BJHS 0(0): 1–32, Month 2011.
doi:10.1017/S0007087411000306

Like birds of a feather: the cultural origins of Iberian geological cooperation and the European Geological Map of 1896

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Abstract. This paper focuses on the relationships between Spanish and Portuguese geologists during the second half of the nineteenth century, and their cooperation in Iberian and European scientific projects, with particular emphasis on the geological map of Europe, whose publication, in 1896, was a symbolic demonstration of Prussia's capacity to dominate the whole continent. We argue that the period from 1857 to 1896 defined a cycle in the relationships between Spanish and Portuguese geologists marked by common generational aspirations, converging intellectual pursuits and political and ideological affinities associated with the intellectual and political movements which stirred the cultural and political life of both Iberian countries. At a time when the unification of Iberia was being discussed on both sides of the Spanish–Portuguese border, this background favoured and shaped cooperation between the Spanish and Portuguese geological surveys, in particular their participation in the geological map of Europe, which, nevertheless, coincided with the end of this cycle in Iberian geology.

The cultural origins of Iberian geological cooperation

In the second half of the nineteenth century, the collaboration between the Geological Surveys of Spain and Portugal derived not only from the need to describe geologically their common territory, but also from the interactions between cultural and political movements which sprang up on both sides of the Iberian border and whose ideological orientations were shared by distinguished Spanish and Portuguese geologists.

In the mid-1860s, the Spanish Moderantismo (or Moderate Party), in power since 1844, was in deep crisis for having been unable to solve the problems affecting the country – the discredit of the Crown and of government institutions, a serious economic depression, an erratic foreign-affairs policy and ensuing military

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The research underlying this paper was carried out in the context of the research project PTDC/HCT/65345/2006, Das Comissões Geológicas aos Serviços Geológicos (1848–1970): História e Herança Científica, funded by Fundação para a Ciência e Tecnologia, Portugal; and of the scholarship programme promoting mobility of teaching staff of the Fundación Universitaria CEU – San Pablo and Universidad CEU – Cardenal Herrera, Spain. Both authors wish to thank Isabel Rábano, director of the Museo Geominero, Instituto Geologico y Minero de España, for kindly supplying the images of the maps included in this article, and the staff of the Historical Archive of Laboratório Nacional de Energia e Geologia, Portugal, in particular Mrs Paula Serrano, for their kind help.

rebellions.[1] The Revolution of 1868, known as La Gloriosa, overthrew Isabel II, and produced the Generation of 1868 (Generación del 68), a movement characterized by a bourgeois political outlook and optimism towards Spain's future as a modern and democratic nation.[2] This period, known as the Six Year Democracy (Sexenio Democrático), ended with the conservative Bourbonic Restoration (*Restauración*) in 1874.[3]

After the Restoration, Spain endured a major blow, in 1898, with its defeat in the war against the United States, which resulted in the loss of Cuba, Puerto Rico and the Philippines. Following these events, a group of intellectuals known as the Generation of 1898 (Generación del 98) reflected on the Spanish situation and adopted a hypercritical and leftist tone in their writings. They were strongly influenced by Regenerationism (Regeneracionismo), a movement which had set out to reflect on the causes of Spain's decline and whose analyses aimed at being objective, documented and scientific.[4]

One of the key materializations of these movements was the foundation, in 1876, of the Free Institution for Teaching (Institucion Libre de Enseñanza), a private, laic institution which covered primary, secondary and higher education. Its leaders advocated freedom of teaching and refused to conform to official dogma in matters of religion, politics and morals.[5] The Free Institution had exceptional repercussions on Spanish intellectual life and was decisive in its renovation. Its main source of inspiration was Karl Krause (1781–1832) and his federalism. Although Krausism was not widespread in Spain, it influenced leading Spanish intellectuals associated with Regenerationism and the Free Institution,[6] such as Eduardo Benot Rodríguez (1822–1907), Francisco M. Tubino (1833–1888), José Macpherson y Hemas (1839–1902) and Lucas Mallada (1841–1921), among others,[7] who corresponded and collaborated with two leading geologists working in the Portuguese Geological Survey, Carlos Ribeiro (1813–1882) and Nery Delgado (1835–1908).

In Portugal, the victory of the Liberals in the revolution of 1820 entailed the transition from an absolute to a constitutional monarchy.[8] Following the civil war (1831–1834),

1 Miguel Artola, *Historia de España Alfaguara. V. La burguesía revolucionaria (1808–1874)*, Madrid: Alianza, 1974. Francisco J. Paredes (ed.), *Historia contemporánea de España (siglo XIX)*, Barcelona: Ariel, 1998.

2 Paredes, op. cit. (1); and Juan I. Ferreras, 'La generación de 1868', in Iris M. Zavala (ed.), *Historia y crítica de la literatura española. Romanticismo y realismo*, vol. 5, Barcelona: Crítica, 1982, part 1, pp. 416–420.

3 The six years' political crisis can be divided into three stages: constitutional monarchy, federal republic, unitarian and presidential republic. Following these three stages the Bourbon monarchy was restored. Paredes, op. cit. (1).

4 Paredes, op. cit. (1). Purificación Mayobre, *O Krausismo en Galicia e Portugal*, Coruña: Edicións do Castro, 1994.

5 Vicente Cacho, *La Institución Libre de Enseñanza*, Madrid: Rialp, 1962. A. Jiménez-García, *El krausismo y la Institución Libre de Enseñanza*, Madrid: Ediciones Pedagógicas, 2002.

6 Paredes, op. cit. (1); Mayobre, op. cit. (4). Juan López-Morillas, *El krausismo español. Perfil de una aventura intelectual*, México: FCE, 1956.

7 For the relationships between some leading Spanish scientists and the Free Institution for Teaching and Krausism, see José M. Sánchez-Ron, *Cincel, martillo y piedra: Historia de la ciencia en España (siglos XIX y XX)*, Madrid: Taurus, 1999, pp. 85–122.

8 These events were influenced by the Spanish Liberal Revolution of 1820, the Portuguese Constitution being inspired by the Spanish Constitution of 1812.

a period of political stability known as the Regeneration (Regeneração) (1851–1868) ensued, whose impact lasted until the late nineteenth century.[9] The Regeneration implemented various reforms aimed at encouraging economic growth and bridging the gap which had separated Portugal from developed European countries.

In 1852 was created the Ministry of Public Works, Trade and Industry (Ministério das Obras Públicas, Comércio e Indústria), an emblematic governmental structure of this period,[10] in the context of which the Portuguese Geological Survey (Comissão Geológica do Reino) was established in 1857, headed by Carlos Ribeiro and Pereira da Costa (1809–1889), as a section of the Geodesic Directorate, led by Ribeiro's friend, General Filipe Folque (1800–1874).[11]

Like Spain, in those days Portugal also experienced influential intellectual movements, notably the Generation of 1870 (Geração de 70), whose members shared an internationalist outlook and advocated the aesthetics of realism and social progress based on science.[12] They were a local expression of the growing interest in sociological positivism and historicism, utopian socialism, Darwinian evolution, and to some extent Marxism. From 1873 to 1875, the 1870 Generation gave way to Defeated by Life (Vencidos da Vida), who reflected on the causes of Iberian decline, and aimed at associating Spain with their project of cultural and social renovation.

Following the Franco-Prussian War (1870–1871), the winds of unification swept Europe, culminating with the unifications of Germany and Italy, which nurtured longings for a unified Iberia. Among the group of Spaniards invited to associate with the Defeated by Life was Tubino, a Freemason and political activist, and leading actor of Spanish intellectual history between La Gloriosa and the Spanish First Republic.[13] An archaeologist and palaeontologist, disseminator of positivism and evolution in Spain, Tubino admired the archaeological work of Ribeiro and corresponded with Delgado.

In the scientific realm, the relationships between Portugal and Spain are hardly known, although they do not seem to have followed the same pattern of the humanities, for which France was the reference. To eminent Portuguese scientists, Spanish science became not merely a matter of interest, but a reference and a model to follow.

Ribeiro and Delgado corresponded with thirty-seven colleagues in Spain, which reflects the difference in the size of the countries and of their respective geological communities. They consolidated through mutual visits, correspondence and cooperation in international enterprises, among which were committees dealing with geological nomenclature and the production of maps, notably participating in the European

9 Maria Filomena Mónica, *Fontes Pereira de Melo*, Porto: Afrontamento, 1998.

10 The ministry became instrumental in the political measures oriented towards the modernization of the country, notably the construction of basic infrastructure associated with transport, regulation of trade and industry, population census and other statistics, and cartography.

11 Both had attended the Army School and fought in the Liberal civil wars.

12 José Mattoso (ed.), *História de Portugal*, Lisbon: Editoral Estampa, n.d.; António José Saraiva and Óscar Lopes, *História da Literatura Portuguesa*, Oporto: Porto Editora, 1975; Maria Filomena Mónica, *Vida e obra de José Maria Eça de Queirós*, Lisbon: Record, 2001.

13 Alejandro R. Díez, 'El pasado revalorizado. Orígenes culturales y Arqueología en el Ateneo de Madrid, 1838–1918', *El Ateneo. Revista científica, literaria y artística* (1996) 7, pp. 56–77.

geological map under the umbrella of the International Geological Congress. The epistolary exchange of these Portuguese geologists went beyond their colleagues of the Spanish Survey, as it encompassed naturalists working on their own or in schools and other Spanish institutions. The exchanged reports and correspondence not only reveal the motivations of the geologists, but also show that geological surveys and cartography, as part of state apparatus, often played an informal role in diplomacy between European states, and in this case between the scientific elites of both Iberian countries.[14]

The subject of the geological map of Europe, coordinated by the Prussian geologists Ernst Beyrich (1815–1896) and Wilhelm Hauchecorne (1828–1900), published in Berlin in 1896, has not been addressed by the secondary literature, which makes analysis of Iberian participation difficult. Fifteen years elapsed between the decision to begin the geological map of Europe and its publication, which reflects the effort and difficulties encountered in the process: first, the coordination of geological information generated in the various countries, in distinct stages of geological reconnaissance and working at different paces, had to be articulated and harmonized; second, the codes used in the representation of geological information needed standardizing; and finally, the complex negotiations between participants, both in the political and scientific domains, had to be completed satisfactorily.[15]

Approaching this question from the vantage point of the Iberian Peninsula seems, however, rewarding, despite the absence of reference studies on the history of the geological map of Europe and its partial character, insofar as both Portugal and Spain were not key players on the European chessboard; rather they were simultaneously participants and spectators more or less uncompromised by the hegemonic pretensions then in play. Despite the territorial differences and distinct orientations of their respective geological surveys, especially regarding foreign affairs, analysis of their participation shows how Portugal and Spain overcame disagreements on the interpretation of geological data and articulated the graphic representation of the geological units they share on the European geological map.[16]

The transnational and international characteristics of nineteenth-century geology are all the more interesting as they coexisted with the eruption of nationalism in Europe. During this period, geological maps, complex objects from the scientific point of view, were invested with multiple meanings.[17] In addition to being a sophisticated product of geological knowledge they gained a symbolic dimension as they became not only part of the paraphernalia of national and regional symbols, but also emblems of internationalism.[18] On par with the ethnic origins of peoples, languages and national cultures,

14 Ana Carneiro, 'Nery Delgado (1835–1908): Diplomacia e Geologia', in *Minutes of Scientiarum Historia II/Encontro Luso-Brasileiro de História da Ciência*, Rio de Janeiro: UFRJ, 2009, pp. 337–343.

15 Jesús Catalá-Gorgues and Ana Carneiro, 'El projecte de la Carta Geològica d'Europa i la participació dels serveis geològics d'Espanya i Portugal', *Actes d'Història de la Ciència i de la Tècnica* (2010) 3 (forthcoming).

16 Catalá-Gorgues and Carneiro, op. cit. (15).

17 Martin J.S. Rudwick, 'The emergence of a visual representation for geological science 1760–1840', *History of Science* (1976) 15, pp. 149–195.

18 Ana Carneiro, 'L'usage technique et symbolique des cartes à la Commission Géologique du Portugal (1857–1908)', in Isabelle Laboulais (ed.), *Les usages des cartes (XVIIe–XIXe siècle). Pour une approche*

patriotism 'sacralized' territory, its cartographic representation being endowed with an iconic dimension: either in the case of vast empires or in the case of nations and regions under domination, geological maps provided a foundation and a means of affirming identity or autonomic pretensions. Concomitantly, archaeological and palaeoanthropological research in which various Europeans engaged by investigating the antiquity and origins of national peoples on a scientific basis contributed to the legitimation of national and regional identities, and to a global effort of affirmation of supremacy measured by scientific capability.[19] An international forum to discuss these matters, the International Congress of Anthropology and Prehistorical Archaeology (ICAPA), was established in 1865, in La Spezia, Italy.[20]

The very nature of geological knowledge, however, implied the need to articulate geological data from neighbouring territories, since geological units do not respect administrative divisions or national borders. Such an articulation entailed negotiation and consensus, which prompted the geological community to create another specific international forum. In 1878, the International Geological Congress (IGC) met for the first time in Paris.[21] From then onwards, the IGC was to reflect both the personal ambitions of individual participants and the rivalries and hegemonic pretensions of the European powers, particularly evident in 1881, when the agreement on publishing a geological map of Europe was reached, at the meeting in Bologna.[22]

Thus it comes as no surprise that from its inception the successive meetings of the IGC were not merely gatherings of geologists, but affairs of state, although not always explicitly. Despite the London meeting of 1888 being organized thanks to private contributions from expert and amateur geologists alike,[23] to a greater or lesser extent governments of different countries were involved in the organization of these events. The diplomatic corps was mobilized and official funding provided; the presence and support of monarchs, official authorities, and scientific and intellectual elites of the hosting countries accentuated the social dimension and political repercussions of these meetings.

pragmatique des productions cartographiques, Strasbourg: Presses Universitaires de Strasbourg, 2008, pp. 257–270.

19 Questions such as the most ancient human vestiges found in Sweden or Hungary or the craniological differences between races which populated Italy were debated in the ICAPA meetings. Recently, the tensions between nationalism and internationalism in anthropology have been dealt with by Chris Manias, 'The *race prussienne* controversy: scientific internationalism and the nation', *Isis* (2009) 100, pp. 733–757.

20 The meetings of the ICAPA had the following sequence: 1866, Neuchâtel; 1867, Paris; 1868, Norwich; 1871, Bologna; 1872, Brussels; 1874, Stockholm; 1876, Budapest; 1879, Paris; 1880, Lisbon; 1889, Paris; 1892, Moscow. See the *Compte rendu* of each of these meetings.

21 François Ellenberger, 'The First International Geological Congress, Paris, 1878', *Episodes* (1999) 22, pp. 113–117 (originally published in *Episodes* (1978) 1, pp. 20–24); *Compte rendu du Congrès internationale de géologie, 1ère session*, Paris, 1880. The meetings of IGC were held in Paris (1878), Bologna (1881), Berlin (1885), London (1888), Washington (1891), Zurich (1894) and so on.

22 Gian Battista Vai, 'The Second International Geological Congress, Bologna, 1881', *Episodes* (2004) 27, pp. 13–20.

23 J.F. Nery Delgado, *Relatorio ácerca da Quarta Sessão do Congresso Geologico Internacional realisada em Londres no mez de Setembro de 1888*, Lisbon: Imprensa Nacional, 1889.

It was then common practice that Portuguese geologists attending such meetings paid a visit to the Portuguese ambassador in the hosting country.[24] But at the IGC meeting of Bologna, Delgado participated not only as a geologist but also as a delegate of the Portuguese government, a fact that was not peculiar to the Portuguese. The absence of geologists acting as delegates of governments only occurred at the meeting in London, due to the private nature of its organization. In all, geologists' status depended on the interests at stake: at the Bologna meeting, Beyrich and Hauchecorne were representatives of the Prussian government,[25] and Edmond Hébert of the French, because at that point the location of the headquarters and the coordination of the geological map of Europe were being discussed, the final decision going to Prussia.[26] This was not simply a political instrumentation of geology and geologists; rather, it was a reciprocal phenomenon. Often, geologists developed strategies of persuasion in order to obtain the required funds and the stamp of officialdom, which they wished to imprint on their scientific endeavours, both in their countries of origin and at the IGC and ICAPA meetings.

Despite the relatively weak influence and poor resources of each country, the fact that the European geological map must cover all European countries made the cooperation of Portugal and Spain indispensable. Indeed all countries had varying motives. To Portugal, participation was an act of civilization and a demonstration of its capacity to join in with other nations; to Spain the map was not a priority; but to Prussia, it was an opportunity for imperial affirmation and a demonstration of its capacity to dominate the whole continent, even if only symbolically on a geological map.

Geological mapping

The theoretical and practical foundations underlying the elaboration of geological maps emerged in the early nineteenth century, in particular with the contributions of William Smith, who produced geological maps of England, Wales and part of Scotland, on a private basis. But within a few years, geological mapping became institutionalized, and from the 1830s onwards special services devoted to their making proliferated throughout Europe. In the mid-nineteenth century, geological maps began to be envisaged differently – territory was viewed from an imperial perspective and maps were

24 In his missions in Spain of 1872 and 1878, and the IGC meeting held in London in 1888, Delgado visited the Portuguese ambassadors.

25 Beyrich, in addition, was one of the IGC vice-presidents, together with Delgado Vilanova. See Gian Battista Vai, 'Giovanni Capellini and the origin of the International Geological Congress', *Episodes* (2002) 25, pp. 248–254.

26 *Compte rendu de la 2e session du Congrès geologique international*, Bologna: Imprimerie Fava et Garagnani, 1882. In addition to these was W.T. Blanford, representative of British Indies. In the 1888 London meeting there were no delegates from foreign governments, or if there were the British did not bother to print their names in the minutes. In the next meeting held in Washington, 1891, the delegates were: von Zittel, Bavarian government; M. Boule, Ministry of Education of France; A.D. Hodgesjr and E.C. Ochsenius, government of Peru; H. Golliez and C. Schmidt, Swiss government. See the *Compte rendu* of each of these meetings.

a means of 'thinking about the earth as a kind of empire, geological mapping being analogous to colonial acquisition'.[27]

The reading of a geological map, in addition, had to be as universal as possible. It was precisely with the aim of normalizing the verbal and visual language of geology that the IGC had been launched in 1878. Periodically, the Congress met with the intent of standardizing the nomenclature of stratigraphic divisions, and the symbols and colours to be used in maps. During this period, the successive IGC meetings, especially between 1881 and 1888, greatly contributed to this end, by reaching both provisional and definitive agreements on the names of many stratigraphic divisions, as well as on the colours and shades for their representation.[28] But this proved to be a difficult task and geological maps became even more problematic: their production was conditioned by distinct interests – political, economic and professional; it required funds, logistics, equipment and experts, not only for the fieldwork on which geological maps are based, but also for their graphic production;[29] it involved organized structures directly linked to central or local powers in matters of funding, planning and elaboration.

The Geological Surveys of Spain and Portugal

The Iberian Peninsula also participated in this movement as both Portugal and Spain organized their respective geological surveys for the production and publication of maps. The first effective organization of a Spanish geological service occurred in 1849, when a commission (Comisión del Mapa Geológico) was appointed to carry out the geological map of the province of Madrid and proceed with general map of Spain.[30] The first director was the engineer Fermín de Arteta y Sesma, but in that same year Francisco de Luján succeeded him, and managed to obtain from the government a modest budget, albeit enough to initiate the work.[31] During those years, various distinguished geologists became involved, such as Casiano de Prado and Guillermo Schultz, who subsequently headed the Spanish Geological Survey.

In the context of the Spanish Survey, memoirs on the geology of various provinces were published, together with the corresponding maps, but organizational and funding problems prevented the Survey from fully accomplishing its tasks. Although by the end

27 David Oldroyd, *Thinking about the Earth: A History of Ideas in Geology*, Cambridge, MA: Harvard University Press, 1996, p. 120.

28 Gian Battista Vai, 'A history of chronostratigraphy', *Stratigraphy* (2007) 4, pp. 83–97.

29 Norman E. Butcher, 'The advent of colour-printed geological maps in Britain', *Proceedings of the Royal Institution of Great Britain* (1983) 55, pp. 149–161. Karen S. Cook, 'From false starts to firm beginnings: early colour printing of geological maps', *Imago Mundi* (1995) 47, pp. 155–172. See also the thematic set of articles on geological mapping and geological surveys in *Earth Sciences History* (2007) 26, pp. 5–171, edited by Pietro Corsi.

30 Ana Blázquez, 'La contribución geológica del naturalismo: los trabajos del Mapa Geológico Nacional', in Josefina Gómez-Mendoza and Nicolás Ortega (eds.), *Naturalismo y geografía en España*, Madrid: Fundación Banco Exterior, 1992, pp. 79–134. Margarita Gutiérrez-Gárate and María Ángeles Rubi, *Cartografía geológica española del IGME*, Madrid, 2007. Isabel Rábano and Santiago Aragón, 'Nuevos datos históricos sobre la Comisión del Mapa Geológico de España', *Boletín Geológico y Minero* (2007) 118, pp. 813–826.

31 Juan M. López de Azcona, 'Mineros destacados del siglo XIX. Francisco de Luján y Miguel-Romero (1798–1867)', *Boletín Geológico y Minero* (1984) 95, pp. 610–617.

of the 1850s it had produced little,[32] in the 1870s it was reorganized and endowed with an administrative structure and a budget which ensured its continuity.[33] This new stage meant the close association of the Spanish Survey with the Corps of Mining Engineers and the end of its involvement of geologists from academia.[34]

In Portugal, prior to the creation of the Geological Survey in 1857, the mineralogical and geological knowledge of the country relied primarily on the occasional work of foreign visitors and was characterized by the lack of topographic maps on which to base geological mapping.[35] Although between 1848 and 1858 a first geological survey had been created in the context of Lisbon's Royal Academy of Sciences (Comissão Geológica e Mineralógica) the outcome was poor.[36] Its structure and organization, in additon, did not fit in the reorganization of the State apparatus of 1850, and its purposes and working methods were not in tune with European geological and cartographic practices.

The Portuguese Geological Survey (Commissão Geologica do Reino) was created on 18 August 1857, but its operation was marked by persistent difficulties regarding funds and scarcity of capable human resources, despite the commitment and scientific competence of its leading geologists – Ribeiro, Delgado and later Léon Paul Choffat, a Swiss geologist who served the instituion for more than three decades.

One of the most salient features of the Portuguese Survey was its willingness to establish relationships with the international geological community: memoirs and articles on Portuguese geology were published in French and its members corresponded with colleagues from all over the world. Occasionally, they inivited foreign experts to collaborate in exchange for the publication of the commissioned research and a Portuguese decoration, then a common pratice.[37] Portuguese geologists, in addition,

32 Manuel Fernández de Castro, 'Notas para un estudio bibliográfico sobre los orígenes y el estado actual del Mapa Geológico de España', *Boletín de la Comisión del Mapa Geológico de España* (1874) 1, pp. 17–68, 309–320; 'Noticia del estado en que se hallan los trabajos del Mapa Geológico de España en 1.º de julio de 1874', *Boletín de la Comisión del Mapa Geológico de España* (1876) 3, pp. 1–89.

33 Blázquez, op. cit. (30). Juan M. López de Azcona and José Meseguer, *Contribución a la historia de la geología y minería españolas*, Madrid: Instituto Geológico y Minero de España, 1964, pp. 137–163. Argimiro Huerga, 'Evolución histórica de la Comisión para la Carta Geológica de Madrid y General del Reino', in *idem* (ed.), *Ciento cincuenta años. 1849–1999. Estudio e Investigación en las Ciencias de la Tierra*, Madrid: Instituto Tecnológico Geominero de España, 2000, pp. 49–68.

34 Lluís Solé, 'Los más antiguos mapas geológicos de España', *Mundo Científico* (1983), 11 (23), pp. 252–262. The tensions between mining engineers on the one hand and university geologists and the naturalist tradition on the other have been generally acknowledged by Spanish geological historiography. Specifically the role ascribed to Vilanova has been object of some debate. Leandro Sequeiros, 'Lucas Mallada y Pueyo (1841–1921): 150 aniversario de su nacimiento', *Revista Española de Paleontología* (1992) 7, pp. 1–2. Rodolfo Gozalo, 'El inicio de la polémica sobre los sufijos utilizados para denominar los "terrenos": -ano *versus* -ico o Casiano de Prado *versus* Juan Vilanova', *Geogaceta* (1998) 23, pp. 71–74. Isabel Rábano, 'Casiano de Prado – Juan Vilanova, una relación imposible', *Boletín de la Comisión de Historia de la Geología de España* (2006) 28, 2–6. There is, however, no work analysing this question systematically.

35 Daniel Sharpe, a British wine merchant and amateur geologist who lived in Portugal between 1835 and 1838, emerges as one of the most relevant. He introduced palaeontology with a geological purpose and stratigraphy, and authored the first geological maps published in Portugal: one of the surroundings of Lisbon and another of the Oporto region.

36 Vanda Leitão, 'Assentar a primeira pedra: As primeiras Comissões Geológicas portuguesas (1848–1868)', PhD dissertation, New University of Lisbon, 2005.

37 These were the cases of Oswald Heer, Perceval de Loriol, Gaston de Saporta and J.F. Pompekj.

participated regularly in various international meetings, with particular emphasis on the meetings of the IGC and ICAPA.[38]

By comparing the Portuguese and the Spanish Geological Surveys various differences emerge. While in Portugal cartography was the driving force behind geological research until 1886, in Spain, it was the mining sector and the close link established between geological practice and the Corps of Mining Engineers. The staff of the Spanish Survey did not specialize, the division of labour being based on the provinces whose geological reconnaissance was ascribed to one or two engineers; in the Portuguese Survey, geologists specialized in geological systems. Financial difficulties were a chronic affliction of the Portuguese Survey, while the Spanish faced economic hardship only until 1870. Moreover, the existence of a Mining School in Madrid provided the Spanish Geological Survey with well-trained experts; in Portugal, the absence of such a school and of other forms of adequate training of geologists and mining engineers led to a chronic scarcity of experts, which compromised the standards and continuity of the institution, following the deaths of Delgado and Choffat.

Modes of dialogue

The first contacts between the staff of the Iberian Geological Surveys began when in 1858, Carlos Ribeiro (Figure 1) travelled through Europe for six months with the aim of establishing relationships with foreign experts and purchasing books, maps and instruments required for fieldwork.[39]

Ribeiro spent the last days of December in Madrid, where he met Casiano de Prado (1797–1866), then the most active geologist of the Spanish Survey. Ribeiro handed him a letter from Phillippe de Verneuil (1805–1873), whom he had met in Paris.[40] In his report, he expressed the greatest esteem in which he held Prado:

> The names of Murchinson in England, Barrande in Bohemia, Angellin in Sweden and Casiano de Prado in Spain will always be ranked among the top geologists of our century as the

38 The involvement of the Portuguese Geological Survey in tasks of this kind and the relative influence it might have had in the course of events is shown in the International Commission on Nomenclature's suggestion at the meeting held in Berlin in 1885 of the adoption of the Portuguese proposal regarding the division of the Tertiary. See Vai, op. cit. (28), p. 89.

39 Vanda Leitão, 'The travel of the geologist Carlos Ribeiro (1813–1882) in Europe, in 1858', *Comunicações do Instituto Geológico e Mineiro* (2001) 88, pp. 293–300. Ana Carneiro, Maria Dores Areias, Vanda Leitão and Luís T. Pinto, 'The role of travels in the internationalization of nineteenth century Portuguese geological science', in Ana Simões, Ana Carneiro and Maria Paula Diogo (eds.), *Travels of Learning: A Geography of Science in Europe*, Dordrecht: Kluwer, 2003, pp. 249–297. Q2

40 This reinforces the argument of Truyols against the veracity of the episode mentioned in publications on the history of geology in Spain according to which, in 1862, Verneuil was requested by the Spanish government to produce a national geological map because nobody in Spain had the skills. When Verneuil arrived at Madrid and met Casiano de Prado, he gave in because he found his colleague fit for the job. In fact, Prado and Verneuil knew each other long before that date, which is also corroborated by Ribeiro's letter. Jaume Truyols, 'Sobre el origen de la relación científica que existió entre Casiano de Prado y Edouard de Verneuil', *Geogaceta* (1998) 23, pp. 151–153.

Figure 1. Portrait of Carlos Ribeiro. Courtesy of LNEG Historical Archive, Lisbon, Portugal.

discoverers or the *savants* who greatly contributed to the knowledge of the faunas of the different ancient formations in their respective countries.[41]

In Madrid, Ribeiro also met Guillermo Schultz and Juan Vilanova y Piera – the most renowned Spanish geologists of the day[42] – and visited the School of Mines, the Museum of Natural Sciences and the headquarters of the Spanish Geological Survey.[43]

41 Carlos Ribeiro, [Relatório da sua viagem a Espanha em 1858], *Boletim do Ministerio das Obras Publicas, Commercio e Industria* (1859) 2, pp. 150–166, p. 163.

42 Isabel Rábano and Jaume Truyols (eds.), *Miscelánea Guillermo Schultz (1805–1877)*, Madrid: IGME, 2007. Rodolfo Gozalo, 'Biografía de Juan Vilanova y Piera', in *Homenaje a Juan Vilanova y Piera. Valencia, 25–27 de noviembre de 1993*, Valencia: Universitat de València/Servicio de Investigación Prehistórica de la Diputación de Valencia/Sociedad Económica de Amigos del País de Valencia, 1993, pp. 11–83; Rodolfo Gozalo and Vicent L. Salavert, 'Joan Vilanova i Piera (València, 1821–Madrid, 1893). Geòleg, paleontòleg i prehistoriador', in Josep Maria Camarasa and Antoni Roca (eds.), *Ciència i Tècnica als Països Catalans: una aproximació biográfica*, Barcelona: Enciclopèdia Catalana, 1995, pp. 287–313.

43 Ribeiro, op. cit. (41), p. 163.

Despite these initial contacts, due to the institutional frailties of both the Spanish and the Portuguese Geological Surveys, the collaboration between their respective members could only truly develop in subsequent years. Only in the 1870s, when they consolidated, did the cooperative effort initiated by the Portuguese have greater chances of succeeding. To the Portuguese geologists the relationships with Spain represented an intermediate level between Portugal and other European countries, more advanced regarding the working conditions of their geological services.

The relationships of Ribeiro and his disciple Delgado with their Spanish colleagues were framed in a spirit of mission to which the fact that the majority of them were engineers surely contributed, since a kind of chivalric ideal was meant to unite this international brotherhood,[44] while generational, cultural and ideological affinities and common aspirations also linked these men.

In the consolidation of the Spanish–Portuguese relationships, correspondence, visits, exchange of publications, maps and collections played a major role. The epistolary exchange reflected necessarily different levels of acquaintance, ranging from the simple institutional formality, to a communion of ideas and even familiarity as expressed in a letter from Prado to Ribeiro, informing him about the recent wedding of their French counterpart, Elie de Beaumont – 'M. Elie de Beaumont got married to a Marchioness with the annual income of 100.000 [French francs]. He told me so.'[45]

In the early years of the Portuguese and Spanish Geological Surveys there were similarities in the work carried out by their respective directors, as in both countries the regions where their capital cities were located were being geologically surveyed: Prado was making the geological description of the region of Madrid, whereas Ribeiro was surveying the region of Lisbon, which explains his interest in Tertiary geological units, while Prado was studying the Quaternary and granitic formations.[46] Following the completion of his book on the geology of Madrid,[47] which also focused on the antiquity of Man, a fashionable topic in his view,[48] Prado sent to Portugal several copies, as well as to Paris, Berlin and London, regardless of the fact that his *Reseña* was written in Castilian.

Initially, Ribeiro had mediated contacts between Prado and French colleagues, but later Prado played a similar role. He sent to Portugal memoirs on the geology of the Basque country, authored by Verneuil and Edouard Collomb, who in 1864 were to publish a 1:1,500,000-scale geological map of Spain and Portugal without setting foot

44 See letter from the Spanish engineer Joaquín Gonzalo y Tarín (1838–1910) to Delgado: 'As an engineer of the Mining Corps … I have the honour of addressing you with no other merit or link than that which unites the engineers of the various countries.' Letter from Gonzalo y Tarín to Delgado, Huelva, 26 December 1876. Historical Archive of the Laboratório Nacional de Energia e Geologia (hereafter LNEG), available at http://geobiblio.ineti.pt/psqsimp.asp?base=AHGM.

45 LNEG, Prado to Ribeiro, 10 March 1860.

46 LNEG, Prado to Ribeiro, 1 May 1860.

47 C. de Prado, *Reseña física y geológica de la Provincia de Madrid*, Madrid: Imprenta Nacional, 1864.

48 LNEG, letter from Prado, Madrid, April 1865.

on Portuguese land.[49] They based the portion of the map corresponding to Portugal on Sharpe and on data sent by Ribeiro. Despite friendly relationships between Spanish and French geologists, Prado criticized Verneuil and Collomb, whose presence in Spanish territory was seen as intrusive.

The archaeology of ideological affinities

The correspondence which perhaps reflects deeper affinities, often with almost confessional overtones, was that exchanged, in the late 1860s, between Delgado and Tubino. He was the only foreign correspondent to whom Delgado confided the events which led to the suspension of the Portuguese Geological Survey, in 1868, a deplorable episode marked by local politics at their worst.[50] It is often apparent from this correspondence that Delgado (Figure 2) wrote to Tubino also on behalf of Ribeiro, then too busy responding to multiple government requests to be able to keep up with all the correspondence.

The interests shared by Tubino, Ribeiro and Delgado in the realm of archaeology and palaeoanthropology are revealed by the translation into Portuguese of an article released in the newspaper *La Andalucía*, in which Tubino reported on the ICAPA meeting held in Norwich, in 1868.[51] The translation was released in 1869, in the Portuguese newspaper *Jornal do Commercio*. Amongst various topics, Tubino singled out the considerations of Edward Burnett Tylor about prehistoric races and today's 'savages', and Thomas Henry Huxley's classification of human races, their features, distribution, and migrations, which had been the object of discussion by participants.[52]

Tubino's article also focused on the state of Spanish and Portuguese archaeology. He deplored the situation of this discipline in Spain, where only Prado and Vilanova had written on 'fossil man',[53] albeit in geology books. In his view, Ribeiro and Delgado were pointing their Spanish colleagues in the right direction in archaeological research, by providing it with a geological foundation, an orientation which Tubino fully endorsed and publicized in scientific societies and journals in Madrid.

But in the late 1860s, Tubino expressed interests which went beyond archaeology. He informed Delgado, 'his dear and distinguished friend', of his whereabouts during *La Gloriosa*, when he was forced to move to Andalusia, because 'the political events

49 The map by Collomb and Verneuil preceeded by three years the making of the first sketch of the geological map of Portugal in the 1:500,000 scale, dating from 1867, and was presented at the Paris World Exhibition.

50 The suspension of the Survey occurred due to deep disagreements opposing Ribeiro against his co-director, Pereira da Costa. Costa's conceptions on geological work, and the fact that he appropriated Ribeiro's and Delgado's work without their consent, led to deep disagreements. Costa, however, was well connected in the political sphere and friendly with the minister of public works. They joined forces and managed to get the Survey suspended, a situation which extended from 1868 to 1869. Leitão, op. cit. (39).

51 LNEG, Tubino to Delgado, 19 February 1869.

52 Among whom Carl Christoph Vogt, Paul Broca, Alfred Russel Wallace, Tylor, Joseph Dalton Hooker and George Busk.

53 Respectively in Prado, op. cit. (48); and in Juan Vilanova, *Compendio de Geología*, Madrid: Imprenta de Alejandro Gómez, 1872.

Figure 2. Portrait of Nery Delgado, 1888. Courtesy of LNEG Historical Archive, Lisbon, Portugal.

demanded my presence in the fight for individual freedom.'[54] Tubino was then interested in promoting the 'good relationship between Portugal and Spain', and asked Delgado about the opinion of the Portuguese on the unification of the Iberian Peninsula.[55] Following the downfall of Isabel II of Spain, the 'danger' of an Iberian union began to be discussed in Portugal, and a motion against republican federalism was approved in the Peers' Chamber.

Delgado cautiously confided his embarrassment in answering Tubino's questions: 'I have kept myself outside politics and I am not affiliated to any party or group among those which in my poor country dispute power only to justify by their acts the disrespect

54 LNEG, Tubino to Delgado, 19 February 1869.
55 LNEG, Tubino to Delgado, 2 May 1869.

of their predecessors.'[56] But well aware of the events reported in Spanish newspapers, he denied the existence of a massive political movement favouring Iberian unification. The rumour was, in his view, explained by the dissatisfaction of the Portuguese with the government: 'some speculators have taken advantage of it in order to fulfil their private interests'. But the fears of unification were in Delgado's view attenuated by the fact that 'Parliament had resumed its functions' and Sá da Bandeira's cabinet would soon fall, because 'everybody is waiting for the storm that he had himself unleashed'.[57]

The rumours then circulating in the neighbouring country of a revolution and of an alliance of Portugal with Spain were ill-founded, because, in Delgado's view, Spanish politicians were misled, due to a lack of trustworthy information. 'If in Lisbon one cannot find a resolute Iberianist, what about in the provinces?' he questioned.[58] Despite being unsympathetic to unification under a monarchic regime, because in his words it meant 'absorption', Delgado contended that the only way the Portuguese might find it appealing would be through a republican federal union. Delgado was in this way expressing ideas common in the republican circles in which his brother-in-law, Gilberto Rola, was active.

Delgado contended that only when Spain had thoroughly demonstrated its political tolerance would the frictions between both countries vanish and unification materialize 'as if by magic', since freedom would be warranted in such a way as to 'render into oblivion the historical legacy of hatred' and war between the countries.[59] Despite Delgado's considerations, Tubino continued to demonstrate enthusiastically his inflamed Iberianism, and pledged his intention to pursue his fight for 'the moral and intellectual union of Portugal and Spain'.[60]

In order to contribute to this plan, he requested data which could enable him to write a history of archaeology in Portugal,[61] but Delgado replied that despite Tubino's optimism, there was not much to add to what he already knew – his and Ribeiro's publications. But Delgado did not consider himself an archaeologist, and his archaeological and palaeoanthropological research was marginal to his duties at the Portuguese Survey. His and Ribeiros's motivations derived from the repercussions of the discoveries of Boucher de Perthes, author of *De l'homme antédiluvien et de ses oeuvres*, published in 1860,[62] following the foundation of the Anthropological Society of Paris, and the publication of Darwin's *Origin of Species*.

56 LNEG, Delgado to Tubino, 2 May 1869.
57 LNEG, Delgado to Tubino, 2 May 1869.
58 LNEG, Delgado to Tubino, 2 May 1869.
59 LNEG, Delgado to Tubino, 2 May 1869.
60 LNEG, Tubino to Delgado, 5 May 1869.
61 LNEG, Tubino to Delgado, 5 May 1869.
62 Perthes concluded that Man was contemporary of certain extinct animals, in a period prior to the flood; climates had changed since there were elephants and rhinoceros in the Somme valley. One was thus able to distinguish a tropical from a glacial and a mild period. Perthes's findings were dated from *c.*500,000 years ago, and were ascribed to Neanderthal populations, although some experts think they date from *c.*1,000,000 years ago; that is, that they are associated with *Homo erectus*.

At this point, in 1869, Delgado mentioned his brother-in-law, Rola, whom he greatly admired, and seized the opportunity to request of Tubino a favour.[63] Delgado had learnt from the Spanish newspapers that Emilio Castelar, a 'prestigious Republican *caudillo*' and later, in 1873, president of the Spanish First Republic, intended to visit Lisbon and Oporto. As Rola was then directing public works in north-eastern Portugal, he was anxious to know the date of Castelar's visit to Oporto. He wished to meet him and discuss political issues 'with the kind of freedom found among brothers in beliefs and aspirations'.[64] Rola then presided over the Democratic Association of Salema Patio (Associação Democrática do Pátio do Salema) and had subscribed to the idea of a peninsular federation since 'the time when those who advocated it were not only seen as traitors, but also as utopian visionaries'.[65]

In 1880, Tubino was to come to Lisbon, accompanied by the brothers Vilanova and Macpherson,[66] to attend the 9th Session of the ICAPA, organized by Ribeiro and Delgado upon the suggestion of two leading actors of French palaeoanthropology, Gabriel de Mortillet and Paul Broca.[67] This meeting followed Ribeiro's alleged discovery of the 'Tertiary Man', attracted the presence of renowned foreign scientists, and had the participation of the local political and intellectual elite and the patronage of the Portuguese royal family.[68]

If at the personal level one finds this kind of complicity linking Tubino to Delgado and Ribeiro, at the institutional level the relationships often followed a similar pattern.

Personal and institutional affinities

All aspects of the Spanish Geological Survey, from its structure and organization to the cabinets where the collections were kept, were a matter of interest for the Portuguese geologists. Delgado asked Tubino for news about the changes of government in 1869 in Spain, and of their repercussions for geological practice. He thought they might influence the course of events in Portugal and 'my future life,' which seems to indicate that the leaders of the Portuguese Survey, Ribeiro and Folque, were following, through Delgado, political events in Spain. Among Ribeiro's Spanish interlocutors were Jacobo Rubio, professor of the Spanish Mining School, whose children lived in Portugal – for this reason he often visited Lisbon and the Portuguese Survey. It was Rubio who informed Ribeiro of the 1870 restructuring of the Spanish Geological Survey.

63 To Delgado, Rola was 'one of the most fervent apostles of democratic ideas and healthy principles of reform' in Portugal. LNEG, Delgado to Tubino, 23 July 1869.

64 LNEG, Delgado to Tubino, 23 July 1869.

65 LNEG, Delgado to Tubino, 23 July 1869.

66 José Macpherson y Hemas, geologist, and his brother Guillermo Macpherson y Hemas (1824–1898), naturalist, archaeologist and translator of Shakespeare into Castillian. See also *Compte rendu de la 9eme session du Congrès international d'anthropologie et d'archeologie prehistoriques en 1880*, Lisbon, 1884.

67 They had founded in 1864 the journal *Matériaux pour l'histoire positive et philosophique de l'homme*. Mortillet was thrilled by Ribeiro's discovery of the 'Tertiary Man', on which subject he taught in Paris.

68 João L. Cardoso, 'As Investigações de Carlos Ribeiro e de Nery Delgado sobre o "Homem do Terciário": Resultados e Consequências na época e para além dela', *Estudos Arqueológicos de Oeiras* (1999–2000) 8, pp. 33–54.

In 1872, Delgado carried out his first mission of scientific diplomacy in Spain, which left his Spanish colleagues with 'pleasant memories'.[69] During this visit, he became acquainted not only with colleagues, but also with the particularities of the organization of the Spanish Survey. He arrived in Madrid on 3 June and his first visit was to the Portuguese ambassador. In the afternoon of the next day, Delgado met Rubio, who, together with Tubino, guided his tour in the Spanish capital, and introduced him to their fellow experts.[70]

Delgado's mission began effectively on 5 June, when he visited the School of Mines, located in an old building at Plazuela del Conde de Barajas. The school left a bad impression on the visitor, who considered one of the rooms 'too small and hardly decent' and deplored the state and scarcity of the equipment.[71] He then met the engineer Justo Egozcue y Cía (Figure 3), professor of geology and palaeontology since 1866, and author of various textbooks.[72]

In the morning of the following day, Delgado visited, again accompanied by Rubio and Ramón Rua Figueroa, a leading figure in the General Board of Statistics (Junta General de Estadística), and author of a monumental Spanish bibliography on mining and related sciences.[73] Rua had translated into Castilian Delgado's paper on the Palaeozoic, first published in the Portuguese journal *Revista de Obras Públicas e Minas*.[74] The translation appeared in that same year in the Spanish journal *Revista Minera*,[75] which probably contributed to making Delgado known in Spain, given this journal's wide audience.

Back at the Mining School, Delgado met Mallada, then participating in the workings of the Spanish Survey, who later became a leading figure of Spanish Regenerationism, notably with his influential book *Los males de la patria y la futura revolución española* (The Ills of the Motherland and the Future Spanish Revolution), published in 1890.[76] He also visited the premises of the Spanish Survey, in Isabel la Católica Street, which he found small and inadequate to house the collections in the future, but appropriate to the work then being carried out.[77] He liked the walnut cabinets in which the collections were kept, describing them in detail, and considered their classification excellent.[78] But the richness of the furniture could not hide the lack of funds allocated to geological research.

69 LNEG, letter from Felipe Naranjo y Garza, 7 July 1873.

70 Jesús Catalá-Gorgues, 'Ligados pela natureza: os inícios da colaboração científica entre Nery Delgado e os geólogos espanhóis, em 1872', *Comunicações Geológicas* (2007) 94, pp. 161–174.

71 Catalá-Gorgues, op. cit. (70).

72 Juan M. López de Azcona, 'Mineros destacados del siglo XIX. Justo Egozcue y Cía. 1833–1900', *Boletín Geológico y Minero* (1988) 99, pp. 986–989.

73 Juan M. López de Azcona, 'Mineros destacados del siglo XIX. Ramón Rua Figueroa y Fraga (1825–1875)', *Boletín Geológico y Minero* (1988) 99, pp. 139–143.

74 J.F. Nery Delgado, 'Breves apontamentos sobre os terrenos paleozoicos do nosso paiz', *Revista de Obras Publicas e Minas* (1870) 1, pp. 15–27; 3–4, pp. 98–110; 6, 168–175.

75 J.F. Nery Delgado, 'Breves apuntes sobre los terrenos paleozoicos de Portugal', *Revista Minera* (1870) 21, pp. 505–516, 529–545, 553–556.

76 Antonio Calvo, *Lucas Mallada (1841–1921). Un geólogo preocupado por España*, (Zaragoza): Gobierno de Aragón, 2005.

77 Catalá-Gorgues, op. cit. (70).

78 Catalá-Gorgues, op. cit. (70).

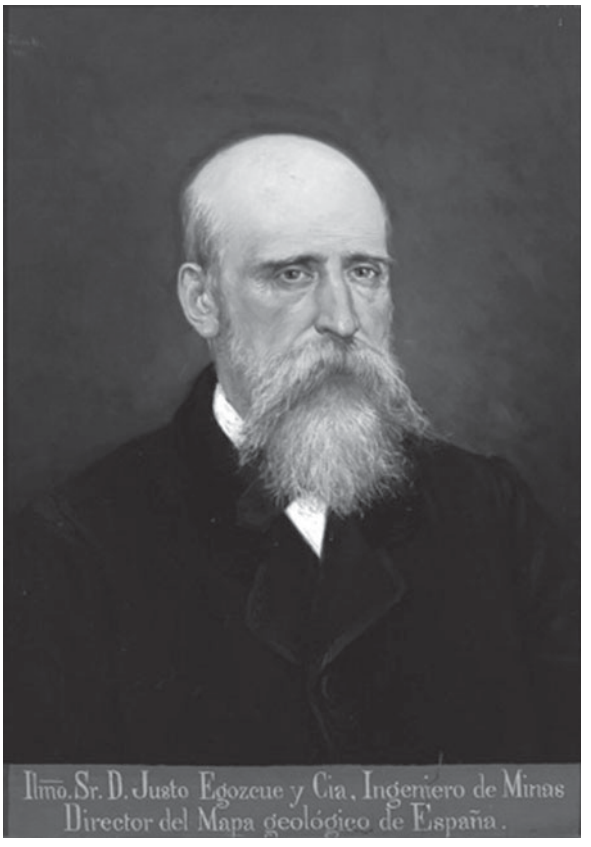

Figure 3. Portrait of Justo Egozcue. Courtesy of Instituto Geológico y Minero de España, Madrid, Spain.

The financial hardship was such that in the year before, the geological surveying of the province of Huesca carried out by Felipe Martín Donayre[79] and Mallada had to be suspended.[80]

Felipe Bauzá, then heading the Spanish Geological Survey, provided Delgado access to the Survey regulations, which had not yet been approved by the government, on condition that he kept the contents confidential, which is an indication not only of institutional and personal trust, but also of the interest the Portuguese had in the

79 There are some doubts as to the biography of this character, beginning with his full name. It is not clear whether or not 'Donayre' is the first or second surname, because in Castilian 'Martín' can be either a first name or a surname, which renders bibliographic references problematic. Here the suggestion of Gozalo, who argued that 'Martin' is the name and 'Donayre' the surname, is followed. Rodolfo Gozalo, 'Donayre, Felipe Martín o Martín Donayre, Felipe: una disquisición nominal', *Noticias Paleontológicas* (1999) 34, electronic version, available at http://www.uv.es/pardomv/np/np34/np34_07a.html.

80 Luis Urteaga, 'Lucas Mallada y la Comisión del Mapa Geológico', *Boletín de la Real Sociedad Geográfica* (1988) 124–125, 213–231.

Figure 4. Portrait of Manuel Fernández de Castro. Courtesy of Instituto Geológico y Minero de España, Madrid, Spain.

structure of the Spanish geological service. Written information on salaries, the organization of the Survey sections,[81] and the current situation of research in the different Spanish provinces (basically memoirs and maps),[82] were also supplied to Delgado. Back in Portugal, he forwarded them to Folque, with the exception of the regulations and salaries, as agreed with Bauzá.

As if Portugal were another Spanish province, in 1873 Felipe Naranjo y Garza, president of the Inspectorate of the Spanish Geological Survey, was to send to Ribeiro by-laws, instructions and other official documents which governed the institution, notably the document appointing the new director, Manuel Fernández de Castro (Figure 4), who inaugurated a period of intense geological research. These same documents had been sent to the chief engineers of the Spanish mining districts.[83]

81 LNEG, 'Sueldos de los Cuerpos de Ingenieros de Caminos, Minas y Montes', p. 1, followed by 'Comisión geologica', pp. 2–4.

82 LNEG, 'Nota de los planos y memorias geológicas publicadas', pp. 1–2, followed by 'Nota de los planos, memorias y reseñas geológicas no publicadas', pp. 3–4.

83 Naranjo, op. cit. (69).

Delgado's visit to Spain, in 1872, fulfilled, if partially, both institutional and personal purposes. He examined the disposition and organization of Spanish collections, which were relevant to the collections of the Portuguese Survey. Spain was disrupted by the Third Carlist War (1872–1876),[84] which explains the delay in sending the copies of the drawings of cabinets and shelves by post, which Delgado had requested from his colleagues. But one of the main advantages of Delgado's visit was surely the direct and personal relationships forged with the Spanish geological community. United by the same ground, Iberian geologists needed a platform for cooperation, and Delgado, himself, greatly benefited from this trip.

His brief stay in Madrid marked the beginning of his scientific career on the international scene, and helped him to reinforce his ideal of a scientific community bound by chivalry and intellectual generosity, an idealized vision which nevertheless oriented the shaping of his scientific persona.[85] Although lacking the time and the strangeness to become what Martin Rudwick has termed a 'liminal' experience, the contacts established and the work carried out by Delgado in Spain over fifteen days – away from the familiar routines of the minuscule Portuguese Geological Survey – contributed to the improvement and consolidation of his own research.[86] In the nineteenth-century scientific context, the growing importance of scientific meetings, together with the demarcation of specialties and the link between teaching and the construction of scientific knowledge, had an impact on the purpose and meaning of scientific travelling.[87]

In 1878, Delgado returned to Spain, where he carried out geological research in various regions.[88] He visited Macpherson, a wealthy independent geologist, who introduced micrographic petrography to Spain and collaborated with the professors of the Free Institution for Teaching, to which Ribeiro and Delgado regularly sent their publications, including geological maps.[89] Delgado also visited Castro and was happy to realize that Spain possessed a geological culture, by congregating individuals devoted to geological research both on an institutional level and on a private basis, like

84 The third Carlist War lasted from 1872 to 1876, and was fought between the partisans of Carlos, Duke of Madrid, the Carlist claimant to the throne of Spain with the name Carlos VII, and the governments of Amadeo I, the First Republic and Alfonso XII. The claimant, who for months had been preparing the insurrection from exile, defined 21 April 1872 as the date of the rebellion. The war was fought especially in Navarre and the Basque country, but also in Catalonia, Valencia and Aragon. Alfonso Bullón de Mendoza, 'Las Guerras Carlistas', in *idem* (ed.), *Las Guerras Carlistas*, Madrid: Ministerio de Cultura, 2004, pp. 19–67.

85 Catalá-Gorgues, op. cit. (70).

86 Martin J.S. Rudwick, 'Geological travel and theoretical innovation: the role of "liminal" experience', *Social Studies of Science* (1996) 26, pp. 143–159.

87 Víctor Navarro, 'Viatgers científics valencians', in Gonzalo Montiel and Elena Martínez (eds.), *Viatjar per saber. Mobilitat i comunicació a les universitats europees*, València: Universitat de València, 2004, pp. 91–113.

88 Ana Carneiro, 'Sharing common ground: Nery Delgado (1835–1908) in Spain in 1878', in Patrick N. Wyse Jackson (ed.), *Four Centuries of Geological Travel: The Search for Knowledge on Foot, Bicycle, Sledge and Camel*, London: Geological Society, 2007, pp. 119–134.

89 'Homenaje a José MacPherson y Hemas (1839–1902)', *Boletín de la Institución Libre de Enseñanza* (2002), 45–46, pp. 9–155.

Macpherson, or simply as 'apostles of science', a situation which found no parallel in Portugal.[90]

Accompanied by Benot – a polymath teaching at the Free Institution for Teaching, minister of encouragement of the First Republic and an influential figure of the Generation of 1898 – Delgado also visited the Spanish Geographic Institute (Instituto Geográfico y Estadístico, founded in 1870).[91] Benot had legislated on the autonomy of this institution, which by then was outside governmental control.

The official report of Delgado's mission was published and sent to various Spanish institutions and geologists, as if Spain were an extension of Portugal. In it, Delgado made himself the interpreter of the difficulties and hopes of his Spanish fellow geologists, by rendering them a service as his considerations and criticisms had the impartiality and authority of an expert outsider. But Delgado also used positive examples of what he saw in Spain to reinforce internally the views he shared with Ribeiro on the organization and policies which institutions of this kind should implement.[92] Back in Portugal, he requested Benot to provide him with more details of the structure and administration of the Spanish Geographic Institute.

The information about these Spanish institutions influenced some restructurings and reorientations of the Portuguese Geological Survey throughout the nineteenth century. For example, Delgado praised the principle followed by the Spanish Survey of publishing annually the geological description of a province, which, depending on depth and length, was released either in its *Memoirs* or in its *Bulletin*. In 1883, during his directorship, the Portuguese Survey began publishing in addition to the *Memoirs* a journal similar to the Spanish Bulletin, titled *Communicações da Commissão dos Trabalhos Geologicos*.

Regarding institutional organization, the reform of 1886 of the Portuguese Survey resembles most its Spanish equivalent. The Portuguese Geological Survey was separated from the Geodesic Directorate to become part of the General Directorate for Public Works and Mining, becoming in this way more directly associated with the mining sector.[93] However, these Portuguese services never reached the degree of administrative autonomy of the corresponding Spanish institutions, as they continued to be part of the Ministry of Public Works.

Portuguese–Spanish cartographic cooperation and the geological map of Europe

The decision to make a geological map of Europe, taken during the Bologna meeting of the IGC in 1881, brought to the surface tensions between advocates of the internationalization of geological science and those engaged in securing the dominant

90 J.F. Nery Delgado, *Relatorio da commissão desempenhada em Hespanha no anno de 1878*, Lisbon: Typographia da Academia Real das Sciencias, 1879, p. 11.

91 LNEG, Benot to Delgado, 8 August 1878. Ibáñez was then director of this institution, but the next year he travelled in order to carry out the triangulation of Spain and Algiers, by using electrical signals and Gauss heliotrophes. The purpose was to take triangulation to the desert. Q5

92 Carneiro, op. cit. (88).

93 Ana Carneiro, 'Outside government science, "Not a single tiny bone to cheer us up!": the Geological Survey of Portugal (1857–1908), the involvement of common men, and the reaction of civil society to geological research', *Annals of Science* (2005) 62, pp. 141–204.

role of the most powerful and influential European nations. If the French, Italians, British and Spaniards were among the former, the latter were represented mainly by the Austro-Hungarians, Russians and Germans. The latter managed to be entrusted with the coordination and elaboration of the European map, under the supervision of an international committee,[94] which included Austro-Hungarians, French, Italians and Russians, with the Swiss Eugène Renevier in the position of secretary.[95]

Ernst Beyrich and Wilhelm Hauchecorne, codirectors of the Preußische Geologische Landesanstalt were appointed coordinators, although direction was entrusted to the latter. Hauchecorne, who had been the director of the Berlin Mining Academy since 1866, was a leading figure among German geologists and an efficient servant of the Prussian government.[96] Geological mapping had a long tradition in Germany, dating back to the 1830s.[97] The Prussian Geological Survey – considered the predecessor of the German Geological Survey, which was to be unified during the Third Reich in 1939 – was created in 1873, relatively late compared with other countries and German states. The creation of a Prussian Geological Survey had been envisaged back in 1865, but the wars with Austria and France caused the postponement of this plan.[98] With the establishment of the German Empire, Prussian hegemony over Germany consolidated and the Prussian Survey became an effective means of serving a militarist political agenda.

The choice of Prussia may seem surprising if one takes into consideration only the short life of its geological service. But the capacity of organization and experience accumulated by Hauchecorne, the potential of a service well endowed with financial and human resources, together with shifts in the European balance of power, certainly played decisive roles in such a resolution. To some extent, both the meetings of the IGC and the project of the European geological map are fine examples of the paradox pointed out by Schroeder-Gudehus regarding the sciences of the late nineteenth century.[99] Schroeder-Gudehus contrasts the expansion of international cooperative scientific endeavours – indeed, the Commission for the Geological Map of Europe evolved soon to become the Commission for the Geological Map of the World[100] – with growing political tension and deep rivalries which fed on nationalism.

When summarizing the disillusionment which surrounded the IGC meeting in Berlin in 1885, Choffat emphasized a basic fault plaguing the organization of the IGC

94 Vai, op. cit. (28).

95 LNEG, copy of the official letter of Delgado to the minister of public works, 2 August 1894, Registo da correspondência administrativa 1893–1899, pp. 533–535.

96 Franz Beyschlag, 'Gedächtnissrede auf Wilhelm Hauchecorne gelegentlich der Enthüllung seiner Büste in der Aula der Königl. Geologischen Landesanstalt und Bergakademie am 15. Januar 1902', *Jahrbuch der Königlich Preussischen geologischen Landesanstalt und Bergakademie zu Berlin* (1901) 21, pp. xvci–cxiv. Alfred Bentz, 'The history of the German Geological Survey', *Geological Magazine* (1947) 84, pp. 169–177.

97 Oldroyd, op. cit. (27), p. 124.

98 Martin Guntau, 'The history of the origins of the Prussian geological survey in Berlin (1873)', *History and Technology* (1988) 5, pp. 51–58.

99 Brigitte Schroeder-Gudehus, 'Nationalism and internationalism', in R.C. Olby, G.N. Cantor, J.R.R. Christie and M.J.S. Hodge (eds.), *Companion to the History of Modern Science*, London: Routledge, 1990, pp. 909–919.

100 Vai, op. cit. (22); *idem*, op. cit. (28).

meetings: the decisions taken through voting depended heavily on the geologists of the hosting country, who outnumbered the representatives of the other countries to the extent that future strategies were undermined, especially when decisions changed from one meeting to the next.[101] Nationalism and scepticism corroded the effectiveness, usefulness and internationalism of the IGC. The words of Macpherson in a letter to Delgado could not be more telling:

> You ask my opinion about the Congress. I can only tell you that as an opportunity for exchanging views and catching up with the latest developments in science it seems excellent to me; now, as a means of making people agree, the results are doubtful.[102]

These and other difficulties were to greatly affect the making of the geological map of Europe, together with specific problems which undermined consensual decisions. Choffat also pointed out another serious fault: that of beginning the publication of the European map without prior agreements on the general principles guiding the whole enterprise, which prevented a genuine consensus among those involved. Rather, the orientations were imposed by 'two or three persons more directly involved in the making of the European geological map'.[103] Choffat also mentioned that a considerable part of the topographic basis of the map (thirty-two sheets out of forty-nine) was already printed. Undoubtedly geological work was making little progress. The national committees had not carried out the task of colouring their respective parts simply because no criteria had been agreed upon as to the boundaries of various stratigraphic divisions. Despite the great effort put into the whole enterprise, all these questions show the difficulties of reaching consensus, both in the meetings held in Bologna and Berlin, and in those which took place in between.

At the next meeting, held in London in 1888, the question of colouring remained unsolved for the whole of the stratigraphic divisions. Delgado expressed his disappointment regarding the participants' inability to negotiate the code of colours to be used in geological cartography:

> Due to lack of time and even because it was found imprudent to open the discussion about this highly important question, which to be truthful is one of the main purposes underlying the creation of the International Geological Congress, it was almost put aside.[104]

The whole issue boiled down to a paper delivered by Hauchecorne, reporting on the state of the art and the difficulties encountered, which attempted to complete a fait accompli, a strategy especially clear when he presented the test sheet corresponding to a considerable part of the German territory, by using about forty colours and the principle thaat the darker the colour, the more ancient the geological unit.

101 Paul Choffat, 'Troisième session du Congrès géologique international', Communicações da Comissão dos Trabalhos Geologicos de Portugal (1887) 1, pp. 211–221. *Compte rendu de la 3e session du Congrès geologique international*, Berlin, 1888.

102 LNEG, J. McPherson to Nery Delgado, 13 November 1888.

103 Choffat, op. cit. (101), p. 220.

104 J.F. Nery Delgado, *Relatorio ácerca da Quarta Sessão do Congresso Geologico Internacional realisada em Londres no mez de Setembro de 1888*, Lisbon, 1889, p. 32. *Compte rendu de la 4e session du Congrès geologique international*, London, 1891.

In the evaluation of this test sheet, Delgado reiterated his views as to the root of the problem being the lack of a prior standardization of the code of colours and the overly hasty beginning of the making of the European map. He was not alone. Jules Marcou, who had published a geological map of the world in 1861, held a similar opinion – that more time and freedom were necessary to reaching consensus – but drew attention to the superimposition of personal ambition on collective endeavours of this kind by vehemently criticizing Beyrich:

> The geological map of Europe will be, in effect, Beyrich's map, because Hauchecorne is only his main assistant. Beyrich is only interested in two things: seeing the Oligocene, a term he has coined, accepted as a great division, and the adoption of the classification of the Devonian of Rhenish Prussia into three great groups. Above all, he wishes to please those who will get him medals, prizes and decorations. Cappellini, who has the same craving for reward, follows in his footsteps. In all, this map will be a personal job, with the support of the Congress, which is wrong.[105]

The involvement of the Portuguese Geological Survey

In Bologna, each country had agreed to pay a sum in order to cover the costs associated with the making of the geological map of Europe. By the end of 1882, the Portuguese paid their first instalment, amounting to 318.75 French francs.[106] References to specific work carried out to this end were first made by Delgado, in 1888. In July of that same year, Beyrich and Hauchecorne sent a corrected print of sheet CIV, to be presented soon at the 1888 London meeting of the IGC, which they considered satisfactory regarding the colours used. However, only a partial consensus was reached in the meeting regarding the underlying criteria. The geologists had adopted the principle of restricting as much as possible the names of localities, and other information considered irrelevant, but this print anticipated the difficulties of coordinating countries, geological surveys and experts. Specifically, the Prussians wished to distinguish alluvial from diluvial for the Quaternary, a criterion which had the agreement of the Danish, Dutch and Belgians, but they failed to impose it on the Swedes, and consequently the sheet showed discrepancies. The Swedes did not represent Quaternary units on the map, but the underlying rocks instead.[107] Delgado replied within a few weeks, agreeing with Beyrich's and Hauchecorne's Quaternary criterion.[108]

105 LNEG, Marcou to Delgado, 26 February 1886. Marcou added that, 'Fontannes de Lyon, le secrétaire du congrès, est surtout un nombre de ces excellents savants qui recherchent et proposent ce travail d'Encyclopédistes. Avec l'âge, ils apprendront tous que le meilleur de tous les moyens, est de laissez faire la liberté et le temps avec ces deux facteurs tout se tasse et tout se classe. Tandis qu'avec les coteries, toujours plus ou moins despotiques, et les cliques de meneurs, eh bien ! Tout lasse, tout casse, et tout passe ! Voilà ma vieille expérience de quarante années des hommes et des théories dans les deux mondes.' Marcou's underlining. Q6

106 LNEG, copy of the letter from Delgado to Hauchecorne. Lisbon, 23 November 1882, Livro de registro de correspondencia de 1882, and Registo da correspondência administrativa, 1882–1886, p. 20.

107 LNEG, translation from German to Portuguese of a letter from Beyrich and Hauchecorne to Delgado (two versions), 18 July 1888. For the Swedish Geological Survey see Christer Nordlund, 'Between science and industry: on the establishment, organisation and practices of the Swedish Geological Survey in the nineteenth century', *Earth Sciences History* (2007) 26, pp. 127–149.

108 LNEG, copy of the letter from Delgado to the directors of the Commission of the International Geological Map of Europe, Lisbon, 13 August 1888, Registo da correspondência scientifica 1886–1890, pp. 304–305.

In London, various national geological surveys presented their respective cartographic productions, which, together with drafts of maps by various private geologists, were part of the exhibition of objects which complemented the sessions. The Portuguese Geological Survey had responded diligently, presenting the draft of the general geological map, at a scale of 1:500,000 authored by Delgado and Choffat, in addition to fossil samples, replicas and various publications by Delgado.[109] Based on that draft, those in charge of the geological map of Europe would begin to colour the part corresponding to Portugal. In November 1888, Delgado requested the proof sheets so that he could revise them.[110] Despite his willingness, the work was delayed. Delgado's commitment to comply with his professional duties as well as his perfectionism were characteristic traits of his personality, surely encouraged and accentuated by his military training. At this point of Portuguese history, however, there were certainly other motivations, deriving from what was perceived as a humiliation inflicted on Portugal by the outcome of the Berlin Conference in 1884–1885, and the ensuing British Ultimatum in 1890. By then, territorial questions had become crucial to the Portuguese: the British had questioned the historical legitimacy of Portuguese possession of its African colonies, because, in the absence of an effective territorial occupation by the Portuguese, they felt entitled to control and possess the region between Angola and Mozambique.

In June 1892, the existence of problems in the topographic basis was recognized. Beyrich sent a sketch of a new version for Delgado's inspection and if he found flaws Beyrich would discard the prior version.[111] It is apparent that this dialogue was marked by tension. Already in 1883 Delgado had pointed out to the Germans a considerable number of mistakes on sheets AV and AVI, representing Portugal, but the Germans had not replied. He complained to the secretary Renevier, in 1894, that he had been forgotten by Hauchecorne since 1883, and that only in August 1892 had he received a letter from him.[112] Meanwhile the only written note known to Delgado was a postcard from Renevier sent to Choffat in 1885, in which he mentioned that he had taken into consideration the objections of the Portuguese Survey regarding the topographic basis.[113] Delgado sent to Beyrich, in January 1893, various topographic maps of Portugal at different scales in order to facilitate the task of their Prussian colleagues, and sheets AV and AVI with his corrections.

The incorporation of Spanish geological information in the geological map of Europe and Portuguese–Spanish cartographic discrepancies

Despite the defective dialogue, in 1888 Delgado had accepted doing a special favour to Hauchecorne. He was asked to act as a mediator between the Prussians and Castro, then

109 Delgado, op. cit. (104).

110 LNEG, copy of the letter from Delgado to Hauchecorne, 5 November 1888, Registo da correspondência científica 1886–1890, pp. 311–312.

111 LNEG, translation from German into Portuguese of the letter from Ernst Beyrich to Nery Delgado, 16 June 1892.

112 Not located.

113 LNEG, copy of the letter from Delgado to Renevier, 10 March 1894, Registo da correspondência científica 1893–1897, pp. 619–620.

heading the Spanish Geological Survey. Contrary to the Portuguese Survey, the Spanish Survey was not involved fully in the workings and agreements of the first meetings of the IGC, and by the same token it had not participated much in the beginnings of the geological map of Europe.[114] Instead, its members had concentrated on state requests during the last three decades of the nineteenth century, in particular during the leadership of Castro when the geological map of Spain at the scale of 1:400,000 was being completed Spanish geologists therefore remained insulated.

Apparently, Hauchecorne had difficulties in obtaining data from the Spaniards. He decided to resort to Delgado, who approached his Spanish opposite number, Castro:

> I must warn Your Excellency that in a conversation I had in London with Hauchecorne, one of the leaders of the Committee in charge of the geological map of Europe, he mentioned that he would write to Your Excellency to beg your collaboration and that of the Spanish Geological Survey in this map. I am only fulfilling his request and later Your Excellency will receive from him all the information such a case requires, which I cannot provide because I ignore it.[115]

A few months earlier, in the summer of 1888, Castro and Delgado, who had corresponded extensively in former years, had exchanged letters on the visit of a Spanish engineer to Lisbon with the purpose of discussing geological matters pertaining to the Spanish–Portuguese borders, associated with the making of the geological map of Spain at the 1:400,000 scale, then well on the way to completion.[116] As Delgado recognized, the work underlying a new version of the Portuguese geological map was much delayed, which was explained by the fact that in the context of the Portuguese Survey only he and Choffat carried out fieldwork. Delgado confided that he was plagued by doubt regarding the geology of the border, but he was nevertheless available to cooperate with Castro and supply all the data when his Spanish colleague visited Lisbon between 8 and 10 August 1888.[117]

Castro arrived in the Portuguese capital accompanied by Daniel de Cortázar, one of the most active engineers working in the Spanish Survey. Later, in 1891, Gabriel Puig y Larraz, Delgado's old friend and visitor to the headquarters of the Portuguese Survey, published a geological memoir of the province of Zamora, near the Portuguese border.[118] These visits activated the collaboration between the Surveys of both countries, resulting in accolades from the Portuguese government to the Spaniards in 1893,[119] which were repaid with Delgado's admission as corresponding member of the

114 LNEG, copy of the letter from Delgado to Hauchecorne, 5 November 1888, Registo da correspondência científica 1886–1890, pp. 311–312.

115 LNEG, copy of the letter from Delgado to Castro. Lisbon 3 November 1888. Registo da correspondência científica 1886–1890, pp. 310–311.

116 LNEG, Castro to Delgado, 6 July 1888.

117 LNEG, copy of the letter from Delgado to Castro, 2 August 1888. Registo da correspondência scientifica 1886–1890, pp. 298–299.

118 LNEG, copy of the letter from Delgado to the Minister of Public Works, 11 April 1893, Registo da correspondência administrativa 1886–1893, pp. 483–484.

119 LNEG, copy of the letter from Delgado to Castro, 1 July 1893. Registo da correspondência administrativa 1886–1893, pp. 495–495.

Royal Academy of Sciences of Madrid, in 1894.[120] But the different working paces in both countries were to cause discrepancies. Between 1888 and 1889, Delgado was able to engage in fieldwork in northern Portugal, in the provinces of Minho and Trás-os-Montes, which enabled him to reconsider some aspects of the Portuguese geological map of 1877, in the 1:500,000 scale, and correlate them with the maps of the Spanish provinces of Salamanca (1880) and Zamora (1883) in the 1:400,000 scale, carried out by the Spanish engineers Amalio Gil y Maestre and Puig.[121]

In the summer of 1890, Delgado had sent to Castro a sketch of the far east of Trás-os-Montes, where he had found graptolites and re-evaluated some petrographic characteristics which led him to classify as Silurian the geological units which had been classified as Cambrian. In this way the presence of the Silurian was increased considerably. He also questioned the classification as Cambrian of the various fossils he had found.[122]

Castro surely needed more conclusive data, because the printing of the sheets of the Spanish geological map, in the 1:400,000 scale, was near completion. In October 1890, Delgado received the print of sheet 6, in the deluxe edition,[123] together with sheets 8, 12 and 16,[124] corresponding to the controversial region, in which the extent of the Silurian had been modified in order to make it consistent with the former Portuguese geological map. (Delgado's recent contributions, however, were not included.)

Castro urged Delgado, or a representative of his, to meet Cortázar, in order to incorporate Portuguese data in the sheets still to be printed; sheet 6 was to be reprinted. The plan was to print twelve sheets (out of sixieen) left over from the deluxe edition, within a year.[125] Delgado felt incapable of delivering the Portuguese data on time, because he was overwhelmed by multiple duties. But he revised data relevant to sheets 5, 9 and 13, which covered portions of the Spanish–Portuguese border, and found various discrepancies on the first, which included the northern Portugal–Spain border, but especially on the second, between the Portuguese Alentejo and the Spanish Extremadura.[126] In view of his objections, Castro then decided to send Puig to Lisbon so that he could incorporate the corrections prior to printing these sheets.[127] Castro requested Puig to incorporate data supplied by the Portuguese and try to reconcile the

120 LNEG, Cortázar to Delgado, 8 December 1894 and letter from Manuel Fernández de Castro to Delgado, Madrid, 12 December 1894.

121 LNEG, copy of the letter from Delgado to Castro, 5 April 1890, Registo da correspondência scientifica 1886–1890, pp. 388–389.

122 LNEG, copy of the letter from Delgado to Castro, 6 August 1890, Registo da correspondência scientifica 1890–1893, pp. 417–419.

123 The geological map of Spain, in the 1:400,000 scale, was released in two versions: one deluxe (sixteen sheets), and the other economy (sixty-four sheets). Blázquez, op. cit. (30).

124 LNEG, copy of the letter from Delgado to the Spanish Geological Survey, 4 October 1890, Registo da correspondência scientifica 1890–1893, p. 425.

125 LNEG, Castro to Delgado, 11 October 1890.

126 LNEG, Delgado to Castro, 6 December 1890, Registo da correspondência scientifica 1890–1893, pp. 435–439.

127 LNEG, Castro to Delgado, 3 February 1891.

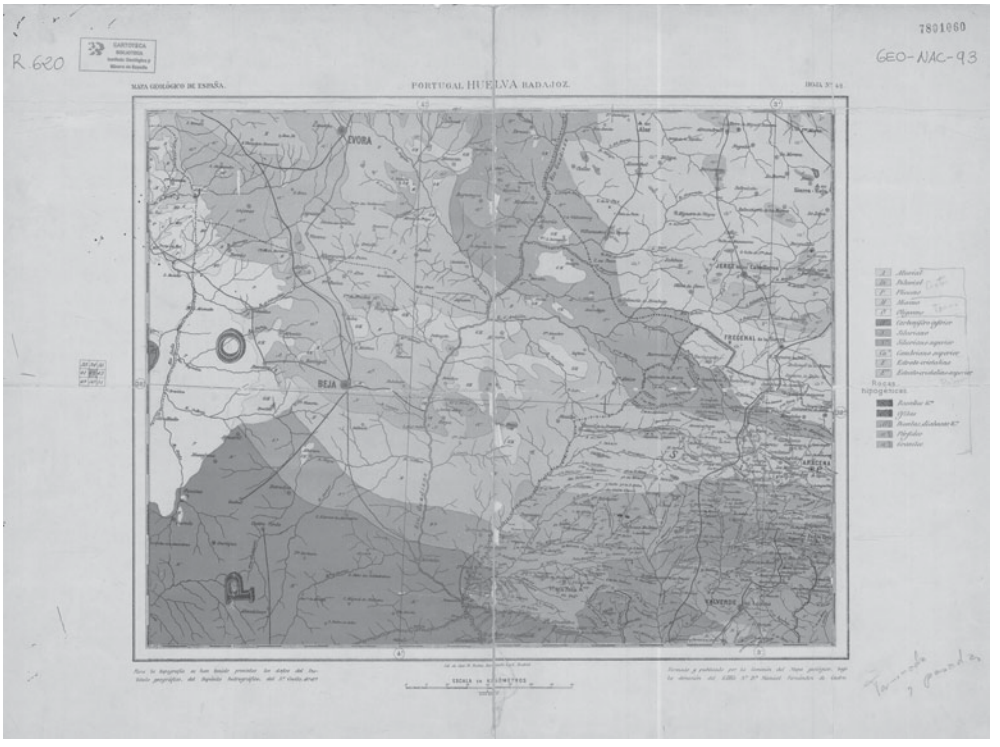

Figure 5. Sheet 42, Geological Map of Spain, scale 1:400,000. Courtesy of Instituto Geológico y Minero de España, Madrid, Spain.

data as much as he could with that of the Spaniards, namely he accepted the use of special symbols in the Portuguese part, which were not being used in Spain.

The Spanish Geological Survey had been most receptive to the objections of the Portuguese, and, although later than initially anticipated, the geological map of Spain in the 1:400,000 scale, which included some Portuguese border regions, was promptly completed (Figure 5).

It provided the basis for the publication, in 1893, of a geological map of the Iberian Peninsula, in the 1:1,500,000 scale, on which is mentioned that it had been made by taking into account 'data from Portugal extracted from the geological map made by the engineers Ribeiro and Delgado, modified by Delgado and Choffat, in 1891'.[128] At least in geological terms the Iberian Peninsula was now unified, if only on a printed map, which certainly would please those who, on both sides of the Spanish–Portuguese borders but mostly in Spain, sympathized with the aim of unifying Iberia. Their hopes

128 Manuel Fernández de Castro, *Mapa Geológico de España. Conjunto reducido del que en escala de 1:400 000 ha formado y publica por orden del Ministerio de Fomento [la] Comisión de Ingenieros de Minas creada en 28 de marzo de 1873 bajo la dirección del Inspector Gral. Exmo. Sr. Don* … (scale 1:1,500,000), Madrid: Ministerio de Fomento, 1889–1893.

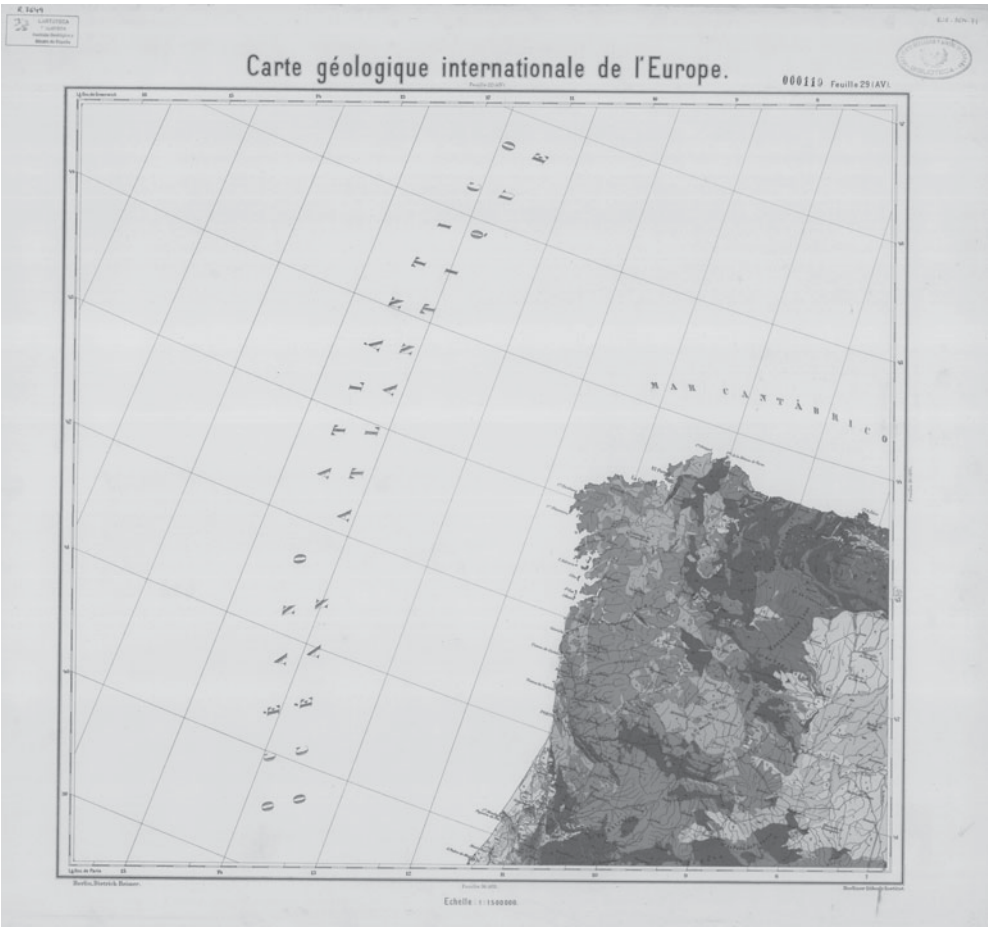

Figure 6. Sheet AV of the Geological Map of Europe, scale 1:1,500,000, 1896. Courtesy of Instituto Geológico y Minero de España, Madrid, Spain.

had in this way materialized in the cooperation underlying the visual representation of the ground beneath their feet.

Meanwhile, the geological map of Europe was progressing. In February 1895, Hauchecorne sent the topographic basis of sheets AV (Figure 6) and AVI (Figure 7), modified according to Delgado's suggestions; at the same time he expressed his hope that 'you will negotiate with Mr. Castro the geological contours along the Spanish–Portuguese border'.[129] Hauchecorne wrote in similar terms to Castro, who during the previous year had been sending data to him, but the Spanish geologists decided to leave to Delgado the final modifications to the version sent by Hauchecorne, in order to avoid delaying the matter further.[130] In any case, Delgado wished to reach an agreement on

129 LNEG, Hauchecorne to Delgado, 18 February 1895.
130 LNEG, Manuel to Delgado, 31 March 1895.

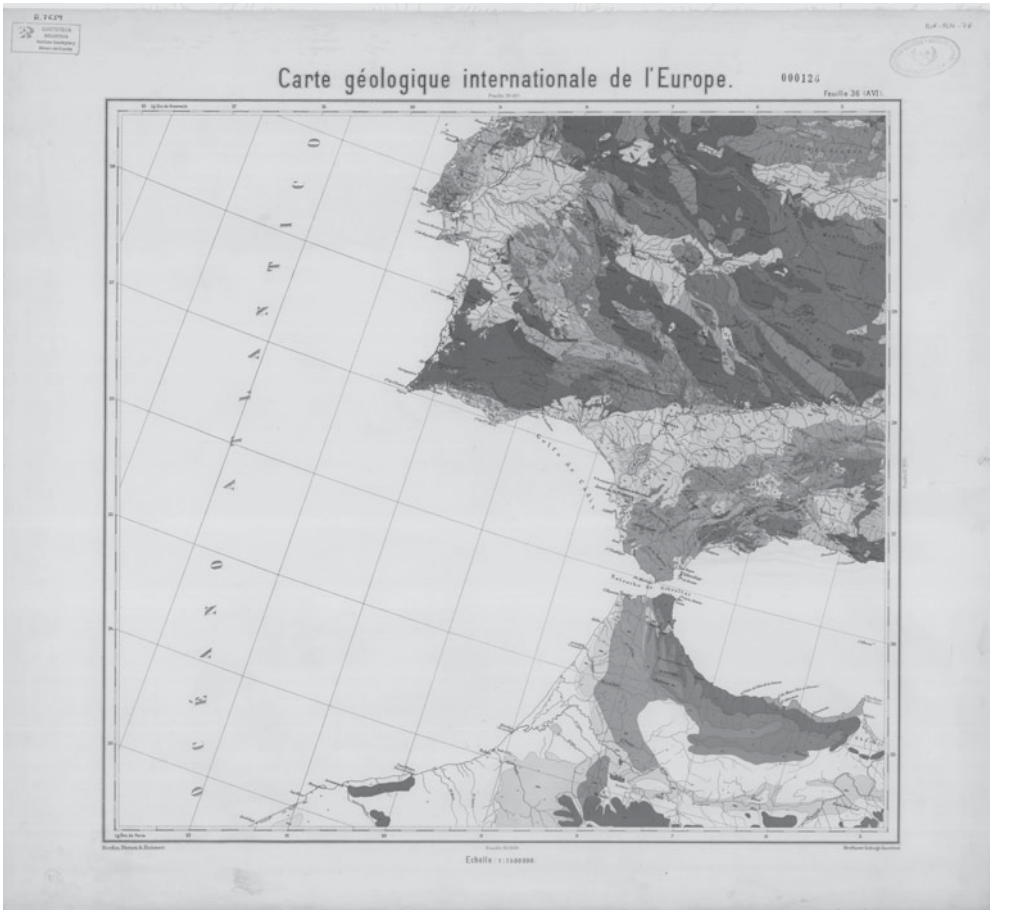

Figure 7. Sheet AVI, Geological Map of Europe, scale 1:1,500,000, 1896. Courtesy of Instituto Geológico y Minero de España, Madrid, Spain.

five discrepancies between the geological map of the Peninsula of 1893, and the draft of the geological map of Portugal, presented in the IGC meeting held in Zurich, in 1894. He wrote to Castro in April 1895,[131] but his Spanish colleague replied, emphasizing the preliminary character of the geological map of Spain in the 1:400,000 scale, arguing that the

> The definitive version . . . will require a permanent effort during the next 60 to 80 years, because both France and England took this amount of time to make the maps they have today, which involved the cooperation of a great number of geologists; meanwhile, we have had available only a limited staff and time span to cover a third of the time spent by the above-mentioned nations.[132]

131 LNEG, copy of the letter from Delgado to Castro, 16 April 1895, Registo da correspondência scientifica 1893–1897, pp. 685–688.

132 LNEG, Castro to Delgado, 25 April 1895.

Castro considered the discrepancies insignificant, because the scale of the European geological map did not allow for detail; in addition, it was far from essential to geological research and only useful to general geological studies.[133] The scepticism surrounding this last judgement may also hint at the apprehension caused by the Prussians' conduct. In his reply, which Castro was unable to read, Delgado had solved three out of five bones of contention. The fourth seemed simple but testified to the difficulty of demarcating the Cambrian in the region of Miranda do Douro in southern Alentejo, in the surroundings of São Domingos, which Delgado classified as Devonian and the Spaniards as Silurian.[134]

Meanwhile, Castro had died and it was Delgado who informed Hauchecorne of his colleague's death and of the name of his successor, Egozcue. While examining Castro's correspondence on the geology of Portuguese–Spanish borders, Egozcue assumed that there were some questions left, which had to be agreed upon with the Portuguese: one was simple – the exclusion of the Cambrian in the surroundings of Miranda do Douro – which Delgado had suggested in his last letter to Castro[135] and was consistent with Puig's observations.

Egozcue, however, was reluctant to accept Delgado's suggestion regarding the Devonian in Alentejo and pointed to an apparent contradiction: Delgado had considered the remains of graptolites (small marine colonial animals, comprising the macroplankton of oceans) and nereites (traces of annelids) found in Barrancos Silurian, whereas in São Domingos, also in Alentejo, he had classified the strata with nereites as Devonian.[136]

Delgado was well aware of scientific developments on the international geological scene. He argued again in favour of the general trend among many European experts of ascribing to the Lower Devonian the strata of Bohemia containing nereites, which traditionally had been classified as belonging to the Upper Silurian. The seeming contradiction between Barrancos and São Domingos would in this way disappear, in as much as in São Domingos only nereites were found and graptolites were absent.[137]

Egozcue replied laconically, expressing his agreement with the views of the Germans, without mentioning anything substantial about the object of disagreement.[138] Their conflicting opinions remained unsolved, as shown in a letter from Delgado to Hauchecorne dated June 1896, informing him of this discrepancy and suggesting falsifying the contacts by moving part of the Lower Devonian to the Silurian and vice versa, a simple change of colour on each side of the border.[139] Delgado's suggestion was accepted as shown on sheet AVI of the geological map of Europe (Figure 7).

133 LNEG, Castro to Delgado, 25 April 1895.

134 LNEG, copy of the letter from Delgado to Castro, 13 May 1895, Registo da correspondência scientifica 1893–1897, pp. 691–693.

135 Sent when Castro had passed away.

136 LNEG, Egozcue to Delgado, 22 June 1895.

137 LNEG, copy of the letter from Delgado to Egozcue, 4 July 1895, Registo da correspondência scientifica 1893–1897, pp. 705–709.

138 LNEG, Egozcue to Delgado, 9 July 1895.

139 LNEG, copy of the letter from Delgado to Hauchecorne, 27 June 1895, Registo da correspondência scientifica 1893–1897, pp. 765–771.

The relationship between the leaders of the Spanish and Portuguese Geological Surveys, however, so intense and congenial in the years prior to Castro's death, never recovered theit prior tone following the fulfilment of the international commitments concerning both institutions. At this particular moment, the final decision regarding the geological discrepancies between Portugal and Spain, personified in Delgado and Egozcue, was in the end left to a third person, the Prussian Hauchecorne.

Conclusion

Until the mid-1890s, the relationships between Portuguese and Spanish geologists both inside and outside their respective Geological Surveys were marked by scientific, cultural and political affinities, associated with intellectual and political movements in both countries, inspired by positivism, republicanism, utopian socialism and democratic federalism, in the context of which Iberian unification was a topic of discussion.

Like birds of a feather, Portuguese and Spanish geologists assumed in this context the role of interpreters of each other's aspirations and hopes. But at some point, Spanish institutions devoted to cartography and geological map-making became a reference for their Portuguese counterparts as models of organization worth following, despite the fact that the Portuguese never reached the same level of institutional autonomy as their Spanish equivalents.

If in the realm of archaeology the Spaniards seemed to have been open to international contacts, as shown by their regular participation in the meetings of the ICAPA, the same does not apply to geology. Spanish geologists published in Castilian, and they seldom participated in the workings of the international geological community, the relationship with the Portuguese being an exception, surely due to cultural and political affinities, linguistic proximity and the territory they shared. One of the outcomes of this scientific cooperation crystallized in the making of the geological map of Spain, which included Portuguese border regions, and the geological map of the Iberian Peninsula, published in 1893. In geological terms, the Iberian Peninsula was in this way symbolically unified.

The Portuguese, however, had a distinct posture in their international relations, which was not limited to their neighbouring country. They were regularly in touch with foreign colleagues and institutions from all over the world, and participated regularly in the meetings of the IGC from its inception. This different attitude explains the reason why they became mediators between their Spanish colleagues and the makers of the European geological map, in the context of the more or less formal diplomatic functions also played by Geological Surveys across the world. This diplomatic function derived not only from the very nature of their object of research – territory – but also from the tensions between nationalism and internationalism, which characterized nineteenth-century science.

The IGC, an organization which materialized the internationalization of geological knowledge and aimed at the standardization of the verbal and visual language of geology, faced from its earliest years difficulties in its attempt to generate consensus among the geologists and geological services of different countries. Despite the many achievements of the IGC to this day, political pressure and hegemonic pretensions often

surfaced, in particular in the making of the geological map of Europe. A division seems to have been established between empires whose possessions were part of Europe, and those colonizing overseas territories, which favoured the leadership of Central European empires in the making of the geological map of Europe. Despite the tensions between the latter, the choice of Berlin reflected the converging availability of material and human resources, organizational capabilities and the growing political supremacy of Prussia.

In this context, the Iberian geologists Delgado, Choffat and Macpherson expressed their scepticism regarding the usefulness of the IGC, because it was able to generate agreement neither on the criteria to be applied to stratigraphic divisions nor on the code of colours and symbols prior to the making of the European map. In this sense, standardization, essential to the graphical representation of geological knowledge and the universality required by the reading and interpretation of geological maps, was imposed rather than consensual. Despite the German geologist's being supervised by an international committee, the leadership strategy followed by Beyrich and Hauchecorne was that of fait accompli. Inevitable adjustments, however, had to be made regarding the articulation of geological data to be represented on the map, the Geological Surveys of both Portugal and Spain, among others, being called upon to participate, because otherwise the whole project would be compromised. In this context, the cooperation and harmonization of data between Portuguese and Spanish geologists is an example of the efforts and tensions that marked the making of the European geological map throughout Europe.

With Iberian participation in this enterprise, a cycle in the relationships between geologists of both countries – marked by frequent contacts and congenial cooperation during the period between the 1850s and the death of Castro in 1895 – ceased. The mid- to late nineteenth-century generation of geologists and archaeologists of both Iberian countries entertained not only scientific but also personal relationships based on shared cultural, political and ideological values, especially concerning the modernization of their respective countries, and specifically on the role of geology, cartography, archaeology and palaeoanthropology in this process.