Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible

Geodiversidad de Andalucía

PARQUE NATURAL Sierra Norte de Sevilla

UNESCO
United Nations Educational, Scientific and Cultural Organization

Sierra Norte de Sevilla
UNESCO Global Geoparks

Geotourism Guide
of Natural Park Sierra Norte de Sevilla
UNESCO GLOBAL GEOPARK

Europa invierte en las zonas rurales

UNIÓN EUROPEA
Fondo Europeo Agrícola de Desarrollo Rural

Junta de Andalucía

GEOTOURISM GUIDE
OF NATURAL PARK
SIERRA NORTE DE SEVILLA
UNESCO GLOBAL GEOPARK

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COORDINATION:
Rosa María Vives Solbes, Pedro Mendoza Domínguez , Vicente Castaño Torres.

AUTHORS:
Ana Belén Pérez Muñoz (NUBIA Consultores), Miguel Villalobos Megía (NUBIA Consultores), Alberto Gil Toja (Tragsatec).

REVIEWERS:
Rafael Pérez de Guzmán Puya, Ana María Tamarit Romero.

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Geotourism Guide
of Natural Park Sierra Norte de Sevilla
UNESCO GLOBAL GEOPARK

Preface

This publication is part of the Collection of Geotourism Guides of Andalusia. The Junta de Andalucía with this collection intends to cover the deficit that exists of a good quality visual guide that values the geological heritage of Andalusian Geoparks and protected natural areas of Andalusia, as well as promote geotourism. This action is part of the specific objectives to the Andalusian Strategy for Integrated Management of Geodiversity. The Geotourism Guide of the Natural Park Sierra Norte de Sevilla – UNESCO Global Geopark, is the first of this collection.

The objective of this guide is to make available to the visitor and the professional of the nature tourism a guide that, in a didactic and entertaining way, describe and explain the geological heritage of the Geopark. The guide also includes items and places of archaeological, monumental and ethnographic interest.

It is a visual guide, with 122 figures and 304 photographs. We can find illustrations, diagrams and geological cross sections which, synthetically and didactical, illustrate the contents of the guide and facilitate understanding the geological events that occurred and currently developed in the Geopark. The guide has also a simplified geological map that shows the most significant geological units.

This Geotourism Guide contains first a chapter over the geological concepts of interest that help to understand the guide. Then in the following chapters include the geological frame, a description of the rocks and geological units of the Geopark, as well as its geological history. In addition, the guide describe and explain the landscapes of the Geopark and its geological interpretation: crag lands, the karstic landscape, its mountains and valleys. On the other hand, is explained the mining story, the importance of water and the ecosystem resources in the Geopark. Likewise, the guide proposes three great routes in which it invites us to know the most highlight landscapes, the geological processes that make them up, and the most emblematic geological geosites, as well as many other places of interest.

Ministry of Agriculture, Livestock,
Fisheries and Sustainable Development

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1

The Geopark Sierra Norte de Sevilla

[1] Viar River Canyon

LOCATION AND GENERAL FEATURES

The Natural Park Sierra Norte de Sevilla, one of the UNESCO Global Geoparks, is located in the western part of Andalusia, to the north of the province of Seville and throughout the mountain ranges that constitute the central area of the Sierra Morena Mountains.

To the north, it borders the Extremaduran plateau; to the south, the meridional Sierra Morena foothills; to the west, the Rivera de Cala river serves as a natural border with the nearest province of Huelva; and to the east, the Onza and Retortillo rivers separate it from the province of Córdoba.

Having been declared a Natural Park in 1989, this protected natural space is one of the largest in Andalusia. Its 177,484 hectares (1,774.84 km^2) link the Sierra de Aracena and Picos de Aroche Natural Park (Huelva) in the west, and the Sierra de Hornachuelos Natural Park (Córdoba) in the east. In its entirety, it comprises the largest Biosphere Reserve in Spain with 424,400 hectares (4,244 km^2): "Dehesas de Sierra Morena" (2002).

Moreover, it is also home to three Andalusian Natural Monuments, two of them of a geological nature, "Cascadas del Huesna" and "Huellas Fósiles de Medusas de Constantina", and the third, of a geological, biotic and ecocultural nature, "Cerro del Hierro".

Fig.1 General situation map

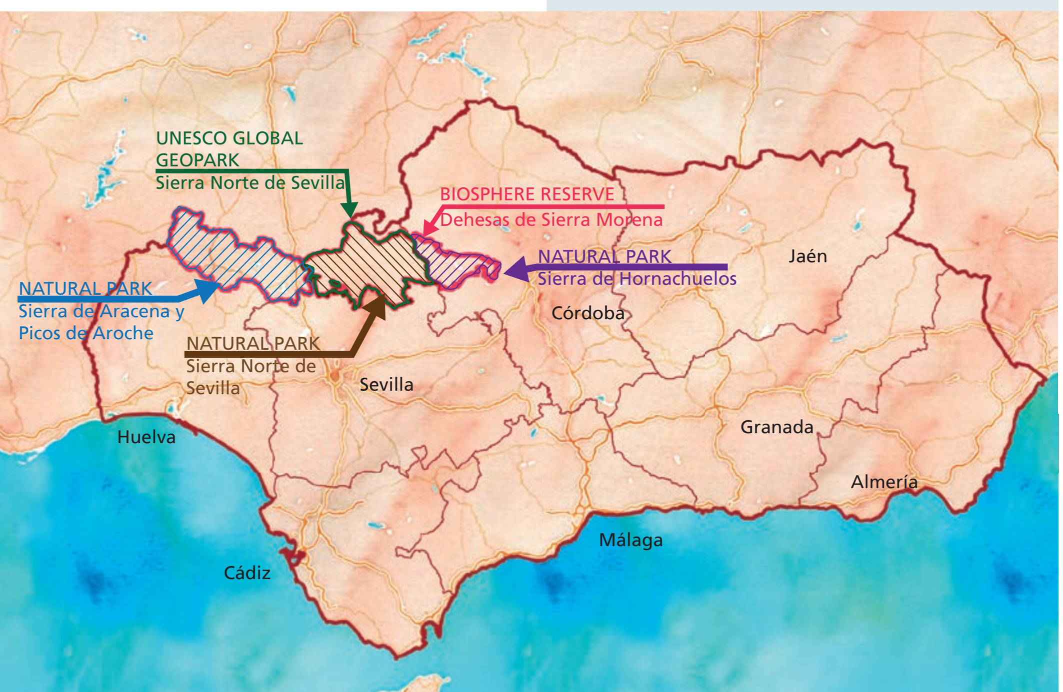


Fig.2 Map of protected natural areas near the Geopark

Most of its rocky outcrops have their origin between the Ediacaran Period (end of the Precambrian Period, between 635 and 541 million years ago [Ma] and the Paleozoic Era (between 541 and 250 Ma). This means that the first of them have suffered the effect of two orogenic cycles, Cadomian (541 Ma) and Variscan (360-300 Ma), while the second ones have only been affected by the Variscan orogeny.

Its topography, a series of gentle hills, mountain ranges and valleys in a northwest-southeast direction, with an altitudinal range of between 100 and 1,000 meters, is slightly steep. This is the result of the erosion suffered by this massif for over 300 Ma.

This ancient topography is dominated by meadows, mainly composed of holm and cork oaks. This precious ecosystem is due to the work carried out on the ancient Mediterranean forest. This landscape is also mixed together in a mosaic with relatively dense Mediterranean bush areas, sometimes accompanied by holm, cork oaks, gall or common oaks, and riverside vegetation valleys, that in some cases like the Rivera de Ciudadeja and the Rivera de Huéznar, create an extremely beautiful forest. It is also possible to find crops—mainly olive groves, but also vineyards, chestnut groves, fruit trees and vegetable gardens.

The Natural Park includes the entire municipalities of Cazalla de la Sierra, El Real de la Jara, San Nicolás del Puerto and Las Navas de la Concepción, and parts of Alanís, Almadén de la Plata, Constantina, Guadalcanal, El Pedroso and La Puebla de los Infantes.

This Geopark has a population of 25,251 inhabitants (data from 2018), primarily dedicated to livestock, forest exploitation and the cultivation of olive trees. Some of the activities based in this territory are the production of olive oil, meat and Iberian cold cuts, goat cheese, cork, as well as liquor and wine production and apiculture.

Fig.3 Geopark's geographical location

The Natural Park's geological, mining, archaeological and monumental heritage as well as its great ecological, historical and cultural value, were key factors in its selection first as a Geopark in September 2011, joining the European Geoparks Network and the Global Geoparks Network, and second, as a UNESCO Global Geopark in 2015.

A Geopark is a territory which possesses not only a singular geological heritage but also a sustainable development strategy. It also has clearly defined boundaries and sufficient space to generate long-term economic growth. The management objectives of a Geopark are to improve the quality of life of its inhabitants and to conserve and disseminate its geological richness.

EUROPEAN AND GLOBAL GEOPARKS NETWORK

In Europe, Geoparks are part of the European Geoparks Network (EGN), launched in June 2000. A total of 76 geoparks members from 25 European countries belonged to the EGN in April 2019.

The Declaration of Madonie was subscribed in October 2005, within the framework of the UNESCO agreement, recognising the EGN as the European Division of the Global Geoparks Network.

Geoparks are now part of the Global Geoparks Network (GGN), a voluntary network supported by UNESCO from the Division of Earth Sciences.

The GGN "is a dynamic network where members commit themselves to work together and exchange ideas on good practices and join in common projects to raise the quality standards of all the products and practices of a Global Geopark".

The Global Geoparks Network has grown, including now in 2019, to 147 geoparks from 41 countries, and has become an increasingly important tool for UNESCO to involve member states and their communities in the dissemination of Earth Sciences and the conservation of geological heritage.

UNESCO INTERNATIONAL GEOPARKS PROGRAMME

In November 2015, 195 Member States ratified the creation of the "UNESCO International Geoscience and Geoparks Programme" (IGGP) in the General Council of UNESCO, recognising sustainable development based on the protection and management of the Geological Heritage of these territories.

UNESCO's Global Geoparks tell the story of 4,600 Ma of the planet Earth and the geological events that caused it, as well as the evolution of humanity itself. Not only do they show evidence of past climate change, but they also inform local communities of current challenges and help prepare for risks, such as earthquakes, tsunamis and volcanic eruptions.

UNESCO's International Geoparks Programme aims to raise awareness about geodiversity and promote best practices in protection, education and tourism. Together with World Heritage sites and Biosphere Reserves, UNESCO Global Geoparks form a full range of tools for conservation and sustainable development, contributing to Agenda 2030 for Sustainable Development (SDA) through the combination of global and local perspectives.

For more information about the Geopark Sierra Norte de Sevilla and other geoparks members of the network, visit the following webpage:

http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/

HOW TO ARRIVE?

BY CAR

▸ **If you are coming from Seville**, take the A-8002 road toward Alcalá del Río. Once there, take the A-8006 road toward Villaverde and Cantillana. Finally, from there, follow the A-432 road toward El Pedroso.

Another option is to take the A4 highway (E-5) from Seville toward Carmona. Once there, take the A-457 road toward Lora del Río, and finally, follow the A-455 road toward Constantina.

If you are coming from the A-66 highway (E-803), take first the A-8175 road toward Almadén de la Plata, and then the A-5301 road toward El Real de la Jara.

It is also possible to access the Geopark from La Puebla de los Infantes by taking the SE-7104 road toward Las Navas de la Concepción, and the SE-7103 road toward Constantina.

▸ **If you are coming from Córdoba**, you should take the A-431 road toward Almodóvar del Río, Posadas, Peñaflor and Lora del Río. From there, follow the A-455 road toward Constantina.

▸ **From Extremadura**, if coming from Fuente del Arco, take the EX-200 road. From Valverde de Llerena, take the EX-309 road or from Azuaga, take the BA-018 road.

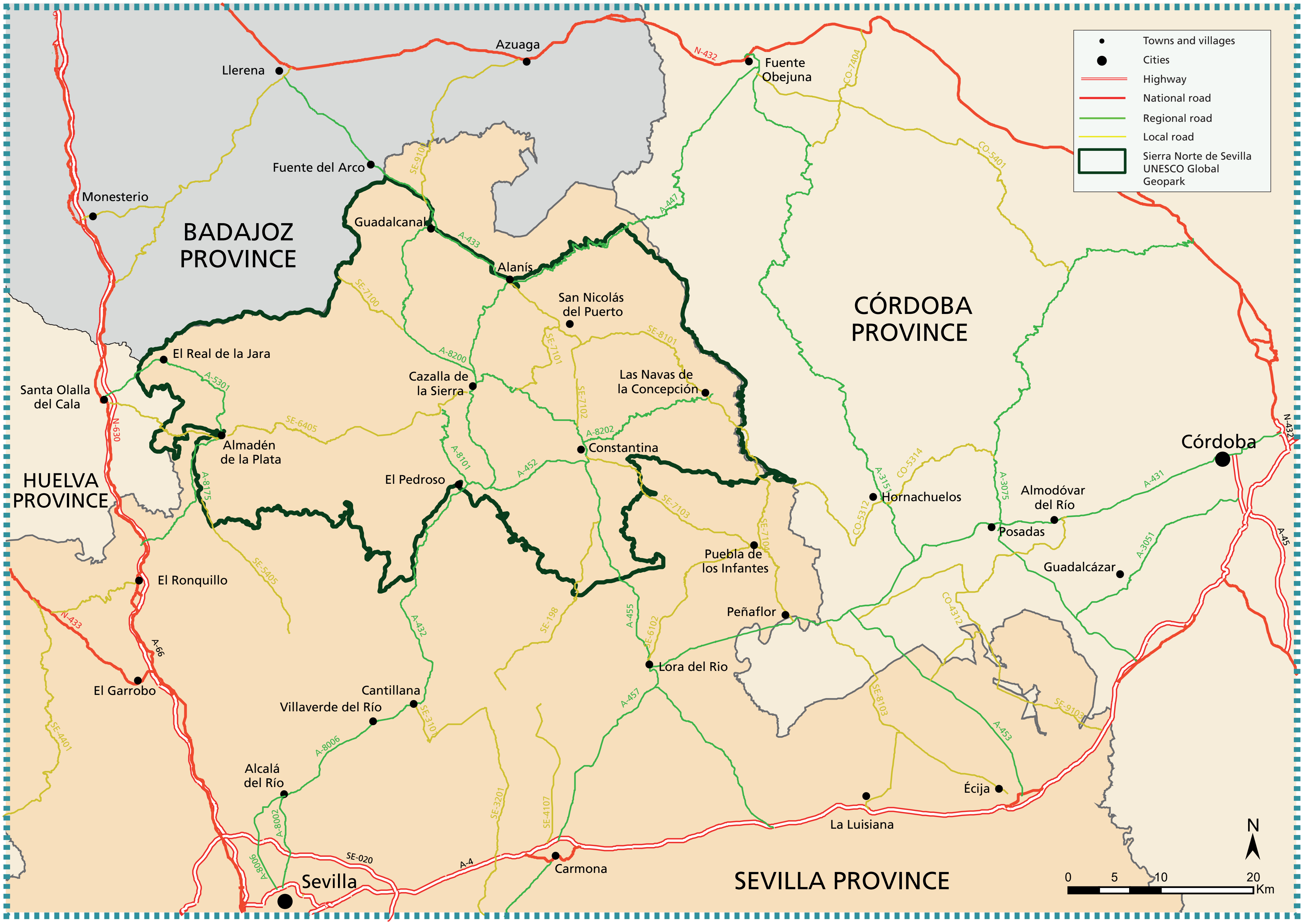
TRAIN:

▸ **Renfe** (Seville) Telephone: +34 954 540 202.

BUS

▸ **Plaza de Armas Bus Station:**
Telephone: +34 954 907 737.

[2] Cerro del Hierro


Towns and villages
Cities
Highway
National road
Regional road
Local road
Sierra Norte de Sevilla UNESCO Global Geopark
BADAJOZ PROVINCE
CÓRDOBA PROVINCE
HUELVA PROVINCE
SEVILLA PROVINCE
Azuaga
Llerena
Fuente Obejuna
Fuente del Arco
Monesterio
Guadalcanal
Alanís
San Nicolás del Puerto
El Real de la Jara
Santa Olalla del Cala
Cazalla de la Sierra
Las Navas de la Concepción
Almadén de la Plata
Constantina
El Pedroso
Hornachuelos
Almodóvar del Río
Posadas
Córdoba
Guadalcázar
Puebla de los Infantes
Peñaflor
El Ronquillo
Lora del Rio
El Garrobo
Cantillana
Villaverde del Río
Alcalá del Río
Écija
La Luisiana
Carmona
Sevilla
N
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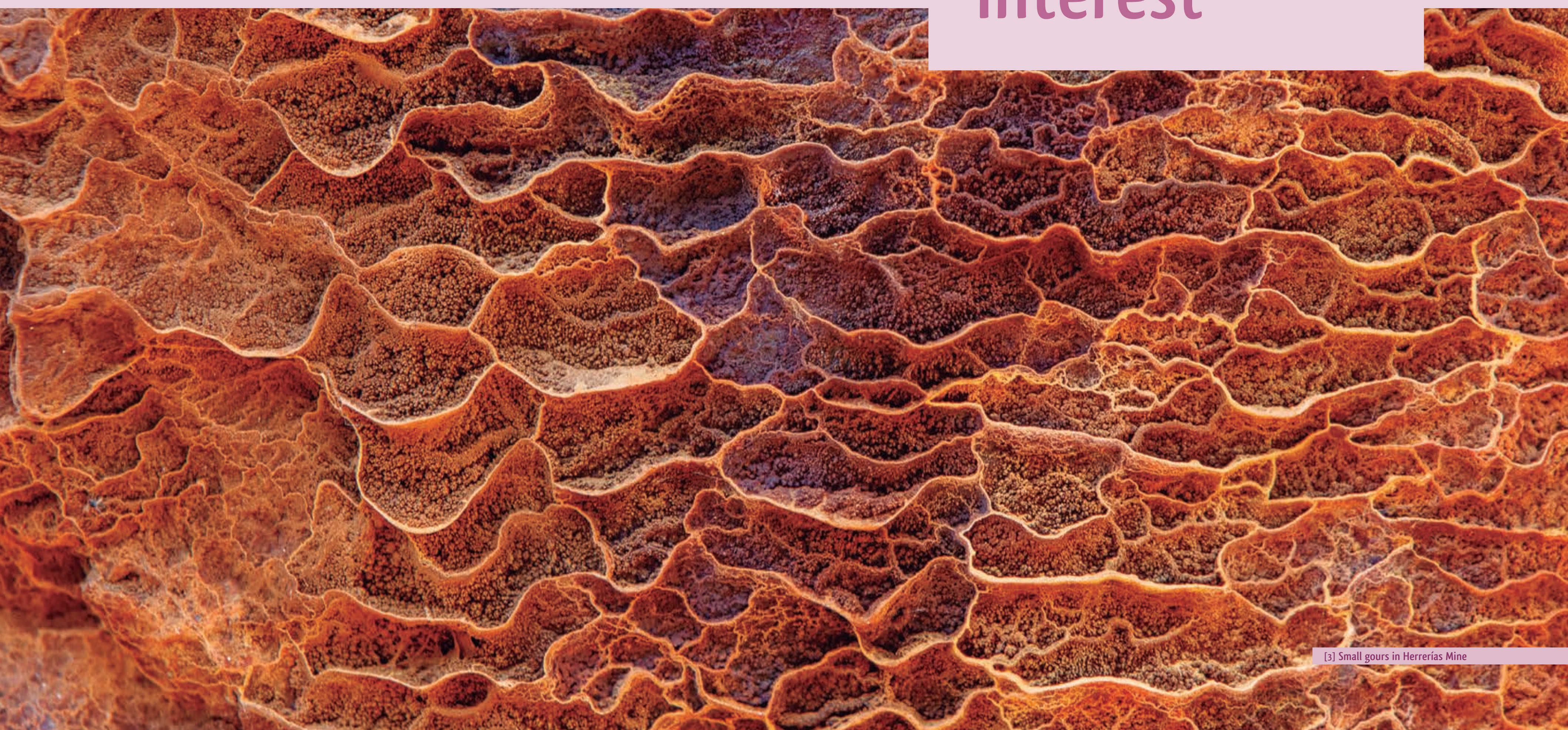
Km

2 Geological Concepts of Interest



[3] Small gours in Herrerías Mine

GEOLOGICAL TIME

Knowing the geological timescale is essential to understand the different processes which control the dynamics of the Earth, considering that most of the geological processes that are happening are extraordinarily slow and can take up to hundreds of thousands and even millions of years.

Within these processes, geological events are occasionally produced almost instantly: a volcanic eruption, an earthquake or a tsunami. These are some of the individual frames within the full-feature film of the Earth's history.

The study of rocks has led to the discovery of some of the major biological and geological events that helped to divide the Earth's history (4,600 Ma) into different sections of time: aeons, which are made up of eras, which, in turn, are made up of periods. These last ones are also divided into other smaller units (series, stage…).

The most well-known time intervals are eras. These are long periods, composed of tens or hundreds of millions of years, which are differentiated by the major biological and geological events that occurred in them:

1. **Precambrian Eon:** The Earth's longest period, which lasted around 4,000 Ma. Within this period, the lithosphere, hydrosphere and atmosphere underwent major changes and lifeforms were extraordinarily primitive.
2. **Paleozoic Era:** Duration of approximately 290 Ma. Within this period, important geological activity took place. The first continents began to form, pluri-cellular life and organisms with skeletons grew and developed extraordinarily.
3. **Mesozoic Era:** Duration of approximately 186 Ma. It coincides with the time of the dinosaurs and large reptiles. The continents finished moving to their current positions.
4. **Cenozoic Era:** Starting around 65 Ma, at this time the Earth's life forms were very similar to those of today. Within this period, the large surface reliefs that we see in the Earth today were created.
5. **Quaternary Era:** The ice recedes and the Earth´s climate becomes milder and warner. The first human beings start to appear as well as a great diversity of flora and fauna very similar to what we have today. Geologically speaking, it marks a period of relative peace and erosion of the Alpine reliefs, with the creation of lakes and river valleys.

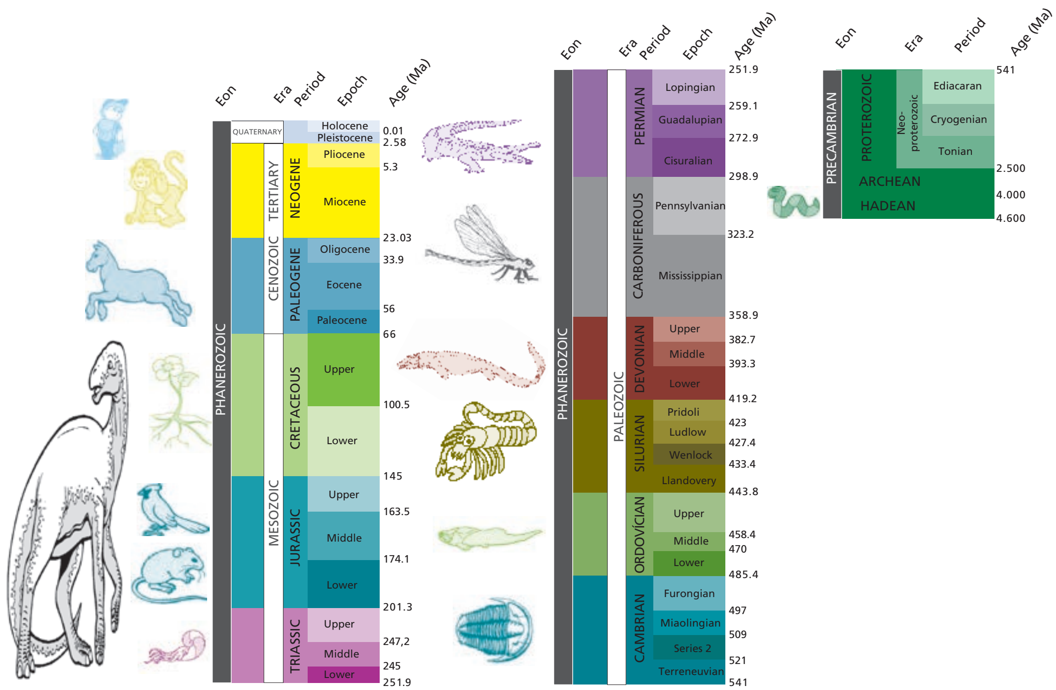


Fig.5 Table of Geological time

THE HISTORY OF THE EARTH, IN ONE YEAR

If we condense the history of the Earth into just one year, we will be aware of the magnitude of geological time as well as of the duration of some of the geological processes described in this guide.

The Precambrian Era, whose final period includes the first living beings, would occupy nearly the whole year, from 1 January to 16 November. The development and diversification of the different forms of life during the Paleozoic Era would happen between 16 November and 14 December. The Mesozoic Era, period of the large reptiles, would occur until 26 December, at the time dinosaurs are extinct. The Cenozoic Era, time of development and evolution of most mammals, would last until 29 December.

The Quaternary Era, when our first ancestors appeared, only occupy a part of 31 December. In the last minute, with the New Year's Eve clock about to strike, the *Homo sapiens sapiens* would appear.

With this comparative study, the geological history of Sierra Norte de Sevilla UNESCO Global Geopark would extend over the whole year, except for the month of December.

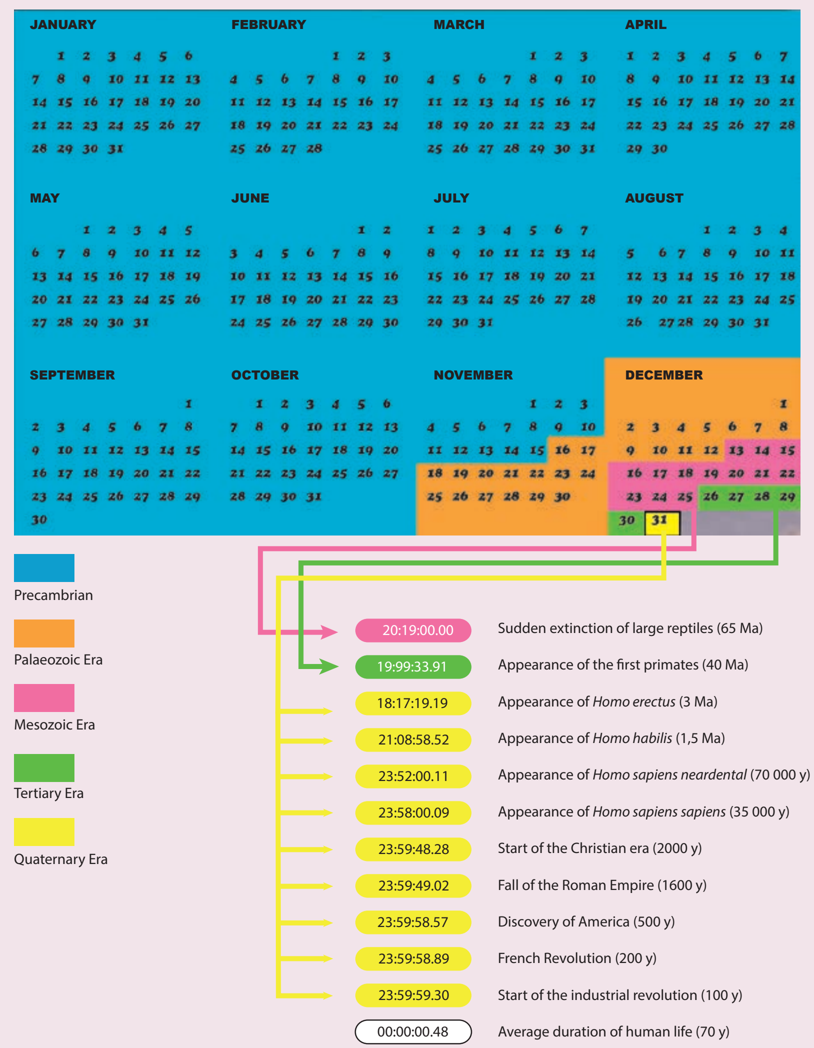


Fig.6 The Geological year

PLATE TECTONICS: THE ORIGINS OF THE CONTINENTS

The Earth's crust is its outermost layer and is divided into two different types depending on whether it is emerged or submerged. The oceanic crust, which comprises the ocean floor, is denser, between 5 and 7 km thick; whereas the continental crust is less dense and can reach between 30 and 65 km in thickness. Both are supported by the Earth's mantle, which is made up of semi-molten material.

Together, the crust and the upper portion of the mantle—the most rigid part—form the lithosphere, which can extend up to 80 km in depth. The lithosphere is divided into large plates called lithospheric or tectonic plates which fit into the world globe as if they were pieces of a puzzle. These plates sit on and move over the asthenosphere, an area of material on the mantle which is more fluid.

The areas of contact between the plates are called plate boundaries, which can be divided into different types depending on the type of movement between the plates:

1.- **Divergent boundaries**, where two plates are moving apart. They can be found in the oceanic ridges, large linear mountain ranges, which are wide, deep and long and located in the central sectors of oceans. Along these boundaries, the ocean floor is created by the solidification of basaltic lava.
2.- **Convergent boundaries**, where two plates collide. The denser plate is subducted underneath the less dense plate, creating a subduction zone. These areas are located on the opposite side of a divergent boundary.

3.- **Transform boundaries**, where plates slide past each other. There is a lateral movement where the oceanic crust is neither destroyed nor created.

Of all these boundary types, convergent boundaries are those that can create large mountain ranges. For example, the Indian Plate collided with the Asiatic Plate, causing the complete destruction of the ocean floor that separated them and led to the collision of the continental masses, which created the impressive Himalaya mountain range.

To adapt to the reduction caused by the collision, layers of materials are stacked, one on top of others. During this process, the sediments which had once composed the ocean floor between the two continents and were deeply buried, are now lifted, piled up and deformed, creating mountain ranges. This "unstoppable engine" works slowly over millions of years and is responsible for the large morphological structures in the landscape that we can see today.

We can find one example of this in the Sierra Norte de Sevilla UNESCO Global Geopark, in the Iberian Massif, or Hesperian or Hercynian, which was created as a result of collisions between several tectonic plates. The sediments deposited over millions of years in the ancient oceans were converted into rocks by the weight of later deposits, a process known as diagenesis. At the end of the Palaeozoic Era, these materials were lifted up and deformed by the collisions between the tectonic plates, in a process called Variscan Orogeny (300 Ma). Since then, the relief remains exposed and subject to erosion.

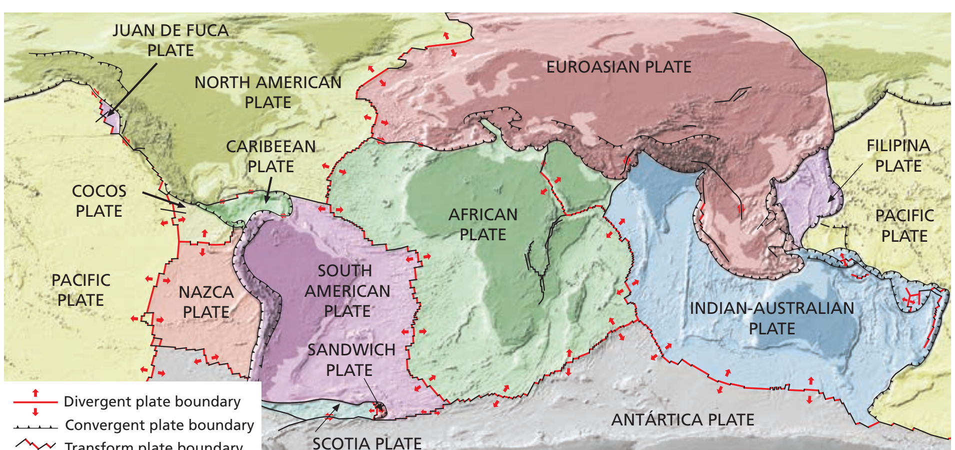


Fig.7 Plate Tectonics

ROCKS

ORIGIN AND CLASSIFICATION

Rocks make up the pages in the book of the Earth's history. Like the black box of a plane, they record everything that happens, not only how and where they were created, but also more importantly, how the climate and life was at that time.

Rocks can be classified into three large groups according to their origin or forming processes: sedimentary, igneous and metamorphic.

SEDIMENTARY ROCKS

Sedimentary rocks are formed by the accumulation and/or precipitation of sediments. Initially, the materials are transported by means of water, wind or ice to be deposited in layers one on top of another on the surface of the lithosphere under relatively low temperatures and pressure. They are subsequently converted into rocks through different physical and chemical processes.

Sedimentary rocks are classified according to their genesis into:

a) Detrital sedimentary rocks: Created by the sedimentation of rock and mineral fragments (clasts) after they have gone through an erosion and transport phase. These rocks are classified by the size and shape of the fragments they are made up of.

If these rocks contain large fragments (greater than 2 mm) linked by a matrix or cement, they are known as conglomerates or rudites. If they have a rounded shape, they are categorised as a puddingstone. If they have an angular shape, they are categorised as a breccia.

Sandstones have medium-sized grains (between 0.06 and 2 mm) that are visible to the naked eye.

Silts and clays, also called lutites, have a very small grain (less than 0,06 mm).


[4] Conglomerates


[5] Breccias


[6] Sandstones


[7] Silts and clays

b) Chemical sedimentary rocks: Created by the precipitation of chemical compounds in aqueous solutions or by the accumulation of organic substances. One of the most common types is limestone, which is often formed by calcium carbonate precipitations or by skeletal fragments (corals, gastropods, ostracods, etc.). This explains why it is often possible to observe fossil organisms within these rocks.


[8] Limestones with stromatolites and archaeocyathids fossils

METAMORPHIC ROCKS

These rocks are the result of the transformation undergone by igneous, sedimentary or even other metamorphic rocks, due to changes to the physical and chemical conditions to which the primitive rocks were exposed. This process, known as metamorphism, provokes both the modification of the mineralogical and chemical composition of the rocks, as well as their structure and texture.

The degree of metamorphism can vary. For this reason, different gradual transitions exist from the igneous and sedimentary rocks to their corresponding metamorphic rocks.

To put it briefly, we can differentiate three types of metamorphism: dynamic or pression metamorphism, when the transformation is caused by large amounts of pressure; contact metamorphism, which occurs when there is an

Metamorphic grade

Rocks of origin	Resulting metamorphic rocks		
Clays	Slate	Phyllites	Schists
Sandstone	Quartzitic sandstone		Quartzites
Limestone	Recrystallized limestone	Marbles limestone	Marbles

Fig.8 Rocks of origin and resulting metamorphic rocks

increase in temperature due to proximity to a magma; and regional metamorphism, which is caused by the simultaneous effect of an increase in both pressure and temperature in large areas of the Earth's crust over long periods of time.

The metamorphic rocks that have been subject to large amounts of pressures have very characteristic structures, called foliation. These are planar structures generated in the rocks by the alignment taken by their minerals during the deformation process and metamorphic transformation. They can be of different types and scales, and they are visible to the naked eye as the schistosity, produced by the parallel alignment of all rock components.

IGNEOUS ROCKS

This rock type is formed by the consolidation (crystallisation) of magma, a molten rock mass. If this crystallisation takes place in the deeper part of the lithosphere, they are called plutonic or intrusive rocks (in the form of batholiths, laccoliths or sills). If, instead, they consolidate on the surface, they are called extrusive or volcanic rocks (such as ash, lava or pyroclasts). If they crystallise near the surface in the form of dikes or seams, they are called subvolcanic rocks.

[9] Slate

[10] Schists

a) Plutonic or intrusive rocks. Created under the Earth's Surface, and therefore subject to high pressures, their minerals grow and merge together, producing non-porous dense rocks. Due to their slow cooling, the crystals of the minerals can be relatively large and easily visible. These rocks are composed of a mixture of different minerals: quartz, feldspar, plagioclase, mica, pyroxene and/or amphibole. If these rocks have a high proportion of quartz, greater than 65%, they are called acid plutonic rocks, such as granite and granodiorite. If the proportion of quartz is between 52% and 65%, they are classified as intermediate, of which the most common is diorite. If the proportion is between 40% and 52%, they are labelled as basic, the most common of which is gabbro. Finally, if the proportion is under 40%, they are categorised as ultrabasic, like peridotite.

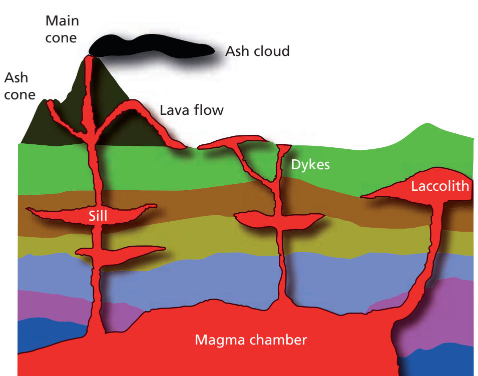
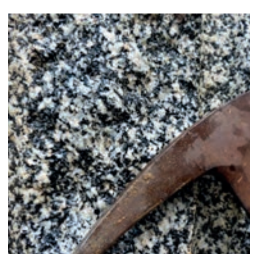


Fig.9 Origin of igneous rocks

[11] Granite



[12] Granodiorite

[13] Gabbro

[14] Rhyolite

b) Volcanic or extrusive rocks. Created when magma rises from volcanic chambers to the exterior of the Earth's surface in the form of lava or pyroclastic rocks. This magma cools quickly on the Earth's surface due to the low temperatures and pressure. As a result, the crystals are small in size and can even be used to create glass rocks. It is common to classify volcanic rocks according to their chemical composition. Basalt, a basic rock, has low levels of quartz, and is very common and easy to recognise because of its dark tones. On the other hand, rhyolite is an acidic rock, rich in quartz and with light tones.

[15] Basalt

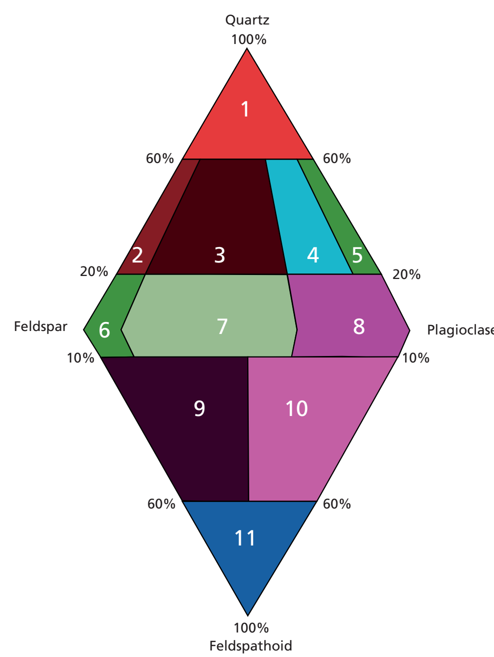


Fig.10 Streckeisen diagram

IGNEOUS ROCKS (PLUTONIC)

1. Quartz-rich rocks
2. Alkali granite
3. Granite
4. Granodiorite
5. Tonalite
6. Alkali Syenite
7. Syenite
8. Gabbro, diorite anda anorthosite
9. Foid Syenite
10. Foid diorite and gabbro
11. Foid-rich rocks

VOLCANIC ROCKS

1. Not described
2. Alkali feldspar rhyolite
3. Rhyolite
4 - 5. Dacite
6. Alkaline feldspar trachyte
7. Trachite and Latite
8. Andesite / Basalt
9. Phonolite
10. Basanite
11. Foidite

c) Subvolcanic rocks. Created when magma solidifies on its way to the surface through fissures (discontinuity lines) inside a rock mass: faults, fracture zones, sedimentary planes or another fissures. They have variable dimensions, where the thickness can vary between centimetres and meters and its length can range from meters to kilometres. In these circumstances, magma solidification can lead to different rock types whose composition will vary from basic to acid, depending on the silica proportion within the original magma. Generally, these rocks are classified by their texture, which is directly linked with the cooling speed. Some examples are pegmatites with large crystals and aplites with small crystals or vitreous masses.

[16] Ejemplo de dique en la diorita de Cazalla de la Sierra

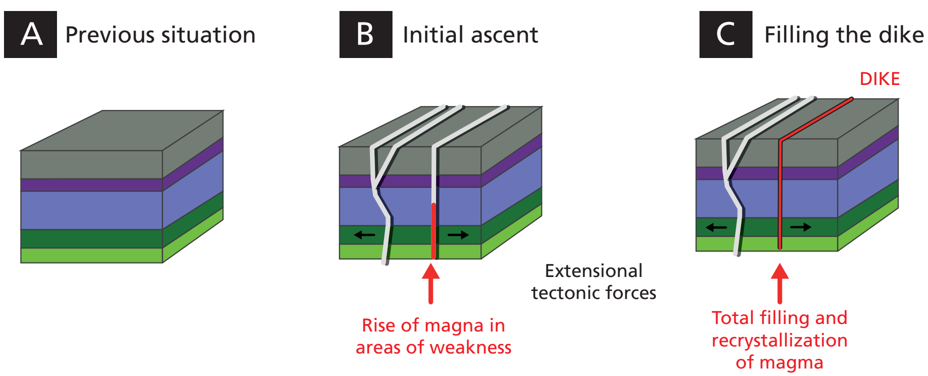


Fig.11 Dike formation

THE ROCK CYCLE

On a global or planetary scale, the genesis of each rock type, either sedimentary, metamorphic or igneous, is linked to two other geological processes: the destruction and transformation of the mineral material.

The law that governs this cycle is that the formation of a type of rock will always depend on the destruction or transformation of a previous rock. This cycle can be conceptually described as follows:

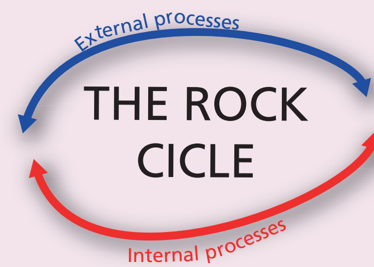
1. **Igneous rock formation**. The first stage of the cycle is the igneous rock formation, through the cooling and solidification of the molten material of a magma. It can occur both by intrusive materials which penetrate more ancient rocks through deep cracks before crystallising or by extrusive materials, associated with volcanic eruptions and processes.
2. **Sedimentary rock formation**. On the surface, igneous rocks are weathered and the eroded material is transported to the bottom of the ocean basins and lacustrines, where it accumulates. These sedimentary deposits are compacted and transformed over time into sedimentary rocks, due to the weight of the successive layers of material - sometimes kilometres thick - in a process called lithification.
3. **Metamorphic rock formation.** Sometimes, sedimentary and igneous rocks can reach great depths when they are part of the contact zones between two tectonic plates. Within this context, they are exposed to high temperatures and pressures which transform them into metamorphic rocks.
4. **End of the cycle**. The cycle finishes at the time the metamorphic rocks are exposed to even higher levels of heat and pressure that transform them into magma and, subsequently, into igneous rocks.

The cycle's order is not rigid. An igneous rock, for example, can be transformed into a metamorphic rock because of the heat and pressure, without passing through the sedimentary phase. Likewise, the sedimentary and metamorphic rocks can be eroded, transformed into sediments and then into new sedimentary rocks

THE ROCK CYCLE AND PLATE TECTONICS

The rock cycle, from the perspective of plate tectonics, can be interpreted as follows:

The eroded material of a continent accumulates at the bottom of the marine basins that surround it and is compacted by lithification until it becomes sedimentary rock. Over time, the continental edge is transformed into the active edge of a converging plate, that is, it is pushed by another plate. In this position, sedimentary rocks can be transformed by high pressure into belts of metamorphic rocks, mountains or mountain ranges, or can be dragged by subduction into deep areas of the crust. In the latter case they suffer an even greater metamorphism, until they reach degrees of pressure and temperature so high that they allow the material to fusion, turning it into magma. In turn, this becomes igneous rock, which can return to the earth's surface, and be eroded starting the cycle again.



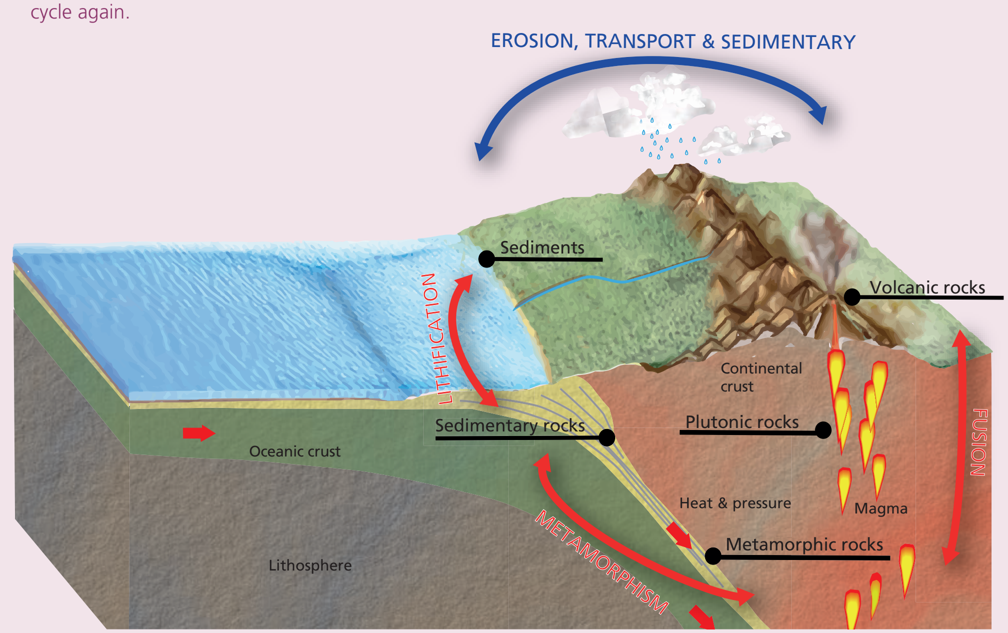


Fig.12 The rock cycle

ROCK DEFORMATION

Rocks, just like any other material, are deformed due to external factors. If we study the geometry of a deformed rock, it is possible to deduce the direction and scale of the force that the deformation produced, and in turn, to understand how the deformation mechanisms work on a large scale.

Rocks respond to external factors in two different ways. In some cases, the deformation is plastic and results in the folding of the materials. This is an irreversible deformation, since it continues, even if the force stops, just as it happens with play dough. In other processes, the deformation is fragile, and the rock breaks as a result of the force. These results in faults, if there is a slipping of the fracture blocks; and joints, if there is no shifting.

Folds are malleable deformations. Their scale can vary from a few millimetres (microfolds) to tens of kilometres. They are classified according to their layered position. They can be anticline, when the most ancient materials are located in the centre of the fold, having an upward convex shape, or syncline, when the most modern materials are located in the centre of the fold, having an upward concave shape.

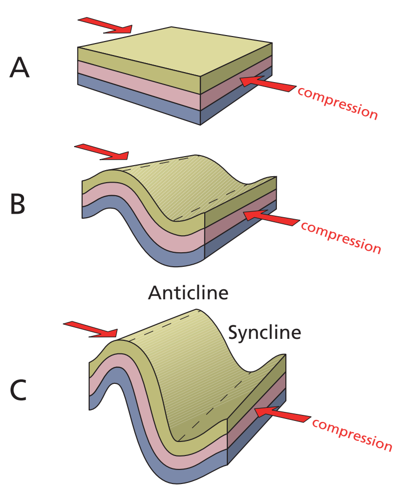


Fig.13 Types of folds

Faults are fragile deformations which we use to differentiate the following geometric elements. The fault block is each one of the parts of the rock mass that was divided and separated by the fracture. The fault plane is the break plane which has produced the shifting. Jump refers to the magnitude of the shift. Based on these characteristics, a fault can be classified as one of the following types:

- Normal fault: when the sunken block stands over the fault plane. They correspond to distension forces that extend the material to which they are applied.
- Inverse or reverse fault: when the raised block stands over the fault plane. It is caused by compression forces that shorten the material to which they are applied.
- Vertical fault: the shifting of the fractured blocks only occurs vertically, without any horizontal movements.
- Strike-slip fault: there is no vertical sliding, only lateral shifting.

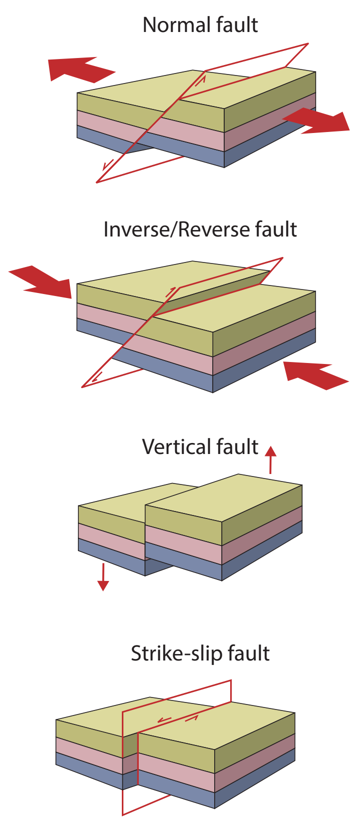


Fig.14 Types of faults

Another kind of fault to consider is the **overthrust fault**. This is a low-angle fault that causes materials to layer on top of each other. In fact, this fault can be considered an inverse fault type by some cartographic magnitude. When a thrust fault displaces a layer or a pile of materials over long distances, they are called thrust nappes. Both thrust nappes and overthrust faults are very common structures in areas of mountain formations (orogeny).

Joints are fractures that separate the rock into two pieces, with no apparent shifting along the break plane.

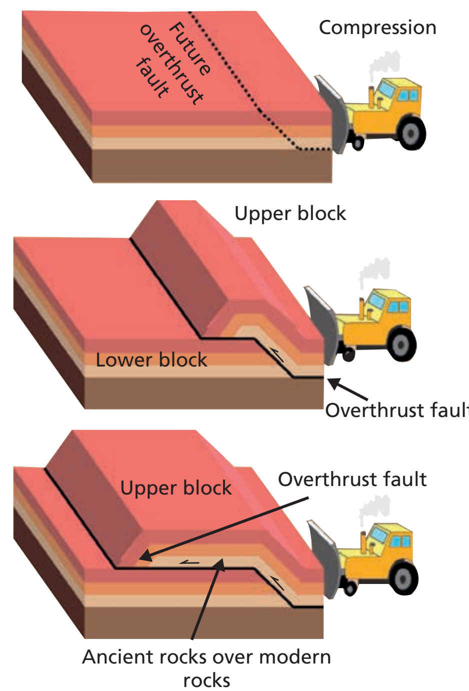


Fig.15 Overthrust fault

THE RELIEF FORMATION

Just as with the majority of the mountain ranges, the elevation of the Iberian Massif was produced by the collision between tectonic plates, leaving the rocks exposed to the action of external erosive agents such as water, wind and ice that sculpted the characteristic shapes of the relief. The action of these agents, combined with the characteristics of the rocks that they shaped, defines the type of erosive modelling. In the Geopark, it is possible to recognise the erosive action—individual and combined—of the fluvial, karstic and denudative - structural systems, all of which have been active since the end of the Paleozoic, since 300 Ma.

THE FLUVIAL SYSTEM: THE EROSIVE ACTION OF THE WATER

In half mountains the rivers are the main agents responsible for the carving of the landscape. This is characterised by a succession of hills or mountain ranges separated by fluvial valleys or plateaus.

This geomorphological shape is the consequence of the progressive setting of the rivers and mountain streams, which deepen their beds through the erosive action of the moving water. Moreover, this setting process is encouraged by the constant tectonic elevation of the massif and its high slopes, giving a greater energy to the water currents, hence its great erosive power. As the river digs and deepens the valley, the slopes are destabilised, stimulating and amplifying their movement: landslides of rocks, collapses, underminings, etc. All of those processes try to stabilise the gravitational balance of the slopes while the river deepens, and evolves and widen the valleys.

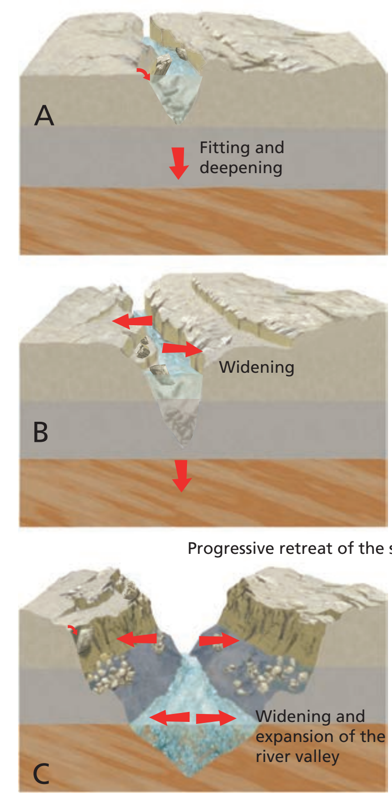


Fig.16 The fluvial system


[17] El Chorro gorge


[18] High Course of the Viar River


[19] Rivera del Huéznar

THE KARSTIC SYSTEM: THE SLOW DISSOLUTION OF CALCAREOUS ROCKS

Limestones are rocks of chemical precipitation and/or formed from the accumulation of ancient fragments of calcareous skeletons of tiny oceanic organisms that lived in the ancient seas. Although they are primarily composed of calcium carbonate, sometimes, during the transformation process of the sediments into rock, some of the calcium can be substituted by magnesium, transforming the limestone into dolomite.

One of the calcareous rocks that we can normally find in our everyday life is marble, which forms when limestone or dolomite reach a high grade of crystallisation due to exposure to elevated temperatures and pressures (metamorphism).

The calcareous rocks, unlike detrital rocks which are easily disintegrated by the action of ice and water, are very resistant to physical erosion. However, they have the capacity to dissolve in the presence of atmospheric water, which is slightly acid, during a chemical process called karstification.

The karstification is caused when the calcareous rock is affected by cold water rich of carbon dioxide that are slightly acid due to the presence of carbonic acid. The reaction of this acid with the calcium carbonate from the rock produces calcium bicarbonate. This very soluble material will dissolve and move into the water, leaving a trace of the very characteristic reddish clay residue called terra rossa.

This dissolution process affects both the superficial and the more profound areas of the rocks due to the infiltration of water with a high quantity of carbon dioxide through crevices and fissures on the surface of the ground, and generates very characteristic geological formations.

In the case that the dissolution affects the limestone surface, the most common formation is limestone pavement (karren) - small furrows with a length that can vary from millimetres to centimetres, which are separated by more or less marked divisions created by the runoff of water over the limestone fissured surface. In some cases, for example, in tropical environments, larger karrens are generated that are measurable in meters in terms of surface and depth.

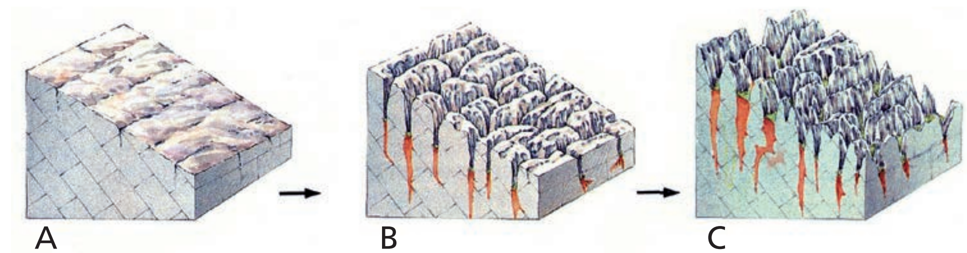
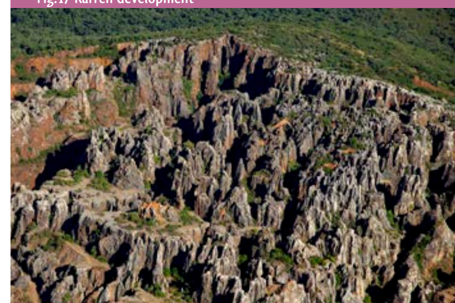


Fig.17 Karren development


[20] Mega karren in Cerro del Hierro


[21] Karstic morphologies in Cerro del Hierro


[22] Karstic marbled limestones in Cerro del Hierro

Other very characteristic forms are dolines, major depressions till dozens of meters, with a circular or elliptic form, that are created by the dissolution and infiltration of the water. During their evolution, they can expand and join with others nearby, forming uvalas. The major karstic dissolution forms in the surface are the poljes, of similar origin, that can stretch from hundreds to thousands of meters of length.

When the surface water penetrates inside the massif through the rock fissures, which facilitates the dissolution progress, it creates a framework of tunnels and caves.


[23] Dolines in the marbles around Almadén de la Plata


[24] Entrance to the Covachos Cave

The formation of a mature karst can last from hundreds of thousands to millions of years. This can be demonstrated by a karst formed in the Cerro del Hierro, which was created 550 Ma ago and is still changing today.

The convergence of fluvial and karstic processes occasionally gives rise to the formation of narrow ravines or gorges, where the evolution is mainly vertical.

ORIGIN AND EVOLUTION OF A FLUVIAL-KARSTIC CANYON

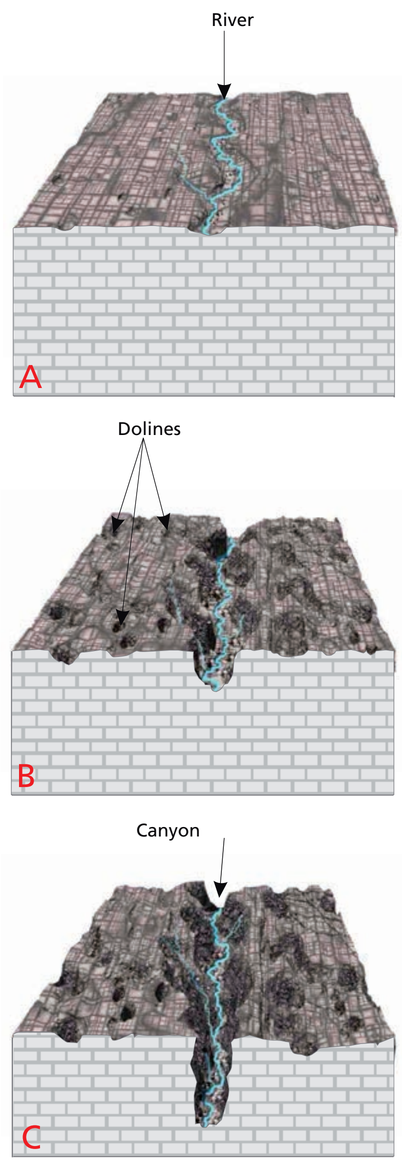


Fig.18 Origin and evolution of a fluvial-karstic canyon

THE DENUDATIVE-STRUCTURAL SYSTEMS: "LOS BERROCALES"

The plutonic rock masses that appear in the Geopark create very characteristic landscapes called "berrocales" (craglands). Their origin is associated with two circumstances: the first is the presence of a tectonised granitic mass on the surface, that is to say, with clear fracturing and joints systems; and the second, a continuous exposure to atmospheric water and temperature changes.

The water penetrates the structural discontinuities and facilitates the disaggregation of the granitic mass, which is carried away in the form of sand and serves in addition as an erosive agent. This sandy residue will accumulate in the lower areas of the relief, creating flatlands or sandy plains, while the weathered granitic mass gradually develops suggestive and capricious, practically spherical shapes. This landscape is so characteristic that it often appears in toponomy, providing the name for the territory. Such is the case of the Las Navas-El Berrocal public forest.

[25] El Pedroso craglands

[26] Typical landscape of granitic bowls of the craglands

EVOLUTION OF A GRANITIC LANDSCAPE

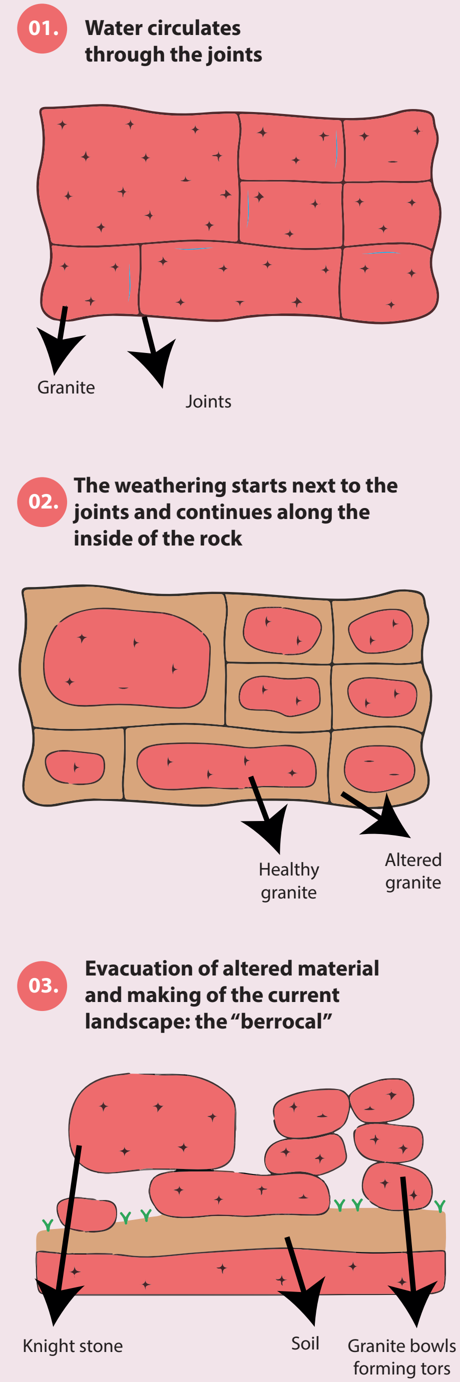


Fig.19 Evolution of a granitic landscape

[27] Cragland morphologies

3

The Variscan Massif

[28] Almadén de la Plata

THE FORMATION OF IBERIA

The distribution of oceans, emerged landmasses, and even the shape of continents have slowly but continuously changed throughout the Earth´s history. Numerous times, emergent landmasses have merged together to form one large and unique continent, only to fragment later into smaller continents that move in a never-ending dance of tectonic plates. The collisions between two plates create the elevations of mountain ranges—a phenomenon known as orogeny—with the resulting ranges being labelled orogen.

The geography of the present-day Iberian Peninsula is the result of the superposition of two important orogenies: the **Variscan** or **Hercynian**, which took place in the Upper Paleozoic era (around 300 Ma), and the **Alpine** (which began roughly 60 Ma) that is still active. Nevertheless, there were more ancient orogenies, such as the **Cadomian** in the Upper Neoproterozoic era, and the **Huronian** in the earlier Precambrian era, which are recognised in other parts of the world.

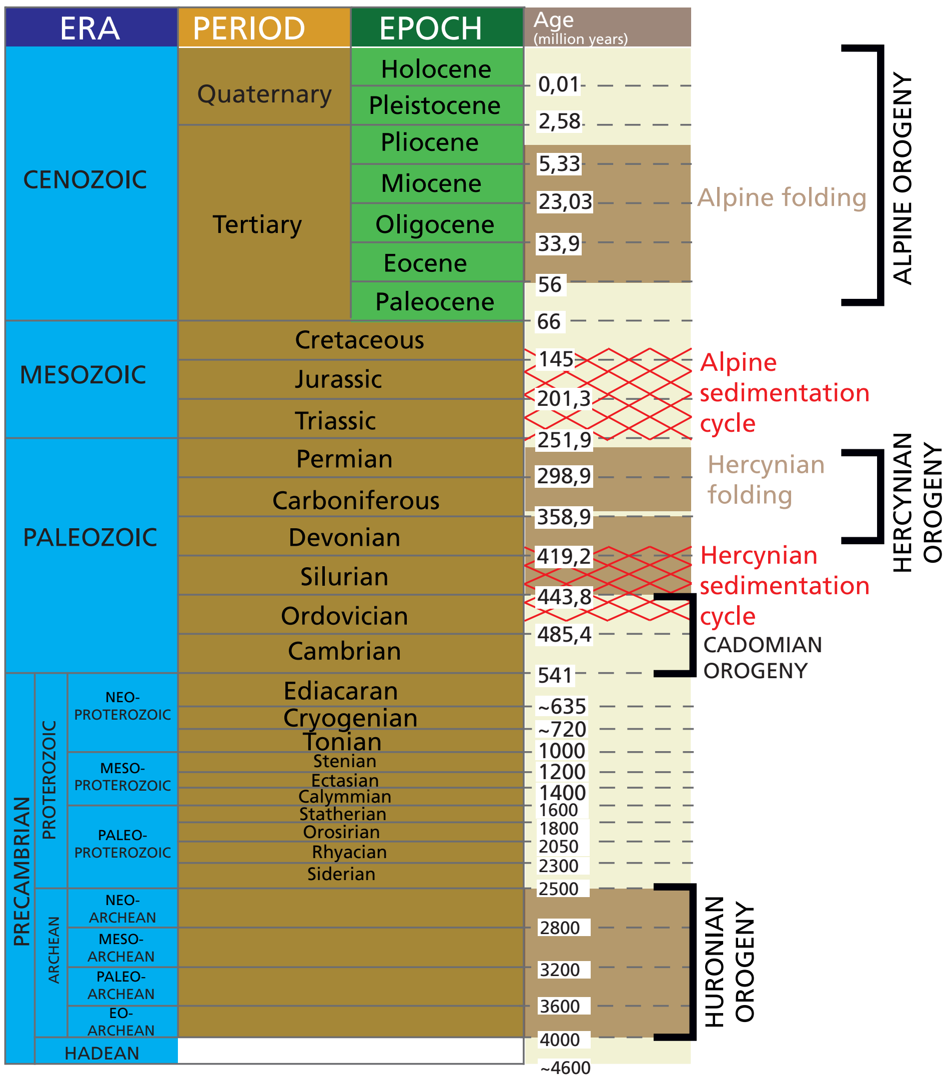


Fig.20 Geological time and orogenies

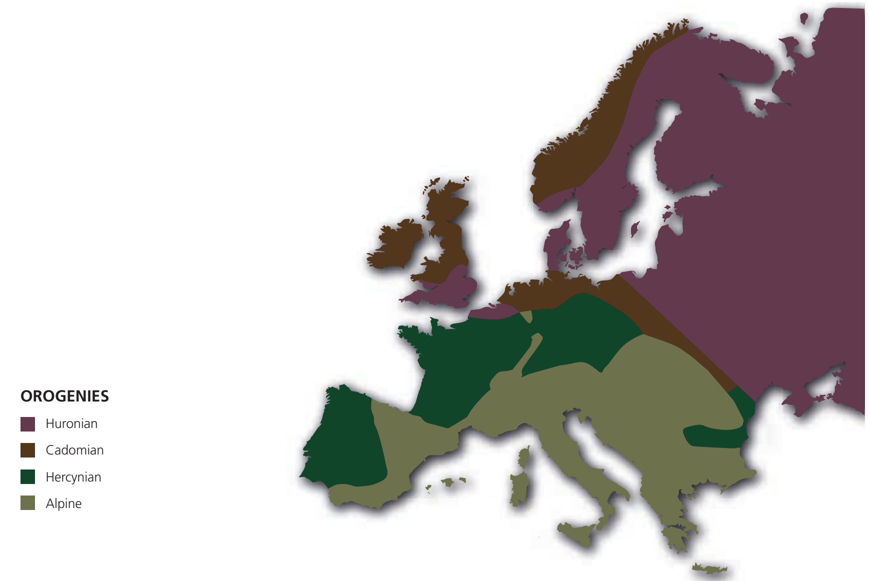


Fig.21 Distribution of orogenies in Europe

In the Iberian Peninsula, we can focus on the events that occurred during the following periods:

1. At the end of the Precambrian, during the Ediacarian period, the Cadomian orogeny takes place, which affects the Precambrian materials, although in a moderate way in the Iberian southwest.

2. During the final stages of the Cadomian orogeny, the Precambrian relief emerges.

3. Over the Precambrian relief new thickness sedimentary deposits is produced, once more in the marine environment, ranging from the Cambrian to the Permian.

4. The Hercynian or Varican orogeny, initiated around the Devonian, produces the emersion, folding and fracture of the Paleozoic sediments.

5. During the Mesozoic era, the relief is exposed to erosion and slightly rejuvenated as a consequence of the Alpine orogeny, which hardly affects the Variscan massif.

6. The erosion on the relief, emerged from that time, still emphasizes the morphological disposition of mountain ranges and valleys, until a kind of relief known as appalachian is formed.

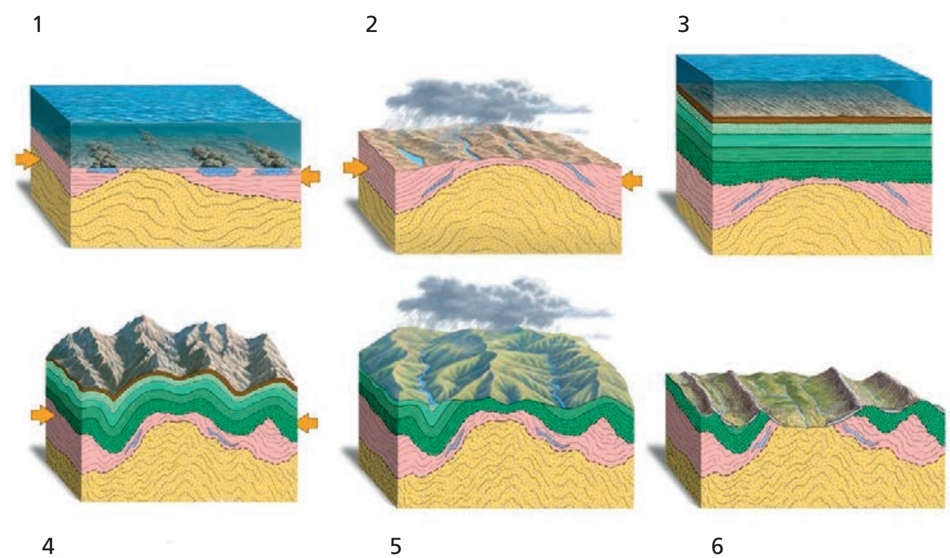


Fig.22 Sedimentation cycles and orogeny

THE PRECAMBRIAN: THE UNKNOWN EON

The Precambrian eon is the first and longest stage of the Earth's history. This supereon began with the formation of the Earth between 4,567.9 to 4,570.1 Ma. The study of the Precambrian period is very complex as generally the rocks formed during this time were deeply transformed by different orogenic cycles, and fossils are very rare.

At the end of the Precambrian eon, during the period known as the Ediacaran period (635-541 Ma), the entire continental crust formed a gigantic, united continent called Rodinia, which was surrounded by the Panthalassa, a single mass of water. It was during this period that unicellular organisms, the first living creatures on Earth, began to appear.

Fig.23 Distribution of emerged land of the Precambrian 630 Mya.

BEGINNING OF THE PALEOZOIC ERA: THE IBERIAN MASSIF STILL HADN'T FORMED

At the beginning of the Palaeozoic era (541 Ma), the Iberian Peninsula still didn´t exist. Its territory was divided: the south of Portugal and the provinces of Huelva and Seville were located on the micro-continent of Avalonia, to the south of Laurasia; the provinces of Cadiz, Malaga, Granada, Almeria, Murcia, Alicante and the Balearic Islands made up part of the Gondwana continent, and the rest of the peninsular territory was immersed under the Rheic Ocean, on the Gondwana continental plate.

Fig.24 Distribution of emerged land of the Palaeozoic 430 Ma.

DEVONIAN-CARBONIFEROUS: THE VARISCAN OR HERCYNIAN OROGENY

Towards the end of the Palaeozoic era, between the Upper Devonian era (382 Ma) and the Lower Carboniferous era (346 Ma), the Variscan orogeny took place. It was caused by the collision of the Laurasia, Gondwana, Avalonia and Armorica tectonic plates, continental landmasses which formed parts of the Pangaea supercontinent.

Fig.25 Distribution of emerged land of the Carboniferous 302 Ma.

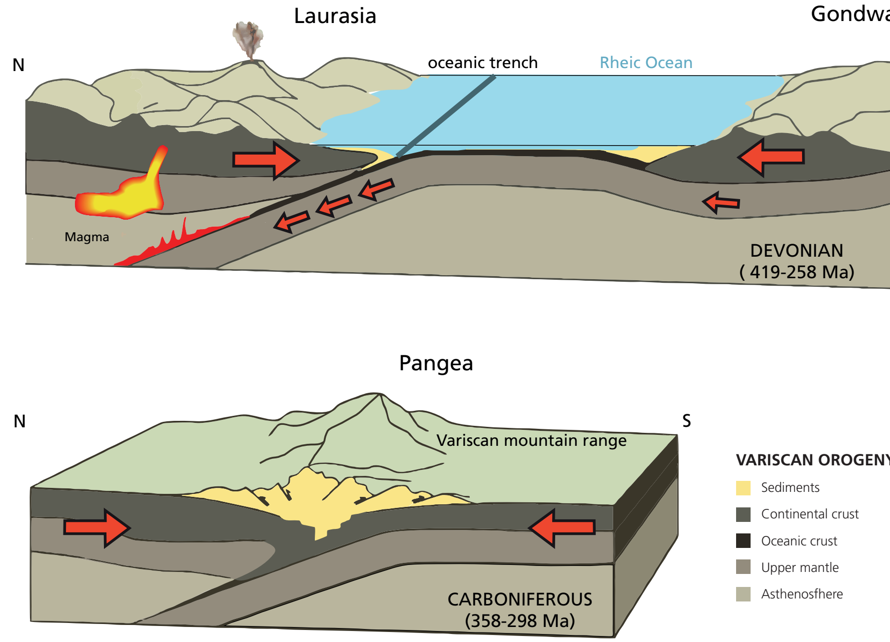


Fig.26 Formation of Varisca orogeny

In Europe, the Variscan orogeny stretches from the Iberian Peninsula to the Balkans, forming a belt more than 3,000 km long and between 700 and 900 km wide. One of the regions which has most complete records of Variscan orogeny and best exposed is the Iberian Peninsula.

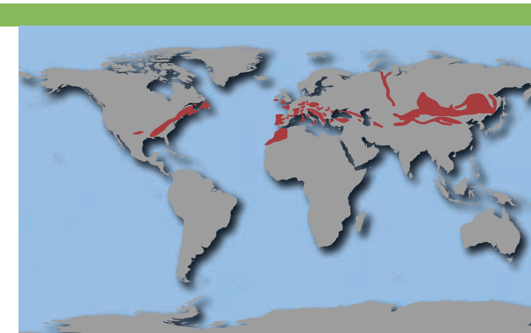


Fig.27 Global distribution of the Variscan orogeny

Fig.28 European distribution of the Variscan orogeny

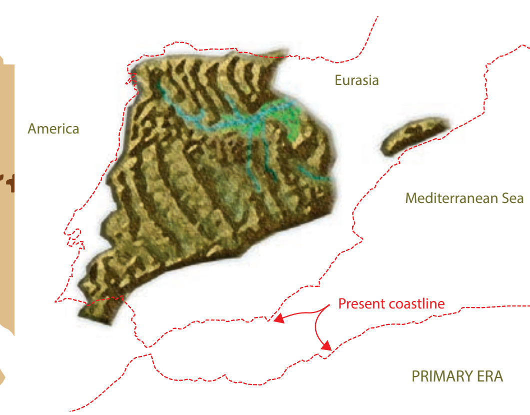


Fig.29 (1) Distribution of emerged land during the Primary Era

END OF THE MESOZOIC ERA AND THE CENOZOIC ERA: THE ALPINE OROGENY

The Iberian Massif, like every mountain range formed during the Variscan orogeny, began its erosive dismantling between the Upper Permian period and the mid-Mesozoic era. It resulted in the formation of peneplains that served as rigid bedrock for the sedimentation of Mesozoic and Cenozoic deposits.

In some areas, like the Geopark, small intramountainous basins formed between Paleozoic reliefs. These basins, which were filled by sediments during the Carboniferous and the Permian periods, are in unconformity over the previous rocks and has a low degree of deformation.

The Alpine orogeny, which began at the end of the Mesozoic era and developed during the Cenozoic or Tertiary era, rise the main and youngest mountain ranges of the peninsula: the Betic Range, the west part of the Cantabrian Range, the Pyrenees and the Iberian Range. Their rocks with Paleozoic, Mesozoic and Cenozoic ages, have an igneous, metamorphic and sedimentary nature.

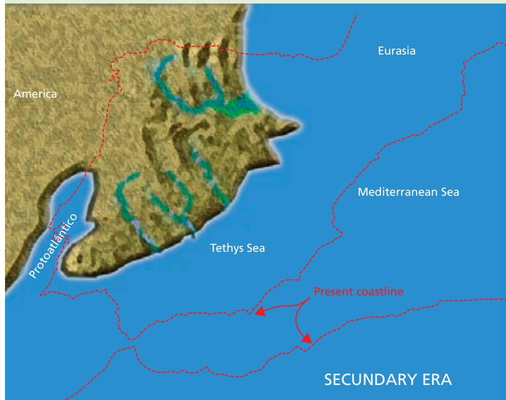


Fig.29 (2) Distribution of emerged land during the Secondary Era

Fig.30 Global distribution of the Alpine orogeny

CENOZOIC SEDIMENTARY BASINS OF THE IBERIAN PENINSULA

Fig.31 Cenozoic sedimentary basins

The Alpine orogeny began 250 Ma and is still active today. Its orogenesis took place when the small Cimmeria plate, the Indian and African subcontinent, collided with Eurasia. At the global level, it is responsible for the creation of mountain chains such as: the Rif, the Alps, the Carpathians, the Atlas Mountains, the Apennines, the Balkans, the Caucasus mountain and the Himalayas.

In the Iberian Massif, it caused a reactivation of some tectonic structures and a lifting of the relief.

The rest of the land on the Iberian Peninsula is younger. It is made up of Mesozoic, Cenozoic and Quaternary platform materials: sediments and sedimentary rocks that are not affected by the alpine cycle, which will fill topographical depressions or basins from earlier periods. Its main outcrops are the sedimentary basins of the Ebro, the Duero and the Tagus, the Betic Depression and the Lusitanian Basin.

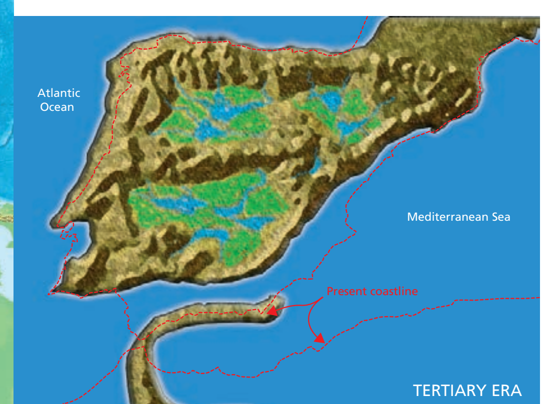


Fig.32 Distribution of emerged land during the Tertiary Era

Fig.33 Distribution of emerged land today

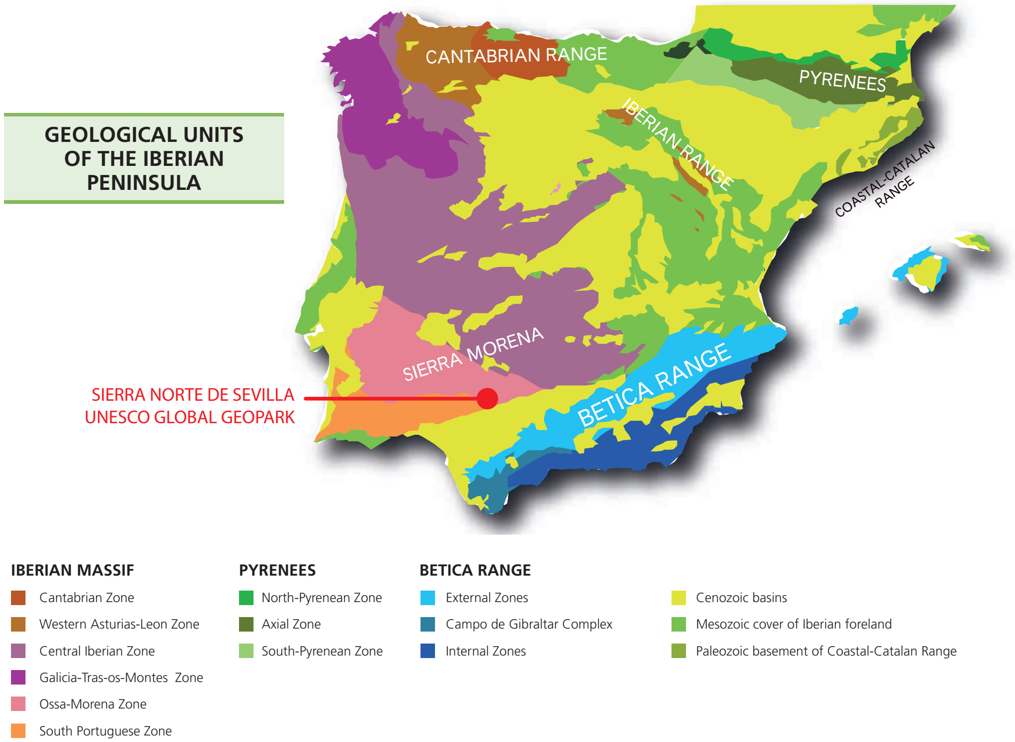


Fig.34 Geological units of the Iberian Peninsula

STRUCTURE AND DIVISION OF THE IBERIAN MASSIF

The Iberian part of the Variscan orogen spread out from Andalusia towards the north, till the Galician and Asturian coasts.

In this Iberian part, different areas can be distinguished due to the characteristics of the rocks and their structures. Those parts, from north to south, are: the Cantabrian, the West Asturian Leonese, the Central Iberian, the Galicia-Trás-os-Montes, the Ossa-Morena and the South Portuguese Zones. The Central Iberian, Ossa-Morena and Southern Portuguese zones are represented in Andalusia, north of the Guadalquivir river, shaping the reliefs of the Sierra Morena, although only the last two has presence in the Sierra Norte de Sevilla Geopark territory.

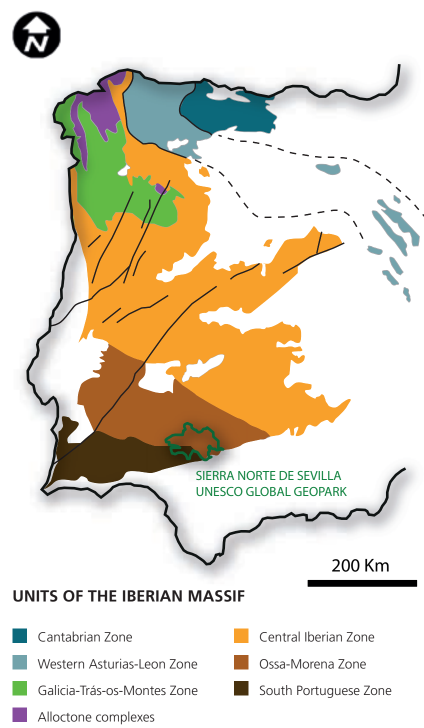


Fig.35 Geological zones of the Iberian Massif

Applying a very simplified form of the genetic model of the orogeny, the Cantabrian and West Asturian Leonese Zones represent the northern flank of the Variscan orogen and the Ossa-Morena and South Portuguese Zones represent the southern flank. The Central Iberian Zone corresponds to the axial zone of the orogen. However, the reality is a little bit more complicated as the South Portuguese Zone, seems to be a fragment of the Avalonia microplate and between this zone and its neighbour, the Ossa-Morena zone, there is a significant tectonic suture.

Although it is not represented within the area of the Geopark, the Central Iberian Zone is the most extensive and heterogeneous of the zones that make up the Iberian Massif. Its most recognisable characteristic is the abundance of intrusive, igneous rocks and the heterogeneity of the degree of metamorphism that its rocks can reach.

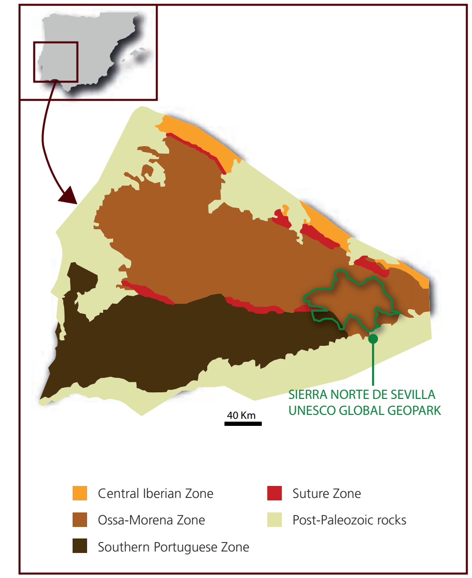


Fig.36 Geological zones of Andalusia

OSSA-MORENA ZONE

The Ossa-Morena Zone, one of the most complex and lesser known areas of the Iberian Massif, stretches through the mountains in the north of the Cordoba and Seville provinces, covering almost the entire area of the Geopark. It has great lithological diversity and the deformation of its rocks is very intense, particularly in those rocks that precede the Paleozoic era. These rocks suffered the effects of two orogenies: the Cadomian, during the end of Precambrian period, and the Variscan, at the end of the Paleozoic era.

Ossa-Morena is considered to be a continental block compressed between two tectonic plates, one solely continental in the north and one continental and oceanic in the south. The Southern contact zone with the South Portuguese Zone is made up of a belt of rocks with oceanic affinity, the remains of an ancient ocean floor which was deformed and metamorphosed during the Lower stages of the Variscan orogeny. The Northern contact zone with the Central Iberian Zone remains marked by the Badajoz-Cordoba Shear Zone (or Central Unit).

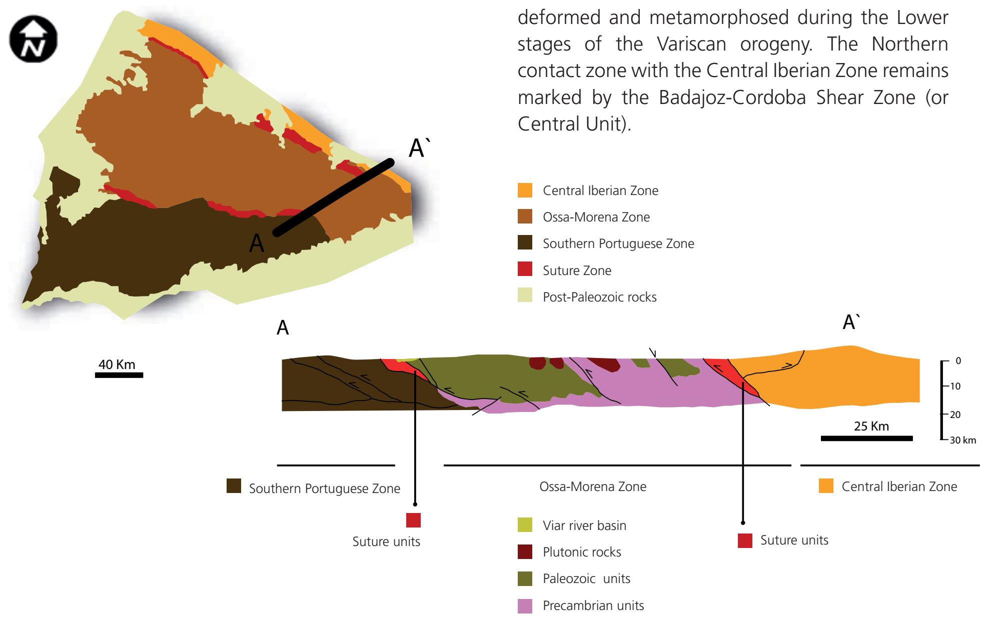


Fig.37 Geological section of the Ossa-Morena Zone

Although the initial movement of these plates was one of collision, the blocks subsequently rubbed against each other with a strong horizontal component. This produced important lateral displacements which are responsible for the current geographic configuration.

The first and most intense stage of collision occurred during the Devonian period. During the Lower Carboniferous period, strong magmatic episodes occurred in a high distension regime. A new compressive stage during the Carboniferous ended with the collision between the blocks, producing important vertical folds and wrench faults.

The age of the rocks from the Ossa-Morena Zone, characterised by their generally low to very low-grade metamorphism, span from the Precambrian era to the Carboniferous period. Their tectonic style is shaped by tilted folds and wrench faults that verge towards the southeast. It presents abundant Precambrian-Cambrian and Carboniferous granitic intrusions, with an age earlier, simultaneous and after the Variscan deformation.

The chronological sequence of materials is summarised with the following terms:

- Evidence of the **Precambrian era** can be found in different formations separated by unconformities. It is made up of dark schist, quartz schist, amphibolite, black quartzite and volcano-sedimentary rocks.
- The **Lower Cambrian** began with detrital levels with arkoses and lutites (the Torreárboles Formation), followed by rhythmic series of slate and a carbonated formation with stromatolite and archaeocyathids (Capas de Campoalla) and slate with trilobite in the upper part (Capas de Benalija).
- The remainder of the **Cambrian**, the **Ordovician** and the **Silurian** periods have detrital facies (slate, sandstone, siltstone and limestone) with marine fauna.
- The **Devonian** period is absent from many of the areas and, when exist, it presents the characteristics facies of shallow water marine environments.
- The **Upper Carboniferous** and **Permian** periods are present in the filling of the post-orogenic intramountain basins of the Viar, Alanís-San Nicolás del Puerto and in the Retortillo Reservoir.
- There are no records from the **Mesozoic** and the **Cenozoic eras**. Only in the south of the Geopark is there a small disjointed outcrops that correspond to sand, silt and limestone of the Miocene filling of the Guadalquivir Basin.

THE SOUTH PORTUGUESE-OSSA-MORENA SUTURE ZONE

The geological zones of Ossa-Morena and South Portuguese in the Iberian Massif have very different characteristics, in both the composition and age of the rocks, which have allowed to be easily distinguished.

Between these two geological zones, there is a collection of rocks, from Beja in Portugal to Almadén de la Plata in Seville, which are very different from those existing in either of the two aforementioned areas: the "Beja-Acebuches amphibolite", which come from the metamorphism of basaltic lava from the ocean floor; and the "Pulo do Lobo Group", whose materials are typical of an accretionary prism, with thin sediments deposited on ocean floors and sandy sediments from a nearby continent.

Those units are considered to belong to the suture zone between two ancient continental tectonic plates, which were separated by an ocean and that converged until they collided and caused the oceanic area of the South Portuguese plate to shift underneath the Ossa-Morena plate.

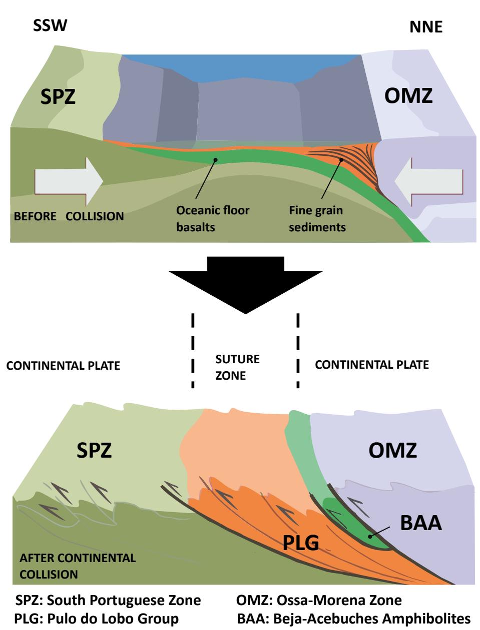


Fig.38 Diagram of the structural blocks of the suture zone

SOUTH PORTUGUESE ZONE

The Southern Portuguese Zone stretches across the most western parts of the provinces of Seville, Huelva and the Portuguese Algarve. In the Geopark, it is only represented in the southern and south-eastern areas of Almadén de la Plata. It corresponds with a external region of the Variscan orogeny, with marine deposits from the Middle Devonian to the Carboniferous periods, low-grade metamorphism, tectonic foliation and abundant magmatism.

The style of this deformation is characterised by folds and large thrust faults, which are associated with low to very low-grade metamorphism. In its north-eastern part, there is an abundance of plutonic rocks whose intrusion, in most cases, came after the main phase of tectonic deformation. This means these rocks are post-orogenic, a good example of which is the granite of El Berrocal in Almadén de la Plata.

During the Upper Devonian and the Lower Carboniferous periods, the marine basin was subject to violent volcanic processes which caused a huge accumulation of volcanic and subvolcanic rocks. This left rich mineral deposits of massive sulphides, like the ones in Riotinto, Tharsis, Sotiel-Coronada and Aznalcóllar, and defined the Iberian Pyrite Belt, a strip of 50 x 230 km that stretches from around Seville to the south of Lisbon.

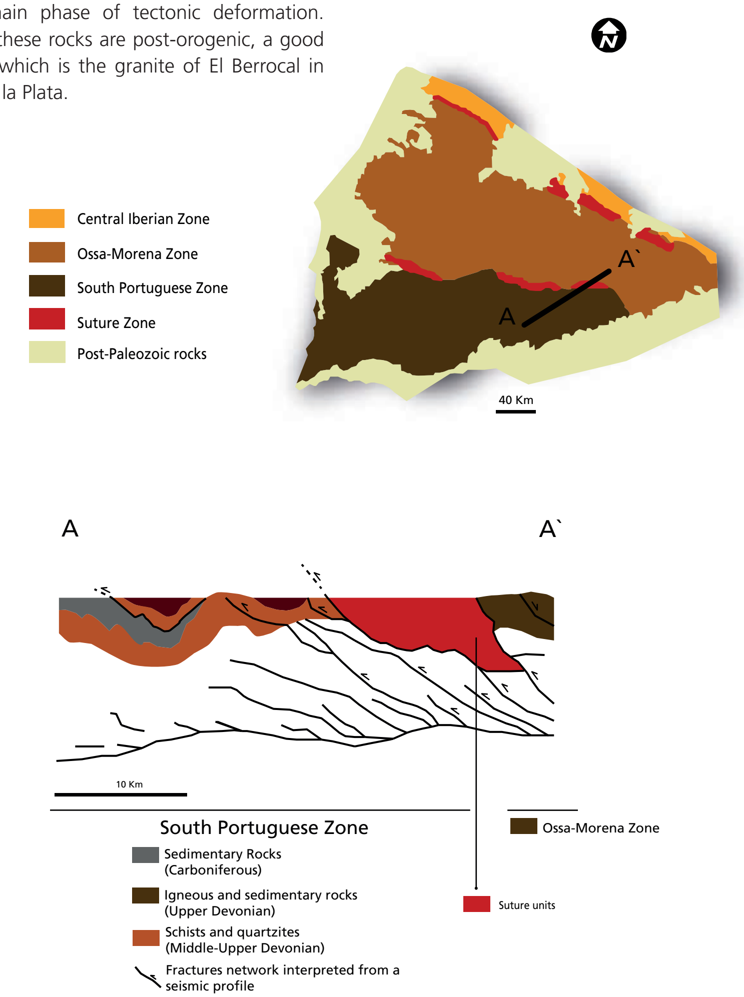


Fig.39 Geological section of the northeast area of the South Portuguese Zone

4 The Geopark

[29] El Pintado Reservoir

THE ROCKS OF THE GEOPARK

The Geopark's rocks and sediments offer a wide lithological diversity and cover a broad spectrum of ages, from the Precambrian eon (more than 541 Ma) to the present. Most of the substrate corresponds to igneous and metamorphic rocks, although sediments and sedimentary rocks, both chemical and detrital, are also widely represented; many of them have suffered a low degree of metamorphism, so their original features are still recognised. These type of rocks or sediments are referred to as metasedimentary rocks.

The Ossa-Morena Zone was affected by the two orogenic cycles explained above, so the Precambrian rocks have the overlapping effect of these two orogenies. They are intensely deformed and present a generalised and more intense metamorphism. The rocks aged between the Cambrian period and the Upper Devonian period only show the effects of the Variscan deformation, which is what shapes the general structure of the Geopark. For its part, the South Portuguese Zone is only affected by the Variscan orogen, since its oldest rocks are from the Middle Devonian period.

The rocks aged beyond the Upper Palaeozoic era have only suffered some side effects of Alpine orogeny, related to the reactivation of ancient fractures, with very little or no deformation.

The following typologies of rocks are present in the Geopark: sedimentary, metasedimentary, metamorphic and igneous rocks.

SEDIMENTARY ROCKS

DETRITAL SEDIMENTARY ROCKS

Conglomerates: the best outcrops correspond to alluvial sediments deposited in post-orogenic basins of the Upper Carboniferous and Permian periods of Viar, Alanís-San Nicolás del Puerto and El Retortillo Reservoirs. They are conglomerates of mostly quartzite pebbles, rounded, with a sandy matrix, little cemented, and with a strong reddish tone due to their high iron content.

[30] Conglomerates

Sands and sandstones: sands are sediments, while sandstones are rocks created by consolidation or lithification of sands. If they are subject to the metamorphic processes, they are transformed into quartzitic sandstones (metasedimentary rocks) or quartzite (metamorphic rocks). The most ancient sediments correspond to fluvial and alluvial deposits, associated with conglomerates, in the Viar, Alanís-San Nicolás and El Retortillo Reservoirs. The most recent ones are currently created in the riverbed and flood channels of the Geopark's rivers and on the weathered granite masses.

[31] Sandstones

Silts and clays: silts have slightly thicker grains, while clays have finer ones. They are associated with conglomerates and sands in the old river deposits, in the post-orogenic Viar, Alanís-San Nicolás del Puerto and El Retortillo Reservoirs as well as in the current river sediments.

CHEMICAL ROCKS:

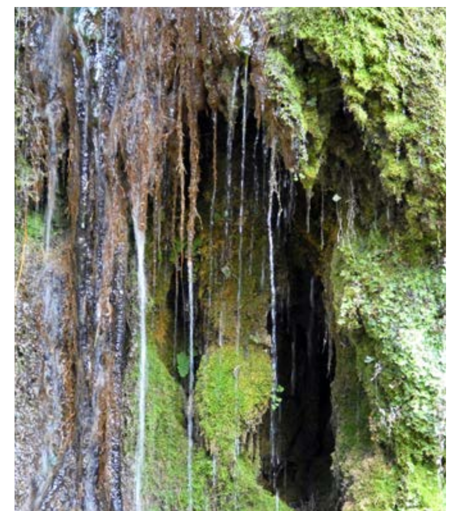
Limestones: Limestones are deposits of calcium carbonate (CO_3Ca_2). In the Geopark, there are excellent examples of limestones in the Lower Cambrian, Devonian, Permian and Cenozoic formations. Most of them contain fossils, which are indicative of the age and sedimentary environment, normally marine and platform, in which they were created. They usually occupy the peaks of mountain ranges, offering karstic landscapes of great beauty, such as the Natural Monument of Cerro del Hierro.

[32] Cambrian limestones

Travertines (or calcareous tufa): Travertines are rocks created by carbonate precipitation around the roots, stems and leaves of the vegetation associated with springs or waterfalls in riverbeds; or inside the karst caves by precipitation. Their creation is ancient, recent and even current, and they are very well represented in another Geopark's Natural Monument, the Huéznar Waterfalls.

[33] Travertine in Huéznar Waterfalls

[34] Karst travertine



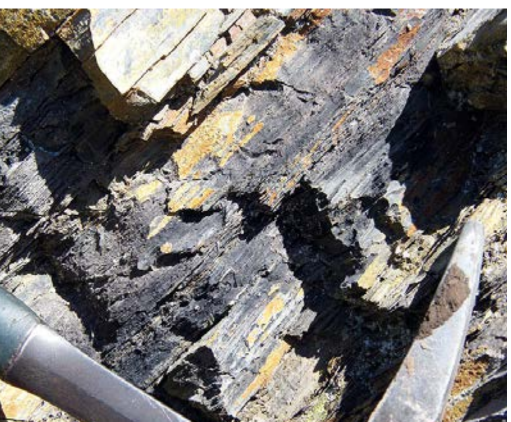
[35] Travertine creation

METASEDIMENTARY ROCKS

Almost all of the Geopark's rocks have, to a greater or lesser degree, evidence of metamorphism. In low-grade metamorphic processes (metasedimentary rocks), the transformation of sedimentary rocks (clays, sands and limestones) into their corresponding metamorphic rocks (slates, quartzite and marbles) is so gradual that, occasionally, the petrology classification of the rock can be difficult. Metasediments are widely extended through the surface of the Geopark, so they will be described on an individual basis.

Slates: clays subjected to metamorphic processes, to temperature and pressure increase, have a characteristic foliation and they are called slates. They are very abundant in the Geopark, highlighting the strata of slates interspersed between the limestones or sandstones of the Capas de Campoallá, and the greenish slates of Capas de Benalija, from the Cambrian period, and the black slates of Valle Syncline Unit, from the Ordovician and the Silurian periods.

[36] Greenish slates of Capas de Benalija



[37] Black slates

Quartzitic sandstones: sandstones subjected to metamorphic processes are transformed into quartzite, but they can also have intermediate stages, in which case, they are called quartzitic sandstones. In the Geopark, they are common in all the formations and they are generally interspersed or alternated with other kind of rocks. The best outcrops are located in the municipality of Las Navas de la Concepción. They come from the sandy sediment of the beaches created in the Cambrian period (541 to 500 Ma).

[38] Detail of a quartzitic sandstone

Marble limestones: they are limestones subjected to a metamorphism process, but to an insufficient degree in order to achieve their complete transformation into marble. Excellent examples can be found in the Lower Cambrian and Devonian formations. The best outcrops are located in the upper part of the Capas de Campoallá, in the surroundings of Guadalcanal and in the Cerro del Hierro.

[39] Marble limestone of Cerro del Hierro

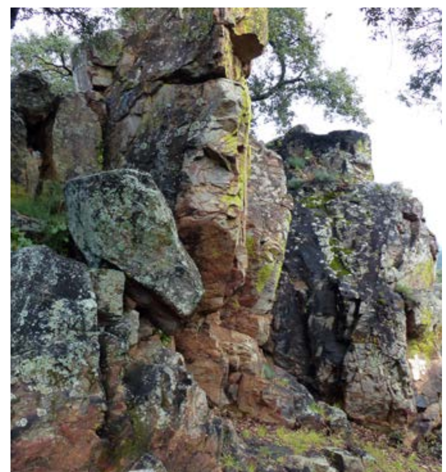
METAMORPHIC ROCKS

The Geopark's rocks have undergone a two nature metamorphism: regional metamorphism related to orogenic processes, and contact metamorphism (thermal metamorphism), produced by the intrusion of magmatic bodies. Both can be found in the Geopark, although the first is much more prevalent. Rocks with regional metamorphism correspond to very deformed Precambrian rocks, affected by the two orogenies: the Cadomian and the Variscan. The thermal metamorphism gives rise to well-developed contact metamorphism aureoles, around plutonic massifs.

Schists and gneisses: they can be found on the roads from Constantina to Lora del Río and to Villanueva del Río and Minas, just on the Geopark's southeast boundary. The degree of metamorphism of these rocks is high and they are represented as schists, green schists, gneisses and migmatites. Good examples can be found also in Almadén de la Plata region, where schists and amphibolites outcrop.

Some of the Geopark's plutons, like the El Pedroso, have led to well-developed contact metamorphism aureoles. This group of magmatic rocks intruded into Cambrian detrital rocks, producing a metamorphism that varies in intensity, from hornfels (s.s.) to mottled schists.

Quartzites: they are sands or sandstones subjected to an intense process of metamorphism. They appear as interspersed layers in various detrital series. The most powerful banks offer geomorphological highlights, given the harness of the material to erosion.



[40] Brown quartzites in Almadén de la Plata

Marbles: within the Geopark's rocks with regional metamorphism, special mention should be made of marbles, which are created by the intense recrystallization of limestones, eliminating the possible existence of fossils. Due to its economic interest, the marble quarries of Almadén de la Plata have been utilised since the Roman period. Another marble area of interest is the one located in Sierra del Viento in Guadalcanal, whose marbles make up the highest relief of the entire Geopark, La Capitana, with 959.2 meters in altitude.

[41] Marbles

[42] Detail of marbles

Amphibolites: they are fine-to-coarse-grained rocks, of a bluish-grey colour with a characteristic banding, with light and dark bands, depending on their richness in plagioclase or amphiboles.

The most significant ones are the "Beja-Acebuches Amphibolites" with greenish and blue tones, coming from the metamorphism of ancient basic volcanic rocks, of similar composition to the basalts located in the oceanic ridge areas. Therefore, they are related to areas of cortical sutures of great tectonic meaning.

Amphibolites can also be found in the Sierra Albarrana Domain, in the Anticlinorio de Monesterio (in the Montemolín and Tentudía Formations), and in the Barrancos Formation, in the north of Almadén de la Plata.

[43] Beja-Acebuches Amphibolites (Almadén de la Plata)

IGNEOUS ROCKS

In the Geopark outcrops in abundance intrusive igneous rocks, like plutonic, subvolcanic, and extrusive or volcanic, all related to an ancient magmatic activity.

PLUTONIC ROCKS

Granites and granodiorites: acid intrusive plutonic rocks, rich in quartz, on which the crag lands are modelled, are mostly granites and granodiorites. They have light colours and they appear forming plutons of great extension in the surroundings of El Pedroso, in the south of El Pintado Reservoir, to the west of El Real de la Jara, and in the south of Almadén de la Plata.

Diorites and gabbros: basic plutonic intrusive rocks, gabbros and diorites, have dark colours and they appear forming small plutons in the surroundings of El Pintado Reservoir, in Cazalla de la Sierra and in Alanís, as well as in the proximities of the town El Real de la Jara.

[44] Detail of El Berrocal granite (Almadén de la Plata)

[45] Diorite (Cazalla de la Sierra)

VOLCANIC ROCKS

Basalt. In the Geopark there are excellent examples of volcanic processes and rocks. The most characteristic outcrops of basic volcanic rocks are located in the southeast of Almadén de la Plata, although they can also be found in the proximities of Alanís village. They are rocks from the Upper Carboniferous-Permian period that came to the surface through fractures. They have dark green to black colours, and they can form lava flows, sometimes of great extension. Very illustrative examples of these rocks and structures can be found in Cordel del Pedroso path, at 5 kilometres to the southeast of Almadén de la Plata.

[46] Basalt lava flows (Almadén de la Plata)

Pyroclastic rocks. Acid volcanic rocks present in the Geopark are relatively abundant and they were formed in different moments of the region's geological evolution. On one hand, there are multiple outcrops of underwater pyroclastic volcanic rocks, from the Precambrian-Lower Cambrian period. On the other hand, the best-preserved outcrops of acid volcanic rocks are those associated to the evolution of post-orogenic basins, from the Upper Carboniferous to Permian period, and among these, those from Viar Basin. In this case, acid volcanic rocks create packages of pyroclasts that can exceed 25 meters in thickness.

[47] Volcanic agglomerates (Viar Basin)

SUBVOLCANIC OR HYPABYSSAL ROCKS

Subvolcanic magmatism gave rise to rocks solidifying at intermediate depths, from 1 to 3 km, in the form of dikes or veins. They can be of varied composition and texture.

Diabases: they are the most frequent subvolcanic rocks in the Geopark, also known as dolerite or microgabbro. Its mineralogical composition is almost identical to its volcanic sister, the gabbro, and they form dikes of great lateral extension.

[48] Diabase dyke (Viar River´s valley)

[49] Detail of diabase

Porphyry: together with the granitic plutons and of similar composition, this rock is characterised by a characteristic texture of grainy paste with large feldspar crystals, from 0.5 to 2 cm in diameter.

[50] Porphyry (Las Navas de la Concepción)

Aplites: With a granite composition, they present a dim colour and a peculiar, fine texture, like fine granite, with crystals of less than 2 mm. The most important outcroppings can be found west of Cazalla de la Sierra village, and they are exploited for the making of porcelain.

[51] Small aplite seam inside a granitic rock

Pegmatites: They do not constitute a relevant lithology in the Geopark. Some outcroppings of pegmatites, forming tabular bodies 2 or 3 metres thick, exist. They are very thick in grain size, more than 20 mm, occasionally including gigantic crystals.

THE GEOLOGICAL UNITS OF THE GEOPARK

In the Geopark outcrops many geological units, of very different ages and lithology, relevance, making up different geological domains. From north to south, there are the following:

- Ossa-Morena Zone
- Suture Zone (between the Ossa-Morena Zone and the South Portuguese Zone)
- South Portuguese Zone
- Post-orogenic basins
- Plutonic rocks

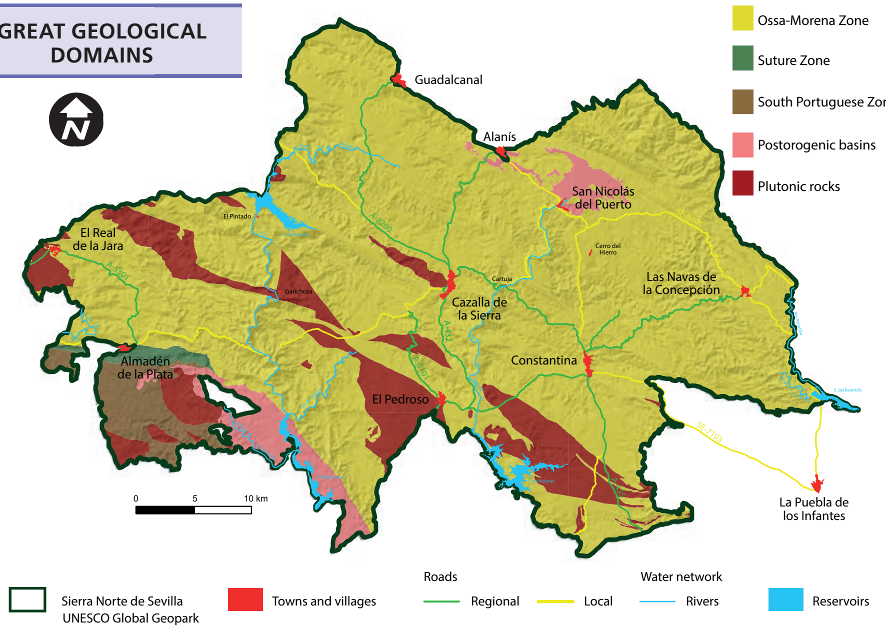


Fig.40 Geological Domains of Sierra Norte de Sevilla Geopark

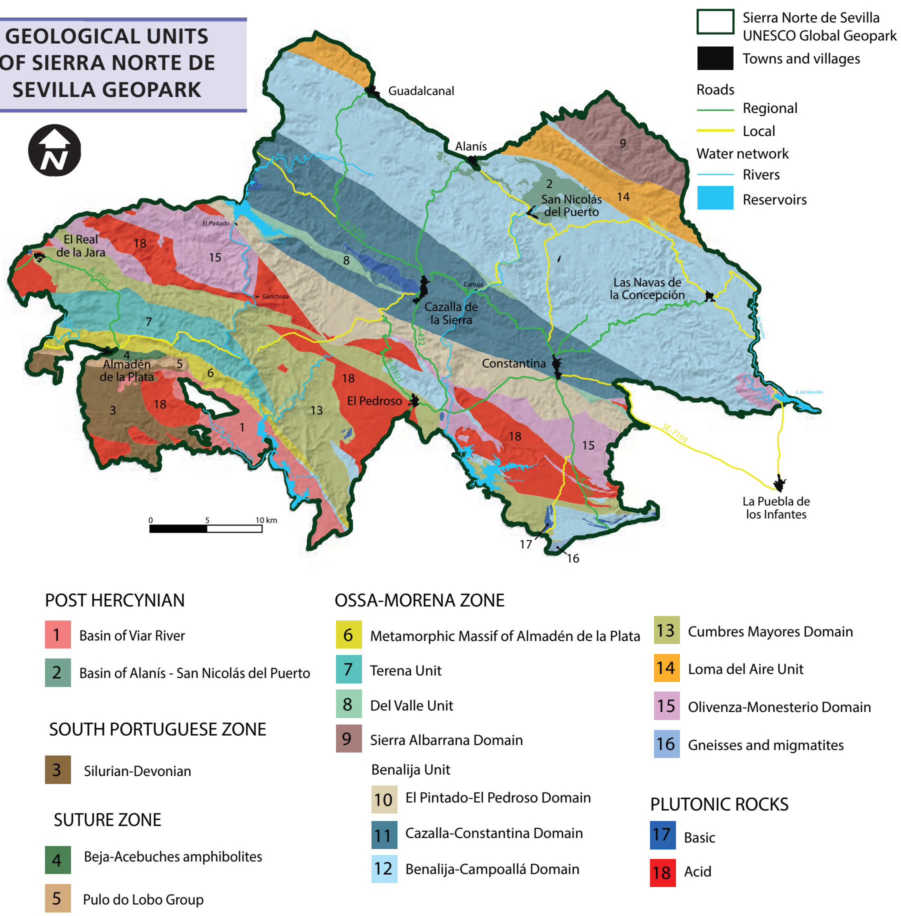


Fig.41 Geological Units of Sierra Norte de Sevilla Geopark

OSSA-MORENA ZONE

The Ossa-Morena Zone represents a surface area of more than half of the Geopark, the northern sector. The age of the materials spans from the Ediacaran period (Terminal Precambrian eon, 635 Ma), to the Permian period (end of Palaeozoic Era, 250 Ma).

The Precambrian rocks present a metamorphism of varying degrees, from low to very high. Meanwhile in Palaeozoic rocks, it is generally of a low degree. It presents abundant Precambrian-Cambrian and Carboniferous granitic intrusions, with an age earlier, simultaneous and after the Variscan deformation.

The great lithological diversity has allowed numerous authors to differentiate minor range units or sub-domains for the type of lithology that outcrop, especially in relation to the type of igneous rocks associated and the degree of local deformation. These subzones or subdomains extend parallel to the dominant structural alignment of the Variscan orogen (northwest to southeast).

In the Ossa-Morena Zone, the following domains or units can be identified:

Sierra Albarrana Domain

It is the northerly unit of the Geopark and consists of a set of phyllites, slates and quartzitic sandstones, with abundant inserts of metabasites of lower and middle Cambrian age. The best outcrops can be seen in the confluence of Los Gavilanes Stream with the Onza River, in the north-eastern corner of the Geopark.

[52] Slates with layers of quartzitic sandstones

[53] Detail of slates (where deformation by landslides can be observed)

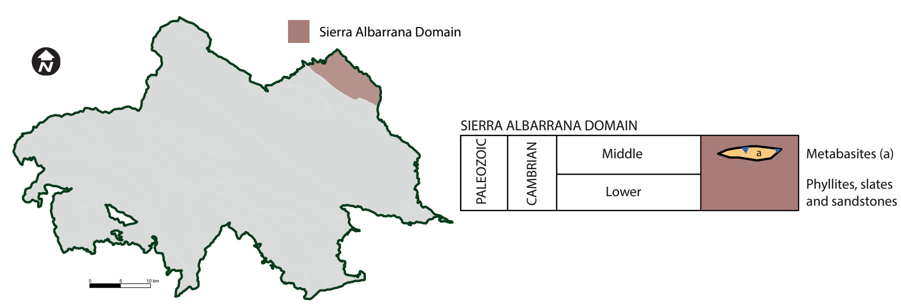


Fig.42 Location and chrono-stratigraphic legend of the Sierra Albarrana Domain

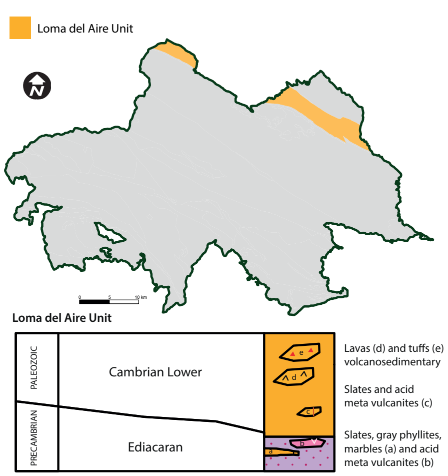
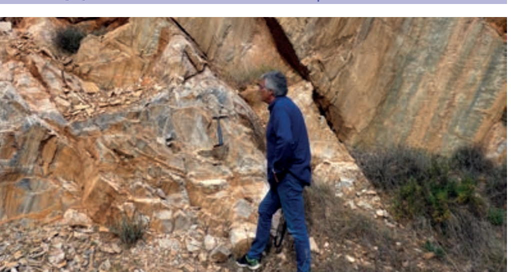


Fig.43 Location and chrono-stratigraphic legend of the Loma del Aire Unit

Loma del Aire Unit

This unit emerges to the south of the previous one, in a band that extends in a southeast direction from Guadalcanal to Alanís and Las Navas de la Concepción. It consists of a lower unit from the Ediacaran period (Terminal Precambrian eon), formed of slates and grey phyllites interspersed with marble and meta vulcanites, and another unit of lower Cambrian age composed essentially of a lower section of slates and meta vulcanites and a higher section mostly consisting of lavas and volcano-sedimentary tuffs.

[54] Marbles of Loma del Aire Unit in La Capitana Hill



[55] Detail of marbles

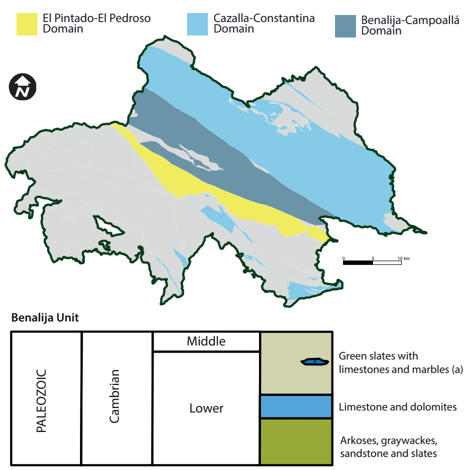


Fig.44 Location and chrono-stratigraphic legend of the Benalija Unit

Benalija Unit

It is the most extensive sedimentary unit in the Geopark and corresponds to formations of lower and middle Cambrian age. The lower part is basically detrital; arkoses, greywackes, sandstones and slates (Torreárboles Formation). They are followed by a series of finely laminated layers of sandstone, slates and limestones, completed by a section of massive limestone or dolomites (Capas de Campoallá), and a formation of greenish slates interspersed with limestones and marbles (Capas de Benalija). The calcareous levels generate the reliefs of the principal summit alignment of the northern part of the Geopark, in a band that comprises the area from the Sierra de San Miguel and Sierra del Agua to Cerro del Hierro.

[56] Massive limestones and dolomites in Cerro del Hierro

[57] Limestones and dolomites finely stratified in Capas de Campoallá

[58] Greenish slates of Capas de Benalija

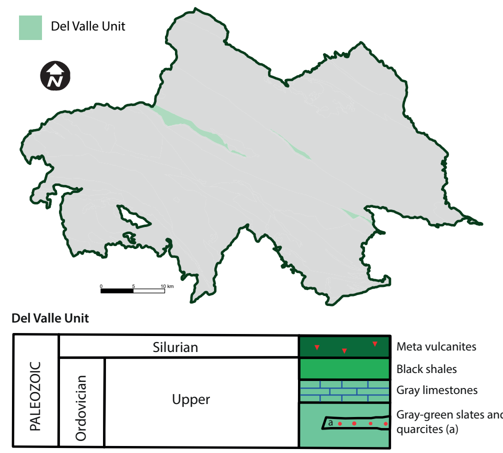


Fig.45 Location and chrono-stratigraphic legend of Del Valle Unit

Del Valle Unit

Composed of a series of green and grey slates, quartzites, limestones and pyroclastic rocks, it narrowly outcrops to the west of Cazalla de la Sierra, in Del Valle Syncline, with smaller outcrops in the surroundings of Rivera del Huéznar and Cerrón de Hornillo, to the south of Constantina.

Del Valle Syncline contains an almost complete sedimentary series, from the Upper Ordovician period to the Silurian period. The Ordovician sequence commences with green and grey slates, followed by sandstones and a succession of slates and limestones. It continues with a series of black slates, with an abundant variety of graptolites, and insertions of carbonates in the upper half. The meta vulcanites predominate towards the upper part of this unit, of Silurian age.

[59] Outcrop of black slates in Cerrón del Hornillo

[60] Metavulcanites in Del Valle Syncline

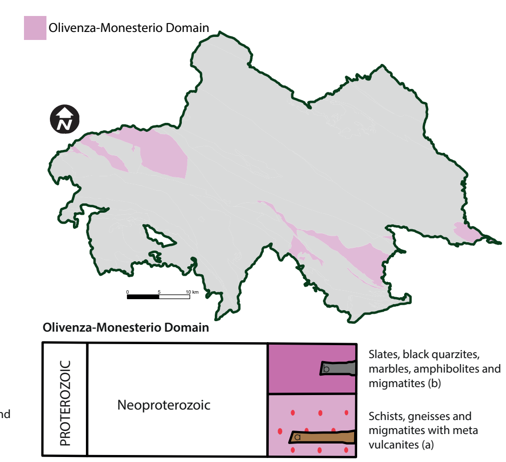


Fig.46 Location and chrono-stratigraphic legend of Olivenza-Monesterio Domain

Olivenza – Monesterio Domain

Towards the central axis of the Geopark, there is an extension of a series of very ancient rocks from the Ediacaran period, between 635 and 541 Ma (end of the Precambrian eon), consisting of a metamorphic unit of schists, gneisses and migmatites interspersed with meta vulcanites (Montemolín Formation), followed by other insertions of slates, black quartzite, marbles, amphibolite and migmatites (Tentudía Formation).

[61] Gneisses and migmatites (Montemolín Formation)

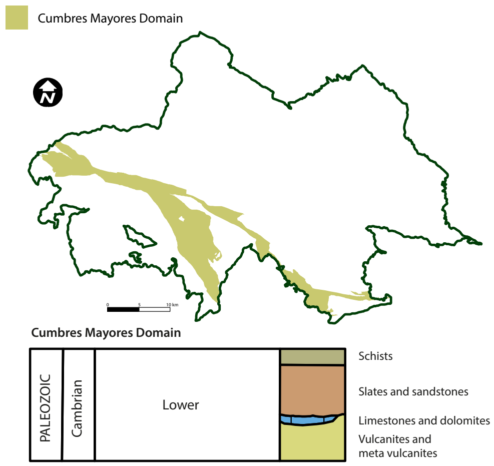


Fig.47 Location and chrono-stratigraphic legend of Cumbres Mayores Domain

Cumbres Mayores Domain

The aforementioned units are covered in the south by a set of units of Lower Cambrian age. They are mostly composed of vulcanites and meta vulcanites (Bodonal Porphyries) with limestones and massive dolomites in its upper part, together with an alternating section of slates and sandstones with schists at the top (Alternancia de Cumbres Formation). They extend from El Real de la Jara and El Pedroso to the south of Constantina.

[62] Schists of Cumbres Mayores Domain

[63] Outcropping of Alternancia de Cumbres Formation

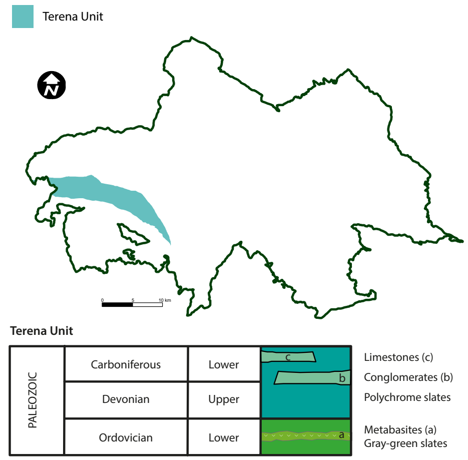
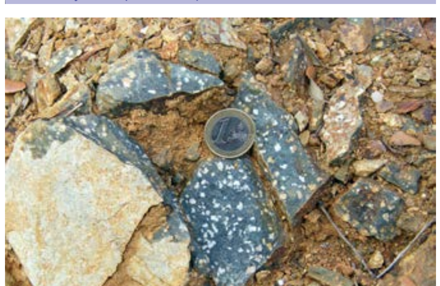


Fig.48 Location and chrono-stratigraphic legend of Terena Unit

Terena Unit

Immediately adjacent to the south of the previous unit, there is a set of materials aged between the Lower Ordovician period and the Lower Carboniferous period. They are mostly grey-green slates interspersed with metabasites and versicolour slates with levels of limestones and conglomerates.

[64] Grey slates (Terena Unit)



[65] Amphibolites (Terena Unit)

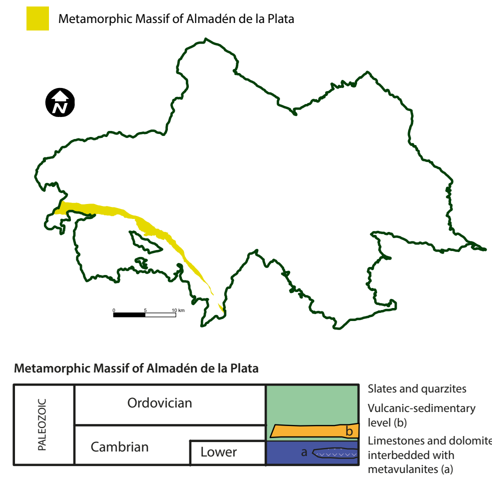


Fig.49 Location and chrono-stratigraphic legend of the Metamorphic Massif of Almadén de la Plata

Metamorphic Massif of Almadén de la Plata

Combination of Paleozoic materials of ages comprised between the Lower Cambrian period and Ordovician period (also called Sierra Aracena Domain, since it was defined in this region for the first time). It consists of marbles, interspersed with meta vulcanites, volcanic-sedimentary levels and detrital series of slates and quartzites. In the Geopark, it is expanded into a band which comprises the area from Almadén de la Plata to the southeast of the El Pedroso batholith.

[66] Marbles from Los Covachos Hill

[67] Level of calcium silicate inside the marbles

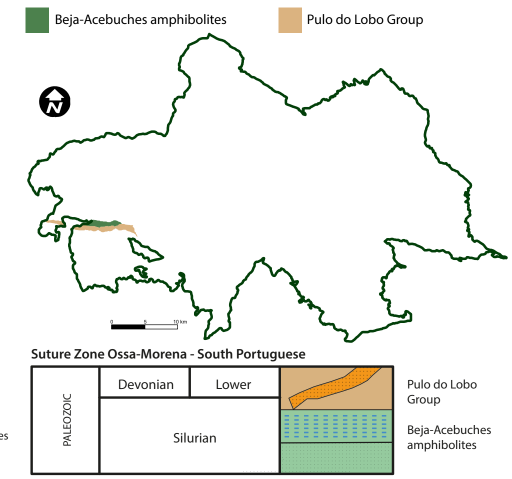
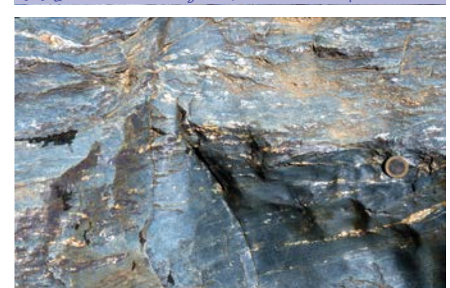


Fig.50 Location and chrono-stratigraphic legend of the Suture Zone

SUTURE ZONE

It constitutes the suture area between the Ossa-Morena Zone and the South Portuguese Zone, located immediately at the south of the village of Almadén de la Plata. It can be recognised due to a combination of rocks with characteristics very different from those existing in the two geological zones. They are grouped into two lithological groups: the Pulo do Lobo Group, consisting of very deformed slates and quartzites, and the Beja-Acebuches Amphibolites, which can be interpreted as the rest of the ocean floor that existed between the two areas.

[68] Quartzite boudin among slates; Pulo do Lobo Group



[69] Beja-Acebuches amphibolites, very deformed

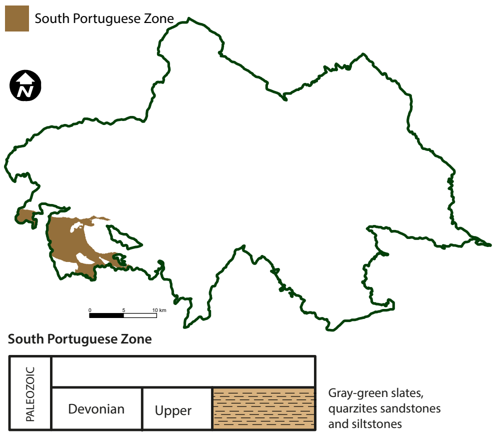


Fig.51 Location and chrono-stratigraphic legend of the South Portuguese Zone

SOUTH PORTUGUESE ZONE

In the Geopark, it is located south of the Suture Zone. It is a detrital series from the Silurian-Devonian periods, composed of an alternation of green, grey and blue slates, quartzitic sandstones and siltstones.

[70] Alternation of quartzitic slates and sandstones

POST-OROGENIC BASINS

On top of the deformed substrate from both the Ossa-Morena Zone and the South Portuguese Zone, there appear the remains of small continental basins filled, during the Upper Carboniferous to Permian period, possibly until the Lower Triassic period, with lake and river sediments. They had frequent volcanic episodes interspersed.

The Viar Basin, south of Almadén de la Plata, appears geographically linked to the northeast limit of the South Portuguese Zone. Its sedimentary filling consists of potent detrital series of conglomerates, sandstones and red-toned shales, with sporadic levels of limestones, and abundant volcanic material, in the form of basaltic lava flows and pyroclastic deposits. Some of the deposits present abundant remains of fossil flora.

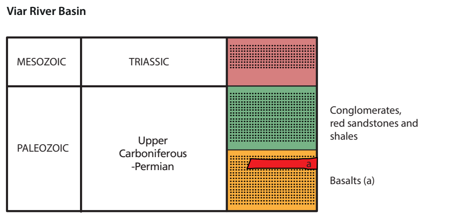


Fig.52 Chrono-stratigraphic legend of the Viar River Basin

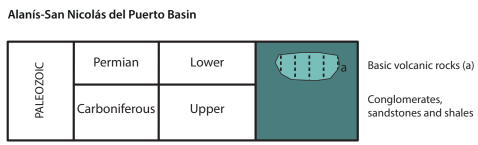


Fig.53 Chrono-stratigraphic legend of the Alanís-San Nicolás del Puerto Basin

[71] Detrital sediments

[72] Lava flows

Between the villages of Alanís and San Nicolás del Puerto outcrops a combination of sedimentary rocks consisting of conglomerates, sandstones and shales, with levels of basalt lava. They correspond to alluvial fan sedimentation, river systems and lake areas, with the occurrence of some volcanic episodes; they contain fossils of leaves and tree trunks. They constitute the filling of a continental basin, partially dismantled, of an age comprised between the Upper Carboniferous period to Lower Permian period, over the deformed basement, similar in spatial arrangement and age to the Viar Basin.

On the surroundings of El Retortillo Reservoir, you can also see the remains of another smaller continental basin.

[73] Layers of sandstone and lutites

[74] Detail of the conglomerates

PLUTONIC ROCKS

In the southern half of the park, there are extensive plutons of intrusive rocks. Acid rocks are dominant; granites and granodiorites, although there are also small plutons of intermediate rocks; diorites and gabbros. There is an abundant accompaniment of associated subvolcanic rocks together with them.

[75] Granite with rocky morphology

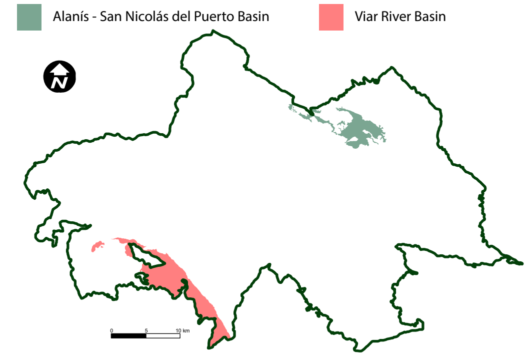


Fig.54 Location of the Viar River Basin and Alanís-San Nicolás del Puerto Basin

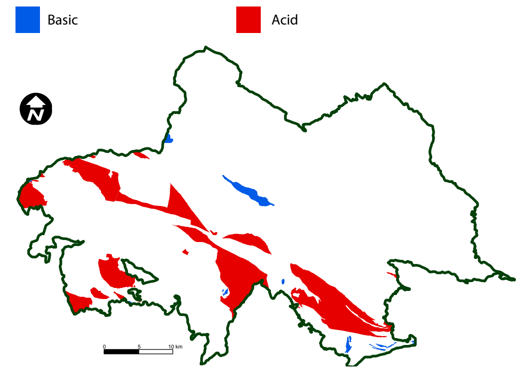


Fig.55 Location of the Plutonic rocks

[76] Weathered granite

[77] Dyke in a diorite

GEOLOGICAL HISTORY

The rocks and fossils of a region allow us to reconstruct the geological, biological and climatic history of the territory in which they formed.

The appearance of life and its evolution on our planet has three essential milestones:

Origin of life: Over the 4,600 Ma of age of the Earth, there is evidence of life in the form of microfossils from the period between 3,770 and 4,300 Ma. It is thought that the first living organisms developed in hydrothermal underwater vents. They were chemically synthetic microorganisms that made their own organic compounds by the oxidation of simple inorganic substances, such as sulphur and ammonia. These subsequently resulted in cyanobacteria, which lived in shallow waters performing photosynthesis and formed stromatolites, that is, bio-constructed sedimentary structures composed of colonies of microorganisms.

Development of pluri-cellular organisms: They are plain-bodied organisms, shaped like discs, feathers, etc., called "Ediacara fauna" because of the place in Australia where they were discovered for the first time, with an age of around 600 Ma.

Origin of skeletons: Represented in their diverse forms: shells, spines, plates or bones. It was in the biological explosion of the Cambrian period (530 Ma), where the most primitive members of many of today's animals appeared.

The rocks of the Geopark captures this final episode of the history of life. The Cambrian limestone layers present a fossil register that reflects the emergence of life forms during the Lower Paleozoic era. The fossil deposits of the Geopark provide evidence of this event, as well as the following one, called the "Great Radiation of the Ordovician". This period featured an exceptional abundance of trilobites, brachiopods, bryozoans, echinoderms, molluscs (bivalve and cephalopods) and graptolites.

Broadly speaking, this is the geological history of the Geopark:

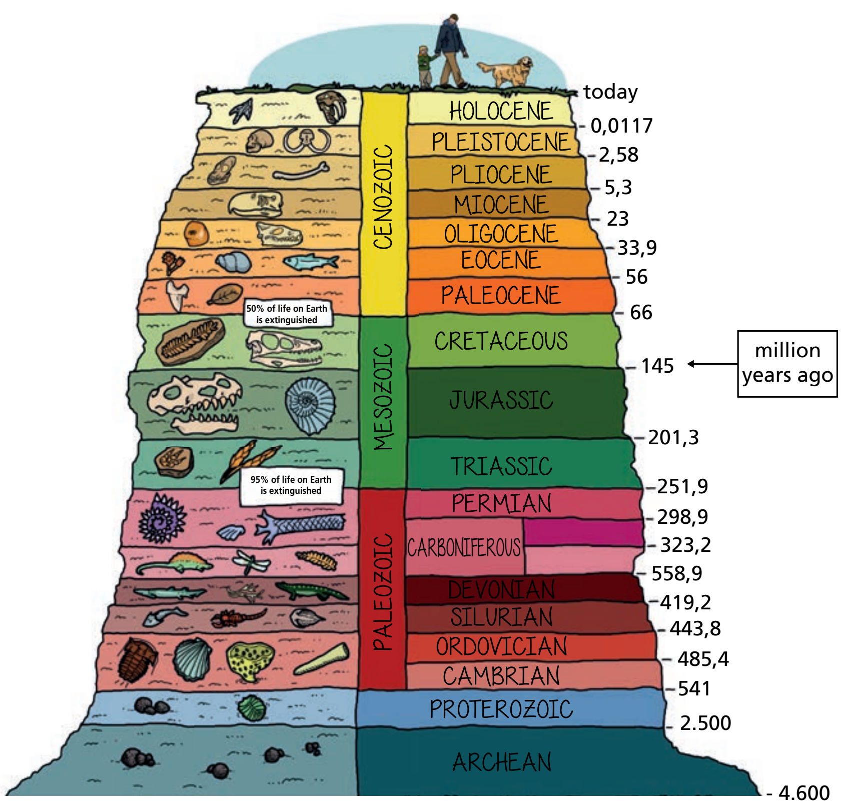


Fig.56 Evolution of the species in geological time

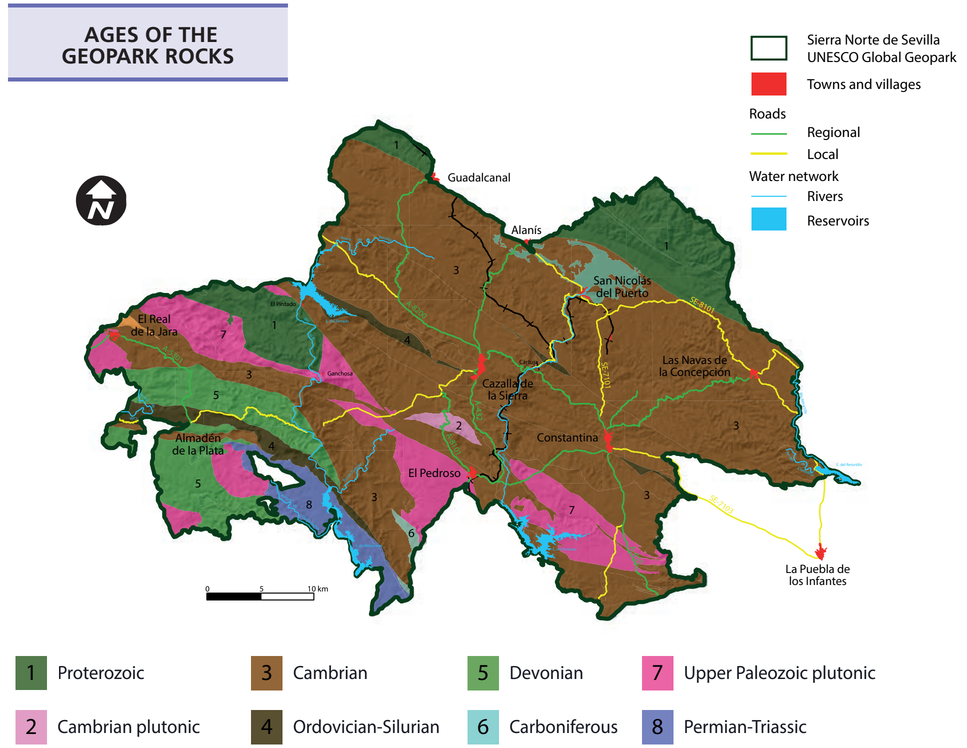


Fig.57 Map of the ages of the geopark rocks

Ediacaran period

(End of the Precambrian eon, 635 to 541 Ma)

The lands emerged during this time were concentrated into only one continent called Pannotia, around the southern hemisphere. However, the events of the Precambrian geological history in the Geopark are largely unknown. Few outcroppings exist and the rocks are intensely transformed and metamorphosed because of the effects of the Cadomian orogeny, which took place at the end of this geological age.

In the Geopark, Precambrian rocks emerge in the northeastern sector, in the Loma del Aire Units and in the northwestern sector, in the centre of Olivenza-Monesterio Anticlinorium, to the west of El Pintado Reservoir. They correspond to schists, gneisses, marbles and abundant volcanic material (meta vulcanites). They do not have fossils, and before the Cambrian period, little biodiversity exists, characterised by single-cell organisms: bacteria, algae, fungi and the first multicellular and pluri-cellular organisms (animals, greens algae and fungi), without hard parts favourable to their conservation.

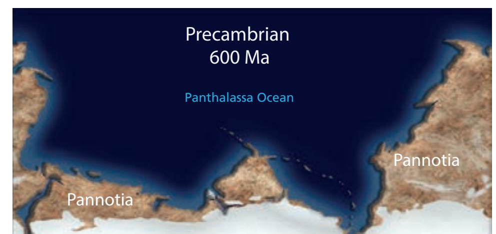


Fig.58 World map containing the distribution of continents and oceans in the Precambrian eon

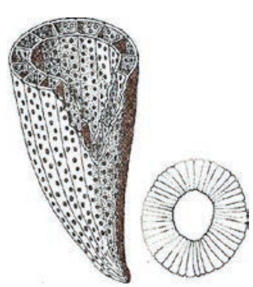
Fig.59 Seabed with the fauna of the Ediacaran period

Cambrian period
(541 to 485 Ma)

The Cambrian period started with an increasingly warmer climate on the planet, which led to a rapid diversification of complex multi-cellular organisms, a phenomenon known as the **Cambrian Explosion**. The main groups of invertebrates appeared: sponges, solitary corals, jellyfish, anemones, worms, sea urchins and molluscs. Organisms that are extinct today, such as archaeocyathids, graptolites and trilobites, were widespread. The breakup of Pannotia began. The largest part, the continent Gondwana, was located in the south and three smaller continents, Laurasia, Siberia and Baltica, moved northward. The Panthalassa Ocean covered most of the planet.

The record of this period is very well represented in the Geopark, in the detrital and limestone sediments of the Benalija Unit. During the Lower Cambrian period, the region was a coast whose seabed was, for large periods, shallow and highly oxygenated, with sludge deposit of calcareous algae and archaeocyathids colony growth. The archaeocyathids - organisms exclusive of the Cambrian period - were small animals, of several centimetres and of cone or conical cylinder shape that would subsequently evolve into the current corals and sponges. Along with the stromatolites, they are responsible for the formation of the reefs that were the origins of the massive limestones of the Capas de Campoallá, an excellent example of this type of formation.

[78] Fossil of archaeocyathids (Cerro del Hierro)



[79] Morphological scheme of archaeocyatids

The region came to the surface for some time, so that on the exposed limestones a karstification process began, in a tropical climate. This is the case of Cerro del Hierro and other places in the Geopark, which when produced in ancient geological periods is called a paleokarst, even though it has continued developing up to the present day.

Later, the sea platform acquired a greater depth, which led to the arrival of sediments of a smaller size, transported mostly by the sea currents. This is how fine levels of silts and clays were deposited, although there were sometimes contributions from the closest body of land in the form of sand. In these soils, we can find a fossil register of trilobites, which are arthropods that are now extinct, with flat and smooth bodies, roughly oval-shaped, divided into three parts, and protected by an exoskeleton of calcium carbonate, which facilitated its fossilisation. They are frequent in the slates of the Capas de Benalija.

[80] Trilobites in Capas de Benalija Formation

[81] Jellyfish imprints

However, there is no doubt that the most interesting Cambrian fossils of the Geopark - because of their scientific value - are the fossil imprints of jellyfish that exist on the detrital banks of the Lower Cambrian period, accumulated in a very shallow seabed of 540 Ma age.

Fig.60 World map containing the distribution of continents and oceans in the Cambrian period

Fig.61 Seabed of the Cambrian period

Ordovician period
(485 to 443 Ma)

In the Ordovician period, a new explosion of life forms happened, again exclusively aquatic. However, it finished with a great extinction event which marked the beginning of the Silurian period, in which approximately 60% of species extinguish.

The split continental fragments of Gondwana continued their movement towards the northern hemisphere through the Panthalassa Ocean. The Cambrian organisms were progressively replaced by new life forms. The first bryozoans and coral reefs appeared (the first solitary corals date back to the Cambrian period), molluscs diversified, especially bivalves, gastropods and cephalopods. The graptolites prospered, and some classes of echinoderms, such as cystoids and crinoids, appeared. At the end of the period, the first fish with jaws appeared.

Regarding the Geopark, the Ordivician period can be found represented by the dark grey and green slates and quartzites of Del Valle Unit, east of El Pintado Reservoir, and Cerrón del Hornillo, south of Constantina. They correspond to a shallow marine basin deposit and they contain graptolites, extinct animals that lived forming colonies. Their name derives from the Greek *graptos*, meaning written, and *lithos*, meaning stone, since their remains resemble inscriptions in the rock. They are used as a fossil guide, that is to say, their presence precisely indicates the Ordovician and/or the Silurian age, and also indicates the depth of water and the temperature of its deposit environment.

[82] Graptolites from Cerrón del Hornillo

Fig.62 Wold map containing the distribution of continents and oceans in the Ordovician period

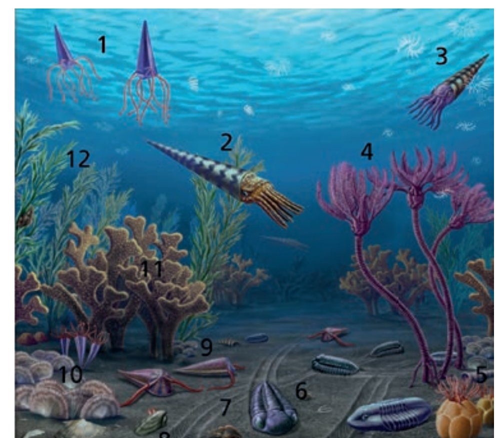


Fig.63 Seabed of the Ordovician period

1. Conulariida	7. Gasteropods
2. Orthocerida	8. Redonia
3. Grapholita	9. Hyolites
4. Crinoids	10. Brachiopods
5. Diploportas	11. Bryozoa
6. Trilobites	12. Algae

Silurian period
(443 to 419 Ma)

During this period, sea levels rose, giving rise to a marine transgression: the sea overtook continental terrain, moving the previous coastline inland. Following the massive extinction at the end of the Ordovician period, in the Silurian period, fish achieved considerable diversification, along with other groups such as the brachiopods, bryozoans, molluscs and trilobites. The terrestrial ecosystems included the first land animals, ancestors of modern spiders and myriapods, and the first vascular plants appeared.

In the Geopark, the register of the Silurian age is a continuation of the one from the Ordovician period, represented in the slates with graptolites and limestone insertion that outcrops in the syncline of the Del Valle Unit and in the Cerrón del Hornillo.

Fig.64 World map containing the distribution of continents and oceans in the Silurian period


Fig.65 Seabed of the Silurian period

Devonian period
(419 to 359 Ma)

The paleogeography of this period is formed by the Gondwana supercontinent to the south, the Siberia continent to the north, and the formation of the Euramerica continent in the middle. The Devonian was a period of great tectonic activity, with Laurasia (the union of Euramerica and Siberia) and Gondwana nearing each other.

In this period, the first widespread expansion of life on land took place, including the diversification of vascular plants. In the oceans, a diversification and expansion of fish, benthic algae, sponges and reefs took place. The brachiopods achieved their moment of great success. The diversification of fish and molluscs continued, and the first ammonoids appeared, commonly known as ammonites, organisms related to the current octopuses, cuttlefish and squid. Trilobites began to decline, but still appeared in new forms, including some of larger size.

The end of the period was marked by a massive extinction crisis that affected marine life more than continental life. The corals that had dominated the period reduced considerably in size and coral reefs did not become important again until the Triassic period. Many marine taxa suffered a great reduction in their diversity; groups like the graptolites disappeared.

The Devonian materials in the Geopark can be found especially in the South Portuguese Zone, south of the Almadén de la Plata. However, there are also some Devonian outcroppings in Sinclinal Del Valle, and, in various places, outcrops limestone conglomerates of this period, reflecting tectonic activity.

Fig.66 World map containing the distribution of continents and oceans in the Devonian period


Fig.67 Seabed of the Devonian period

The Carboniferous period
(359 to 298 Ma)

The Carboniferous period was an age of great orogenic activity, as the lands that would form the supercontinent Pangea were gathered: Gondwana collided with Laurasia and this collision resulted in the Variscan orogen in Europe.

In the Carboniferous oceans, the most important groups of invertebrates were the foraminifera, corals, bryozoans, brachiopods and echinoderms. Regarding molluscs, the bivalves and gastropods were abundant, but cephalopods were dominant, especially the goniatites from the Devonian period until their extinction in the Permian period. Trilobites were less frequent, and already in great decline, while fish diversified.

On land, plants of the Lower Carboniferous period were very similar to those of the end of the Devonian period, but they proliferate massively - especially ferns - and new groups were created. Amphibians were diverse and common in the middle of the Carboniferous period, being the first reptiles of this time.

In the Sierra Morena region, towards the end of the Carboniferous period, the new Variscan mountain range reached its maximum height. From this moment, the emerged mountains were subjected to erosion processes that largely determined their current smooth orography. On the deformed Variscan basement, small, intermountain continental basins would open. Through the end of the Permian period and beginning of the Triassic period, these basins were filled with lake and river sediments from the erosion of surrounding reliefs, with abundant volcanic deposits and contributions of organic material, which would transform into carbon, and many remains of fossil flora. These records are observable in the Viar Basin, Alanís-San Nicolás del Puerto and the surroundings of El Retortillo Reservoir.

Fig.68 World map containing the distribution of continents and oceans in the Carboniferous period


Fig.69 Earth life in the Carboniferous period

Permian period
(298 to 251 Ma)

At the beginning of the Permian period, with the continents still united as Pangea, the flora from the Carboniferous period was still dominant. However, in the middle of this period, there was a transition in vegetation, where conifers and the first angiosperms began to dominate (plants with "packaged seeds", that is to say seeds enclosed in the fruit). The great land herbivores and carnivores appeared, as well as Archosaur reptiles, giving rise to dinosaurs in the Mesozoic era.

At the end of the Permian period, the largest mass extinction of animal life on Earth took place, which would end more than 96% of marine species and 70% of life on earth, including the biggest insects that have lived on earth. Many theories have tried to explain the cause of this extinction, including an asteroid impact, massive volcanic eruptions, the explosion of a nearby supernova, the release of enormous amounts of greenhouse gases trapped in the seabeds in the form of methane hydrates, or a combination of factors that converged at the time.

In the Geopark, Permian sediments are located in the Alanís-San Nicolás del Puerto Basin and in the Viar Basin. Both basins are filled with conglomerates, sandstones and shales with smaller interspersing of limestones and small layers of coal, as well as volcanic rocks (basalts and pyroclasts).

Fig.70 World map containing the distribution of continents and oceans in the Permian period

The sediments contain abundant fossil flora. In the Viar Basin, there exists a large forest mass, with Araucaria's forests, giant trees of more than 30 metres in height, that were violently buried by a series of volcanic eruptions. The ash emitted by the volcanos buried some of these magnificent trees and with time, the wood was transformed into silica causing fossilised trunks. In the Cortijo El Berrocal Visitors Centre, in Almadén de la Plata, you can visit a spectacular fossilised trunk of this trees discovered in 2005.

[83] Reconstruction of a volcanic eruption in the Permian period

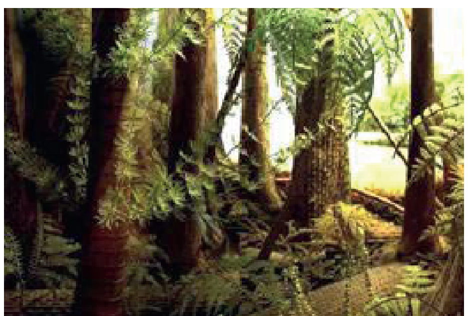


Fig.71 Reconstruction of an Araucarias forest in Permian period

[84] Fossilised trunk exposed in the Visitor's Centre of Cortijo de El Berrocal, before being transferred

[85] Fossilised trunk (calamites) in life position (Viar Basin)

Mesozoic era

(251 to 66 Ma)

The Mesozoic era (formed of the Triassic, Jurassic and Cretaceous periods) was a time of great tectonic, climatic and evolutionary changes. In this era, the break-up of the supercontinent Pangea and the beginning of the Alpine orogeny occurred, provoking the rise of the Betic Range in Andalusia and the sedimentary filling of the Guadalquivir Basin. At the end of the period, the continents had reached a form quite similar to the current one.

The extinction of almost all of the animal species at the end of Paleozoic era allowed the emergence of many types of life forms during the first part of the Mesozoic era. The extinction of the great herbivores and carnivores left spaces which would be occupied by the reptiles that had survived the extinction at the end of the Permian period, and that would evolve into the great dinosaurs. Animal life during the Mesozoic era was dominated, in this manner, by dinosaurs, mammals and birds. Angiosperm plants grew massively during the last Mesozoic period, the Cretaceous, during which they would compete with cycas and ferns for flora dominance.

However, no record of this era exists in the Geopark. During the Mesozoic era, the region was emerged and submitted to erosion processes, and because of this, no sedimentary record exists.

Fig.72 World map containing the distribution of continents and oceans in the Triassic period

Fig.73 World map containing the distribution of continents and oceans in the Jurassic period

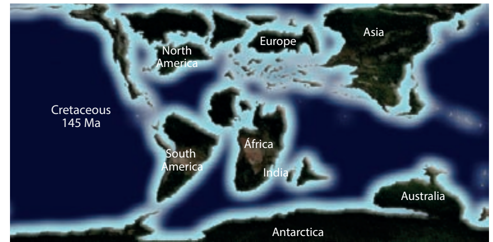


Fig.74 World map containing the distribution of continents and oceans in the Cretaceous period

Fig.75 Scene of life in the Mesozoic era

Cenozoic era

(66 Ma to date)

During the Cenozoic era, the continents reached their current positions, and after a terrible mass-extinction at the end of the Cretaceous period, which according to the most well-known hypothesis, was caused by the impact of a large meteorite on the face of the earth, a new great expansion of life took place. During its course, an immense variety of mammals grew from only a few lines coming from the Mesozoic era, giving way to all land and sea species that are familiar to us today, as well as some that are already extinct now. Birds also evolved during the Cenozoic era, being the dominant species in certain regions of Earth during some periods. The bushy savannahs were the most widespread vegetal formation during prolonged periods of time of this period, in many areas of the planet.

The Betic Range continued to rise to the south of the emerged Variscan Massif, and the Guadalquivir Sedimentary Basin would be filled with the sediments resulting from erosion of the massif and the Betic Range.

To the east of the Huéznar Reservoir, south of Constantina, a reduced extension of sedimentary rocks from the units of the Guadalquivir Basin appeared, proving that its coastline reached this point around 7 Ma. They correspond to levels of limestones, very rich in fossil record, and white and yellowish clays. Marine fossils of bivalves, brachiopods, barnacles, gastropods, Scaphopoda, corals and sea urchins are relatively frequent.

Fig.76 World map containing the distribution of continents and oceans in the Pliocene epoch

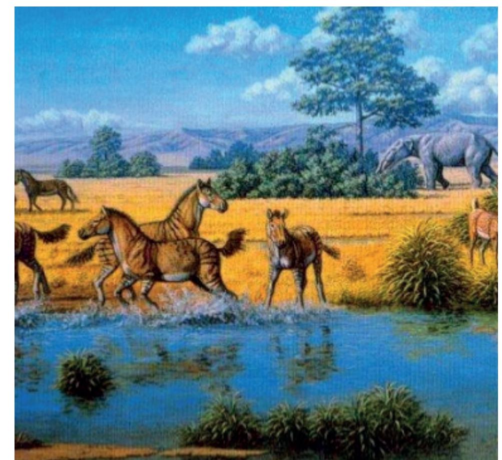


Fig.77 Scene of life in the Cenozoic era

[86] Limestone with several fossil remains

GEOLOGICAL LANDSCAPES

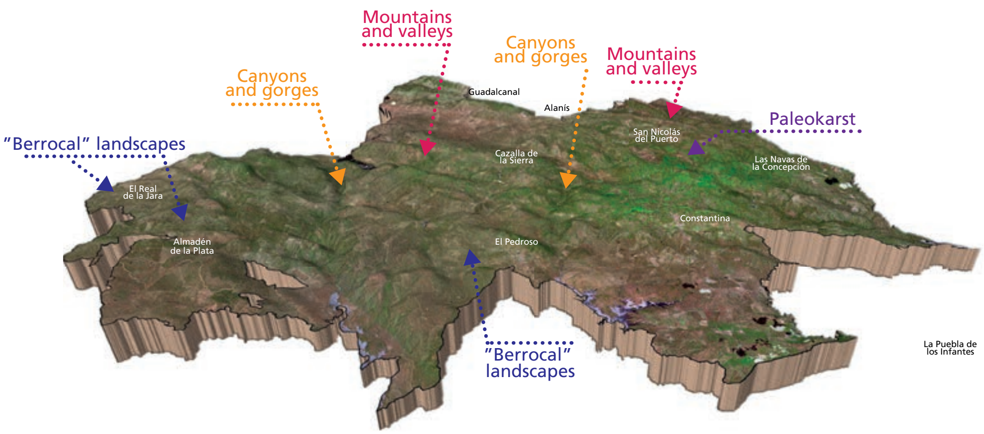


Fig.78 Geological landscapes of Sierra Norte de Sevilla Geopark

ROCKY AREAS

The granite landscapes commonly known in Spanish language as "berrocal" (granitic rocky areas), are the result of the physical and chemical weathering and the erosion of granite rocks and diorites, plutonic rocks of acid or intermediate composition.

For weathering process - that is to say, the breaking off, fragmentation and polishing of the rock - and erosion - which is the cleaning and transportation of this weathered material - plutonic rocks must be at an area closer to the surface by the dissipation of the material that has covered them, since they were formed several kilometres underground.

The cutting of the overlying materials makes the rocks decompress, and as a result, they tend to extend themselves, causing non-displaced fractures (joints) both horizontal and vertical, to which fault fractures can be added. These fractures favour the chemical decomposition of the minerals that form the rocks, due to the action of the water that infiltrates in them. This action is greater in the vertical tracks, since there is a mayor surface in contact with water, which is why the corners suffer a higher wearing away and their characteristic rounded shapes are produced.

This continuous action and the subsequent surface erosion gave rise to the elements that make up the "berrocal" granitic landscapes.

*See figure 19 in page 35

[87] Crevices in granitic rocks

Depending on the level of weathering of the terrain, these elements are classified into larger and smaller forms. In the Geopark, the larger forms present are domes, flat stones, stone balls areas, stone beds and sand valleys. The smaller ones present include knight stones, tors (rock columns) and ball rocks.

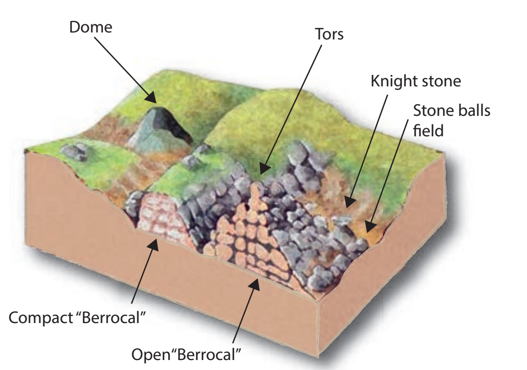


Fig.79 Elements of a granitic rocky area

Domes: relief forms with a characteristic dome shape, both symmetrical and asymmetrical. They are formed by the curved fracture of the granitic rock that, due to the freezing of water that penetrates into the fissures, exerts a wedge pressure that breaks the rock. This explains why they usually have an accumulation of blocks or slabs at their base.

Ball rocks: rounded rocks produced by a widespread alteration of the area of medium intensity, following an orthogonal frame of joints, both vertical and horizontal, and by a subsequent evacuation of the altered materials.

Knight stones: rocks stacked in apparent instability on top of other.

Tor or column of rock: piles or towers of overlapping blocks that may have been generated by the weathering of rocks of greater resistance than those around them.

Stone field: groups of ball rocks and blocks in a chaotic manner.

Sand valleys: granite is scattered through sandy deposits on the fresh rock or in valleys with a low slope.

In the Geopark, berrocal areas can be found, mainly in the western half, in the municipalities of El Real de la Jara, Almadén de la Plata, Cazalla de la Sierra and Constantina. Those from Upper Carboniferous granitic rocks are embedded into rocks from the Upper Paleozoic era; and those from the Cambrian-Ordovician granitic rocks into rocks from the Pre-Cambrian era, both in the Ossa-Morena and South Portuguese Zones. Despite being all granitic formations, they have different morphologies due to their composition and evolution degree.

[88] Tor or column (Rocky Area of Almadén de la Plata)

[89] Knight rock (Rocky Area of Almadén de la Plata)

[90] Knight rock (Rocky Area of El Pedroso)

[91] Dispersed boulders (Rocky Area of El Pedroso)

[92] Cairn of boulders (Rocky Area of El Pedroso)

Fig.80 Stages in "berrocal" formation

[93] Panoramic view in the Rocky Area of Almadén de la Plata.

KARST

The karst landscape or more simply, a karst, takes its name from the Slovenian region Carso in the German language. It originates from the chemical weathering of certain rocks, such as carbonates (limestones, dolostones, marbles), salts and gypsum. In the Geopark, this weathering takes place in the limestones and marbles which are extended to a greater or lesser areas throughout all municipalities.

The Geopark's carbonates - which are more resistant to physical weathering - gave rise to many of the higher hills, for example: Montón de Trigo Hill (650 m. El Real de la Jara), Los Castillejos Hill (397 m. Almadén de la Plata), Sierra de Santiago (615 m. Cazalla de la Sierra), Sierra del Pedroso (666 m. El Pedroso), Gibarrayo Hill (740 m. Constantina), Sierra del Viento (959 m. Guadalcanal), San Pedro Hills (709 m. Alanís), Martín Álvarez Hill (546 m. Las Navas de la Concepción), Sierra del Caballo (546 m. Las Navas de la Concepción), Las Beatas (524 m. La Puebla de los Infantes).

The shape of the karst landscape is related to the pressure of carbon dioxide, because the solubility of the carbonated rocks depends on it. This implies that if environmental conditions change, a karst can be created or destroyed.

Carbon dioxide (CO_2) present in the atmosphere is dissolved in rainwater or snow (H_2O) forming a weak carbonic acid (H_2CO_3). This acid reaches the soil and comes into contact with the limestone rock (calcium carbonate: $CaCO_3$, or magnesium carbonate: $MgCO_3$), provoking a chemical reaction in which bicarbonate is formed ($CaHCO_3$), that will be dragged with water, since it is soluble. If the rock has fractures, which is common, this acid will get infiltrated through them, increasing the dissolving surfaces.

Dissolution of the limestone will be faster or slower depending on atmospheric, climatic and temporal factors, which will vary the concentrations of dissolved CO_2. Thus, this increases with pressure and low temperatures, with the existence of living beings that emit CO_2 and if the contact of the rock with water is prolonged over time.

This dissolution produces another process that is precipitation, and normally dragging and sedimentation of clays, not soluble in water, that are included among limestone rocks. They take part of the karst landscape and are called decalcification clays or "terrarossa". They are responsible for the reddish colours of the soils that accompany the karsts.

Conditions may also occur for water with dissolved bicarbonate ($CaHCO_3$) to precipitate the excess of calcium carbonate (CaCO3), resulting in chemical limestone precipitation forms.

Two types of forms can be differentiated in the karst landscape, exokarst and endokarst, depending on if they are formed on the landscape or inside the karst. In the Geopark, the easiest forms to identify are the following:

Exokarst forms

Lapiaz or karrens: they are grooves or cavities separated by more or less acute partitions. Grooves are created by runoff waters in slopes or on flat surfaces with fissures.

Dolines or sinkholes: they are depressions formed in places where water infiltrates or stagnates. They can take many diverse forms and unite with others nearby to form uvalas.

Poljes: they are long depressions of horizontal background embedded within steep slopes. They are totally or partially covered by streams of water, which suddenly disappear through sinks or wells to continue circulating underground.

Alleys and corridors: dissolution structures on fracture lines, similar to small vertical-walled valleys.

Pinnacles, needles and hillocks: pyramidal, conical or cylindrical reliefs of residual nature.

Endokarst forms

Caves and galleries: they are formed when water is dissolved or infiltrated into the limestone rocks from the subsoil. Stalactites are usually formed from the water, rich in calcium carbonate, dripping from the roof, as well as stalagmites, from the calcium carbonate deposited in the soil.

Chasms: they are narrow openings that connect the surface with the underground galleries.

Apart from recent karst morphologies, in the Geopark can also find the Cerro del Hierro, the unique European karst that has a tropical karst morphology. Its process began during the Cambrian period after a first emersion process, a point that will be developed in route 2.


[94] Example of a current tropical karst: Stone Forest (Shilin Geopark), China

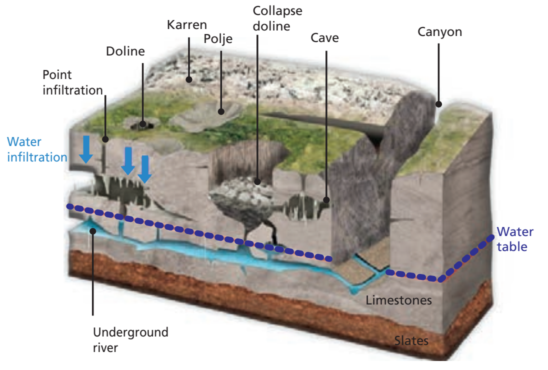
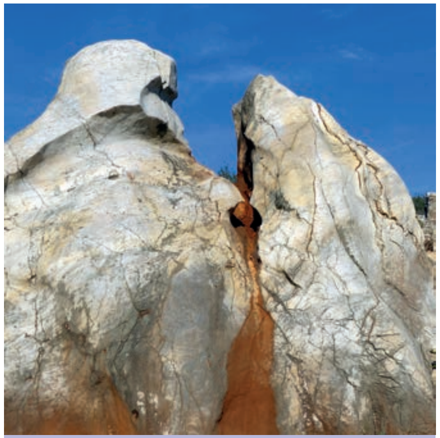


Fig.81 Karst morphologies


[95] Current karst morphology:
Los Lanchares in the Sierras Subbéticas Geopark


[98] Tropical karst morphology of Cerro del Hierro


[96] Tropical karst morphology of Cerro del Hierro

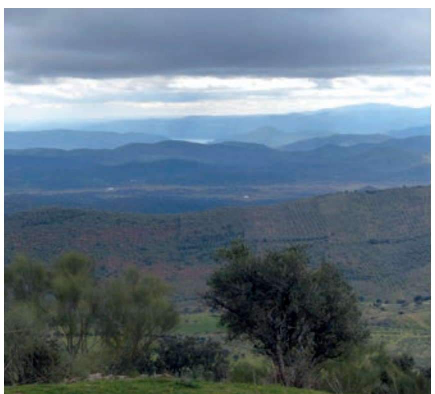

[99] Pinnacles in Cerro del Hierro


[97] Tropical karst morphology of Cerro del Hierro

MOUNTAIN RANGES AND VALLEYS

The geological origin of the Geopark's relief dates back to the elevation of the Variscan Massif (320 Ma), since the Alpine orogeny (60 Ma) only reshaped with low intensity its structure. This means that the predominant slaty materials, highly brittle, have been subjected to erosion for 320 million years, causing a significant wearing away of the original relief.

Those circumstances determine a relief of Appalachian characteristics, that it is composed by a succession of hills and small mountain ranges of soft shapes that align according to the predominant direction of folding. In the case of the Geopark, structures aligned in a northwest to southeast direction, with the rocks most resistant to erosion, mainly limestones or dolomites and some quartzites, giving rise to the highest part of the mountains and hills.



[100] View of the Geopark´s mountain ranges and valleys from La Capitana Hill

This generalized pattern is interrupted by areas of almost horizontal topography that may correspond with outcroppings of strongly eroded plutonic rocks or ample valleys covered by recent sediments; the Rivera de Benalija´s valley in Guadalcanal, the area of Los Prados, to the east of Cazalla de la Sierra, the region around the Huéznar Reservoir, the western area of the Batolito de El Pedroso, the Viar River Valley around the Melonares Reservoir, or several high plateaus to the south of Constantina.

The basic geomorphological characteristics of the relief are the low altitude, as it is the lowest of the Spanish mountain ranges. Its relief has an altitude between 959.2 metres of the peak La Capitana and approximately 100 metres of the lower riverbed of the Viar River, with an elevation range of around 859 metres.

This relief, together with the essential impermeable nature of the Geopark's rocks, cause that most of the rainwater to superficially circulate through the drainage net, which entirely flows into the Guadalquivir River, except in a few subterranean aquifers. From west to east, the main rivers are Rivera de Cala, Viar, Rivera del Huéznar, Onza and Retortillo. The superficial water resources are regulated in some rivers by the El Pintado Reservoir and Melonares in Viar River, and Huéznar and Retortillo in the rivers of the same name.

The main riverbeds cut the mountain alignments mainly from north to south. In some cases, this is due to the overcoming of old rivers with this orientation, and in other cases, due to the existence of large faults. Several beautiful cliffs or river gorges exist: the Viar Canyon, the Gargantafria Canyon, El Chorro gorge and the Riscos Blancos holes.

RELIEF OF SIERRA NORTE DE SEVILLA GEOPARK

Fig.82 Map relief in 3d

FORMATION OF A RIVER GORGE ON HARD ROCK

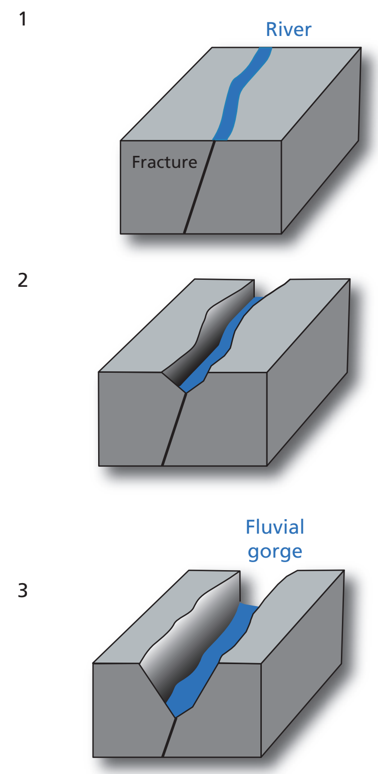
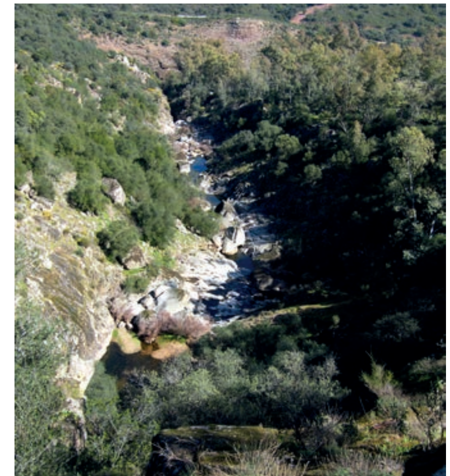
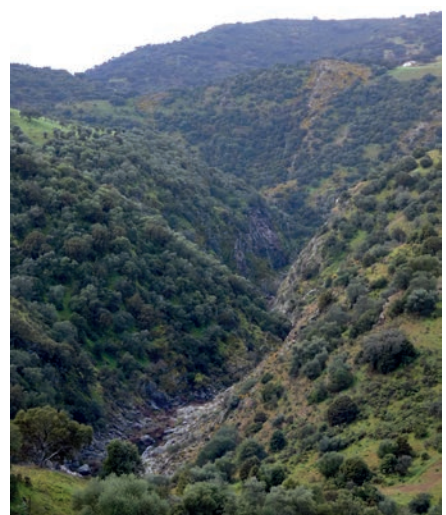


Fig.83 Scheme of formation of a river gorge

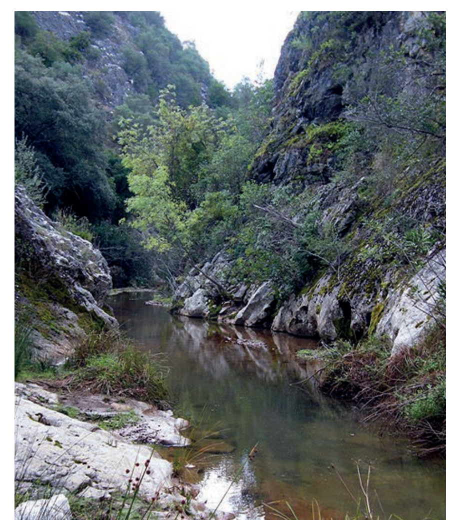


[102] Upper view of El Chorro gorge

[103] Waterfalls and holes in the Riscos Blancos Stream



[101] A sector of Viar Canyon



[104] Canyon of Gargantafría Stream

MINING

In the Sierra Norte de Sevilla Geopark, the mineral wealth has led to a continuous presence of different cultures that first exploited copper, then silver and later and most intensely, iron.

The use of geological resources dates back to the beginning of human occupation. Within the area, there exists evidence of prehistoric inhabitants, at least since the Neolithic (6,000 to 3,500 years before Christ, hereinafter B.C.), that took advantage of some of the lithic resources for the production of dolmens, instruments and stone tools; clays for the production of ceramic; and copper and ceramic objects found in the archaeological record of the La Sima Cave (Constantina) and Los Covachos Cave or in the Necropolis cists of La Traviesa (Almadén de la Plata), one of the biggest in the Bronze Age, between 2,250 and 1,000 years B.C.

The neighbouring city of Munigua or Mulva, an important archaeological site located 14 km at south of El Pedroso, has its origin over 4,000 years ago. It was a significant metallurgy centre, first with the Carthaginians and later with the Romans.

[105] Necropolis of La Traviesa

[106] Access to Los Covachos Cave

But it was with the latter, when two important development periods occurred, holding the title of *Municipium Flavium Muniguensis*. They go from the second half of the first century B.C. to the first half of the first century A.C., focused on the copper exploitation and metallurgy. The other period started at this date and stretched to the first half of the third century, during which the exploitation of copper was substituted by the iron. This is evidenced by the remains of this activity found in the surrounding areas of Munigua, as well as by the research conducted in the smelting slags, which show that the benefitted iron ore mainly came from the Navalázaro Mines (El Pedroso).

Also, during Roman times, Almadén de la Plata was one of the main marbles producing centres in Andalusia, with several quarries that sent the extracted pieces to the carving workshop in Italica. The use of these marbles in Roman monumental remains is well documented in Italica, Carmona, Alcalá del Río and North Africa.

[107] Part of the Roman city of Munigua

The conservation of archaeological remains in mining areas is often difficult, since later exploitations removed the evidence of previous activities. However, in the case of the Los Covachos quarry, the exploitation front was preserved after being buried under debris of subsequent exploitation. The preservation of Los Castillejos Hill is due to its abandonment in Roman times and no later exploitation.

[108] Los Covachos Roman quarry

[109] Roman block of marble in Los Covachos

[110] Roman blocks of marble in Los Castillejos Hill

Another mining exploitation can be found in the riverbed of Calzadilla (or Cezadilla) Stream in Almadén de la Plata and in a tributary, where several quarry fronts in conglomerates and thick sandstones can be found, focused on the extraction of stones from quern-stones and watermills, probably between the Upper Roman period and the Medieval period.

[111] Quarry fronts of hand mill´s rocks

In Medieval times, several examples of the continued exploitation of geological resources can be found in El Real de la Jara, in the marble limestones extracted in the quarries of the village that were used for its castle building, and the iron exploitation, mainly in Constantina and El Pedroso, encouraged by the demand for ship-building in Seville. This was an activity which increased during the 16th and 17th Centuries, due to the boom experienced by the port of Seville related to the West Indies Fleet.

In the 16th Century, Guadalcanal municipality experienced the silver rush. The accidental discovery of silver veins led to an economic and social upheaval all over the Sierra Norte of Seville. The initial richness of the Pozo Rico Mine would provoke its confiscation by the Crown, in what was the first formal nationalisation. The depletion of veins and the technological problems derived from the increasingly depth and more flooding labours, ended the dream. Although until the 20th Century, there were some attempts to resume its exploitation, without success.

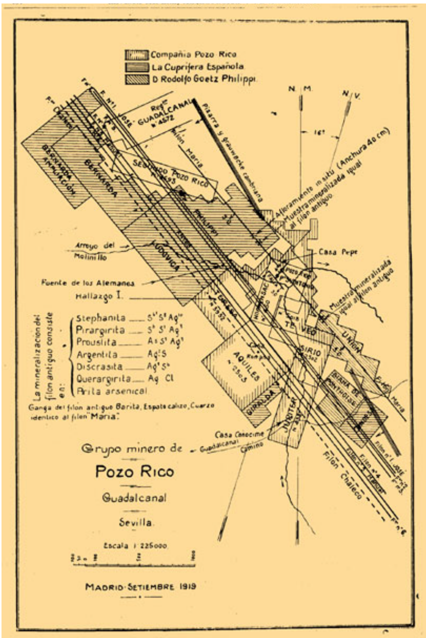
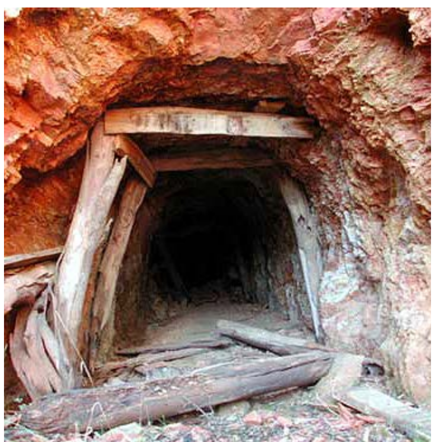


Fig. 84 Ancient plan of the Guadalcanal mines


[112] Gallery's entrance in Guadalcanal Mines

The most intense exploitation of the geological resources of this area, especially iron, took place during the 19th and 20th Centuries, coinciding with the Industrial Revolution. This allowed the progress in the extraction and transport techniques, where the arrival of the railroad to the large exploitations was crucial. Some examples of this period are Cerro del Hierro, where iron was exploited and later barite, and in the surroundings of El Pedroso, where an intense mining took place in order to supply the blast furnaces of the El Pedroso Foundry.

"…Oligist iron is found in Cerro del Hierro, near the village of San Nicolás. It is, in fact, as its name shows, a mountain of iron. At its peak, enormous house-sized blocks of a blackish colour form a crest. When you look closely at them, it is admirable that they are composed of the most beautiful oligist iron in a remarkable state of purity. When the mineral is mixed with other substances, it is a white and crystalline calcareous stone. Far from being inconvenient, it should ease the melting process. However, this mineral is not only found at the peak. Going around the mountain, it can be found everywhere throughout the land, in numerous blocks, and with a surprising purity. Cerro del Hierro is a wonder because of the quantity and beautiful quality of its mineral, providing a supply of all the iron needed to the biggest industry…"

Fragment of the geological report written by Ferdinand Röemer (University of Breslau, Germany), commissioned by the Company of Mines and Foundry of El Pedroso, and dated 12 November 1872. Extracted from CARVAJAL Y ACUÑA, Eduardo (1944). Hierros de Sevilla. In Criaderos de Hierro de España, volumen IV, Memorias del Instituto Geológico y Minero No. 46, pag. 302. Taken from IAPH.

For more than one century, El Pedroso was the focal point of mining activity in region. In is surrounding areas, there are several iron mines, together with the remains of an important 19th Century foundry that represent one of the frustrated attempts of industrialisation in Andalusia, making use of foreign capital during the 19th Century. The abundance of iron mineralisation in the surroundings, the existence of relatively close coal mines in Villanueva del Río and Minas, as well as the possibility of using the hydraulic energy of the Rivera del Huéznar and San Pedro Stream, led to the building of an iron foundry in the mid-19th Century, which definitively closed at the beginning of the 20th Century after several transformations.


[113] Part of the ruins of El Pedroso Foundry

In Cerro del Hierro, the last active iron mine, the extraction during the 19th Century was executed on a small-scale, by transporting the mineral through cavalries. In 1893, the mines were leased and in 1895 they were finally sold to Baird Mining & Co, a Scottish company that began the industrial exploitation and undertook the building of a 15 km railway that connected this area to the Seville-Mérida railway line, allowing the mineral to reach the harbour of Seville. This company built the village of workers, engineering houses, a church, workshops or other facilities, incorporating British aesthetics into the landscape of the region.

In 1946, it was taken over by Nueva Montaña Quijano until 1966, and later transferred to a new company, Cerro del Hierro S.A., which took advantage of the mine between 1972 and 1977. In the 1980s, the mine was a cooperative owned by the workers, who, on a limited level, extracted the existing barite in the mineral deposit. Finally, the mines closed due to the low profitability of the sector.


[114] Current panoramic view of a section of the Cerro del Hierro


[115] Ancient gallerie in Cerro del Hierro

There are some other ancient mines in the Geopark. The Herrerías de San Carlos Mine is located between Almadén de la Plata and El Real de La Jara. In the west of Guadalcanal village can be found the remains of the Herrerías Mine, an iron mineralisation similar to Cerro del Hierro, that was taken advantage of during the first half of the 20th Century. To the west of El Pintado Reservoir, there is the ancient lead, zinc and silver Mine of San Luis, which was intermittently exploited from the end of the 19th Century until the 1980s.


[116] Herrerías mine (Guadalcanal)

The underground copper mines can be found in the surroundings of Almadén de la Plata and near Alanís: the Cerezo Stream Mines - a combination of small copper mines, also known as Discusión Mine.


[117] Industrial holdings of the Cerezo Stream Mine


[118] Aerial view of Cerro del Hierro during the 1950s

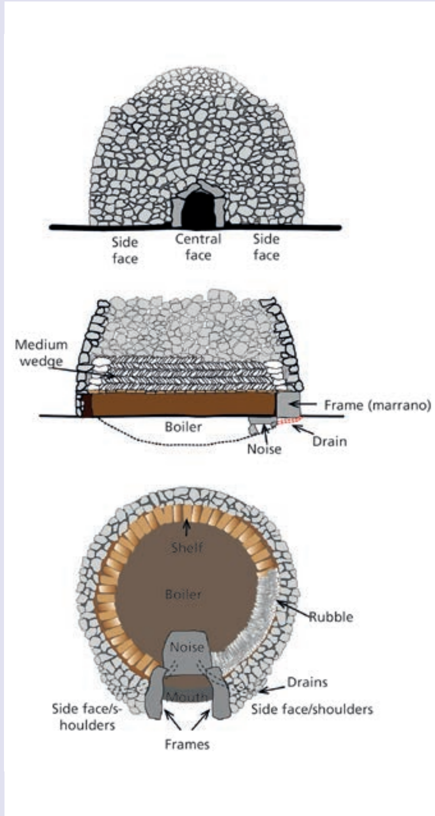
THE LIMEKILNS

In several municipalities where there are limestones and marbles these materials have been exploited to manufacture lime in a traditional way. This is a semi-industrial activity that is closely related to the traditional whitewash architecture of Andalusia. Remainders of several lime kilns and quarries involved in this activity are still preserved in the Geopark.

Lime kilns were ovens where carbonate rocks were calcined to obtain lime. Lime is a term for all physical forms in which calcium oxide [CaO] or calcium magnesium oxide [$CaMgO_2$] are present.

Lime is obtained by calcining limestone rocks or marbles (calcium carbonate $CaCO_3$) or dolomite rocks (calcium and magnesium carbonate [$caMg(Co_3)_2$]) at an approximate temperature of 900°C by the following chemical reaction: $CaCO_3$ + heat ---> CaO + CO_2. Industrial calcination is performed in vertical or horizontal rotary ovens. Ancient methods used a handcrafted vertical oven, generally built of dry stone.

Every village in Sierra Norte de Sevilla always has had a limestone quarry as well as a family that was specialised in this work. These people have been traditionally known as "caleros", due to their knowledge was passed from father to son as a way of life.



[119] Limekiln diagram with the denomination of its parts

[120] Remainders of one of the limekilns in Cerro del Hierro

[121] Informative panel about the limekiln of Cerro del Hierro

More recently, minerals and industrial rocks have been exploited in small mines within the Geopark. Currently, the only active mines in the Geopark are El Realejo Mines, to the west of Cazalla de la Sierra, where several aplite holes are exploited to extract sodium feldspar (albite) destined to the manufacture of sanitary ceramics and a limestone quarry in the hill of Hamapega, in Guadalcanal.

WATER

SURFACE WATERS

From a hydrographic point of view, the Geopark's territory is integrated into the Guadalquivir Basin. The hydrographic network is composed of many water flows; some of them give rise to wide valleys, although some have narrow morphologies of canyons and gorges.

From the point of view of rainfall collected, the Natural Park is the most important place in the province of Seville. This fact gives this place a strategic role in terms of the production of the water resource.

The average annual rainfall in the Geopark is 730 mm, although there are differences between some areas of this territory. The pattern of rainfall is characterised as being irregular, both annually and inter-annually, with extended periods of drought that determine its natural vegetation.

The main river sub basins correspond, from west to east and from north to south, to the following riverbeds: Rivera de Cala, Viar River and its tributary Rivera de Benalija, Rivera del Huéznar, Onza River (tributary of Bembezar River), El Retortillo River and its tributary Rivera de Ciudadeja, and the Guadalbacar River. In the Geopark's south-eastern sector, we can find the riverbeds of other Guadalquivir's minor tributaries: Galapagar and Algarín streams. The water regime of these rivers is typical of the Mediterranean region, marked by strong inter-annual flow oscillations, as a result of the irregular rainfall and an annual regime with a very pronounced summer minimum and winter maximum.

These rivers are regulated by several reservoirs whose main uses are the supply of good quality drinking water, irrigation and hydroelectric energy. The four most important are El Pintado and Melonares, on the Viar River, and those of Huéznar and Retortillo, on the rivers of the same name.

HYDROGRAPHIC BASINS AND DRAINAGE NETWORK

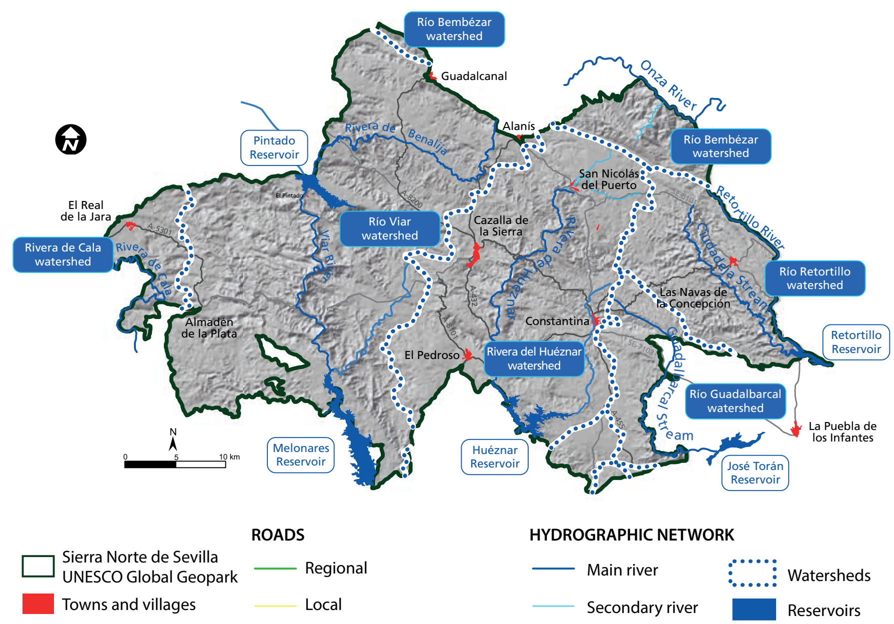


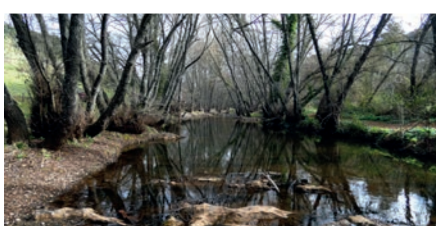
Fig.85 Hydrographic basins and drainage network

[122] Onza River (with a low water level)

[123] Rivera del Huéznar Waterfalls (rapids)

[124] El Pintado Reservoir

[125] Retortillo Reservoir



[126] Rivera del Ciudadeja

[127] El Chorro, in Calzadilla Stream (fluvial gorge)

GROUNDWATER

Most of the Geopark's rocks are very old rocks that either lost their primary porosity during the diagenesis and metamorphism processes, or they already presented a very low porosity in their own formation, as happened with the plutonic rocks. However, the subsequent fracturing and weathering, and karstification in limestones and marbles, led to an increase in their permeability, as the water can circulate and be stored inside them. That is why there are notable hydrogeological differences not only among the different types of rocks but also depending on the fracturing intensity, the level and depth than weathering reach in certain rocks, as well as on the thickness and disposition of the permeable materials themselves.

The calcareous formations, limestone, dolomite and marble, create the most important aquifers in the Geopark. This is due to the fact that these rocks have a medium to high permeability because of the intense fracturing and the holes resulting from karstification. This results in a karstic aquifer, which with an impermeable base, has a channels net inside their rocks leading the underground water storage and circulation from the aquifer surface to its discharge points. This is of great importance during dry seasons, since it provides water both to animals and plants.

In the Geopark, the main calcareous formations are the Precambrian marbles of Sierra del Viento, in Guadalcanal, those of possible Cambrian age in the proximities of Almadén de la Plata, together with the limestones from Lower Cambrian period in the Benalija Unit, in the central and eastern area of the Geopark. These limestones, more or less marbled, are part of the Capas de Campoallá Formation, composed of slates, sandstones and/or limestones. When packages of limestones with sufficient thickness and extension emerge, they give rise to karstic aquifers. On other occasions, however, the interspersing of different slate levels reduces permeability to the rocks set.

The three major subterranean aquifers placed within the Geopark, of mainly calcareous nature, are:

- Aquifer of Guadalcanal-San Nicolás
- Aquifer of Constantina-Cazalla
- Aquifer of Almadén de la Plata

AQUIFER OF GUADALCANAL–SAN NICOLÁS

The aquifer of Guadalcanal-San Nicolás, with a surface of 160 km^2 of permeable outcrops, has an elongated shape in a northwest to southeast direction, with a length of 35 km and an average width of about 4 km, and it is composed of more or less massive limestones from the Lower Cambrian period (Capas de Campoallá Formation). Its boundaries, of tectonic nature, are composed of slates, phyllites and meta vulcanites to the north, and of slates from Lower Cambrian period to the south. The impermeable substratum of the aquifer is a Lower Cambrian thickness slate formation.

The main discharge springs of the aquifer are EL Borbollón, the source of the Rivera del Huéznar in San Nicolás del Puerto and those of the Rivera del Benalija, whose source is found to the north-west of Alanís.

HYDROGEOLOGICAL MAP

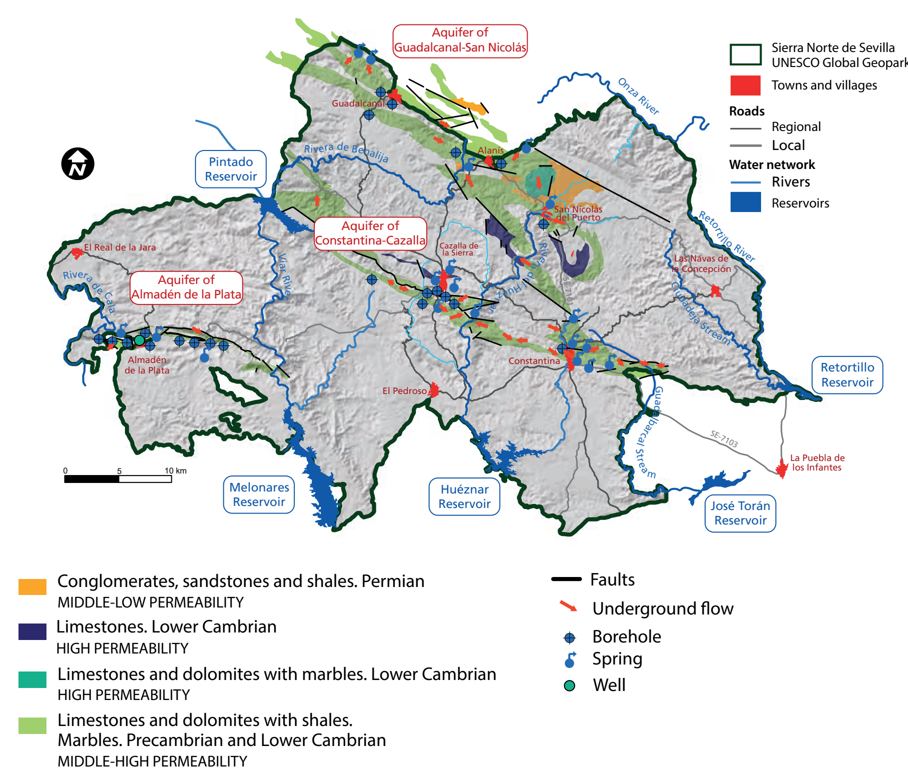
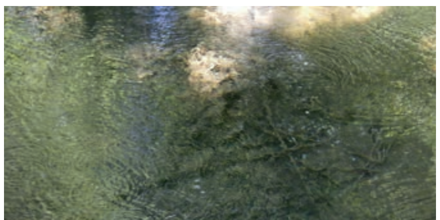


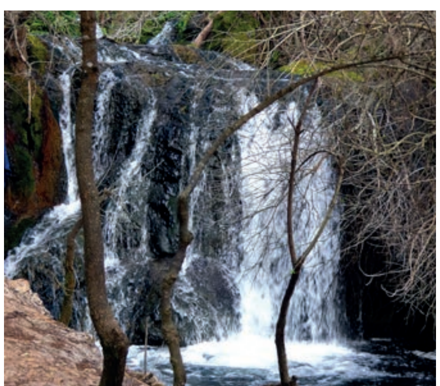
Fig.86 Hydrogeological map of Sierra Norte de Sevilla UNESCO Global Geopark


[128] Refill area in Cerro del Hierro


[129] El Borbollón, Rivera del Huéznar Spring


[130] Bubbles of carbonic anhydride in the spring of Huéznar


[131] Huéznar Waterfalls


[132] Huéznar Waterfalls

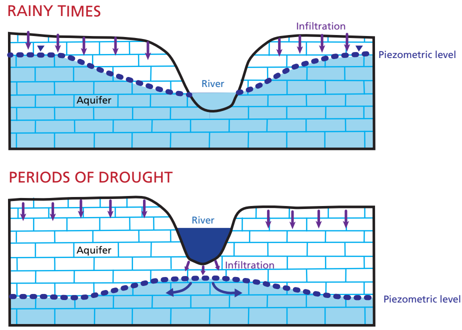


Fig.87 Scheme of river-aquifer recharge in dry season and wet season

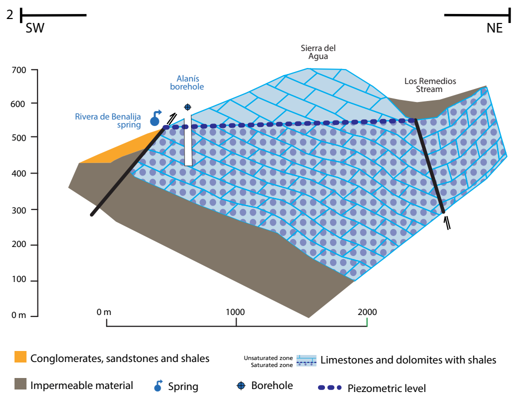


Fig.88 Hydrogeological cross-section 2-2´

INFLOWS (hm³/year)	
Rainfall	15 hm³/year
OUTFLOWS (hm³/year)	
Pumpings	3 hm³/year
Surface water outflows	12 hm³/year

Fig.89 Water balance of the aquifer of Guadalcanal – San Nicolás

The riverbeds of Rivera del Huéznar and Rivera de Benalija go through Cambrian limestone outcrops, resulting in a hydraulic connection between the river and the aquifer, which varies according to the relative position of the piezometric level and the river sheet of water. In times of high rainfall, the piezometric level is at highest absolute level compared to the superficial riverbed's sheet of water, so the aquifer provide water to the river. Conversely, in dry seasons, the piezometric level is at lowest level compared to the riverbed's sheet of water, so the aquifer receives the river's water by infiltration, which results in a loss.

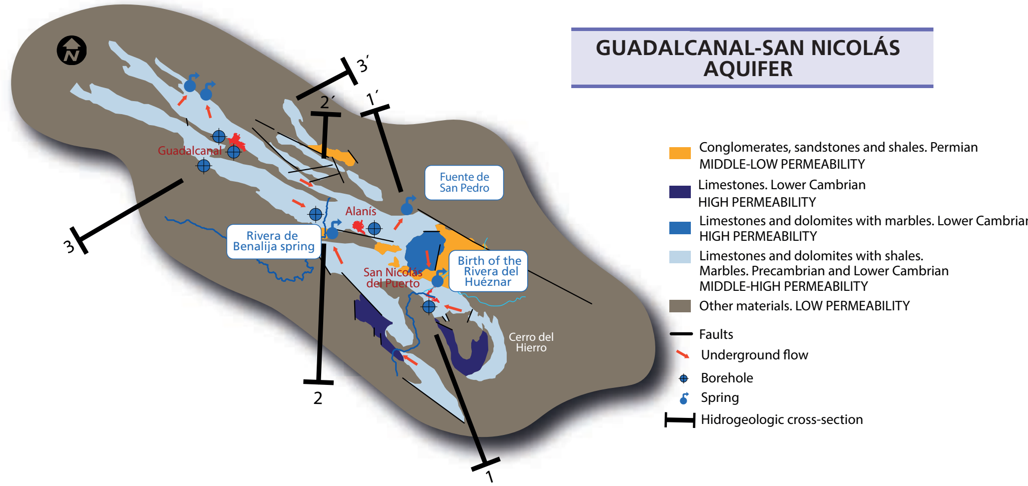


Fig.90 Guadalcanal-San Nicolás aquifer

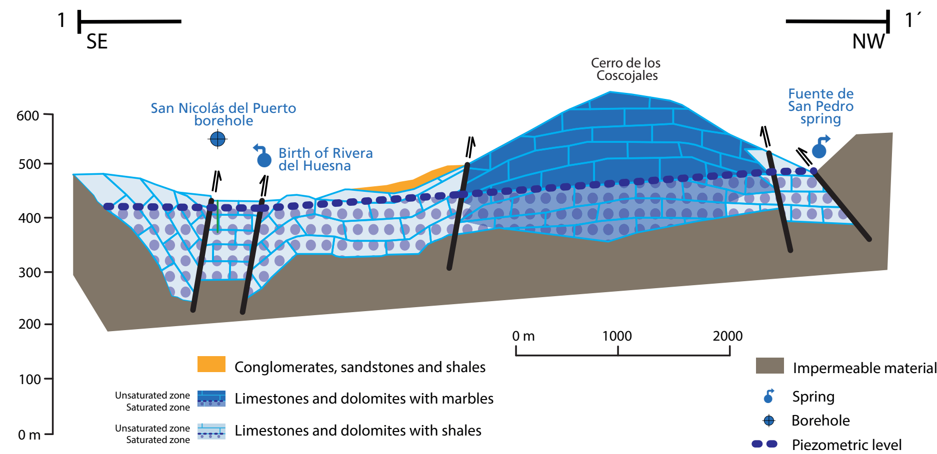


Fig.91 Hydrogeological cross-section 1-1´

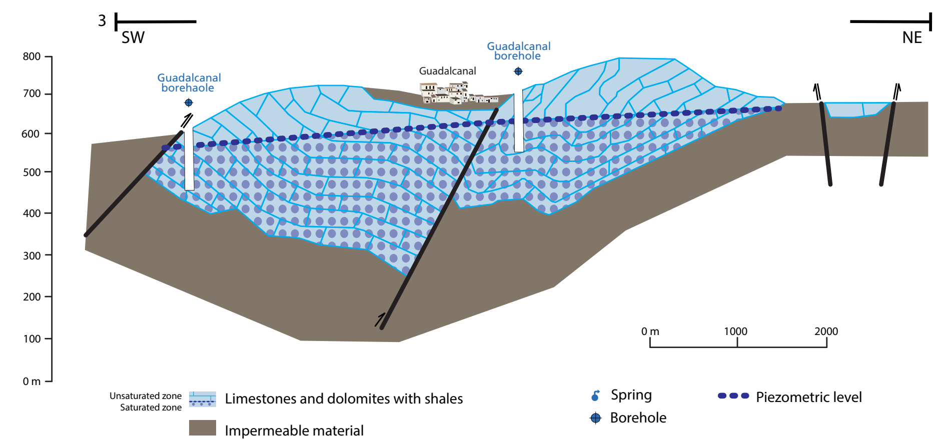


Fig.92 Hydrogeological cross-section 3-3´

AQUIFER OF CONSTANTINA – CAZALLA

The permeable materials that composed this aquifer are mainly limestones and dolomites with interspersed slates, and to a lesser degree, marbles, belonging to the detrital-carbonate sedimentary unit known as Capas de Campoallá. Its age is Lower Cambrian period and the permeable formations have thickness between 50 and 200 m. The refilling is almost exclusively produced by rainwater infiltration that directly falls on the permeable outcrops. One source of a certain flow with practically permanent character is San Francisco Spring, in Constantina, whose water is used to supply this village.

INFLOWS (hm^3/year)	
Rainfall	4 hm^3/year
OUTFLOWS (hm^3/year)	
Pumpings	1,2 hm^3/year
Surface water outflows	2,8 hm^3/year

Fig.93 Water balance of the aquifer of Constantina - Cazalla

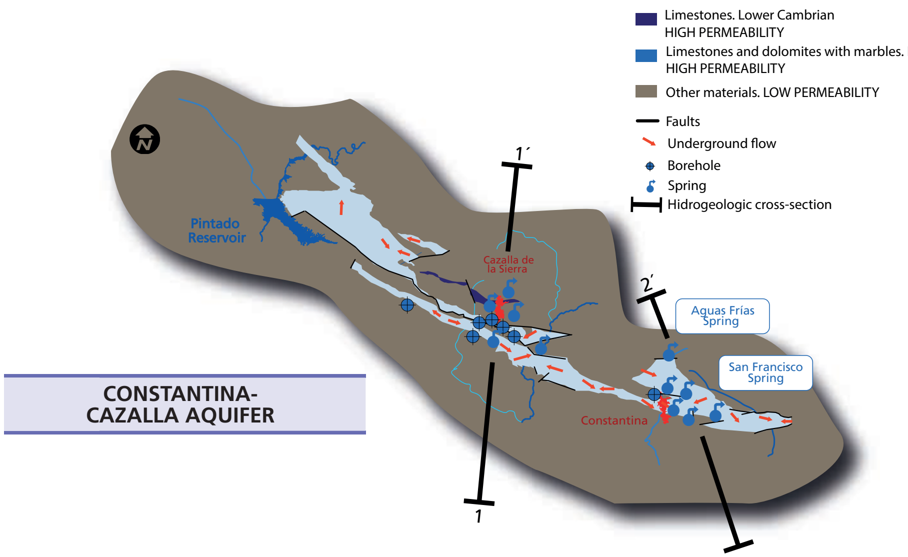


Fig.94 Constantina-Cazalla aquifer

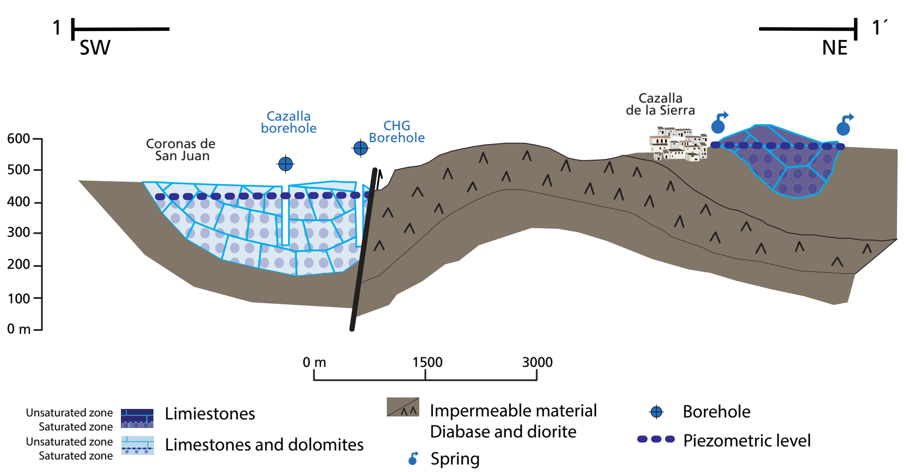


Fig.95 Hydrogeological cross-section 1-1´

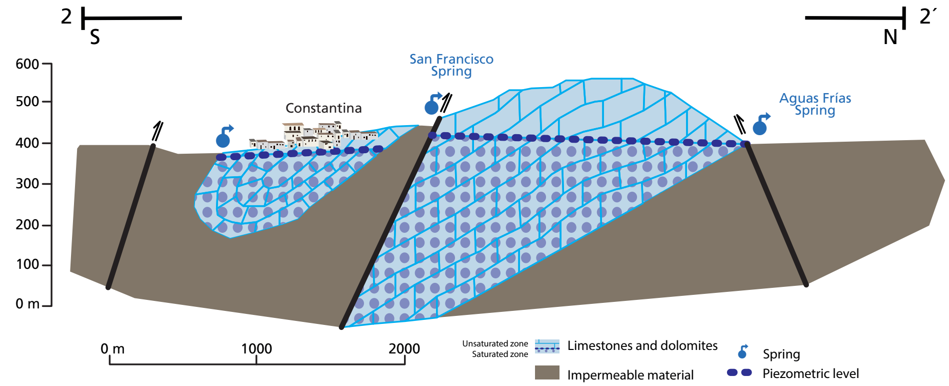


Fig.96 Hydrogeological cross-section 2-2´

[133] Fountain in Cazalla de la Sierra

[134] Sotillo Reservoir (Cazalla de la Sierra)

AQUIFER OF ALMADÉN DE LA PLATA

The aquifer of Almadén de la Plata is located in the municipality of Almadén de la Plata, except for a small part that crosses the provincial boundary and is located in the municipality of Santa Olalla de Cala in Huelva. It has a surface are of 25 km^2 of permeable outcrops, with an elongated shape in an east-west direction, a length of about 18 km, and a variable width between 0.5 and 2 km. Its boundaries, of tectonic nature, are made of low permeability materials, such as slates, schists, quartzites, amphibolite and basalts.

The permeable rocks of the aquifer are marbles of the Metamorphic Nucleus of Almadén de la Plata. The aquifer's structure is very complex. It is, in fact, a series of small aquifers, close but hydro-geologically disconnected from each other, and affected by intense tectonics. Within this group, those of greatest hydrogeological interest are the Bordalla and Covachos-Pedrera, in the western sector, and the La Cabrera Hill in the eastern sector.

The refilling of these small aquifers is exclusively produced by rainwater infiltration that directly falls on the permeable outcrops. Discharging is naturally produced through numerous and small springs of seasonal nature, except for the aquifer of the Covachos-Pedrera hills, where most of the output is due to pumping to supply Almadén de la Plata village.


[135] El Calvario Fountain in Almadén de la Plata


[136] Pilar Square Basin in Almadén de la Plata


[137] Riverbank with watercress; Gargantafría Stream

INFLOWS (hm³/year)	
Rainfall	4 hm³/year
OUTFLOWS (hm³/year)	
Pumpings	3,8 hm³/year
Surface water outflows	0,3 hm³/year

Fig.97 Water balance of the aquifer of Almadén de la Plata

ALMADÉN DE LA PLATA AQUIFER

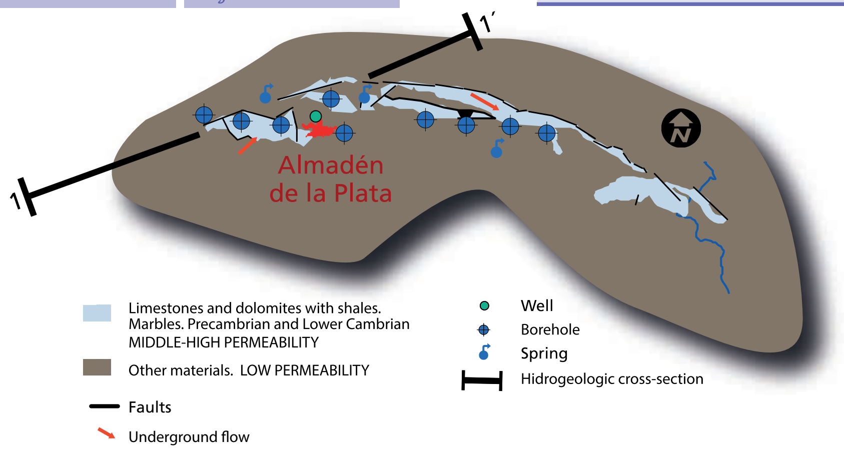


Fig.98 Almadén de la Plata aquifer

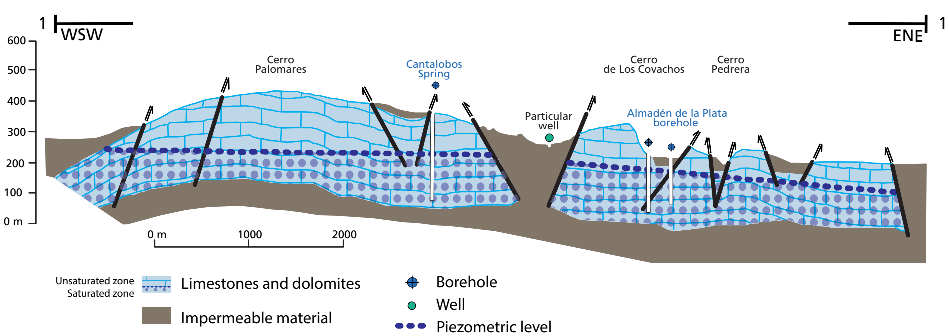


Fig.99 Hydrogeological cross-section 1-1´

ECOSYSTEM RESOURCES

In Sierra Norte de Sevilla, the two natural elements that characterise its landscape, history and culture are minerals and water. Since the moment the man has been using natural resources in this area, a cultural landscape has been built, structured around the richness in both natural elements.

WHAT ARE ECOSYSTEM AND GEOSYSTEM SERVICES?

Ecosystem services are benefits that people obtain from ecosystems: soil to produce food, wood for building, water for drinking, etc. Ecosystem services include the geosystems. These last have their origin in geological processes or resources (minerals, rocks, water), so this means that the greater the geodiversity of the area, the larger the services are.

Ecosystem benefits can be direct or indirect. The former are the more evident, such as the supply and provision of basic resources: food, water, mineral raw materials, energy, etc. Indirect benefits, which are less visible to society, are related to the running of the essential physical processes of the ecosystems that provides direct services. For example, the maintenance of the physical processes that generate and maintain the biological productivity of soils is essential to ensure the ability to produce food.

In the case of Sierra Norte de Sevilla, the ecosystem services provided by geodiversity to its villages are of extraordinary value, reaching most of the population of the province of Sevilla.

WHAT IS GEODIVERSITY?

The geodiversity of a territory, understood as the variety of geological records, rocks, sediments, minerals, fossils, soils, landforms and natural processes that make them, constitutes the basis of the ecological, aesthetic and cultural value of natural landscapes. It is an indivisible part of the natural heritage and it performs many important services. In addition, knowing the bio-physical processes that occur in an ecosystem is essential in order to conserve its biodiversity and enable the sustainable management of forests, rivers, wetlands and coasts that are sensitive to possible modifications that global climate change may cause.

The link between geodiversity and biodiversity is not always noticed by the population. This makes it necessary to highlight the importance of geodiversity:

- Provides the essential physical basis for enabling the development and conservation of biodiversity.
- Offers support for the elements that shape the landscape and the cultural heritage.
- Regulates and provides the essential elements that enable life.
- Reinforce the cultural identity of inhabitants.
- Easing the realization of leisure activities in nature, contributing to extend the catalogue of touristic resources.

SIERRA NORTE DE SEVILLA: A MINE OF STORIES

Since the Neolithic age, minerals and rocks have prematurely attracted the settlers of this mountain range, so this area entails a great cultural heritage, and in particular, it features great geological and mining richness. Since then, in one way or another, the region's rhythm of life has revolved around mining activity until the mid-20th century, witnessing times of splendour during certain periods. We can find one example in the old open mines of Cerro del Hierro, where nature, mining history and sustainable development go together. Mining activity has given way to leisure, cultural and sport activities together with research, which has become an economic engine in the area.


[138] Old buildings in Cerro del Hierro


[139] Mining gallery in Cerro del Hierro


[140] Remains of a mineral treatment plan in Cerro del Hierro

Today, the mines and their surroundings declared a Natural Monument, are complemented by the old wide-track railway branch that transported the mineral extracted in the mining operation to the Mérida-Seville line, which has become one of the most attractive tourist infrastructures of the Geopark: the Greenway of Sierra Norte de Sevilla, which runs from the Cerro del Hierro to Los Prados-Cazalla train station, passing near the Cascadas del Huesna Natural Monument.

THE GREEN WAY

The remodelling of the railway as the Green Way of Sierra Norte de Sevilla has made it possible go through it on foot, bicycle and even on skates. The route begins in the old mining station, goes through Casas de los Ingleses, where one of the houses has been restored as an Information Point of Cerro del Hierro, and through the mining town where the workers lived. From this green way, emerge two marked trails, El Rebollar and Cerro del Hierro, where you can enjoy the excellent views offered by their viewpoints.


[141] Greed Way of Sierra Norte de Sevilla

WATER: SOURCE OF LIFE

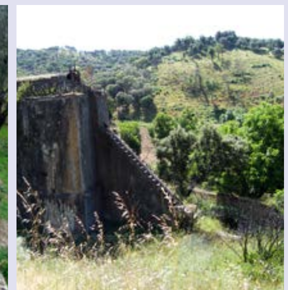
Water is an element that gives an identity to the natural and cultural landscape of Sierra Norte in the form of chiselled valleys and gorges, mountain ranges and rocky areas, and also water mills, old hydraulic dams that provided energy to mines, old disused engines, snow wells, and old or modern reservoirs and hydroelectric plants. The Rivera del Huéznar, classified as a Cultural Landscape, in Los Molinos Stream - in Almadén de la Plata -, the Rivera del Ciudadeja - in Las Navas de la Concepción -, in La Villa de Constantina Stream, are some of the water courses where we can see remains of the hydraulic mills that until the 20th century, were in charge of grinding the area's grain.

However, the greatest identity, the one which has passed on from parents to children, corresponds to fountains and springs. They are currently less valued because our homes are supplied by the drinking water network, but they are the main reason behind human settlements being in the place they are located today.


[142] Millstone, Rivera del Ciudadeja


[143] Machinery of the hydraulic mill El Frances, Rivera del Ciudadeja


[144] Canal (water pipe) of a hydraulic mill


[145] Hydroelectric mill in Rivera del Huéznar

SPRINGS AND FOUNTAINS IN SIERRA NORTE DE SEVILLA MUNICIPALITIES

Alanís: El Cañuelo, Los Caños, De Panfalto, Del Pilarejo, Las Pilitas, Los Pringosos, De San Pedro, De Santa María, De La Sartén.

Almadén de la Plata: Becerrilla Fountain, Del Camino de La Dehesa del Viar, Camino del Cortijo El Membrillo Fountain, Pilar del Cortijo Morilla, La Finca Huerta de Becerrilla Fountain, Pilar del Davazo Del Esparto, De La Palmera, El Pilar, Reloj Fountain, De Santiago, Del Título.

Cazalla de la Sierra: Spring of Casa del Chivo stream, Pilar de Los Burros del Moro, Camino de la Estación Fountain, Del Cañito, Cartuja Spring, Chorrillo Fountain, Del Concejo, Del Convento, De la Huerta del Chorrillo, Del Judío, Del Judío Bajo, Lagarito Spring, León Fountain, De la Malena, Del Moro, De la Noria, De Pachicha, Del Peón Caminero, Del Pocito, Del Puerro, De la Recacha, Tena Fountain, De la Virgen.

Constantina: Casa de Los Miradores Fountain, De la Cierva, Venero del Confitar, Cristinos Fountain, Basin of la Dehesa de Majalimar II, El Chorrillo Fountain, Torricos, De Majalimar, Nogalera Spring, Plata Fountain, De la Primitiva, San Francisco Spring.

Guadalcanal: Cava Basin, Coso Fountain, De Juan Blanco, Del Piojito, De la Plaza, De la Porrita, Puerto Basin, Santa Ana Basin.

Las Navas de la Concepción: Aceronal Basin, Cachorro Fountain, De la Cuesta del Molino, De Currillo Potaje, Chorreras Spring, Mena Fountain, De la Molineta, Del Peón.

El Pedroso: Fuente Redonda Basin.

La Puebla de los Infantes: La Aliseda Spring, De Angorrilla, De los Antiguos Huertos del Retortillo, Source of Altar, Spring of El Torilejo Stream, Fuente de Banduro, Del Camino de la Ermita, Del Cañuelo, Del Cortijo stream, El Monte, El Laurel Spring, La Florida Basin, Burgana Fountain, De Hierro, De la Higuera, De la Huerta de la Virgen, Huerta de Las Vegas Spring, Huerta de Tobalo Waterwheel, Huerta El Pesebre Spring, Huerto de Domingo Fountain, Fundición Spring, La Medina Well, La Medina Well-Watering hole, Las Calveras Fountain, De López, Linos Spring, Palomas Fountain, Pilas Washing site, Santa Ana Well, Tío Mateo Fountain, Umbría del Huertezuelo Basin, Vera I Fountain, Vera II fountain, Villa Romana de Angorrilla Spring.

El Real de la Jara: Fuente pública.

San Nicolás del Puerto: Fuente del Área Recreativa El Martinete, Del Cortijo del Águila, Nacimiento del Galindón, Rezume del Guindalillo, Fuente del Martinete, Nacimiento del Rivera del Huéznar, Fuente de la Vía Verde.

Source: Springs and Fountains of Andalusia (www.conocetusfuentes.com/home.php)


[146] Fountain

At the entrance to Constantina from the north, the unique "snow well" can be seen. From the 17th Century until the mid-19th century, the ice was generated there and transported to Seville at night.

[147] Snow well in Constantina

The reservoirs system of El Pintado, Melonares, Huéznar and Retortillo regulates the surface water resources provided to Seville, the towns within its metropolitan area and the surrounding areas, and mainly the irrigated land of the Guadalquivir Valley.

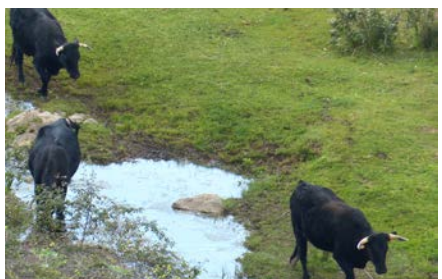
The power plant of El Pintado Reservoir, and to a lesser extent, the one in Huéznar Reservoir, produce more than 50% of the hydroelectric power generated in the province of Sevilla (around 34 MW).

[148] Location of the power plant of El Pintado

[149] Signpost of the power plant of El Pintado

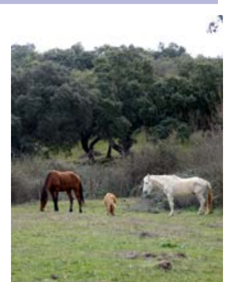
The water also gives shape to the living landscape, in the form of springs that supply the villages, as well as the cattle ponds and watering holes built for the large herd of cows, sheep, Iberian pigs and fighting bulls that live here, that are one of the economic pillars of the Geopark population.

[150] Red cows in cattle pond



[151] Fighting bulls

[152] Sheep



[153] Horses

These small artificial water reservoirs are also essential for wildlife, sustaining another significant economy activity in the area: hunting.

THE BIOSPHERE RESERVE OF THE DEHESAS DE SIERRA MORENA

The territory of Sierra Norte de Sevilla Geopark is part of one of the nine Andalusian Biosphere Reserves - the Dehesas de Sierra Morena - designated in 2002. Between the mountain ranges of northern Huelva, Seville and Córdoba, with a total area of 424,000 hectares, the Dehesas de Sierra Morena constitute the largest space of the Spanish Network of Biosphere Reserves. It comprises three natural parks in northern Andalusia: Sierra de Hornachuelos in Córdoba; Sierra Norte in Seville; and Sierra de Aracena and Picos de Aroche in Huelva. This natural Mediterranean setting, made up of extensive pastures full of holm oaks and cork oaks, has for centuries been the basis of the area's economy, with a model of sustainable and exemplary agricultural use.

[154] Panoramic view of a wooded pasture

[155] Iberian pigs in a wooded pasture

THE "BERREA"

One of the natural spectacles you can enjoy in Sierra Norte de Sevilla is what is known as "La berrea" (the bellowing), a name that comes from the hoarse bellowing emitted by stags with the aim of attracting does and demonstrating their strength and superiority over other males. It normally takes place in mid-September or early October, depending on when the first rains fall. When the does go into heat, they gather in open areas outside the mountain, and the stags also come out to form harems that can reach up to fifty females. Sometimes, the signs of strength and superiority are not enough to drive away the rest of the stags, resulting in confrontations or fights of colliding their heads armed with antlers.

[156] "Berrea"

[157] "Berrea"

Water sports can be practised in the Geopark: canyoning in El Chorro and Riscos Blancos streams, or canoeing and kayaking in El Pintado Reservoir and the Huéznar Reservoir.

[158] Canyoning in El Chorro

[159] Kayac

Crops are interspersed between pastures and Mediterranean forests. The most widespread is the olive grove, which generates valued local virgin oils.

[160] Olive grove

[161] Olive oils

The wine-making tradition in the area, which during the 15th, 16th and 17th Centuries was one of the main exporters of wine to America, promoted because of the exclusivity of the Port of Seville sending ships to the New Spain, is being recovered thanks to the initiatives of young wineries. The distillation of anises and liquors in Constantina and Cazalla de la Sierra is preserved from that distant period.

[162] Vineyards

[163] Wines from Sierra Norte

[164] Signpost of a distillery

The richness and enormous floral diversity of the mountain range is not only exploited by beekeepers. Many plants have been used in food, traditional medicine and for obtaining oils and natural essences. One of the most appreciated products is labdanum, substance with a resinous appearance, brown colour, and pleasant and long-lasting aroma. It is obtained from the sticky cistus, and is widely used in the perfume and cosmetics industries.

LABDANUM

Today, it is mainly produced for the perfume industry, although it has been traditionally used as a medicinal remedy. The raw resin is extracted by steam distillation from the leaves and new branches of the sticky cistus. It is highly valued in the perfume industry for its stickiness and ability to improve multiple aromas.

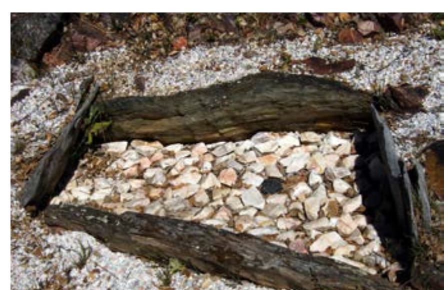
Nowadays the resin is extracted in Almadén de la Plata, and in the neighbouring Real de la Jara, it is possible to visit an old still that distilled the essences and aromas of plants.

[165] Thicket of sticky cistus

A TERRITORY WITH HISTORY

The history of the Geopark's territory is extensive and drawn out over time. Human activity, in its broadest sense, has left a vast cultural heritage. From the time when human life was developed in hidden caves, this natural space has had a significant historical importance. Iberians, Romans and Arabs chose it to establish important settlements.

There is evidence that the first inhabitants arrived during the Middle or Upper Palaeolithic, although material remains have been only found from the Neolithic. These first settlers left material evidence of their presence in the Caves of Santiago (Cazalla de la Sierra), the cave of Los Covachos (Almadén de la Plata), whose engravings and cave paintings compose the first prehistoric manifestations documented in a cave in the province of Sevilla, and La Traviesa necropolis from the Bronze Age, declared an Archaeological Site.



[166] Burial of La Traviesa

Among the pre-Roman people that live in the region, we can find the Celtics, which founded Alanís. And Almadén de la Plata, Constantina, Guadalcanal and El Pedroso are from the same period.

The Sierra Norte de Sevilla was also the place where the main routes of communication between the west of Andalusia and Castilla were traced. Through these routes, the north cultural currents flowed, causing both the settlement and development of their population centres and the formation of an important cultural legacy, which has left numerous historical and artistic testimonies.

The Roman road from Seville to Mérida passed through Almadén de la Plata and Real de la Jara, and centuries later, it was used as the route for the Mozarabic path to Santiago. In the Middle Ages, the western part of Sierra Morena was also an area of highly important economic activity, due to its strategic geographical position as a communication route between the Guadalquivir Valley and Lower Extremadura, close to the Ruta de la Plata (Silver Route).

Indeed, because of this strategic nature, close to the border with Portugal, during the Upper Medieval Age, it became a defensive post against possible attacks from the neighbour country. It also shaped part of the territory known as Banda Gallega (the Galician Band), the name of the defensive belt in a large part of the current Sierra de Aracena (Huelva) and Sierra Norte de Sevilla, since being conquered by the Christian Monarchs. This denomination was created due to the repopulation of these lands by Galicians and Leonese people after the expulsion of Muslims. The castles of El Real de la Jara, Almadén de la Plata, Cazalla de la Sierra, Alanís, Constantina and La Puebla de los Infantes are part of the set of military fortifications of the Banda Gallega in the Geopark.

[167] Castle of Alanís

The territory contributed to the conquest of America, and through it the mercury supplies needed to produce the gold and silver that the Crown so much needed goes to the new continent, using the so-called Camino Real del Azogue (Mercury Royal Road).

As a medical prescription for the depression he suffered, in 1730, Philip V installed in Cazalla de la Sierra his summer residence and Spanish Court's, from 13 June to 20 August. That year, courts were held there, making it the capital of the Kingdom of Spain.

Commercial traffic along these roads suffered the activity of bandits - the Toledan and Extremaduran "Golfines". References to the presence of these bandits are very old. They already existed in 1254, when the beekeeper's ordinances were promulgated. In 1280, King Alfonso X referenced to this situation on the Ruta de la Plata, in the village of Realejo (El Real).

In addition to the aforementioned elements of military architecture, the Geopark has others, among these highlights the Mudejar Chapel of Santa Ana (15th-16th centuries), the Baroque Chapel of San Benito (17th century) and the Plaza Mayor in Guadalcanal, a village with an important artistic heritage that has been declared a Historic Site and is included in the Network of Historical and Artistic Heritage of Andalusia. Also of interest are the Historic Sites of Cazalla de la Sierra and Constantina. The first features houses built in the 15th Century, highlighted by the Cortijo and Cartuja. In Constantina, the castle-chapel of La Hiedra (16th Century) and the Church of Santa María de Gracia (16th Century) are the most notable.

CAMINO REAL DEL AZOGUE (MERCURY ROYAL ROUTE)

During the 16th to 18th centuries, the route of *azogue* (mercury) was the most important communication route in the Iberian Peninsula, up to the point of being declared Royal and being placed under the protection and administration of the Spanish Crown.

Through the Sierra Norte de Sevilla Geopark passed two of the routes to cross Sierra Morena: the eastern wagon route and the mules route, both essential for supplying mercury to the silver mines of South America. The arrival of mercury became an imperative necessity for the Spanish Crown, because it was used in mining, among other applications, in order to produce the mixture to extract gold and silver from the minerals containing it. They were vital for financing the colonization of America and paying the Crown's interests in Europe.

The transcontinental route between Europe and Central America passed by land between the mercury mines of Almadén (Ciudad Real) and Seville, by the Guadalquivir River between Seville and Cádiz, and by the maritime transport of the West Indies Fleet between Cádiz and Veracruz (Mexico). From Veracruz, it was distributed to the different silver mines in Central and South America.

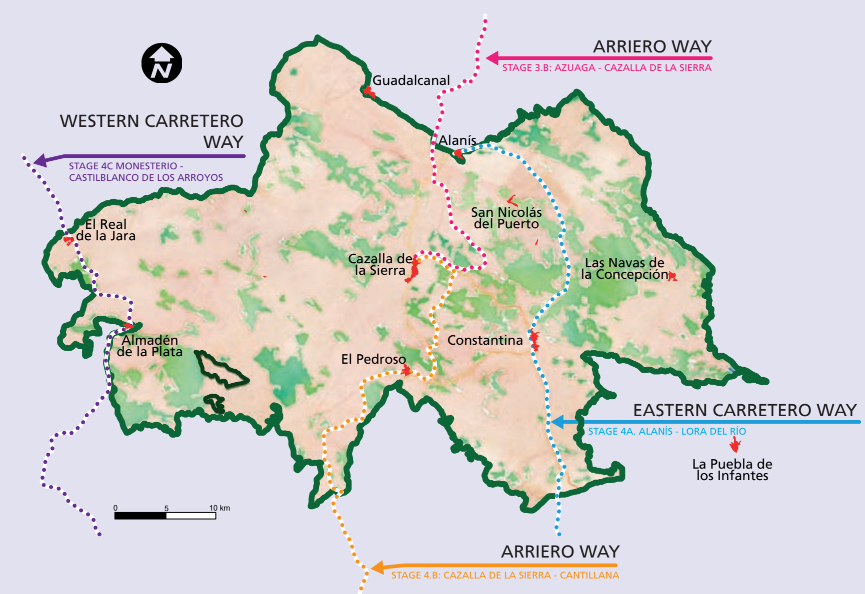


Fig.100 Map with the tracks of the Mercury Royal Route through the Geopark

ELEMENTS OF SIERRA NORTE DE SEVILLA GEOPARK'S CULTURAL HERITAGE DECLARED ASSET OF CULTURAL INTEREST

Alanís
Castle
Church of Santa María de las Nieves

Almadén de la Plata
Castle

Cazalla de la Sierra
Ancient Cartuja Monastery of Inmaculada
Concepción Castillo
Historical Centre of Cazalla de la Sierra
Church of Nuestra Señora de la Consolación
Urban wall

Constantina
Castle of la Hiedra
Castle of Cerro del Almendro
Castle of Cerro del Castillo
Castle of Cerro del Hierro
Castle-Chapel of Nuestra Señora de la Hiedra
Historial centre of Constantina
Church of Santa María de la Encarnación

El Pedroso
Church of Nuestra Señora de la Consolación

El Real de la Jara
Castle
Castle of Las Torres

Guadalcanal
Chapel of San Vicente
Chapel of Ventosilla
Castle of Monforte
Historical Centre of Guadalcanal
Chapel of San Benito
Church of Santa Ana Iglesia de Santa María de la Asunción
Urban wall

La Puebla de los Infantes
Castle

Las Navas de la Concepción
Castle of la Armada

Other architectural landmarks that can be found in the Geopark's territory are the country houses *(cortijos)* and farms. Their origin comes from the Roman *villae*, and subsequent Arab farms. It was in the 16th Century when the constructions we know today as country houses or farms appeared, and proliferated during the 18th and 19th Centuries. At the time, the bourgeoisie and agrarian nobility prospered and were dedicated to vineyards and olive tree farming, as well as livestock.

The ethnological heritage also offers very interesting samples of the most recent economic activity: mining installations of industrial interest, blast furnaces, foundries and mines, elements of the hydraulic heritage, flour mills, shepherds cabin *(torrucas)*, apiaries, etc.

[168] Castle of El Real de la Jara

[169] Stele with the date of construction in an old building

[170] Shepherds cabin *(torruca)* in Cerro de la Capitana

[171] Ruins of the El Pedroso Foundry

[172] Apiary in the rocky area of Almadén de la Plata

[173] Mill of Sofio (La Puebla de los Infantes)

THE GEOPARK IN THE STARLIGHT RESERVE OF SIERRA MORENA

The Sierra Norte de Sevilla Geopark is located at the heart of the Starlight Reserve of Sierra Morena, a paradise for astrotourism enthusiasts.

Andalusia features the optimal conditions for night-time observation of the sky: the best climate, clear, transparent and without light-polluted skies. In addition, as it is the area of Europe closest to the equator, it is possible to observe a larger expanse of the universe, which means that many celestial bodies are only visible from Andalusia.

Sierra Morena is the largest Starlight Reserve and Tourist Destination in the world, an ideal place to observe the sky in the best conditions. It covers an area of more than 400 kilometres along the north of the provinces of Jaén, Córdoba, Sevilla and Huelva, 57 municipalities, more than 400,000 hectares that include six natural parks: N.P. Despeñaperros, N.P. Sierra de Andújar, N.P. of Cardeña and Montoro, N.P. Sierra de Hornachuelos, N.P. Sierra Norte de Sevilla and N.P. Sierra de Aracena and Picos de Aroche.

The Certification of Sierra Morena as a Starlight Reserve and Destination, granted by the Starlight Foundation and endorsed by UNESCO, is a certification of barely light pollution. More than 60% of its nights are clear and the darkness of its night sky is equivalent to that of many professionals' observatories at international level. It also implies an institutional commitment to preserve its great biodiversity, guaranteeing the visitor a complete offer to enjoy the night sky and the natural environment of this reserve.

In the Geopark, it is possible to enjoy the services associated with this night experience in the astronomy observatory of Guadalcanal. A complete network of strategically located and conditioned viewpoints completes the infrastructure for observing the mysteries of the celestial sky.

RESERVA STARLIGHT SIERRA MORENA

SPORTS AND LEISURE ACTIVITIES IN NATURE

The Geopark, due to its size and diversity, offers the possibility of enjoying countless leisure and sports activities in the middle of nature, an active way of enjoying the beauty of its landscapes and hideouts.

Hiking, bike touring and horse-riding enthusiasts can choose from a large number of routes and paths where they can enjoy their leisure time and their passion for sport. Most of the routes are signposted with explanatory panels for walking, horse-riding or mountain biking. There are also several information points on routes and bicycle rentals. Because of its beauty, the Green Way of Sierra Norte is an unforgettable family journey.

Hunting, both big and small hunter, and fishing are traditional activities in this region. El Pintado and Sotillo Reservoirs are especially appreciated for cyprinids and black bass. In several Geopark reservoirs, water sports can be practised in kayaks and canoes.

The vertical walls of Cerro del Hierro are regularly visited by climbers. Canyoning can be practised in El Chorro (Calzadilla Stream) and in Riscos Blancos Stream. Caves and chasms, mainly concentrated in Alanís, San Nicolás del Puerto, Almadén de la Plata and Cazalla de la Sierra, allow visitors to get closer to the fascinating world of speleology. In order to practice these three activities, it is required to have a federative licence and an authorization from the Park, as well as one from the owner of the land where it is practiced.

Lovers of nature photography can enjoy wonderful settings, as well as the opportunity to capture the impressive natural spectacle of the bellowing and trying night photography and astronomy observation.

It is advisable to conduct these experiences together with professional guides. In the villages of the Geopark, there is a network of active tourism companies that provide this type of services.

INTANGIBLE HERITAGE: CUSTOMS, USAGES AND TRADITIONS

In addition to the common vegetable products, travellers can discover in these mountains an exquisite variety of seasonal wild vegetables, such as sorrel, similar to the spinach at first sight; the bladder campion, soft, tender and of tiny leaves; asparagus, Spanish oyster thistle, watercress, palm hearts and mushrooms. The region's mycological tradition is very intense, and the gastronomy during mushroom season is a luxury for the palate.

The exploitation of Iberian pig is the most important activity, and of great economic significance, although those of sheep, cattle, goats and horses are also significant. Iberian ham is a flagship product, and homemade pig butchering is one of the oldest and most emblematic popular traditions of this area. Popular knowledge has transcended from generation to generation up to the present day, despite the process of industrialization. Cheese elaborated with goat's milk using the traditional method is another local gastronomic product of interest.

Honey is one of the most exquisite products produced in the mountains. The typical one is called multi-flower or mountain honey, made from the bees sucking from the great variety of bushes blooming in spring, such as thyme, rosemary, gorse, broom, Spanish lavender, etc.

Other gastronomic delicacies of these villages are the confectioneries, very influenced by the Arab past, that offers sweets made in convents in Constantina, to quality handmade sweets, particularly by employing a frying pan, such as *dulce de miel, pestiño, roscos, gañote*, etc.

[174] Iberian pig products

[175] Sweets

[176] Spanish oyster thistle

[177] Scrambled eggs

[178] Goat's milk cheese

FAIRS AND EVENTS

The festive calendar of the villages located in Sierra Norte de Sevilla features events of particular significance, including the traditional pilgrimages celebrated during the summer period: San Diego in San Nicolás del Puerto, San Pedro in Alanís, Ntra. Sra. del Monte in Cazalla, Virgen del Robledo in Constantina, the Virgen del Espino in El Pedroso, the pilgrimage of Virgen de Guaditoca in Guadalcanal and the Pastora in Almadén de la Plata.

In addition, throughout the year, different promotional events of gastronomy, craftwork and tourism resources in different villages are celebrated:

On 31 August and 1 and 2 September, Medieval Days took place in Alanís.

In the first week of December, the Old Music Festival of Seville province is celebrated in Cazalla de la Sierra.

In October, Constantina celebrates its Mycological Days, with field trips to pick mushrooms, talks by experts in the field, a popular Iberian pig slaughter and tasting of both mushrooms and typical products from the slaughter.

Each year, Las Navas de la Concepción celebrates its Hunting and Ecotourism Fair.

Every year, in the first week of December, El Pedroso organises a multitudinous Regional Trade Fair, where the visitor can taste dishes from the exquisite mountain gastronomy and admire the work of its booming craftwork.

In the second or third week of March, Almadén de la Plata celebrates the Ham Fair, with an exhibition and tasting of the typical products of the village and region, and the Hunting Fair in the last week of September or first week of October.

[179] Poster of 2019 Regional Trade Fair of El Pedroso

[180] Mycological Days of Constantina

[181] Medieval Days in Alanís

5 Routes

[182] El Cerro del Hierro

ROUTE 1
EL VIAR - ALMADÉN DE LA PLATA - EL REAL DE LA JARA

This route passes through the southwestern sector of the Geopark. The path goes mostly through the river basin of the Viar River, among large areas of holm and cork oak pastures, some of which are set on beautiful granite rocky areas. The route runs through the Viar Basin and the Suture Zone between the South Portuguese Zone to the south and the southernmost part of the Ossa-Morena Zone to the north. Both detrital and volcanic filling units can also be observed in the intra mountainous Viar Basin.

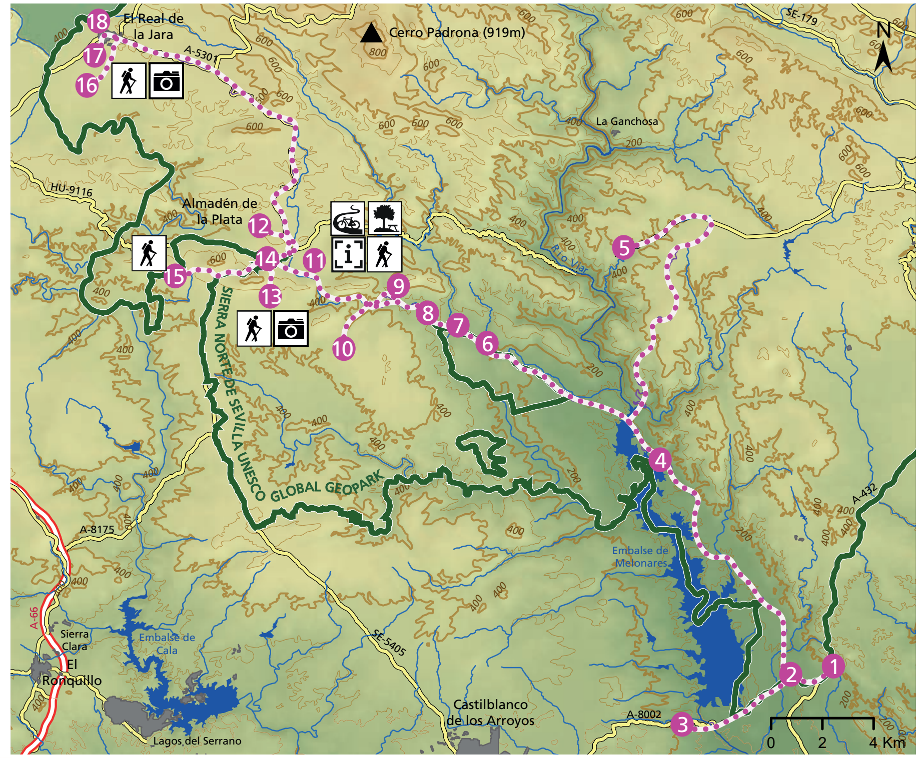
General data

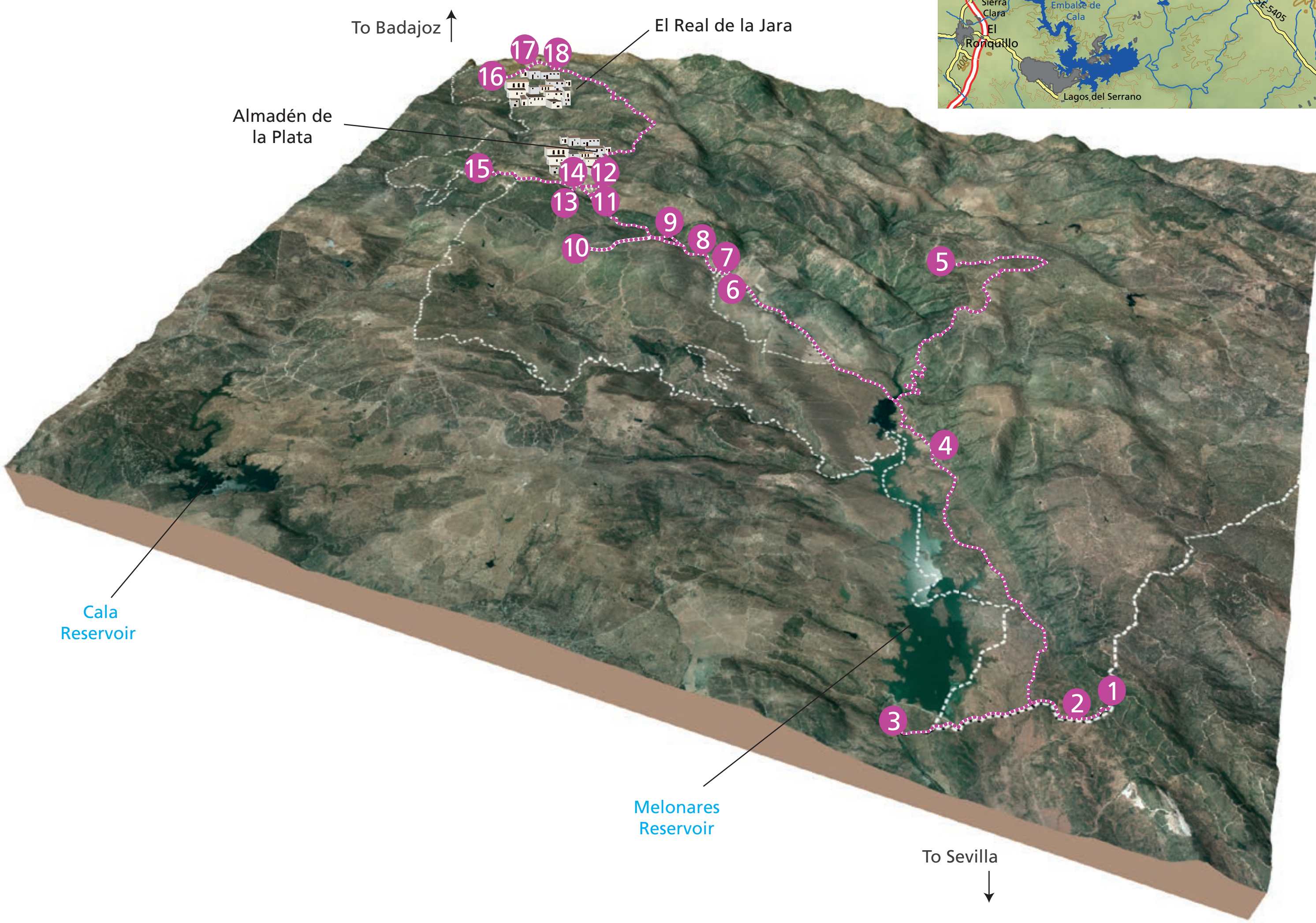
81,5 km | 8 hours | Linear

Also suitable for:

Public Equipment

Visitor Center | Viewpoint | Path | Cycle route | Recreational area





1 Viar Fault

Difficulty of the geological concept HIGH

The route begins in the immediate surroundings of the intersection of the A-432 Road Cantillana-El Pedroso and the C-433 Road Castilblanco de los Arroyos-El Pedroso. Here, it is possible to observe the Viar Fault in the slope of the old road. Although it may seem insignificant, it is a great tectonic accident that brings together the sedimentary filling of the intra mountainous Viar Basin, at the southwestern side, sited over the South Portuguese Zone, and the reliefs of the Ossa-Morena Zone at the northeast side.

It represents a large fracture zone with several parallel reverse faults, where the oldest materials are on top of the most modern. It constitutes the eastern edge of the Viar Basin, with a width between 200 and 1,200 metres and a length over 25 km. It overlap Palaeozoic rocks (Cambrian marble limestones, Ordovician schists with vulcanites and Devonian limestones) over the alluvial - fluvial sediments which filled the intra mountainous Viar Basin (siltstones with levels of carbonates and conglomerates from the Upper Red Unit of the Viar Basin), of Upper Carboniferous and Permian age.

The Viar Fault activation is subsequent to the structuring of Sierra Morena and to the sediment deposit which filled the Viar Basin, units which are affected. It is probably a fracture system that already outlined the eastern limit of the Viar Basin, which was reactivated later during the tectonic movements generated by the Alpine orogeny.

[184] Conglomerates and sandstones of the Viar Basin, indicating the sedimentary facing

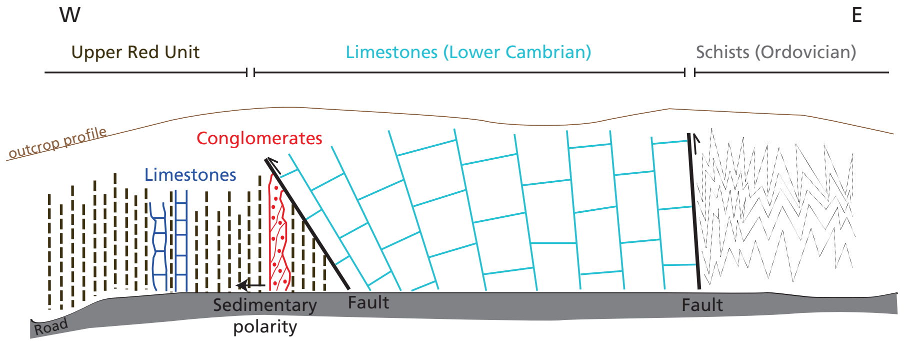


Fig.104 Geological scheme of the southern area of the Viar Fault

2 Upper Red Unit

Difficulty of the geological concept: LOW

Following the C-433 Road down to the Viar River and Melonares Resevoir dam, there are excellent outcroppings from the Upper Red Unit (“Serie Roja Superior”).

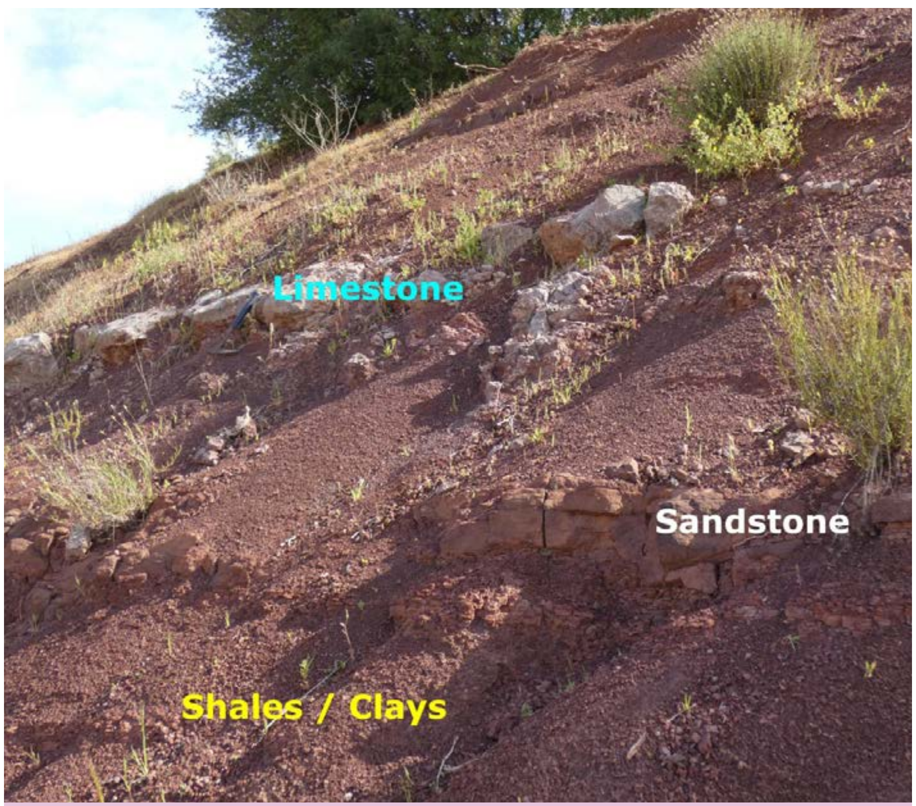
This is a set of detrital sediments of a strong red colour, which forms the roof of the sedimentary filling of the intra mountainous Viar Basin. It is called Upper Red Unit to differentiate it from other units with the same colouring in a lower position inside the filling of the basin.

It is composed of conglomerates, sandstones, shales, clays and levels of carbonates in nodules. Shales, made up of particles of a size between clay and silt, show that they were deposited in an aquatic environment with little dragging force. In this case, it was a lacustrine environment, since we are in a continental basin. Conglomerates and sandstones were deposited due to the dragging by local temporal streams, probably occasional storms. Finally, the thin levels of light limestone interspersed within the layers of shales and red clays, indicate long periods of droughts that totally evaporate the lakes, producing a transport by capillarity to the surface of the calcium carbonate dissolved in the water.

[183] Photography of the southern area of the Viar Fault with the geological explanation

[185] Layer of conglomerates, and sandstones above them, among deposits of shales

[186] Layers of sandstones, among deposits of shales and clays



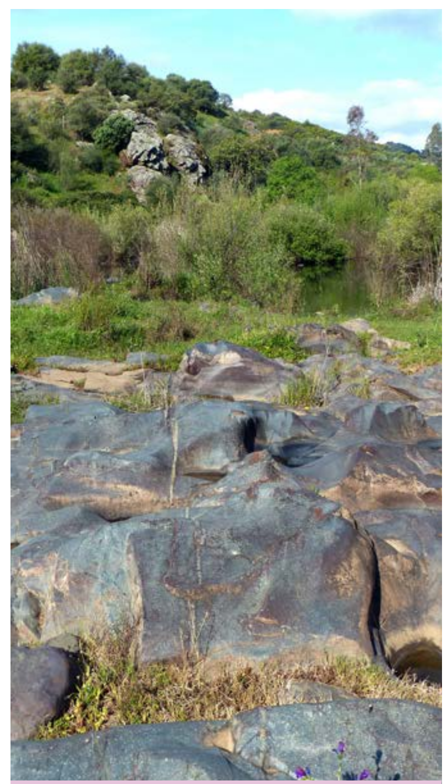
[187] Layers of sandstones and limestone among deposits of shales and clays

3 Viar diabase dike

Difficulty of the geological concept MEDIUM

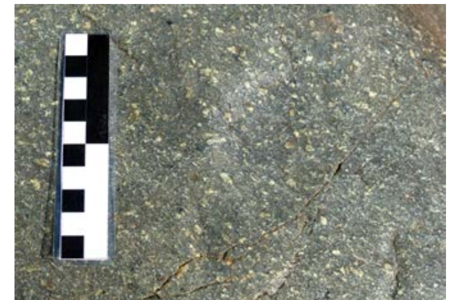
Just under the bridge of the C-433 Road over the Viar River, on its left bank, there is an excellent example of a dike composed of subvolcanic rocks. In this case, it is a diabase dike, that we can observe due to the fact that the Viar River has eroded the layers of the mountainous sedimentary Viar Basin (conglomerates, sands and shales), still seen on the sides. It was created due to the injection of the magma from the El Berrocal pluton, forming a laminar-shaped conduit with sub-vertical positioning. Its thickness is variable, from one to several meters, as well as its position, of several hundred meters with a northwest-southeast direction.

Its composition is basic and has a thick grain texture, with many dark grey or black crystals, that is why it can also be called black granite. Associated to this diabase are some segregated granite rocks, which were separated by their difference in density due to their acid and less dense composition.



[188] Appearance of the diabase outcropping in the riverbed of the Viar River

[189] Diabase dike with the granitic segregations on the sides



[190] Detail of the diabase

[191] Detail of the granitic segregations

4 Mud flows

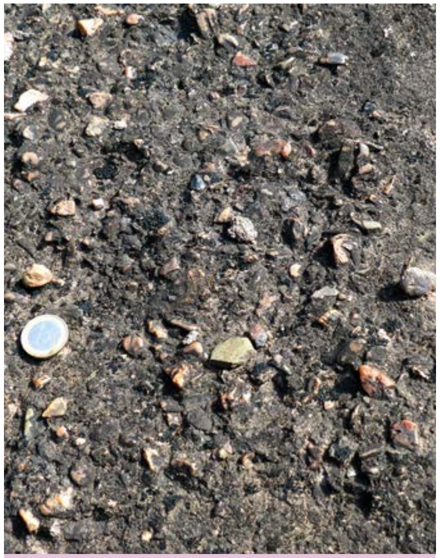
Difficulty of the geological concept LOW

From the previous point, the route resumes by returning north until reaching the intersection of the C-433 Road with the Cordel del Pedroso, heading towards Almadén de la Plata. This is a trail for livestock, and is passable by vehicle, which goes through the sedimentary filling of the Viar Basin. At the beginning of this route, the different deposits of the Upper Red Unit can be seen. Near the tail end of the Melonares Reservoir, and the Melonares counter-dam, the route cuts through an excellent example of mud flows.

Mud flows are interspersed inside the detrital sediments of the Upper Red Unit and represent sediments produced by mass transport, that is, the mobilisation and sedimentation of other deposits located on the old slopes; sands, clays and volcanic ashes, during the periods of intense rain became over-watered and flowed downwards, causing mud avalanches, similar to lahars.

In this case, several levels of sandy-clay deposits can be observed, with a colour going from dark red to black, of about 20 cm thick, containing small pebbles, and occasionally, fragments of fossil flora. The surfaces of the top of each flow deposit present small, unclassified, angular and sub-rounded pebbles, showing that they were transported while floating, due to the high density of the flow of this transport mechanism.

[192] Outcropping with several layers of mud-flows



[193] Detail of the pebbles in the top of the mud-flows

5 Volcanic chimneys

Difficulty of the geological concept HIGH

From the previous point, following the Cordel del Pedroso path towards Almadén de la Plata, there is a detour to the right, going up around 7 km along the Dehesa de UPA path until reaching the road from Cazalla de la Sierra to Almadén de la Plata, turning left until the road becomes a dirt road. During the route, there is a series of Cambrian quartzitic sandstones and slates belonging to the Cumbres Mayores Domain, which can be seen on the slopes of the road.

On a section of the dirt road, it is possible to observe some remains of volcanic chimneys, corresponding to the centre of emission of the volcanic deposits of the Viar Basin, the pipes through which the magma responsible for the volcanic eruptions came up to the surface. These pipes or chimneys are identified by the existence of some breccias with volcanic tuff matrix and fragments of volcanic and host rocks (sandstones and slates from Cambrian period), which have been uprooted and dragged in the ascent of magma. In some cases, fine-grained explosive rocks (pyroclastic) and deposits of volcanic ash are found, representing the base of the volcanoes.

The presence of several volcanic pipes has been acknowledged, in an area with an extension of more than 5 square kilometres, showing the existence of an important volcanic centre with several craters. However, since they were formed around 300 Ma, the subsequent erosion has only maintained the rocks that filled the pipes.

[194] Breccia with volcanic tuff matrix and fragments of host rock

[195] Detail of the breccia: matrix and volcanic pebbles in brown and dark colour, fragments of host rock in white colour

6 Lava flows

Difficulty of the geological concept MEDIUM

From the previous point, coming back from the same path travelled until returning to Cordel del Pedroso, the route continues towards Almadén de la Plata. Some kilometres north, in the Gargantafría Stream Valley, wonderful outcrops of lava flows can be seen.

During the sedimentary filling in the intra-mountainous Viar Basin, several volcanic episodes occurred. The layers of lava we can observe in this site correspond to the first volcanic episode, overlapping the first alluvial and fluvial deposits of the basin. These basalts are made up of different lavas flows, with thicknesses between 15 to 20 m. Their weathering gives rise to a characteristic structure of "onion layers", making them very recognisable. Weathering in onion layers is produced because of chemical disintegration, due to water infiltration, and physical alteration caused by the difference in temperature between the surface, heated by solar radiation, and the internal area, that keeps the same temperature for longer.

[196] Appearance of lava flows

[197] Detail of the weathering in onion layers

7 Alluvial Deposits of the Viar Basin

Difficulty of the geological concept MEDIUM

In the final phase of the Variscan orogen, an intra-mountainous basin, known as the Viar Basin, was created on the deformed Palaeozoic rocks during the Upper Carboniferous period. From this age and Permian period, a set of sediments of alluvial, fluvial, fluvial-lacustrine and lacustrine nature were deposited in this internal basin, with materials coming from the erosion of the surrounding reliefs, and with the deposits provided by several important volcanic episodes.

At this point, we can see the first sediments that filled the intra mountainous basin, composed of a mixture of alluvial fans, river flows and valley bottom deposits.

They correspond to conglomerates and conglomeratic sandstones, with levels of thick sandstones, and angular pebbles of different materials and sizes. Erosion marks on the base of the layers of conglomerates are common, as well as a certain decrease in the size of the pebbles towards the roof, commonly going from coarse grain to medium grain sandstones; pebbles and sandstones have an intense reddish colour.

Many of the rounded pebbles of the conglomerates have polished surfaces with a shiny patina called "desert varnish", indicating that pebbles were exposed to an arid, desert or sub-desert climate. Sedimentary structures are very abundant, especially crossed layering and grain-classification.

[198] Outcropping of conglomerates and sandstones of an alluvial fan

[199] Detail of the conglomerates with several pebbles with desert varnish

8 Old millstone quarries of La Calzadilla Stream

Following the Cordel del Pedroso path, in La Calzadilla Stream valley, there are several areas of extraction of stones for hand mills and horse mills of the Late Roman period or Middle Ages, probably during the Islamic period. * *See also photo 111.*

Quarry fronts are located in La Calzadilla riverbed, where apart from the signs of hand mills of 50 centimetres in diameter each, there are also signs of water mill stones of 80 centimetres in diameter. The areas of extraction are restricted to some points where a thick sandstone or micro-conglomerate outcrop, with rounded pebbles smaller than 1 centimetre in size.

[201] Hand mill stone conserved in its place of extraction

[200] Signs of the extraction of a water mill stone

9 El Chorro Gorge

Difficulty of the geological concept MEDIUM

The Calzadilla (or Cezadilla) Stream has its source to the north of the village of Almadén de la Plata. Around 5 kilometres at south the urban area, the stream goes through the northern end of the granite pluton El Berrocal, creating a spectacular gorge, with various waterfalls and rapids of singular beauty.

This place can be accessed by going upstream on a path starting at the intersection of the stream and the Cordel del Pedroso. Most of the rocks of this path are quite eroded granites, while on the opposite bank of the stream, outcrops the alluvial deposits of the Viar Basin.

The Calzadilla Stream riverbed, once reaching the point where there is a diabase dike crossing the granite, changes its orientation drastically, following the dike's direction. The differential erosion on the two types of rocks of the substratum: granite and diabase, make the stream fit in the dike. Since it is more erodible and has a vertical position, there is a quickly nesting of the channel, giving as a result a spectacular gorge of vertical walls, which in Almadén de la Plata is called as El Chorro.

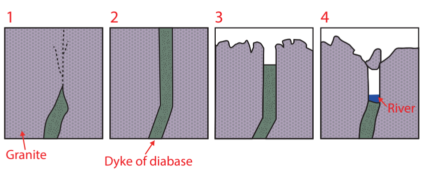
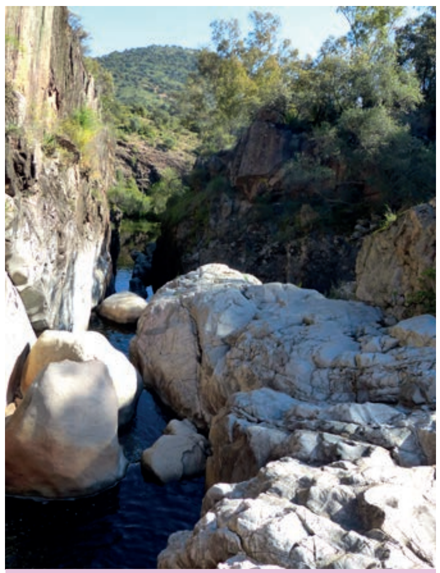


Fig.105 Gorge formation scheme

Another important aspect is the presence of large rocks embedded between the gorge walls, adjacent granite boulder rocks that have fallen. They have been embedded by being dragged by the stream flow during flood periods. Some of them have a more spherical shape, whereas others have a wedge shape. This is because the boulder rocks closer to the riverbed are more eroded by the water, whereas those far from there, are only eroded in heavy rainfall periods.

In the plainest riverbed area, upstream from El Chorro and near the entrance of Las Navas - El Berrocal Public Forest, it is possible to observe giant kettles and other forms produced by fluvial erosion.

[202] El Chorro Gorge, where embedded boulders can be observed



[203] View of the gorge, from the top

[204] Pond at the bottom of the gorge

10 Rocky Area of Almadén de la Plata

Difficulty of the geological concept LOW

Returning to the Cordel del Pedroso, the path towards Almadén de la Plata is resumed. After 1 km, there is the detour to Cortijo del Berrocal Visitors Centre, which is located in the public forest Las Navas - El Berrocal. It is a place of great scenic beauty that is home a beautiful recreational area located between plant formations typical of the Sevillian mountain range, holm oaks and cork tree forests, riverside vegetation and Mediterranean mountains of mastic, rockroses and strawberry trees. One of the cork oaks near the Centre has been declared a Singular Tree of Andalusia due to its age, size and morphological characteristics. Among the abundant fauna species, the deer population stands out. It is one of the most suitable places to enjoy the bellowing during their mating season.

This beautiful landscape is located on a granite pluton known as Berrocal Granite. It is a relatively small intrusion, of about 16 km^2 of surface area, which was set during the Upper Carboniferous period in the northernmost part of the South Portuguese Zone. ** See pages 35 and 72.*

It is pink-coloured grain texture granite, with a thick crystal size, which shows that it cooled at a slower rate, allowing for greater crystallisation. The thick crystal size also implies a greater weathering, resulting in a rocky geomorphology (named "berrocal" in Spanish language), and it constitutes an excellent place for observing different aspects of this granite rock modelling: pile of boulder rocks, domes, tors or columns, flat granite outcrops, knight rocks and sandy flatlands.

The Visitors Centre offers an interesting exhibition about the most significant rocks, minerals and fossils of the Geopark. Among its most outstanding features, the Viar fossil trunk stands out, which was discovered in 2005 in a nearby area. This is an extraordinary specimen, possibly from a conifer similar to an araucaria, which is notable for its size and characteristics as well as its good fossilisation, resulting in an excellent state of conservation. It is an example of the forest existing 300 million years ago in the nearby Viar Basin.

[205] Pile of boulder rocks

[206] Knight rock

[207] Cork oak of El Berrocal

[208] Recreation of the forests in the Upper Carboniferous - Permian period

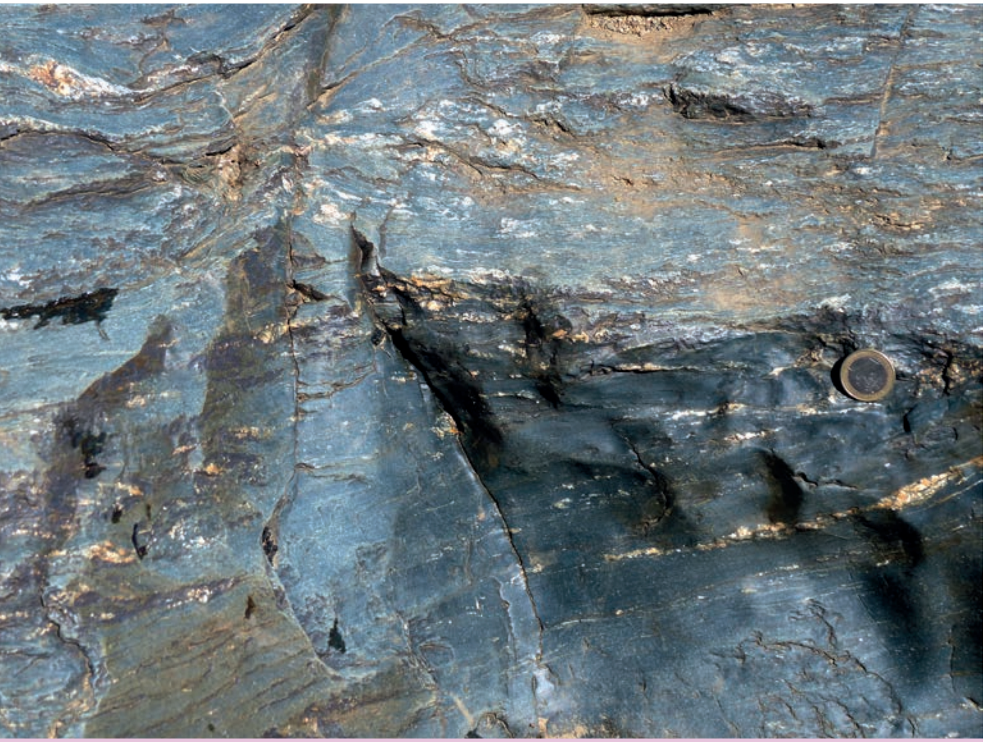
11 Amphibolites of Almadén de la Plata

Difficulty of the geological concept HIGH

In the village of Almadén de la Plata, there are a blue-grey rocks set that form a band with east-west orientation and about 10 km in length. These rocks are amphibolites called "Beja - Acebuches Amphibolites" (when it were first defined, took their name from the towns of Beja, in Portugal, and Acebuches, in Huelva). This type of rock, usually of greenish and blue colours, is very rare and comes from the metamorphism of ancient basic volcanic rocks. In fact, geochemical analysis shows a similar composition to the basalts existing in the areas of oceanic ridges, so they are interpreted as remains of an oceanic crust incorporated into the terrestrial crust during the Hercynian orogeny.

A very characteristic feature is their thin foliation, produced by the mineral's disposition in layers, due to the high pressures they have suffered during the placement process.

[209] Appearance of the amphibolites outcropping in the Calzadilla Stream, near the village of Almadén de la Plata



[210] Detail of the amphibolites

12 Ancient Roman quarries of Los Covachos

The Cerro (hill) de Los Covachos is located about 1,000 meters north of the urban centre of Almadén de la Plata. Among other things of interest, this hill offers the possibility of seeing an ancient Roman marble quarry. During the Roman Age, the region of Almadén de la Plata was one of the main centres of marble production in Andalusia, of which the quarry of the Cerro de Los Covachos is an excellent example.

The remains of the front of extraction of blocks have been preserved after being covered by subsequent spoil, and no later extractive activity has been executed in this sector of the hill.

It is easy to see the channels surrounding the blocks, made using circular perforations with a pointer, until making the cavities where the wooden wedges were introduced and later wet, so when increasing its volume, it breaks the stones.

The marbles of this area are interspersed with clay and ferruginous enrichment, among other components. These factors provide marbles with layers of a great variety of colours, from red-pink, grey and even green, very appreciated in Roman times, and which was the most important in the Hispania Baetica province.

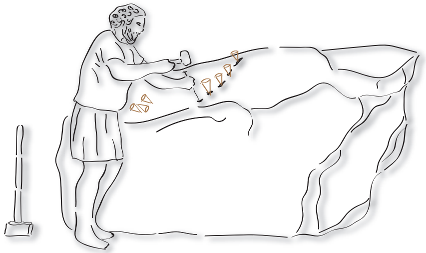


Fig.106 Extraction technique with wood wedges

Marble was used for the construction of architectural elements, sculptures and epigraphic supports in the Roman era of Augustus, during the first and second centuries B.C. The use of marble from Almadén de la Plata is documented in the cities located at the navigable Guadalquivir Basin, particularly in Italica, as well as in different parts of the Atlantic coast of the Baetica province and in North Africa. However, it was not finded along the Mediterranean coast. After being extracted, blocks were carried by the Roman roads until Naeva (Cantillana), where there was an important fluvial port of the Guadalquivir River. From that point, marble was distributed to Córdoba and Écija, and, of course, to the city of Italica (Santiponce).

[211] Panoramic view of the Roman quarry in Cerro de Los Covachos

[212] Extraction points and abandoned blocks

[213] Marks of tools at an extraction point

13 Cerro del Calvario Viewpoint

Difficulty of the geological concept MEDIUM

To the south of the village of Almadén de la Plata, in an extended band of rocks of about 15 kilometres long and less than 1 kilometre wide, outcrops a formation composed of a set of white schists and pale quartzites interspersed, derived from the metamorphism of clays and sands.

Some of the interspersed quartzite reaches a few metres thick, and due to their great hardness, creates the line of peaks with east-west orientation located to the south of the village: Loma del Puerto, Cerro del Calvario, Cerro Palomares, Cerro Montes, Cerro Traviesa and Cerro Gallego.

This geological unit is called "Pulo do Lobo Group" and it has been interpreted as "a accretionary prism or accretion complex", that is sediments located in a subduction area, of Lower-Middle Devonian age (420 to 380 Ma). Fine sediments from the seabed, and sandy layers from the nearby continent, are embedded when the oceanic crust located under these sediments pass under the continental crust. These sedimentary materials are subjected to great pressures and deformations. The pressures due to the depth they were subjected to and the large amount of accumulated materials, and the deformations due to the forces that cause the collision of the two continents. These is evidenced from the abundance of boudins of quartzites and stretched quartz veins, as well as the stretched alignment and foliation of the schists, further evidence of the intense longitudinal deformation suffered by these ancient sediments.

At this point can be seen the great morphological differences between the South Portuguese Zone and the Ossa-Morena Zone. From the southern viewpoint, we can see a very soft relief, with several abrasion surfaces of the South Portuguese Zone. From the northern viewpoint, we can observe the succession of mountain ranges and valleys conforming a more steep and irregular relief of the Ossa-Morena Zone, an Appalachian relief. These morphology differences are caused by the different types of rocks, which are more resistant to erosion in Ossa-Morena (generally marbles and limestones), as well as their rocks organisation.

TECTONIC SCHEME OF THE ACCRETIONARY PRISM

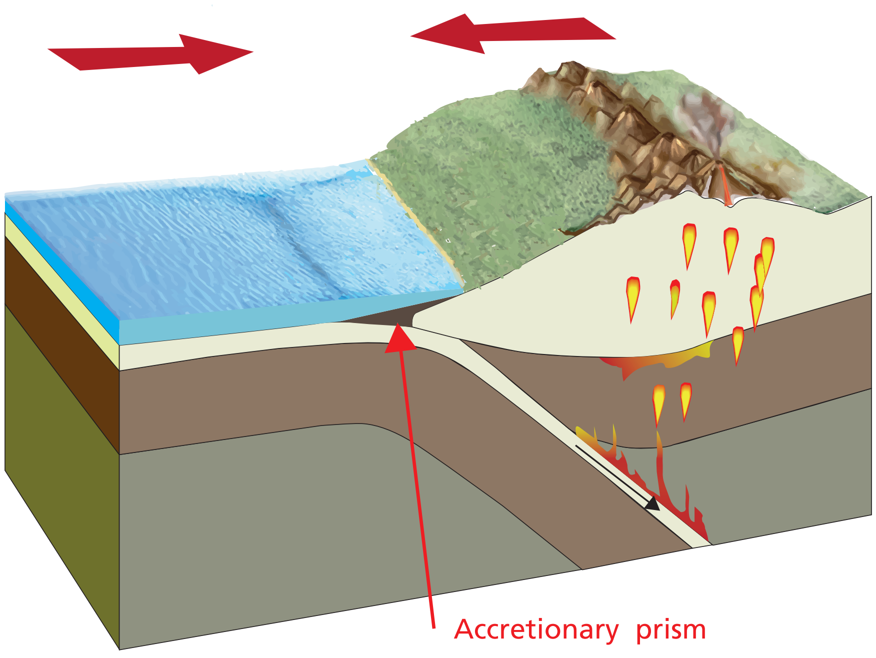


Fig.107 Tectonic scheme of the accretionary prism

[214] Level of quartzites that makes the mountain peaks

[215] Boudin of quartzite among schists

[216] Stretching lineament on of schists

14 Almadén de la Plata

Almadén de la Plata owes its name to the importance of the way of communication between the Guadalquivir valley and the Extremaduran plateau: the Vía de la Plata (the Silver Road). Phoenicians and Greeks took advantage of its marble richness, and it was with the Romans when it reached its peak, who called it Iluria, and the Arabs, who called it Al-Medin. Its urban nucleus, sheltered among hills, offers a morphology composed of houses aligned in rectilinear streets.

Almadén offers a journey through history. Los Covachos Cave offers numerous samples of cave paintings, engraved with the dominance of lines and cross hairs and schematic paintings with red dots and black lines, representing the first example of cave paintings in the province of Seville. In its surrounding areas, there are two dolmenic necropolises: Cañalazarca and Castillejos.

The castle was built in the Muslim period, during the 14th Century. The Town Hall has been erected among its remains. The town was built in its shadow, over the remains of a Roman fortification probably built to protect a mine located at the place where the Church of Santa María de Gracia is located today.

[217] Panoramic view of the urban nucleus of Almadén de la Plata

[218] Milestone of Camino de Santiago (Way of St. James)

[219] Bell tower of the Church of Santa María de Gracia

This church dates to the late sixteenth and early seventeenth centuries. It was built, among others, by the renowned Vermondo Resta and Hernán Ruiz II. The ancient municipal offices, an old hospital from the 15th century, renovated in the 17th century as a hermitage, has a tower of Neo-Mudejar inspiration that was added in 1905, with a square sole with a clock on the top. This is why this building is called Torre del Reloj (Clock Tower), in which a panoramic viewpoint is installed.

The Mozarabic Way to Santiago de Compostela passes through this village.

The Viewpoint of Cerro El Calvario is another point where you can enjoy an interesting panorama of the town and its surroundings.

Among the typical dishes that you can taste in Almadén de La Plata, the most notable are meats from local fauna, migas and Almadén soup, a very ancient recipe that it is usually cooked after a pig slaughter. The main ingredients are vegetables and different parts of the Iberian pigs, or mushrooms in Autumn. Confectionery is also special, pastries such as the hornazo melojero, melojas, pestiños, boyas, gañores, virutas or buñuelos should be tasted.

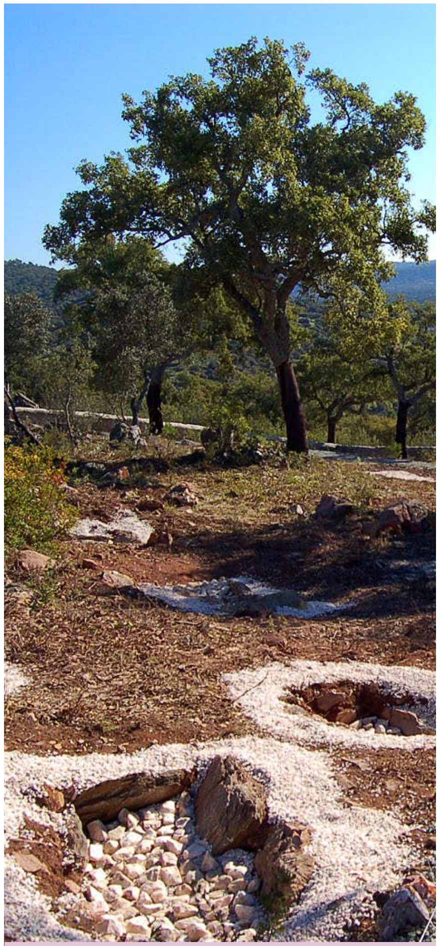
Particularly, and linked to industrial tourism, special mention should be drawn to the Oil Museum, which offers a surprising exhibition of the machinery of a mid-twentieth-century olive press. In addition, other events of interest to tourists are the Ham Fair, an exhibition and tasting of the typical products of the town and the region. It is held during the second or third week of March. There is also the Hunting Fair, which takes place in the last week of September or first week of October.

[220] Clock Tower

15 La Traviesa Necropolis

To the west of the village of Almadén de la Plata, La Traviesa Necropolis can be visited, located at the public forest of the same name, among cork oak pastures. It was discovered in 1986 and excavated in 1992 and 1993. It is one of the largest necropolises from the Bronze Age discovered in southwestern Spain, from between 2,250 to 1,000 B.C. It is composed of a total of 29 burials in cists. A cist (from the Greek: κίστη, chest or box) is an individual megalithic funeral monument, of small dimensions. It is composed of a four-sided grave covered with slabs (plain stones) vertically placed and coated by several slabs, thus forming a chamber, where a person was placed in the foetal position.

The topographical layout of the burials in La Traviesa has a peculiar pattern, since 28 of the burials are arranged in a semicircle around a main burial located at a higher level and of larger dimensions, in a tumulus structure. A bronze halberd was found in this cist, making this burial even more different from the rest, only containing ceramic bowls. It is considered to correspond to a person of the highest social status, identifying him as the military leader of the community due to its funerary offerings.



[221] View of a part of the necropolis

[222] One of the cists

16 Rocky Area of El Real de la Jara

Difficulty of the geological concept LOW

Beautiful rocky landscapes can be found in El Real de la Jara municipality. They are shaped on granites very rich in silica: granodiorites and tonalites. They are part of an extensive plutonic batholith of more than 100 km² of surface and semi-circular form that extends from the neighbouring village of Cala, in Huelva, to here. It is called Cala Batolith and it was set 332 million years ago between slate and volcanic sedimentary units, and producing an intense contact metamorphism.

The weathering of granite, exposed for more than 300 Ma to the action of atmospheric agents, and favoured by its intense degree of fracture and jointing, has given rise to a rocky landscape, although it has greatly evolved due to the high erosion of rocks and intense human action, so that now, the most common elements are the granitic flat outcrops and sandy valleys. * See page 72.

There are several morphologies of alteration of the granite rocks; rocky areas, boulder rock fields and piles of loose stones ("majanos") made by humans for the creation of grasslands and cultivable lands.

[223] View of the rocky area

[224] Piles of loose stones ("majano")

17 Old marble quarries of El Real de la Jara

In the vicinity of the urban area of El Real de la Jara, on the western side of the industrial estate of La Encina, there are several quarries of marble limestones, which were used in the Middle Ages for the extraction of the stone blocks that were used in the construction of El Real de la Jara Castle. They are in a small mountain range constituted by an alignment of marble limestones, very similar in its petrological characteristics to the Lower Cambrian limestones existing in other areas of Sierra Norte. These limestones are inside the aureole of the Cala Batholit, so they were affected by a contact metamorphism: they were recrystallized and partially replaced by silicate minerals, mainly amphiboles.

[225] General aspect of the quarry fronts

[226] One of the quarry fronts

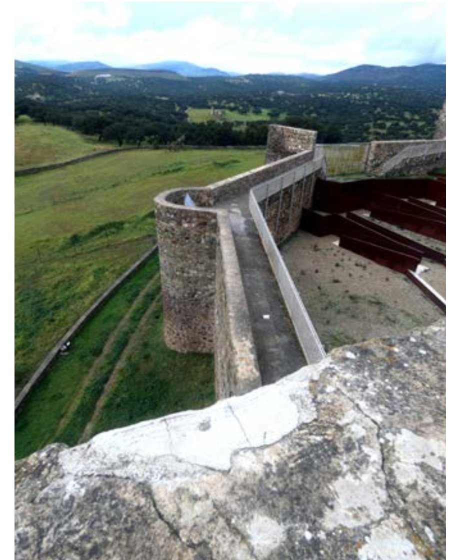
18 El Real de la Jara

The Romans turned El Real de la Jara into a stable settlement and fortified it. It was enlarged by the Arabs, who called it Xara, reaching great importance during the Almohad period, when it was emancipated from the Caliphate of Cordoba.

The urban area, formed by a web of streets with whitewashed houses, offers the visitor a beautiful historical and artistic heritage. It features buildings such as the castle, erected at the end of the 14th Century, from where its viewpoint can be seen the landscape of three provinces: Badajoz, Huelva and Seville. There is also Las Torres Castle, from the same period, the Hermitage of Nuestra Señora de los Remedios and the Parish Church of San Bartolomé. This church was built in Mudejar style, and is home to the painting *Las Ánimas*, attributed to Zurbarán.

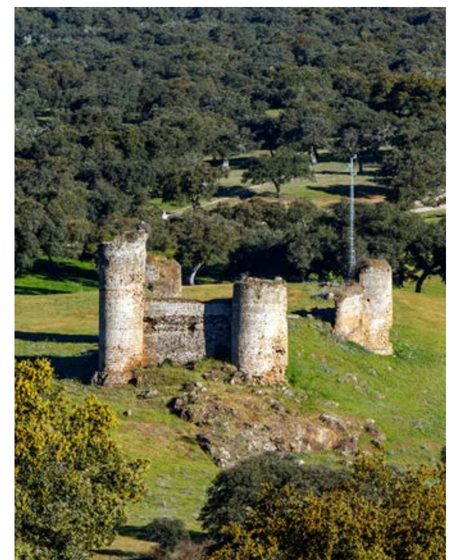
Its municipal district offers panoramic views of great scenic interest from viewpoints such as La Padrona, Puerto Quejigo and La Loba.

Typical dishes of the traditional cuisine are burdock root and bean stew, asparagus with eggs and "Caldillo". Goat cheese, elaborated in the traditional way, is also very appreciated.



[229] One of the walls of the castle

[227] Parish Church of San Bartolomé



[228] Las Torres Castle

[230] Panoramic view of the urban area from the castle

ROUTE 2
CAZALLA DE LA SIERRA - SAN NICOLÁS DEL PUERTO – ALANÍS - GUADALCANAL

This route takes us through the heart of the Geopark and its northernmost sector. It crosses over the sedimentary units of the Capas de Campoallá, the Capas de Benalija and the Loma del Aire Unit, and on a special plutonic rock. It is close to the places of greatest geological, landscape and tourist interest, the Natural Monuments of Cerro del Hierro and Huesna Waterfalls, and the Green Way of the Cerro del Hierro.

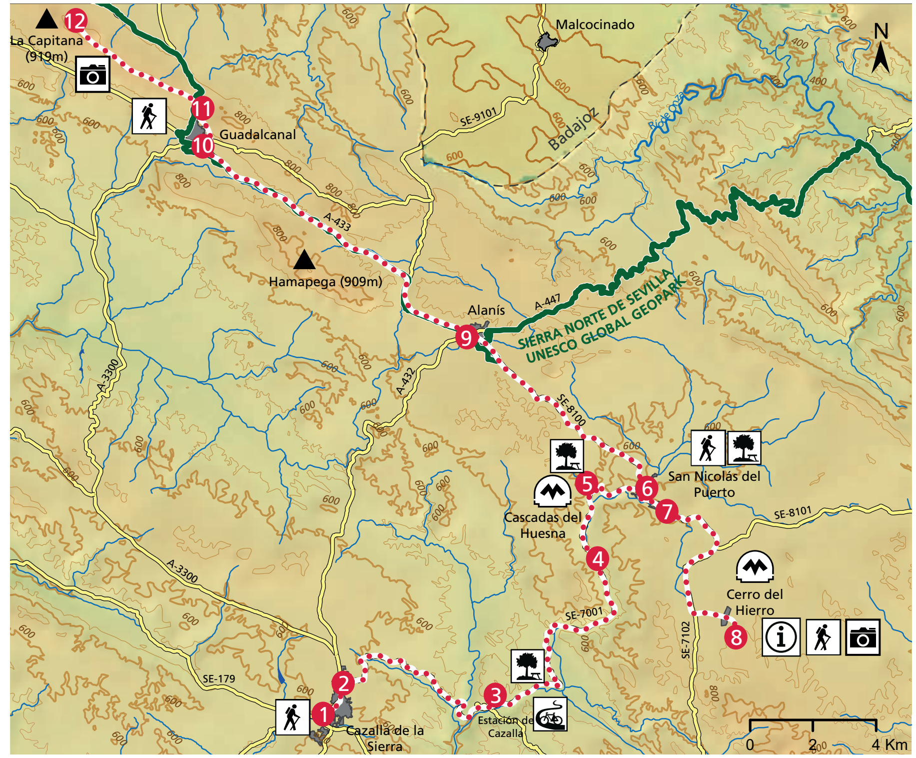
General data

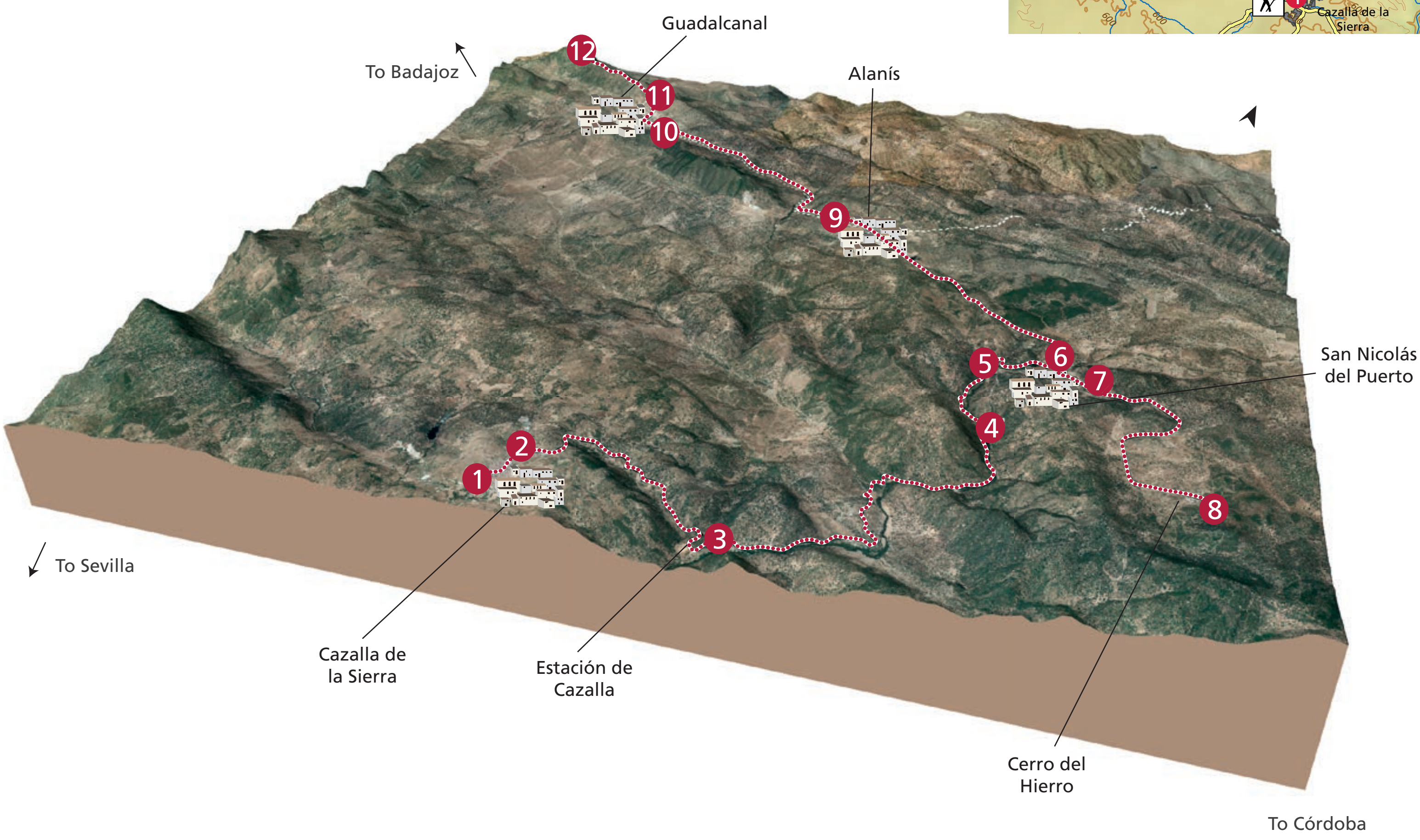
54,7 km | 6 hours | Linear

Also suitable for:

Public Equipment

Visitor Center | Information point | Natural Monument | Viewpoint | Path | Cycle route | Recreational area





1 Diorite of Cazalla de la Sierra

Difficulty of the geological concept: LOW

The route begins in the village of Cazalla de la Sierra where outcrops a special igneous rock that extends from the urban area to the northwest. It is a small diorite pluton, an intrusive igneous rock similar to granite, but of intermediate composition: less acid (with less quartz), and a greater proportion of dark minerals; amphiboles and pyroxenes. This pluton fits within the rocks of the Capas de Campoallá Formation, of Lower Cambrian period, in this area, a set of limestones and carbonated shales. The best diorite outcrops can be seen around El Judío Fountain, at the exit of Cazalla de la Sierra on the road to El Real de la Jara, and on the path to El Sotillo Reservoir.

In the southern limit of the pluton, abundant dikes of aplites are located. They are rich in feldspar, a mineral which is currently exploited for its quality for the manufacture of bathroom equipment and other products.

[231] Rocky area in the diorite, in the area of El Judío Fountain

[232] Detail of the diorite

2 Cazalla de la Sierra: the land of anisette

The mythical Cazalla de la Sierra, the Roman *Callentum* and the Muslim *Castalla*, arose around a defensive point on the edge of the old road connecting Castile and Andalusia. It belonged for several centuries to the Council of Seville and became one of the strongholds that defended its Kingdom from Portuguese attacks. The population reached its splendour in the 16th and 17th Centuries, becoming the residence of Philip V in the beginning of 18th Century.

The most interesting monuments are the remains of the castle, in which there are Almohad elements (13th Century) and others from the Christian period (14th Century). There is also the Church of Nuestra Señora de la Consolación, and the Cartuja, all of which have been declared Historic-Artistic Monuments. Within the urban enclosure, a group of houses of artistic interest is conserved. The oldest ones date back to the 16th Century, but the most numerous are from the Baroque period, especially from the 18th Century.

Cazalla de la Sierra was an important wine producing centre, becoming the main exporter of this product to the New World (America), whose fame was immortalised in works by Cervantes, Lope de Vega and Mateo Alemán. The loss of importance of the region's wine was compensated in the 20th Century by the marketing of liquors. It had up to fifteen factories dedicated to the production of spirits, of which only two survive: El Clavel and Miura, whose distilleries can be visited. Such was the prestige and diffusion of the product that in many places in Spain people gave the liquor the generic name of "Cazalla". Nowadays, this municipality and the neighbouring municipalities form the Protected Designation of Origin Wines of Sierra Norte de Sevilla.

The Centre of Spirits in Cazalla de la Sierra has exhibitions that teach the history of making wine and spirits. It has a shop where you can buy its famous products.

In the first week of December the Festival of Ancient Music of the province is celebrated here.

[233] Panoramic view of the urban area of Cazalla de la Sierra

[234] Panoramic view of the Church of Nuestra Señora de la Consolación

[236] Signpost of a distillery

[235] One of the streets of the town

3 Isla Margarita Recreational Area and Hang Forest Park

Protected by a lush riverside forest and embraced by two arms of the Rivera del Huéznar, Isla Margarita Recreational Area invites visitors to rest and enjoy the sound of the rumour water, the songs of the birds or the wind in the ash and alder trees.

In addition to beautiful riverside vegetation, its Recreational Area offers parking, tables and benches, barbecue grills, bicycle parking, toilets and a kiosk-bar. Close to this is the beginning of the Green Way. Here you can take a quick breather and do this route on bicycle or walking.

It also has an interesting and funny Hang Forest Park with adventure circuits, climbing walls, zip wires and other elements that will delight adults and children.

[237] Image of the Hang Forest Park

[238] Signpost

[239] Detail of the Hang Forest Park

4 Capas de Campoallá Formation

Difficulty of the geological concept **MEDIUM**

The geological substratum of the north-eastern sector of the Geopark is made up of the Capas de Campoallá Formation, a stratigraphic unit from the Lower Cambrian period, shaped of slate, sandstone and limestone, originally clays, sands and calcareous muds, deposited in a wide and shallow marine basin.

This sedimentary formation usually presents an appearance of an alternating sequence of strata, with a thickness ranging from centimetres to meters. Sometimes, only one of the rocks appears, or two or the three rocks appear in variable proportions, with a very significant increase in the calcareous levels towards the upper part of the formation, until forming a section of massive limestone that usually form the upper area of hills and mountain ranges, given their high resistance to erosion.

The intense tectonics suffered by these materials is recognised in the multitude of visible structures, such as fractures and joints, fault breccias or folds. Despite the deformation suffered, a great variety of sedimentary structures are also visible, such as ripples, crossed and horizontal stratifications, laminations and algal meshes.

Good outcrops can be seen in the slopes of the Green Way of Sierra Norte de Sevilla and in Las Laderas Path. You can access the Green Way from the road between Cazalla de la Sierra and San Nicolás del Puerto, or from the latter village. Las Laderas Path starts from the village of Cazalla de la Sierra and can be accessed from the Recreational Area Molino del Corcho, in Rivera del Huéznar river.

[240] Normal outcrop of Capas de Campoallá Formation

[241] Ripples and joints on the surface of a layer

5 Huéznar Waterfalls

Difficulty of the geological concept LOW

The Natural Monument of Huéznar Waterfalls is located downstream of the source of Rivera del Huéznar. In this area, the river is divided in two branches: on the left, there are two higher waterfalls, called Chorrera Grande and Chorrera del Moro; and on the right, there is a group of smaller waterfalls known as Las Chorreritas.

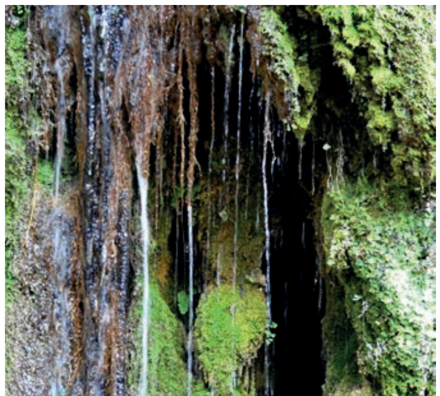
The origin of the waterfalls is due to the existence in the subsoil of several vertical faults, provoking slopes in the terrain. The topographic arise of the Huéznar Waterfalls has been related to the rejuvenation, during the Alpine Orogeny, of the relief of the southern edge of Sierra Morena, through the reactivation of old Variscan fractures.

The waters of the river have produced, and continue producing currently, large deposits of travertines or calcareous tuffs. They form levels that in some cases can exceed 15 m of thickness. The oldest ones are located at the highest topographic levels without any connection to the current channels. They constitute hanging terraces, showing the setting processes and variation in the river's trajectory. * *See page 51.*

The formation of these characteristic rocks is linked to the deposit of dissolved calcium carbonate carried by groundwaters. Its dissolution or precipitation depends on the concentration of carbon dioxide and environmental conditions. This precipitation process is favoured in the waterfalls by the loss of water pressure.

This precipitation is produced over the rocks located at the bottom of the river and over the leaves, stems and branches of the surrounding vegetation. As time passes, the organic matter decompose, leaving the holes with the initial shape.

[242] Chorrera Grande



[243] Travertines in formation

[244] A section of Las Chorreritas

FORMATION AND EVOLUTION OF THE HUÉZNAR WATERFALLS AND TRAVERTINES

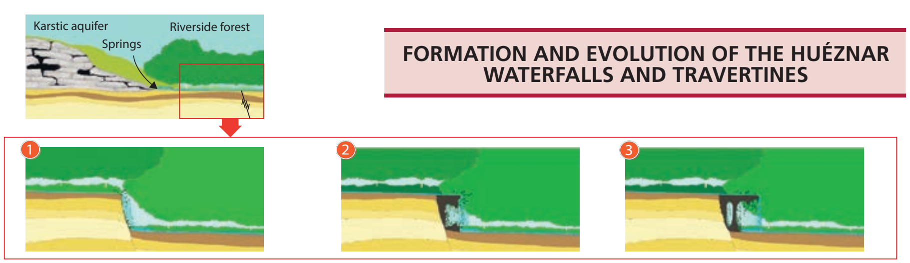


Fig.111 Formation and evolution of the Huéznar Waterfalls and travertines

OUTLINE OF THE OPERATION OF THE HUÉZNAR WATERFALLS

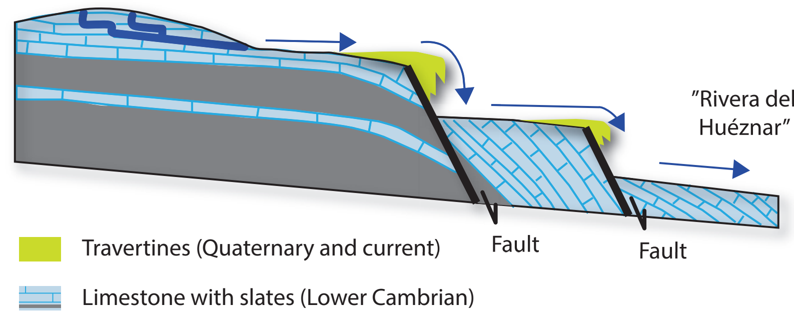


Fig.112 Outline of the operation of the Huéznar waterfalls

6 San Nicolás del Puerto: the source of Rivera del Huéznar

The source of Rivera del Huéznar, one of the largest rivers in the Geopark, is located, in the village of San Nicolás del Puerto, in an extraordinary place surrounded by a gallery forest of ash trees and poplars.

Los Parrales Stream, another river course, is slowed down in the village and next to the Roman / Medieval bridge was built a dam to retain the water during summer. This is how the "San Nicolás Beach" was created, a very familiar, pleasant and well-known meeting point in these mountain ranges.

The village centre of San Nicolás del Puerto, with simple and traditional architecture, forms a harmonious and peaceful ensemble with its surroundings. The Romans left their peculiar mark in this place, which is witnessed today, thanks to the important vestiges left by them. The most important ones are the stone bridge, located over Los Parrales Stream, although its current appearance is due to medieval modifications.

The Arabs were the authors of the local progress. The great fortress was built at the time of the Muslim king Aznnar Benajaque. The remains of the fortress - one of its towers in particular - serve as a testament to that period.

[245] Roman / Medieval bridge over Los Parrales Stream

The most outstanding elements of its monumental heritage are the Church of San Sebastián, a Mudejar building with a single transept and simple exterior and the Hermitage of San Diego, also of the Mudejar style, the two from the 15^{th} and 16^{th} Centuries.

It is also important to highlight the stone Calvary crosslocated at the exit of the village, dating back to the 16th Century and assembled on a Corinthian column.

In addition to the hunted animals and cured meats of Iberian pig, its gastronomy is also notable for the beans with partridge and cod in sauce. Sweets from San Nicolás del Puerto, scented with cinnamon and almonds, are famous throughout the region of Sierra Norte de Sevilla. Many of them are elaborated with the excellent honey of the region.

[246] Panoramic view of the village centre

7 Source of Rivera del Huéznar

Difficulty of the geological concept LOW

The Rivera del Huéznar, a tributary of the Guadalquivir River, that flows permanently throughout the year, starts in a karstic upwelling located in the village of San Nicolás del Puerto, called the Borbollón. It is the main natural discharge zone of the “Guadalcanal - San Nicolás” underground aquifer and the widest spring in the province of Seville.

The aquifer is constituted on the massive limestones of the Capas de Campoallá Formation, with a high level of karstification. Its main water refill area is the karst of Cerro del Hierro.

The Borbollón is located at the tectonic contact point, by several faults, between the limestones that constitute the underground aquifer, and some slates located over the limestones that are much less permeable. An interpretative panel explains the geology of this beautiful source.

The faults make possible a way for water, which arises from several points, though most of the water discharge is concentrated in two pools. The average total flow of the spring is 150 litres per second, with maximum flows of 500 litres per second. Only on rare occasions has it dried up due to long periods of drought.

[247] Drainage canal of the pool

[248] Carbonic acid bubbles

[249] One of the pools in the source

8 A very special karst: Cerro del Hierro

Difficulty of the geological concept LOW

Cerro del Hierro, a unique site declared Natural Monument, is located about 5 km south of San Nicolás del Puerto. Nature and history combined to build this beautiful spot, a spectacular karst modelled on Cambrian limestones, and dug out by iron mining operations, which date back to Roman times, and maintained their discontinuous activity until the end of the 20th Century. Its amazing geological landscape is formed over a labyrinth of rock forms where at first glance, we can identify some karst forms such as pinnacles, buttes, chasms, narrow alleys, sinkholes and large karrens, geological formations on which the infrastructures built by mining exploitation are overlapped, such as the platforms for accumulated material, tunnels and paths for mineral extraction.

By itself, Cerro del Hierro is a great example of paleokarst (an ancient karst buried by younger rocks), modelled on a set of Cambrian limestones, corresponding to the higher levels of the “Capas de Campoallá” sedimentary unit, interspersed between Cambrian slates.

The formation of this impressive rocky massif is mainly due to a group of living beings called stromatolites. They are important because they constitute one of the first fossil evidences of life (from around 3,500 Ma till today that exist in different parts of our planet); although in Cerro del Hierro there were other life forms such as archaeocyathids (sponges). * *See page 66*.

Stromatolites are a microbial benthic community: microscopic living beings that lived on the seabed, with an organised structure composed of cyanobacteria, heterotrophic and chemolyotrophic bacteria that trap and fix the sediment or produce mineral precipitation.

Cerro del Hierro was located on a shallow marine platform close to the coast, due that cyanobacteria need a certain amount of light to perform photosynthesis. These cyanobacteria generate the organic matter on which heterotrophic bacteria feed. In some parts, conditions are meet for the development of chemolyotrophic bacteria, which will continue helping to trap and fix the sediment, as well as the mineral precipitation. This causes the growth, compaction and foundation of the stromatolite, which over time, produces a sedimentary rock.

This process took place for thousands of years, given that the thickness of the limestone set of Cerro del Hierro reaches several dozens of meters, adding, among other minerals, iron inside the layers, which was extracted during the mining exploitation.

Subsequent to this deposit and during the Lower Cambrian period (541-521 Ma), limestones emerge over sea surface and the karstification process begins, in a region close to the equator. This characteristic makes Cerro del Hierro a different karst: a tropical paleokarst with the development of large karrens (macro karrens). This favoured the transformation of the primary iron minerals into oxides and hydroxides, which were concentrated as a filling in the karst cavities: narrow alleys, caves and galleries. At the same time, they formed a red soil enriched with iron.
* *See pages 33 and 74*.

At the end of the Cambrian period, the area was submerged again, but this time deeper. Since then, a detrital sedimentation dominated, causing the deposit of great thicknesses of slates, with fossil fauna of well-preserved trilobites.

This submerged state continued until the Upper Devonian-Lower Carboniferous period, the most decisive period of the Variscan orogen. During this era, most of the folding, fractures and lifting occurred, producing a thermal metamorphism of the limestone. This resulted in the emersion of the entire region. The karstification was reactivated and is still active today.

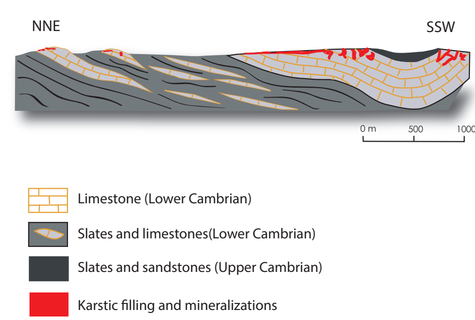


Fig.113 Geological cross-section with the tectonic structure of Cerro del Hierro

The most intense exploitation of Cerro del Hierro took place during the 19th and 20th Centuries. In 1872, the company El Pedroso Mines, founded in 1817, applied for the first time to exploit Cerro del Hierro. Due to difficulties establishing a railway line, they were not able to compete with the foundries of northern Spain. As a result, the company El Pedroso closed in 1884, selling the rights of Monte del Hierro (Cerro del Hierro) to pay creditors a few years later in 1893. These rights were then transferred to the Scottish company William Bairds Mining and Co. Ltd., from Glasgow, which started the exploitation in 1895. Almost all the constructions and branches we can see today, were made by this company between the late 19th Century and early 20th Century. In 1946, the exploitation passed to Spanish hands, to the company Nueva Montaña Quijano, and subsequently, in 1972, to the company Cerro del Hierro S.A. In the early 1980's, barite was exploited by a cooperative constituted by the workers, but exploitation ceased at the end of the 1980's, and since then, no mining activity has been conducted.

Iron was open-pit exploited. In the landscape, several cuts of different dimensions can be observed, with up to five levels of grading. The tunnels that can be seen today are basically for the paths used by the carts to extract the mineral from the mining area. In 1899, the 15 kilometre railway branch started its activity, and joining to Seville-Mérida line. This facilitated the connection with the port of Seville, where the mineral was shipped to Glasgow. The English architecture in the village of Cerro del Hierro remains from that period, including the church and houses of the engineers, which are called the Houses of the Englishmen.

GEOLOGICAL HISTORY OF CERRO DEL HIERRO ÁREA

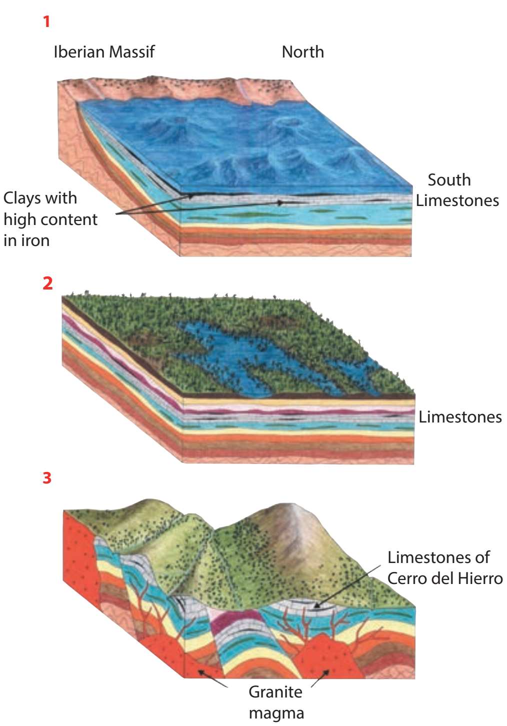


Fig.114 Geological history of Cerro del Hierro área

EVOLUTION OF KARSTIFICATION AND MINERY IN CERRO DEL HIERRO

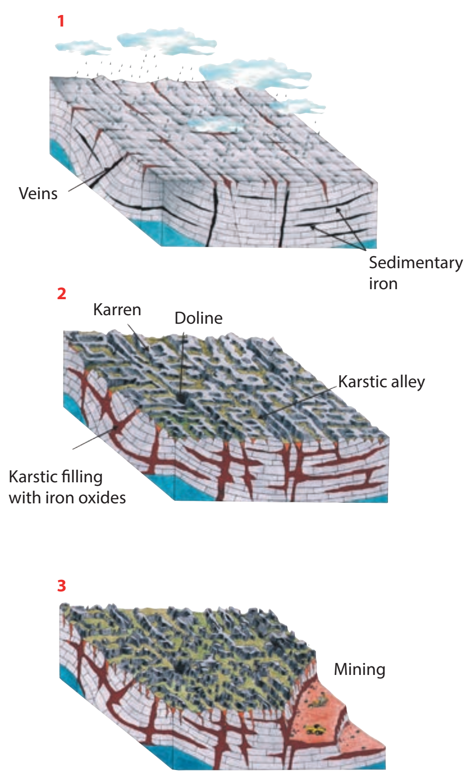
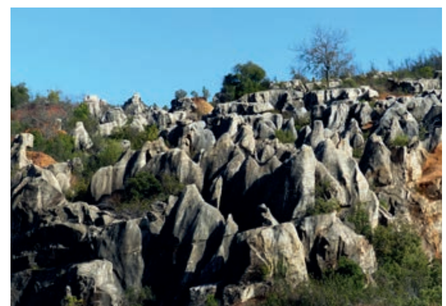


Fig.115 Evolution of karstification and minery in Cerro del Hierro

[250] Aerial photograph of Cerro del Hierro area

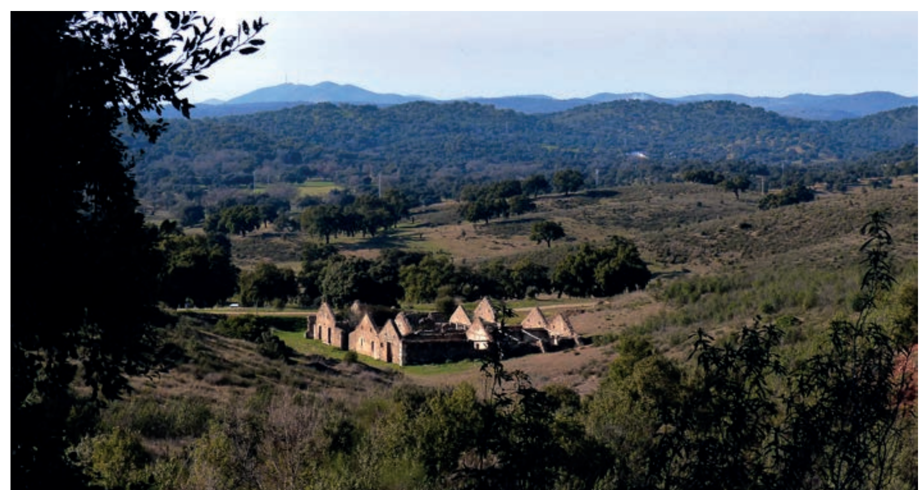
[251] Macro karrens of Calizas Chicas

[252] Gallery



[253] Limestone karrens in Cerro del Hierro Path

[254] Pinnacles



[255] Panoramic view of mining facilities ruins

CERRO DEL HIERRO INFORMATION POINT

Some architectural vestiges of interest remain from the extraction period conducted by William Bairds Mining and Co. Ltd., such as the English architecture of the Cerro del Hierro village, the stables, stations, garages, loading docks, as well as the church and the houses of the engineers. The Cerro del Hierro Information Point is located in one of these "Houses of the Englishmen", which offers very interesting information about the geological origin of the Cerro, its mining history, its biodiversity as well as the possibilities that this singular Natural Monument and the Geopark offer in general.

The visit to the Information Point is free, and you can access useful information to contact local active tourism companies and even rent bicycles directly.

The establishment is adapted for people with reduced mobility.

[256] Information point

[257] Information point

9 Alanís: the enchanted castle

The current urban structure has a star shape as the urban area is located at the junction of three important roads.

The monumental and artistic catalogue of the village starts with the remains of the medieval castle. After being rebuilt by the French during the reign of King Joseph I, it was blown up by the Gallic detachment when leaving the place before surrendering. Among the religious architecture, there are jewels such as the 14th Century Church of Nuestra Señora de las Nieves, and the chapel of Jesus of Nazareth, from the late 19th Century, the hermitage of Nuestra Señora de las Angustias and the Hermitage of San Juan Evangelista.

It is said that the castle and the hermitage are haunted, and that the Moriscan Acsia shows up in there. The legend contributes to reinforce the theory that the town is full of underground passages leading to the castle.

A no-less-important religious construction is the recognisable remains of the former Monastery of San Miguel de la Breña, founded by Basilian monks committed to spiritual retreat. Its existence has been documented since 1667, and its activity lasted until 1788. It suffered irreparable damage by the French when passing through Sierra Morena in 1810. The Spanish confiscation in 1835 resulted that the monastery's lands and facilities were progressively passed into individuals' hands, which made transformations to adapt the complex to the new farming functions.

There is one curious feature that is known in Alanís as "Alberca del Huevo" (The Egg Pond), a large oval-shaped pond that exists about five hundred metres from the complex, following a path.

[258] Panoramic view of the urban area from the Castle

[259] Roundabout at the entrance of the urban area

[260] Castle and Hermitage of San Juan

BANDA GALLEGA (GALICIAN BELT)

Banda Gallega is the name that was historically used to refer to a large part of the current Sierra de Aracena and Sierra Norte de Sevilla, after they were conquered by the Christian Monarchs as a defensive belt. This denomination was due to the repopulation of these lands by Galicians and Leonese people after the expulsion of the Muslims, in parallel with the so-called Moriscan Band, referring to the border zone with the Kingdom of Portugal.

The Castle of Alanís is part of the group of military fortifications of the Banda Gallega. It forms the northern frontier of the Kingdom of Seville during the Middle Ages. It extended to the border castles with Portugal all over the north of the Sevillian villages, bordering with the lands of the Order of Santiago.

[261] Galician Belt

10 Guadalcanal: the city of silver

Its current name comes directly from the *Arabic Guad al-Kanal* ("river of the canal").

On the route through the natural environment of Guadalcanal, the viewpoint in Sierra del Viento is a must-see: La Capitana viewpoint. On the dividing line between Andalusia and Extremadura, this viewpoint offers marvellous views of Sierra Norte de Sevilla, to the south and west, and of the countryside of Badajoz to the north and east. There is interpreted information at the panoramic views. This viewpoint can be reached via the signposted path of Sierra del Viento.

Due to its strategic geographical location, it was a very fortified city. Remains of the castle and medieval walls can still be found. In 1241, Guadalcanal was reconquered by the knights of the Order of Santiago, turning it into a main frontier bastion of the Sierra Norte de Sevilla.

In the middle of the 16th Century "Pozo Rico" (rich hole) silver deposits were discovered. These are mines that produced silver of great quality, surpassing the mines of New Spain during its first years of exploitation.

The historical heritage of the village is represented by the Church of Santa María de la Asunción, a Gothic-Mudejar building built from remains of an Almohad canvas wall that constitutes the north wall of the church, built in the 14th Century. Works carried out in the 16th Century are added to the magnificent rectangular five-body brick tower on an Almohad base. The Church of Santa Ana was built in the Mudejar style in the late 15th and early 16th Centuries, and with a single nave. The Hermitage of San Benito was built in the baroque style in the second half of the 17th Century. The Church of La Concepción dates back to the first quarter of the 17th Century. It is made of brick and has a single nave covered with a half-barrel vault. Finally, the Church of San Vicente dates back to the 18th Century, and features a Latin cross floor plan.

[262] Panoramic view of the urban area from Sierra del Viento

[263] Church of Santa Ana

POZO RICO: GUADALCANAL'S SILVER

Mining in Guadalcanal, as in other parts of the Geopark, dates back to ancient times, as evidenced by the mine locally known as San Francisco Cave or Potosí, in which there was a period of exploitation during Roman times and in the 19th Century.

But the most important mine in Guadalcanal was discovered in 1555 by a citizen of this village, Martín Delgado. Once exploitation began, news of the discovery did not take long to reach the court of Valladolid, whose declined vaults were waiting for a stroke of luck of this nature. Therefore, they immediately contacted the governor of Llerena, the highest royal authority in the area, commissioning him with the royal collection of the fifth part of the production, which was surprisingly rich in its beginning, so much so that the crown gave orders to expropriate the mines in 1559. It was the first nationalisation of a company, giving way to the Royal Mining Enterprise of Guadalcanal.

By 1559, more than 1,200 workers worked in the silver mines.

Thus, a new village in Guadalcanal was born, but subjected to royal jurisdiction by express desire of the crown, thus eliminating any possible local interference in the affairs of the mine. At that time, the importance of the silver mines of Guadalcanal was such that the daily postal between the court of Valladolid and Seville, which was the most important and richest city of the empire at that time, was modified to include Guadalcanal in its route.

But the boom didn't last long, just enough for the best technological inventions known at the time to become inadequate due to the depths involved with the extraction tasks and the water that invaded them.

These circumstances, plus the decreasing wealth earned from the extracted mineral, which was already critical around 1570, was accentuated in 1576 due to the general sinking of the holes, after a period of heavy rains. Works ceased, and machines and workers moved to the mercury mines in Almadén (Ciudad Real).

In 1725, the subject of the Swedish Monarchy, Liberto Wolters, obtained a licence to exploit the mines of Guadalcanal for thirty years, as well as the mines of Cazalla, Riotinto, Aracena and Galaroza. To this end, he set up a mining company, which was soon divided into two: one for Guadalcanal and the other for Riotinto.

In 1767, the licence was transferred to Thomas Sutton, who established the Guadalcanal Company in Paris, which would also go bankrupt and would force to transfer the rights to a new French company, which also closed its exploitation in 1778.

But neither time nor continuous failures managed to erase the mythology of Guadalcanal. In 1847, a new mining company, The Guadalcanal Silver Mining Association, was constituted in London, and resumed work again until 1850.

Just the last century, there were two attempts to reopen the mine: the first in 1911, which was interrupted at the onset of World War I without obtaining positive results; the second in 1919, by Pozo Rico Company and the Spanish Copper Company, which also quickly exhausted their budgets before earning profits.

[264] Iglesia de Santa M. Asunción

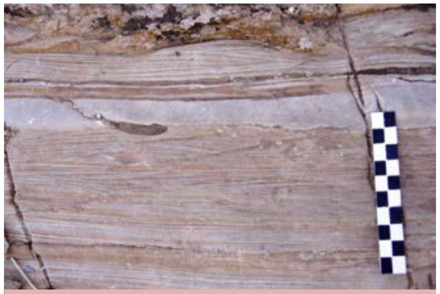
11 Guadalcanal marbled limestones

Difficulty of the geological concept MEDIUM

Sierra del Viento, located to the north of the village of Guadalcanal, constitutes the northern limit of the Sierra Norte de Sevilla Geopark. It is the highest mountain range in the area and separates the hydrographic basins of two rivers: to the north, the Bembézar Basin and to the south, the Viar Basin.

This mountain range is constituted of marbled limestones of clear colours, bio-constructed by algal meshes, recrystallized and with terrigenous quartz and levels with abundant phyllosilicates. These marbled limestones can be matched with the massive limestones of the upper section of Capas de Campoallá Formation, which outcrops in this region of the Ossa-Morena Zone, or they can be interpreted as a lateral equivalent of the Malcocinado Formation, characterised by an important development of limestones.

[265] Outcrop of marble limestones



[266] Detail of marble limestones

12 Cerro La Capitana Viewpoint

Difficulty of the geological concept LOW

The signposted path of Sierra del Viento is located one kilometre from the exit of the village of Guadalcanal, following the A-433 road toward Fuente del Arco, and after a distance of almost five kilometres, leads to Cerro La Capitana. This high point, the tallest peak of the Geopark, 952 metres above sea level, is a splendid natural viewpoint with views of the depressions, mountains ranges and elevations located to the southwest of this mountain range, which reflect the distinguishing erosion caused by the presence of rocks with different susceptibility to erosion. To the northeast, we can observe the plain of Extremadura between Llerena and Azuaga.

A recreation of an old construction known in the area as "torruca" is located at the top of the hill, with a round base and dome roof, whose uses have been quite varied, from permanent or temporary housing for shepherds, farmers, day laborers, guards and miners, to its use as a refuge and shelter next to roads, paths and tracks.

In Guadalcanal and Alanís, it is frequent to see torrucas next to grain threshing floors, and are used for protection both from the summer rains and the heat of the day, and from the cold and the rains of the winter.

[267] Torruca and explanatory panel

[268] Signposting of the Sierra del Viento Path

ROUTE 3

EL PEDROSO – CONSTANTINA - LAS NAVAS DE LA CONCEPCIÓN - PUEBLA DE LOS INFANTES

This route starts in El Pedroso Batholith rocky area and runs eastwards through the eastern and south-eastern sector of the Geopark, over the sedimentary units of Capas de Campoallá Formation and Torreárboles Formation. In the surrounding areas of El Retortillo Reservoir, the road crosses outcrops of fluvial and alluvial filling of a small post-orogenic intra mountanious basin, with deposits of detrital materials.

The route stops at sites associated with the fluvial dynamics and the historical use of water in the Geopark in the riverbanks of Rivera de Ciudadeja. In El Pedroso, its glorious mining past is still recognised. Constantina is the place of a Visitor's Centre and El Robledo Botanical Garden is an essential visit.

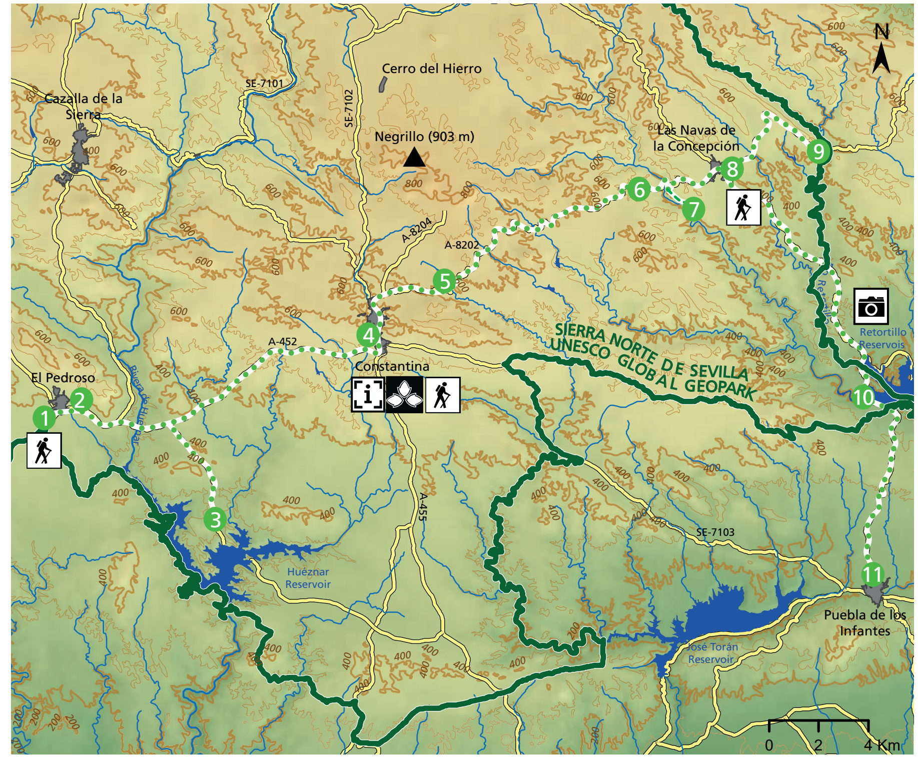
General data

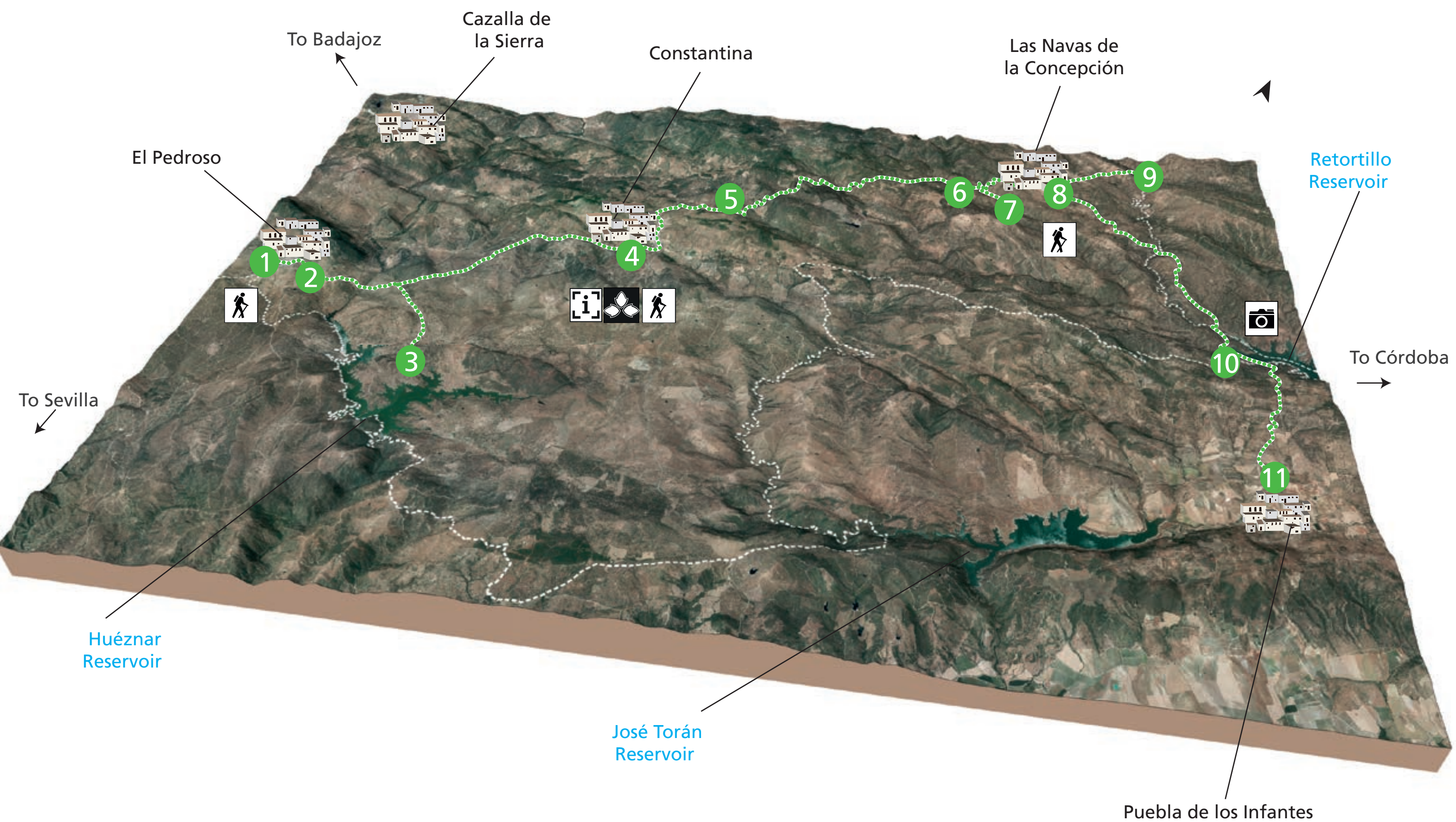
68 km | 8 hours | Linear

Also suitable for: cycling, walking

Public Equipment

Visitor Center | Viewpoint | Path | Cycle route | Recreational area | Botanical garden





1 Rocky Area of El Pedroso

Difficulty of the geological concept: LOW

El Pedroso Batholith is a granitic pluton of a great extension, with more than 150 km² of surface area, oriented in a northwest-southeast direction towards the central zone of the Geopark.

The diverse composition of the batholith's granitic rocks has influenced the degree of weathering suffered, generating large sandy valleys in the western part, with a large development of soils and rare outcrops of intact rock. However, in the eastern part, their composition makes them more resistant to chemical alteration, offering the characteristic landscape of a *berrocal* (rocky area), consisting of soft reliefs, with sandy soils, on which flat stones, knigth rocks, piles of boulders and other whimsical stone forms are developed, called here locally *"porrillas"*, due to the spanish name of the hammers used to cut granite stones by the stonecutters or quarry workers.

The Arroyo de las Cañas circular signposted path starts in the village of El Pedroso, and is of great interest for those who wish to enjoy the landscape of this granitic rocky area.


[269] Pile of boulder rocks


[270] Dispersed boulder rocks

ARROYO DE LAS CAÑAS PATH

Large granitic boulders, wide pasture where herds roam and a stream where black stork fish are some of the attractions of this path, one of the most beautiful to get into the rocky area's landscapes.

The circular path, with the pasture and rocky morphology as the main protagonists of the landscape, starts in El Pedroso along the Almadén de la Plata Path, and goes through the Cordel de Juncalejo and Cordel de Cazalla a Cantillana (or Seville Path), and comes back to the village through Vereda de Navahonda.

It goes through curious granite outcrop areas, called "montonás" (rocks pile), travelling next to stone walls built with the stones collected to gain space for the pastures and sown fields, to reach to Las Cañas Stream. It continues through holm oak pastures, and in the surroundings of the village, to the left, there is a mountain in which the dumps of the old Lima Mine can be seen.

We must not fail to notice the house called Las Alberquillas, which is located before reaching the road. It is interesting because it has a façade and a construction more similar to one placed in northern Spain than in these latitudes. It is a traditional house that belonged to the los Latorre family, from Santander, which settled in El Pedroso for the exploitation of several mines.

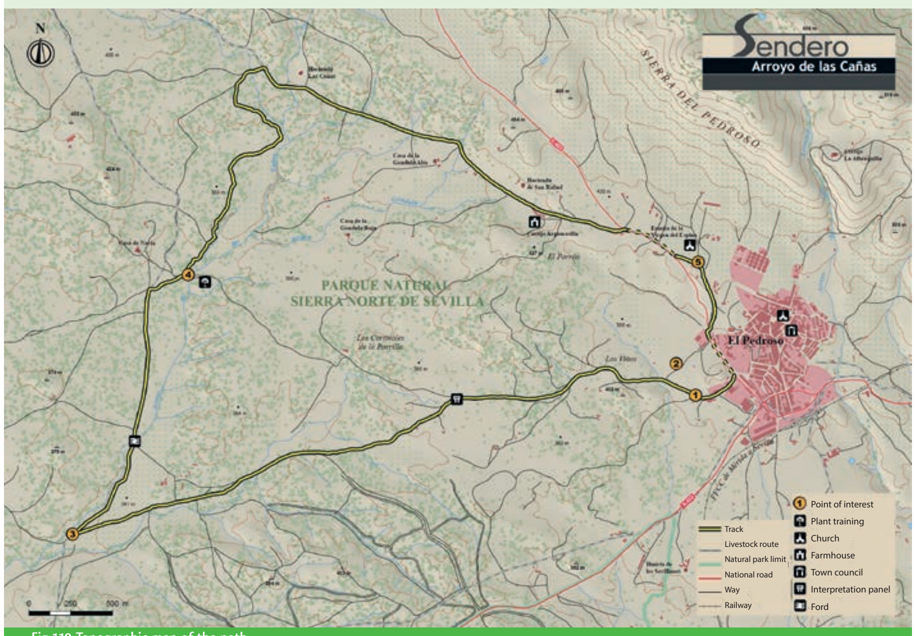


Fig.119 Topographic map of the path

2 El Pedroso; an entrance to Sierra Norte de Sevilla Geopark

The name of this municipality refers to its granitic landscapes, and is one of the gateways to the Geopark, since it is easy to access from Sevilla.

Some of the elements that form its cultural heritage are the Church of Nuestra Señora de la Consolación, the Humilladero cross, erected in the 16th Century, the Hermitage of Virgen del Espino, a Mudejar temple dating back to the 15th Century, and the Hermitage of Cristo de la Misericordia, a medieval building which has suffered important transformations during the 19th and 20th Centuries.

It has two small museums: the Escuelas Nuevas Cultural Centre, with a part dedicated to El Pedroso mining history and another one dedicated to the history of writing, as well as the Museum-House of Ancient Customs.

The trade fair of typical and artisan products from Sierra Norte de Sevilla is very famous throughout the province. It is held every year during the long weekend on 6th and 8th December, attracting more than 20,000 people to the village.

There are several paths that go through the surrounding areas of the town by local paths. Las Piñas Path ascends to Sierra del Pedroso, offering excellent panoramic views.


[271] Panoramic view of the urban area


[272] Church of Nuestra Señora de la Consolación

EL PEDROSO FACTORY (FOUNDRY)

About 7 km from El Pedroso, along the road to Cazalla de la Sierra (A-432), in the confluence of Rivera del Huéznar and San Pedro Stream, in the municipality of Cazalla de la Sierra, there is a foundry known as "El Pedroso Irons Factory". It was founded by El Pedroso y Agregados Mining Company, company created in 1817 by entrepreneurs from Cádiz and Seville.

The strategic location that the steel plant enjoys, allowed it to take advantage of the waters from both rivers as a driving power, the iron ores of the surrounding deposits and the surrounding forest mass to produce charcoal.

The foundry was equipped with a hydraulic infrastructure to ensure the supply of water to a series of wheels, which were responsible for making the different elements of the establishment work. Two masonry dams, each with brick canals leading to two tanks, a series of internal channels in the factory and a set of hydraulic wheels were built. Traces of those hydraulic infrastructure can still be seen today.

The Company had the licences of "Monteagudo", "Juan Teniente", "Navalostrillos" and "Abundancia" mines, in the municipality of El Pedroso, as well as "Grajas or Cerro del Hierro", in the municipality of San Nicolás del Puerto, covering an area of 34 hectares. In them, the Company exploited the iron ore, adjusting its production to the needs of the steel plant.

At the beginning, a single blast furnace was built, which had to be completely rebuilt, due to its disastrous construction and consequent malfunction. Apart from these failures, it was the first Andalusian blast furnace to be built under the paradigm of Industrial Revolution, between 1817 and 1825. Therefore, the Company was the author of the first private steel business initiative within the framework of industrialisation. A total of three blast furnaces were built: the reconstruction of the first one was conducted approximately between 1831 and 1835; the construction of the second one was finished in 1839; and the third one in 1847. The fuel they used was charcoal, although in 1886, there was a new blast furnace completely built to run on coke. In El Pedroso foundry, cast iron, soft iron, and a minority of steel were produced.

The modernisation that the El Pedroso factory's facilities were suffering made it an integral steel plant, due to the incorporation of blast furnaces to produce smelting, refining, moulding, rolling, etc. Between 1839 and 1866, the number of works directly employed in the iron factory was invariably around 250.

From the very first moment, the developers of El Pedroso steel factory were faced with a very deficient road network, which had to overcome significant unevenness. Transport was conducted by means of carriages pulled by cavalries, in addition to other draught animals. The cast iron ingots sent to Seville were used in the foundries of the city, such as the foundry of Narciso Bonaplata, who built the bridge of Isabel II (1845-1852), popularly known as "Puente de Triana"; or the foundry of Real Maestranza de Artillería de Sevilla. Iron was also used to build the bars of the Royal Tobacco Factory (1859-1862).

In 1856, the railway branch from Mérida to Sevilla was put up for auction; however, in 1865, construction had not yet begun. Finally, in 1869, a concession was granted between Mérida and Los Rosales (Seville). The section of Villanueva del Río and Minas (Seville) to El Pedroso was opened in 1874; however, the section between Llerena (Badajoz) and El Pedroso, which passed through the foundry, was inaugurated ten years later. It was finished the following year, reaching Tocina, where it connected with the main line from Córdoba to Seville.

The Company maintained its operating facilities until 1887, the year in which it was forced to close the mines and the steel factory, thus ending 70 years of operation. One of the periods of great splendour of this industry was lived due to the Gipuzkoan artilleryman, Francisco Antonio Elorza y Aguirre, who was hired as Functional Director. His stay in the Sierra Norte de Sevilla lasted from 1831 to 1843, the year in which he resumed his military career and was assigned to the Arms Factory in Trubia (Asturias). During this period of twelve years, he carried out great activity in terms of the Company's modernisation and expansion of the steel establishment.

Source: ORCHE, P. "Analysis of the evolution of iron extraction activity in El Pedroso, province of Seville, with special attention to the prevision of occupation risks" Doctoral thesis. University of Vigo, 2017, 1.006 pp.


[273] El Pedroso factory


[274] El Pedroso factory

3 Rocky area of La Jarosa

Difficulty of the geological concept LOW

On the north bank of Huéznar Reservoir, we find another granitic landscape of interest: the rocky area of La Jarosa, an elongated granitic pluton, of about 16 km in length and 5 km in width, with an approximate northwest-southeast orientation.

This pluton, composed of several types of granitic rocks; biotite granite, leucocratic granite and cordierite white-granites, is embedded in schists, black quartzites, gneiss and migmatites from the Montemolín Formation and Tentudía Formation, in slates, sandstones and limestones from the Capas de Campoallá Formation, and in feldspathic sandstones and slates from Alternancia de Cumbres Formation.

The weathering of granitic rocks is highly developed, due to their compositional and structural characteristics, resulting in a very evolved rocky area landscape, with very gentle hills and valleys. There are plenty of granite boulders or "porrillas" isolated between the meadows and sandy flatlands. The landscape is also notable for the boulders grouped into *"majanos"*, carried out by humans to de-stone the ground and create pastures and sowing areas.


[275] Rocky area landscape


[276] Majanos

4 Constantina: medieval flavour

With its neighbourhoods embracing the riverbed of La Villa River, this village has over 5,000 inhabitants, which is the most populated urban site in the Geopark, and it's surrounded by chestnut groves and lands of olive groves and vineyards. Its current name comes from the name it had during the Roman colonisation: *Constancia Iulia*.

The administrative offices of the Geopark are located here, as well as two of its main facilities, the El Robledo Visitors Centre and Botanical Garden. The marked trails of Los Castañares, Camino de la Jurdana and Camino de Campovid, start from the village, supported by a wide network of public paths and livestock trails that pass through the area, facilitates activities such as mountain biking, horse riding and hiking.

Its centre has been declared a Historical Site. The urban structure is peculiar, with long-distance streets and a north-south orientation, parallel to the course of the underground river, and whitewashed houses, in which the difference in elevation between both façade lines, requires stairs to save the unevenness.

In its urban centre, there remains a type of buildings related to majestic or bourgeois architecture, and other remarkable buildings, such as the Church of Nuestra Señora la Encarnación, a 14th Century Mudejar temple, the Church of Nuestro Padre Jesús, an 18th Century building, the Church of la Concepción and the Convent of Santa Clara. The Castle, which dates back to the Arab period, is also remarkable. It is based on the remains of a previous Roman castrum and probably other military structures that were built to take advantage of the hill's domain over the Osa Valley.

From a more recent period, there are examples of important buildings, such as the Neoclassical Town Hall.

[277] Panoramic view of the urban area

[278] Constantina Castle

Basic elements that make up the cuisine in Constantine are meats, bushmeat, cured meat and cold meats, which are recommended to be washed down with local wines and musts, celebrating its Wine Fair in March; this event brings together the wines of Sierra Morena wineries.

In spring, you must taste the asparagus and black bryony, bladder campions, common golden thistles and fennels. The mushrooms, particularly the pheasant mushroom *(Boletus)*, are very characteristic of the autumn cuisine. They are a real treat and the basis for the annual celebration of the tasty Mycological Days. Local confectionery must be savoured with a glass of the typical liquors of the area, and especially tasting the cream of cherries and other liqueurs made in their distilleries. The gin, a recent creation, is a nice surprise.

EL ROBLEDO VISITOR CENTRE

El Robledo Visitor Centre is located 1.4 kilometres away from the village of Constantina. It offers an exhibition which allows visitors to understand how the current Sierra Norte is the result of a balance between humans and nature. Its greatest feature is the tree pasture (dehesa), the most emblematic landscape of the Geopark. For ages, the great variety of resources offered by these mountains have attracted numerous cultures, which have left their mark on the area. The transformation undergone and the use of these resources are the central issues of this interpretative discourse.

[279] El Robledo Visitor Centre

[280] El Robledo Visitor Centre

EL ROBLEDO BOTANICAL GARDEN

El Robledo Botanical Garden is located in the surrounding area of the Visitors Centre and is part of the Andalusian Network of Botanical Gardens, serving as a model and reference of the typical vegetation of Sierra Morena.

The different botanical species are arranged around an itinerary that simulates a journey through the most representative plant formations of Sierra Morena in general, and the Natural Park in particular.

The route recreates the ascent from the Guadalquivir valley, which has less rainfall and more hours of sunshine, to the higher parts of the Geopark, which have more precipitation and fewer hours of sunshine. This will determine, together with the type of soils, the vegetation we will find, and can observe the different adaptations / strategies to soil and climatological conditions. Our route will continue from the source of a river to its mouth.

The route begins by recreating the lowest areas of the region, the olive groves and their related flora. It continues through thickets and then get into the oak grove. Here, we move on to aromatic plants. Although they do not represent a plant association, they deserve a special mention, together with the orchard tress, because of their direct association with humans, so we can find a rich sample of shrubs closely linked to traditional uses: culinary, medical and cosmetic. From these, we move on to cork tree-heath and gall-oak grove. The garden also reproduces the route of a mountain river, and through the different types of gallery or riverside woods, from alder groves to ash groves, elm groves and poplar groves, to tamarisk formation and white poplars.

The route of the Botanical Garden includes a selection of the most representative rocks of Sierra Norte de Sevilla Geopark and Sierra Morena.

It also has a traditional orchard and a space dedicated to the conservation and reproduction of endangered species from the vegetation sector it represents, being included into the conservation programme of the Network of Botanical Gardens.

[281] El Robledo Botanical Garden

[282] Sample of a representative rock

CONSTANTINA: THE ROMAN CONSTANCIA LULIA

In Roman times, the city of Constancia Lulia, whose archaeological remains can be found in the Cerro del Almendro, was an important place due to its strategic location, both in relation to the layout of the ways which connected the Guadalquivir Valley and Lusitania, and for the use of natural resources related to copper and silver mining. The wines extracted at this time were famous even in Rome, using the name of "Cocolubis".

This main site had in its vicinities other fortified spots such as the bastion of the hermitage of Yedra, the Armada Castle and some towers created to reinforce the territorial control of this natural communication path.

During the Islamic period, the village began to shape its appearance as a compact population centre. The first urban development was created in the Morería Neighbourhood, today known as Las Cuestas, located in the form of a suburb on the southern slope of the castle hill.

The Arab fortress defended the north-south axis to Seville and reinforced the defensive line of the Cora de Firrish. The ensemble is placed around a large parade ground and a large semi-buried cistern; a wall with eight towers was erected to protect them. The entrance was curved and was protected by the tribute tower, which was larger than the others and served to control the village and the Osa Valley.

In Christian times, it was governed by the Council of Seville, due to its strategic importance in the Banda Gallega regarding the defence of the Castilian kingdom. It was appointed as an independent town, and was donated by the House of Medina-Sidonia to the Catholic Monarchs in 1478.

During the first half of the 19th Century and part of the 20th Century, Constantina was distinguished for its industrial framework, with several ice factories, distilleries, cork factories, oil mills, etc.

At present, there is still an anisette factory, specialised in the production of creams and different artisan liqueurs.

From Constantina, you can continue along the route described, or head to the north until the Natural Monument of Cerro del Hierro (see Route 2), taking the forest path that starts approximately 1 km before reaching the viewpoint of Puerto de Robledo. Return from Cerro del Hierro along the same path to continue the route towards Las Navas de la Concepción.

5 Torreárboles Formation

Difficulty of the geological concept MEDIUM

Leaving the village of Constantine, heading east on the A-8202 towards Las Navas de la Concepción, the materials of the Benalija Unit are crossed, in a complete, although discontinuous series.

Towards the beginning of the road, we can observe a sequence of fine stratum of grey and white slates, slightly metamorphosed greywackes and arkoses, from the Lower Cambrian period, corresponding to Torreárboles Formation, the most basal of the Benalija Unit. These sediments are interpreted as deposits in littoral areas very close to the coastline.

[283] Overview of the outcrops in Torreárboles Formation

[284] Detail of the stratum of slates, greywackes and arkoses

NATURAL MONUMENT JELLYFISH FOSSIL IMPRINTS OF CONSTANTINA: PIEDRA ESCRITA

Located on a private estate south of the road from Constantine to Las Navas de la Concepción, around 14 kilometres from Constantine, there is an outcrop that displays a magnificent paleontological site of jellyfish fossil imprints.

It is formed by ninety large discoidal imprints, recorded in a bedding plane of arkosic greywackes of Lower Cambrian age (541 to 521 Ma), belonging to the detrital basal formation (Torreárboles Formation) of the Benalija Unit. Formerly, it was believed that these marks on the rock were petroglyphs, created by primitive humans, hence the name of the outcrop was "Piedra Escrita" (Written Stone).

Nowadays, it is known that these prints correspond to imprints of soft bodies of ancient marine organisms, specifically to the external moulds of ancient coelenterata type hydrozoan, similar to the current Aequorea type.

The site is interpreted as a deposit of greywacke in very shallow waters with a massive accumulation of jellyfish, which may have been stranded on the coast during a specific storm episode.

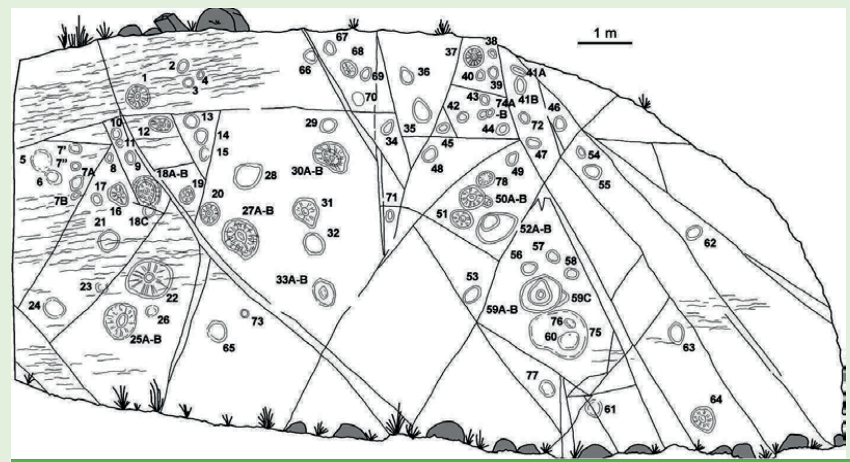


Fig.120 Scheme of the jellyfish imprints deposit

[285] A view of the jellyfish fossil imprints site

[286] Jellyfish fossil imprints

[286] A jellyfish fossil imprint

6 Capas de Campoallá

Difficulty of the geological concept LOW

Following A-8202 road, around 3 kilometres from Navas de la Concepción, in the surroundings of Rivera de Ciudadeja, there are good outcrops of the Cambrian levels of limestones and dark grey dolomites that are included in Capas de Campoallá Formation. In this case, they are slabbed in banks of one to several centimetres, with fine clay inter-stratum levels.


[288] General view of clay outcrops


[289] Detail of limestones

7 River terraces and hydraulic mills of Rivera de Ciudadeja

Difficulty of the geological concept LOW

The gallery forest that accompanies Rivera de Ciudadeja is one of the best preserved in Sierra Morena, and the main attraction of the path that extends next to it. It offers a beautiful alder forest accompanied by ashes, poplars and willows, under which develops a dense undergrowth of brambles and ferns. During the autumn sunsets in the meadow valley, it is easy to hear the bellowing, with the male deer in heat roaring and crashing their horns to show off, conquer or maintain their harems of females. In spring, it is also worthwhile to walk the path, to enjoy the incomparable beauty of this valley.

There are historical vestiges that will ignite visitors' interests, such as old hydraulic mills, foundries or the Armada Castle.

There is a path that leads to the Hermitage of Belén, that features a cosy recreation area equipped with tables, benches and barbecue grills. The path starts where the road pass through the course of the river. The remains of the French Mill, one of the various hydraulic mills that mark the riverbank, are below the hermitage, with the remains of the buildings, dam, canal and part of the manoeuvre where the milling was carried out.

Underneath the road, the riverbank allows us to appreciate several low terraces, related to the most recent river activity and the remains of other mills, some of which are in the process of being restored.

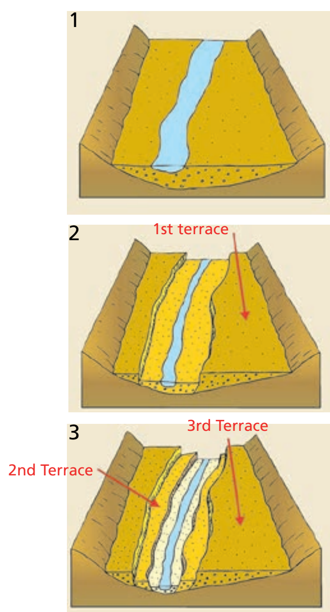


Fig.121 Scheme for the formation of a terrace system

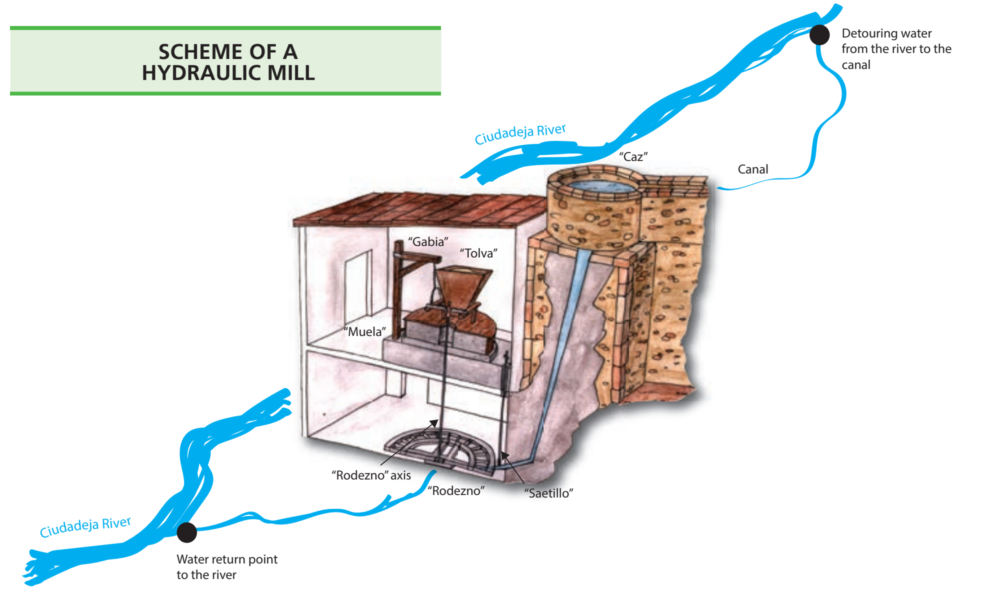


Fig.122 Scheme of a hydraulic mill


[290] View of a river terrace


[291] Part of the manoeuvre of a hydraulic mill


[292] Water canal to the mill

8 Las Navas de la Concepción: the youngest village

Las Navas de la Concepción is located in an open valley. It is the youngest village in the Natural Park, founded in 1557 by the monks of the Order of San Basilio. It depended on Constantine for three centuries until 1854, when Queen Elizabeth II granted it the status as a municipality.

It is surrounded by olive groves and vegetable gardens and when moving away from the urban area, there are farms dedicated to forest work, such as the extraction of cork and cattle farms, although hunting activity is also very important. The hunting species most valued by hunters are deer, wild boar and roe deer.

Once we have reached the village, several chimneys emerge from the first few houses. Notable among them is the Sulfuro Tower, which is particularly high. This structure was integrated into an industrial complex dedicated to extracting olive pomace from the from the four oil mills that the village had years ago. Next to it, a red brick factory was also installed. It is a very characteristic architectural element of this village, which used the pomace produced to fuel its ovens.

The most outstanding monumental building in the village is the Church of Purísima Concepción, built in the 18th Century. It has a baptismal font from the 15th Century, as well as other elements of historical and artistic interest, such as the image of El Cristo Crucificado, from the 16th Century, and the sculpture of Santa Ana and the Virgin, dating to the 17th Century.

Two of its most interesting routes are known as La Rivera Route, to the Hermitage of Belén, and to La Molineta.

Its gastronomic offer includes Iberian pork and deer, *"la fritá de faisanes"* (mushrooms), scrambled eggs with asparagus or eggs fried in virgin olive oil with chorizo. Its confectionery is especially recreated in frying sweets such as *roscos, pestiños, flores, tortas de manteca* and *tortas de chicharrones.*

The Hunting and Ecotourism Fair, which is held annually around 12 October, is the main tourist event of interest in the municipality.

[293] Sulfuro Tower

[294] Square and Church of Purísima Concepción

[295] Panoramic view of the urban area

9 El Retortillo Canyon

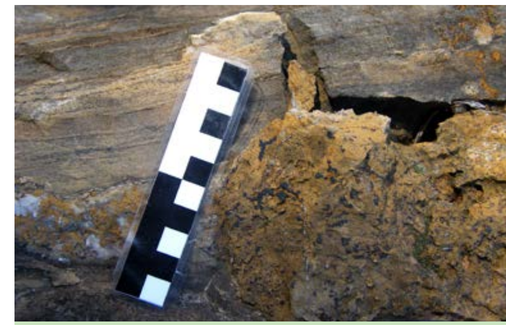
Difficulty of the geological concept — LOW

About 7 kilometres east of the village of Las Navas de la Concepción, the SE-8102 road crosses El Retortillo River, which in this area has a karstic canyon morphology.

El Retortillo has a general north-south direction in this section and just at the limit of Sierra Norte de Sevilla Geopark, it crosses a massive limestone outcrop of the Capas de Campoallá Formation, around 500 metres wide. The river waters have generated a deep fluvio-karstic canyon between 100 and 150 metres deep and around 300 metres wide.

On the slopes of the road, several good outcrops of the limestones of the Capas de Campoallá Formation can be found, with folds, algal laminations and spaces of karstification with different fillings.

[296] Folds in the limestones



[297] Karstic space with filling

10 El Retortillo Reservoir: Carboniferous rivers

Difficulty of the geological concept — LOW

The road that leads from Las Navas de la Concepción to La Puebla de los Infantes (SE-131) allows us to observe, in its descent to El Retortillo Reservoir, outcrops of conglomerates and coarse reddish sandstones, interpreted as the fluvial filling of an intra-mountainous basin subsequent to Variscan orogeny, of Upper Carboniferous to Permian age, formed between 323 and 250 Ma ago.

River sediments are discordant over the substratum and arranged horizontally. In the sandstone layers, characteristic structures of river sediments; erosion scars, low angle cross stratifications, grain-classification, etc. can be observed.

Many of the pebbles, essentially quartzite and very rounded, have very polished surfaces, the so-called "desert varnish", which indicates that before being deposited, they suffered the inclemency of an arid climate.

A viewpoint is located downstream of the reservoir, ideal for observing the waterfowls that come to the reservoir; it is common to observe grey herons. In winter, there is a large influx of ducks, such as the mallard and the spoon duck. This area is also frequently used by coots, cormorants, grebes, ducks and ospreys.

The reservoir came into service in 1970 and covers an area of 517 hectares. Its water is used mainly for irrigation and for urban supply. At its margins, there are frequently fishermen who come, drawn by the quality and the size of the fish that reside here.

[298] Image of the conglomerates and sandstones


[299] Detail of the conglomerates with pebbles with "desert vanish"


[300] Viewpoint at El Retortillo Reservoir


[301] El Retortillo Reservoir

11 La Puebla de los Infantes: the castle route

Surrounded by holm oaks and olive trees, the village is presided over by the Almenara Castle, a 14th Century Mudejar Gothic fortress. In its time, it was constituted by a quadrangular enclosure of mud walls, equipped with four square towers, one in each corner. Currently, only two of these towers remain. It must have belonged to the line of fortifications that defended the Castilian border and in which the castles of La Armada, Constantina, Alanís and Guadalcanal were grouped.

Other monuments of interest are the Church of Nuestra Señora de las Huertas, from the late 15th and early 16th Centuries and the Hermitages of Santiago, 14th Century, and Santa Ana, 15th Century, both of Mudejar style.

Some parts of the village preserve the taste of yesteryear. One of them is the site known as Las Pilas, home to the old public washing places, dating back to 1881, and another is the Curro Herrero Art and Popular Customs Museum, where a traditional mountain house is recreated. A viewpoint located at its highest part offers magnificent views of the village and its surroundings.

From the village, there is a road to the east that leads to the banks of El Retortillo River, in the place where the Sofio Mill was installed. This 6-kilometre route is signposted and equipped with several panels explaining the geology of the area and the characteristics of the mill's hydraulic works.

Among the most typical delicacies of the gastronomy of La Puebla de los Infantes are the partridge with pique pepper, marinated deer, the Spanish oyster thistle with beans and the *faisanes* (boletus). Typical desserts include *gachas* (porridge), *arroz con leche* (rice pudding) and *leche frita* (fried milk). *Gañotes, pestiños, roscos* and flowers with honey are notable in the area of frying confectionery.


[302] Towers of Almenara Castle

[303] Panoramic view of the urban area

6 Useful information

[304] Cazalla de la Sierra

GLOSARY

A

Abrasion. Mechanical destructive process, developed on the earth's surface, caused by friction between particles during transport.

Accretion prism. Accumulation of wedge-shaped sediments in a subduction zone, composed of pelagic and turbiditic oceanic sediments affected by overthrust faults.

Agglomerate. Rudite in which the fragments of rock that compose it are scarcely or non-cemented. Its cemented equivalent is the conglomerate.

Alkaline. Content on silica, in an igneous rocks serie (according to the Peacock index); rocks less than 51 are called *alkalines*; those between 51 and 56, *alkaline-calcium*; rocks between 56 and 61, *calc-alkaline*; and rocks above 61, *calcium rocks*.

Alluvial fan. The accumulation of detrital materials in the form of a fan or cone segment, deposited by a fluvial or torrential current, in sectors where there is a sudden change in the slope, such as the boundary between a mountain and an adjacent plain.

Alluvial. Sediments deposited by waters in river valleys and deltas.

Amphibole. Mineral from the group of silicates, of a dark green or black colour and pearl shine, structurally characterised by the existence of double silica tetrahedron chains.

Amphibolite. Metamorphic rock of dark green colour composed mainly by amphibole and plagioclase.

Andesite. Intermediate, generally porphyritic volcanic rock composed by acid plagioclase accompanied by one or more ferromagnesian minerals.

Anticline. Fold whose nucleus is constituted by the stratigraphically oldest rocks. In general, it is an antiform, although it can be a synform on some occasions.

Anticlinorium. Composed anticline structure of regional scale, consisting of a succession of anticlines and synclines; the enveloping surface of the composed structure is antiformal.

Antiform. Upward convex fold (A-shape).

Aplite. Light-coloured, fine-grained rock igneous rock, with saccharose texture (sugary appearance), rich in silica, generally associated with granitic plutons.

Aquifer. Porous or cracked geological formation, saturated with water and with sufficient permeability to allow the flow of water in significant quantities towards springs or towards the customary catchments, such as wells or galleries.

Aragonite. Mineral of the class of carbonates, with a $CaCO_3$ formula, calcite polymorphic, which crystallises in the rhombic system, usually into prismatic crystals and on some occasions into pseudohexagonal twins.

Archaeocyatids. Group of extinct benthic forms (fixed to the seabed), of calcareous skeleton and that were abundant enough to generate reefs, exclusive to the Lower Cambrian period (from 541 to 509 Ma), which are considered intermediate between the Porifera (sponges) and Coelenterata.

Arkose. Sandstone with a proportion of quartz lower than 75% of the total of terrigenous elements.

Asthenosphere. Inside layer of the Earth extending approximately 50 and 100 km deep, below the lithosphere, probably formed by viscous materials that can be deformed. This is where isostatic adjustments and magma generation take place.

B

Barite. Barium sulphate, barium ore mineral with a $BaSO_4$ formula, which crystallises in the rhombic system.

Basalt. Dark to black volcanic rock with SiO_2 content between 45% and 52%, with microcrystalline or porphyry texture, containing calcium plagioclase and pyroxenes, usually augite, with or without olivine. Its plutonic equivalent is gabbro.

Basement. Group of rocks that is located under a sedimentary cover and behaves competently during deformation.

Basic. Magma, lava or rock containing between 42% and 52% silica.

Batholith. A large intrusive complex usually composed of several plutonic units with very complex relationships between each other.

Boudinage. Common structure in rocks deformed by stretching, in which a competent layer placed between two less competent ones is stretched, made thinner and loses its lateral continuity, forming isolated, elongated bodies, called boudins (its appearance in a cross section is similar to a string of sausages).

Breccia. Clastic rock composed by angular-shaped elements of different sizes, irregularly arranged and cemented by a microcrystalline or amorphous mass, or a fine detrital matrix.

C

Calcarenite. Sedimentary detrital carbonate rock formed by the consolidation of calcareous sands.

Calcite. Mineral of carbonate class, with a $CaCO_3$ formula, which crystallises in the trigonal system, sometimes forming rhombohedron and other times, massive crystalline aggregates, fibrous or fibrous radiated.

Cambrian. First period of the six in which the Palaeozoic period is divided. It covers from 541 to 485 million years (Ma) before present times.

Canal. Canal of a hydraulic mill that collects and conducts water to its machinery.

Canyon. Valley of fluvial or glacial origin, with vertical or near-vertical walls, whose depth is always greater that its width.

Carboniferous. Fifth of the six period into which the Palaeozoic period is divided. It covers approximately from 359 to 299 Ma before present times.

Cement. Material of chemical precipitation (mainly calcite or silica) that totally or partially fills the pores of a sedimentary rock.

Cenozoic. The third more ancient era (or erathems) of the three existing into which the Phanerozoic eon (or eonothem) is divided. It covers, approximately, the last 66 Ma of geological history. It includes the Paleogene, Neogene and Quaternary periods.

Clast. Fragment of a mineral, a rock or a fossil, included in a rock, forming a constituent part of it.
Clastic. Rock or sediment constituted by fragments of minerals or older rocks, or by fossil fragments.

Clay. Sediment or rock made up of an aggregate of hydro-alumine silicates that may be accompanied by other minerals. The diameter of the clay particles is less than 0.0039 mm.

Colluvium. Sediment constituted by loose material accumulated on the slopes by gravity.

Competent. Rock, stratum or rocks set with little ductility.

Complex. Association of rocks with a very complex structural configuration that could masks the original succession; it can be constituted by various types of rocks (sedimentary, igneous or metamorphic rocks).

Conglomerate. Sedimentary rock composed, in more than a 50%, by rounded detrital elements of more than 22 mm in diameter and thickened with cement or a fine detrital matrix (or both).

Contact. Surface, flat or irregular, that separates two types of rocks or two sets of strata of different ages.

Continental accretion. Addition of land on the active edge of a pre-existing continent by the effect of various processes, including the collision of lithosphere fragments or their incorporation by displacement along transforming faults.

Continental crust. Part of the earth's crust corresponding to continents, with an average thickness of 30 km, composed by sedimentary rocks, metamorphic rocks and igneous rocks, with a density of about 2,700 kg/m^3.

Continental shelf, continental platform. Underwater extension of the continent, with a gentle slope, comprised between the coastline and the beginning of the continental slope, which usually occurs at a depth of about 200 m.

Crater. Opening of a volcano through which incandescent materials, gases and water vapour escape.
Cretaceous. Third of the three periods into which the Mesozoic period is divided. It covers from 145 to 66 Ma before present times.

Cross-stratification. Sets of secondary strata arranged at an angle to the main stratification, separated from each other by surfaces caused by abrupt changes in sedimentary conditions, including erosion and sedimentary disruption.

D

Detrital. Synonym of clastic.

Devonian. Fourth of the six periods into which the Palaeozoic period is divided. It covers approximately from 419 to 359 Ma before present times.

Diagenesis. Process by which a sediment experiences alteration, both in its texture and structure (compaction, recrystallization), and in its composition (cementation), and it is transformed into a sedimentary rock.

Dike, dyke. Tabular intrusion of igneous rocks filling a fracture or discontinuity. In general, it cuts the stratification, foliation or the rock's structure where it is embedded.

Diorite. Intermediate plutonic rocks generally composed of sodium plagioclase and hornblende. It is the intrusive equivalent of andesite.

Doline. Closed depression of moderate size and approximately circular shape frequent in karstic terrains.

Dolomite. Mineral of the carbonate class, with formula $CaMg(CO_3)_2$, which crystallizes in the trigonal system with rhombohedral forms.

Dolomite. Carbonate sedimentary rock, whose composition is made of dolomite mineral by at least 50%. It is created by chemical precipitation (primary dolomite), or during the diagenesis (secondary dolomite), which is the most frequent.

Downship fault, normal fault. Fault whose roof block moves downwards in relation to the wall block.

E

Earth crust. Solid top layer of the globe lying over the mantle. Its composition and structure are different on the various continents and oceans.

Earth's mantle. Part of the Earth's interior between the crust and the core, whose boundaries are marked by the Mohorovicic discontinuity, a transition area between the mantle and core, and the Gutenberg discontinuity, a division between mantle and core. It is divided into the upper and lower mantle, separated by the transition area located at a depth of 665 km.

Ediacaran. Named for the Ediacara Hills. It is the third and last geological period of the Neoproterozoic Era. It began around 635 Ma and ended 541 Ma, followed by the Cambrian period, the first Paleozoic period.

F

Facies. Set of characteristics of the rocks of a geological unit, reflecting the conditions in which they were formed. In sedimentary rocks, lithographic (lithofacies) and paleontological (biofacies) characters are considered.

Fault plane. Surface along which the fault blocks move. This plane can have an orientation (vertical, horizontal, or inclined).

Fault. Fracture or fracture zone, on whose surface was produced a relative displacement between the two blocks (faults walls), into which the affected rocks was divided.

Feldspar. Each of the minerals that compose the group of aluminium silicates (of potassium, sodium and calcium), within the class of silicates and the subclass of tectosilicates. It includes orthoclase and plagioclase.

Ferromagnesian. Minerals of the silicate type containing iron and/or magnesium as essential components.

Foliation. Structure of rocks constituted by parallel surfaces that are very close to each other.

Formation. Fundamental litho-stratigraphic unit stablished in the International Stratigraphic Guide.

Fumarole. Emission of gases or vapours at high temperatures through fissures in a terrain or through cooling of lava.

G

Gabbro. Plutonic rock mainly composed of calcium plagioclase and pyroxene, with or without olivine or amphibole; it is the intrusive equivalent of the basalt. It is distinguished from diorite because of the nature of plagioclase, which is higher in calcium content than in sodium.

Gneiss. Metamorphic rock with a gneissic structure.

Gneissic structure. Structure defined by preferred orientation of medium to coarse-grained minerals that gives the rock a coarse, less defined, more spaced and more discontinuous foliation than in the schistose structure, and in which the bands (generally more than 5 mm thick) are usually of contrasting mineralogy, grain size or texture.

Gondwanaland, Gondwana. Southernmost continent existing at the end of the Palaeozoic era and beginning of the Mesozoic period.

Graded bedding. Selection of clasts by size, within a layer, which are accumulated from wall to roof, in increasing or decreasing size.

Granite. Plutonic rock with a granular texture composed of similar amounts of quartz, alkaline feldspar, plagioclase and mica as essential minerals, and smaller amounts of other minerals, such as biotite, muscovite, hornblende and garnet.

Granitoids. Plutonic rocks whose quartz content is comprised between 20% and 60%.

Granodiorite. Plutonic rock of the granitoid family characterised by having quartz, and with plagioclase constituting more than two-thirds of all feldspars. Generally, together with granites, it is the most abundant rock of the great batholiths.

Gravel. Rudite made up of uncemented pebbles.

Graywacke, greywacke. Very abundant type of sandstone characterised by having more than 15% of fine detrital matrix, generally of dark colour and formed by turbidity currents. It is considered an immature sedimentary rock, and it has been generally found in Paleozoic strata.

H

Hematite. Mineral of the class of oxides and hydroxides, with a Fe_2O_3 formula, which crystallises in the trigonal system. It has a steel grey, deep red or black colour, a red or brownish red stripe and a metallic shine and is opaque. It has a diverse origin (sedimentary, metamorphic or hydrothermal), and it is one of the main minerals in iron ores.

Holocene. The most recent of the two periods that compose the Quaternary system, corresponding to the current interglacial period, comprising the last 11,700 years and characterised by the disappearance of the great ice caps. During this period, the Mesolithic, Neolithic, Chalcolithic, Bronze, Iron, Roman, Medieval and Modern cultures were developed, according to the archaeological chronology.

Hornblende. Informal name used to call a series of minerals from the "amphibole group", with a colour between black and dark green. This name brings together aluminosilicate minerals that form a solid solution, with minerals between iron-hornblende in one end ($Ca_2[(Fe^{2+})_4Al](Si_7Al)O_{22}(OH)_2$) and magnesium-hornblende at the other end ($Ca_2[Mg_4(Al,Fe^{3+})](Si_7Al)O_{22}(OH)_2$), in which gradual substitution of iron by magnesium gives the different minerals of the series.

Hornfels. Metamorphic rock originating from contact metamorphism, very hard, with fine to medium grain.

I

Igneous activity. Set of processes concerning the generation, movement and consolidation of magmas within the Earth's crust.

Igneous. Rock coming from the melting mass existent within the Earth.

Insular arch. Alignment of nearby islands parallel to an oceanic trench, associated with seismic or volcanic phenomena.

Intra-mountainous basin. A post-orogenic sedimentary basin located within a mountain range, immediately generated after folding and in which important volumes of sediments are accumulated.

Intrusion. Body of igneous rock that has crystallised from molten magma under the Earth's surface.

J

Joint. Fracture that separates a mass of rock into two parts, without displacement along it.

Jurassic. The second oldest period of the three into which the Mesozoic era is divided. It covers approximately from 201 to 145 Ma before present times.

K

Karren. Rough limestone terrain with numerous holes and sharp edges, caused by karstic erosion.

Karst. Land of calcareous or evaporite rocks in which the dissolution by water creates exokarstic and endokarstic forms.

Karstification. Processes of water dissolution in calcareous and evaporite materials.

L

Lava flow. Fluid mass of lava that comes out from a crater and flows down towards the slopes of a volcano.

Lava. Viscous, molten material that is expelled from a volcano at high temperature during an eruption. When it cools down, it leads to the formation of effusive rocks or scoria.

Layering. Structure of igneous rocks, especially in basic and ultrabasic rocks, consisting of alternating layers of variable thickness (from centimetres to metres) with different mineralogical composition. The alternation can be rhythmic. It is generally due to the gravitational accumulation of crystals with different density that precipitate from a magma.

Layer, stratum. A level of rock or sediment that was deposited over a specified time interval and that it is bounded by surfaces (called stratification surfaces), caused by changes in sedimentation, by sedimentary disturbances, or by both.

Limestone. Sedimentary rock mainly composed by calcium carbonates ($CaCO_3$).

Lithosphere. Upper layer of the solid Earth comprising the Earth's crust (both continental and oceanic) and the outermost part of the mantle. On a global scale, it is divided into different solid and relatively rigid plates, called lithospheric plates.

Lutite. Sedimentary rock constituted by very fine grains, less than 0.062 mm.

M

Ma. Million years notation, an usual unit of time in geology.

Mafic, melanocratic. Adjective applied to minerals and rocks of dark colour (rich in magnesium and iron).

Magma. Molten rock material, mobile, fluid or pasty, with dissolved gases and solid silicates in suspension, generated within the Earth and susceptible to intrusion or extrusion. It is the material from which, by consolidation, igneous rocks are derived.

Magmatism. Set of phenomena associated with the formation and evolution of magma.

Marble. Compact metamorphic rock formed from limestone rocks which, after subjected to high temperatures and pressures, reach a high degree of recrystallization. The basic component of marble, with content more than 90%, is calcium carbonate; the rest of components gives marble its great variety of colours and define its physical characteristics.

Marl. Sedimentary rock containing between 35% and 65% of calcium carbonate and the rest of clay, with a muddy aspect and easily eroded.

Mesozoic. The second oldest era of the three into which the Phanerozoic eon is divided. It covers approximately from 252 to 66 Ma before present times.

Metabasite. Metamorphic rock whose precursor is a basic igneous rock.

Metamorphic grade. Intensity or range of metamorphism measured by the difference between the mineralogical composition of the parent rock and the resulting metamorphic rock.

Metamorphism. Set of textural and mineralogical changes that a rock undergoes under conditions of pressure and temperature different from those of its formation, excluding diagenetic processes of sedimentary rocks.

Miocene. The most ancient period of the two periods in which the Neogene system is divided. Covers approximately from 23 to 5.3 Ma before current times.

O

Oceanic crust. Part of the Earth's crust corresponding to the oceans, with an average thickness of 6-7 km, consisting essentially of basalts, gabbros and pelagic sediments, with a density of about 3,000 kg/m^3.

Oceanic ridge. An underwater mountain range thousands of kilometres long and hundreds of kilometres wide, situated on a divergent edge of lithospheric plates, rising up to 2-3 km above the abyssal plains of the ocean floor, and in the centre of which there is a depressed area through which igneous material comes out of the mantle which, as it solidifies, causes the growth of the oceanic crust.

Oligist. A variety of hematite characterised by laminar aggregates that can be arranged by forming rosettes or squama aggregates.

Oligocene. Third of the three periods in which the Paleogene period is divided. It covers approximately from 34 to 23 Ma before current times.

Olivine. Each of the minerals integrated into the class of silicates and subclass of nesosilicates comprising two main series, the magnesium series ($Mg_2SiO_4Fe_2SiO_4$), more common, and the calcium series ($CaMgSiO_4$-$CaFeSiO_4$).

Ophiolitic complex. Associations of ultramafic and mafic igneous rocks constituting the oceanic crust and lithosphere. They are tectonically located in the continental crust and have a characteristic structure.

Ordovician. The second oldest period of the six into which the Palaeozoic era is divided. It covers approximately from 485 to 444 Ma before current times.

Ore. A rock or substance from which useful minerals or metals can be extracted for economic benefit.

Orogeny, orogenesis. Set of geological processes that give rise to the generation of an orogenic belt: long, linear or arched region, of great extension, that has been built by folding and other deformations, including magmatic, metamorphic, sedimentary and tectonic processes.

Orthose. Mineral of the class silicates, subgroup tectosilicates, and within them belonging to the feldspars, with chemical formula of KAlSi3O8. It is one of the most abundant rock-forming minerals in the Earth's crust, also known as potassium feldspar.

Overthrust fault. An inverse fault with an angle of less than 45° in which rocks with a lower stratigraphic position are pushed upwards, above more recent strata.

P

Paleogene. The first oldest period out of the three into which the Cenozoic era is divided. It covers approximately from 66 to 23 Ma before current times. It is subdivided into the Palaeocene, Eocene and Oligocene periods.

Paleozoic. First in antiquity of the three eras into which the Phanerozoic eon is divided. It covers approximately from 541 to 252 Ma before current times. It is subdivided into the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian systems.

Pangea. Supercontinent that existed at the end of the Palaeozoic era, before the current continents were separated during the Mesozoic period, which grouped most of the emerged lands of the planet.

Pelagic sediment. These are the deepest open sea sediments, mainly from particles suspended in the sea. These particles can come from marine plankton (calcareous or siliceous) and from clays. Peridotite. Ultramafic plutonic rock with olivine as its essential constituent.

Permian. Sixth and last of the periods into which the Palaeozoic era is divided. It covers approximately from 299 to 252 Ma before current times.

Phanerozoic. Geological eon that stretches from 541 million years ago to the current times. Its name means "visible life", referring to the size of organisms that emerge at this period.

Phyllite. A fine-grained metamorphic rock characterised by a lustrous appearance and well-defined schistosity resulting from the preferential orientation of phyllosilicates. Generally, phyllites are low metamorphic grade rocks.

Phyllosilicate. Each of the minerals of a subclass, within the class of silicates, characterised by having, as a common trait, a flaky (phyllon = leaf) or squama nature derived from the existence of a perfect basal exfoliation.

Piezometric level, groundwater head. Height, in relation to a horizontal reference plane, which the groundwater reaches in a piezometer, well or borehole.

Plagioclase. Series of minerals from the feldspar group (tectosilicate subclass, silicate class) with compositions between albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_2O_8$).

Plate tectonics. Theory that explains the dynamics of the most superficial part of the Earth (lithosphere) admitting that it is divided into a number of large pieces or resistant plates that move relatively among themselves; most of the geological activity (seismicity, vulcanism, deformation, etc.) is concentrated in the limits of these plates.

Pleistocene. The oldest of the two periods that conforms the Quaternary period. It covers from 2.5 Ma to 11.700 years ago. It began with the formation of the icecap in the northern hemisphere and is the time interval characterised by the alternation of glacial and interglacial periods, which follow a variable cycle.

Pliocene. Second of the two periods in which the Neogene period is divided. It covers approximately from 5.3 to 2.5 Ma before current times. During this period, there were already modern forms of mammals and appeared the australopitecus, primitive precursor of humans.

Pluton. Extensive mass of consolidated igneous rock inside the continental crust.

Porphyritic. Texture of some volcanic and dike rocks in which a microcrystalline matrix comprising larger crystals can be seen under the microscope.

Porphyry. Volcanic or dike rock with a porphyritic texture, containing phenocrystals of quartz or feldspars, included in a vitreous or microcrystalline matrix.

Postorogenic. Relative to intervals immediately following an orogeny.

Pothole. Open circular cavity in the rocky bottoms of a river formed by the whirling movement of pebbles and grains carried by the water.

Precambrian. Geological eon before the Phanerozoic eon and therefore before the Cambrian system. It covers approximately from 4600 to 541 Ma before present times.

Pyroclastic breccia. Breccia mainly composed by angular pyroclasts with an average diameter of more than 64 mm (blocks) and directly created by an explosive volcanic eruption.

Pyroclastic. Breccia, flow, sediment, etc.: deposit related to clastic rocks formed by explosive volcanism.

Pyroxene. Each of the members of a group of minerals, belonging to the class of silicates and to the subclass of inosilicate, structurally characterised by the existence of simple chains of silica tetrahedrons. Its general formula is XY $(Si, Al)_2O_6$, where "X" can be calcium, sodium, iron^{2+}, manganese, lithium or magnesium, and "Y" represents smaller ions such as chromium, aluminium, iron^2, iron^3+, magnesium, manganese or titanium.

Q

Quartz. Mineral of the silicate class, and of the subclass of tectosilicate, silica group, with a formula of SiO_2. It is the most abundant mineral in the Earth's crust and it is found in acid magmatic and metamorphic rocks, and in the detrital sedimentary rocks, due to its great resistance to weathering.

Quartzite, quartz rock. Metamorphic rock resulting from the recrystallisation of sandstones with more than 80% quartz. Due to its strong crystallisation and hardness, it has a great resistance to erosion.

Quaternary. Last period of the Cenozoic era, comprising the last 2.58 Ma and two series, the Pleistocene (the oldest one) and the Holocene (the most modern one).

R

Reef. Biogenic structure of a calcareous nature whose surface, very irregular, is close to sea level. It is composed of building organisms, mainly corals and calcareous algae.

Reverse fault. Sloping plane fault, whose roof block moves upwards to the wall block.

Rhyolite. Volcanic acid rock, subalkaline or alkaline, rich in glass and with quartz crystals, alkaline feldspar and biotite and with a flowable texture.

Ripple. Sedimentary structure with crest form created by waves or water or air currents on the surface of a sedimentary deposit, generally sandy.

Rocky area. Granitic landscape where there are a large number of rounded rocks or ball rocks.

Rudite. Detrital sediment or sedimentary rock whose average grain is greater than 2 mm; it includes gravels, conglomerates and breccias.

S

Sand. Sediment composed of mineral grains of size between 0.062 and 2 mm, which originates from the weathering of the rocks and has been selected by the transport agents. It can have any mineralogical composition.

Sandstone. Consolidated terrigenous rock, in which the grain size varies between 0.062 and 2 mm.

Schist. Group of rocks characterised by the preponderance of laminar minerals that favour their fragmentation into thin layers.

Schistosity. Flat anisotropic rock texture defined predominantly by large phyllosilicates, visible to the naked eye, and showing in most of the grains a preferential orientation of their larger dimension.

Sedimentary basin. Area of the Earth's surface in which large thicknesses of sediments have been accumulated over a long period of geological time.

Sedimentary cycle. A sequence of related strata (or sedimentary processes) that repeat in the same order in a stratigraphic sequence.

Sedimentary structure. Geometric arrangement of the elements that make up a sediment or sedimentary rock, expressed in different ways, preserved on the stratification surfaces or inside the strata.

Sequence. Succession of different sedimentary terms established within a stratigraphic section.

Shale. Sedimentary rock composed of very fine grains of less than 0.062 mm.

Shear band. Small shear zone.

Shear. Stress in which the forces act in parallel but in opposite directions, resulting in displacement deformation along closely spaced planes.

Silica. Erosion-resistant component of many rocks consisting of silicon dioxide, SiO2. It is isolated in various minerals (quartz, chalcedony, cristobalite, tridymite, opal, jasper) and combined as part of the silicates.

Silicates. They are the most abundant group of minerals, since they constitute 95% of the Earth's crust, as well as the group of most geological importance, since they are the minerals that form the rocks. All silicates are composed of silicon and oxygen accompanied by others elements such as aluminium, iron, magnesium or calcium.

Silt. Fine detrital sediment whose particles have an average size between 4 and 62 μm.

Siltstone. Sedimentary rock formed by the compaction of silt.

Silurian. Third of the six periods into which the Palaeozoic era is divided. It covers approximately from 448 to 419 Ma before current times.

Slate. Metamorphic rock with ultra-fine or very fine grain (not visible to the naked eye) that has well-developed foliation, formed from shales under very low metamorphic conditions.

Stalactite. Crystalline aggregate with a fibrous-radiated and concentric structure, which gives rise to a conical body of variable dimensions, formed by the action of gravity. It frequently originates inside the caverns, from a crack or fissure in the roof where water drips, and is formed by calcium carbonate, with a central channel through which water can circulate.

Stalagmite. Crystalline aggregate arranged in concentric layers formed by accretion, which gives rise to a more or less conical body of variable dimensions. Normally, it is formed in caves, often under a stalactite, by a deposit of calcium carbonate released by water drops when they hit the cave floor or the stalagmite itself.

Stratification, layering, bedding. Arrangement of the sedimentary rocks in successive layers or strata.

Stratigraphic discontinuity. Relationship between two superimposed litho-stratigraphic units between its deposit has mediated a measurable interruption (period of time).

Stratigraphic. From the stratigraphy or related to it.

Stratigraphy. Part of the geology that studies and interprets the processes registered in the sedimentary successions, which allows us to know the nature and disposition of the stratified rocks, the correlation of both the materials and the events, and the correct temporal arrangement of the sequence of materials and events.

Stratotype. Selected part of a stratigraphic section in which a stratigraphic chronological unit (a stage) or a stratigraphic litho-unit (a formation) is defined.

Strike-slip fault, wrench fault. Fault in which the displacement is parallel to the direction of the fault surface, also called a directional displacement fault.

Stromatolite. Sedimentary structure (calcareous, dolomite or silicified), finely laminated and with a variable shape (dome, convex, columnar, spheroidal, etc.), originated from the metabolic activity of cyanobacteria in surface waters and with temperatures above 20°C.

Subduction zone. Zone that coincides with a convergent plate boundary, in which subduction occurs.

Subduction. Geological process associated with the convergence of lithospheric plates whereby one plate sinks under the adjacent one.

Substrate, substratum. Geological formation, generally older than others it serves as a base.

Suture zone. Boundary between old plates in collision orogens (collision continent-continent, arc-continent, arc-arc). It is usually evidenced by the high deformation, the presence of ophiolitic and rocks with high pressure metamorphism. It occurs at the convergent plate boundaries.

Syncline. Fold whose nucleus is made up of the most modern stratigraphic rocks. In general, it is synformal, although it can sometimes be antiform.

Synform. This is the name given to the concave fold (U or V shape); it is normally used instead of the term syncline when the chronological order of the sedimentary succession is not known.

Synorogenic. Related to processes or periods simultaneous to an orogeny.

T

Tectonics. A set of larger scale deformations expressed in rocks, strata and/or plutonic masses that define a region and allow it to be differentiated from others.

Terrigenous. Sediment or deposit that comes from solid ground.

Tertiary. Old name of the geological period that comprises the Paleogene period and the Neogene period, from 66 to 2,5 Ma before now.

Texture. Set of characteristics of the mineral grains that form a rock, referring to size, shape, degree of angularity and development.

Triassic. First of the three periods into which the Mesozoic era is divided. Covers approximately 252 to 201 Ma before modern times.

Trilobites: class of extinct arthropods, within the subphylum Trilobitomorpha. They are the most characteristic fossils of the Palaeozoic Era; almost 4,000 species have been described.

U

Ultrabasic or **ultramafic.** Magma, lava or rock with a very low silica content (less than 45%), usually more than 18% of MgO, high FeO, low potassium, and is usually composed of more than 90% of basic minerals (blackish coloured, high magnesium and iron content).

V

Variscan. Related to Variscan orogen.

Variscan orogen or **Hercynian orogeny**. Orogenesis in which its main deformations occur during the Upper Paleozoic era.

Volcanic activity. Set of phenomena, sensed or displayed, which are produced in volcanoes, such as lava flows, explosions or fumaroles emissions.

Volcanic agglomerate. Pyroclastic material consolidated or not, in which predominates rounded pyroclasts of more than 64 mm in size.

Volcanic ash. Product expelled in the course of a volcanic eruption, formed by grains of less than 2 mm. It can remain in suspension in the atmosphere for a considerable time and be deposited at great distances from the source of emission.

BIBLIOGRAPHY

Anguita, F.,1993. *Procesos Geológicos Externos y Geología Ambiental*. Rueda, S.L. 311p.

Bates, R.L. and Jackson, J.A. (eds), 1982. *Glossary of Geology.* American Geological Institute. 751p.

Boillot, G., 1984. *Geología de los márgenes continentales*. Masson S.A. 141p.

Consejería de Medio Ambiente (editor), 2008; Carmen Moreno, Reinaldo Sáez y Felipe González. *GUÍA GEOLÓGICA E ITINERARIOS: PARQUE NATURAL SIERRA NORTE DE SEVILLA*, 140 p.

Consejería de Medio Ambiente y Ordenación del Territorio, 2017. *Guía de Lugares de Interés Geológico del Parque Natural Sierra Norte de Sevilla Geoparque Mundial de la UNESCO*. Ed. Consejería de Medio Ambiente y Ordenación del Territorio, 109 p.

Cornicabra (autor), 2011. *Guía Oficial del Parque Natural de la Sierra Norte de Servilla*. Ed. Almuzara Editorial, Córdoba, 208 p.
Gibbons,W. and Moreno, M.T. (eds), 2002. The Geology of Spain. Geological Society of London. 649p.

Hall, A., 1996. *Igneus Petrology*. Elsevier. 551p.

J.A. López Geta, M. Martín Machuca, C. Mediavilla Laso, A. Cosano Prieto, J.L. Girón Méndez, (coords), 2011. *Guías didácticas de los acuíferos del Parque Natural Sierra Norte de Sevilla*. Ed. Instituto Geológico y Minero de España y Diputación de Sevilla. 2 volumenes.
Kearey, P. and Vine, F.J., 1990. *Global Tectonic. Blackwell Science*. 382p

Klein, C. and Hurlbut, C.S., 1996. *Manual de Mineralogía* (vol.1). 4ª Edición. Reverté. 368p.

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Nichols, G.,1999. *Sedimentology & Stratigraphy*. Blackwell Science. 355p.

Pedraza, J., 1996. *Geomorfología: principios, métodos y aplicaciones*. Rueda, S.L. 414p.

Sierra, S., 2003. *Análisis Estratigráfico de la Cuenca Pérmica del Viar (SO de España). Tesis Doctoral, Universidad de Huelva*. 289p. (no publicada)

Strahler, A., 1992. *Geología física*. Ed. Omega, 629 p.

Tarbuck, E. y Lutgens, F., 1999. *Ciencias de la tierra: una introducción a la geología física.* Prentice Hall, D.L.

Vera, J. A. (editor), 2004. *Geología de España.* Ed. Sociedad Geológica de España-IGME, Madrid, 884 p.

Wagner, R., 2001. *Fósiles vegetales*. Serie: Recursos Naturales de Córdoba nº 6. Editado por Diputación de Córdoba. Departamento de Medio Ambiente y Protección Civil.

Wagner, R.H. y. Mayoral, E. J, 2007. *The Early Permian of Valdeviar in Sevilla province, SW Spain: basin history and climatic/ palaeogeographic implications.* Journal of Iberian Geology 33 (1) 2007: pp: 93-124.

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Address: Edificio Administrativo Los Bermejales, Avda. de Grecia, s/n, 41071. Sevilla
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Address: Ctra. Constantina-El Pedroso km. 1, 41450 - Constantina. Sevilla
Phone: (+34) 600 163 653
E-mail: pnSierraNorte.dtse.cagpds@juntadeandalucia.es / geosierranorte.capgds@juntadeandalucia.es

EL ROBLEDO VISITOR CENTRE
Address: Ctra. Constantina-El Pedroso km. 1, 41450 - Constantina. Sevilla
Phone: (+34) 610 663 214
E-mail: cvelrobledo@reservatuvisita.es

CORTIJO EL BERROCAL VISITOR CENTRE
Address: Camino Rural Almadén de la Plata-Los Melonares, km 5,5. 41240 - Almadén de la Plata. Sevilla
Phone: 955 762 026
E-mail: cvcortijoelberrocal@reservatuvisita.es

CERRO DEL HIERRO INFORMATION POINT
Address: Casa de los Ingleses - San Nicolás del Puerto, Sevilla
Phone: 955 260 000/ (+34) 648 140 091
E-mail: picerrodelhierro@reservatuvisita.es

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ACCOMMODATION

ALANIS

CASA ADRIANO
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C/ BARRIONUEVO, Nº 8
658 426 197

NUESTRA SEÑORA DE LAS ANGUSTIAS
Casa Rural Superior
CARRETERA DE LA ERMITA, S/N
954 885 412

LOS GAVILANES
Casa Rural Superior
CTRA. ALANIS FUENTEOBEJUNA KM
955 954 034

SOLANA DEL CASTILLO
Casa Rural Superior
CALLE Hierros s/n
954 885 412/ 677 563 956
luisnarbonaniza@me.com

LA SOLANA DE LA CAPILLA
Casa Rural Básica
CTRA. ALANIS-CAZALLA, S/N
954 675 113

LA PAJARETA
Casa Rural Básica
C/CORREDERA, Nº 26
954 885 515/ 660 662 899

FINCA SAN AMBROSIO
Casa Rural Básica
CAMINO DE LOS CARROS, KM. 6,3
607 732 024

CASA RURAL LAS AMAPOLAS
Casa Rural Básica
FINCA San Pedro (Ctra. Alanis-las navas de la Concepción) Km 4
677 406 183
m_rosam_7@hotmail.com

ALMADEN DE LA PLATA

ALBERGUE CASA CLARA
Pensión Única
PLAZA CONSTITUCION Nº 6
665 617 723
Fax: 954 577 456
j.castro59@hotmail.es

CORTIJO EL BERROCAL
Pensión Única
FINCA EL BERROCAL

CAMINO DE LA PLATA
Pensión Única
LA CRUZ, 8
954 735 043

EL ROMERAL
Casa Rural Básica
C/ ANTONIO MACHADO, Nº 57
954 735 453

CAZALLA DE LA SIERRA

POSADA EL MORO
Hotel 2 Estrellas
PS DEL MORO, S/N 0
954 884 326

VEGA DE CAZALLA
Hotel 2 Estrellas
C/ DURILLO, 6
954 884 680

EL REMOLINO
Pensión Única
FINCA LA GARGANTA CTRA CAZALLA, S/N
954 884 902

LAS NAVEZUELAS
Casa Rural Superior
CTRA. SE-196, KM. 42
954 884 764

EL PALACIO DE SAN BENITO
Casa Rural Superior
SAN BENITO, S/N
954 883 336
Fax: 954 883 162

CASA LA PATU
Casa Rural Superior
CABO MARTIN, 2
659 655 301

EL LAGAR DE LAS ALMENTAS
Casa Rural Superior
CTRA. A-455, KM 4.100
659 650 777

CASA RURAL"CAZALLA NATURALMENTE"
Casa Rural Superior
CTRA. Cazalla de la Sierra - Guadalcanal C8200 Km 5900
666 459 507
mcmj64@gmail.com

MARIPASA
Casa Rural Básica
CARRIL DEL OBISPO, KM. 3
954 884 567

RISCOS ALTOS
Casa Rural Básica
CTRA. CAZALLA-CONSTANTINA, KM. 5,5
954 613 518

TRASIERRA
Casa Rural Básica
FINCA TRASIERRA
954 884 324
Fax: 954 883 305

EL BERROCAL
Casa Rural Básica
CTRA. REAL DE LA JARA Km 1
954 884 422
603 425 639
carmencortijo@hotmail.com

EL CORTADILLO
Casa Rural Básica
CTRA. GUADALCANAL, KM. 3
954 883 819

CASITA DEL HORTELANO
Casa Rural Básica
FINCA LA CARTUJA, S/N.
954 884 516

LA PLAZUELA
Casa Rural Básica
C/ CARIDAD, 4
605 276 377

PARAISO DEL HUEZNAR- LA GARZA REAL
Casa Rural Básica
CTRA. CAZALLA-CONSTANTINA, KM. 8
609 512 579

PARAISO DEL HUEZNAR -LA TRUCHA-
Casa Rural Básica
CTRA. CAZALLA-CONSTANTINA, KM. 8
609 512 579

EL MARTIN PESCADOR
Casa Rural Básica
CTRA. A-455, KM 8
955 954 203

SIERRA NORTE
Casa Rural Básica
CTRA. SANTUARIO DEL MONTE, 4
608 416 141

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Casa Rural Básica
PZ JUAN CARLOS I, 12
954 884 483

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Casa Rural Básica
CTRA. DE LA ESTACIÓN, KM 7,8
955 954 249

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Casa Rural Básica
CAMINO DEL CORCHO. FINCA VILLA ROSARIO
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EL LAGAR DE VIÑA VIEJA
Casa Rural Básica
CTRA. CANTILLANA-ALANIS (A-432), KM 49
956 855 670
mercedessousam@yahoo.es

EL RUISEÑOR
Casa Rural Básica
CTRA. A-455-KM 8
955 954 203/ 609 512 579
antonio@elrincondesanbenito.com

SANTA MARTA
Casa Rural Básica
CALLE DURILLO Nº 9
659 615 777
sanchezmenchon@gmail.com

ESCUTIA VIA VERDE
Casa Rural Básica
VIA VERDECERRO DEL HIERRO Km 1
654 620 937
escapadaecuestre@gmail.com

ESENCIAS DE LA VEGA
Casa Rural Básica
FINCA LA VEGA, S/N Km 69
645 470 534

CASA RURAL LA PIÑA
Casa Rural Básica
CTRA. Estación de Cazalla Nº A-455
954 884 463/ 603 519 423

CASA RURAL EL BONITO
Casa Rural Básica
CTRA. LA PUEBLA DEL MAESTRE Km 1
699 649 764/ 686 806 940
cecatran@yahoo.es

CASA RURAL BLUE MOON
Casa Rural Básica
CALLE SAN FRANCISCO Nº 12 Pta. 2
682 205 503
trinoinver@gmail.com

LAGAR DEL MARRAQUIO
Casa Rural Básica
CTRA. GUADALCANAL Km 3
689 637 982
JOSEMIGUELVEGAMARTIN@HOTMAIL.COM

CASA RURAL LA DEHESILLA
Casa Rural Básica
CTRA. A-450 Km 16 Compl.Dom. FINCA LA DEHESILLA, CAZALLA DE LA SIERRA POLÍGONO 15, PARCELA 11
699 609 242
nievescubero1980@gmail.com

CONSTANTINA

SAN BLAS
Hotel 3 Estrellas
CL MIRAFLORES, Nº 4
955 880 077
Fax: 955881900

HOSPEDAJES LA CASA
Pensión Única
JOSE DE LA BASTIDA, 25
955 880 282

LA SIERRA
Pensión Única
CTRA. DE LA ERMITA S/N
955 954 098

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LAS ERILLAS
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SENDERO DE LOS CASTAÑARES, S/N
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FINCA EL CHIRRIÓN
659 956 959

CASA RURAL SANTO CRISTO
Casa Rural Básica
C/ SANTO CRISTO, 11
610 728 357
info@grupoavil-cast.com

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CTRA. CONSTANTINA-SAN NICOLÁS DEL PUERTO Km 6
954 663 085
bethencourtsl@hotmail.com

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610 275 471
portatil@disban.com

El Cortijo de Cazalla
Casa Rural Básica
CTRA. DE CAZALLA Km 7
620 952 879
escapadaecuestre@gmail.com

KENZA
Casa Rural Básica
CTRA. A-452 EL PEDROSO-CONSTANTINA Km 7
607 514 888
lola.carballomillares@gmail.com

LA MINA
Casa Rural Básica
CALLE HERMOSA ALTA SN Nº SN
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615 048 523

LOS POZOS DE LA NIEVE
CTRA. DE CONSTANTINA A CAZALLA DE LA SIERRA (A 455), Km 17.50.
680 411 428
constantina@lospozosdelanieve.com

GUADALCANAL

POZOBERRUECO GUADALCANAL RURAL
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607 333 246

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fincalaherencia@gmail.com

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igonzalezmoyano@yahoo.es

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695 952 296

LOS CERRILLARES PATIO DE LOS NARANJOS
Casa Rural Básica
CTRA. LAS NAVAS, KM. 17,5
955 956 130
FAX: 955 956 150
udo@cerrillares.com

LOS CERRILLARES PATIO DE LOS OLIVOS
Casa Rural Básica
CTRA. LAS NAVAS, KM. 17,5
955 956 130
FAX: 955 956 150
udo@cerrillares.com

LA POSADA DEL INFANTE
Casa Rural Básica
C/ RAIMUNDO MARTINEZ, 6.
954 808 043

EL ARGARÍN
Casa Rural Básica
CALLE CAMINO HUERTA PESEBRE
645 865 195
oscarpuebla@hotmail.es

CASA DE LA MARIOLA
Casa Rural Básica
PLAZA SANTA ANA Nº 6
646 958 989

CASA DE LA TITA VITORIA
Casa Rural Básica
CALLE ARQUILLO Nº 6
646 958 989
info@villagesrural.com

EL REAL DE LA JARA

LA ENCINA
Hostal 2 Estrellas
POLIGONO INDUSTRIAL LA ENCINA, MANZANA I, PARCELA 5
954 733 189

MARIA CARMEN BAYON EL REAL BAYON
Casa Rural Básica
C/ CORDOBA, 2
954 733 468

LA ERA
Casa Rural Básica
CTRA. SANTA OLALLA-REAL DE LA JARA KM 7
635 591 819

SAN NICOLÁS DEL PUERTO

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Casa Rural Básica
FINCA VALDEVACAS
955 954 246

CASA RURAL NACIMIENTO DEL HUÉZNAR 1
Casa Rural Básica
CALLE TOMILLO Nº 17 Compl. Dom.
RESIDENCIAL VARAJONDILLO
955 720 581
607 959 907
jmzulategui@gmail.coM

CASA RURAL NACIMIENTO DEL HUÉZNAR 2
Casa Rural Básica
CALLE TOMILLO Nº 23 Compl.Dom.
URBANIZACIÓN VARAJONDILLO
607 959 907
jmzulategui@gmail.com

ESCOLASTICA I
Casa Rural Básica
CALLE ROMERO Nº 6
651 826 445
suc.alejandromorillo.compras@gmail.com

ESCOLASTICA II
Casa Rural Básica
CALLE ROMERO Nº 8
651 826 445
suc.alejandromorillo.compras@gmail.com

ESCOLASTICA III
Casa Rural Básica
CALLE ROMERO Nº 10
651 826 445
suc.alejandromorillo.compras@gmail.com

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info@aventuramontaraz.com
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619 921 432 / 689 918 629
oficinadeturismoelpedroso@gmail.com
Hiking, mountain biking / cycling and equestrian routes

LA BICICLETA ROJA
648 140 091
info@labicicletaroja.es
Hiking, mountain biking / cycling

MONTAÑA VIVA S.L
626 720 720
info@montanaviva.com
Canyoning in Risco Blanco and Calzadilla streams

NATURES S. COOP. AND
+34 648 140 091
natures@natures.es
Hiking, biking, speleology and astronomical observation

NUGESPORT
615 133 584
info@nugesport.com
Hiking, biking and equestrian routes

SIERRA EXTREME
637 727 365
info@sierraextreme.net
Barranquismo

SULAYR AVENTURA
677 428 199 / 699 970 336
info@sulayraventura.com
Canyoning

THE ROCK ADVENTURE
627 811 375 / 651 823 452
theRockAdventur3@gmail.com
Canyoning in Risco Blanco and Calzadilla streams

VIVA AVENTURA
628 34 86 43
vivaventura@vivaventura.es
Barranquismo Risco Blanco y Calzadilla

Source: Tourism Registry. Ministry of Tourism, Regeneration, Justice and Local Administration. Junta de Andalucía, June 2019.

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Fig.26 Formation of Varisca orogeny. Author: © Parque Nacional de Monfragüe. Guía Geológica. Roberto Rodríguez Fernández. Editor. Madrid: Instituto Geológico y Minero de España; Organismo Autónomo de Parques Nacionales, 2017.

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Fig.29_1 Distribution of emerged land during the Primary Era. Author: NUBIA Consultores. Source: www.lahistoriaconmapas.com. ©History & Maps.

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Fig.30 Global distribution of the Alpine orogeny. Author: © Parque Nacional de Sierra Nevada. Guía Geológica. Roberto Rodríguez Fernández. Editor. Madrid: Instituto Geológico y Minero de España; Organismo Autónomo de Parques Nacionales, 2017.

Fig.31 Neogene sedimentary basins. Author: NUBIA Consultores. Source: https://es.wikipedia.org/wiki/Geología_de_la_península_ibérica#/media/Archivo:Cuencas_sedimentarias_cenozoicas_ibéricas.svg. ©Wikimedia Commons.

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Fig.35 Geological zones of the Iberian Massif. Author: NUBIA Consultores. Source: Geología de España. ©IGME y SGE.

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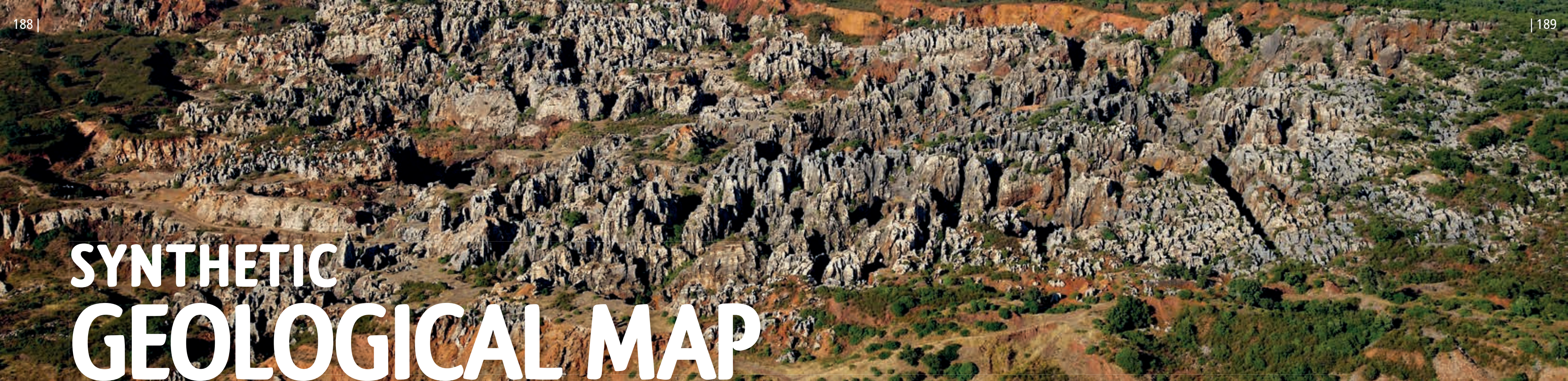
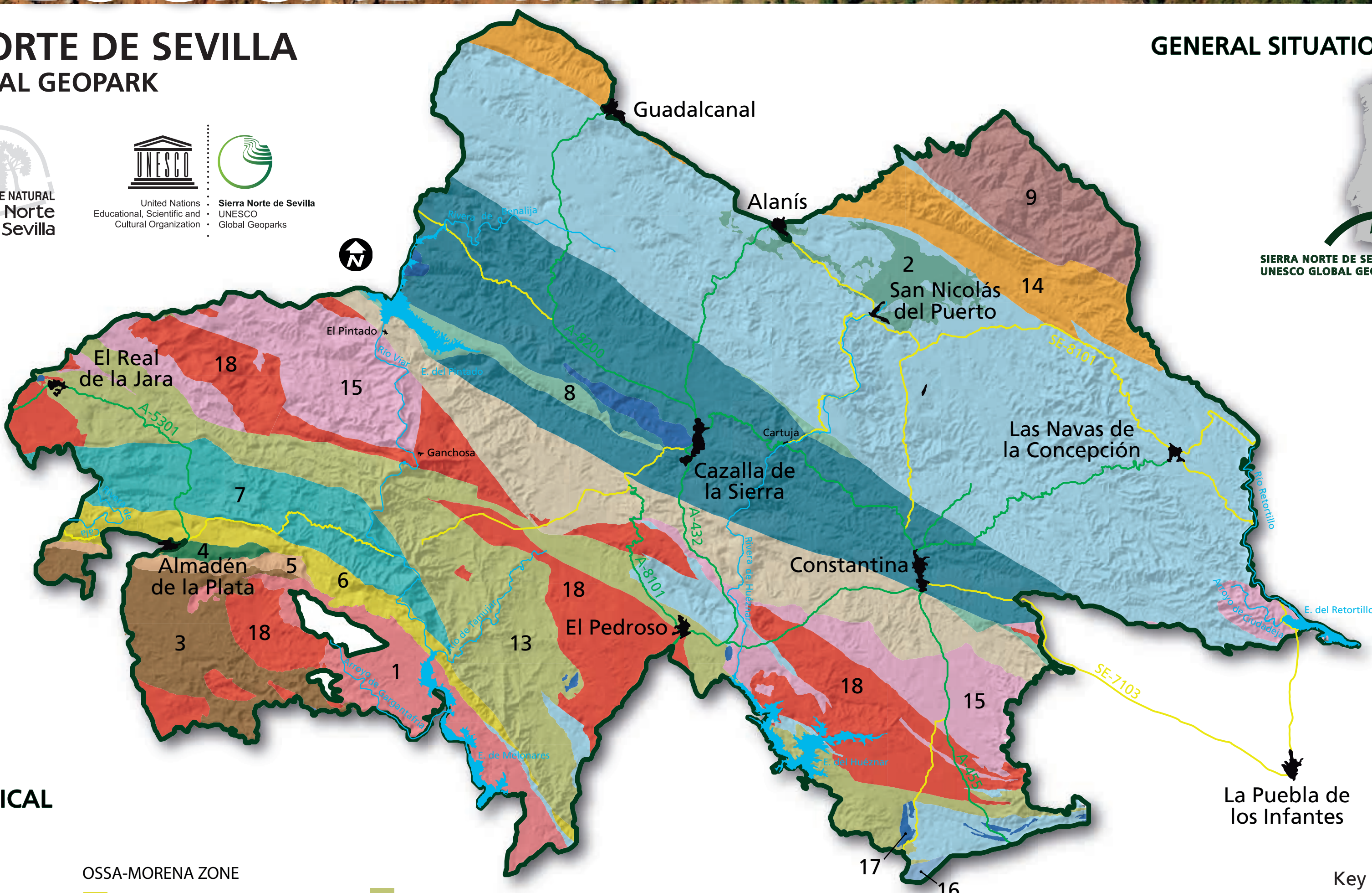


SYNTHETIC GEOLOGICAL MAP

SIERRA NORTE DE SEVILLA
UNESCO GLOBAL GEOPARK

PARQUE NATURAL Sierra Norte de Sevilla

UNESCO — United Nations Educational, Scientific and Cultural Organization · Sierra Norte de Sevilla UNESCO Global Geoparks



GENERAL SITUATION MAP

GREAT GEOLOGICAL UNITS

POST HERCYNIAN
- 1 Permian basic of Viar River
- 2 Permian basic of San Nicolás del Puerto

SOUTH PORTUGUESE ZONE
- 3 Silurian-Devonian

ZONA DE SUTURA
- 4 Beja-Acebuches amphibolites
- 5 Pulo do Lobo terrain

OSSA-MORENA ZONE
- 6 Metamorphic Massif of Almadén de la Plata
- 7 Terena Unit
- 8 Del Valle Unit
- 9 Sierra Albarrana Domain

Benalija Unit
- 10 El Pintado-El Pedroso Domain
- 11 Cazalla-Constantina Domain
- 12 Benalija-Campoallá Dominio
- 13 Cumbres Mayores Domain
- 14 Loma del Aire Unit
- 15 Olivenza-Monesterio Domain
- 16 Gneisses y migmatites

PLUTONIC ROCKS
- 17 Basic
- 18 Acid

Key
- Sierra Norte de Sevilla UNESCO Global Geopark
- Towns and villages

Roads
- Regional
- Local

Water network
- Rivers
- Reservoirs

SIERRA NORTE DE SEVILLA
UNESCO GLOBAL GEOPARK

PARQUE NATURAL Sierra Norte de Sevilla

United Nations Educational, Scientific and Cultural Organization · Sierra Norte de Sevilla UNESCO Global Geoparks

ROUTE 1

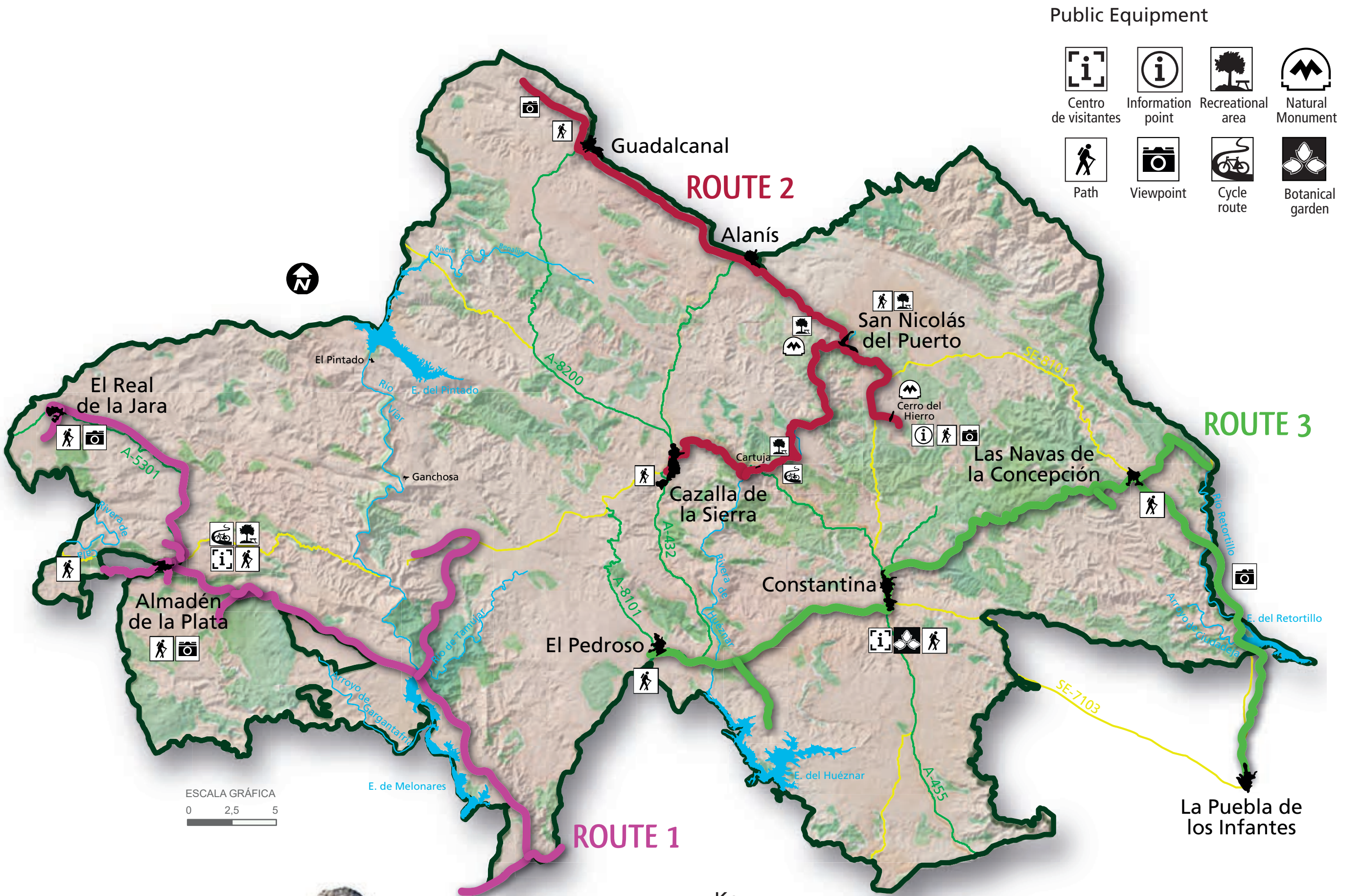
EL VIAR - ALMADÉN DE LA PLATA - EL REAL DE LA JARA

ROUTE 2

CAZALLA DE LA SIERRA - SAN NICOLÁS DEL PUERTO – ALANÍS - GUADALCANAL

ROUTE 3

EL PEDROSO – CONSTANTINA - LAS NAVAS DE LA CONCEPCIÓN - PUEBLA DE LOS INFANTES



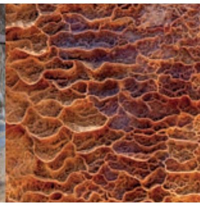
Key
- Sierra Norte de Sevilla UNESCO Global Geopark
- Towns and villages

Roads
- Regional
- Local

Water network
- Rivers
- Reservoirs

ROUTE MAP



This guide introduces us to Sierra Norte de Sevilla UNESCO Global Geopark, in its rich geological, mining, archaeological and monumental heritage, with rocks of very old ages, showing 700 millions of years of Earth's history. Between the multiple places of geological interest in this territory, impressive rocky landscapes produced by the combined action of tectonics and erosive processes: karst, crag lands, waterfalls, gorges, canyons.

Through the three routes that the guide proposes, we can walk through the granite rock forests of the crag lands, see closely how water and time have created a gorge within a dike – the El Chorro Gorge -, walk through the interior of a karst of more than 500 million years old - Cerro del Hierro - and enjoy of its wonderful rivers and the historical uses of water in the Geopark.

The Geopark hides true geological treasures such as the Cerro del Hierro, the Huéznar Waterfalls, El Chorro Gorge, the Huellas Jellyfish Fossils Imprints of Constantine, the large Fossil Tree in the Berrocal Visitor Center and multiple and varied geological morphologies.

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