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The spreading fossil heritage: how to valorise the lithographic limestones of the La Pedrera de Meià and La Cabrua quarries in the Orígens Unesco Global Geopark (Southern Pyrenees, Catalonia)

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Abstract

The Orígens Geopark UGGp situated in Lleida (Catalonia), is characterized by a rich Cretaceous fossil heritage. One of the most impressive fossil collections comes from the Meià Quarry (Vilanova de Meià village), which has provided a huge amount of lithographic limestone slabs with vertebrates, non-vertebrates (including insects), plants and coprolites of Barremian-Aptian ages (about 125 mya) preserved as two-dimensional structures that shows even the soft parts of their morphology.

This palaeontological site is known for providing one of the most primitive angiosperms plants (*Montsechia vidalii*) and the presence of two specimens of the primitive bird (*Noguerornis gonzalezi*). Hitherto the site has yielded 112 holotypes and paratypes, and 151 different species, which gives a real indication of its palaeoecological importance.

However, this site is almost unknown except for specialized researchers, because these fossils have been disseminated in more than 10 public collections and an indeterminate number of private ones. The collection of the fossils from both European universities and local amateurs, started at the beginnings of commercial exploitation as a lithographic limestone quarry, in 1898. The weak palaeontological Spanish scientific network together with the lack of heritage laws, have allowed this dispersion during the first 75 years of the twentieth century. This situation changed with the implication of the Institut d'Estudis Ilerdencs, a scientific and cultural branch of the Diputació de Lleida, which was involved in the fieldwork campaigns of the site and keeps in its collection more than 4.000 fossils. This collection is the basis of the exhibition housed in Vilanova de Meià, that shows the most interesting fossils found in the quarry and its history. This exhibition should be one of the cultural attractions of this small village and a point of attraction for cultural tourism. Finally, in order to assign the real importance of this palaeontological site, a global European database of the spread fossils is being built to disseminate them on a virtual platform.

Introduction

Only two Lower Cretaceous fossil Conservation Lagerstätten (Konservat-Lagerstätten), following Seilacher *et al.* (1985), are known from the Iberian Peninsula: Las Hoyas, in Cuenca Province, and La Pedrera de Meià (also known as Pedrera de Santa Maria de Meià, Pedrera de Rúbies or Pedrera de Montsec), in Lleida Province. The latter is often associated with a third small outcrop called La Cabrua (or La Cabroa) of slightly similar age and proximal to La Pedrera de Meià by about 6 Km. While the discovery of Las Hoyas in 1985 is somewhat recent, and fieldwork has always been carried out under modern heritage legislation, the chronology of La Pedrera de Meià limestones tells a different story. The quarry was already known in 1898, a time of severe industrialization of Catalonia, and both exploitation and scientific works were conducted without any regulation (see more in Lacasa 2013). As a consequence, thousands of fossils from the sites were systematically scattered across some European institutions and private collections. Vital fossil control has been introduced from 1993, when the Catalan legislation on archaeological and palaeontological heritage was developed, and today, an endorsement from the Catalan Department of Culture is needed for arranging new palaeontological campaigns, which enforces fossil deposition in registered museums.

Institutional abbreviations: **EMAUG**, Ernst-Moritz-Arndt-Universität Greifswald, Greifswald, Germany; **GZUG**, Geowissenschaftliches Zentrum der Universität Göttingen, Göttingen, Germany; **ICP**, Institut Català de Paleontologia Miquel Crusafont, Sabadell, Spain; **IEI**, Institut d'Estudis Ilerdencs, Lleida, Spain; **IGME**, Instituto Geológico y Minero de España, Madrid, Spain; **MCD**, Museu de la Conca Dellà, Isona, Spain; **MCNB**, Museu de Ciències Naturals, Barcelona, Spain; **MNCN**, Museo Nacional de Ciencias Naturales, Madrid, Spain; **MNHN**, Muséum National d'Histoire Naturelle, Paris, France; **MSCB**, Museu del Seminari Conciliar de Barcelona, Barcelona, Spain; **NHM**, The Natural History Museum, London, UK; **MNHU**, Museum für Naturkunde, Berlin, Germany; **UAB**, Universitat Autònoma de Barcelona, Barcelona, Spain.

The Dinosaurs of the Pyrenees project

For over a hundred years, the outcrops of La Pedrera de Meià and La Cabrua have yielded nearly 112 new types and a great number of extremely well-preserved fossil plants, invertebrates, vertebrates and ichnites. Despite its richness, the fossil site is still unknown for the general public. Currently, the project Dinosaurs of the Pyrenees (www.dinosauresdelspirineus.cat) is working to recover and disseminate all scientific information obtained from both outcrops. For this, some actions have begun to be accomplished: first, a new database is being created to collect all the information from those European institutions where fossils have been deposited throughout the past century. The database has been built by examining the collections of Spain (AG and AG-D), France (JP), Great Britain (JP) and Germany (AG, AG-D and JP). Additionally, research has been done on the old campaigns and data from scientific field logs and imaging files have been documented and added to the database; second, a public outreach event has been launched in an exhibition settled in the little town of Vilanova de Meià, the closest village to the sites, within the Orígens Geopark, to display a selection of relevant specimens from IEI collection. As a matter of fact, one of the most relevant geological features within the Geopark is the continental Cretaceous fossil record, especially the dinosaur remains and fossil plants. In its beginnings, in 2001, the Dinosaurs of the Pyrenees project resulted as a

joint collaboration between the MCD and the IPC. With this agreement, the fossil collection was kept at the MCD and the scientific work was conducted by ICP researchers. In this way, the Dinosaurs of the Pyrenees project established a dissemination proposal with a clear balance between the divulgation of scientific information among several localities near the fossiliferous sites. The aim was to build a big palaeontological museum distributed among different centres, in the same way that a museum does, with its distinct exhibition rooms. Currently, there are already four dissemination centres open to the public (Fig. 1). The Dinosfera, located close to a unique sauropod nesting area at the village of Coll de Nargó, has dinosaur reproduction as the dominant subject. At the locality of Cercs, the Fumanya Dinosaur Centre has a special mention to sauropod tracks and predator-prey relationships. In Tremp there is the Epicentre, which addresses the rising of mammalian groups after the K-Pg extinction event. Finally, at the Centre de Dinamització de Tartareu, near the Espinau dinosaur fossil site, an exhibition is focused on microvertebrate remains. The MCD acts itself as a dissemination centre, revisiting hadrosaurian and titanosaurian new species and Maastrichtian ecology. Besides these, the Centre d'Interpretació del Montsec is situated in Vilanova de Meià and houses an exhibition of the best-preserved specimens of La Pedrera de Meià and la Cabrua and marine fossils from these areas. This latter dissemination centre should be an excellent opportunity to use fossils and geology as a socio-economical tool to attract cultural tourism to these depopulated rural areas.

FIGURE 1 HERE

Figure 1- Map of the Dinosaur of the Pyrenees dissemination centres. The red line outlines the geographical extension of the Orígens Unesco Global Geopark.

Geographical and Geological settings

The fossiliferous sites of La Pedrera de Meià and La Cabrua are located in the Montsec de Rúbies Range, at the municipality of Vilanova de Meià, Lleida Province, Spain, inside of the Orígens Unesco Global Geopark (Fig. 2). These two outcrops and the third one near El Reguer ravine, are known as '*Les calcàries litogràfiques de Sta. Maria de Meià*' (the lithographic limestones of Sta. Maria de Meià) (Lacasa 1991; Lacasa 2013).

Structurally, the Montsec de Rúbies Range is part of the Central South Pyrenean Unit, one of the five structural units that define the Pyrenees according to Losantos et al. (1988). The Pyrenees are an asymmetrical chain with principal south displacement nappes by the subduction of the Iberian plate under the European plate (Muñoz et al. 1984). The emplacement of the Central South Pyrenean Unit began in the Late Cretaceous and occurred until the late Eocene (Cuevas and Mercadé 1986). It should be noted that this unit is divided from north to south into three imbricated thrust sheets: the Bòixols, the Montsec and the Marginal sheets (Losantos et al. 1988). The Montsec thrust sheet is a wide syncline with an East-West trend that contains a sedimentary record of 2000 m, from the Triassic to the Lower Eocene. It is formed principally by rocks from the Early Jurassic, with a complete Cretaceous-late Eocene section. The sedimentary sequence is dominated by carbonate rocks with disconformities in both the Lower and lower Upper Cretaceous segments (Seguret 1972, Solé Sugrañes 1978), and the thickness of the Mesozoic sediments varies considerably from 5,000 m in the north, to barely 100 m in the south. Thus, the Lower and

Upper Cretaceous are represented by 400 m and 1,500 m respectively at the Montsec sheet (Losantos et al. 1988). Ruiz de Loizaga and Martínez-Delclòs (1990) (see also Mercadé 1991) defined six different sedimentary facies for La Cabrua site, one of the fossil outcrops and the site that it was exploited only by scientific exploration. One of these facies, lithographically dominated by mudstones with parallel lamination, rhythms and punctual framboidal pyrite, is where the main paleontological studies have been done, enhancing the stratigraphy, the sedimentological dynamics and the systematics (Martínez-Delclòs 1987, Ruiz de Loizaga and Martínez-Delclòs 1990). The other facies consist of mudstones with deformed lamination and fenestral porosity, wackestones-packstones with charophytes, carbonated breccias with intraclasts, silts with high content in plant remains, and slumps affecting all the other facies (Mercadé 1991). Peybernès (1976) encompassed all this stratigraphic record in his early Cretaceous lithostratigraphic synthesis of the Pyrenees, where he included the *Calcaires lithographiques à Plantes et Vertébrés de la Pedrera de Rúbies* Formation within the newly defined *Ensemble de Calcaires à Charophytes du Montsec*.

FIGURE 2, HERE

Figure 2- Geographical location of the two main palaeontological sites with lithographic limestones.

Age of the outcrops

The age of the outcrops has been a subject of intense debate during the last century. First after its discovery, a Kimmeridgian age (Upper Jurassic) was assigned to the rocks of La Pedrera de Meià based on lithological criteria (Vidal 1902), as for example on similarities between some fossil fish, such as *Microdon* or *Leptolepis*, with those from Kelheim, Solnhofen or Cerin sites (Gomez Alba 1997; Lacasa 2013). Although a Kimmeridgian age was initially accepted by the majority of authors, Krusat (1966) assigned a Lower Cretaceous age to the sediments for the first time with consistency, after an extensive study of the Cretaceous stratigraphic record which led him to see similarities with the English Weald. Nevertheless, the age of these lithographic outcrops was still a matter of discussion and later geological studies published in the second half of the twentieth century (Peybernès and Oertli 1972; Barale et al. 1984) proposed a more specifically Berriasian-Valanginian (Lower Cretaceous) age for the outcrops and interpreted the depositional environment as a carbonated coastal pond with punctual sea connections. At present, the most accepted age is Barremian (Lower Cretaceous) supported by charophyte studies, specifically by the presence of *Atopochara trivolis* Grambast, 1968, and the special configuration of fossil assemblages and regional stratigraphy by Mercadé (1991) and Martín-Closas and Morón (1995), and the environment redefined as lacustrine with no marine connections. It would be the most accepted model until future studies that do not contradict it.

Chronology of the fieldwork

Discovery of the first fossil

Luis Mariano Vidal, mining engineer and geologist, recognised the first fossil remains at La Pedrera de Meià in 1898 (Vidal 1902). He briefly described the presence of an exceptional specimen, the amphibian *Monsecobatrachus (Paloebatrachus) gaudryi*, probably discovered at the beginning of 1901, as well as some fish and plant imprints (Vidal 1902). Shortly after, Sauvage (1903) uncovered the richness in fish

diversity of the outcrop after examining in more detail the first specimens, thanks to the fossils provided by Vidal.

The palaeontological campaigns

The commercial activity of the quarry was developed between 1898 and 1917 (Fig. 3). Only during the first six years the quarry was at full production, which resulted in many lithographic slabs removed by the workers, and therefore, in the discovery of important vertebrate remains, in addition to the *Monsecobatrachus* published by Vidal, such as the neosuchian *Montsecosuchus depereti* or the squamate *Meyasaurus faurai*. The fossils that Vidal collected during his many visits to the quarry, were deposited at the MCNB in 1922 after his demise (Gómez-Alba 1997).

FIGURE 3 HERE

Figure 3- Pictures from La Pedrera de Meià quarry during their commercial working (*circa* 1900). Left, miners extracting the lithographic slabs. Right, quarry workers preparing the slabs under surveillance of mining company employees. © Arxiu Centre Excursionista de Catalunya.

The first palaeontological campaign was promoted by Vidal in 1910 and consisted of a 25 days field trip to collect more specimens from the area.. In the meantime, a new way to obtain fossils from this site was proposed by the Santa Maria de Meià Presbiter in exchange of money, although the number and quality of the consignments were extremely poor (Gomez Alba 1997). A few years later, Vidal (1915) published four new species of fish from the quarry, two new reptile species (*Meyasaurus faurai* and *Alligatorim depereti*) and one coleopter.

With the death of Vidal in 1922, the quarries were almost forbidden except for amateur palaeontologists like Lluís Ferrer i Condal, who began his fossil collection in 1950. Ferrer discovered a new anuran (*Eodiscoglossus santonjae*) in a slab and a counter-slab. Ferrer sold the best-preserved specimen to the MCNM and bought a scooter with the profits to use it professionally as a doctor and for gaining better access to the quarry (Lacasa 2016). Unfortunately, after his demise in 2011, his collection remained private without any possibility to be visited or studied.

Ferrer also counted on collaborations from professional palaeontologists through his international network. In 1954, Dr Wonnacot from the British Natural History Museum of London, contacted Ferrer which prompted him to visit La Pedrera de Meià between 1955 and 1960, and Dr. Bell in 1956 (Walley & Jarsembowski 1985).

A series of seven campaigns were carried out between 1964 and 1972 at La Pedrera de Meià quarry by the Muséum National d'Histoire Naturelle de Paris (MNHN) and the Laboratori de Paleontologia de la Universitat de Barcelona were conducted by Dr Sylvie Wenz. This period of activity turned out to be very prolific for the site, collecting an abundance of fossils from which approximately 3,200 are deposited at the MNHN. The interest on the site came out after Professor Miquel Crusafont i Pairó, principal Chair in Palaeontology at the Universitat de Barcelona, and Professor Jean-Pierre Lehman, principal Chair in Palaeontology at the MNHN, were intrigued on a private collection whose owner, Dr Ferrer Condal, was believed to sell (Wenz 2002). They asked Sylvie Wenz, a PhD student and future eminence in fossil fish at

the MNHN, to evaluate the collection and elucidate the truth upon the selling issue. Eventually, it was found that the collection was not on sale and Wenz gained access to some of the specimens, a fortunate fact that allowed her to be aware of the significance of the collection, as she stated years later in a personal document '*la collection est superbe*' (Wenz 1974). From then on, all efforts were put into the organisation of a number of Franco-Spanish campaigns planned by Wenz until 1972, although she re-joined them in 1981 following the invitation from the Institut d'Estudis Ilerdencs and the Laboratoire de Paléobotanique de Lyon, who arranged the subsequent expeditions. After the first four campaigns, outcomes came out soon in the shape of two publications on the revision of some of the fossil fish from the Condal collection and new material (Wenz 1964; 1968), especially taking notice of the small specimens, hitherto overlooked.

In the early seventies, Antoni Lacasa led the nonprofessional society 'Amics de la Paleontologia' and started up the next collecting episode. This group was included in the IEI, which depends upon the Diputació de Lleida, and a long-term collaboration began between this institution and the enthusiast collectors. The first campaign took place in 1979 under the supervision of Dr Barale from the Université Claude-Bernard of Lyon. In this expedition, new fossils were discovered at La Cabrúia, which became from that moment the main focus of the excavations. From 1979, nineteen expeditions were accomplished and more than 4,000 specimens were deposited at the IEI, some of them donated by particular collectors.

Finally, a mixed team from the ICP and the MCD have been working from 2008, mainly in La Pedrera de Meià, in order to understand the complex sedimentology of the Lower Cretaceous lithographic limestones of the Montsec and to obtain new specimens, which are currently deposited at the MCD.

The Collection

In order to comprehend the extension, diversity and richness of the Montsec lithographic limestones, it has been crucial to conceive an accurate fossil database that compiles taxonomic identification, description, images, year of collection and references of each specimen, to help trace back the great dispersion undergone by the fossils through more than a hundred years. With time, some of the private collections have been deposited in registered museums (e.g. Vidal collection at the MCNB). However, in this paper we have only taken into account those kept in public institutions accessible to researchers and the general public.

The Institutions

Institut d'Estudis Ilerdencs de Lleida (IEI)

The IEI is located in Lleida city and it's part of the Diputació de Lleida, a provincial administration devoted to supporting the municipalities. For more than 40 years, the IEI has collected and stored fossils from the quarries and today its collection contains 4,100 specimens. Most of them (88,5%) were obtained under campaigns funded by the IEI itself, whereas the rest (11,5%) were acquired through donations from private collectors.

At its facilities, the IEI keeps the biggest record of holotypes from La Pedrera de Meià and La Cabrúia with 45 types from which 35 represent insect species (see Supplementary Information). It is worthy to mention as well the type material of the primitive bird *Noguerornis gonzalezi*. This collection will be the basis for the exhibition housed in the Vilanova de Meià Interpretation Centre.

Museu de Ciències Naturals de Barcelona (MCNB)

The MCNB has nearly 140 years of history and its geological section, called Museu Martorell de Geologia, is one of the oldest. In 1922, this section received a remarkable fossil collection after the death of Vidal. Most of the fossils collected by him had their origin at the industrial times of La Pedrera de Meià. Today, the collection encompasses 204 fossils and 18 holotypes (Gomez Alba 1997), it's worth mentioning the type material of what could possibly be the most primitive angiosperm identified hitherto, the aquatic *Montsechia vidalii* of Barremian age (Lower Cretaceous). It is worthy to mention as well the holotypes of the actinopterygian fishes *Lepidotes ilergetis*, *Caturus tarraconensis*, *Vidalamia catalunica*, *Amiopsis woodwardi*, *Propterus vidali*, *Ichthyemidion vidali*, the sarcopterygian *Holophagus leridae*, the anuran *Palaeobatrachus gaudryi*, the squamates *Meyasaurus faurai* and *Pedrerasaurus latifrontalis*, and the neosuchian *Montsecosuchus depereti*. Moreover, another 10 types are temporarily stocked at the facilities of the Universitat de Barcelona.

Other private collections have been procured by the MCNB along the years such as the Serradell collection, acquired in 1931 (15 specimens), the Suñer i Coma collection in 1956 (28 specimens), and the Villalta collection, the last one coming from la Pedrera de Meià, acquired in 1988 (26 specimens) (Gómez Alba, 1997).

Figure 4- Location of the European Institution with specimens from La Pedrera de Meià and La Cabrua sites.

Museu del Seminari Conciliar de Barcelona (MSCB)

The MSCB collection consists of 321 specimens which have been incorporated from different contributors since the mid-fifties. This collection is composed of two amphibians, two feather impressions, 30 crustaceans, 19 insects, 99 fishes, 144 vegetals, 70 ichnological traces and some indeterminate fossils. The collection encompasses four holotypes, three crustaceans (*Oplophorus roselli*, *Paleaga ilerdensis* and *Pseudoastarus llopisi*) and one insect (*Artitocoblatta colominasi*).

Institut Català de Paleontologia Miquel Crusafont (ICP)

Only few specimens are stored at the ICP, although all correspond to holotypes: *Ophiopsis montsechensis* (holotype and paratype), *Rubiesichthys gregalis* (holotype), *Leptolepis crusafonti* (holotype and paratype), and *Ilerdaesaurus crusafonti* (junior synonym of *Meyasaurus*, Evans & Barbadillo 1996). Professor Crusafont never visited the Meià quarry, but he intended to control as many Spaniard fossil vertebrate sites as possible. During the organisation of the campaigns led by the NHMUK and the MNHN, Professor Crusafont was contacted for giving logistic advice and for some kind of legal "permission". The Crusafont Archives (ICP) bear witness to the correspondence between Dr Wenz and Professor Crusafont, focusing the interest of the latter to control the results of each campaign.

Museu de la Conca Dellà (MCD)

The MCD (the closest registered museum to the lithographic limestones) in collaboration with the ICP, have recently arranged some palaeontological campaigns. This fieldwork has provided new material which has consistently increased the fossil record of the assemblage stored in the museum, along with contributions from private donations. In fact, prior to 2020, the collection consisted of more than 220 pieces, including 54 fossil fish, seven insects, two decapods, two gastropods, over 100 plants, 35 coprolites, and nine ichnites. Neither holotypes nor paratypes are yet housed at the MCD until now. However, new material from the last paleontological campaigns organized in the summers of 2019 and 2020, which includes more fish and plant specimens, might yield new unknown taxa.

Museo Nacional de Ciencias Naturales de Madrid (MNCN)

The MNCN is a historical institution within the CSIC (Consejo Superior de Investigaciones Científicas) and manages an exceptional palaeontological heritage. Even if the fossil collection from the Montsec lithographic limestones is poor (only eight pieces), it includes the holotype of the anuran *Eodiscoglossus santoniae* from the Santa Maria de Meià site, sold by Lluís Ferrer i Condal. The assemblage features some other interesting specimens such as a second anuran *Monsecobatrachus gaudryi*, the ray-finned fish *Microdon egertoti*, and one coprolite. Efforts to digitise the collection are currently underway.

Instituto Geológico y Minero de España (IGME)

A second institution located in Madrid, the IGME, also stores a collection with high historical content due to particular donations during the past century. This tradition has significantly contributed, however, to a lack of informative data, a common issue inherent from this kind of collection. Nonetheless, the Montsec collection housed at the IGME comprises nearly one hundred fossils, from which the majority are referred to the flowering plant *Montsechia vidalii*. The taxonomic diversity includes also seven insect specimens, ten fishes, three decapods, and one bird of an indeterminate genus.

Muséum National d'Histoire Naturelle de Paris (MNHN)

The biodiversity richness of the site is well illustrated by such an assemblage held at the MNHN, which encompasses an extraordinary representation of fossil fish and plants, as well as important examples of insects, crustaceans and amphibians.

The collection includes the type material of the pycnodontiform fish *Ocloedus subdiscus*, two dipters *Hirmoneura* (*Hirmoneura*) *richterae* and *Hirmoneura* (*Eohirmoneura*) *neli*, two hymenoptera *Ilerdosphex wenzii* and *Pompilopterus montsecensis*, the conifer *Nageiopsis hispanica*, and the flowering plant *Ranunculus ferreri*. The enigmatic frog *Eodiscoglossus santoniae*, although represented by eight specimens, maintains its phylogenetic position unresolved (Vergnaud-Grazzini and Wenz 1975; Báez and Gómez 2016). At the time of this paper, no study of the fossil insect specimens was yet done. However, a preliminary inspection evidenced a good representation of Ephemeroptera by several adult forms of the mayfly *Mesopalingea lerida*, as well as probably some nymphs. Some other specimens were identified as wasps indeterminate and fragments of thoraxes and abdomens. Much of the fossil plants were preserved in the shape of imprints of fragmented elements of the vegetative and reproductive organs. They included the type material (holotype) of one of the oldest angiosperms, the aquatic species *Ranunculus ferreri* (Blanc-

Louvel 1984). Several specimens are also referred to another angiosperm, *Montsechia vidalii*, and the conifers *Aracaurites*, *Podozamites*, *Brachyphyllum*, *Pagiophyllum* and *Frenelopsis*. Crustaceans were also represented in the collection, although access has been restricted due to ongoing investigations, which results will be published elsewhere.

The Natural History Museum of London (NHMUK)

Part of the collection of La Pedrera de Meià was gathered between 1955 and 1960 by Dr H.W. Ball, the former Keeper in Palaeontology at the NHMUK, and Frederick M. Wonnacott (Whalley and Jarzembowski 1985). Attempts to digitise and document this important assemblage, estimated in approximately 1,000 fossils between fish, insects, plants and a few bird feathers, have been recently considered and will be probably accomplished in the near future.

Fossil fish makeup near three hundred specimens from a wide taxonomic spectrum, from which almost half are referred to the leptolepiform genus *Leptolepis*. The insect assemblage is of significance on account of the type material (holotype) of some taxa (Whalley and Jarzembowski 1985), such as the nymph of *Mesopalingea lerida*, the dictyopter *Artitocoblatta hispanica*, the odonata *Condalia woottoni*, the hemiptera *Wonnacottella pulcherrima*, and the coleoptera *Chrysobotris* (?) *ballae* and *Eobelus solutus*. Other specimens are referred to *Artitocoblatta colominasi*, some dipterous larvae, a possible aleyrodoid pupa, some indeterminate Geocorisae, and a few of uncertain taxonomic classification. Finally, fossil plants constitute a significant part of the NHMUK collection with 413 specimens, including the type material (holotype and paratype) of the conifer *Frenelopsis rubiesensis*, as well as some more currently under revision.

Museum für Naturkunde (MNHU)

According to scientific literature, the MNHU has in its collections specimens from the Montsec quarries. During the last two years, transactions have been carried out in order to fathom the origin of these fossils, as well as to verify their taxonomic value. In that sense, it seems that there is evidence of the existence of some fossil fish and amphibian specimens, namely the holotype of the anuran *Neusibatrachus wilferti* (Seiffert 1972, Báez and Sanchiz 2007). However, although it has been published the location of the holotypes of the Hymenoptera insects *Leridatoma pulcherrima* and *Cretephialtites pedrerae* (Rasnitsyn and Ansorge, 2000), a communication from the museum states that there are no fossil insects from the lithographic outcrops. This is an example of a common problem when a collection is scattered around several institutions (confusion, possible loans to another museum without registration, wrong location within the collection), and specimens undergo from past times collecting methods and transportation strategies.

Geowissenschaftliches Zentrum der Universität Göttingen

The Geowissenschaftliches Museum is a classic European institution founded in 1773 and affiliated to the Göttingen University. During the 250 years of its history, this institution has built a collection of around four million pieces, among which are two holotypes from La Cabrúa outcrop, the hemipter *Mimamontsechia*

1 *cretacea* and the raphidioptera *Iberoraphidia dividua*, from La Cabrúa outcrop (Szwedo and Ansorge 2015,
2 Jepson et al. 2011).
3

4 *Ernst-Moritz-Arndt-Universität Greifswald*

5
6 The beginnings of the Greifswald collection are in 1877, when collecting actions were carried out
7 conscientiously since the last years of 19th century and beginnings of the 20th century. The geological
8 heritage of this institution consists of twenty different collections spread over three major domains such as
9 geology, mineralogy and palaeontology, being the latter the most extensive. In fact, the Institut für
10 Geographie und Geologie stores 2,5 million objects and more than 1,000 holotypes. Research has been
11 done in La Cabrúa and the type material of eight fossil insects are housed in this institution.
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16 **The dissemination proposal. The impact of the exceptional fossil-lagerstätten in the Orígens Unesco** 17 **Global Geopark** 18 19 20

21 The importance of the fossils discovered at the lithographic limestones of La Pedrera de Meià and La
22 Cabrúa is far to be understood because of its extreme dispersion. Only a few specialists are aware of the
23 high number of the holotypes described from the quarries and the extreme diversity of plants, crustaceans,
24 insects, fishes and tetrapods species. All these species depict a precise picture of this Aptian-Barremian
25 ecosystem. For that reason, the main purpose to start our investigation on the spreading of fossils has been
26 to build a virtual database encompassing all the holotypes, paratypes as well as the maximum number of
27 different species and specimens. Each fossil has been digitised in order to evaluate its quality and
28 completeness and to help in the identification of several non-determined specimens. This will be a dynamic
29 database, open to the scientific and general public through the Orígens Geopark portal
30 (pedrerademeia.geoparcorigens.cat).
31
32

33 A second important goal for this work is focused on the popular dissemination of the lithographic
34 limestones on the territory, through the projects Dinosaurs of the Pyrenees and the Orígens Unesco Global
35 Geopark (www.geoparcorigens.cat). The Orígens Geopark covers about 2,000 square kilometres and has a
36 population of 16,000 inhabitants, which means a ratio of eight inhabitants per square kilometre. Their
37 economy is based on primary production and incipient rural tourism industry. Vilanova de Meia has less
38 than four hundred inhabitants and a very old aged population. Some natural scenery activities such as
39 hiking, mountain climbing, cycling, cultural heritage or local gastronomy are some of the alternative
40 possibilities for this new sustainable industry.
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43 The Cretaceous continental fossil record is also in the spotlight of the Orígens Geopark, and a variety of
44 facilities such as the palaeontological museums, visitor centres and outdoors sites, help to display its value.
45 In this way, the Centre d'Interpretació del Montsec aims to become a pole of attraction for the visitors and,
46 for this, is necessary to build an excellent dissemination argument.
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49 Despite the great number of fossils listed in this paper, only the collections of the IEI and the MCD has
50 been used for the public dissemination. The IEI collection has the largest number of specimens and it has
51 facilitated a magnificent sample representative of the abundant fauna and flora remains. Up to a short while
52 ago, the specimens had been physically stored in Lleida city at the ancient Hospital Santa Maria building,
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1 a relic of the Catalan historical heritage erected during the 15th and 16th centuries, and currently the IEI
2 headquarters. This significant sample of the best-preserved specimens from the IEI will be exhibited in the
3 Vilanova de Meià Interpretation Centre. This facility, under the legal umbrella of the Museu de la Conca
4 Dellà and Museu de la Noguera, explains the geological history of the Montsec range, linked to the
5 Pyrenean tectonics, focusing on the Pedrera de Meià and La Cabrua best fossils. The origin of this exhibition
6 was a temporal exhibition housed at the Gothic Room of the Hospital of Santa Maria building, in Lleida city,
7 with a modular structure able to be adapted to the Vilanova de Meià building. The original name of the
8 exhibition was “Lleida land of Palaeontology - The Meià quarry and the origin of the modern world” and
9 was opened to the public from September 2018 to February 2019 and highlighted four decades of amateur
10 and professional paleontological field-work, and to pay tribute to the figure and work of Mr Antoni Lacasa,
11 one of the impellers of the palaeontological section at the IEI.

12 Finally, from the end of 2020, this exhibition is being operative at the Centre d'Interpretació del Montsec,
13 (CIM) housed in a two floors building of 100m². Two main museographic arguments are differentiated for
14 each floor. The ground floor welcomes visitors with a short documentary depicting the Cretaceous
15 landscapes, fauna and flora and the main dinosaurs that inhabit the area that today are the Pyrenees. This
16 documentary is common to all the centres included in the Dinosaures dels Pirineus project and allows to
17 acquire a global view of the south Pyrenean cretaceous fossil sites richness. Once made this introduction,
18 the visitor can do time-travel by the means of “Garcia-Castellanos” collection, a set of more than three
19 hundred fossils donated to the Vilanova de Meià Town Hall, which covers a wide range of time, from
20 Ordovician to Cenozoic. The biggest part of this collection comes from the Upper Jurassic-Upper
21 Cretaceous outcrops of the Montsec Ranges and they help, also, to understand the fossilization mechanism.

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33 **Figure 5- View of the Pedrera de Meià exhibition in the second floor of the Centre d'Interpretació de Meià**
34 **(Vilanova de Meià, Lleida).**

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38 The second floor is devoted to the La Pedrera de Meià and La Cabrua fossils. The sample is composed of
39 103 specimens, including two amphibians, one reptile, one feather, two arachnids, seventeen insects, six
40 crustaceans, thirty-one fishes, thirty-four plants, together with ichnites, coprolites, and lithographic rocks.
41 Nineteen of these fossils correspond to holotypes and the visitor can appreciate up to forty different species.
42 Next steps in the musealization will include an audio guide in several languages and complete didactical
43 units adapted for the kids and young students.

44 45 46 47 48 49 **Conclusions**

50 The Mesozoic fossil record of the Montsec de Meià Range is one of the most relevant features of the Orígens
51 UGp. The Pedrera de Meià fossil sites have provided an extremely rich assemblage of plants, insects,
52 arachnids, fish, and tetrapods, with precious holotypes such as the early flowering plants *Montsechia vidalii*
53 and *Ranunculus ferreri*, or the primitive bird *Noguerornis gonzalezi*. This high biodiversity and the
54 extraordinary preservation make the Cretaceous lithographic limestones of La Pedrera de Meià and La
55 Cabrua sites a unique Konservat-Lagerstätten.

1 Historical circumstances have had a great influence on the current dispersion of holotypes and specimens
2 in several museums and private collections and, thus, on the poor knowledge of it, both in a scientific and
3 popular point of view. Also, the scattered nature of the collection currently difficulties its study and implies
4 serious additional problems such as fossil misplacing, information obscuring or even the complete loss of
5 some specimens.
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7 This situation changed when, in the middle seventies of the past century, the IEI together with young fossil
8 enthusiasts started with a series of nineteen fieldwork campaigns that allowed to collect more than 4,000
9 specimens. These specimens, kept at the IEI headquarters, have served to describe new species and to use
10 in several temporal exhibitions. A new project to valorise these paleontological sites, together with the aim
11 to develop the cultural tourism in the core of Orígens UGGp, has joint the efforts of several institutions and
12 Museums (IEI, Vilanova de Meià municipality, Museu de la Conca Dellà and Museu de la Noguera) to
13 create an Interpretation Centre (Centre d'Interpretació del Montsec) with all the guarantees of heritage
14 protection, a clear and didactic museography, and with the aim of helping the socio-economic development
15 of the area.
16

17 Finally, a global fossil database, as a part of a more ambitious website, has been created to encompass all
18 the specimens and their information, hitherto including 112 types and up to 150 species. The virtual access
19 of the collection, open to all the public, will be a successful instrument to enhance research on the fossils
20 of La Pedrera de Meià and La Cabrua quarries.
21

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31

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Figure 1

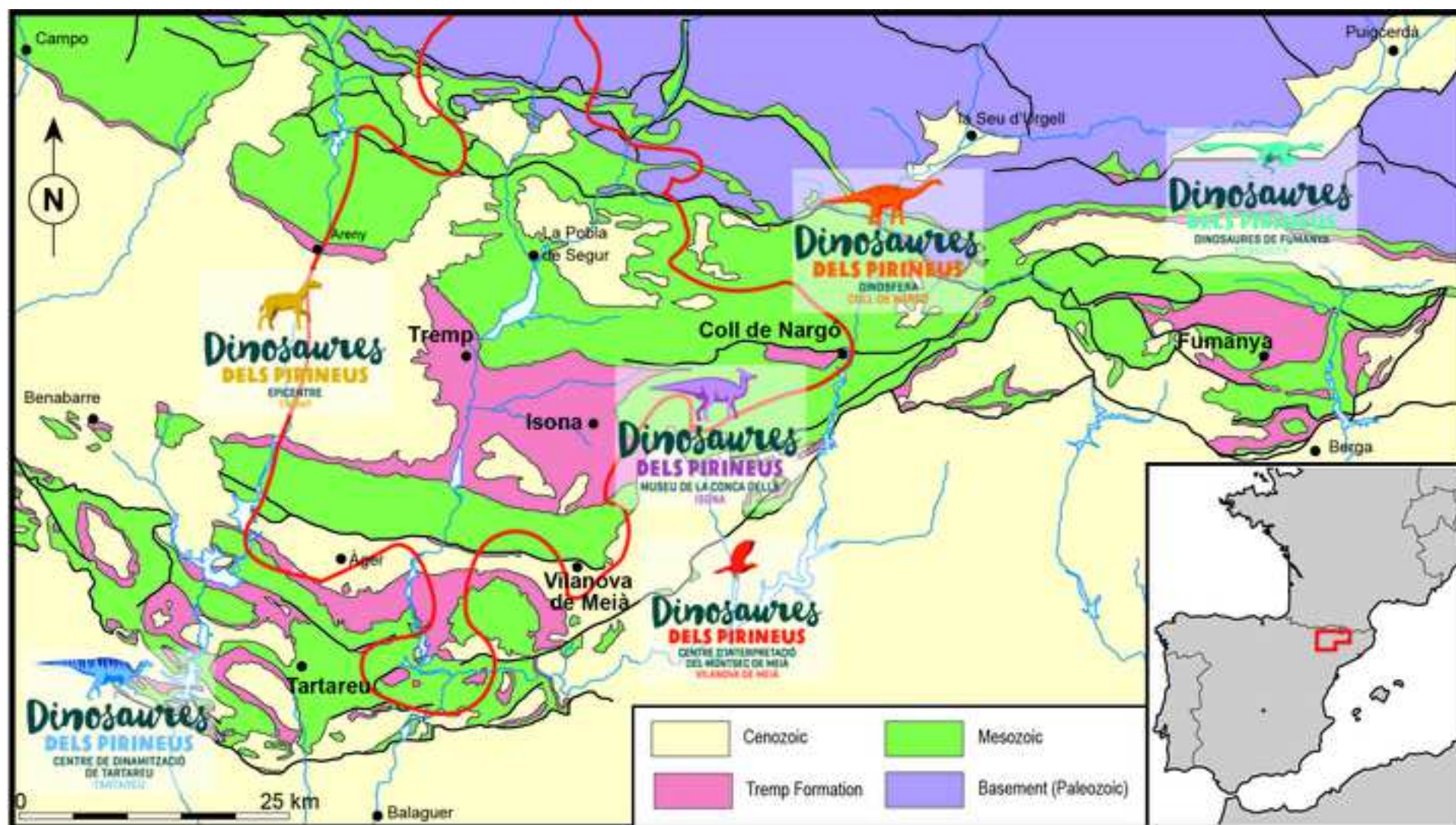


Figure 2

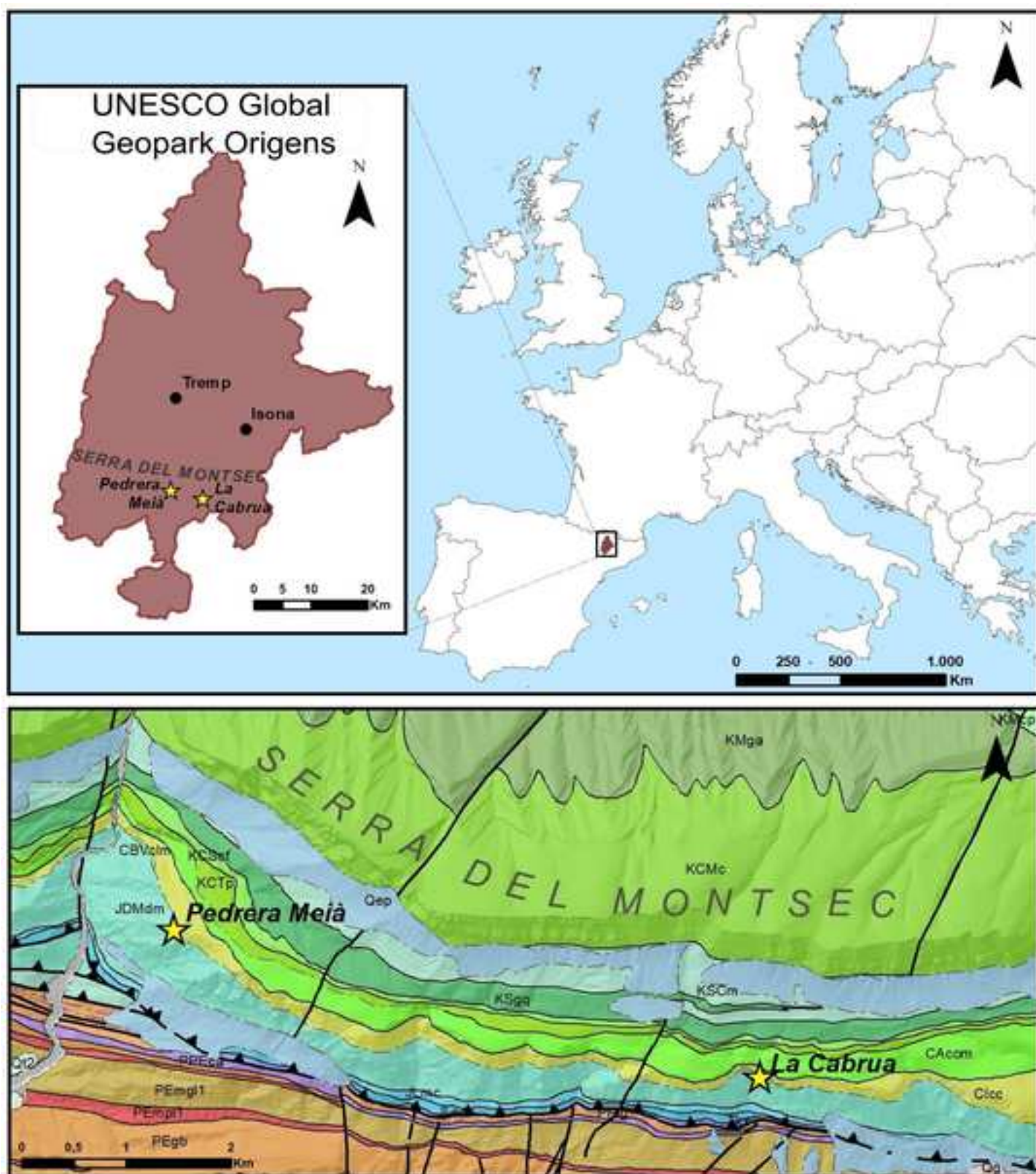


Figure 3



Figure 4

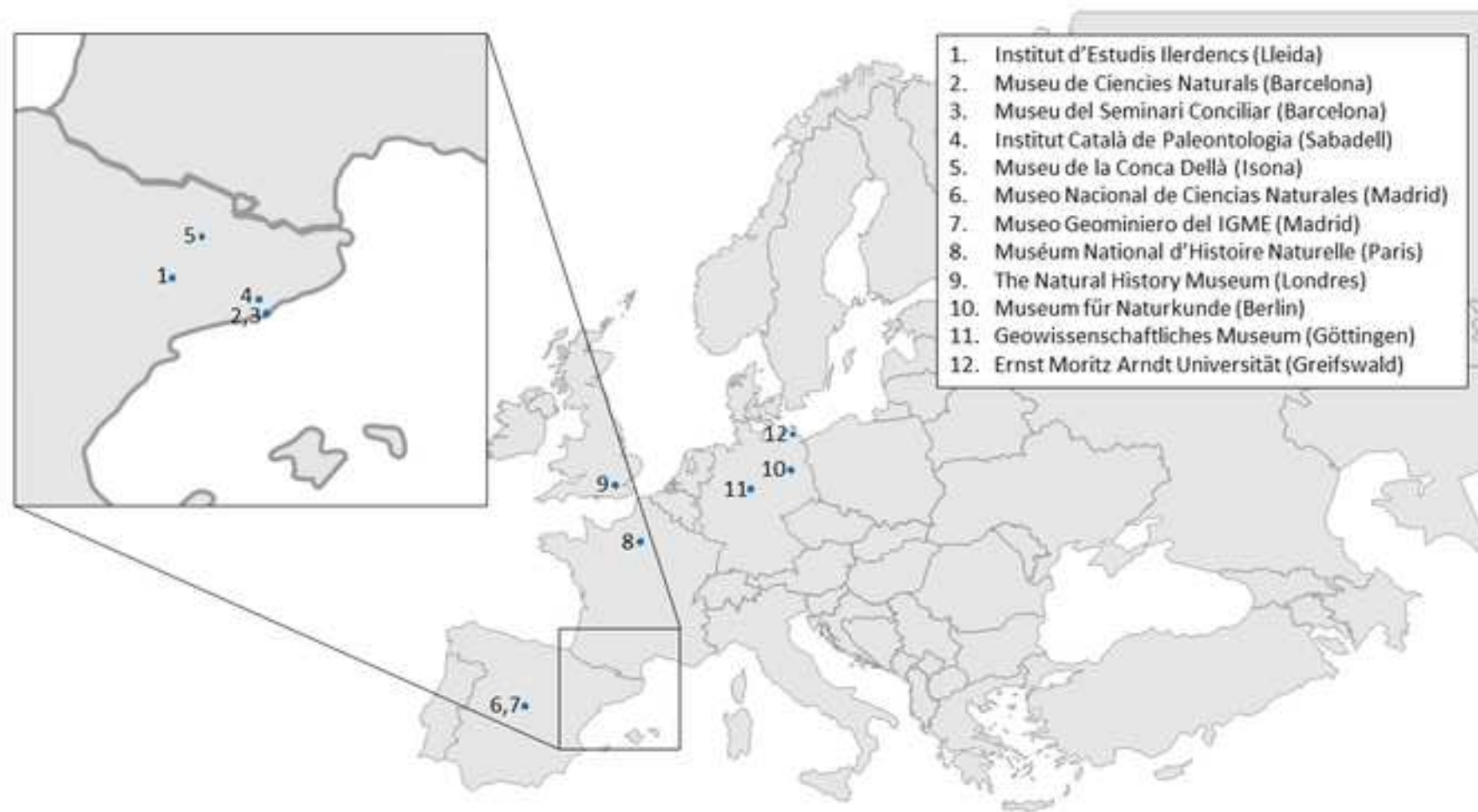


Figure 5

