

CHAPTER 20

CARBONATE AND EVAPORITE KARST SYSTEMS OF THE IBERIAN PENINSULA AND THE BALEARIC ISLANDS



Lagunas de Cañada del Hoyo (Cuenca). Sinkholes or collapse dolines, formed in Cenomanian dolostones with an almost perfect circular shape and partially filled by ground water.

Karst modeling is the result of water dissolving rocks formed by soluble minerals. This process is initially controlled by the interaction of a soluble solid phase (rock) and a fluid one (water), under favorable geological conditions for water circulation, favorable climate (temperatures and rainfall) and the necessary time for the karst process to take place on surface and in depth. The dissolution of soluble rocks with the aforementioned conditions creates a characteristic and very spectacular morphology, typical of the exokarst and the endokarst.

The variety and geological heterogeneity of the Iberian Peninsula and the Balearic Islands originate carbonate or evaporite rock formations in the different geological domains (Paleozoic, Mesozoic and Cenozoic) and in a different quantities, which are prone to be karstified (Durán and López, 1989). The abundant karst systems, modern or past, have a great scientific interest and a remarkable landscape diversity.

Karst modeling originates many different relief elements resulting in a great morphological diversity, from micro and mesoforms (channelings, grooves and cavities – lapiaz or lenars), to macroforms (karstic canyons, poljes, dolines). In this sense, karst processes are not only limited to the surface (exokarst), but its underground development is perhaps more important and undoubtedly more spectacular, as it creates caves, channels, sinkholes and a variety of dissolution-precipitation structures (endokarst). In addition, karst systems have a great scientific and economic interest with regard to the flow and accumulation of underground waters, since an important part of the Iberian peninsular and Balearic island underground waters are karstic and contain an important volume of the underground water resources. Karst also plays a significant role in geotechnical, mining and environmental issues.

Karst distribution in the Iberian Peninsula and the Balearic Islands is linked to geological and bioclimatic changes, being its development controlled by physical-chemical, stratigraphic and sedimentologic parameters. The Spanish territory, except for the volcanic Canary Islands, presents unique karst geosites in each one of the big morphostructural units (Cantabrian Mountain Range, Pyrenees, Iberian Mountain Range, Betic Mountain Range, etc.) with the highest international relevance.

Among the many **exokarst landscapes**, the Paleozoic limestone rocks of Picos de Europa, Pyrenees and the Internal Areas of the Betic Mountain Range are particularly significant for their spectacularity, including some morphological singularities such as the sinkhole fields (*jous*) of Picos de Europa. Mesozoic carbonate formations in the Iberian Range, Cantabrian Coast and Betic Mountain Range –including its Balearic extension– display a wide variety of karst landscapes, from big poljes (such as Zafarraya, Granada) to megalapiaz fields (Majorican Tramontana region), or the so-called *ciudades de piedra* (stone cities) of Torcal



Figure 1, above. “*Ciudad Encantada*” (*enchanted city*), Cuenca (photo by L. Carcavilla).

Figure 2, below. *Ruidera lakes*.

de Antequera in Málaga and Ciudad Encantada in Cuenca (Figure 1).

Endokarst morphologies (caves and sinkholes) are very abundant, rich and varied. More than 30,000 karst cavities are known in Spain, a big amount of which have a great horizontal or vertical development. Standing among them are some vertical caves (*simas*) with depths exceeding 1000 m, and the best developed horizontal underground network of Ojo Guareña Complex (Burgos) which exceeds 100 km. The presence of several speleotheme generations in some caves has allowed geochronologic, isotopic and paleoenvironmental studies (Durán, 1996) which are extremely interesting for the knowledge of Quaternary climatic evolution in the western Mediterranean



On the other hand, some of the Spanish carbonate underground waters have been very well studied, as they suffer overexploitation due to the intensive irrigation (western Mancha), or marine intrusion problems (Mediterranean coastal underground waters). There are also notable examples of unique karst springs, many of them related to the birth of some of the most important rivers in the Peninsula (Ebro, Guadalquivir, Segura and Mundo, among others).

The great scientific importance of the paleontological and archeological record of the Spanish endokarst must be mentioned. Some of the world's most important examples come from the exceptional Middle Pleistocene paleoanthropological record in Atapuerca (Burgos), the Paleolithic cave ceiling paintings of Cueva de Altamira (Cantabria) –first known station of end-Pleistocene man art (Figure 3)-, Cueva de Tito Bustillo in Asturias, etc.

Although most of the karst processes are linked to carbonate rocks, as they are more abundant on the Earth's crust, the gypsum formations of the Mesozoic (Triassic) and Cenozoic (Paleogene and Neogene) have also developed karst systems of international relevance. An example is the karst in Sorbas, Almería, in the southeastern region of the Iberian Peninsula. Here, more than 600 cavities are found in just 16 km² of Messinian gypsum exposures, some of them more than 6 km long (Calaforra, 1996). The exokarst and endokarst morphologies, and the interest in the study of the gypsum's hydrogeological behavior, make this already protected area and exceptional geosite of international relevance.

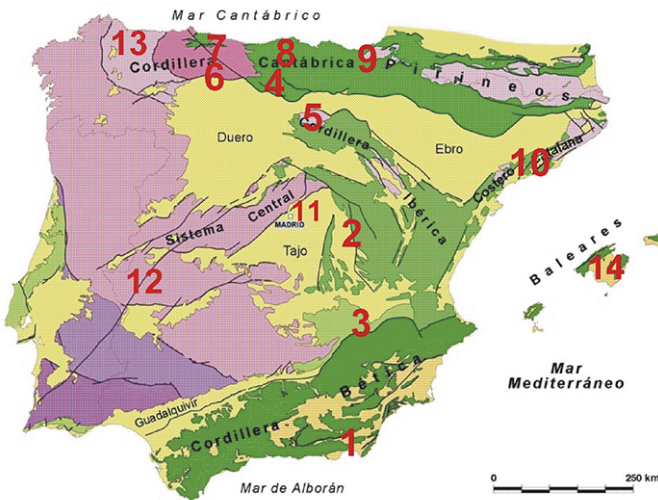


Figure 3, above.
Cave ceiling paintings of Cueva de Altamira (Cantabria).

Figure 4, below.

- 1a) Antequera, Nerja and Sorbas
- 1b) Gruta de las Maravillas
- 2) Ciudad Encantada
- 3) Mundo river and Ruidera lakes
- 4) Las Tuerces
- 5) Ojo Guareña and Puente de Y
- 6) Valporquero
- 7) Tito Bustillo
- 8) El Soplao and Coventosa
- 9) Cueva de Mina Europa
- 10) Cueva del Salnitro and Cardona's salt mountain
- 11) El Reguerillo
- 12) Castañar
- 13) Cova do Rei Cintolo
- 14) Drac and Sierra de Tramontana

(Cueva de Valporquero in León; Cueva de Nerja in Málaga; several coastal caves in Mallorca island).

From the hydrogeological point of view, the underground waters originating these karst systems also have great scientific and applied interest (Figure 2). The urban water supply of several towns is extracted from karst underground water of an excellent chemical quality.

Related to the secondary effects caused by karst processes, the subsidence phenomena caused in the alluvial deposits of some Cenozoic sedimentary basins (mainly Ebro and Tajo), and those due to the underlying karst of Mesozoic and Tertiary evaporite formations are worth mentioning (Gutiérrez, 1996). They are unique examples in the world of synsedimentary and postsedimentary paleo-subsidence, as well as present geologic analogues of active karst subsidence, with great socio-economic implications due to the hazard they represent for urban infrastructures.

Lastly, we should mention the environmental and socio-economic implications of the Spanish exokarst and endokarst areas from the point of view of protection and public use. There are fifty karst caves open to underground tourism, most of them grouped in the Asociación de Cuevas Turísticas Españolas (ACTE). Some of these caves (Nerja in Málaga; Maravillas in Huelva; Drach and Artá in Mallorca; El Soplao in Cantabria) receive hundreds of thousands of visitors every year and significantly contribute to the sustainable development of the local economies (Durán *et al.*, 1997). Equally, many of the protected natural spaces in Spain are remarkable karsts from a geological perspective. Among them are the National Parks of Picos de Europa, Ordesa, Tablas de Daimiel and Cabrera Archipelago. In the regional context there are abundant Natural

Parks (Cazorla and Segura Ranges, Sub-Betic Range, etc.), Natural Landscapes (Torcal de Antequera), and Natural Monuments (Cueva de Castañar on Precambrian limestones, in Cáceres; Ojo Guareña, in Burgos) associated to karst systems.

Among the many examples of unique karst sites of geologic interest and international relevance in the Peninsula and the Balearic islands, some of the most representative have been selected (Figure 4): Torcal de Antequera, Cueva de Nerja, Gruta de las Maravillas, and gypsum karst of Sorbas (Andalusia); Ciudad Encantada of Cuenca, Lagunas de Ruidera, and the birth of the Mundo river (Castilla-La Mancha); Lora de las Tuerces, Puentevedy, Ojo Guareña and Valporquero (Castilla y León); Cuevas de Candamo and Tito Bustillo (Asturias); Cueva Coventosa and El Soplao (Cantabria); Cueva de Mina Europa (Basque Country); Cueva del Salnitro (Cataluña); Cueva del Reguerillo (Madrid); Cueva de Castañar (Extremadura); Cova do Rei Cintolo (Galicia); Cueva del Drac and lapiaz (karren) of the Sierra de Tramontana (Balearic Islands).

The **Torcal de Antequera** (Málaga) is one of the best examples of exokarst relief in the Spanish and Andalusian landscapes, and very likely is one of the most emblematic on the planet, forming what is known as a stone city (Figure 5). Its geological structure consists of a big mushroom-shaped fold with a very wide hinge and horizontal strata and narrow steep flanks limited by faults favoring water infiltration from the surface. The most karstified portion of the stratigraphic series are Upper Jurassic limestones (Torcal Formation, Penibetic).

Karst erosion has shaped many forms, among which the *torcas* stand out giving name to the landscape, as well as the *tornillos* (screws). The Torcal de Antequera takes up more than 2000 ha. The karst gives the land a high geodiversity and ecological value, being declared Natural Site of Interest in 1929, and becoming a Natural Landscape in 1989.

Cueva de Nerja (Málaga) is one of the most important Spanish caves, both for its speleogenetic evolution recorded by forms of chemical precipitation and detrital deposits, and for the archeological site found there. It is located in the southeastern edge of Málaga province, near the towns of Maro and Nerja, on the eastern side of the Sierra de Almijara, on Triassic dolomitic and limestone marbles. Its development is essentially horizontal, with a depth not exceeding 70 m. Its origin is related with dissolution processes in the fresh-salty water interphase at a time of high sea level in the Upper Miocene.

Cueva de Nerja presents a distribution of channels connected with big chambers, such as the Sala del Cataclismo (in the tourist zone) or the Sala de Montaña (in the restricted higher galleries). In all of them, it is possible to observe abundant forms of chemical precipitation which in some cases are unique for this cave. Of particular relevance are formations of nails (spele-



Figure 5, above. *Torcal de Antequera (Málaga)*.

Figure 6, below. *Epiaquatic speleothemes in Cueva de Nerja (Málaga)*.

othemes formed by capillarity), excentrics, epiphreatic speleothemes (formed just above the phreatic level), stalagmites, stalactites and others (Figure 6).

The **Gruta de las Maravillas** is within the town of Aracena, Huelva. It was one of the first Spanish caves prepared for tourist visits in the beginning of the XX century. It extends for a little more than two kilometers, distributed into three levels of galleries. The lower level has abundant lakes fed by the water table of the Paleozoic marble where the cave is developed. It displays a large quantity and variety of speleothemes, among which the excentrics of blue aragonite stand out.

The **karst on gypsum of Sorbas** is in the northeast of the province of Almería and is developed in the Miocene gypsum unit called "Yesares Member". It creates an extraordinary karst landscape developed on evaporites (gypsum) and is considered one of the most spectacular gypsum karst models in the whole world. The gypsum exposures, with an extension of 12 km², have more than 600 caves, including Cueva del Agua among them (Figure 7), the biggest Spanish cave developed in evaporites.



Figure 7. Phreatic galleries in Cueva del Agua, Sorbas (Almería).
Photo Jabier Les.

Figure 8, right. Gypsum speleothemes, Sorbas (Almería).
Photo Jabier Les.



The landscape in Sorbas is a unique example of gypsum karst. The most common surface forms are dolines and tumulus. The dolines present different types, with the most common being the dissolution doline (of the outcropping gypsum strata) and the structural doline. Collapse dolines are less frequent, although they are very spectacular given the spectacular shapes they create, especially in the underlying part of dome, where the fallen blocks lay. All of them are conditioned by the underground channels previously developed. The tumulus, unlike the dolines, creates a positive relief on

the outcropping stratum of the formation, developed as a semi-spherical bulge reaching several metres in diameter.

Underground morphologies at Sorbas include examples of caves with phreatic origin, such as Cueva del Agua or Cueva del Machalico, with more than 8 km of galleries beneath a 1 km² karst depression, through which an underground river flows intermittently siphoning the channels. It is common to find speleothemes in this cave, both carbonate and evaporitic (Figure 8).

The alternation of gypsum and clayey marl levels favors the development of an interbed karst. This alternation causes the caves to be located at different depth levels, with 6 different levels developed in a series of 120 m in the Covadura System. As a consequence of the alternation of fluvial and karst processes, there are also fluviokarst caves linked to the capture of a ravine by a cave with development of underground channels which continue on the surface (Barranco del Infierno and Cueva del Yeso).

La Ciudad Encantada (the Enchanted City) of Cuenca is another of the most excellent karst landscapes in Spain, and recognized worldwide. It is located in the Serranía de Cuenca, north of the city of Cuenca, extending over a surface of 20 km². It consists of Late Cretaceous (Turonian) calcareous dolostones with differential erodability favored by the intense fracturing between marly limestones at the base and more resistant upper dolostones. Locally, in the eastern sector, dolostones are completely dissolved cre-

Figure 9, below.
El Tormo, emblematic shape of Ciudad Encantada (Cuenca).

Figure 10, right.
Ruidera lake and waterfalls on travertines.

Figure 11, below right.
Cueva de Los Chorros, birth of the Mundo river.

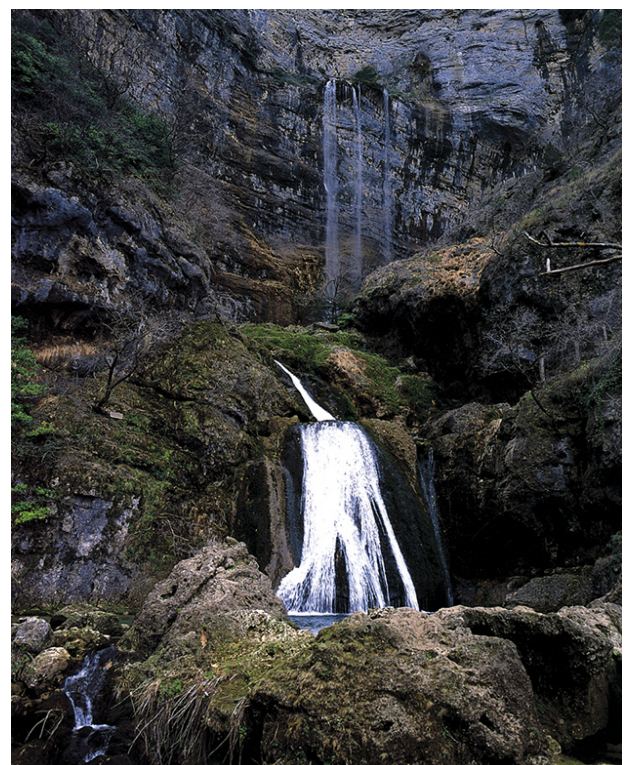




Figure 12. *Lora de las Tuerces: karst landscape with isolated shapes.*

ating “plazoletas” (main squares) surrounded by the peculiar “tormos” (Figure 9), whereas in the western part there are table lapiaz (karren) associated to “callejones” (street maze) morphologies.

The aforementioned processes created a ruiniform landscape known as “stone city” with the formation of an exokarst network which resembles the layout of streets. Karst processes in this site not only have developed the distinctive shapes for the relief, but have enabled the development of a very peculiar ecosystem, closely related to the processes. The high value of landscape and the diversity of features led to its declaration as Natural Park in 1989, and the subsequent implementation of management plans.

The **Lagunas de Ruidera** are a set of lakes connected along a river valley, where underground water and related dissolution phenomena have caused collapse processes, creating flooded basins. They are located between the towns of Peñarroya and Ruidera, scattered between the provinces of Albacete and Ciudad Real. These set of lakes is under protection as a Natural Park, with an extension of 3,800 ha and a maximum altitude difference of 122 m. From the geological point of view, these lakes sit on Jurassic karstified limestones. During the Quaternary, travertine deposits developed originating natural dams,

and short but spectacular waterfalls in high water season (Figure 10).

With respect to the morphostructure, lake development was controlled by a set of faults which allowed underground water circulation, acting as feeding source for the lakes, and leading to dissolution related to the genetic processes.

The **spring of the Mundo River** is another example of spectacular karst development in the Segura Ranges (Albacete province). The Sierra del Calar del Mundo is a first degree karst complex, extending for 15 km long and 4 km wide, and with development of river-snow genesis exokarst forms (dolines, karst depressions, etc.). Infiltration causes a well developed endokarst where water flows through kilometers of galleries until it finds its way out at Cueva de los Chorros, where it jumps from more than 100m high, forming spectacular waterfalls. The morphology of the Calar del Mundo is a slightly deformed calcareous platform formed by Upper Cretaceous (Coniacian-Maastrichtian) limestones deposited on Cenomanian-Turonian dolostones. Standing out on this dolostone stretch there is Cueva de Los Chorros (spring of the Mundo river), developed upon the upper limestone rocks, and with an explored length reaching 8 km long.



The ruiniform karst landscape of **Lora de las Tuerces** is located near Aguilar de Campóo, in the province of Palencia (Castilla y León). Geologically, it is located on a syncline fold with E-W vergence and associated to a fault. The best outcropping series are the Upper Cretaceous carbonate rocks, reaching a thickness of 450 m (Heredia and Rodríguez, 2001). Intense fracturing affected these materials, composed of highly soluble lithologies, and has been the main control factor in the configuration of this spectacular karst relief. Among its shapes stand out the *loras* or tables (Figure 12), apart from dissolution pinnacles, dolines, lapiaz (karren) and other features.

The karst complex of **Ojo Guareña** (Figure 14), located in the region of Las Merindades, north of the province of Burgos, is the most important in the Iberian Peninsula from the point of view of its longitudinal development. Its known galleries exceed 110 km and form a complicated and thick underground labyrinth network. It has abundant connections to the surface, through sinkholes, springs, dolines, wells and caves. Some of its galleries show current hydrologic activity, while others, abandoned by water, display big collapses originated by tensional readjustments. The complex, developed in Cretaceous rocks, is partially prepared for tourist visits and has been declared Natural Monument by the Junta de Castilla y León (regional government).

Puentedey is a natural bridge with karstic origin (Figure 13), located near the town of Puentedey (Burgos), north of the Ebro Canyon, and carved on Upper Cretaceous (Turonian-Coniacian) limestones.



Figure 13, above. *Puentedey (Burgos), natural bridge corresponding to an ancient karst cavity.*

Figure 14, below. *Ojo Guareña.*

These units are affected by the Villarcayo syncline, which locally controls karst development. Puente de Dios (God's bridge) is but a small part of an old karst cave which used to be crossed by the river Nela, similarly to today but underground. The structure follows the bedding planes, well defined in this part of the series. This relict underground feature has an approximate height of 15 m and a width around 12 m (Armenteros, 2001).

The **Cueva de Valporquero** is located in the northern margin of the Cantabrian Mountains, north of León. It is carved in Paleozoic limestones of the Barcaliente and Valdeteja Formations (known as "Caliza de Montaña" or Mountain Limestone, Lower Carboniferous). It has an extension of almost 3,500 m and a depth not reaching 250 m. A third part of its length is open to tourism.

It is hosted in a syncline structure displaying subvertical strata. The cave is controlled by fractures which determine channel orientation, and by the alternating lithologies (limestone -dolostone) which control its position and development within the series.

Fluvial activity in the area is closely linked to the cave. In this sense, the Arroyo de Valporquero disappears as it passes through the Carboniferous series, creating in that area the active flow of the cave. In addition, it has other higher levels which are proof of endokarst evolution of the cave (Durán *et al.*, 2001). Cueva de Valporquero displays a relatively rectilinear karst framework where narrow passages alternate with the big size chambers. It is in these locations where spe-

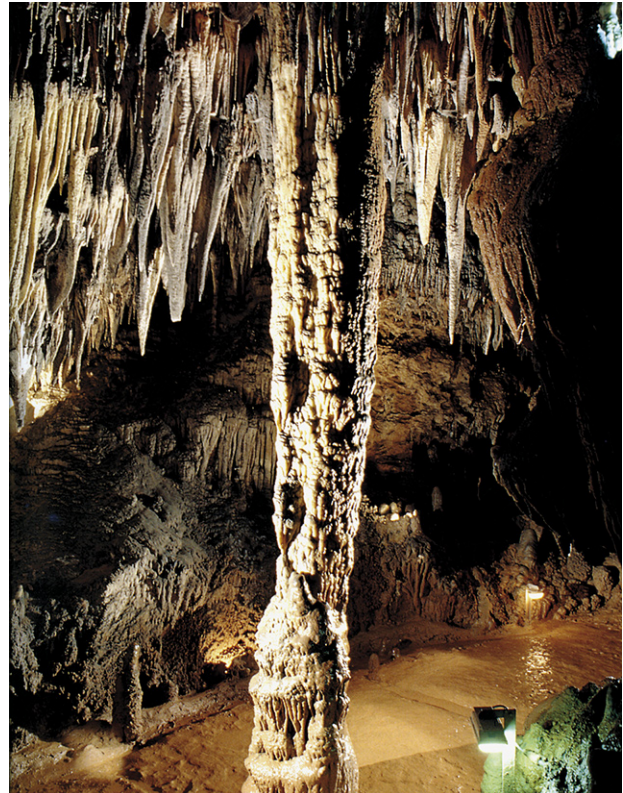


Figure 15, above. *Cueva de Valporquero (León): view of one the chambers with development of speleothemes.*

Figure 16, below. *Speleothemes in Cueva de Tito Bustillo (Asturias).*



leothemes stand out for their variety, beauty and uniqueness (Figure 15). These forms of chemical precipitation, together with some travertine, allowed to establish the end-Quaternary carbonate-growth stages and to obtain conclusions about the paleoclimate and paleoenvironmental conditions of that time (Durán *et al.*, 1999).

The Cantabrian Mountain Range is one of the most important locations in the Iberian Peninsula for the development of endokarst systems. The predominant limestone substrate of Carboniferous age favors dissolution processes, which have shaped impressive reliefs such as Picos de Europa during the last millions of years. This relief originates a characteristic landscape dominated by closed depressions such as poljes and dolines, some of them controlled by the presence of snow (*jous*). However, the most remarkable feature of the karst system is undoubtedly the underground caves. The most relevant karst location, shared by Asturias, Cantabria and Castilla y León regions, is the Picos de Europa and its three massifs declared as a National Park with an extension close to 650 km².

Asturias and Cantabria are the most important Spanish regions in the development of caves, many of them prepared for tourism. One of the



Figure 18, above. *Excentrics* in Cueva El Soplao, Cantabria.

Figure 17, below. “*Gran Marmita*” in the canyon of Cueva Coventosa.



many Asturian touristic caves containing wall paintings is Cueva de Tito Bustillo and Candamo. **Cueva de Tito Bustillo** is located in the Sierra de Ardines, near Ribadesella, developed in the Escalada Limestone Formation (Carboniferous), and it is conditioned by the existence of two orthogonal fracture systems (north-west-southeast and northeast-southwest) as well as by the course of the river San Miguel, which enters a sinkhole at Gorgocera, flowing underground in the lower floor of the cave and cropping out again near the estuary of Ribadesella. Inside the cave, open to the public since 1969, it is possible to observe important Paleolithic wall paintings, as well as “coladas” (flows), stalactites, stalagmites, and blocks caused by the collapse of the cave ceiling (Figure 16).

Cueva Coventosa (Peña Lavalle) stands out among the abundant and important caves in Cantabria. It includes one of the biggest karst systems of the Cantabrian Mountains, with more than 32 km length and a depth of 810 m. It is carved in Lower Cretaceous (Aptian-Albian) limestones on the southern flank of the Socueva anticline. The karst is controlled by fault systems defining a set of galleries and big chambers. It displays a variety of endokarst deposits, with the Sala de Coventosa standing out for its stalactites, which seem to be modeled by air currents, or spectacular

underground lakes such as the “Gran Marmita” in the cave’s canyon (Figure 17).

Another of the abundant Cantabrian caves is **Cueva del Soplao**, already mentioned in chapter 7, and recently partially prepared for tourist visits. El Soplao is a subterranean complex of great extension, intercepted by mining galleries which benefitted zinc mineralizations. It is developed on Cretaceous rocks with different lithologies, and presents a relatively simple structure. Apart from the large dimensions of some of its chambers and galleries, El Soplao stands out for the quantity and variety of its speleothemes. Most likely, it hosts one of the most numerous and varied set of excentrics in Europe (Figure 18).

The Basque Country has a similar karst development which is an extension of the Cantabrian system, with Mesozoic limestones, and locally the Tertiary, being the most affected ones. The endokarst generally displays

Figure 20, right. *Lapiaz (karren) formed on the salts of Cardona (photo by P. Lucha).*

Figure 19, below. *Cueva de la Mina de Europa (Vizcaya).*



a moderate depth and well developed networks of subhorizontal channels. **Cueva de la Mina de Europa** (Figure 19) stands out among the many interesting karst caves, located in the Barranco de Aranga, Montes de Trianao (Vizcaya). It is related to the Bilbao anticline, and developed in connection with the two main fault systems: one longitudinal to the cave's axis, and the other one transverse and controlling underground drainage. It is carved in the "Galdames Limestones" (Lower Cretaceous) and displays a development of 4.5 km and a depth of 240 m. The speleothemes are abundant in the inactive galleries, being so abundant that they fill some galleries. The giant stalagmites are worth mentioning.

Catalonia, despite its geologic diversity, does not have a high number of big subterranean caves, but it does have a great underground geodiversity, as it is developed on rocks of very different ages, origins and lithologic composition. One of those examples is **Cardona's Salt Mountain**, an Eocene salt massif formed by alternating layers of gem salt (halite) and potassium salts (carnalite and sylvinit) as well as thin interbedded layers of clay. The rock's karstification, with an essential lithologic control, follows that alternation generating very spectacular shapes and products. The chemical precipitation forms in the shape of clusters stand out thanks to the textural properties of salt. The walls of the galleries inside the mountain display a whitish and brown cover due to the continuous precipitation processes on the surface. The vertical grooves caused by the salt layers dilution on surface are also noteworthy (Figure 20).



Figure 21, above. *Surface modelling of the Montserrat conglomerates, inside of which groundwater has carved an underground world whose best representative is Cueva del Salnitre.*

Figure 22, below. *Cueva del Reguerillo (Madrid): a) third floor gallery, b) semispheric gallery on the second floor, and c) stalagmites eroded by underground water currents on the first floor (photos by C. Puch).*





Figure 23, above. *Speleothemes in Cueva de Castañar (Cáceres).*

Figure 24, left. *Cova do Rei Cintolo (Mondoñedo, Galicia). Photo Jabier Les.*

Cueva del Salnitro, located near Collbató, is the most emblematic in Catalonia, as it is carved in the heart of Montserrat. Its name comes from the fact that since the XV century it was used to extract nitrate from within it. Montserrat Massif is formed by Eocene siliciclastic rocks. The tectonic evolution and the modeling of the different lithologies have caused a spectacular "saw-like" (serrated) landscape (Figure 21) and a very interesting endokarst system in the conglomerates.

Cueva del Reguerillo is the most important endokarst system near Madrid for its size and paleontological aspects, and most likely so too in the central area of Spain (Figure 22). It is located between the Valdeventales gorge and the Lozoya river, in the Cerro de La Oliva, near the town of Patones. It is carved on Upper Cretaceous calcareous dolostones, lying unconformably on Paleozoic slates, exceeding 8,900 m in length and a depth below 20 m. The endokarst system consists of an orthogonal network divided into three levels, the third of which, at the lowest height of the cavity, is currently active by the flow of the Lozoya river. Cave passages are connected by chambers, some of them big, such as the Sala del Confesionario, where it is possible to observe chemical precipitation deposits as stalactites, stalagmites and flows. In these chambers and in some of the galleries there are also small lakes and gours. In addition, there are detritic deposits, some of them caused by collapse processes, contributing to the geometry of the cavity.

Apart from its geological and geomorphological features, the presence of paleontological deposits stand

out, especially those of *Ursus spelaeus* (cave bear) and some wall paintings and carvings.

Cueva del Castañar is one of the most important caves in Extremadura. It is near the town of Castañar de Ibor, in the Ibores region (Cáceres). This cave is developed on Precambrian schists and carbonate rocks of the Iberian Massif. It is placed on a stratified sequence oriented NW-SE which is followed by the cave channels. The rocks are very folded and fractured (with well-developed joint systems) related to the Guadalupe-Ibor anticline. One of its peculiarities comes from the development of this set of channels in a carbonate package alternating dolostones, limestones and calcschists among other slaty lithologies (Durán, 1997).

The endokarst system of Castañar is formed by a series of galleries forming a complex network exceeding 2,100 m of horizontal extension and a depth smaller than 35 m. The most relevant aspect of the cave is the abundance of different calcite and aragonite speleothemes covering the ceiling and walls, outstanding for their beauty and uniqueness (Figure 23).

The **Cova do Rei Cintolo**, also in the Iberian Massif, is another of the few and important karst systems in this morphostructural unit. This endokarst system is found in the hillside of Coto Redondo, near the town of Mondoñedo, in the province of Lugo. It is excavated in the Lower-Middle Cambrian Vegadeo Limestone, within the Mondoñedo Nappe. This unit is never thicker than 100 m due to the interbeds of slates in



Figure 25. *Mouth of the karstic canyon of Pareis, north of Mallorca.*

the Slate unit of Cándana. This also limits the continuity of the endokarst system development, which is remarkably big in spite of that. Subterranean karst systems are also conditioned by the monocline dip of these strata, with Cova do Rei Cintolo presenting an E-W orientation with a dip close to 30°.

The development of the underground system exceeds 6,500 m with a depth of 75 m, taking up a total area of 5.5 ha. It has several horizontal levels where only the lower one is presently active, with the Celtas river flowing along it, disappearing in a siphon hard to access, and reappearing in the “Salas Finales” (last chambers). Inside this cave’s central section, especially in the chambers along the cave, the presence of very beautiful speleothemes (Figure 24) such as stalagmites, stalactites, flows, flags and spectacular gour (especially those in the Gours Chamber) and some underground lakes is common.

Due to their geological structure, the Balearic islands present a wide variety of exo- and endokarst forms of a high scientific interest and spectacularity. **Cueva del Drac** is one of the best examples of tourism development of the Balearic caves, receiving more than one million visits per year. This cave is located in the Mallorca east coast, near Porto Cristo, and sets an example for the kind of cavities found in this part of the island. It is a coastal cave of horizontal development, 700 m long and with shallow depth (Ginés, 1989), excavated in the Miocene carbonate platform upon calcareous dolostones of Messinian age.

Its origin is related to dissolution phreatic processes by fresh-salty mixed waters, which causes an irregular distribution of its channels. It is possible to observe detritic rocks related with collapse processes within its chambers. The speleothemes are abundant and varied, the so called phreatic standing out as they precipitated in relation to the water table of the cavity during successive relative sea level rise and descent events. The salt water lakes flooding some of its chambers are also worth mentioning. In many of them, the typical dissolution shapes of the mixing area can be seen, with irregular and continuous holes. Chemical precipitation shapes such as flags, stalagmites, stalactites and big flows are also noteworthy.

Apart from being the most emblematic relief in Mallorca, the **Sierra de Tramontana** displays a spectacular exokarst morphology. Lapias (karren) shapes are unevenly scattered all along the ridge relief, but more intensely in the central area. Its exposure is linked to Lower Lías (Jurassic) limestones as well as to Lower Miocene calcareous conglomerates. Its formation shows different lithological components in almost any possibility, but in some shapes which occasionally make use of some element favoring the dissolution processes. It presents a morphological distribution with a height gradient directly related to some vegetation types.

The **Torrent de Pareis** is located to the northwest of the island of Mallorca, and is part of the Serra de Tramontana. It is a karst canyon carved following big tectonic faults and caused by the confluence of the fluvial-torrential courses of the Gorg Blau and Lluç (Ginés, 1989).

Fluvial and karst activity cuts into the Mesozoic rocks, with lower Lías limestones and breccias, and Burdigalian (lower Miocene) conglomerates being the most affected layers. Its course is longer than 3 km and it is possible to observe in it all the former endokarst shapes, when the karst canyon behaved as a real underground river. Proof of that is a stretch from the Gorg Blau torrent, known as Sa Fosca, where surface fluvial activity disappears and turns into a subterranean channel almost 1 km long. In some of the surface terms the canyon walls are higher than 300 m, reaching 50 m widths (Figure 25).

Apart from the lapias (karren) fields in the Sierra de Tramontana, there are also other highly relevant exo- and endokarst shapes in the relief of the Mallorcan ranges. The dolines appear in small groups with moderate dimensions, never wider than 200 m in diameter (Ginés, 1989). The poljes, although not currently active, they do show up as relict depressions in the form of torrent-captured valleys. Shapes such as sinkholes and caves are also frequent in the surroundings of the Tramontana.

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