Lama gracilis* and *Lama guanicoe*), Pleistocene horses (*Hippidion saldiasi*) and two species of ñandúes (Rheidae), as well as birds of smaller size but also gregarious and associated with lagoon environments, such as great wild geese (*Chloephaga*) and others from the Anatidae family (ducks and swans), which must have constituted excellent places for the hunter–gatherers to modelize a colonization landscape. In this area the specific places for ambush and kill are alternated with transit and residential places; *locus* for obtaining pigments and minerals for working hides, cosmetics and rock art; quarries for the provision of lithic raw materials; places for celebrating ceremonies; and even those empty spaces, steep and strategic enough to observe the movements of animals, and perhaps other human groups. This hierarchy of use of different microenvironments during Pleistocene/Holocene transition is being detected from archaeology and can be read as differential ways of use of spaces (i.e. domestic and sacred places, between places of generalized social access and those restricted to certain social segments by sex or age categories, or others). The reasons which are inherent to the human group, such as the risk at an unknown and not peopled space, or the seasonality of resources (Rowley, 1985; Soffer, 1985; Gamble, 1993b, 1994; Soffer and Praslov, 1993; among others) or the minimum risk which exists in a region where the human occupation is becoming consolidated and where the availability as well as the concentration of resources, are already known, and also by other exterior reasons such

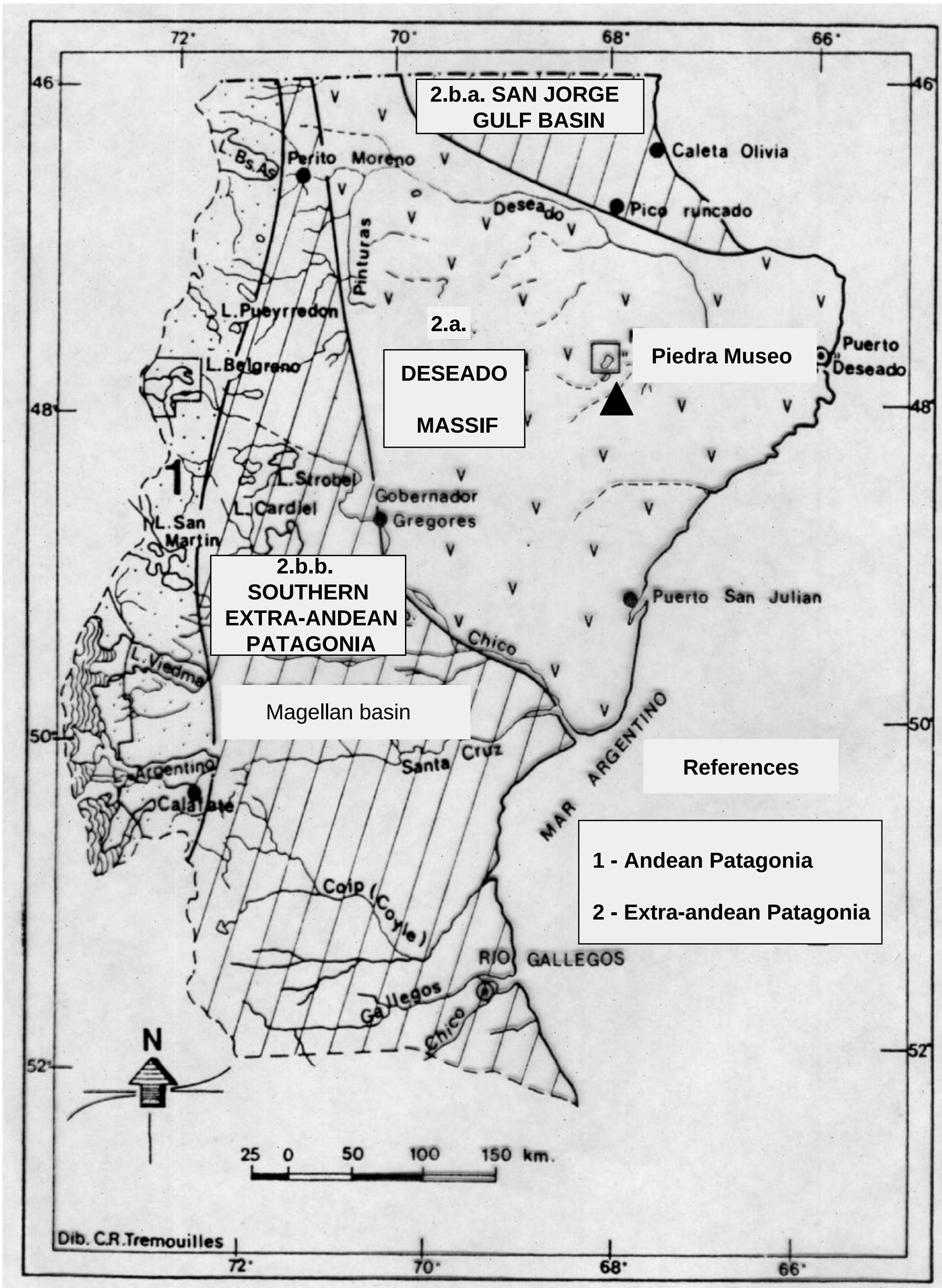


Fig. 2. Map of Santa Cruz with the geological structural blocks.

as the ecological potential of the region which is being colonized (Miotti, 1995, for this region), can fit the model of the "traveler-processor" continuum stated by Bettinger and Baumhoff (1982, 1983) based on a theoretical sophistication of Binford's model (1980) about the "forager-collector" continuum, and also with Marshall's model (1993) about hunter–gatherer societies who develop strategies of immediate benefit or strategies that differ from the resources in order to minimize the environmental risk.

With these basic assumptions, the relation between hunter and gatherer people and environment can provide us with more and better ideas in order to start to discover in the geographical space to be studied the ancient social landscapes and the different material and symbolic ways in which the different rationalities of the ancient inhabitants were expressed. This way of perceiving and researching a region, both archaeologically and environmentally, allows us to interpret the ways of colonization and consolidation of spaces relating the mobility, ecology, economy, technology, symbology and social networks of hunter–gatherers where goods and material objects circulate (Ingold, 1986, 1993; Gamble and Soffer, 1990; Vicent García, 1991; Criado Boado, 1993, among others).

According to the palaeoenvironmental indicators from different archaeological localities (Borromei, 1998; Páez et al., 1999); to the spatial analysis (intra and intersite) developed in this sector of the Central Plateau (Miotti, [1989]1998, 1990, 1992, 1993a; Miotti et al., 1999a), which is related to studies of the use of animal resources in Piedra Museo and in the nearby localities (see Fig. 10.1 in Miotti, [1989]1998) and to the palaeoenvironmental studies of the Patagonian region (Heusser and Rabassa, 1987; Rabassa, 1987; Clapperton, 1992, 1993; Heusser, 1993; Mancini et al., 1993; Borrero et al., 1998; Miotti and Salemme, 1999; Páez et al., 1999; Stern, 1999) it is now suggested that in the extra-Andean steppe, located between the rivers Deseado and Santa Cruz, the microenvironmental differences are very strong at present, and must have been even stronger in the interval between 13 and 8.5 ky BP. Furthermore, it can also be stated that these places are more than those considered up to the moment, and it is inferred, based on the palaeoenvironmental information, that they were more abundant during the Pleistocene–Holocene transition than at present. However, and according to Gamble (1993b), these are not understood as "Gardens of Eden", as they were understood in another frame, where people did not need to move because they had all the necessary elements to develop a sedentary life. This nationalist vision, which was applied to the Patagonian archaeology by the cultural-historical European point of view of the 1930s decade, and which was readapted in recent years in different parts of the world (Trigger, 1992) does not yield any alternative for the interpretation of the archaeological variability and cultural change, and at the same time is contradictory to explain the human migration at long distance and in the long term. Instead of this, it seems more proper to refer to the differential use of spaces by colonizing societies in new continents following Beaton's concepts (1991, pp. 222–223), of "Estate Settlers" and "Transient Explorers".

The excavation carried on in Piedra Museo AEP1 rock shelter covered ca. 48 m^2, and followed the natural microlayers of a soil. In addition, surficial open-air sites are also being analyzed, because lithic raw material of Pleistocene/Holocene transition in AEP1 came from outcrops and quarries of Cerros Colorados, Pedrero Blanco, 17 de Enero (Miotti, 1996), El Fortín, La Porfiada, Laguna D (Hermo and Vázquez, 1999; Miotti and Hermo, in press) and La Matilde Formation of Laguna Grande (Miotti and Cattáneo, 1997a, b). Radiocarbon dates place the archaeological contexts of Piedra Museo between 12,890 and 7470 years BP (Miotti et al., in press; Miotti and Salemme, 2003).

AEP-1 rock shelter is up to the moment the only site in the Argentinean Patagonia where fragments of FTP and extinct Pleistocene fauna such as *Hippidion saldiasi*, and *Lama* (*V.*) *gracilis* have been found in reliable stratigraphical association. Similar associations have been found in the Magellan region at Fell Cave and Cueva del Medio, as well as at Tagua–Tagua open camp site in central Chile (Núñez Atencio et al., 1994), and sites from the Pampean region such as Cerro El Sombrero and La China (Flegenheimer, 1987), Cueva Tixi, Los Pinos (Mazzanti, 1997a, b, 1999), and Paso Otero 5 (Martínez, 1997, 1999), illustrated in Fig. 1.

2.1. Lithic materials

The lithic materials include bifacial and unifacial artifacts from the first occupation of the site (Miotti, 1992; Miotti and Cattáneo, 1997a, in press; Cattáneo, 1999). Although in previous papers the materials from the Pleistocene or Paleoindian Component have been mainly characterized, there was not any fundamental technological difference registered between the contexts with Clovis points from North and Central America, and the FTP contexts from South America. The difference, which shall be detailed as follows, suggests for Piedra Museo, a greater technological relationship with other sites from the Pampean-Patagonian region than with the Paleoindian contexts from North America, during the Pleistocene/Holocene transition (13–9.3 ky BP). This difference refers to the "technological conceptions" within which the FTP from southern South America were generated and to the "technological conception" of the Clovis toolkits from North America. According to Politis' proposal (1991), it is observed that one of the main causes of the variability of sizes and shapes of the South American FTP is the reshaping and continuous use of these formal instruments (see Andrefsky, 1991, 1994). Meanwhile, another cause to explain the great size variability observed in Pampean FTP could be the manufacture of children's toys (in the sense of Politis, 1998). If this hypothesis is confirmed, it could be suggested that FTP might be considered items of symbolic/cultural significance beyond the purely utilitarian idea for societies of the Pleistocene/Holocene transition. This difference in the possible use and maintenance of these lithic artifacts is manifested in the more constant size recorded in the Clovis points (see Table 2). This can be suggest that the use and conservation of both tools were different because of the greater degree of reutilization of the FTP until elimination of the functional utility of the instrument active cutting edges, and the possibility that these forms were reproduced in toys, in contrast to a shorter use regarding the fracture or damage in the Clovis points. In this way, and contrasting with North America, where most of the Clovis points are in killing sites and "caches", in the Humid Pampas (Argentina) and Ultima Esperanza Region (Chile), workshop and quarry sites, or sites for the primary shaping of the first hunter–gatherer's toolkit have been found, as well as equipment sites (Flegenheimer, 1991, 1994; Mazzanti, 1997a, 1999; Nami, 1987), multiple activity sites, and killing sites for the primary processing of prey (Núñez Atencio et al., 1994; Miotti, 1992, 1993, 1996).

However, the two fragments of FTP found in Piedra Museo associated to unifacial technology for the manufacture of scrapers and knives (Fig. 3) represent an assemblage that belongs to the same technical conception. The detailed study of the largest fragment of FTP shows that it was made with a very homogeneous red silex, of an excellent quality for knapping and retouching by pressure, but with evidence of having been exposed to a thermal treatment to improve the rock knapping qualities. On the other hand, this instrument does not have both faces slimmed by retouch, but in both penetrating flakings can be seen in several directions; a marginal squamous retouch is only circumscribed to the contour of the piece, from what it can be inferred that, as in the big unifacial side-scrapers from the site, the technical conception of retouch is limited to the marginal regularization of blades. In none of these faces does the retouch penetrates more than 5 mm from the border. This same concept of marginal retouch over large flakes with prominent bulbs and with a greater width than length, appears in the associated materials of this and other lithic early assemblages from the Southern Cone, where although the raw materials change, the conception of the FTP is the same: the production of big flakes, which are thin enough and which are slimmed by a bifacial retouch and later retouched in the borders to achieve the final shape. These FTP can be fluted or not, in Piedra Museo they are fluted on both faces, but some points from other sites like Fell, Cueva del Medio, Tagua–Tagua, Cerros La China and El Sombrero, Cueva Tixi and Abrigo Los Pinos do not have a fluted stem. Moreover, in the early human occupations from C3T, Lago Sofía 1, Tres Arroyos and Los Toldos, no projectile points belonging to the technical conception of the FTP appeared, but at Los Toldos (Nivel 11) as well as at C3T, the instrumental assemblage suggests the same technological conception as the materials associated to Piedra Museo FTP.

Analyzing the contexts of Clovis points in the same way, it can be noticed that this technical conception is different. There have been very few primary shaping sites or quarry-workshop sites detected for Clovis, up to the present. Most of the Clovis contexts are caches or killing sites for the primary processing of prey. The production sequences of these points cannot be found in any of them, and in the few base camps or multiple activity sites associated with the Clovis cultural systems, the associated artifacts correspond to formal instruments related to a conception which is directed to the formation of the pieces with penetrating retouches on both faces (Frison, 1990; Bradley, 1993). This conception also appears in the rest of the artifacts associated with the Clovis points.

At Piedra Museo, the context associated to the first occupational event, recovered from the stratigraphical unit 6, lacks FTP, but contains large flakes of bifacial reduction, approximately 8 cm long, which belong to an advanced stage of a biface (Fig. 1 in Miotti and Cattáneo, 1997a). The two fragments of FTP were recovered in the latter occupations, belonging to units 4/5.

Table 2
Technological characteristics of the Clovis technology and assemblages associated to FTP

FISH TAIL POINTS From the Southern Cone	Technological characteristics of the assemblages on a regional scale	CLOVIS of North America (Following Bradley, 1993; Frison, 1990, 1993)
Big to very big flakes	Blanks of formal tools	Bifaces and blades
Unifacial over big and wide flakes, and discoidal polished tools	Associated tools	Bifacials or over flakes resulting from a bifacial reduction process (pièce esquillée)
Between 36 and 120 mm	Size[a]	Between 70 and 160 mm
Slimming in several directions that do not cross the whole surface of the face (from one border to the other)	Re-knapping	Slimming flakings with prepared platforms for obtaining thin blades. They cross both faces of the piece (starting in one border and ending in the other)
Marginal, it does not penetrate in the piece face	Retouch	Parallel to subparallel kind. It regularizes the whole surface of the face/faces

[a] Without considering the FTP and Clovis miniature reproductions found in some sites (Storck, 1991; Politis, 1991).

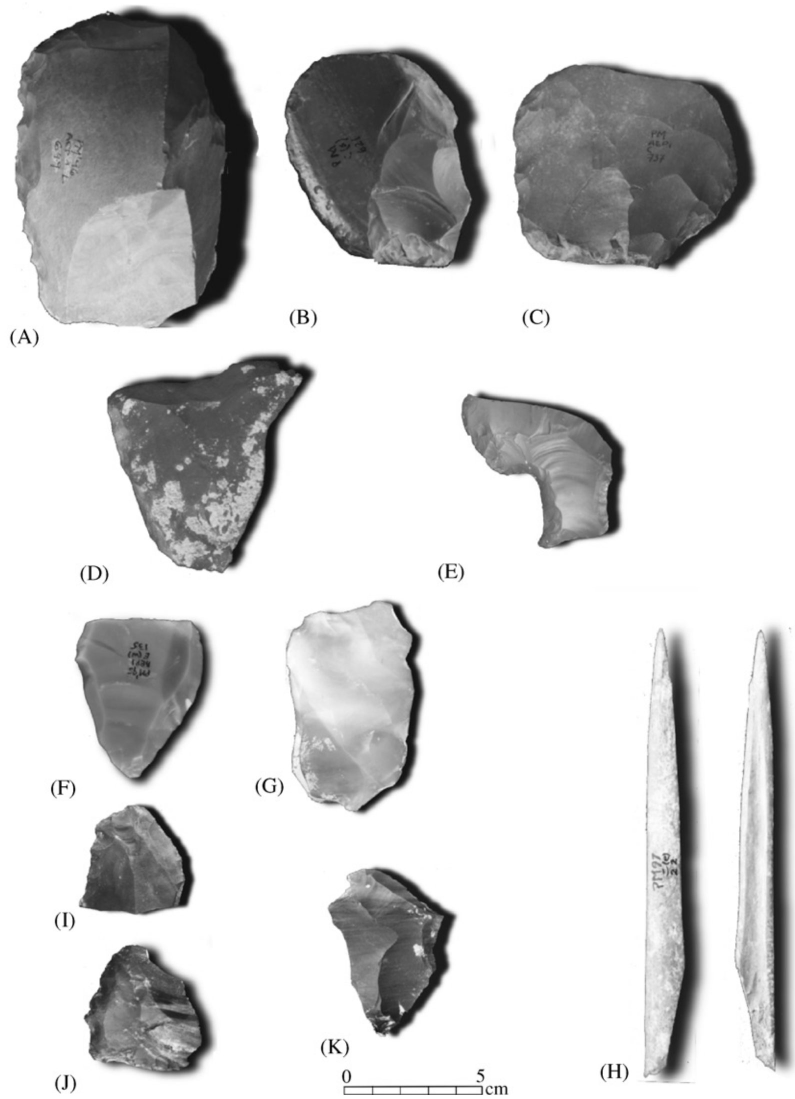


Fig. 3. Lithic materials and bone artifacts with FTP.

However, the few associated instruments (see Table 3) were made on large flakes with prominent bulbs in which only the active blades were re-sharpened by marginal retouch. Most of these instruments are broken (Fig. 3). This special context with a few cutting tools shows an expediency aspect; all of them are broken and associated with two broken FTP as well; it was interpreted as a toss zone of killing and butchering locus (Miotti, 1995; Miotti et al., 1999a).

At Piedra Museo, there are lithic materials with thermal alteration. In many cases they show a damage that is probably related to a long permanency at very high temperatures within the hearths. Although there are not many in the occupations belonging to the Pleistocene/Holocene transition, they are abundant in the Holocene Component. In other cases, such as in some bifaces and even in the red FTP (Fig. 3), the features indicate thermal treatment for improving the

Table 3
Lithic Materials from AEP-1

Temporal block	Lithic artifacts			
	Cores	Tools	Debitage	Total
Holocene	22	83	5107	5.212
Pleistocene/holocene transition	3	22[a]	69	94
Total	25	105	4.976	5.306

[a] Two belong to FTP fragments.

knapping quality of the raw materials. These characteristics of the lithic materials were also observed in the materials of the workshops and quarries located between 3 and 8 km from AEP1, and in the quarry-workshop of El Sargento and 17 de Enero. The raw material for the large FTP was obtained at the quarry-workshop "17 de Enero", 3 km southeast from AEP1.

The other fragment, belonging to the stem base of another FTP, is made on a pink chalcedony (Miotti, 1992, 1995, 1996; Miotti and Cattáneo, 1997a) and fluting can be observed on both faces of the piece. The source of this last raw material has not been detected yet, but can be found as nodules, in the tuffs belonging to La Matilde and Chön Aike Formations, in the rock exposure of El Museo Formation and in the deposits of ancient beaches and littoral lacustrine bars that surround the present low land, at the border of which the shelters and caves are placed (Panza and Genini, 1998).

The bipolar technique was not developed in Piedra Museo, but it is present in the bony artifacts (Fig. 1 of Miotti and Cattáneo, 1997a). A very polished awl appears in the transition between units 5 and 6 and more formal tools of greater variety than in the Lower Component were found in the Holocene occupations. The dating of both occupations is detailed in Miotti and Salemme (2003). This reduction technique of the rocks is manifested in Pampean sites associated to FTP (Flegenheimer, 1991).

As the characteristics of the raw materials have been detailed in previous publications (Miotti and Cattáneo 1997a, b, in press; Cattáneo, 1999; Miotti and Hermo, in press), the quantity of lithic materials recovered in both components, as well as the lithic raw materials from the First Colonization or Pleistocene context to the context of Effective Occupation of Space (Early and Middle Holocene), are briefly summarized in Tables 3–5.

According to these results, it is suggested that in both temporal blocks the raw materials were of local origin, and the only case that could be considered as foreign is the obsidian from the Andean Range. Although Stern (1999) shows that it may well come from the Hudson volcano eruption, these analysis are not conclusive and, furthermore, there are several sources of obsidian in the area which are not farther than a 30 km radius from the site.

2.2. Taphonomy and faunal analysis

To evaluate the depositional and post-depositional processes from the Lower Component of the site, not only the parameters coming from the modifications of the bone surfaces were used, but also other parameters of concordance such as geoarchaeological and palynological analyses, and those of intrasite spatial distribution (Miotti and Salemme, in press). For the study of disarticulation, fractures and cut marks, a sample of long bones was used, since they are considered as the most diagnostic for this kind of analysis. The results obtained from the degrees of meteorization, articulation, fracture and modifications of bone surfaces are introduced in Figs. 8–11. Most of the long bones were recovered complete (Fig. 3, in Miotti et al., 1999a) and the degree of fragmentation is also low, since most fragments of long bones correspond to the measures of more than 10 cm (Fig. 4). The most common kind of fracture is the helicoidal and some flakes correspond to the refuses of this fracture. Also the cut marks, although scarce (approx. 5% in the Pleistocene occupations) show a concordance with that expected for sites where the primary processing activities, as well as the piling up of big anatomical units, and the extraction and/or consumption of small quantities of bone marrow were carried out.

According to the analysis of horizontal and vertical distributional skeletal parts and to the faunistic structures introduced in previous works (Miotti, 1993, 1996; Miotti et al., 1999a) the distribution of faunistic materials is concentrated in piles within lower occupations of the site (Miotti, 1991, 1992, 1993, 1996) or First

Table 4
Use of lithic raw materials in each temporal block from Piedra Museo

Temporal block	Raw material					
	Silica	Chalcedony	Petrified Wood	Silicified Tuff	Obsidian	Total artifacts by Temporal Block
Holocene	3055	1350	416	220	171	5212
Pleistocene/holocene transition	50	20	16	8	0	94
Total	3105	1370	432	228	171	5306

Table 5
Use of lithic raw materials % from Piedra Museo

	Raw material				
	Silica (%)	Chalcedony (%)	Petrified wood (%)	Silicified tuff (%)	Obsidian (%)
Holocene	59	26	8	4	3
Pleistocene	53	21	17	9	0
Total	59	26	8	4	3

Colonization Context (Miotti, 1994, 1995; Miotti and Salemme, 1999). Piles from units 4 and 5 could belong to the same occupational event, or to short events, since in both units anatomical and articular refitted could be achieved. However, the pile belonging to unit 6 could represent another event separated by hundreds of years and previous to the other two units. Based on the analysis of taxonomical abundance and skeletal parts (MNE, Survival Index, MAU, %MAU, and correlations between indexes MGUI%/DO, and MGUI/%MAU%) of guanacos, it is suggested that from the beginning of the human occupation until the Early Holocene, the site was used for watching, hunting nearby the palaeolake shore, and piling up the guanacos carcasses (main prey since the first human occupation during the Late Pleistocene until the Middle Holocene occupations) in the rock shelter (Miotti et al., 1999a; Miotti and Salemme, in press).

The archaeological resolution is good and the integrity of the context is greater in the medium part of the piles than in their extremes, where the action of post-depositional agents, such as rodent teeth marks and roots prints have modified the bone surfaces more intensively; the action of carnivores is in this sense very low (less than 2%, see Fig. 5a). This integrity can be explained because the major quantity of the sample falls within the Berhensmeyer's 1–2 stages, in other words, it is low (Fig. 5b). It can be inferred that the bones were briefly exposed to the meteorization agents. However, this integrity and high resolution could have also been favored by post-depositional processes, such as the illuviation of pedogenetic carbonates. The analysis of correlations for the different indexes of economic utility, for bone density and the index of survival, according to Spearman's coefficient, are coherent with the interpretation expressed above about the bone piles as a result of human activities of selection and discard (Miotti, 1992, 1993, 1996; Miotti et al., 1999a). In this sense, the first hunter–gatherer Pleistocene occupations in the site would have been specific, referred to the processing of carcasses.

The refitting of skeletal parts and the analysis of bone surface modification, as well as the distributional and taxonomic analysis suggest that during the Pleistocene/Holocene transition (13–9.3 ky BP) AEP1, at least in two occupations temporally separated by hundreds of years, was used as a locus of activities related to the primary processing of big mammals and large flightless

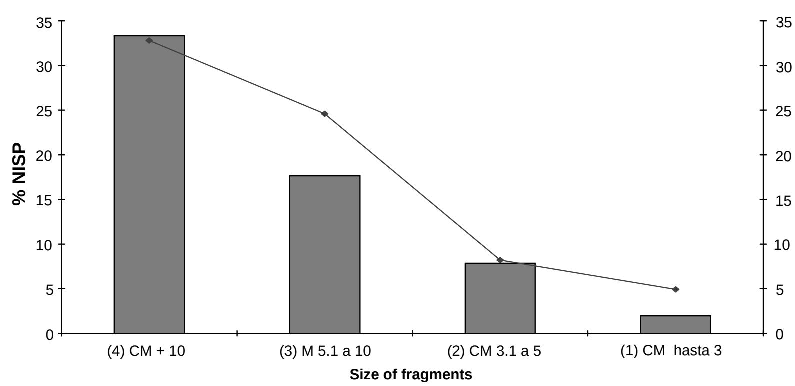


Fig. 4. Fracture pattern in long bones: (a) sizes of fragments from u6 and u4/5, and (b) comparison of fracture degree.

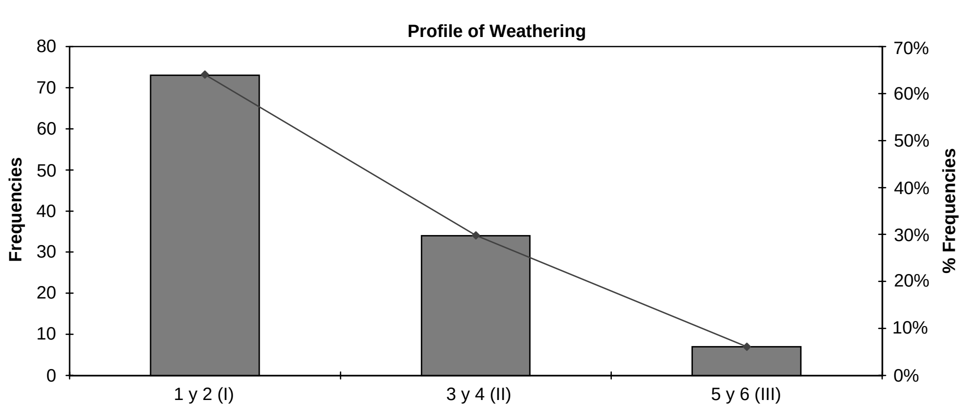


Fig. 5. Weathering profile of AEP-1.

birds. The first event with a radiocarbon dating of 13–11 ky BP, corresponds to the stratigraphical unit 6; the second occupation corresponds to other events of prey butchering that were developed between 10.5 and 9.3 ky. BP, and is placed in the stratigraphical units 4 and 5. These butchering events could have been produced by hunting nearby the rock shelter and by the palaeolake shore (50 m south the shelter). Therefore, during the colonization moments at the Late Pleistocene/Early Holocene transition, this rock shelter was used redundantly, at least during two opportunities (Miotti and Salemme, in press).

The surrounding geomorphologic features show that this locality—rock shelters, pathways, mounts, terraces, lake in the depression, high pampas—would have been an excellent place for the cinegetical watching practices, as well as for the killing, butchering and meat preparation (or preparation of other resources extracted from the prey) practices. It can also be suggested that the anatomical parts with a high meat content found in the site would be the product of the removal of flesh and abandonment of bones without marrow consumption, or the product of the piling up of certain anatomical parts for the immediate or future provision of meat. In this sense, the idea that the site would have been frequently visited by hunters is supported. The relationship with open campsites and isolated findings by the surroundings, allow us to infer that this locality could constitute, within a radius of 3–9 km, a situational complex that was redundantly occupied towards the end of the Pleistocene and the beginning of the Holocene.

3. The intersite relationships in the regional and multiregional scales

In the region of the Central Massif of Santa Cruz there are other localities with sites and components that belong to the same temporal block as Piedra Museo (Table 1b), the Pleistocene/Holocene transition. These are: Depositional Unit 5, "Nivel 11 Component" of C1C3T (Paunero, 1996); Casa del Minero cave (Paunero, in press); the "Nivel 11" and "Toldense" Industries of Cueva 3 at Los Toldos (Cardich et al., 1973) and possibly, although without radiocarbon dates, the archaeological context of Level 12, assigned by Cardich (1987) to the "Nivel 11 Industry" at El Ceibo.

In the Río Pinturas basin the earliest occupations were recorded in layer 11b of Cueva Grande at Arroyo Feo and in layer 6b of Cueva de las Manos Pintadas, both assigned to the Phase I of the regional "Río Pinturas" tradition (Gradín, 1980). For the Andean basins of Río Belgrano and Lago Posadas, which according to Aschero, are related to the Río Pinturas basin or are an extension of the same, ***"la base de la secuencia de ocupación de CCP7 (ca.* 9700/9100 *AP) representaría un momento temprano de exploración y lo 'colonization'****…of the ARBLP area***"** (Aschero, 1996, p. 19). The remark in the text is mine, since the categories stated by Aschero are taken from Borrero (1990, 1991) and both would fit in the evolution stage of Exploration and Colonization which the author considered in the same way as Borrero Miotti (1989) 1998, p. 528]. However, later, exploration and colonization would be integrated into only one stage of colonization, although the hypothesis of the exploration stage in a new environment is not discarded at a theoretical level. However, the sites belonging to this stage lack clear characteristics at a regional scale (Miotti, 1994, p. 39).

In regards to these sites, the interpretation is that these caves contain evidence of "*… espacios de actividad doméstica es conclusiva; sumado al hecho de una marcada redundancia de ocupación en CCP7 …*" (Aschero, 1996, p. 18 and Table 1). However, these localities, located between 120 and 400 km from Piedra Museo towards the west, are different in several aspects. The main features are:

(a) the resolution of the contexts is very coarse at Los Toldos and El Ceibo although both have good archaeological integrity; medium or high coarse at the sites from C3T, Casa del Minero, Río Pinturas and ARBLP;
(b) the geoforms where the sites are situated differ: a not very deep canyon at Los Toldos, with the excavated caves located at the bottom of it or in a very direct relationship with the present valley, while Río Pinturas is a canyon of great depth and the excavated caves are in intermediate and high points of the slopes that form the valley, far from the present basin of the river and far from the plateau that borders this valley; and
(c) the panoramic views from each site are also very varied, which implies very different situations for hunting, different distances from water sources and from the rest of the resources. However, and in spite of these differences of location, the authors inferred multiple functions for each of the sites, except El Ceibo, that was considered as an occupation of limited activities by the end of the Pleistocene. C3T, Casa del Minero and El Ceibo are related to lacustrine basins and the panoramic view from three sites is wide over the depression, but (except in the second) restricted respect the high surrounding plateaus.

The projectile point found by Paunero at C3T does not belong to the FTP type, but the lithic artifacts from this occupation are techno-morphologically similar to those from Nivel 11 at Los Toldos and El Ceibo (Paunero, 1993–94), Casa del Minero, and also similar to most artifacts associated to the first Pleistocene occupations from Piedra Museo. The sources of origin of the raw materials used in these sites, taking each site as a central point, do not exceed in any case the microregional scale.

In the Magellan Basin the sites with reliable occupations within this period are Fell, Pali Aike, Las Buitreras, Cueva Lago Sofía 1 and Cueva del Medio although the archaeological resolutions of the sites are also different here. FTP was found only in Fell, Pali Aike and Cueva del Medio. These were interpreted as multiple activity sites (Bird, 1988; Nami, 1987; Prieto, 1991). Regarding Fell Cave, not all the points from the Lower or Fell 1 component ($n = 15$) belong to the FTP, since one of them ($n = 1$) is triangular with a concave base (Bird, 1988, Fig. 57), similar to that from C3T and to those from the initial Toldense (see Cardich, 1977). The resolutions from Cueva del Medio and Cueva Lago Sofía 1 are high, while at Fell, Pali Aike and Las Buitreras they are low and there is diversity in the integrity of the contexts. A site that should be outlined for this period is Tres Arroyos (Massone, 1984), in Isla Grande of Tierra del Fuego. In this sense, it could be inferred that projectile points have not been found in this site, whereas, cutting tools on larger flakes and some bipolar tools were found. The geomorphologic and contextual characteristics of this small rock shelter, placed on a cliff from which a wide sector of the surrounding plain can be seen, suggest that there was a brief occupation more than 11,000 years ago. There is evidence of extinct fauna processing (Mengoni, 1988; Borrero, 1991, this volume), and the processing of some prey inside the rock shelter was suggested. The archaeological resolution for this site is good and it was defined as a site of multiple activities, although without a redundant occupation.

All these occupations in the Patagonian southern extreme, of equal or earlier chronology than the North American Clovis Technologies suggest:

- The presence of projectile points, whether they are FTP or large subtriangular points (6 cm long or more), with or without fluting, are not the only evidence of a human colonizer component in the Central Plateau, nor in other regions of far Southern Patagonia.
- The presence or absence of points in the colonizer contexts of the area is related, on one hand, to the site formation processes according to the zones of low or high (sedimentary traps) depositional rates in which the materials are found, and on the other hand to the differential use of the Andean foothill region and the plateau (which implies different geomorphologic landscapes) by the first colonizer societies. Therefore, it is more possible to find points in those sites directly related to hunting practices, such as Piedra Museo, where the broken lithic points could have been discarded and replaced by new ones, or Fell, interpreted as a site of equipment and change of lithic points. Points are not expected at places where limited activities which are not related to hunting nor to the equipment of projectile points have been inferred; this is the case of El Ceibo Cueva 7, considered as a small hide leather workshop. It showed the edge resharpening of scrapers and side-scrapers (Mansur-Franchomme, 1983) and also was considered as a place in which the consumption of meat and marrow of certain transported guanaco anatomical parts was held Miotti ([1989] 1998). Lithic points are neither expected in sites of multiple activities and short duration, such as residential bases within a forager mobility system, but with enough indicators of specific situations which would show a logistic strategy; that is the case of Nivel 11 at Los Toldos Cueva 3, an area of domestic activities related to Piedra Museo, 100 km southeast from this locality, where, as mentioned, specific killing activities and the primary processing of prey was conducted (Miotti [1989] 1998, 1993).
- The site formation processes are not excluded as a reason of the absence of projectile points, for example in places of low resolution, where the possibility of the palimpsest effect has not been controlled or was minimized in the interpretations. Typical cases are layers 11b and 10 at Los Toldos Cueva 3, with the "Nivel 11 Industry" and the consecutive "Initial Toldense Industry" (see Cardich et al., 1973); and in places that were reoccupied during a long term, producing the reutilization of the abandoned points in previous occupations. In the last case the reused points would be associated with more modern contexts than those in which they were produced and used. In this site, the medium subtriangular projectile points were found within the "Toldense Industry" context, while in the previous "Nivel 11 Industry", characterized by Cardich as unifacial technological system, no points and no bifacial technique were found (Cardich et al., 1973; Cardich, 1987). This argument, based on the technological characteristics described, was interpreted as completely different from the "Toldense Industry" of the same site. Therefore, the Toldense should be considered a new technique, developed by a new migration of peoples (Cardich et al., 1973; Cardich, 1987). However, our analysis leads to the idea that the 47 artifacts (Mansur-Franchomme, 1983) belonging to Los Toldos "Nivel 11 industry" have a technological conception very similar to those found by us at Piedra Museo, and to those found in the region at C3T, Casa del Minero 1 and El Ceibo. The main difference between these sites and Piedra Museo is that in the latter site, in addition to large side-scrapers made on flakes with prominent bulbs,

fluted FTP as well as a bone instrument with a high degree of polish were found (Fig. 3, and Tables 3–5; see Miotti et al., 1999a). The only date obtained from "Nivel 11" at Los Toldos, which has lower archaeological resolution than this one, should be tested, because a reliable technological division between "Nivel 11 industry" and "Toldense industry" does not exist. I believe both are part of the same technological conception applied to different functions of the tools. On the other hand, no intermediate dating exists that allow us to suggest the end of the "Nivel 11" occupation and the beginning of a second occupation by 11 ky BP, such as Cardich expresses for the beginning of the Toldense at this site. Moreover, against Cardich's hypothesis, artifacts of "Nivel 11" technology were also found in several Pleistocene/Holocene transition sites: Fell, Pali Aike, Cueva del Medio (Nami, 1995), Arroyo Feo, Cueva de las Manos, La Martita, Casa del Minero, C3T, as well as in the Pampean sites and Tagua–Tagua (Chile), containing FTP. Another argument to allow us to support the antiquity and lack of independence—as a technological system—of Nivel 11 is its occurrence in El Ceibo Cueva 7, where a phalange of Hippidion saldiasi was dated by AMS ca. 9500 ^{14}C years BP (Cardich, pers. comm. 1997). The greatest difference is not found in the technological concepts of their artifactual assemblages, but in the kind of raw materials that were used, which although of good quality and remarkable selection, are always found within the region of the sites, related to the supply sources at a regional scale. The datings of the Pampean sites are relatively more recent than those from the Patagonian area. A case which could clearly exemplify and demonstrate why one should not make general statements about technological and sociocultural changes, is that from Tagua–Tagua, indicating the extent to which there has been an abuse of the term "industry" that, further from implying ethnic connotations, is transferred to a wider theoretical level to explain the cultural change by replacement of "industries". This interpretation of changes does not end here, but on the contrary, it is a tacit indication of the significance of major categories that imply the replacement of human populations (see discussion in Scheinsohn, 1998). In this sense, it is convenient to have a background of regional information fairly calibrated respecting time and variability of the archaeological record, in order to allow generalizations about the use and circulation of raw materials and lithic artifacts at a regional level. The example from Tagua–Tagua is focused in the history of the investigations that were carried on. It was initially excavated during the 1960s by the archaeologist Julio Montané and its context was frequently correlated to "Nivel 11 Industry" from Los Toldos by different authors. The relationship was based on the presence, in both sites, of an unifacial technology (rough industry) made on large flakes, with marginal retouches, without projectile points and with an extinct fauna, mainly of Pleistocene horses and camelids. However, despite Menghin's (1952) report about a FTP found on surface at Los Toldos creek, nobody paid much attention to this reference. Although Cardich, in different papers, makes reference to this point, he does not stimulate a discussion by assigning it to any of the "lithic industries" defined for this locality; but reading his publications, it can be thought that he would have assigned it to the Toldense, the industry that he considered equivalent to Fell 1 of the Magallanes sequence. This outline was thus reinforced by the sequence of Los Toldos and its relationship with Tagua–Tagua. The unifacial technologies, typical from the first peopling of the Southern Cone and related in some way to the European Mousterian (according to the resemblance of both American and European industries), would have led to the development of bifacial technologies as the product of new populations that occupied these two regions of the Southern Cone. Most of the authors have sustained this hypothesis during the seventies. It means that "Nivel 11", strictly unifacial and with Mousterian characteristics (Cardich, 1977) would represent the first groups that peopled Patagonia, and according to the inventory of formal items from Tagua–Tagua, it would also represent the first people who occupied less extreme latitudes. However, the last findings made by Lautaro Núñez Atencio in another section of the ancient Tagua–Tagua lagoon, demonstrated that the previous information was only partial, since in his excavations, Núñez and collaborators (Núñez Atencio et al., 1994) recovered ca. 20 m from Montané's excavation, almost a complete mastodon carcass in an unquestionable association with FTP and to other instruments made on large flakes such as those that Montané had found 3 decades ago, where Núñez named Tagua–Tagua I. The new dating of Tagua–Tagua II (Núñez Atencio et al., 1994) places this occupation from the Central Chilean Basin at 11.8 ky BP. This site is interpreted as a *locus* of restricted activities, where the killing of some proboscideans, horses and camelids was developed, as well as the primary processing of prey by the paleolagoon shores. Here, as in Piedra Museo, the unifacial cutting artifacts were associated with bifacial artifacts, the FTPs. So the question is: Why should we keep the unilineal sequence of the "Unifacial Industries" that are replaced by "Bifacial Industries" in the Southern Cone, and in some extent accept that a replacement of population is necessary for the development of this technological change? This argument seems to be completely insufficient against the present evidence, and the great intersite variability detected for transitional Pleistocene/Holocene occupations certainly does not fit with it.

- Although the last example kept us away from the regional scale, there are several considerations to emphasize if we return to this scale. The variability of the archaeological materials from the southern Magellan Basin and Tierra del Fuego can be checked in sites such as Fell, Pali Aike, Cueva del Medio, Lago Sofía 1 and Tres Arroyos (Fig. 1) which represent colonization contexts. There is as much variability detected in the use of space as in the Central Plateau. Although most of them were considered as places of multiple activities, in some cases such as Cueva del Medio and Fell, the first and last sequences of projectile point production can be observed, while in others such as Pali Aike, the presence of a FTP associated to human burials turns the grain of archaeological resolution coarser, due to the complexity of human burial and thus, the site formation processes and participant agents. In this case, remains of extinct fauna are added to the human burial. In this context, the interpretation of only one use within the cave becomes difficult. Cueva Sofía 1, unlike the rest of the sites, only contains a Pleistocene occupation (unicomponent site). Therefore, it also contributes to the great variability in the site formation processes respecting the short-term redundancy of occupation, which increases the intersite variability and concomitantly, the differences in the reoccupation of places.
- At a supraregional scale, involving Patagonia, Pampa and Central Chile, we observe that the archaeological variability of the colonization continues to be large, with sites of instrumental equipment (El Sombrero top hill), killing, primary and secondary processing sites (Paso Otero 5, Tagua–Tagua), watching sites, ochre caches and lithic workshops (Cerro La China 1 and 2), multiple activity and reoccupation sites (Monte Verde, Cueva Tixi, Abrigo Los Pinos, Arroyo Seco 2). At this spatial scale, the chronological location becomes important, because excepting Monte Verde II and Arroyo Seco, the rest are places in which FTP have been found associated with instruments made on large flakes with marginal retouch and in some cases with bipolar knapping. They are placed within the North American Clovis-Folsom temporal ranks. Even Monte Verde II is a stratigraphical context that lacks projectile points, in Río Bueno site, 250 km north from Monte Verde, Dillehay found a fluted point in a test pit which he compared with the Clovis points from North America and to which he assigned an age of 10.5–9.5 ky BP (Dillehay, 1997, p. 50).
- Finally, and at a hemi-continental scale, a great variability of Clovis and Preclovis contexts were found. However, the problem of the first humans in the Southern Cone cannot be reduced to the presence/absence of Clovis markers. They have a medium to high resolution and they are geographically located in very different landscapes (savannas, plains, hills, rain forest, arid valleys, Fig. 1 and Table 1b). I assume that FTPs are formal tools, of a technological development exclusively from Southernmost South America. Thus, it is not a technology derived from Clovis (Miotti, in press; see Politis, 1991and references cited there). Among the main sites with non-FTP projectile points older than 11.5 ky BP can be mentioned Taima–Taima (Ochsenius and Gruhn, 1979), El Abra, Tibitó 1 (Correal Urrego, 1986), Caverna de Pedra Pintada (Roosevelt et al., 1996), Alice Boër (Gruhn, 1986, 1989), and Tuina-San Lorenzo (Núñez Atencio and Grosjean, 1994) see Table 1b and Fig. 1. The unique site with FTP in the stratigraphy north of 33°S is El Inga (Bell, 1965; Mayer-Oakes, 1986), but all the dates obtained show ages of 9.5 ky BP on average. Furthermore, the resolution degree of this context is low, and the cultural sequence was established according to the shape modification of lithic materials recovered in the successive artificial excavation levels. These levels are contained within an only stratigraphical block with a thickness of 40–50 cm. El Inga is up to the present the most questionable site to defend the hypothesis of a Clovis groups' advance or at least their technologies from north to south. If we have some clue, at the moment it seems more parsimonious to explain the presence of FTP at El Inga as: (a) an independent center, (b) as a product of the population dispersion, or (c) from the circulation of technological ideas which might come from farther south with a production that could have been developed in the Patagonian and Pampean areas, in the Southern Cone. On the other hand, it is important to emphasize the great variability of environments, with their varied archaeological representations in the Southern Cone by 13–11.5 ky BP. It would imply that peopling of South America was advanced and the populations had just reached the knowledge of availability and access to resources in each one of these environs. That means an ample social network. At this time, the caves were frequently occupied in South America for different uses, while in the great North American plains this phenomenon is not manifested, since most stratified Clovis sites are open air sites. So, the selection of stone tools during 12–10.5 ky BP is so high in Pampean and Patagonian regions, that it implies the human populations knew those territories absolutely, and this frame does not seem reflect a phase of

exploration, but instead a colonization stage. This difference makes the panorama of the first New World colonizers even more complex, a fact that will be discussed later. In this summary I believe to have found the arguments to discuss Clovis as a phenomenon of first pan-continental colonization, since it cannot explain the great variability of life styles that existed at the same time in South America. Likewise, this problem should be discussed adding information on ancient shorelines and bioanthropological data, as well as the earliest contexts from Atlantic rim and the drainage basins linked to it.

4. The bioanthropological evidence: searching for the transgressor chromosome

Returning to the continental scale, but now from the bioanthropological indicators, at present there are 2 theories in conflict about the first Americans: one that suggests 3 migrations (Turner, 1983, 1992) which fits perfectly to the "Clovis, the first American colonizers" paradigm. This theory is based on the morphodental characteristics of the American Indians and the Asian groups. Therefore, for this author and his collaborators, it is difficult to accept one non-mongoloid migration older and more successful than that from Asia to Alaska, and produced earlier than 15 ky BP.

The second anthropological theory is based on the morphological characteristics of the cranium. With that aim, the present populations from America and Siberia were sampled and the craniums from different archaeological sites such as Lagoa Santa and other South American collections were measured (Neves and Pucciarelli, 1991; Pucciarelli et al., this volume). In this sense, the authors suggest that migrations of different biological modern humans (as the last explanation, coming from Asia through Beringia and the Pacific rim) would have been the colonizers of the New World. This proposal used a much deeper chronological frame than the other, which extends from 30 to 40 ky BP, in order to explain why in South America the oldest bioanthropological patterns have been recorded with dates older than 11.5 ky BP. Although this theory adds anthropological and ethnic variability to the peopling process, the information generated during recent years by genetics studies is readdressing the theories for the American Peopling towards an even greater spectrum of ethnic groups which, since at least 40 ky ago must have started to enter the New World (Bianchi et al., 1997; Bianchi, 1999). This theory, however, uses the same entrance gate for the colonizers as the two previous ones, that is Beringia and the Pacific coast. In this sense, and based on purely archaeological data, it had already been promoted as the safest route since the 1970s, when Alan Bryan supported his circumpacific perspective (Bryan, 1978) and Müller Beck (1969) stated the entrance of the "first elephant hunters" from the Urals to America.

Based on the archaeological, genetics, linguistic (Greenberg et al., 1986) and biological evidence, it is now suggested that the colonization, for the Southern Cone, was a long and complex process that started towards the end of the Pleistocene. At that time huge environmental and social changes, occurred simultaneously at a worldwide scale, with the massive receding of the glaciers, the massive extinction of large mammals that prolified during the whole Pleistocene, and the human colonization of the last wild continent. Not only Bering and the Pacific rim, as it was thought until a short time ago, were the unique ways of entry. Especially for South America, the Atlantic and its ample littoral border that emerged, as presently, ca. 35 ky BP ago, could have been another gate for people that were coming to America from the Old World with a long adaptive history to the rough and pure glacial and periglacial environments from this old continent (Gamble and Soffer, 1990).

5. Atlantic façade: its the role in the colonization of South America

Up to now, the South American Atlantic Façade was not considered significant for the peopling of South America. Perhaps, archaeologists underestimated its importance in the processes of human colonization. However, we now must pay more attention due to: (a) The maximum lateral movements of coastlines during the last 20 ky BP have varied from as much as 1000 km in some areas to less 1 km in others (Erlandson, 2001and references quoted there), as the major part of the South Atlantic rim are vast plains; (b) The availability of territories risen was greater than on the Pacific rim, for the same age; (c) the largest basins such as Orinoco, Amazonas, Paraná and Uruguay, including the Colorado, Negro, Chubut, Deseado, Chalía, Santa Cruz and Chico rivers drain into this littoral; (d) the Pacific Façade has several transversal rivers but they are short because they drain across a narrow band of land between the littoral and the Andean cordillera; and (e) rivers always were interesting ways used to explore new terrains hinterland, and probably they could have helped in social communication.

Knowledge about navigation and flexible complex instrumental equipment as well could allow a variety of uses in different situations (Erlandson, 2001). With these assumptions and the archaeological evidence presented above, I will discuss some aspects of the technological organization of the first Patagonian inhabitants, as well as the archaeological map of the Pleistocene/Holocene transition, in order to understand the archaeological

South American variability, the context of the first American peopling and the socio-natural landscape in which this process took place, in diverse environments.

Up to now, many archaeologists feel that "the great American gate" through Beringia and the North Pacific rim was the best chance, but when the first populations entered the interior of the continent, the pathways and routes should have multiplied. Later on, the main route of Circum-Pacific coast could have continued southwards, meanwhile in narrow territory of Central America other route could have bordered. In this term, the Caribbean coast could have been part of a short exploration. Nowadays, there is evidence (see Fig. 1 and Table 1) along this coast that demonstrates different terrestrial and aquatic adaptations (Erlandson, 2001and references there quoted). Then, the huge territories available in northern South America could offer a diversity of attractive environments along the Atlantic rim towards the south. Several extensive fluvial basins drain from the heart of the continent to the Atlantic, such as the Magdalena, Orinoco, Amazonas, Del Plata basin, Colorado, Negro, and Deseado. In this sense, we might pay more attention to several sites (Fig. 1) belonging to this rim or related to it in relationship with the great rivers, such as Taima–Taima (Ochsenius and Gruhn, 1979); Monte Alegre (Roosevelt et al., 1996), Lagoa Santa, Lapa Vermelha, Santa Elina, Alice Boër (Prous and Fogaça, 1999), Uruguayan and Pampean localities (Suárez and López Mass, in press; Flegenheimer et al., 2003), and also, the localities of Extra-Andean Patagonia: Los Toldos, Piedra Museo, El Ceibo, C 3 T, Casa del Minero, Fell, and Tres Arroyos.

6. Discussion and conclusions

Based on our own results and those obtained by other researchers and introduced in this article, we are able to answer the first questions, keeping in mind the temporal scale 13–8.5 ky BP, and adding details to the three first geographical and geomorphological scales from the southern section of South America, with the scope of approaching a hypothesis of the peopling at the last level of data integration.

(1) At a microregional scale, it corresponds to the basin of the low eastern gullies and to the residual basins such as Piedra Museo paleolake and the Laguna Grande at the Petrified Woods Natural Monument near Jaramillo, where the mentioned temporary streams end.
(2) At the regional scale, it includes the Deseado Massif, which includes several residual and active basins, ending in the large collectors that constitute the northern and southern limits of this geological structure, such as Deseado, Chalía and Coyle rivers.
(3) At a multiregional scale, it includes the cordilleran ridges, the southern Magellan Basin together with the basins of Santa Cruz and Chico-Gallegos rivers, the sections from the Atlantic Coast and what is nowadays Tierra del Fuego and Última Esperanza areas, as well as the Pampean Region and the southern and central Chilean valleys.

The three main aspects selected to assess the use of space are: the intersite and intrasite variability, the area for supply of lithic raw materials, and the archaeofaunistic assemblages. These will guide us in the interpretation of the degree of human knowledge and settlement in the different regions.

The record of colonization sites with a temporal interval controlled by radiocarbon dating is low. Only Piedra Museo yielded a Paleoindian context which contains, at least, two occupational pulses, the first one between 12.9 and 11 ky BP with dates which are closer to 11 ky AP, and the second one between 10.5 and 9.2 ky BP (Miotti et al., in press). Although the complete geological report about the microscopic mineral composition of the materials from the quarries and workshops and those from the site is not available yet, at a macroscopic level it can be sustained that the raw material of the artifacts from these occupations come from places around the site, at a radius that does not go beyond 20 km (Cattáneo and Carrasquero, pers. comm. 2000). With respect to its function within the regional and microregional settlement system, Piedra Museo had a strategic role in the synergetic framework, as well as for the activities of initial and primary butchering of prey. Although the outcropping in which the site is placed is low and has a low visibility from the hills and plateaus that surround the depression at a radius of 15 km, from its top the main heights of the landscape, such as Cerro Madre e Hija and Cerros Colorados, can be seen. Both hills contain the largest outcrops of excellent quality silica and petrified wood that were used by earliest people of these occupations In this sense, and assuming that there was a low demography during the colonization (ca. 13–11 and 10.5–8.5 ky BP), the panoramic view of access ways such as the gullies and the most prominent landscape points implies an optimal localization to maintain an inclusive social communication (Gamble, 1993b) and a knowledge of the mobility pathways, as essential requirements to minimize risk for societies who are initially occupying an unknown and uninhabited space. Madre e Hija Volcano is the highest point of a hillock formed by columnar basalts. This natural monument, as well as representing a place for supplying lithic and fossil raw materials, could be symbolizing a sacred place far from the domestic space, as was revealed by the finding of a secondary burial. Besides, at the foothills of the same volcano, there is a field of "chenques" that allow it to be considered as an area redundantly used as a mortuary space. Although the burials probably belong to late moments of the Indian occupations in the area, the emphasis and high visualization of Cerro Madre e Hija are remarkable in the plateau landscape.

Two groups of localities are also complementary references to Piedra Museo and its microregion: (a) The basins of Río Seco where C3T, Casa del Minero, La María and El Ceibo are placed, which temporal resolution is given by the two radiocarbon dates belonging to the second site (ca. 11.5–9.5 ka BP); and (b) Zanjón del Pescado, flowing towards the Deseado river, where Los Toldos locality is located with the sites Cueva 2 and Cueva 3. In this case, the archaeological resolution is coarser. The temporal block 12.6–8.7 ka BP is sustained by only two radiocarbon dates available for both sites (Table 1). This group of sites in the Deseado Massif allows us to infer a great intersite variability during this period of colonization. Residential bases occupied repeatedly and the places of specific activities, such as the hide workshops and watching sites, are usually near sources of drinking water. On the other hand, the use of raw materials has a microregional rank or is linked to the immediate landscape to the sites, and thus a logistical mobility strategy seems to be shown. An example is El Ceibo, where the raw materials of the artifacts recovered from the stratigraphy of the small rock shelter, came from the top of the rock formation in which the site is placed. In that quarry of silica nodules, the first stages in the elaboration of bifacial and unifacial pieces are reflected (Mansur-Franchomme, 1983).

In this way, the integration of these sites to Piedra Museo, as part of the same sociocultural system that colonized the Central Massif region during the period 13–8.5 ky BP is suggested. Although there is not a strict correspondence of dating, the techno-morphological information, as well as the raw materials used, do not contradict the two occupational pulses suggested for Piedra Museo microregion. In the same way, it must be emphasized that from the top of Los Toldos Canyon, Cerro Madre e Hija, as well as the group of depressions that integrate the basin of the Blanco and Elornia gullies to the east, can be seen.

On the other hand, there is a recurrence at a micro- and macroregional level, during the lapse of colonization, through the use of raw materials in certain assemblages of lithic artifacts, which are usually projectile points. Such selection of excellent quality rocks for knapping and for pressure can be interpret as a search of perfection at a limited assemblage of instruments that constitute a conservative instrumental equipment (see for example, Flegenheimer, 1994; Núñez ñez Atencio et al., 1994, among others). However, it is worth to note that in the region of the Deseado Massif, unlike other regions, the availability of lithic raw materials of good to excellent quality for knapping is nowadays abundant and has a high visibility. Therefore, it is assumed that these raw materials were even more available during the first occupational advance. In these terms, it is suggested that the attractiveness of the Central Massif could have generated for the first hunter–gatherers must have been enormous, since it is important to notice that even in other regions (Flegenheimer, 1994; Núñez et al., 1994; Frison, 1990) at the same time, people selected different raw materials for the confection of the most sophisticated and/or conservative instrumental, whether they were available within or outside the region. This rich availability is one of the possible reasons for the absence of places for storing raw materials in the Patagonian region, such as those of the Pampean Region, or like the "caches" from the North American Great Plains.

The cordilleran foothills, in the Río Pinturas and Río Belgrano—Lago Posadas basins contain early colonization sites, but evidently towards the end of the Pleistocene, when the first occupations took place in the Deseado Massif, this Andean region still remained without signs of human occupation. It would probably have still been under the influence of a glacial environment. Therefore, the first effective explorations and occupations would have started ca. 9700 years BP, corresponding to the second pulse of colonization and territorial consolidation of the Central Massif, and could likely show the expansion of this sociocultural system to the western habitats of foothill, cordillera, and high plateaus (ca. 1000 ma.s.l.). The raw materials from this region also show the management of local resources. So, it is possible to maintain the hypothesis that these first occupations are the result of the expansion and consolidation of the groups from the Central Plateau with the same technologies, which share the unifacial and bifacial techniques for different purposes, and the selection of the best quality raw materials for the highly conservative instruments. However, here the intersite variability seems to be lower than in the other region, which supports the assumption that here the trend of the settlement system goes towards the residential forager segment, with multiple activity and aggregation sites, repeatedly occupied over short and long terms. On the other hand, this evidence is coherent with a peopling exploration and dispersion strategy from a region where the effective colonization has already started. It must also be noticed that in this western region, neither FTP nor associations with extinct fauna exist, which strengthens the idea of an area that was explored and selected later than the Central Plateau, when the Pleistocene megamammals had already disappeared. Although the resources from this region are good and varied by the times of the first occupations, the altitude and the cordilleran effect generated in these places a more seasonal occupation than in the eastern lowlands.

In Magellan and Ultima Esperanza region, other colonization sites have been found, in two cases associated with the FTP technology. The dates here are not older than 11,000 years BP, except for the case of Lago Sofía 1 and Cueva del Medio, in which dating from each site yielded an age older than 12.5 ky BP. However, in the first case the authors are not sure of the contextual anthropic association (Prieto, 1991), and in the second case, the author rejects it because it is the only date that goes beyond the rank of 10.7–10.2 ky BP (Nami, 1995). Here, the intersite variation is greater than in the latter area described and all the raw materials are of local origin, although, as in the other two regions, the selection of those with better conditions for knapping, at least for some groups of artifacts as the projectile points, continued being a constant. Another difference with the Central Massif is that in Magellan area the excellent quality silica is much more restricted and there is a greater difference between the areas. Basalt was the most popular raw material used in Fell during the Pleistocene, and silica the most popular from Cueva del Medio.

There is a site with colonization characteristics for 11,300 years BP, in the island zone. The occupation of Tres Arroyos could be a product of the expansion of the groups that were peopling the Magellan zone, since at that moment Tierra del Fuego Island was still attached to the continent. According to the technological characteristics it is assumed that this site would belong to the same colonizer system in expansion. Due to the lower availability of raw materials in this region, the use of bipolar technique as a strategy to maximize it in the instrument manufacture could explain this difference.

The Atlantic coast does not show cultural manifestations from the first colonization during the late Pleistocene/early Holocene Transition. It is true that if it had occurred by the Atlantic rim, the sites could be under the sea, in the continental platform, due to its sinking during the Holocene. But it is also certain that the present search for specific landforms, such as paleobasins or paleolagoons, has not been systematically developed in this ambit. It must be remembered that Ameghino (1918) described the paleobasin from the Gulf of San Jorge, mentioning an association of fauna similar to that of Lujanense (Pleistocene) stage of Buenos Aires province.

This compact presentation of the main Patagonian sites as well as the Pampean sites and those from the Central and Southern Chilean basins (Fig. 1 and Table 1) related in the last point, allows to formulate that the mobility, subsistence and technology strategies had low diversity but were widespread at a microregional and regional level, with a differential use of spaces and an occupational redundancy at a short and long term in strategic places related to the water critical resource, and probably to lithic raw materials and faunistic resources. At this scale, we find that the segments of technologies found in each of those sites: assemblages according to my concept and "industries" see Menghin, 1952; Cardich et al., 1973; Cardich, 1977, among many others) are answering questions of landscape hierarchy and its differential use and not questions of ethnical identity nor different peopling waves. Therefore, it is at the regional level where we first find the complementarity of the technological non-excluding and non-territorial wide mobility systems of the first colonizers.

In these terms, and although there is not a correspondence between the landforms and the site function, a preferential use of positive topographies can be argued for this interval. Assuming that between 13 and 11 ky BP demography was low (see Miotti and Salemme, 2003), not only in the region but also all over the Southern Cone of America, this hypothesis of the hierarchical use of landscapes is quite relevant since it suggests a deep knowledge of the space and possibilities offered, regarding the economical resources and communication networks among the first human groups. It is also outlined, as in previous contributions (Miotti, 1994, 1995) that the present evidence reinforces the idea of an inclusive communication among these populations. The information networks among the pioneers could has been a way of minimize risks in environments that are being explored and/or colonized.

At a multiregional scale the variability sensitively increases respecting what is found at a regional scale, but it can be suggested that the first colonizer groups could have reached the southern end of the continent, not only through its interior, but also along the Atlantic and Pacific coasts, penetrating the hinterland or through different sections (see Table 1 and Fig. 1). In Central and Southern Patagonia, they could be spreading from the Central Deseado Massif towards other areas such as southern Magellan Basin, and later on to the Cordilleran area with the same strategy that shows more logistical segments in the Central Plateau and Magellan area, and more residential segments in the Andes. However, the combination between sites of specific activities and small sites of multiple activities gives us an idea of the great knowledge that these people had about these regions, at least 12 ka BP. If this is accepted, then we should ask: How long did the first human groups that arrived in the Southern Cone take to get to know deeply the locations of the raw materials for the instruments, the locations of water, and the locations of shelters? Maybe this learning had such speed that it cannot be recorded at an archaeological scale, as Miotti and Flegenheimer (1994) expressed. But these aspects of the hierarchization of the geomorphologic landscapes suggest that during the end of the Pleistocene in the entire Pampean and Patagonian regions the hunter–gatherer societies were consolidated and spreading to new environments, such as the cordilleran, that would not have been available until the early Holocene.

So, what do the dates of 12.5 and 11.4 ky BP from the Chilean sites of northern Patagonia and Central Chile Basin, respectively, show? They accurately guarantee the use of different strategies with an important knowledge of the mentioned regions, and probably the wide knowledge among the different colonizer groups at a long distance, which would imply a non-excluding communication strategy, as well as different gates of entry to the continent. But, until more bioanthropological information is available, we will not be able to state if these groups belonged to different societies or to fissioned groups from the same initial population that, due to a greater geographical isolation (because of the Andean Range), evolved independently from the populations of the eastern side of the Andes.

As we increase our geographical scale, the archaeological variability, as well as the ecological and environmental variability, also increases. The variability of the archaeological assemblages is due to several reasons, i.e. methodologies according to the different disciplinary matrices from which the research was carried on in each site, the range of visibility, and the taphonomical history. However, the main reason might be related with the different ways the human groups co-constructing the colonization landscapes. This process, that by 11.5 ky BP is achieved in the whole continent, suggests that by that time the populations settled all over America would have left behind the risk implied in the exploration of an unknown place, empty of human population. At that moment, populations of the New World knew perfectly the territory they inhabited. In this sense is manifested the hierarchy of spaces (sacred places, domestic places and places of transit).

Based on the differences mentioned above about their technological conceptions, the North American Clovis assemblages and the South American FTP assemblages should be kept separated, since we interpreted them as different in their shapes (conserved, formal or of prestige) and in the technological conception of their associated artifacts. The idea of the cultural Drift recently recreated by Morrow and Morrow (1999) from Gamble's (1993a) concept of Drift is not accurate enough to derive the FTP from the Clovis points, neither to derive the South American FTP from only one human group. If, on the contrary, we understand the concept of "Cultural Drift" (Gamble, 1993b, pp. 314–315) as a random phenomenon, it could be reasonable to think about independent invention phenomenon in North and South America without the necessity of using the underlying concept of Cultural Drift that comes from the Model of Center and Periphery discussed by Hrdlicka in 1909 (taken from Gamble, 1993a, p. 314). If the Clovis conception was adopted in North America, it seems to be a later phenomenon that could involve contexts from the Early and Middle Holocene, corresponding to the end of the colonization and to the beginning of the territorial consolidation stage of hunter–gatherer societies. The sites with lithic assemblages with most artifacts made on blades, and the so-called "Casapedrense", "Fell 2 and 3" or "Río Pinturas a and b", in Patagonia, can be mentioned as examples. But they have no resemblance with the previous technological conceptions developed by the colonizer groups from the late Pleistocene, who share with Clovis, only partially, the same temporal scale. However, both technologies have a high degree of sophistication in their most conservative assemblages of artifacts, such as the Clovis points and their formal associated tools in North America, and the FTP in South America.

The high mobility strategies of the small human groups or microbands (between 10 and 25 people) could have been a good strategy of movement and knowledge of ample geographical spaces. Learning about the dangers and potentials of the region will lead the groups to a process of control and colonization of landscapes. On the other hand, the choice that a hunter–gatherer group makes on certain spatial sectors to use them for different purposes during a relatively long time (including their reoccupation), shows that these groups had already been colonizing this place, but their wide dispersion does not mean that these had been occupations of people passing by with great speed through a whole continent as was suggested decades ago by Martin (1973). The initial flow of population must have been more complex than archaeologists have imagined up to now, and I suggest that it should not be interpreted as unidirectional (constant advance from north to south), but on the contrary, in multiple directions, exploring and colonizing region by region and at the same time from different parts of the Old World (Eurasia, Africa, Oceania). In these terms, some highly conserved artifacts such as the FTP of the Southern Cone or the Clovis points from North America, can be interpreted as playing an important role in the social communication during the colonization moments. Therefore, it can be thought that there was not only one direction of this peopling from north to south, but assuming the entrance points of different populations to America would be the Atlantic rim, the Pacific rim, and Beringia, it can be suggested that these groups whose technologies are found in the Southern Cone, could have had a continental dispersion, not only from north to south, but in multiple directions.

If it is assumed that not only one group, coming through the interior from the north, would have arrived in Patagonia by the end of the Pleistocene, it is then suggested that the Southern Cone was an important place from which the population dispersal could also have started towards different parts of the continent even to the north. This could have the strongest evidence in the sites from Ecuador and their dates and all the other sites from South America related to Clovis or Pre Clovis ages (Fig. 1).

The social landscape of the region south of 33° changed from the end of the Pleistocene to the beginning of the Holocene and it is suggested that the relationships among the colonizer groups were kept through alliances and exchanges of goods considered as material objects, as well as symbolic, communication and identity objects, and not only as efficient technological items. Artifacts such as FTP and marine mollusc shells, for example, are special candidates to suggest directions or flows of communication among the hunter–gatherers. These could be indicating the circulation of ideas, material goods, and people in the different territories, that towards the Pleistocene/Holocene transition had not yet been consolidated; consolidation seems to be achieved in southern sector of Patagonia during Middle Holocene, as it is shown through a growing number of archaeological sites all over the American continent.

The concept of colonization as synonymous with hunter–gatherer or generalist economies, and high mobility populations with a simple band organization is, in fact, our present vision to modeling the process of the American peopling, but it is not satisfying. Based on the great cultural and ecological South American diversity (i.e. Monte Verde, San Isidro and Peña Roja, Paiján, Monte Alegre; Las Vegas, localities in Fig. 1), it is suggested that colonization was a complex process of mobile societies, complex in their exploration and in the appropriation of nature mechanisms of very different environments. To conquer this New World, complex social systems had to be developed. Until now, we have simplified the explanations due to the traditional description and interpretation of exclusively technological aspects, leaving behind aspects of their comprehension of the New World, which are important, but difficult to determine.

Acknowledgements

Different grants from National Geographic Society, CONICET, and the Faculty of Natural Sciences of La Plata University, financed different aspects of this research about the First Americans. Colleagues and friends: Lautaro Núñez and Mónica Salemme stimulated my own ideas about the role of Patagonia in the frame of human colonization and encouraged me to write this contribution. Cristina Bellelli, Rafael Suárez, and Nora Flegenheimer, patiently read this manuscript and made very accurate comments to improve some of my risky thoughts about the American peopling. I am very grateful to reviewers who had a great task to decipher the manuscript and suggest smart comments to make it better. Natalia Carden and Chiche Gilardenghi revised the translation. However, although their struggles were valuable to make these ideas clearer and better expressed, the reader should not make them responsible for what is written. The proper or improper assumptions of this paper are the exclusive responsibility of the author.

References

Adovasio, J., 1993. The ones that will not go away: biased view of pre-Clovis populations in the new world. In: Soffer, O., Praslov, N. (Eds.), From Kostenki to Clovis: Upper Paleolithic—Paleo-Indian Adaptations. Plenum Press, New York, London, pp. 199–218 (Chapter 15).

Adovasio, J., Gunn, J., Donahue, J., Stuckenrath, R., Guilday, J., Lord, K., 1978. Meadowcroft rockshelter. In: Bryan, A. (Ed.), Early Man in America from a Circum-Pacific Perspective. Occasional Paper #1, Department of Anthropology, University of Alberta, Edmonton, Canada, pp. 140–181.

Aldenderfer, M., 1999. The Pleistocene/Holocene transition in Peru and its effects upon human use of the landscape. Quaternary International 53/54, 11–20.

Andrefsky, W., 1991. Inferring trends in prehistoric settlement behaviour from Lithic production technology in the Southern Plains. North American Archaeology 12 (2), 129–144.

Andrefsky, W., 1994. Raw material availability and the organisation of the technology. American Antiquity 59 (1), 21–34.

Ameghino, F., 1918. La Antigüedad del Hombre en El Plata. Editorial. La cultura argentina, Buenos Aires, 2 tomos.

Ardila, G., Politis, G., 1991. Nuevos datos para un viejo problema. Investigación y discusiones en torno al poblamiento de América del Sur. Revista del Museo del Oro, Colombia, pp. 2–45.

Aschero, C., 1988. Arqueología Precerámica de Antofagasta de la Sierra. Quebrada de Inca Cueva (Jujuy). Estudios Atacameños 7, 62–72.

Aschero, C., 1996. El área Río Belgrano-Lago Posadas (Santa Cruz): problemas y estado de problemas. In: Gómez Otero, J. (Ed.), Arqueología, Sólo Patagonia. CENPAT, Puerto Madryn, pp. 17–26.

Beaton, J.M., 1991. Colonizing continents: some problems from Australia and the Americas. In: Dillehay, T., Meltzer, D. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, USA, pp. 209–230.

Bell, R., 1965. Investigaciones arqueológicas en el sitio de El Inga, Ecuador. Editions Casa de la Cultura Ecuatoriana, Quito.

Bettinger, R., Baumhoff, M., 1982. The Numic spread: Great Basin Cultures in Competition. American Antiquity 47, 485–503.

Bettinger, R., Baumhoff, M., 1983. Return rate and intensity of resources use in numic and prenumic adaptative strategies. American Antiquity 48, 830–834.

Bianchi, N., 1999. Un único "padre" para los americanos? Ciencia Hoy (Buenos Aires) 9 (59), 12–15.

Bianchi, N., Bailliet, G., Bravi, C., Carnese, R., Rothammer, F., Martínez-Marignac, V., Pena, S., 1997. Origin of Amerindian Y-Chromosomes as inferred by the analysis of six polymorphic markets. American Journal of Physic Anthropology 102, 79–89.

Binford, L., 1980. Willow smoke and dogs' tails: hunter–gatherers settlement systems and archaeological site formation. American Antiquity 45, 4–20.

Bird, J., 1938. Antiquity and migrations of the early inhabitants of Patagonia. Geographical Review 28, 250–275.

Bird, J., 1988. In: Hyslop, J. (Ed.), Viajes y arqueología en Chile austral. Ediciones de la Universidad de Magallanes, Chile.

Bird, J., Cooke, R., 1979. Los artefactos más antiguos de Panamá. Revista Nacional de Cultura 6, 7–29.

Bonnichsen, R., 1991. Clovis: origins and adaptations. In: Bonnichsen, R., Turnmire, K. (Eds.), Clovis: Origins and Adaptations. Center for Study of the First Americans, Department of Anthropology Oregon State University, Corvallis, Oregon, pp. 309–329.

Borrero, L., 1983. Los factores de extinción de la megafauna: la hipótesis de competencia interespecífica. Arqueología Contemporánea (Buenos Aires) 1 (1), 3–48.

Borrero, L., 1990. Spatial heterogeneity in Fuego-Patagonia. In: Shennan, S. (Ed.), Archaeological Approaches to Cultural Identity. Unwin Hyman, London, pp. 258–266.

Borrero, L., 1991. Fuego-Patagonian bone assemblages and the problem of Communal Guanaco Hunting. In: Davis, L., Reeves, B.O.K. (Eds.), Hunters of the Recent Past. Unwin Hyman, London, pp. 373–399.

Borrero, L., 1995. The archaeology of the far south of America: Patagonia and Tierra del Fuego. In: Johnson, E. (Ed.), New World Places and Peoples. Museum of Texas Tech University, Lubbock, pp. 207–215.

Borrero, L., 1996. The Pleistocene-Holocene transition in Southern South America. In: Straus, L., Eriksen, B., Erlandson, J., Yesner, D. (Eds.), Humans at the End of the Ice Age: The Archaeology of the Pleistocene–Holocene Transition. Plenum Press, New York, pp. 339–354.

Borrero, L., Zárate, M., Miotti, L., Massone, M., 1998. The Pleistocene–Holocene transition and Human Occupations in the Southern Cone. Quaternary International 48, 191–199.

Borromei, A., 1998. Palinología de la localidad Piedra Museo y relaciones paleoambientales con otros sitios de la estepa patagónica. Unpublished report.

Bradley, B., 1993. Paleo-Indian flaked Stone Technology in the North American High Plains. In: Soffer, O., Praslov, N.D. (Eds.), From Kostenki to Clovis. Plenum Press, New York, pp. 251–262.

Bryan, A. (Ed.), 1978. Early Man in America, from a Circum-Pacific Perspective. Occasional Papers 1, Department of Anthropology, University of Alberta, Edmonton, pp. 1–327.

Bryan, A. (Ed.), 1986. New Evidence for the Pleistocene Peopling of the Americas. University of Maine, Orono.

Bryan, A., 1995. Disproof of commonly held assumptions relevant to the peopling of the Americas. Current Research in the Pleistocene 12, 6–9.

Cardich, A., 1977. Las culturas pleistocénicas y post-pleistocénicas de Los Toldos (Santa Cruz, Argentina). Tomo Centenario del Museo de La Plata, sección Antropología 1, 39–50.

Cardich, A., 1980. Origen del Hombre y la Cultura andina. Historia General del Perú (J Mejía Baca, Ed), 1: 29–156, Lima, Peru.

Cardich, A., 1987. Arqueología de Los Toldos y El Ceibo (Provincia de Santa Cruz, Argentina). Investigaciones Paleoindias al sur de la línea ecuatorial. Estudios Atacameños (Chile) 8, 98–117.

Cardich, A., 1991. Descubrimientos de un complejo Precerámico en Cajamarca, Perú. Notas del Museo de La Plata, Antropología XXI (83), 39–50.

Cardich, A., Cardich, L., Hajduk, A., 1973. Secuencia arqueológica y cronología radiocarbónica de la Cueva 3 de Los Toldos (Santa Cruz, Argentina). Revista Relaciones, Sociedad Argentina de Antropología (Buenos Aires) VII, 87–122.

Carlson, R.L., 1991. Clovis from the perspective of the ice-free corridor. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Corvallis, pp. 81–90.

Cattáneo, G.R., 1999. Organización de la tecnología en la Patagonia Centro Meridional: El caso de la localidad arqueológica Piedra Museo, Pcia. De Santa Cruz. In: Diez Marín, C. (Ed.), XII Congreso Nacional de Arqueología Argentina, Actas III. Facultad Ciencias Naturales y Museo de la Univ. Nac. De La Plata, pp. 16–24.

Chauchat, C., 1988. Early Hunter–gatherers on the Perúvian coast. In: Keatinge, R.W. (Ed.), Peruvian Prehistory. Cambridge University Press, Cambridge, pp. 41–68.

Cinq Mars, J., 1979. Bluefish Cave I: a Late Pleistocene Eastern Beringian cave deposit in the Northern Yukon. Canadian Journal of Archaeology 3, 1–32.

Civalero, M.T., Franco, N., 2003. Early human occupations at the west of Santa Cruz province, Southern End of South America. Quaternary International. (PII: S1040-6182(02)00204-5).

Clapperton, R., 1992. La última Glaciación y Deglaciación en el Estrecho de Magallanes: Implicaciones para el poblamiento de Tierra del Fuego. Anales del Instituto de la Patagonia (Punta Arenas, Chile) 21, 113–128.

Clapperton, R., 1993. Quaternary Geology and Geomorphology of South America. Elsevier, Amsterdam, 779pp.

Clark, D., 1991. The Northern (Alaska–Yukon) fluted points. In: Bonnichsen, R., Turnmire, K. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Corvallis, pp. 35–48.

Correal Urrego, G., 1986. Apuntes sobre el medio ambiente pleistocénico y el hombre prehistórico en Colombia. In: Bryan, A. (Ed.), New Evidences for the Pleistocene Peopling of the Americas. University of Maine, Orono, USA, pp. 115–132.

Criado Boado, F., 1993. Visibilidad e interpretación del registro arqueológico. Trabajos de Prehistoria (Madrid) 50, 39–56.

De Aparicio, F., 1933/35. Viaje preliminar de exploración en el territorio de Santa Cruz. Publicaciones del Museo Antropológico y Etnográfico, Facultad de Filosofía y Letras de la Universidad de Buenos Aires, Serie A, T III, 71–92.

Dillehay, T., 1984. Un poblado del final de la edad glacial en el sur de Chile. Investigación y ciencia 99, 70–77.

Dillehay, T., 1997. Monte Verde. A late Pleistocene Settlement in Chile, Vol. 2. Smithsonian Institution Press, Washington, London, 1069pp.

Dincauze, D., 1993. Fluted points in the Eastern Forests. In: Soffer, O., Praslov, N.D. (Eds.), From Kostenki to Clovis. Plenum Press, New York, pp. 279–292.

Driver, J., 1996. The Significance of the fauna from the Charlie Lake Cave site. In: Carlson, R., Dalla Bona, L. (Eds.), Early Human Occupation in British Columbia. University of British Columbia Press, Vancouver, pp. 21–28.

Driver, J., 1998. Human Adaptation at the Pleistocene/Holocene Boundary in Western Canada, 11,000 to 9,000 BP. Quaternary International 49/50, 141–150.

Erlandson, J., 2001. The archaeology of aquatic adaptations: paradigms for a new millennium. Journal of Archaeological Research 9 (4), 287–350.

Fladmark, K., 1983. Times and places: environmental correlates of Mid to Late Wisconsinan human population expansion in North America. In: Shutler, R. (Ed.), Early Man in the New World. Sage Publishing, Beverly Hills, pp. 13–24.

Flannery, K. (Ed.), 1983. The Preceramic and Formative of the Valley of Oaxaca, Mexico. Academic Press, New York.

Flegenheimer, N., 1987. Recent research at localities Cerro La China and Cerro El Sombrero, Argentina. Current Research in the Pleistocene 4, 148–149.

Flegenheimer, N., 1991. Bifacialidad y piedra pulida en sitios pampeanos tempranos. Shincal 3, 64–78 X Congreso Nacional de Arqueología Argentina, Catamarca.

Flegenheimer, N., 1994. Consideraciones sobre el uso del espacio en las Sierras de Lobería (Provincia de Buenos Aires). Revista del Museo de Historia Natural de San Rafael XIII, pp 14–18.

Flegenheimer, N., Bayón, C., Baeza, J., Femenías, R., 2003. Long distance tool stone transport in the Argentine pampas. Quaternary International. (PII: S1040-6182(02)00202-1).

Frison, G., 1990. The North American High Plains Paleoindian: an overview. Revista de Arqueología Americana 2, 9–54.

Frison, G., 1993. The North American High Plains Paleoindian hunting strategies and Waponry assemblages. In: Soffer, O., Praslov, N.D. (Eds.), From Kostenki to Clovis. Plenum Press, New York, pp. 237–249.

Gamble, C., 1993a. The Center at the edge. In: Soffer, O., Praslov, N.D. (Eds.), From Kostenki to Clovis. Plenum Press, New York, pp. 313–321.

Gamble, C., 1993b. People on the move: interpretations of regional variation in Palaeolithic Europe. In: Chapman, J., Dolukhanov, P. (Eds.), Cultural Transformations and Interactions in Eastern Europe. Avebury, London, pp. 37–55.

Gamble, C., 1994. Timewalkers: The Prehistory of Global Colonization. Harvard University Press, Cambridge.

Gamble, C., Soffer, O., 1990. Introduction Pleistocene polyphony: the diversity of human adaptations at the Last Glacial Maximum. In: Soffer, O., Gamble, C. (Eds.), The World at 18,000 BP. Vol. 1. Unwin Hyman, London, pp. 3–38.

García, A., 1995. Agua de la Cueva Rockshelter and its relationship to the Early Peopling of Central West Argentina. Current Research In the Pleistocene 12, 13–14.

Gnecco, C., 1995. El Paradigma Paleoindio en Suramérica. El Poblamiento de América del Sur en el Pleistoceno Final-Holoceno Temprano y sus relaciones con América del Norte. Curso de Postgrado de la Fac. de Ciencias Naturales y Museo—UNLP, pp. 37–77.

Gnecco, C., 1998. An archaeological perspective of the Pleistocene/Holocene Boundary in northern South America. Quaternary International 53/54, 3–10.

Goebel, T., 1999. Pleistocene human colonization and peopling of the Americas: an ecological approach. Evolutionary Anthropology 8 (6), 208–226.

Goebel, T., Powers, R., Bigelow, N., 1991. The Nenana complex of Alaska and Clovis origins. In: Bonnichsen, R., Turnmire, K. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Department of Anthropology, Oregon State University, Corvallis, pp. 46–53.

Gradín, C., 1980. Secuencias radiocarbónicas del sur de la Patagonia argentina. Relaciones de la Sociedad Argentina de Antropología XIV, 177–194.

Greenberg, J., Turner, C., Zegura, S., 1986. The settlement of the Americas: a comparison of the linguistic, dental and genetic evidence. Current Anthropology 27, 477–497.

Gruhn, R., 1986. Stratified Radiocarbon-dated Archaeological sites of Clovis Age and Older in Brazil. In: Bryan, A. (Ed.), New Evidences for the Pleistocene Peopling of the Americas. University of Maine, Orono, USA, pp. 283–286.

Gruhn, R., 1989. The Pacific Coastal Route of initial entry: an overview. In: First World Summit Conference on the Peopling of the First Americans. University of Maine, Orono, Abstract pp. 6–7.

Guidon, N., 1986. Las unidades culturales de Sao Raimundo Nonato, sudeste del Estado de Piaui. In: Bryan, A. (Ed.), New Evidence for the Pleistocene Peopling of the Americas. University of Maine, Orono, pp. 157–172.

Guidon, N., Delebrias, G., 1986. Carbon-14 dates point to man in the Americas 32,000 years ago. Nature 321, 769–771.

Haynes, V., 1967. Carbon-14 Dates in Early Man in the New World. Pleistocene Expedition, Yale University Press, New Haven CT.

Haynes, V., 1974. Paleoenvironments and cultural diversity in Late Pleistocene South America: a reply to A. Bryan. Quaternary Research 4, 378–382.

Haynes, V., 1984. Application of accelerator dating to fluted point paleoindian sites. M.S. presented at the Symposium New Experiments upon the record of Eastern Paleoindian culture, Salem, MA.

Hermo, D., Vázquez, M., 1999. Cuánto que caminamos: Primeros resultados de las prospecciones en Cerro Vanguardia y Monumento Natural Bosques Petrificados. In: Diez Marín, C. (Ed.), XII Congreso Nacional de Arqueología Argentina, Actas III. Fac. Ciencias Naturales y Museo de la Univ. Nac. De La Plata, pp. 475–483.

Heusser, C., 1993. Palinología de la secuencia sedimentaria de la Cueva Traful 1 (Provincia de Neuquén República Argentina). Praehistoria (Buenos Aires) 1, 206–210.

Heusser, C., Rabassa, J., 1987. Cold climatic episode of Younger Dryas age in Tierra del Fuego. Nature 328, 609–611.

Ingold, T., 1986. Territoriality and tenure: the appropriation of space in hunting gathering societies. The Appropriation of Nature Essays on Human Ecology and Social Relationships. Manchester University Press, Manchester, UK, pp. 130–164.

Ingold, T., 1993. The temporality of the Landscape. World Archaeology 25, 152–174.

Johnson, E., 1991. Late Pleistocene cultural Occupation on the Southern Plains. In: Bonnichsen, R., Turnmine, K. (Eds.), Clovis: Origins and Adaptations. CSFA, Oregon State University, Corvallis, pp. 215–236.

Johnson, M.F., 1997. Additional research at Cactus Hill preliminary description of Northern Virginia Chapter-ASV's 1993 and 1995 excavations. In: McAvoy, J.M., McAvoy, L.D. (Eds.), Archaeological Investigations of Site 44SX202, Cactus Hill, Sussex County, Virginia. Appendix G. Virginia Department of Historic Resources, Research Report Series No. 8. Richmond.

Lagiglia, H., García, A., 1999. Las ocupaciones tempranas del Atuel (Nuevos estudios en la Gruta del Indio). Actas del XII Congreso Nacional de Arqueología Argentina (La Plata) 3, 251–255.

Lavallée, D., 1985. Telarmachay, Chasseurs et Pasteurs Préhistoriques des Andes I. Ëditions Recherche sur les Civilisations, "synthese" no. 20, Institut Francais d'études Andines, París, France.

Lavallée, D., Julien, M., Bearez, P., Usselmann, P., Fontugne, M., Bolaños, A., 1999. Pescadores-Recolectores Arcaicos del Extremo Sur Peruano. Excavaciones en la Quebrada de Los Burros (Tacna, Perú). Bulletin Institute Francaise des études andines 28 (1), 13–52.

Lynch, T., 1990. Glacial Age Man In South America? A critical review. American Antiquity 55 (1), 12–36.

Lynch, T., 1991. The peopling of the Americas—a discussion. In: Dillehay, T., Meltzer, D. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, FL (Chapter 10).

Mancini, V., Páez, M., Prieto, A., 1993. Recent pollen spectra from forest and steppe of South Argentina: a comparison with vegetation and climate data. Review of Palaeobotany and Palynology 77, 129–142.

Mansur-Franchomme, M.E., 1983. Traces d'utilisation et technologie lithique: exemples de la Patagonie. Ph.D. Dissertation, Université de Bordeaux I, France.

Marshall, D., 1993. Food Sharing and the Faunal Record. In: Hudson, J. (Ed.), From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains, Center for Archaeological Investigations, Occasional Papers 21, Southern Illinois University at Carbondale, pp. 228–246.

Martin, P., 1973. The discovery of America. Science 179, 969–974.

Martin, P., 1984. Prehistoric overkill: the global model. In: Martin, P., Klein, R. (Eds.), Quaternary Extinction. A Prehistoric Revolution. University of Arizona Press, Tucson, pp. 354–403.

Martínez, G., 1997. A preliminary report on Paso Otero 5, a Late Pleistocene Site in the Pampean Region of Argentina. Current Research in the Pleistocene 14, 53–54.

Martínez, G., 1999. Ocupaciones arqueológicas en el curso medio del río Quequén Grande (Pdos. de Lobería y Necochea). In: Berón, M., Politis, G. (Eds.), Arqueología Pampeana en la Década de los '90. Museo de Historia Natural de San Rafael (Mendoza), X Congreso Nacional de Arqueología Argentina. INCUAPA, Facultad de Ciencias Sociales (Olavarría) UNCPBA, pp. 71–84.

Massone, M., 1984. El poblamiento humano aborigen de Tierra del Fuego. In: Culturas Indígenas de la Patagonia. Biblioteca del V Centenario. Cultura Hispánica. Madrid, pp. 131–144.

Mayer-Oakes, W., 1986. Early Man projectile points and lithic technology in the Ecuadorian Sierra. In: Bryan, A. (Ed.), New Evidence for the Pleistocene Peopling of the Americas. University of Maine, Orono, pp. 133–156.

Mazzanti, D., 1997a. Secuencia arqueológica del sitio Cueva Tixi (Partido de General Alvarado, provincia de Buenos Aires). In: Berón, M., Politis, G. (Eds.), Arqueología Pampeana en la década de los '90, Museo de Historia Natural de San Rafael (Mendoza) e INCUAPA, Universidad del Centro de la Provincia de Buenos Aires, pp. 127–135.

Mazzanti, D., 1997b. El sitio abrigo Los Pinos: Arqueología de la ocupación paleoindia. Tandilia oriental (Pcia. De Bs. As.). XII Congreso Nacional de Arqueología Argentina, Libro de resúmenes, Facultad de Ciencias Naturales y Museo, La Plata, 26pp.

Mazzanti, D., 1999. Ocupaciones humanas tempranas en Sierra La Vigilancia y laguna La Brava, Tandilia oriental, Provincia de Buenos Aires. In Diez Marín, C. (Ed.), XII Congreso Nacional de Arqueología Argentina, Actas III, Fac. Ciencias Naturales y Museo de la Univ. Nac. De La Plata, 149–155.

Meltzer, D., 1993. Pleistocene Peopling of the Americas. Evolutionary Anthropology Bulletin 1, 157–169.

Menghin, O.F.A., 1952. Fundamentos cronológicos de la prehistoria de Patagonia. RUNA (Buenos Aires) V (1–2), 23–43.

Mengoni Goñalons, G., 1988. El estudio de huellas en arqueofaunas. Una vía para reconstruir situaciones interactivas en contextos arqueológicos: Aspectos teórico-metodológicos y técnicas de análisis. In: Haber, A., Ratto, N. (Eds.), De procesos, Contextos y Otros Huesos. Facultad de Filosofía y Letras, University of Buenos Aires, pp. 17–28.

Miotti, L., 1998 [1989]. Zooarqueología de la meseta central y la costa de la provincia de Santa Cruz. Un enfoque de las estrategias adaptativas y los paleoambientes. Museo de Historia Natural de San Rafael, Mendoza, pp. 1–306.

Miotti, L., 1990. In: Oliva, F. (Ed.), Cómo, cuándo y por dónde se produjo el primer poblamiento americano: Una historia que comenzó mucho antes de 1492. Publicaciones científicas de la Secretaria de Cultura Ministerio de Educación y Justicia de la Provincia de Buenos Aires, setiembre de 1990, pp. 4–34.

Miotti, L., 1991. Modelos ecológico-evolutivos en la Patagonia extra-andina centro-meridional. Simposio: Estrategias Adaptativas en Fuego-Patagonia, Temuco, Chile, pp. 6–10.

Miotti, L., 1992. Paleoindian occupations at Piedra Museo Locality, Santa Cruz province, Argentina. Current Research in the Pleistocene 9, 30–32.

Miotti, L., 1993. Piedra Museo: La ocupación diferencial del espacio como estrategia logística Paleoindia en Patagonia. Resúmenes Taller Internacional "El Cuaternario de Chile". Universidad de Chile, UNESCO, p. 54.

Miotti, L., 1994. El paleoindio y los primeros americanos desde el Cono Sur. Actas y Memorias del XI Congreso Nacional de Arqueología Argentina (Precirculados). Tomo I, San Rafael, Mendoza, pp. 37–40.

Miotti, L., 1995. Piedra Museo locality: an special place in the New World. Current Research in the Pleistocene 12, 37–40.

Miotti, L., 1996. Piedra Museo (Santa Cruz): nuevos datos para el debate de la ocupación Pleistocénica en Patagonia. In: Gómez Otero, J. (Ed.), Arqueología, sólo Patagonia. Publicaciones Secretaría Cultura de Chubut y CONICET, Puerto Madryn, pp. 27–38.

Miotti, L., in press. Quandry the Clovis Phenomenon, The first Americans, and the View from the Patagonia Region. In: Lepper, B. (Ed.), New Directions in First American Studies. Texas A&M University Press, and The Center for the Study of First Americans, Corvallis, co-publisher, USA.

Miotti, L., Cattáneo, G.R., 1997b. Bifacial technology at 13,000 years ago in Southern Patagonia. Current Research in the Pleistocene 14, 62–64.

Miotti, L., Cattáneo, G.R., 1997b. Recursos culturales arqueológicos en el Monumento Natural Bosques Petrificados, Dpto. Deseado, Santa Cruz, Argentina. Actas XII Congreso Nacional de Arqueología de Argentina, Septiembre, 1997. UNLP, M.S. National Parks Bureau (confidencial report).

Miotti, L., Cattáneo, G.R., in press. Variation in the strategies of the lithic production and faunal exploitation during Pleistocene/Holocene Transition at Piedra Museo and surrounding region. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of the First Americans, University of Texas A&M, USA, 2001, in press.

Miotti, L., Flegenheimer, N., 1994. El paleoindio y los primeros americanos desde el Cono Sur. Actas y Memorias del XI Congreso Nacional de Arqueología Argentina. (Precirculados). Introduction: Tomo I, pp. 8–12.

Miotti, L., Hermo, D., in press. El efecto zoom para relacionar los desechos líticos de un sitio y los paisajes arqueológicos de cazadores-recolectores del Holoceno en la meseta central de Santa Cruz. Revista Intersecciones. Universidad Nacional del Centro de la Provincia de Buenos Aires.

Miotti, L., Salemme, M., 1999. Biodiversity, Taxonomic Richness and Generalist-Specialists during Late Pleistocene/Early Holocene in Pampa and Patagonia (Argentina, Southern South America). Quaternary International 53/54, 53–68.

Miotti, L., Salemme, M., in press. Hunting, butchering events at late Pleistocene and early Holocene in Piedra Museo (Patagonia, Southernmost South America). In Bonnichsen, R. (Ed.), Paleoamerican Prehistory: Colonization Models, Biological Populations, and Human Adaptations. Center for the Study of the First Americans, University of Texas A&M, USA, 2001.

Miotti, L., Salemme, M., 2003. When Patagonia was colonized: people mobility at high latitudes during Pleistocene/Holocene transition. Quaternary International. (PII: S1040-6182(02)00206-9).

Miotti, L., Salemme, M., Menegaz, A., 1988. El manejo de los recursos faunísticos durante el Pleistoceno final y Holoceno temprano en Pampa y Patagonia. Precirculados de las ponencias científicas del Simposio de Estrategias adaptativas of IX Congreso Nacional de Arqueología Argentina. Universidad de Buenos Aires, Fac. de Filosofía y Letras, pp. 102–118.

Miotti, L., Vázquez, M., Hermo, D., 1999a. Piedra Museo un Yamnagoo Pleistocénico en la Colonización de la Meseta de Santa Cruz. El estudio de la Arqueofauna. In: Rafael Goñi (Ed.), Soplando en el Viento, 3ras. Jornadas de Arqueología de la Patagonia, pp. 113–136.

Miotti, L., Carden, N., Canosa, M.J., 1999. Paisajes arqueológicos de cazadores-recolectores, arte rupestre y lagunas: Los nuevos hallazgos de petroglifos en la meseta central de Santa Cruz. In: Diez Marín, C. (Ed.), XII Congreso Nacional de Arqueología Argentina, Actas III. Fac. Ciencias Naturales y Museo, Universidad Nacional de La Plata, pp. 54–61.

Miotti, L., Salemme, M., Rabassa, J., in press. Radiocarbon Datings of Piedra Museo, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of the First Americans and University of Texas A&M, USA, 2001.

Morrow, J., Morrow, T., 1999. Geographic variation in fluted projectile points: a hemispheric perspective. American Antiquity 64 (2), 215–231.

Muller-Beck, H., 1969. Paleohunters in America: origin and diffusion. Science 152, 3726.

Nami, H., 1987. Cueva del Medio: Perspectivas arqueológicas para la Patagonia austral. Anales del Inst. de la Patagonia (Chile) 17, 73–106.

Nami, H., 1995. Archaeological Research in the Argentinian Río Chico Basin. Current Anthropology 36 (4), 661–664.

Nami, H., 1997. Reseña sobre los avances de la arqueología finipleistocénica del extremo sur de Sudamérica. Chungara 26 (2), 145–163.

Nami, H., Menegaz, A., 1991. Cueva del Medio: aportes para el conocimiento de la diversidad faunística hacia el Pleistoceno-Holoceno en Patagonia austral. Anales del Instituto de la Patagonia 20, 117–132.

Neme, G., 2001. Arqueología del Alto valle del Atuel, provincia de Mendoza. Tesis Doctoral, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Inédita.

Neves, W., Pucciarelli, H., 1991. Morphological affinities of the first Americans: an explicatory analysis based on early South American human remains. Journal of Human Evolution 21, 261–273.

Núñez Atencio, L., Grosjean, M., 1994. Cambios ambientales Pleistoceno-Holocénicos: Ocupación humana y uso de recursos en la Puna de Atacama (Norte de Chile). Estudios Atacameños (Chile) 11, 11–23.

Núñez Atencio, L., Varela, J., Casamiquela, R., Schiappacasse, V., Niemeyer, H., Villagrán, C., 1994. Cuenca de Tagua Tagua en Chile: el ambiente del Pleistoceno superior y ocupaciones humanas. Revista Chilena de Historia Natural (Chile) 67, 503–519.

Ochsenius, C., Gruhn, R., 1979. Taima Taima, A late Pleistocene Paleo-Indian Kill site in Northernmost South America. In: Ochsenius, C., Gruhn, R. (Eds.), Final Reports of 1976 Excavations. Caracas, Venezuela.

Páez, M., Prieto, A., Mancini, V., 1999. Fossil pollen from Los Toldos locality: a record of the Late-glacial transition in the Extra-andean Patagonia. Quaternary International 53/54, 69–75.

Panza, J.L., 1982. Informe Geológico de las Hojas: 55a Gobernador Moyano y 54c Cerro Vanguardia, provincia de Santa Cruz. Servicio Geológico Nacional (MS).

Panza, J.L., Genini, L., 1998. Hoja Geológica Monumento Natural Bosques Petrificados 4769-II. Instituto de Geología y Minería, Boletín 214, SEGEMAR, República Argentina.

Paunero, R., 1993/94. El sitio Cueva 1 de la Localidad Arqueológica Cerro Tres Tetas (Estancia San Rafael, provincia de Santa Cruz, Argentina). Anales de Arqueología y Etnología 48/49, 73–90.

Paunero, R., 1996. Noticia sobre nuevas fechas radiocarbónicas del sitio Cueva 1, C3T, Santa Cruz Argentina. Anales de Arqueología y Etnología 50–51, 189–199.

Paunero, R., in press. The presence of a Pleistocene colonizing culture in La Maria archaeological locality: Casa del Minero 1, Argentina. In: Miotti, L., Salemme, M., Flegenheimer, N. (Eds.), Ancient Evidence for Paleo South Americans: From Where the South Winds Blow. Center for the Study of the First Americans and University of Texas A&M, USA, 2001.

Politis, G., 1991. Fishtail projectile points in the Southern Cone of South America. In: Bonnichsen, R., Turnmine, K. (Eds.), Clovis: Origins and Adaptations. University of Maine, Orono, pp. 287–303.

Politis, G., 1998. Arqueología de la infancia: una perspectiva etnoarqueológica. Trabajos de Prehistoria (Madrid) 55 (2), 5–19.

Politis, G., Gutiérrez, M., 1998. Gliptodontes y cazadores-recolectores de la Región Pampeana (Argentina). Latin American Antiquity 9 (2), 111–134.

Politis, G., Prado, J.L., Beukens, R., 1995. The human impact in Pleistocene-Holocene Extinctions In South America-The Pampean case. In: Johnson, E. (Ed.), Ancient Peoples and Landscapes. Museum of Texas Tech University, Lubbock, Texas, USA, pp. 187–205.

Prieto, A., 1991. Cazadores tempranos y tardíos en la Cueva Lago Sofía 1. Anales del Instituto de la Patagonia (Serie Ciencias Sociales) 20, 75–100.

Prous, A., Fogaça, A., 1999. Archaeology of the Pleistocene-Holocene boundary in Brazil. Quaternary International 53/54, 21–42.

Pucciarelli, H., Sardi, M., López Jiménez, J., Serrano Sánchez, C., in press. Early peopling and evolutionary diversification in America. Quaternary International, this volume.

Rabassa, J., 1987. The Holocene of Argentina: a review. Quaternary of South America and Antarctic Peninsula 5, 269–290.

Rick, J., 1988. The character and context of highland preceramic society. In: Keatinge, R. (Ed.), Peruvian Prehistory. Cambridge University Press, Cambridge, pp. 1–40.

Richardson III, J.B., 1978. Early man on the Peruvian north coast: early maritime exploitation and the Pleistocene and Holocene environments. In: Bryan, A. (Ed.), Early Man in America From a Circum-Pacific Perspective. Archaeological Researches, International University of Alberta, Edmonton, pp. 274–289.

Roosevelt, A., Costa, L., Machado, L., Michab, N., Mercier, N., Valdas, H., Feathers, J., Barnett, W., Silveira, M., Henderson, H., Silva, J., Chernoff, B., Rease, D., Homan, J., Toht, N., Schick, R., 1996. Paleoindian Cave Dwellers in the Amazon: The peopling of the Americas. Science 272, 373–384.

Rowley, S., 1985. Population movements in the arctic. Études/Inuit/Studies 9, 3–21.

Santoro, C., 1989. Antiguos cazadores de la Puna (9.000 a 6.000). In: Hidalgo, J. (Ed.), Culturas de Chile. Prehistoria desde sus orígenes hasta los albores de la conquista. Santiago de Chile.

Scheinsohn, V., 1998. Explotación de las materias primas óseas en la isla Grande de Tierra del Fuego. Ph.D. Dissertation, Facultad de Filosofía y Letras, UBA, Bs. As., pp. 320. Unpublished.

Soffer, O., 1985. The Upper Palaeolithic of the Central Russian Plain. Academic Press, New York.

Soffer, O., Praslov, N. (Eds.), 1993. From Kostenki to Clovis, Upper Paleolithic-Paleo-Indian Adaptations. Plenum Press, New York, 323pp.

Stanford, D., 1991. Clovis Origins and Adaptations: An Introductory Perspective. In: Bonnichsen, R., Turnmine, K. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, University of Oregon, Corvallis, pp. 1–13.

Stern, Ch., 1999. Black obsidian from Central-South Patagonia; chemical characteristics, possible sources and regional distribution of artefacts. Soplando en el Viento, Actas de las III Jornadas de Arqueología de Patagonia, S.C. de Bariloche, Río Negro

Storck, P., 1991. Imperialists Without A State: The Cultural Dynamics of Early Paleoindian Colonization As Seen From the Great Lakes Region. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Clovis: Origins and Adaptations. Center for the Study of the First Americans, Corvallis, pp. 153–161.

Stothert, K., 1985. The Preceramic Las Vegas Cultures of Coastal Ecuador. American Antiquity. 50, 613–637.

Suárez, R., López Mass, J., in press. Archaeology of the Pleistocene Holocene Transition in Uruguay: an overview. Quaternary International, this volume.

Trigger, B., 1992. Historia del Pensamiento Arqueológico, 1st Edition 1989. Crítica Barcelona, Cambridge, 475pp.

Turner, Ch., 1983. Dental evidence for the peopling of the Americas. In: Schutler, R. (Ed.), Early Man in the New World. Sage Publications, Beverly Hills, pp. 147–158.

Turner, Ch., 1992. New World origins: new research from the Americas and the Soviet Union. In: Stanford, D., Day, J. (Eds.), Ice Age Hunters of the Rockies. Museum of Natural History and University Press of Colorado, Denver, pp. 7–50.

Vicent García, J., 1991. Fundamentos teórico-metodológicos para un programa de investigación arqueo-geográfica. In: López, P. (Ed.), El cambio cultural del IV al II milenios A.C. en la comarca noroeste de Murcia. Consejo Superior de Investigaciones Científicas, Madrid.

PERGAMON

Quaternary International 109–110 (2003) 175–179

Some difficulties in modeling the original peopling of the Americas

Alan L. Bryan, Ruth Gruhn*

Department of Anthropology, University of Alberta, Edmonton, AB, Canada T6G 2H4

Abstract

Preoccupied with bifacial projectile points, North American archaeologists prefer to work with the 60 year old model that the earliest Americans made Clovis fluted points to hunt mammoths on the Great Plains, where several Clovis mammoth kill sites have been dated between 11,200 and 10,900 ^{14}C yr BP. Clovis points actually are more common in the Eastern Woodlands, where they have been dated somewhat earlier at several sites. However, only one Clovis megamammal kill site has been found in the Eastern Woodlands, and none west of southeastern Arizona. Clovis points are relatively rarely found in Central America as far as Panama. A few Clovis-like points have been reported from Colombia and Chile, but stemmed "fishtail" points are more common in South America. Several sites in the southern cone of South America have yielded fishtail points dated as early as 11,000 ^{14}C yr BP. Some North American archaeologists hypothesize that fishtail points, a few of which appear to be fluted, are the work of Clovis migrants. However, such a hypothesis requires that a viable breeding population traversed about 12,000 km across deserts, mountains, and through jungles within a few hundred years.

A simpler alternative hypothesis is that sometime in the Late Pleistocene, the first Americans brought a simple retouched flake industry with them from East Asia. Experimental knappers in various parts of the Americas eventually innovated bifacial points of different styles from these retouched flakes. It is time that this alternative model, which is more than 25 years old, be more seriously considered because it would better explain available evidence in South America as well as North America.

1. A critical overview

By 11,000 years ago, people in various parts of South America had developed many distinctive technological adaptations to the diverse ecosystems present on this continent. Although not as well recognized, economic and technological diversity also had been developed in North America by that time. Such diversity should not be a problem of interpretation; however, a major problem arises from a significant difference in the perspective of archaeologists working in North or South America.

How does the archaeological situation in South and Central America differ from what is known in North America? The main difference is that bifacially flaked stone points are much more common throughout the United States and southern Canada than they are in Central and South America. Not only are bifacial points (mostly shaped for tipping projectiles, but also for use as knives) very abundant, but a great many distinctive point styles were developed by prehistoric North Americans in the interval from early Holocene into protohistoric times. It is notable that bifacial points are relatively rare south of northern Mexico, although some North American archaeologists search for and sometimes find bifacial points in various parts of Central and South America. In many parts of lowland South America, bifacially flaked stone projectile points were not used in early Holocene times, and evidently in some areas people never did innovate this technology. Spears, darts, and arrows tipped with bone, ground stone, and wooden points, including durable palm wood, evidently proved to be such effective tools in many forested areas that they continued to be employed into recent times. In fact, people occupying some shell middens in southern Brazil evidently did not flake stone at all for extended periods of time (Bryan, 1993). This fact is usually ignored by many archaeologists because they are so dependent on finding distinctively shaped artifacts that preserve well in all contexts, which of course means stone artifacts. Bifacial stemmed points are present by early Holocene times in several open environments of South America; but interestingly, even on the sparsely forested Sabana de Bogotá bifacial points were rarely used (Correal Urrego, 1986). We all know that

*Corresponding author.

E-mail address: rgruhn@maildrop.srv.ualberta.ca (R. Gruhn).

1040-6182/02/$ - see front matter © 2002 Elsevier Ltd and INQUA. All rights reserved.
PII: S1040-6182(02)00211-2

bifacially flaked stone points are very important conceptual tools for modern archaeologists, but evidently they were not very important for many native South Americans.

We do not know of any part of the world where bifacially flaked stone points are as common as in southern North America, where they prevailed for many millennia in most ecosystems. North American archaeologists thrive on this abundance because it is easy to distinguish point styles, from which classification schemes can be developed that assist greatly in defining prehistoric cultures, components, phases, periods, etc. Long before radiocarbon dating was developed, North American archaeologists were able to perform typological wonders with points and potsherds. Many local and regional typological sequences lacked good stratigraphic control, but were based on extrapolations from other areas, especially from the well-documented point sequence established on the Great Plains, where Clovis points are demonstrably earliest (Dixon, 1999). From this fact, it is often assumed that all unfluted Paleo-Indian points, wherever found, must postdate Clovis. Nevertheless, the postulated chronological sequences of stylistic change in prehistoric material culture is a major reason why many North American archaeologists feel they have better methodological control than South American archaeologists, and therefore have the right to say that their methods and models are the best for South America as well as North America. It also means that North American archaeologists have a fixation on bifacial points to the extent that other artifact types tend to be slighted. In fact, an archaeological site lacking bifacial points in the lower levels is sometimes abandoned without digging to bedrock, because if only flakes, even with marginal retouch, are present, there is nothing diagnostic to work with; and the typable artifact sample size is inadequate. Even if an early radiocarbon date has been obtained on strata yielding retouched flakes, but there are no bifacial points in or immediately above the dated level, archaeologists commonly suspect that either the dated material or the flakes are somehow intrusive. Another argument often presented is that the flakes, even if retouched, were somehow created naturally.

The North American archaeologists' fixation on ubiquitous projectile points helps to explain why the "Clovis-first" model has so easily been accepted in North America; and why North American archaeologists, few of whom have field experience in Latin America, insist that the model should hold for the entire western hemisphere (e.g., Fiedel, 1987). Furthermore, some insist that any evidence that does not fit the accepted model must somehow be wrong, whether the site is in North, Central, or South America (e.g., Owen, 1984; Lynch, 1990). Despite radiocarbon and other evidence to the contrary, any reported archaeological site that does not fit the accepted model is simply ignored or explained away by proposing alternative hypotheses which the proponent makes no effort to test. The fact that the excavator may already have evidence to disprove the alternative hypothesis is considered irrelevant. This procedure is not how science should work. Models are based on a body of fact, plus a set of assumptions stated as working hypotheses which are testable by all interested parties against facts. After a period of time, many, if not most, working hypotheses are disproven; and a new body of factual evidence accrues, so a new model must be formulated that better fits the available body of facts. In science, models are proposed to explain available facts; but if it becomes necessary to force a considerable amount of evidence to fit a model, scientists generally recognize that the time has come to change the model (Kuhn, 1962).

New evidence has been accruing for well over a quarter of a century that the Clovis-first model is wrong; but many, perhaps most, North American archaeologists continue to support that venerable model partly because a mystique has developed around the beautifully flaked Clovis fluted points. Not only do they represent an epitome of skilled craftsmanship, but the finder of a true Clovis point can immediately assume that it is about 11,000 years old because he knows they have been found at several dated sites of that age. Various styles of fluted points persisted much later, but true Clovis points drop out of the dated record by about 10,800 ^{14}C yr BP (Bryan, 1991). Because Clovis points have been dated between 11,200 and 10,900 ^{14}C yr BP at several mammoth kill sites (Haynes, 1987), some archaeologists vehemently argue that this means that the Clovis-first model must be correct. However, most archaeologists remain quiet. If asked, they say they are "conservative" archaeologists, meaning that they support the mainstream majority view and want to stay out of any controversy.

For some time a consensus has been maintained among North American archaeologists that the earliest generally accepted evidence for "Paleo-Indians" shows that they were hunters who made distinctive Clovis fluted points. The fact that Clovis points have been found, mostly on the surface, throughout the eastern United States, less commonly in the West, and a few in Central America as far south as Panama has led to the extrapolation that these big game hunters spread rapidly in all directions from the Great Plains; and even peopled South America (Fiedel, 1987; Morrow and Morrow, 1999), where the presence of true Clovis points has not been verified. Based on the generally accepted assumption that the advanced flaking technology exhibited on Clovis points must have originated elsewhere and could not have been developed indigenously by knappers experimenting with edge-retouched flakes, another extrapolation has been made all the way back to the European Upper Paleolithic (Fagan, 1987; Haynes, 1987). Thus the classic Clovis-first model has Eurasian big game hunters spreading across Siberia, the Bering Land Bridge, and unglaciated north-central Alaska and northern Yukon to move southward through an hypothesized ice-free corridor that conveniently opened between the Laurentide continental ice mass and glaciers that covered most of British Columbia. These rapidly moving Upper Paleolithic big game hunters suddenly appeared about 11,200 years ago on the High Plains, where they hunted mammoths (Fagan, 1987).

This exciting model, commonly found in the popular literature as well as in textbooks, ignores many facts:

(1) There are no Clovis fluted points in Siberia and no true Clovis points in Alaska.
(2) There are several reported sites in the Eastern Woodlands of the United States that yield artifacts, even biface points, below Clovis levels (Meltzer, 1988). Cactus Hill in southern Virginia has yielded many Clovis points, but also unfluted lanceolate points in a lower stratum dated ca. 15,000 ^{14}C yr BP (McAvoy and McAvoy, 1997).
(3) The only known Clovis megamammal kill site east of the Great Plains is at Kimmswick, Missouri (Graham et al., 1981), and there are none west of southeastern Arizona. Proboscidean remains that contain evidence of human alteration are present in several states (Fisher, 1984; Overstreet, 1998), but they are associated with Clovis points only on and near the southern Great Plains. We must conclude that there is remarkably little evidence that Clovis hunters migrated rapidly to kill megamammals, despite the fact that Clovis points have been found throughout much of southern Canada, the contiguous United States, and Central America. Evidently most people that made Clovis points were not specialized big game hunters but general hunter–gatherers like the later Archaic people (It can be interjected that a sufficient explanation for the presence of several mammoth kill sites on and near the Great Plains is a working hypothesis that opportunistic hunters from the Eastern Woodlands ventured onto the Great Plains and took advantage of animals under stress that had congregated around waterholes that were drying up during the so-called Clovis drought about 11,000 years ago.)
(4) In the Intermontane West, the earliest radiocarbon-dated sites containing bifacial points do not yield fluted points but rather leaf-shaped and stemmed forms (Bryan, 1991; Bryan and Tuohy, 1999). Available dates suggest that sometime before 11,000 years ago fluted points developed east of the High Plains, while stemmed points developed west of the Plains.
(5) Los Tapiales, Guatemala, the only excavated fluted point site in Central America, is dated only 10,700 ^{14}C yr BP (Gruhn and Bryan, 1977), too late to support the model of rapid southward migration that supposedly peopled Central and South America, so this report is usually ignored. Also, all sites in North or South America dated earlier than Clovis are simply ignored or explained away by the Clovis-first supporters because these sites do not support the accepted model.

A number of sites throughout South America, dated more than 11,000 ^{14}C yr BP, do not fit the Clovis-first model (Gruhn, 2003). In fact, essentially all late Pleistocene and early Holocene sites in South America have to be explained away by supporters of the Clovis-first model. We contend that it is long past time to look at alternative models for the peopling of North and South America that have been in the literature for several decades.

An alternative model for the peopling of the Americans should be simple but sufficient to fit all available evidence. The basic questions to be answered are: when did people first colonize the western hemisphere; what route did they use to enter the Americas; and what level of technology did they bring with them? A model with simple answers proposes that the earliest people came from eastern Asia into Alaska sometime in the Late Pleistocene, carrying an edge-retouched flake industry, plus many normally perishable artifacts made of wood, fiber, and bone.

Unfortunately, available evidence creates many complexities for this simple model, when one tries to encompass these questions and answers into a model which is based on testable working hypotheses. We will still try to keep it simple. We base our answer to the first question largely on the fact that all American skeletal remains belong to the species *Homo sapiens*. Although it is possible that an early transitional form with prominent browridges could have come first, the only evidence for this possibility is that populations with relatively heavy browridges exist in several areas of the Americas. The fact that there are archaeological sites dated to at least 250,000 years ago in central Siberia (Waters et al., 1997; Derev'anko, 1998) and north China suggests to us that we may yet confirm solid evidence for occupations in the Americas considerably earlier than a few sites now dated about 35,000 years ago (Dillehay and Collins, 1988; Guidon et al., 1996). So far we do not have good evidence older than about 35,000 years, but we should not construct arbitrary temporal barriers, like the Clovis-first model has done, that prevent consideration of earlier reported evidence.

The question of what route the earliest people took is complicated by the fact that the best evidence for the earliest reported sites is now in South America, which has led to various trans-Pacific and trans-Atlantic hypotheses. Such hypotheses are difficult if not impossible to test, and we think they remain unlikely because there is nothing early enough on any oceanic islands to support a really early trans-oceanic migration. Most likely the earliest people traversed the western Pacific coasts, and eventually entered Alaska. Despite the fact that nothing earlier than about 12,000 ^{14}C yr BP has been found in Alaska (Dixon, 1999), we think this situation will change when archaeologists expand their search in unglaciated refugia on and near the Alaskan coast, as well as looking beneath glacial deposits, and in new geological contexts in the unglaciated interior. Except for a few refugia, the south Alaskan coast remained glaciated between about 25,000 and 11,000 ^{14}C yr BP (Gruhn, 1994), although parts of southeastern Alaska and the British Columbia coast were deglaciated earlier (Dixon, 1999). We should point out that the hypothetical ice-free corridor long proposed as an early migration route east of the Rocky Mountains has now been called into question. Geologists have determined that the northern part of the corridor, in the Great Slave Lake basin, remained glaciated into the mountains passes along the continental divide between about 30,000 and 11,000 ^{14}C yr BP (Lemmen et al., 1994). In sum, the ice-free corridor was closed to traffic by viable breeding populations between 30,000 and 11,000 radiocarbon years ago. However, people could have entered through the interior before 30,000 ^{14}C yr BP. Also, hunter–gatherers could have expanded along the Pacific coast, perhaps using watercraft, and later travelled up rivers to penetrate the interior.

The third question, what level of technology did the earliest people bring with them, has elicited the most controversy because of the long-maintained fixation on bifacial projectile points, especially fluted points, by North American archaeologists. Several North American archaeologists (Krieger, 1964; Willey, 1971; MacNeish, 1976; Rouse, 1976; Hurt, 1977), and ourselves, who have obtained field experience in Latin America, have put forward variations on a model that the earliest people brought with them a simple lithic technology, on a Middle Paleolithic level, that consisted mainly of edge-trimmed flakes, and tools flaked on pebbles or cobbles if they were available. Of course, such simple artifacts continued to be made throughout prehistoric times, so by themselves they are not diagnostic of any early period. They must be excavated from early geological contexts, which are now more easily dated than when the prevailing model based on bifacial points associated with extinct fauna was first promulgated. This simple but sufficient model was presented a quarter of a century ago (e.g., Willey, 1971; Rouse, 1976) because only retouched flakes are found in so many early sites in both North and South America. In fact, bifacial points were never innovated in many parts of South America, although they were innovated quite early in some unforested open areas including Patagonia, where, as on the Great Plains, the most productive way to make a living was to hunt large mammals before as well as long after some species became extinct.

One North American archaeologist (Lynch et al., 1985) dug Guitarrero Cave in Peru, a site that contained retouched flakes in a context radiocarbon-dated older than 12,000 years. However, as the original report was criticized for having only one early date, and the shelter admittedly had somewhat mixed stratigraphy, Lynch decided that it would be better not to defend his evidence; and as well, to discount all other sites in South America which were dated before 11,000 ^{14}C yr BP. Tom Lynch's arguments (e.g., 1990) have become influential because they are readily acceptable by most North American archaeologists who prefer to maintain the Clovis-first model, to which they have become accustomed after several generations of reiteration.

Supporters of the Clovis-first model have had to reject a great deal of contradictory evidence from South America. This situation has created an impasse which we thought (Bryan and Gruhn, 2000) was finally broken by the evidence from the Monte Verde site (Dillehay, 1989, 1997), when a group of visitors to the site and collections accepted the clear evidence presented that people occupied that uniquely well-preserved site yielding an abundance of non-lithic artifacts by at least 12,500 radiocarbon years ago (Meltzer et al., 1997), more than a millennium before Clovis points were first used to hunt mammoths on the High Plains. Monte Verde gives us a glimpse of the many artifacts of wood and fiber that the earliest Americans probably brought with them. But no, supporters of the Clovis-first model remain adamant that there must be something wrong with the evidence from Monte Verde because it is too early to fit the accepted model. Alternative bizarre hypotheses presented are that mastodons brought the exotic plant material to the site when they used it as a latrine (Fiedel, 1999), or that glacial outwash extended into the area and mixed things up to make it look like an early archaeological site (Haynes, 1999). These desperate hypotheses are easily disproven. However, for many they have placed a cloud over the site, which means that the Clovis-first model lives on in the minds of many North American archaeologists.

We contend that valuable time is being wasted, and unnecessary verbiage is being expended by archaeologists who continue to defend the Clovis-first model. We must adopt a simple, sufficient, and flexible model which explains reported evidence and does not require that dozens of sites throughout the western hemisphere be explained away. At the same time, the alternative model we have proposed allows elimination of the artificial barrier to acceptance of sites dated earlier than about 12,000 ^{14}C yr BP. Hopefully, serious consideration and eventual acceptance of this venerable but sufficient model, which has been ignored for too long, will precipitate a search for more sites that contain simple retouched flake industries in early datable contexts.

References

Bryan, A.L., 1991. The fluted point tradition in the Americas—one of several adaptations to late Pleistocene American environments. In: Bonnichsen, R., Turnmire, K. (Eds.), Clovis Origins and Adaptations. Center for the Study of the First Americans, Oregon State University, Corvallis, pp. 15–33.

Bryan, A.L., 1993. The sambaqui at Forte Marechal Luz. In: Gruhn, R., Bryan, A.L. (Eds.), Brazilian Studies. Center for the Study of the First Americans, Oregon State University, Corvallis, pp. xvii + 111.

Bryan, A.L., Gruhn, R., 2000. Observations on the final demise of the Clovis-first model. In: Litvak, J., Mirambell, L. (Eds.), Arqueologia, Historia, y Antropologia: In Memorium, José Luis Lorenzo Bautista. Instituto Nacional de Antropologia e Historia, Colección Científica 415. México, pp. 85–101.

Bryan, A.L., Tuohy, D.R., 1999. Prehistory of the Great Basin/Snake River Plain to about 8500 years ago. In: Bonnichsen, R., Turnmire, K. (Eds.), Ice Age Peoples of North America. Oregon State University Press, Corvallis, pp. 249–263.

Correal Urrego, G., 1986. Apuntes sobre el Medio Ambiente Pleistocénico y el hombre prehistórico. In: Bryan, A.L. (Ed.), New Evidence for the Pleistocene Peopling of the Americas. Center for the Study of Early Man, University of Maine at Orono, pp. 115–131.

Derev'anko, A.P. (Ed.), 1998. The Paleolithic of Siberia. University of Illinois Press, Urbana.

Dillehay, T.D., 1989. Monte Verde: A Late Pleistocene Settlement in Chile, Vol. 1, Paleoenvironment and Site Context. Smithsonian Institution Press, Washington, DC.

Dillehay, T.D., 1997. Monte Verde: A Late Pleistocene Settlement in Chile, Vol. 2, The Archaeological Context and Interpretation. Smithsonian Institution Press, Washington, DC.

Dillehay, T.D., Collins, M.B., 1988. Early cultural evidence from Monte Verde in Chile. Nature 332, 150–152.

Dixon, E.J., 1999. Bones, Boats and Bison. University of New Mexico Press, Albuquerque.

Fagan, B.F., 1987. The Great Journey: The Peopling of Ancient America. Thames and Hudson, New York.

Fiedel, S., 1987. Prehistory of the Americas. Cambridge University Press, Cambridge.

Fiedel, S., 1999. Artifact provenience at Monte Verde: confusion and contradictions. Monte Verde revisited. Discovering Archaeology, Special Report. Scientific American, Discovering Archaeology 1(6), pp. 1–12.

Fisher, D.C., 1984. Taphonomic analysis of Late Pleistocene mastodon occurrences: evidence of butchery by North American Paleo-Indians. Paleobiology 10, 338–357.

Graham, R.W., Haynes, C.V., Johnson, D.L., Kay, M., 1981. Kimmswick: a Clovis-Mastodon association in eastern Missouri. Science 213, 1115–1117.

Gruhn, R., 1994. The Pacific Coast route of initial entry: an overview. In: Bonnichsen, R., Turnmire, K. (Eds.), Method and Theory for Investigation of the Peopling of the Americas. Center for the Study of the First Americans, Oregon State University, Corvallis, pp. 249–256.

Gruhn, R., 2003. Current archaeological evidence for a Late Pleistocene settlement of South America. In: Lepper, B.T. (Ed.), New Perspectives on the Peopling of the Americas. Texas A&M University Press, College Station, in press.

Gruhn, R., Bryan, A.L., 1977. Los Tapiales: a Paleo-Indian campsite in the Guatemala highlands. Proceedings of the American Philosophical Society 121 (3), 235–273.

Guidon, N., Pessis, A., Parenti, F., Fontugue, M., Guérin, C., 1996. Nature and age of the deposits in Pedra Furada, Brazil: reply to Meltzer, Adovasio and Dillehay. Antiquity 70, 405–421.

Haynes, C.V., 1987. Clovis origins update. The Kiva 52 (2), 83–93.

Haynes, C.V., 1999. Monte Verde and the pre-Clovis situation in America. Monte Verde revisited. Discovering Archaeology Special Report. Scientific American, Discovering Archaeology 1(6), pp. 17–19.

Hurt, W.R., 1977. The edge-trimmed tool tradition of northwest South America. Museum of Anthropology, University of Michigan, Anthropological Papers 61, 269–294.

Krieger, A.D., 1964. Early man in the New World. In: Jennings, J.D. (Ed.), Prehistoric Man in the New World. University of Chicago Press, Chicago, pp. 23–81.

Kuhn, T.S., 1962. The Structure of Scientific Revolutions. University of Chicago Press, Chicago.

Lemmen, D.S., Duk-Rodkin, A., Bednarski, J.M., 1994. Late Glacial drainage systems along the northwestern margin of the Laurentide ice sheet. Quaternary Science Reviews 13, 805–828.

Lynch, T.F., 1990. Glacial-Age man in South America: a critical review. American Antiquity 55 (1), 12–36.

Lynch, T.F., Gillespie, R., Gowlett, J., Hedges, R., 1985. Chronology of Guitarrero Cave, Peru. Science 229, 864–867.

MacNeish, R.S., 1976. Early man in the New World. American Scientist 63, 316–327.

McAvoy, J.M., McAvoy, L.D., 1997. Archaeological Investigations of Site 44SX202, Cactus Hill, Sussex County, Virginia. Commonwealth of Virginia, Department of Historic Resources, Research Report Series 8. Richmond, Virginia.

Meltzer, D.J., 1988. Late Pleistocene human adaptations in eastern North America. Journal of World Prehistory 2, 1–52.

Meltzer, D.J., Grayson, D.K., Ardila, G., Barker, A.W., Dincauze, D.F., Haynes, C.V., Mena, F., Nuñez, L., Stanford, D.J., 1997. On the Pleistocene antiquity of Monte Verde, southern Chile. American Antiquity 62 (4), 659–663.

Morrow, J.E., Morrow, T.A., 1999. Geographic variation in fluted projectile points: a hemispheric perspective. American Antiquity 64 (2), 215–230.

Overstreet, D.F., 1998. Late Pleistocene geochronology and the Paleoindian penetration of the southwestern Lake Michigan basin. The Wisconsin Archeologist 79 (1), 28–52.

Owen, R.C., 1984. The Americas: the case against an Ice-Age human population. In The Origins of Modern Humans: A World Survey of the Fossil Evidence. Liss, New York, pp. 519–563.

Rouse, I., 1976. Peopling of the Americas. Quaternary Research 6, 597–612.

Waters, M.R., Forman, S.L., Pierson, J.M., 1997. Diring Yuriakh: a lower paleolithic site in central Siberia. Science 275, 1281–1284.

Willey, G.R., 1971. An Introduction to American Archaeology, Vol. 2. South America. Prentice-Hall, Englewood Cliffs, NJ.