Geographical and geological explorations of the La Plata Museum 1884–1905

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Abstract: The contributions of the La Plata Museum to the geology of Argentina began following the exploratory trips of its founder, F.P. Moreno, in the 1870s. The geological expeditions of the La Plata Museum started in the 1880s and covered the Andean region, although they were focused in the Patagonian Andes. They became more important from 1893 when they were related to explorations aimed at fixing the boundary between Argentina and Chile. Within 10 years the geographical and geological bases of large and almost unknown regions were established. R. Hauthal studied the area between the Last Hope Inlet and Lake Belgrano, defining its stratigraphy and publishing the first geological map of the Cordilleran region between *c.* 49° 30′ and 52° S. The geology between Lake Buenos Aires and the Rio Negro (41–47° S) was established by Santiago Roth. The stratigraphic succession, facies and structural changes through the Argentine–Chilean Cordillera at the latitude of Lake Nahuel Huapi and Lake Lacar were studied by L. Wehrli, while studies at the latitude of Neuquén and Mendoza (36–39° S) were carried out by C. Burckhardt. Mesozoic and Cenozoic fossils were studied either in the Museum or abroad.

Supplementary material: Map of southern South America (Argentina and Chile) showing the distribution of towns in 1870 is available at http://doi.org/10.6084/m9.figshare.c.3283385.v1

By 1852, Argentina had concluded the almost 40 years of political turmoil that followed Independence Day on 9 July 1816. Buenos Aires had 76 000 inhabitants, the country had a population of one million and more than 80% of the population were illiterate. A significant number of intellectuals who had been exiled abroad, where they had the opportunity to travel to Europe and the USA, returned to Argentina. Much of the ruling class that shaped the country in the following decades, in the so-called National Organization Period that followed enactment of the National Constitution in 1853, emerged from this group of exiles. The strong promotion of European immigration and education meant that, by 1910, the country had six million inhabitants, almost two million of whom were European, and the illiteracy rate had been reduced to 34%.

During the National Organization Period, three pre-existing institutions – the Public Museum of Buenos Aires and the universities of Córdoba and Buenos Aires – acquired relevance for the first time in the promotion of geological studies.

The University of Buenos Aires was founded on 9 August 1821 as a provincial institution, but it was not until 1865 that the formal teaching of geology in Argentina began there under the Italian Professor Pellegrino Strobel (1821–95).

The Public Museum of Buenos Aires, today the Museum of Natural Sciences Bernardino Rivadavia, was founded on 27 June 1812 as a dependency of the Academy of Medicine and Sciences, but it did not have much relevance until the time of the National Organization Period, when Hermann Burmeister (1807–92) became its director in 1862. Burmeister had graduated from the University of Halle in Germany and taught at the universities of Berlin and Cologne before resigning as a professor at the University of Halle to obtain a grant, with the help of A. von Humboldt, to visit Brazil. He also visited Argentina at the end of the 1850s and, in 1862, was appointed as the Director of the Public Museum of Buenos Aires by the President of Argentina.

Burmeister was seminal to the development of geological studies in Argentina during the final three decades of the nineteenth century because he was directly or indirectly involved in the creation of the National Academy of Sciences and La Plata Museum, from which all basic studies on Argentinan geology would be made. Burmeister organized and was the first director of the National Academy of Sciences, founded in 1869 in the University of Córdoba, the oldest in the country (1613). His influence in the creation of the La Plata Museum in 1884 was indirect and must be sought in the teachings and example given to its founder, Francisco P. Moreno (1852–1919). He was also influential in arranging that most of the first foreign geologists were graduates from German universities and that most palaeontological studies were performed there, a pattern that continued well into the twentieth century. Between 1827 and 1892 Burmeister published 290

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papers on different topics of the natural sciences and, when he died, the Argentine government decreed three days of national mourning and ordered that the national flag was flown at half-mast; the whole government attended his funeral.

Contributions of the National Academy of Sciences to the geology of Argentina during the second half of the nineteenth century were mainly focused in the central and northwestern regions of the country and were carried out by the German geologists Alfred Stelzner (1840–95), Ludwig Brackebusch (1849–1906), Wilhelm Bodenbender (1857–1941) and the palaeobotanist Fritz Kurtz (1854–1920). The work of the La Plata Museum covered most of the country, but its most important achievements were in the Patagonian region.

Geological knowledge of Patagonia before 1870

Until 1870, when the English Captain George Musters (1841–79) joined a group of Indians to cross Patagonia from Punta Arenas to Carmen de Patagones (Musters 1871), knowledge of the whole region was restricted to some isolated observations on the Atlantic coast, mostly made by foreign sailors and explorers.

In 1826 the British ships *Beagle* and *Adventure* began a series of scientific explorations under the command of Captain P. Parker King (1791–1856), which continued between 1830 and 1836 under Captain Robert FitzRoy (1805–65). The 22-year-old naturalist Charles Darwin (1809–82) joined the expedition in 1831 and carried out the first important geological studies of Patagonia.

It was on that trip that Darwin (1842, 1846) made various geological observations along the coast and in the Patagonian interior, describing the 'gravel formation' or 'Great Shingle Formation of Patagonia' (=Rodados Patagónicos) and some Tertiary stratigraphic units. He also described the Cretaceous succession of Mount Tarn near Punta Arenas. The Cretaceous and Tertiary fossils he collected were described by E. Forbes and G.B. Sowerby (Darwin 1846).

At about the same time, Alcide d'Orbigny (1802–57), during his trip through South America, arrived at Carmen de Patagones in 1829. He remained in this locality for nine months and explored the region, especially the coast between 40 and 42° S, and carried out studies on the Tertiary strata, which would later be incorporated into the geological synthesis of his article 'Voyage dans l'Amerique Méridionale' (d'Orbigny 1842).

At that time the southern end of 'civilized' Argentina was along a frontier line located south (*c.* 35–37° S) of the Buenos Aires, Córdoba, San Luis and Mendoza provinces; beyond this line was a territory occupied by groups of wandering Indians. The city of Bahia Blanca (38° 35′ S) was isolated and it was dangerous to cross from there to Azul in the centre of Buenos Aires province.

Carmen de Patagones (40° 48′ S, 63° W), the city founded by Antonio de Viedma in 1779, was a lonely and isolated lookout on the Atlantic coast. The Welsh colony established in 1865 at the mouth of the Chubut river (*c.* 43° S) was an oasis in the wilderness and Pavon island, at the mouth of the Santa Cruz river (50° S), and the Isla de los Estados (54° 46′ S) were the only places where a small group of men led by Commander Luis Piedrabuena (1833–1883) represented Argentina as far as Cape Horn.

Explorations of Moreno: 1875–80

Moreno's explorations in Patagonia always had the same purpose; in his own words, to know those territories 'to convince with unquestionable evidence the sceptic and the apathetic, the great factor of progress that Patagonia would be if appreciated at its true value' (Moreno 1898).

His first trip to Carmen de Patagones in 1873 was followed in 1874 by another to the mouth of the Santa Cruz river and, in early 1876, at the age of 23, he became the first non-native man to reach Lake Nahuel Huapi from the Atlantic. In 1876–77 he made an expedition to explore the Santa Cruz river and to reach its headwaters. He arrived at two lakes, which he named Argentino and San Martín (Moreno 1879).

In 1879–80 Moreno crossed Patagonia from Carmen de Patagones to Tecka (43° 28′ S, 71° W), returning through the Nahuel Huapi region. His visit to the shelters of the Indian chieftain Shaihueque in Caleufu ended in a legendary six-day escape in a raft along the Collón Cura and Limay rivers.

In the accounts of these exploratory trips, Moreno's geological observations are mostly anecdotic and/or confirmatory of the findings of others. They include those (Moreno 1879) related to the Tertiary formation named 'Patagonian' by d'Orbigny (1842), the gradual uplifting of Tertiary strata that resulted in the formation of plateaus at different altitudes above sea-level, and the composition, distribution, west–east decrease in size and origin of Darwin's 'gravel formation'.

Among other contributions, Moreno also described the Patagonian salars, the different types of rock units found in the routes he travelled, the structural layout of sedimentary strata in the upper valley of the Shehuen river and the eruptive origin of the Kachaike and Moyano hills in the regions of

the San Martín and Argentino lakes (Moreno 1879). He also discovered fossil localities of Tertiary vertebrates in the valley of the Santa Cruz river, Cretaceous invertebrates and lower Tertiary plants in the region of the San Martín and Viedma lakes, and Tertiary marine molluscs in the Rio Negro region. He also highlighted the geological similarities of Patagonia to the other southern continents based on the main features of the Cenozoic fossils (Moreno 1882). He thought that Patagonia, Australia, New Zealand and Africa had been part of a large southern continent, which gradually began to fragment at the end of the Mesozoic.

La Plata Museum

The city of Buenos Aires, until then the capital of Buenos Aires province, became the capital of Argentina in 1880. This resulted in the creation of a new provincial capital on 19 November 1882: the city of La Plata. One of the outcomes of this was the transfer of the provincial museum to the national government and the foundation of a new museum in the city of La Plata. Thus, on 17 September 1884, the La Plata Museum was founded and Francisco P. Moreno was appointed as its director.

According to Moreno, the goals of La Plata Museum were to carry out explorations and investigations of a geographical, geological, biological, ethnological, sociological and historical nature, together with studies of natural resources and their industrial applications, and to encourage intellectual development through publications, conferences, courses and excursions (Moreno 1890).

Moreno (1890) took the Smithsonian Institution as a model for the museum. The Smithsonian Institution had been founded in the city of Washington in the USA in 1846 as a museum complex that sought to integrate all areas of knowledge in the fields of natural and cultural sciences, from mathematics and physics to anthropology, agriculture, history and art (cf. Goode 1897). Therefore the La Plata Museum covered the past and present physical and moral history of the continent and was to be part of a complex including an astronomical observatory, botanical and zoological gardens, and a school of arts and crafts, with a programme to serve both Argentinian nationals and foreigners in the progress of science.

To fully understand the significance of the project, it should be noted that the city of La Plata only existed on the newest maps of the time and that the Museum was built in the middle of a virtually empty Pampa. Only 25 years after the publication of *The Origin of the Species*, the museum's oval building represented, in the words of Moreno (1890), 'the universal evolution' and was 'the first to be built according to the evolutionary biological theories … in a city of foundation so recent that is not yet included in the geographic charts'. The project was, in fact, of such a magnitude that the building, as first planned by Moreno, was twice the size of that finally built. The Museum building and its exhibitions were completed in four years and opened to the public on 19 November 1888, on the sixth anniversary of the founding of La Plata. In 1890 the Museum began publishing the *Revista* and the *Annals*, the excellent quality printing of which was carried out in the Museum's printing workshop.

Moreno surrounded himself with a group of good scientists and technicians, such as the Argentines Carlos Ameghino (1865–1936) and Florentino Ameghino (1854–1911), and Carlos Burmeister, who were joined by foreign specialists, such as the German geologist Rudolph Hauthal (1854–1928), the English palaeontologists Richard Lydekker (1849–1915) and Arthur Smith Woodward (1864–1944), the Swiss geologists and palaeontologists Santiago Roth (1850–1924), Alcides Mercerat, Leo Wehrli (1870–1954) and Carl Burckhardt (1869–1935), and the Swiss geographer Enrique A.S. Delachaux (1864–1910). Outstanding collaborators were Hauthal, Roth and Burckhardt. Hauthal had attended lectures by F. Quenstedt in Tübingen and studied in Leipzig and Strasbourg before arriving in Argentina as a tutor for members of a rich family; after meeting Burmeister and Moreno he was appointed as head of the La Plata Museum Geology and Mineralogy Section in 1891. Roth arrived in Argentina with his family in 1866 and, during his youth, was an amateur collector of Cenozoic fossil vertebrates and became known for his knowledge of the stratigraphy and palaeontology of the Pampas region. As a result, he was appointed as head of the La Plata Museum Palaeontology Section in 1895 and the University of Zurich awarded him an *honoris causa* PhD in 1900. Burckhardt studied with A. Heim in Zurich, with Waagen and Suess in Vienna, and with Zittel in Munich; in 1896 he was invited by Moreno to work in the Explorations Section of the La Plata Museum.

In the 20 years that the museum was under the direction of Moreno, numerous expeditions to different regions of the country took place, many of them linked to the work of the Argentina Commission that was in charge of fixing the international boundary with Chile.

Thus between 1884 and 1905 the Museum had a clear national purpose, despite its provincial character, focused primarily on exploration, research and public display. All these activities enhanced the national and international status of the Museum within a short time interval, so that Henry A. Ward

(1834–1906), an American naturalist who visited Argentina at that time, placed it 'among the ten best in the world for its collections, exhibitions and research' (Ward 1890). At that time its size was similar to that of the Smithsonian Institution, which had served as its model.

In 1905 the Museum became part of the newly created National University of La Plata and Moreno resigned in opposition. Since then, as a Natural Sciences Museum, it has been considered as a completed project, when, in fact, it was the core of a much broader – but never materialized – vision.

Explorations and studies of the La Plata Museum

First expeditions: 1886–89

Although the construction of the building for the Museum was not completed until 1888, by 1886 Moreno had organized a series of expeditions, most of them centred in Patagonia and in the province of Buenos Aires. These activities were directed to explore the geography and to collect palaeontological, biological and anthropological materials to improve the Museum's collections and exhibitions. In this initial period, however, geological observations were not important and were limited by the level of knowledge of those in charge of the explorations.

Between 1888 and 1889 the National Exploring Section of the La Plata Museum made several expeditions to collect materials in the fossiliferous deposits of the Santa Cruz river, discovered by Moreno in 1877, and to carry out surveys and collections in Isla de los Estados, Tierra del Fuego and central Chubut (Moreno 1890).

The expedition to Chubut began on August 1888 and continued through 1889. The first shipment of materials sent from the field included 14 crates of palaeontological (mainly mammals and dinosaurs) and anthropological remains. The vertebrate fossils collected by Carlos Ameghino were studied by his brother Florentino and the invertebrates by H. von Ihering (1850–1930). On that basis, Ameghino (cf. 1900–02, 1906) developed a stratigraphic scheme for the sedimentary formations of Patagonia, especially the Upper Cretaceous and Tertiary.

An expedition to the Santa Cruz river departed in October 1888 and arrived at Punta Arenas in early November. There the expedition members studied the Tertiary lignite formation and continued on horseback to Rio Gallegos, where they collected fossil mammals. Then they went to the region of the Santa Cruz river, where they traversed the distance between the Atlantic and the Andes several times and made an important collection of fossil vertebrates. They returned to La Plata in August 1889 with 100 boxes of fossils. At about the same time, the La Plata Museum received abundant fossil material from the Quaternary of Buenos Aires province, especially from Monte Hermoso and Lujan, two classical localities visited by Darwin in 1832.

At the end of this period, in 1890, the first issues of the *Annals* and *Revista* of the La Plata Museum appeared, which included papers by Mercerat (1890, 1891*a*, *b*), the first head of the Palaeontology Section, and Moreno & Mercerat (1891*b*) on fossil mammals collected by Moreno in 1874–75 and 1876–77 in the Tertiary of Chubut and Santa Cruz. Moreno & Mercerat (1891*a*) also published a Spanish–French bilingual catalogue of fossil birds and Moreno (1891, 1892*a*, *b*) published on other vertebrates, especially cetaceans, from the Tertiary of Chubut and Santa Cruz.

Expeditions of 1890–95

Between 1890 and 1895, the expeditions of the La Plata Museum continued with the exploration of southern and western Argentina and, from 1893 onwards, the amount of work increased as the national government began providing funds (Moreno 1898). Thus between 1893 and 1895 the Museum staff travelled along the Andes from the Puna (22° S) in northwestern Argentina to San Rafael (34° 15′ S) in the province of Mendoza, studying the geography, geology and mineralogy, and reporting the main characteristics of barely known regions (Moreno 1898)

In late 1891, a commission lead by the Museum naturalist Carlos Burmeister continued the exploration of southern Patagonia. This expedition was based in a museum warehouse, close to Puerto Santa Cruz. From there, Burmeister made fossil collections from Tertiary strata in Mount Observation, south of Mount Entrance (Burmeister 1891). From 29 December 1891 onwards, the expedition used a heavy four-wheeled cart to explore the whole region along the Santa Cruz and Shehuen rivers, between the Atlantic coast and the Andes, reaching the Viedma and Argentino lakes and beyond the Hobler and Castle hills. Among other fossils, they found dinosaur remains east of La Leona river and returned to Puerto Santa Cruz at the end of March 1892 with important collections (Burmeister 1892).

Dinosaurs, whales and fossil ungulates obtained by the expeditions of the Museum in Neuquén, Chubut and Santa Cruz were studied by Richard Lydekker, who, invited by Moreno, visited the Museum between September and November 1893. His studies were concluded in a relatively short time and released immediately (Lydekker 1893, 1894) in two Spanish–English bilingual editions of the Museum's *Annals*. In one of these papers he

described the species *Titanosaurus australis* – today included in the genus *Neuquensaurus* Powell – the skeleton of which was displayed for the first time in the Museum exhibitions in 1928.

The Cenozoic invertebrates and vertebrates collected in Santa Cruz by Moreno in 1877, and by other staff of the Museum between 1887 and 1896, were also made known as a result of the studies of F. Lahille (1861–1940) (Lahille 1896, 1898, 1899), Mercerat (1890, 1891*a*, *b*), Moreno & Mercerat (1891*a*, *b*) and Ameghino (1887, 1889).

The stratigraphic context of these findings was established in detail by Mercerat (1897), who, between 1892–93 and 1893–95, as a researcher at the National Museum of Buenos Aires, completed 10 regional stratigraphic sections south of the Santa Cruz river. In these contributions, Mercerat (1896, 1897) established the correct relationship between the marine ('Patagonian') and the continental ('Santacrucian') Tertiary, and described Darwin's 'shingle formation', which he named Rodados Tehuelches and referred to the Pliocene.

In June 1892, another expedition of the Museum led by Rodolfo Hauthal assessed some coal deposits in the San Rafael region in southern Mendoza province. On this trip, Hauthal (1892*b*, *c*) made, in addition to the first description of Upper Cretaceous coal deposits, a series of geological observations at the latitudes of the cities of Mendoza and San Rafael and also further south, between the Diamante and Atuel rivers. Moreno supplemented these observations, publishing a 1: 25 000 geological map of the region north of Mendoza River in the Museum's *Annals* (Ave Lallemant 1892).

All these studies were completed in 1894 when Hauthal, by order of Moreno, made a detailed topographic and geological study of the same region. As a result, and within a period of about two months, Enrique Wolff and Gunardo Lange made 1: 500 000 surveys of 35 000 km^2 and, together with Hauthal, a 1: 25 000 topographic–geological map of 88 km^2 between the Atuel and Diamante rivers (Moreno 1896; Lange 1896; Hauthal 1896*a*). Hauthal (1896*a*) studied the stratigraphy of the region, especially the Jurassic and Cretaceous, and made a survey (Hauthal 1895) of the glaciers between the Mendoza and Atuel rivers.

At about the same time, Hauthal (1892*a*) studied the southern hills (Sierra de la Ventana) of Buenos Aires province, where he made a stratigraphic section and described the lithology and folding of the strata. He later extended his lithological, stratigraphic and structural observations to the northern mountains of Buenos Aires province, where he complemented studies made by another member of the Museum staff, the German geologist J. Valentin (1867–97) (Valentin 1895), describing Early Palaeozoic strata (Hauthal 1896*b*).

Between September and October 1894, Valentin made a field trip to San Luis province, where he examined some gold mines and the mining district (Valentin 1896). The studies of the La Plata Museum on the geology of that province also included those of Kurtz (1895) on Late Palaeozoic plants collected by Moreno in 1883.

La Plata Museum expedition of 1896 to the region between San Rafael and Lake Buenos Aires

In 1896, Moreno decided to study the geography and geology of the region immediately to the east of the Andes, between San Rafael and Lake Buenos Aires, an extension of 1400 km (Moreno 1898). For that purpose he divided his collaborators into several groups according to the areas to be explored.

The staff of the topographic and geological sections of the La Plata Museum began work at the beginning of January 1896. Moreno went to San Rafael and from there to Lake Buenos Aires, covering 1400 km on horseback and meeting the different groups along the way to supervise the studies on the ground (Moreno 1898).

The expedition carried out by the Museum from January to June 1896 travelled 7155 km on horseback to survey an area of 170 000 km^2 between San Rafael and Lake Buenos Aires to make a 1: 400 000 map. This work included: the determination of three longitudes, 328 latitudes and 201 azimuths, 360 stations with theodolite and 180 with prismatic compass, 1072 stations of barometric readings, 271 trigonometric height measurements; the capture of 960 photographs; the collection of 6250 samples of rocks and fossils; and the drawing of the first preliminary maps of the Nahuel Huapi region and of the 16th of October valley.

In this expedition, Roth, who had joined the Museum in 1895 as the head of the Palaeontology Section, described the fossiliferous strata of General Roca in Rio Negro (Roth 1899*a*), collecting materials that were studied and correctly dated as Late Cretaceous–Paleocene by Burckhardt (1902*b*), who also concluded that the fossils originated from an Atlantic ingression. Fossil invertebrates from this locality, collected by Roth in later trips, were also studied by von Ihering (1903, 1904, 1907) and Wilckens (1905).

Roth (1899*a*) made also a geological cross-section of *c.* 750 km at about the 40° S, from the town of Carmen de Patagones on the Atlantic to Lake Falkner in the Andes (71° 30′ W), establishing the stratigraphy of the whole region. He discovered early Jurassic marine fossils at Piedra Pintada (Roth 1902), the plants and invertebrates of which were studied by Kurtz (1902*b*) and Burckhardt (1902*c*),

respectively; collected vertebrates from Cretaceous continental strata, which were described by Woodward (1896, 1901); and found and described remains of fossil mammals in strata that are today included in the Miocene Collón Cura Formation

On this trip, and in 1898–99 and 1902, Roth (1899*a*, 1904*a*, 1908, 1922, 1925) found Lower Jurassic marine strata in Chubut, referred to the Tertiary rocks later included in the Andesitic Series, discovered Tertiary plants and marine invertebrates in the neighbourhood of Lake Nahuel Huapi, and collected (cf. Roth 1899*a*, *b*) Cretaceous and Tertiary vertebrates in eastern, central and western Chubut. It should be mentioned that, until a few decades ago, most of the geological knowledge of the region between Lake Fontana and Esquel (43–45° S) in western Chubut was mainly due to Roth, who was also considered at the time to have the best knowledge of the Pampas geology (cf. Roth 1888, 1921).

Roth also made many discoveries of fossil mammals and the first detailed study of the auditory system of South American ungulates, recognizing a new group for which he proposed the name Notoungulata. His ability to reconstruct and assemble skeletons contributed to the international fame of the La Plata Museum which, as a result, could display unique collections of Pampean Cenozoic mammals, which are unsurpassed to this day.

The explorations and observations made by the expedition carried out by the La Plata Museum in early 1896 found natural continuity in the work of the International Boundary Commission, chaired by Moreno from September of that year. In this way, Moreno integrated his ideas for the geographical and geological investigations of the La Plata Museum with the determination of the economic potential of the country and of its western international boundary.

Studies of the commission on the international boundary with Chile: 1892–98

Moreno was the first person to determine the extent of glaciers and glacial sediments on the eastern slopes of the Patagonian Cordillera and the significance they have for the divergence between the *divortium aquarum* and the line of the highest peaks. To the north of the Patagonia region the boundary between Argentina and Chile is clearly established by the highest mountains of the Andes, which determine the continental divide of the waters, but south of 40° S the Cordillera loses altitude and its highest mountains do not always coincide with the continental divide.

The main problem in the demarcation of the border between Argentina and Chile was therefore focused in the Patagonian region, where it was

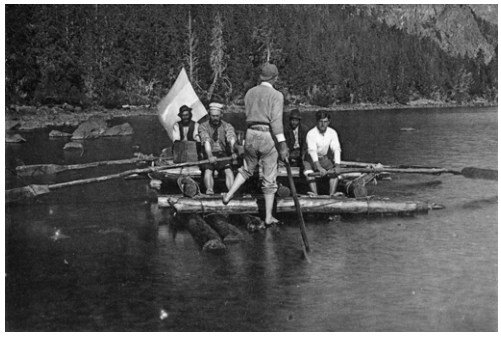

Fig. 1. La Plata Museum explorers at Lake Traful in 1896 (from Moreno 1898).

necessary to decide whether it should follow the line of the high peaks or the line on which the continental waters divide to go to the Pacific or the Atlantic. Moreno and Argentina were in favour of the first position, whereas Chile was in favour of the second. The two countries agreed to submit their standings to the arbitration of the British crown and based their positions on detailed studies of the regions involved.

Moreno, as an expert and the head of the Argentina Commission on the question of limits with Chile, directed the scientists and staff of the La Plata Museum to participate in this work from 1896 onwards; he himself made numerous trips between Buenos Aires, Santiago de Chile and the Andean region.

The works of the Argentina Boundary Commission (Figs 1 & 2) were in charge of nine subcommissions (Argentine Republic 1900) covering different areas and their work led to the discovery of 43 lakes and several major rivers. Roth and

Fig. 2. F.P. Moreno greeting a horseman working for the Argentine Commission on the International Boundary with Chile. In the middle to the left, with a black coat, Sir T.H. Holdich. 1902. Photo credit: F.P. Moreno files, Museum of San Carlos de Bariloche.

Hauthal used their work to perform numerous geological observations and make important fossil collections. The topographical maps made by the Argentine Commission between 38 and 52° S were, until the middle of the 1980s, the most detailed cartography of this region.

In 1900, after a stay in London for the presentation of the documents exposing the Argentine position on the question of limits with Chile, Moreno returned to the country and, in 1901, accompanied Colonel Sir Thomas Holdich, Commissioner of the Arbitral Tribunal appointed by Queen Victoria, in a survey from Lake Lacar (40° S) to the Last Hope Inlet (52° S). After that trip he returned to England and came back with Holdich in 1902 to participate in the work of fixing the landmarks according to the arbitration award signed that year by King Edward VII (cf. Holdich 1904*a*, *b*). All these studies, between 1897 and 1899, improved, either directly or indirectly, the geological knowledge of the eastern slopes of the Patagonian Andes and surrounding areas.

The study of the region between the rivers Negro and Limay and Fontana Lake in western Chubut was carried out by Roth (cf. Roth 1898, 1899*a*, 1904*b*, 1905). The region between Lake Belgrano and Last Hope Inlet was studied by Hauthal from 1897 to 1902 (Hauthal 1898, 1904*b*). These studies resulted in the first geological map of the region between Lake Argentino and the Last Hope Inlet (Hauthal in Wilckens 1907*a*) (Fig. 3), where the stratigraphic sequence of the entire region was established, as well as the first stratigraphic scheme of the Lake Belgrano region (Hauthal in Wilckens 1905); until 30 years ago, this was the only published geological map of the region. Invertebrate fossils collected by Hauthal in the Mesozoic and Tertiary of this large area were studied by Wilckens (1907*b*), Favre (1908) and Paulcke (1908) and the plants by Kurtz (1902*a*).

Cretaceous and Tertiary molluscs were also submitted for study to von Ihering (1904, 1907), who established the proportion of living species for each 'formation' from the Eocene to Quaternary and the relationship of the oldest Tertiary faunas with those from New Zealand and the Indian Ocean.

Hauthal (1904*b*) also carried out a survey of glacial deposits, assigned to the Jurassic rocks that today are included in the El Quemado Complex, and described the findings of the Mylodon's (or Eberhardt's) cave (Hauthal 1899; Hauthal *et al.* 1899; cf. Moreno 1899; Moreno & Woodward 1899; Roth 1899*c*; Woodward 1900). Hauthal (1904*a*) also studied the distribution and classification of volcanoes along the Argentine–Chilean border from the Puna to Tierra del Fuego.

The work carried out in the southern part of the Patagonian Andes was supplemented by some foreign expeditions. Thus G. Steinmann in 1883–85 and 1895–97 contributed to the geological knowledge of the region between the Strait of Magellan and Lake Argentino (cf. Steinmann 1883) and in 1895–7 a Swedish expedition, under the direction of Otto Nordenskjöld (1869–1928), made studies in Tierra del Fuego and the region of Ultima Esperanza Inlet and the eastern slope of the Cordillera to 51° S (cf. Nordenskjöld 1897; Steinmann & Wilckens 1908). Between 1896 and 1899, John B. Hatcher (1861–1904) of Princeton University, USA conducted a comprehensive geological and palaeontological study of an area of the territory of Santa Cruz, located to the north of Lake San Martín (Hatcher 1897). The results of this expedition were published in eight volumes (Hatcher 1903; Scott 1903–1932) describing the geology and stratigraphy, Cretaceous and Tertiary invertebrates, and Cenozoic vertebrates.

Studies of the Andes at the latitude of Neuquén and Mendoza

Between 1897 and 1898, Leo Wehrli and Carl Burckhardt, who had joined the Museum in 1896, following the instructions of Moreno, made two geological sections of the Argentine–Chilean Andes at the latitudes of Malargüe (Mendoza) (35° 45′ S) and Las Lajas (Neuquén) (38° 50′ S) (Wehrli & Burckhardt 1898; Burckhardt 1899).

These sections, and the study of the invertebrate fossils found there (Burckhardt 1900*a*, *b*, 1903), were used to establish the stratigraphy of the region and their west–east changes in facies (Fig. 4) and structures. Burckhardt (1902*a*, 1903) could also identify, on the basis of changes in the rocks today referred to as the Rio Damas and Tordillo formations, the existence of a western coastline along today's Chilean coast and an eastern Jurassic marine embayment within a regional palaeogeographical reconstruction for the Jurassic of the whole region.

Wehrli (1899*a*, *b*) made geological sections in the Lake Lacar region and between Puerto Montt and Lake Nahuel Huapi, determining the geology of both areas.

Conclusions

Studies made by the La Plata Museum in the late nineteenth century established within *c.* 10 years the geography of Patagonia, until then virtually unknown. The geographical discoveries and topographical surveys, which in many instances were not surpassed for nearly a century, were used to describe the main geological and palaeontological features of Patagonia. In those few years topographic and geological maps and sections and

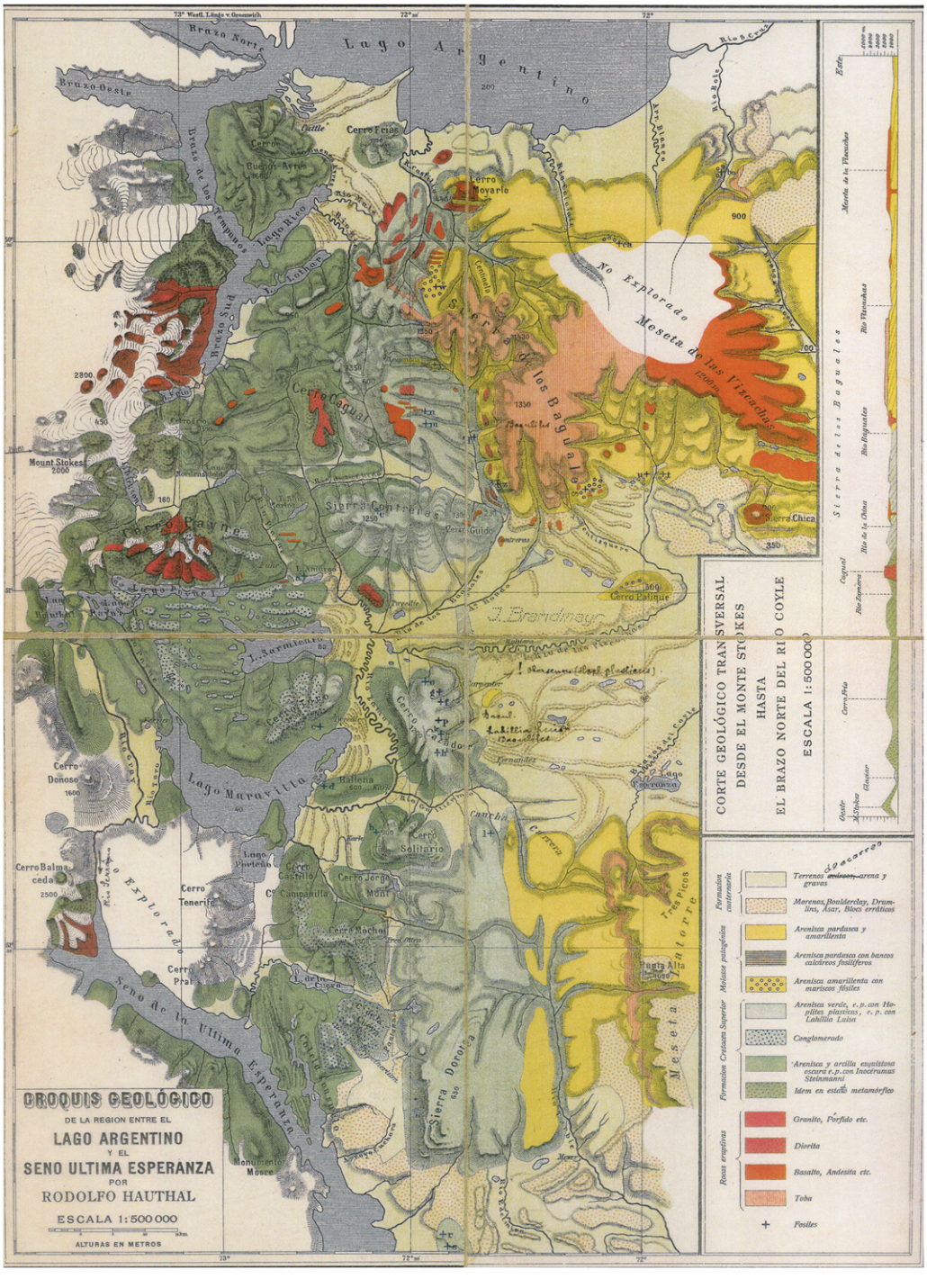

Fig. 3. Geological map showing the area between Lake Argentino and Last Hope Inlet (from Hauthal in Wilckens 1907*a*).

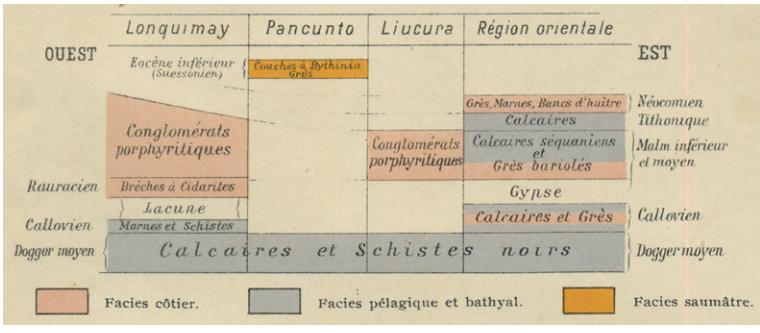

Fig. 4. Stratigraphy between Lonquimay (Chile) and Las Lajas (Argentina) (from Burckhardt 1900*b*).

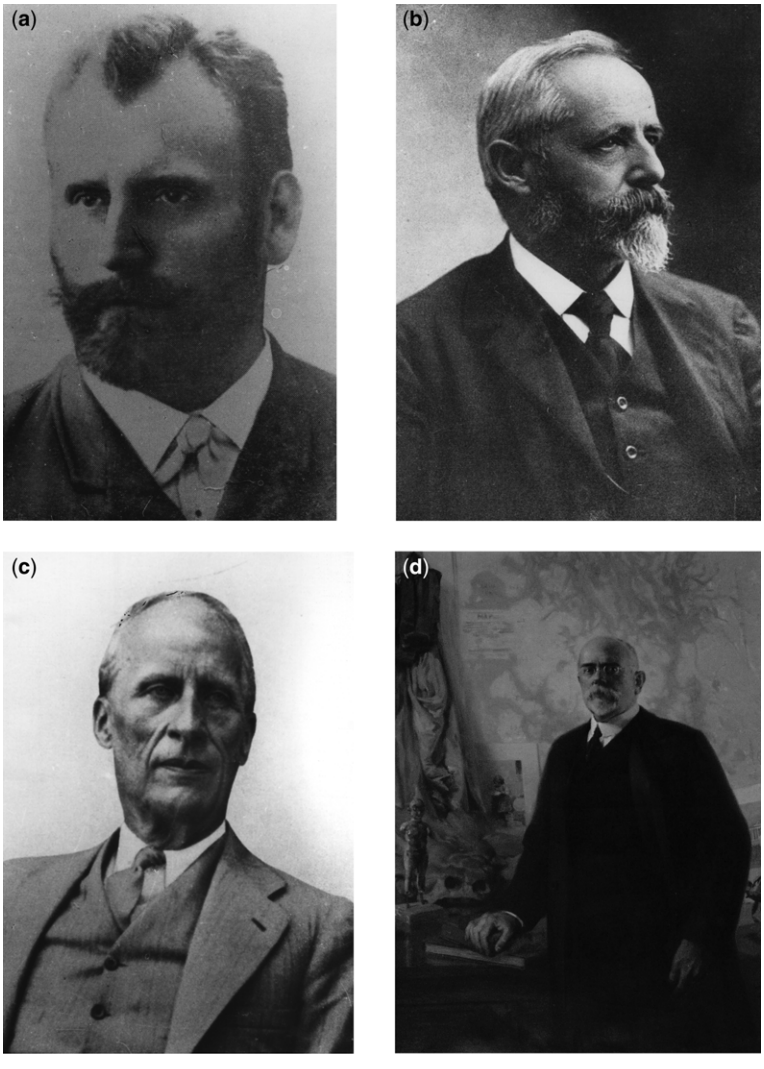

Fig. 5. (**a**) Rudolph Hauthal (1854–1928); (**b**) Santiago Roth (1850–1924); (**c**) Carl Burckhardt (1869–1935); and (**d**) Francisco P. Moreno (1852–1919).

countless observations were made and thousands of samples were collected and studied by the Museum staff or third-party collaborators.

Explorations and research were carried out within a true team effort, with precise instructions and as quickly as possible in relation to the available resources. Field trips were executed following written instructions drawn up by Moreno, who, in most instances, oversaw them personally on the ground. There he discussed the reasons for the studies, the goals to be achieved, the topographic and geological maps to be drawn, the fossils and rocks to be collected and the arrangements to be made for shipping the collections to the museum, the trip logistics and the responsibilities of each party member (e.g. Moreno 1896). Nothing was improvised and routes and alternative tasks were anticipated. The material collected in the field was studied immediately by the Museum staff or specialists from other institutions and the results of the work were released immediately, mostly through the Museum's own publications.

Thus, in just 10 years, a virtually unexplored region of Argentina hundreds of thousands of square kilometres in size was studied. The advancement of the geographical and geological knowledge produced in such a short period can be considered as one of the most important in the history of these sciences in the country.

Only four men had primary responsibility for all this work: Rudolph Hauthal (1854–1928) (Fig. 5a), Santiago Roth (1850–1924) (Fig. 5b) and Carl Burckhardt (1869–1935) (Fig. 5c), who made the discoveries in the field, and Francisco P. Moreno (1852–1919) (Fig. 5d), who planned and oversaw all tasks from the field studies to the printing of publications. It is not surprising that Moreno (1896), in recommending more systematic work, looked forward to the time when 'a dozen of active geologists' could investigate the country.

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