

The early history of the Spanish Geological Survey: the Commission for the Geological Map of Spain (1849–1910)

Abbreviated title: Early history of the Spanish Geological Survey

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Abstract: It was not until the mid-nineteenth century that geological investigation in Spain became institutionalised. This occurred in 1849 when a commission was formed to create a geological map of the province of Madrid, work on which was scheduled to culminate in the creation of a national geological map. Despite its name, the idea was not only to cover geological cartography but also to create a geographical map and catalogues of the botanical and faunal resources. After the commission was dissolved in 1859, these objectives were lost, and work on the geological map continued in the General Statistics Board. The project was once again modified in 1870, with the creation of a new organisation, the Commission for the Geological Map of Spain, which fulfilled its objectives in 1889 with the publication of the first national geological map. The change of paradigm produced by the loss of the colonies and the need to discover new sources of wealth and take advantage of the subsoil's resources was the reason for a change in the Commission's aims. The institution was modernised in 1910 and became the new Spanish Geological Institute, which in January 1927 would be re-formed as the Spanish Geological and Mining Institute.

Knowledge of Spanish geology up until the mid-nineteenth century was extremely scarce and fragmented. During the eighteenth century, Spanish science experienced moments of glory through a wide-ranging reform plan undertaken to alleviate Spain's considerable scientific and technological underdevelopment. Though scientific activity in universities was almost non-existent, several scientific or technical institutions were created, and many Spaniards were awarded a grant to continue their studies in diverse European countries. Evidence of that magnificence was the creation of the *Real Gabinete de Historia Natural* (Royal Cabinet of Natural History), the *Real Gabinete de Máquinas* (Royal Machinery Cabinet), the *Real Seminario de Minería* (Royal Mining Seminary), the *Academia de Artillería de Segovia* (Segovia Artillery Academy) and the *Observatorio de la Marina* (Navy Observatory). The latter promoted significant scientific works, such as the Malaspina Expedition (1789–1794), the first Spanish project to circumnavigate the globe in order to map territories, explore the seas and gather information on populations, flora and fauna.

This momentum was lost in the early nineteenth century. The Napoleonic invasion and the Peninsular War put an end to these efforts at scientific renewal. Many institutions found it difficult to continue their activities. In the field of mining, the process of colonial emancipation

which began in 1809 negatively influenced the scientific bodies established to investigate American natural resources.

One could state that geological investigations in Spain were not legitimised until the first *Ley de Minas* (Mining Act) was passed in 1825, which had the aim of promoting and regulating Spanish mining. It was the first Director General for Mines, Fausto Elhuyar (1775–1833) – the co-discoverer, along with his brother Juan José, of tungsten – who promoted in 1829 the study of natural coal seams in northern Spain for industrial use. In 1830, he contracted the German mining engineer Guillermo Schulz (1805–1877) to create the geological map of north-west Spain (a region with significant mineral resources), and in 1832, the military professional Angel Vallejo (1778–1840) to collaborate on the project to create the geological map of Spain. As well as their work, and some regional investigations carried out by mining engineers from their locations in different Spanish provinces, there were several other studies conducted by foreign engineers, geologists and naturalists who, for different reasons, became interested in Spain during the first half of the nineteenth century (Rábano 2015). It was not until 1849 that a moderate government in the service of Queen Isabella II encouraged the furthering of knowledge of the country's natural resources for the benefit of industry, agriculture and farming, and the institutionalization of geological investigations in Spain took place.

A commission of engineers and naturalists in her majesty's service

The proposals advanced in the first half of the nineteenth century to obtain full knowledge of the country's natural resources were not successful. A fresh attempt was made in 1849 by the government of Queen Isabella II through the creation of a "Commission to create the geological map of the terrain of Madrid and bring together and coordinate the data for the general [map] of the Kingdom" (soon to be known as the *Comisión del Mapa Geológico*, or Commission for the Geological Map [of Spain]). Despite this title, it would not be solely concerned with putting together the geological map, but must also gather geographical data to support the creation of the map and collect zoological and botanical information into a series of catalogues on the country's natural productions. In essence, this was an innovative project for its time; one in which the association of engineers and naturalists working side by side was to provide the nation with valuable tools for improving the quality of life. Likewise, it should be used as a working model: a methodology would be implemented that would collate all the data from one province, which would then be used as a template for the other provinces, culminating in the full knowledge of the country's natural resources.

The Commission was organized into five sections that were to deal with all the branches of natural history: the Geographical/Meteorological, the Geological/Mineralogical, the Geological/Paleontological, the Botanical and the Zoological sections. The first of these sections was led by the highway engineer José Subercase (1812–1885), and his aim was to set out the geographical map of Madrid province, which would be used as the model by which the other sections must detail their results. The second section was entrusted to the mining engineer Rafael Amar de la Torre (1802–1874), whose job it was to recognise the igneous terrain in the province. For sedimentary terrain, he was helped by another mining engineer, Casiano de Prado (1797–1866). Both sections had to start by building the geological map of

Madrid province, and continue with the other provinces in order to gain full knowledge of the country's geology. The Zoological and Botanical sections were led by the naturalists Mariano de la Paz Graells (1809–1898) and Vicente Cutanda (1804–1866), respectively, from the Museum of Natural Sciences and the Botanical Garden. Of these five personalities, Prado and Graells were the two who doubtless excelled most in Spanish science of the time and were most active in the Commission.

Casiano de Prado (Fig. 1) was a mining engineer and an exceptional geologist. He was known to be impulsive and non-conformist and he had faced many administrative problems during the period when he was director of the Almadén mercury mines. This was from 1841 to 1843, in a period when Spain was a world mining power and the foremost producer of this metal, which maintained its strategic value due to the decline of the Peruvian mercury mines. In 1843, Prado was replaced in his position at Almadén because he agreed with General Espartero's liberal, progressive ideas. The selfless work he had undertaken at Almadén, as was the case in the previous positions he had held, sparked great jealousies in his predecessors in the post. These machinations, along with the political movements of the time, caused the Director General of Mines, Rafael Cavanillas, to pen three reports against him. In them, he accused de Prado of a decrease in mercury production, delays in reaching deeper areas of the mines, and the poor state of repair of the reinforcement timber. Hounded by Cavanillas, in June 1844, de Prado resigned from his position in the Corps of Mining Engineers and henceforth devoted himself to the private practice of his profession. In June 1848, he rejoined the Mine Corps and was named inspector in the district of Madrid, where he began work on the geological map of the province. But in December of that same year he was commissioned to undertake a mission in the mines of Riotinto, where once again he had problems with his superiors (González Fabre 2004). He was relieved of his commission and given another position, one more suitable to his character. It was at this juncture that they named him director of one of the sections of the recently formed Geological Map Commission. It should be noted that in 1849 de Prado was of an age that could be considered advanced: fifty-two. Yet he was in fighting form, both physically and intellectually, and keen to devote himself to what he loved – scientific investigation, a job that enabled him to discover and disseminate multiple aspects not just of national geology but also of palaeontology and archaeology, which he exercised tirelessly until his death in 1866, when still on active service (Gutiérrez-Marco & Rábano 2011). In addition to all his achievements in the field of geology, de Prado introduced prehistoric studies to Spain (García Sánchez & Ayarzagüena Sanz 2000) as well as the practice of mountain climbing. He was the first person to scale the second-highest of the *Picos de Europa* (Peaks of Europe) in 1856 (Villa 1997).

Mariano de la Paz Graells (Fig. 2), the Commission's zoologist, was the founder of modern entomology in Spain. His professional activity was linked to the Museum of Natural Sciences in Madrid, where he arrived in 1837 from Barcelona, a city where he had held the Chair of Zoology and Taxidermy at the Academy of Natural Sciences. In 1851, the naturalist became the director of the Museum, a post he held for sixteen years. He was the director of the Cabinet of Natural History, of the Botanical Garden and a promoter of an innovative experience for the time, a zoological garden for the acclimatisation of exotic species, an experience that was tried for the first time in France in 1854, via the *Société zoologique d'acclimatation* (Aragón 2005). After stepping down from the institution in 1867, Graells continued his teaching and research

practically to the end of his days. Graells was always conscious of the scarce knowledge Spain possessed regarding its own natural productions. This situation, along with the need to have information on the national subsoil for the benefit of mining, were the motors that spurred the government to create the Commission for the Geological Map in 1849 (Rábano & Aragón 2007).

The sections of the Commission worked irregularly and with serious financial problems for several years, until in late 1859 a Royal Order dissolved the Commission (Rábano 2015). The Geographical section was the one that held the greatest financial and human resources, but the objective of completing the geographical map of Madrid was not achieved. The creation of a new Commission for the Geographical Map in 1853, dependent on the War Ministry, meant the transfer of those competencies to the new Commission, so the section was badly weakened, reduced just to its topographical aspects. Of the two geological sections, the Geological/Paleontological, under the command of Casiano de Prado, was the first to achieve its objectives. In 1853, de Prado published the geological map of the province of Madrid, on a 1:400,000 scale, and his exhaustive dedication to geological investigations meant that that same year he also finished the map of Segovia province. In later years, he completed the provinces of Valladolid (1854) and Palencia (1856). With the aim of progressing in the study of certain regions, in 1854 new sections were created in support of the geological works. For example one, led by Juan Vilanova (1821–1893), was devoted to geological study of the Kingdom of Valencia, while others were dedicated to investigations into coal seams. However, they did not achieve their objectives. The Geological/Mineralogical section barely engaged in any activity. Vicente Cutanda, in charge of the Botanical section, always had numerous problems coordinating his work in the Botanical Garden with his field campaigns, so his results were not very noteworthy. Yet the Zoological section was highly active due to the strong personality of its director, Mariano de la Paz Graells. He undertook numerous campaigns to categorise the fauna of Madrid, completing several catalogues, which he published extensively in the Commission's reports. Yet the task was so vast and support staff so scarce that the Commission's dissolution meant he was unable to complete his work.

Only maps: the period of the General Statistics Board

This model combining all the aspects of the country's natural history into a single commission had been shown not to be viable, especially in a country affected by huge political instability and with serious economic problems. In 1856, the *Comisión de Estadística del Reino* (Statistics Commission of the Kingdom of Spain) was created. This was a consultative organisation for the President's Office of the government, to unify the statistical operations that were carried out in the different branches of the government administration. It was reorganised as the General Statistics Board in 1861. In 1859, all the cartographic departments were brought together in this body: maritime, geological, hydrological, forestry, urban and surveying. That was the year in which the Commission for the Geological Map ceased its operations, and construction of the geological maps continued in the Statistics Commission. Three of the mining engineers who had been working for the recently dissolved organisation continued in the new body as the heads of its geological brigades: Casiano de Prado, Amalio Maestre (1812–1872) and Juan

Manuel Aránzazu (1817–1880), who were joined later by Federico de Botella (1822–1899) and Felipe Martín Donayre (1825–1890). A promising new age began for the advancement of geological knowledge in Spain, since the reorganisation that the government proposed to reinforce the cartographic and land registry operations meant an increase in the funds earmarked for Statistics.

From 1860 to 1867, geological studies for the provinces of Palencia, Santander, Teruel, Barcelona, Tarragona, Burgos, Navarra, Álava, Guipúzcoa, Vizcaya, Logroño, Soria, Zaragoza, Guadalajara and Madrid were completed. Casiano de Prado published the Madrid study in 1864, improving on the one he had published in 1853. This map complemented his fundamental work on Madrid geology, *Descripción física y geológica de la provincia de Madrid* (Physical and geological description of Madrid province) (Prado 1864).

To demonstrate to European countries that Spain was also advancing in its knowledge of its national territory, in 1861, the General Statistics Board prepared a plan to gather all the geological information available and collate it into a single national geological map. This project arose as a reaction to the news that had come from France that Édouard de Verneuil (1805–1873) was preparing a map with information on Spain to contribute to the geological map of Europe. Verneuil had extensive knowledge on Spanish geology as a result of eleven explorations he had undertaken in the country from 1849 to 1862 (he concluded the twelfth in 1867) (Truyols 2008, Aragonés 2013). In 1863, Amalio Maestre completed his synthesised map on Spain's geology, into which he projected the knowledge he had gained to date. Yet publication was delayed until 1864 due to the complex internal bureaucracy to which he had to submit for approval, as well as a last-minute decision to change the scale and the corrections that had to be made at its author's request. The same year Verneuil also completed his *Carte géologique de l'Espagne et du Portugal*, in collaboration with Édouard de Collomb (1801–1875).

The revolution of September 1868 ended the reign of Isabella II, paving the way for several democratic governments, which found the government coffers empty and a large debt. The Ministry of Development (Fomento) cancelled many of the projects that it had been running in the area of natural resources, and modified its strategies in the area of mining resources with the aim of attracting foreign capital. The General Statistics Board stopped producing its thematic maps. The geological brigades were dissolved and the projects for creating the geological map cancelled.

The geological map of Spain: termination of a long-awaited project

After many years of different governments hatching and unravelling strategies to map the territory during the reign of Isabella II, the situation changed with the cultural dynamism of the ensuing period. The so-called *Sexenio Democrático* (democratic six-year term from 1868 to 1874) and liberalisation of the Bourbon monarchy, restored in the 1880s, encouraged development of earth sciences. During the *Sexenio* the foundations were laid for a lasting reform of the institutions which were to show leadership in undertaking these tasks. Specifically, two institutions were created in 1870: the *Instituto Geográfico* (Geographical

Institute), in charge of geographical, topographical and land registry studies, and the new Commission for the Geological Map, which would be solely responsible for national geological cartography. These decisions passed through the hands of the then Minister for Development, José Echegaray (1832–1916), a singular and multi-talented figure in late nineteenth-century Spain. He was a highway engineer, a politician, an economist, a mathematician and a writer (he received the Nobel Prize for Literature in 1904), and he pushed through significant improvements in his ministry.

The new Commission for the Geological Map remained dependent on the Corps of Mining Engineers, and was composed of seven board members to be named by the Minister for Development. Felipe Bauzá y Rávora (1802–1875) was appointed as head of the Commission and certain engineers who had worked for Statistics, such as Federico de Botella and Felipe Martín Donayre, continued to collaborate. In 1870, the Commission also added to its team a young engineer by the name of Lucas Mallada (1841–1921) who would play a fundamental role years later, as we shall see below.

The organisation for the creation of the geological map was structured into three departments and, as in previous periods, requested the engineers stationed in the provinces to provide their data to that the regional geological maps could be created more quickly. Yet, as on previous occasions, the reality was quite different. The government did not provide this new project with the necessary resources, nor did the team receive the desired responses from the provinces which were so critical for the project's success. From 1870 to 1873 the team managed to complete very few projects, none of which were published. In early 1873, Felipe Bauzá retired and another mining engineer was named Director of the Commission: Manuel Fernández de Castro (1825–1895) (Fig. 3). He occupied the position for 22 years, up until his death. This long presidency provided the Commission with a stability and magnificence in terms of achievement that it had lacked up until that point. Fernández de Castro always made sure that the goals were reached, the ultimate aim of which was the creation of the geological map of Spain.

With the aim of transforming the Commission into a stable organisation, Fernández de Castro proposed a new structure to the ministry: a special department of a higher rank, one which would approve the annual reports and the projects submitted for publication; as well as an executive commission, formed of mining engineers devoted exclusively to the creation of the geological map. Furthermore, the Commission was placed under the coordination of the *Junta Superior Facultativa de Minería* (Higher Faculty Board of Mines), an organisation of the Ministry of Development that was not subject to political fluctuations. To disseminate his results, Fernández de Castro created two new series of publications, in a format similar to what geological societies in London and France were publishing. On one hand, *Memorias de la Comisión del Mapa Geológico de España* (Reports of the Commission for the Geological Map of Spain) would publish the provincial geological sketches that would contribute to the national geological map; and on the other, the *Boletín de la Comisión del Mapa Geológico de España* (Bulletin of the Commission for the Geological Map of Spain) would document the progress occurring in geological and mining investigations in Spain, as well as containing Spanish translations of articles by foreign researchers on geology in Spain. The first *Memoria* (Report) was published in 1873 (Donayre 1873), and the first *Boletín* (Bulletin) in 1874. The latter

continues to be published to this day under the name *Boletín Geológico y Minero* (Mining and Geological Bulletin). It is the official journal of the *Instituto Geológico y Minero de España* (Geological and Mining Institute of Spain).

Fernández de Castro was the great ideologue and architect of the modern geological map, but he would never have achieved his objective had he not had people by his side who became committed to achieving his plans. Under his direction, many mining engineers formed part of the Geological Map Commission and contributed significant results (Rábano 2015, tables 10–13), among whom we can highlight Daniel de Cortázar (1844–1927), Joaquín Gonzalo y Tarín (1838–1910), Rafael Sánchez Lozano (1854–1922), Gabriel Puig y Larraz (1851–1917), Pedro Palacios (1847–1921) and Lucas Mallada, who was mentioned above.

Lucas Mallada (Fig. 4) was a young 29-year-old engineer when he joined the Commission's team in 1870. He worked there until his retirement in 1911. He was the author of geological records in eight provinces, and fervently believed in the application of fossils to geological investigations. He was the author of a catalogue of Spanish fossils, which aimed to be a practical tool for students of geological formations. He is considered the undisputed founder of Spanish Palaeontology, or at least of the branch of stratigraphical palaeontology. As a consequence of many journeys through Spanish geography to conduct his geological investigations, he was a direct witness of the social problems the country was suffering. His writings on the subject made him a leading figure in a cultural movement that arose in the late nineteenth century, known as Regenerationism. Mallada identified the physical and geological causes of poor soil quality, and asked the government to undertake actions to halt the deterioration of Spain – hounded by its loss of the colonial system and a notable backwardness in its scientific and technical system, as well as by a high illiteracy rate (Mallada 1890).

In 1889, sixteen years after taking over the reins of the Commission (and forty years after creation of the first Commission in 1849), Fernández de Castro achieved his goal: the first complete geological representation of Spain – the Geological Map of Spain at a scale of 1:400,000. From this, he also published a version on a scale of 1:1,500,000 (Fig. 5). The trust that Fernández de Castro placed in his faithful collaborator, Lucas Mallada, meant that Mallada was the person designated to write the monumental explanation of this map, which Fernández de Castro's subordinate split into seven volumes (Mallada 1895–1911).

The relationship between Spanish and Portuguese geologists had its beginnings in 1854, with the exchange of research residencies in their respective countries in order to cover common themes. Yet, beginning in 1870 these contacts increased as a result of an interest in sharing experiences and knowledge, as well as unifying the geological data on formations that were common on both sides of the border, but also due to Fernández de Castro's interest in including the Portuguese data in his geological map. Another reason for collaboration between both countries was the alliance they maintained with regard to the Geological Map of Europe, which had been initiated in 1881 under the direction of the coordinators of the Prussian Geology Service, Ernst Beyrich (1815–1896) and Wilhelm Hauchecorne (1828–1900) and was completed in 1896. Manuel Fernández de Castro from Spain and Filipe Nery da Encarnação Delgado (1835-1908) (better known as Nery Delgado), who from 1882 was director of the Commission for the Geological Map of Portugal, merged their respective information in order

to add Iberian geological data to the Geological Map of Europe (Catalá-Gorgues & Carneiro 2013).

With Manuel Fernández de Castro's death in 1895, the most prosperous period for geological investigation in Spain to date drew to a close. The words of Mallada's speech of admittance to the Royal Academy of Sciences of Madrid in 1897 are highly significant when he referred to the years in which he worked under Fernández de Castro's intelligent direction:

What movement! What boiling activity in that vertiginous period, thanks to the tireless zeal, to the wise leadership of Fernández de Castro! As the finished volumes [of the *Boletín* (Bulletin) and the *Memorias* (Reports)] were being distributed, the printers were setting the originals of the next volume, my colleagues were writing their reports and notes while preparing their plans and drawings as they travelled thousands of kilometres throughout Spain. (...) all our mountains, all our valleys, all our rivers and streams, all our plains were tirelessly and unflaggingly crossed by young scientists, [who were] roused and encouraged by such an enthusiastic Director.

Fernández de Castro's successors in the Commission presidency, Justo Egozcue y Cía (1833–1900), Gregorio Esteban de la Reguera (1831–1915) and Ramón Pellico y Molinillo (1843–1903), did not achieve any noteworthy results. It wasn't until a close collaborator of Fernández de Castro's, Daniel de Cortázar, was named president of the Commission in 1901 that the deceased president's spirit of enterprise was rekindled. The *Boletín* and the *Memorias*, which have been suspended, began to be published again, geological and mining explorations were once more undertaken and new themes for investigation were suggested, such as hydrogeological studies. Cortázar's resignation in 1908, due to differences of opinion with the Minister for Development, led to the appointment of Luis Mariano Vidal y Carreras (1842–1923), a Catalan mining engineer who only directed the Commission for a year, but who brought in a gust of fresh air and modernised its publications. After him, the directorship was occupied by Luis Adaro y Magro (1849–1915), the last president of the Commission for the Geological Map of Spain. The reorganisation that occurred in the institution in 1910 changed its working model and even changed its name to the Instituto Geológico de España (Spanish Geological Institute). It continued with the creation of the Geological Map of Spain, but would also become responsible for new lines of work, among which were investigations into mineral and energy resources and subterranean waters. The recently created Spanish Geological Institute formed a new team of mining engineers whose productive efforts made possible the transfer and extension of competencies from the Commission for the Geological Map of Spain to the current Spanish Geological and Mining Institute.

Conclusions

The creation of the first Geological Map of Spain followed a torturous route throughout the second half of the nineteenth century. It had its beginnings in 1849 when a moderate government in the service of Queen Isabella II proposed to increase knowledge of Spain's natural history. This was when the institutionalisation of geological investigation took place in Spain with the creation of the "Commission to form the geological map of the territory of Madrid and collate and coordinate the data from around the kingdom for the general map",

which was to provide the nation with valuable tools for improving its quality of life. Under this title, a team of engineers and naturalists was formed to gather the geographical and geological data, as well as zoological and botanical information into catalogues of the country's natural productions. The political circumstances and economic problems that Spain experienced during the second half of the nineteenth century seriously affected this Commission's progress. Alternating moderate and progressive governments, along with the political and economic events that shaped the period, were faithfully reflected in the arduous progress of this enterprise, which was suspended in late 1859. The different investigations then set off on separate paths and construction of the geological map was transferred to be part of a master plan within the General Statistics Board which, in pursuit of more efficiency, took over the creation of all the thematic maps.

It wasn't until 1870 when a new Commission, made up of mining engineers only, was set up to create the national geological map. In order that political circumstances would not again adversely affect a plan as vital to the country as this one – namely deciphering the territory's geological nature – in 1873 the Commission for the Geological Map of Spain, as it was formally called from then on, was separated from the political administration and came under the direct responsibility of the Corps of Mining Engineers. In 1889, forty years after it was begun, the geological representation of the country was finally completed, culminating in the creation of the Geological Map of Spain at a scale of 1:400,000. The change of paradigm produced by the loss of overseas possessions and the need to discover new sources of wealth and take advantage of the subsoil's resources led to changes in the Commission's aims at the beginning of the twentieth century and its reorganisation in 1910. As a result of this, the institution was modernised and became the new Spanish Geological Institute, which in January 1927, after Spain's celebration of the XIV International Geological Congress in 1926, once again reviewed its functions and adapted them to new national needs, and was reorganised as the Spanish Geological and Mining Institute.

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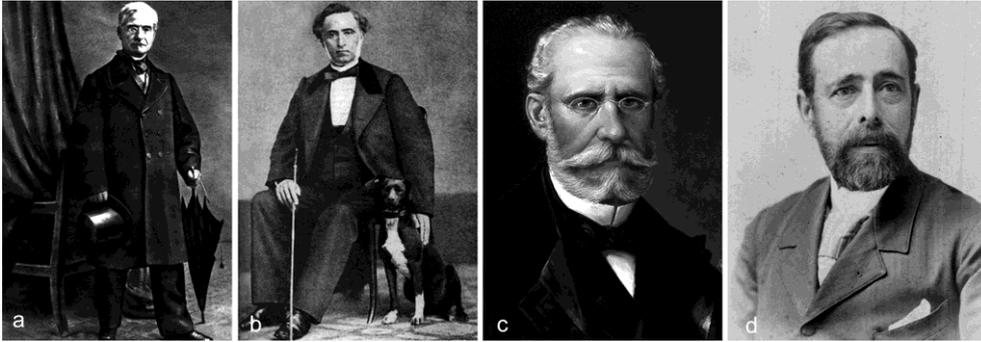


Fig. 1. a, Casiano de Prado (1797–1866). Photo by Bisson Frères, Paris. Spanish Geological and Mining Institute. b, Mariano de la Paz Graells (1809–1898). Portrait published in Issue 1 (1943) of the magazine *Graellsia* (Rábano, 2015). c, Manuel Fernández de Castro (1825–1895). Portrait gallery from the Spanish Geological and Mining Institute. d, Lucas Mallada (1841–1921). Family archive (Rábano, 2015).

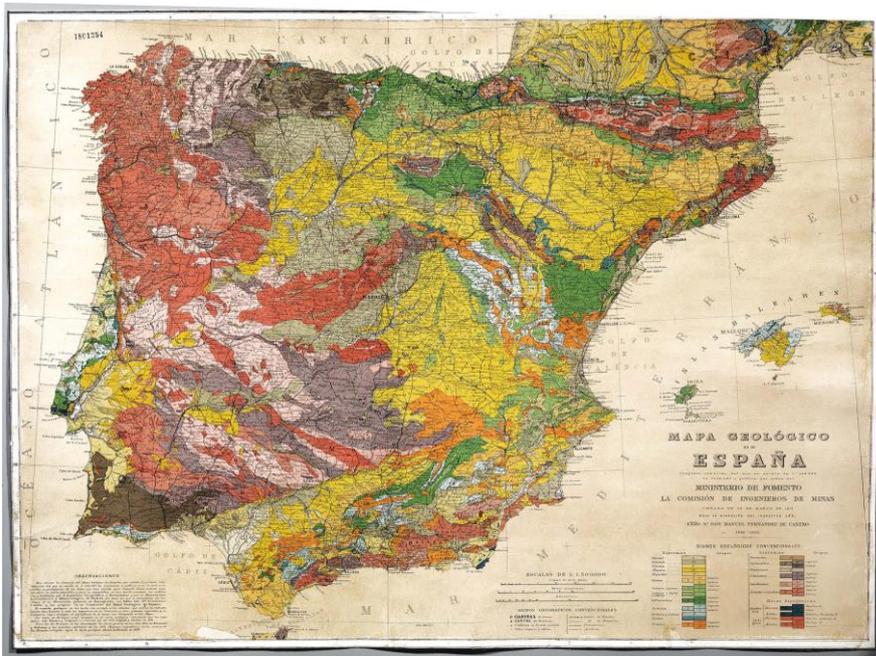


Fig. 2. Geological map of Spain, published in 1889 on a scale of 1:1,500,000, under the direction of Manuel Fernández de Castro, the president of the Commission for the Geological Map of Spain. Spanish Geological and Mining Institute.