MONTE ARCI GEOMUSEUM

Stefano Incani

Masullas Museum System

"I Cavalieri delle Colline" Museum

This museum is dedicated to Monte Arci and its minerals and rocks (in which we can read an old and complex geological history). We'll try to show you this history by recreating the paleo-environment and through original finds belonging to the Vincenzo Incani Collection and found in this region during the past century.

THE FATE OF MONTE ARCI IS LINKED TO THE ORIGINS OF SARDINIA

The history of the volcano that originated Monte Arci begun with the birth of the West Proto-Mediterranean. Starting from a single supercontinent, the so-called Pangaea, all the events that led to the current geography originated from a global process called "plate tectonics". This process is based on the mechanisms controlling life on Earth. The crustal plate is characterized by different types of rocks; cold and solid on the surface, with depth they gradually become warmer and more fluid, until melting. However, the crustal plate, which is colder and more solid, is actually very friable and is divided in plates floating like big rafts, thanks to the balance of the forces acting between the plates and the underlying asthenosphere, which is made of liquefied magma. These plates can move vertically (***sinking*** or ***rising***) or horizontally (***sliding*** or ***translation***) on the asthenosphere. As a consequence, mountains and volcanoes are built where the plates meet, and hollows, oceans and new volcanoes are formed where the plates split. Therefore, volcanoes are the relief valve for the magma pouring out towards the surface under the power of the increasing pressure acting along the most breakable spots of the earth crust. Today, thanks to the satellite data collections, it is possible to observe these subtle and slow movements shifting the plates of 1-10 centimetres per year. After "just" 1000 years, an island such as Sardinia can move of more than 100 metres. This is exactly what happened: since 23 million years ago, Sardinia detached from France and Spain and moved of approximately 500 km towards the heart of the Mediterranean Sea.

DID THE MEDITERRANEAN SEA ORIGINATE FROM THE TETHYS OCEAN?

Starting from the last century, as the "plate tectonics" theory was asserted, scientists could recreate almost all the events that led to the development of the Mediterranean Sea, where Sardinia is situated. Previously, the Mediterranean Sea was considered to be a sign of what remained of the old Tethys Ocean; the Tethys is supposed to have connected the Atlantic and the Pacific Oceans, by dividing in two parts the primordial supercontinent. After the discovery of the expansion of the ocean floors, occurred at the end of the 60s of the last century, it was possible to realize that the West Mediterranean Sea bottoms begun to take shape 23 million years ago, at the end of the Oligocene epoch; therefore, their formation can be dated in a period following the closing of the Tethys Ocean. It seems more and more probable that, at first, the so-called "Tethys Ocean" was characterized just by groups of marine basis and that, only afterwards, these basins met and connected with each other and with the two big oceans.

BIRTH AND DEATH OF THE TETHYS OCEAN

According to the most recent studies, 160-150 million years ago, during the Jurassic period, the Atlantic Ocean was connected with the basins that gave birth to the west Mediterranean Sea, where Sardinia is currently situated. At that time, when the big dinosaurs were already settled almost everywhere, Pangaea split apart to form two continents: the northernmost Laurasia and the southerly Gondwana. Since 90 million years ago, Africa began to detach from South America initiating the break of the South Atlantic Ocean and starting the formation of new mountain chains, such as the Alps and the Andes.

THE FORMATION OF THE MEDITERRANEAN SEA

The Alpine Tethys surrounding the Iberian Peninsula stretched from the region north of the Alps mountain chain and gave birth to the western half of the coming *Mare Nostrum* (Latin for "Our Sea"): the West Proto-Mediterranean. Since 23 million years ago, along the French and Iberian coasts, the Alkapeca micro-continent (which during the Paleocene epoch avoided the pushes and the pressures among continental plates), split apart in four sections that originated Sardinia and Corsica, Kabylie, the Balearic Islands and Calabria. These microplates begun to separate from each other, following the formation of the West Proto-Mediterranean.

Without analyzing the complex collision, rotation and bounce processes that occurred among the continental plates, we can state that this eternal "struggle" among continents (which is still ongoing) led to the birth of the Mediterranean Sea and of the Alps, Apennines and Andes mountain chains. In some areas involved in the process, such as Sardinia (where the Sardinian Rift was originated), Europe and North Africa, the earth crust collapsed. As a consequence of these tectonics forces, many Proto-Mediterranean volcanoes restarted their activity allowing the vent of the magmas ascent towards the asthenosphere. One of these volcanoes was to give birth to the Sardinian Monte Arci.

ROTATION AND DRIFT OF THE SARDINIA-CORSICA MICROPLATE

Since 23 million years ago, while the Ligurian Sea was expanding, Sardinia and Corsica moved and rotated together counterclockwise towards the heart of the West Proto-Mediterranean. Later, the Kabylie microplates reached Algeria and stuck to it while, less than 2 million years ago, Calabria was reaching the Italian Peninsula to shape it as it is now. Since then, the East Proto-Mediterranean (already Neotethys) and the West Proto-Mediterranean begun to combine and form the current Mediterranean Sea.

Recent studies revealed that, 20.5-15 million years ago Sardinia was subject to a 45° counterclockwise rotation compared with Europe. Most part of this rotation (30°) occurred 15-18 million years ago, the same period in which Monte Arci was rising. The period of the most rapid rotation of the Island corresponds to the period in which the Arci volcano activity was at its peak.

THE PRIMITIVE ARCI STRUCTURE

Perhaps even before the Miocene epoch, the powerful tectonics forces affecting Europe begun to open deep fractures along the entire continent and in the Mediterranean Sea.

Some of these fractures produced a huge hollow called *"rift"*, thousands of metres deep, which stretched from the Gulf of Cagliari to the Gulf of Asinara. As a consequence, begun a marine ingression towards the island, making it an archipelago. Through those fractures, huge masses of basalts were erupted in the sea bottoms and blended with the sediments.

In particular, in the current Monte Arci area, a great volcano formed; its continuous eruptions caused the accumulation of huge quantities of lava which favored the rising of a submarine relief whose tops, as the sea level dropped, were progressively approaching the marine surface.

MONTE ARCI PILLOW-LAVAS

The liquid lava derived from some of these submarine eruptions produced typical pillow shaped flows, defined by geologists *"pillow-lava"*. They are formed in depth, under the pressure of water, when the incandescent lava contracts and cools down to form blocks. The external side, rapidly cooling down, produces a thick glassy crust containing the hotter section in its inside. Slowly cooling down, the internal lava keeps on pushing outwards breaking the superficial crust to form another *pillow*, and so on. As a consequence of this process, we have a continuous chain that lasts until the supply of lava lasts. A good example of this process is the *Mega-Pillow*, still visible in the Masulla suburbs.

JASPERS DERIVED FROM THE VOLCANIC ACTIVITY IN MASULLAS

Over the course of millions of years, marine sediments such as marine clays, silts, sands and others can set down and form layers which can be thousands of meters thick; the total weight of the layers and the action of water flowing inside lead to the formation of new rocks (lithogenesis). In this way, depending on the dimension of the particles and their different chemical composition, limestones, dolomites or other rocks can be created. The injection of subvolcanic high-temperature lava flows between the layers of these rock formations and their circulation through subterranean fractures inside the rocks of hydrothermal vents in silicate and carbonate solutions caused the transformation of many original rocks. These fluids permeated the sedimentary rocks surrounding Monte Arci and completely changed their chemical composition, often leaving the signs of their original stratified structure. Most of the jaspers and flintstones of the Pompu, Masullas and Morgongiori area represent the result of these geochemical processes.

CUTTING JASPERS

Two centuries ago, in the ***Dizionario Geografico Storico Statistico della Sardegna*** (Statistical Historical Geographic Dictionary of Sardinia), written by V. Angius and G. Casalis, there was for the first time a description of the jaspers found together with other minerals, such as quartz and calcite, in the Masullas area (whose mineralogy has been stated as one “of the most considerable of the Island”). Later, during the 800s, some explorers and travelers, such as General Alberto della Marmora and Guglielmo Jervis, mentioned the jaspers of this village in their studies and travel reports. However, we can now state that, some distinguishing features make these jasper unique in Italy but comparable with other jaspers found in more popular areas.

These jaspers can be classified as follows: monotone, without any internal ornamental motif, striped with different colors and “bruneau”, showing many internal ornamental motifs shaped as circles more or less concentric. The latter two varieties can have a great commercial value, especially when the internal motif is complex and they can be used for cabochon products. The interesting internal motif of bruneau jaspers, when observed through an imaginary three-dimensional cross section, shows the shell shape characterized by a particular concentric motif.

HYDROTHERMAL MINERALS OF MONTE ARCI

When the rainwater, carried by the streams and the rivers, descends deep down to the crustal plate through the fractures and the subterranean cracks, it gradually heats up by going deeper. In this way, the heated up water “attacks” the different rocks it runs into.

With the water climbing up again, the mineral salts contained increase until saturation and then precipitate, crystallizing many mineral species. In some cases, and under particular physical and chemical conditions, crystallizations can be remarkable and perfect, as for the minerals shown here.

In particular, in the Pompu and Masullas area, the hydrothermal activity produced a huge quantity of chalcedony nodules, often linked with crystalline quartz, also amethyst, inside druses and veinlets. It is possible to find also zeolites such as analcime, within crevices opened through the basalt blocks; big crystals of calcite; small quantities of pyrite, dolomite, siderite and, in particular, fluorite.

FLUORITE MINERALIZATION OF NURAGHE ONIGU, IN MASULLAS

Most of the metal-bearing mineralization and industrial materials exploited in Sardinia are very old and date back to a period included between 540 and 240 million years ago, although some have formed more recently. Around 1950, some mineral explorers discovered a fluorite mineralization near Nuraghe Onigu, in Masullas. The discovery soon became a matter of interest for the scientific world, since it was the first fluorite mineralization ever observed until then in the youngest geological formations (dating back to 20-15 million years ago). Those first mineral researches were conducted by a group of explorers-entrepreneurs led by Mr Mario Orgiu from Masullas, who managed a group of entrepreneurs from Iglesias. The mineral permission was then given away to “Monte Pirastru” Mineral Research Company of Masullas and, later, renamed as “Nuraghe Onigu”, it was acquired by the Monreale S.p.A. Company, which already owned the nearby fluorite mine of Sardara. Unfortunately, being the result of excavation of those years so poor, authorities withdrew all the permissions and put a stop to all the researches. Besides fluorite, which is characterized by purplish-grey small cubical crystals, we can find quartz, calcite and other unidentified varieties of zeolites.

MASULLAS CHALCEDONY AND AGATES

Chalcedony, whose name derives from ***chalkèdon***, an old town in Bithynia near Istanbul (Turkey), is a type of cryptocrystalline quartz made of an aggregate of microscopic and fibrous crystals. These crystals are produced through chemical precipitation by silica-rich hydrothermal solutions, streaming inside the fractures of the rock. These solutions then deposit in lodes, veinlets, bulks or layers, in the form of stalactites, mamelons or nodules. When the chalcedony nodule is made of alternate and concentric layers, it is called agate. It can assume a wide range of colors depending on the impurities contained in the fluids from which it derives. For this reason, on varying of the sequence of the impurities, layers of different colors can be formed. Agate is one of the most valued among the ornamental hardstones and its nomenclature, since ancient times, is based on the different colors characterizing it.

AGATE, THE STONE PAR EXCELLENCE

In ancient times, chalcedony was thought to have magic powers such as invincibility and protection against poisons, but Ancient Egyptians, who were more practical, used it to create seals, moulds and hardstone carvings. Thanks to its structure and hardness, chalcedony is ideal for polishing and cuttings, operations which enhance the inner motif of the stone. The most requested cuts are cabochon in thin layers or hardstone carvings. The complexity of the ornaments, the number of stripes and the brilliance of the colors determine the value of chalcedony. Carnelian is a variety which comes in a red-brownish color due to ferrous impurities. Chrysoprase, on the contrary, normally comes in an apple-green shade which derives from small quantities of nickel contained in it. Heliotrope (or bloodstone), is a green chalcedony with red inclusions of iron hydroxide. Onyx is a white and black banded variety, while the musky variety is characterized by arborescent shapes inside. A first description of chalcedony of Masullas can be found in the ***Dizionario Geografico Storico Statistico della Sardegna*** (Statistical Historical Geographic Dictionary of Sardinia) written by V. Angius and G. Casalin around mid-nineteenth century.

CALCITE IN THE SEDIMENTARY ROCKS OF MASULLAS

Crystals carried by hydrothermal fluids can have different dimensions depending on the chemical and physical conditions they find (stability, pressure and temperature). The larger the cavities are, the bigger the crystals will become (other things being equal). The nature of the rocks soaked by the fluids favored the copious formation of minerals such as quartz and calcite. In particular, calcite must have found stable environmental conditions for its crystallization, since it produced crystals with a distinctive size and aspect, so much that they represent a singular event in Sardinia and, maybe, all over Italy. From a mineralogical point of view, calcite creates crystals (solids) with variable aspect: it can be pyramidal- bipyramidal rhombohedral to lenticular, tabular or lamellar, but always characterized by three or six faces. When pure, calcite is colorless and transparent but, normally, it is observed in its colored form. This is due to its “allochromatism”, that is, the capability to exhibit different shades when the mineral is charged with impurities by the crystallization fluids; another peculiarity of this mineral is to show a pink or red fluorescence when it is hit with UV rays. Unlike the other types of crystallization found in Sardinia, the veins found in this territory show three common kind of crystallizations: bladed (which shows falsified rhombohedrons derived by the three-sided “trigonal” bipyramid), another rhombohedral and, the most characteristic, tabular with pseudohexagonal shape.

PSEUDOHEXAGONAL CALCITE CRYSTALS OF MASULLAS

The mineral itself can grow and originate crystals with different structures but ascribable to the same atomic network model. Calcite, in particular, can be found in at least 800 different forms of crystals.

Actually, the “pseudohexagonal” calcite of Masullas, is the result of “gemination” and interpenetration of different tabular crystals (flat), properly arranged. The result is a fake prism which “simulates” the real hexagonal symmetry, since it is much more similar to the (tri)gonal system key pattern; for this reason these crystals look like the ones of other minerals, such as bloodstone, trigonal too, whose formula is Fe_2O_3. So, these minerals must be considered the most unique in Sardinia and, maybe, all over the world.

RHOMBOHEDRAL CALCITE CRYSTALS OF MASULLAS

Calcite, whose formula is $CaCo_3$, can be ascribed to the trigonal system, ditrigonal-scalenohedral class, so we expect their shape to appear like a scalene pyramid. Chemistry occurring during the formation of the crystals of this particular calcite of Masullas made the crystalline structures very similar to other minerals like dolomite or siderite. Moreover, particular local genetic conditions have largely modified the initial chemical composition of the mineralizing fluids, by leaving a silica layer over the big crystal shown here.

THE SECOND ERUPTIVE CYCLE

At the end of the Messinian Age and during the Plio-Pleistocene epoch, the Arci volcanic activity restarted through the re-opened fractures and the new volcanic chimneys. So the volcano erupted rhyolitic, intermediate and alkaline acid lava flows. The rhyolitic lava flow produced the deposition of obsidian, which has been at the heart of the mining activity for tens of thousands of years. About 1.8 million years ago, on Monte Arci and on the old Marmilla valleys, huge basaltic lava flows particularly fluid poured out. In some spots of the Masullas territory, it is still possible to observe the “ropy” flow structures due to the typical cooling of these lavas, which take the name from the Hawaiian *“Pahoehoe”*.

MONTE ARCI MICRO-MINERALS

After more than 20 million years of activity, the volcanic structure of Monte Arci is complete. Its rocks, like obsidian, attracted mankind already thousands of years ago. Starting from the last century, the mining activity and the researches led by scientists and collectors highlighted how the succession of rhyolites, andesites, dacites, alkaline trachytes and sub-alkaline basalts produced new and unique mineral species. The formation of these minerals is mainly due to the presence of gas trapped within the lava bubbles. At first, scientists and collectors focused the attention on these minerals during the mining activities of the Funtanafigu quarry, situated on the west side of Arci; afterward, other areas were researched. Among these minerals it’s worth mentioning: osumilite, mullite, pseudobrookite and hematite, all perfectly crystallized. The study of these mineralizations revealed many similarities with the ones of the vulcanites of Eifel in Germany and of Thomas Range Quarry in the Wah-Wah Mountains of Utah (USA), which are other popular areas for the scientists of all over the world.

PERLITE AND MICROMINERALS OF THE RHYOLITIC MAGMAS

In the Conca ‘e Cannas mine, situated on the south-west side of the volcano and opened during the last century for the mining of perlite for industrial purposes, we can find the greatest obsidian vein of the entire Monte Arci.

Perlite is a true siliceous volcanic glass which differs from the other glassy rocks since it can expand to twenty times its original volume when it reaches high temperatures, close to the point where it softens. When, reduced to granules, under temperatures of 800-1000°C, it expands and vaporizes the water trapped in the structure. This process is irreversible and produces granules containing micro-bubbles which lend a great lightness and a thermal insulating power to it. Perlite is exploited by the construction industry to create thermo-acoustic insulation panels and in order to lighten the anti-seismic structures, but it can also be employed in the farm industry for multiple purposes, especially when mixed with the ground to improve the plantation soil substrate. The mineralogy of the magmas of this mine is still to know, but it is characterized by an interesting complex formed inside the lithophysae during cooling within the rhyolitic lava flows. These cavities, generally spherical shaped, are characterized by a central cell whose linings are covered by minerals; these minerals have formed during the condensation stage of the gas trapped inside the cooling lava. Many unique micro-minerals perfectly crystallized, such as Osumilite-Mg, topaz, bloodstone and tridymite, set down on the surfaces of these shells.

THE PREHISTORIC OBSIDIAN MINE OF CONCA CANNAS AND MASULLAS

Inside the Conca ‘e Cannas mine, situated on the south-west side of the volcano and opened during the last century for the mining of pearlite for industry purposes, we can find the greatest obsidian vein of Monte Arci. Obsidian is a volcanic glass, generally black, used for the production of cutting tools such as scalpel blades. Already during the Neolithic epoch, the extraction of obsidian led Monte Arci to the heart of trades in the west of the Mediterranean Sea, by facilitating the establishment of new social and human relationships of the Sardinian people with other populations. The Masullas-Conca ‘e Cannas area saw its obsidian mining and working activities intensified and this phenomenon is proven by the numerous lithic workshops found in the council territory. Also during the following millenniums, the human activity left proves inside the nuraghes built all over the territory.

FOSSILS

In the intervals between eruptions, in the course of millions of years, life around Monte Arci flourished. We can now confirm this fact thanks to the finding of several fossils, preserved inside the rocks of this territory. The development process of fossils occurs especially within the sedimentary rocks set down on lake, river or sea bottoms or, more infrequently, in other particular environments. The superficial erosion of rocks produces sediments which are taken to the lakes or to the sea, where they deposit and cover the remains of plant organisms or dead animals. As they increase, these sediments and their content will slowly collapse under their own weight, becoming rock. Inside those sediments, the biological remains or the marks left by the buried organisms will fossilize. Even when modified, sometimes these marks keep their original form and become a proof of the life and the environments existed in that place millions of years ago.

BARRIER REEFS AROUND RISING MONTE ARCI

During the Burdigalian stage, until the Langhian age, although with brief variations, climate favored the development of barrier reefs, atolls and lagoons. In central Sardinia, it has been possible to observe signs of these barrier reefs around Masullas, Mogorella and Isili, while in southern Sardinia along the areas of Campidano near ~~di~~ Furtei, Segariu and Villagreca. Every single coral is composed by a calcareous cell divided in septa, where the polyp is settled; polyps stick out their arms to capture particles floating in clear water. Each colony can host thousands of polyps, which breed growing the colony in width, until they fill every available space. When the first layer of polyps die, other polyps settle on their cell, and grow the colony in height too. On the marginal reefs, corals advance and build new reefs towards the blue water. On the contrary, on the atolls, the coral colonies settle on the top of submarine volcanoes (as Monte Arci at that time); as these volcanoes lower, due to erosion or to the slow sinking of sea bottoms, barrier reefs grow in height in order to keep the same distance from the sea surface. Inside and around these barrier reefs, one of the widest biodiversity of the planet flourished. The necessary bare minimum sea surface temperature for the development of the barrier reefs is of 20°C so, today, in the Mediterranean Sea they can't be found but have been replaced by the so-called "coralligenous" habitat.

FOSSILS AND PALEOENVIRONMENTS

Fossils are the proof of life forms and environments of the past; through them and the signs they left, geologists can access useful information for the reconstruction of life evolution steps.

Starting from the beginning of the Miocene epoch, the average annual temperature rose up to a "Climatic Optimum", reached between the Burdigalian stage and the Langhian age. The echinoid fossils (sea urchin) like *Clypeaster* and *Echinolampas* currently floating in the Caraibic and Pacific hot waters are a proof of this theory. On the other hand, the findings of pinaceae strobile (pine cone) and echinoids such as *Spatangus* and *Schizaster*, which can still be seen in the Mediterranean Sea, confirm the occurrence of temperate climate periods with great periodicity.

SEA BOTTOM INHABITANTS

During that epoch, coastal waters were rich in bivalve mollusks and gasteropods such as *Cardita, Flabellipecten, Ostrea, Glycymeris* and *Natica, Conus* and *Cypraea*. Nowadays, the rocks formed in the coastal environment don't exist anymore, completely eroded millions of years ago. Thanks to submarine landslides, these mollusks have reached us, carried down to the deep sea bottoms (those now emerging around Monte Arci).

TROPICAL SEAS ECHINOIDS

Echinoids, are one of the most ancient and common sea animals all over the world; these organisms are characterized by a thin skeleton made of plates properly arranged in order to protect vital organs and, on the external side, they show thousands of spines and pedicellariae (pimples) which allow them to move, grab nourishment or defend themselves. In the course of time, echinoids have developed new and different forms. During the recurring tropical storms in the Marmilla coasts, populations of *Clypeaster, Parascutella* and *Amphione* were raised from the sands and then partially submerged and gathered, until death. Recently, many groups of fossils have been found in different outcrops of the Marmilla area.

ECHINOIDS OF THE DEEP SEA BOTTOMS

Going through a channel opened between the Alps and the Apennines, during the Burdigalian stage, these populations of echinoids slowly moved from Sardinia towards Middle East and the Indian Ocean, passing through the Indonesian archipelago in order to reach the Western Pacific Ocean coasts, where their descendants are currently settled. Some species kept their features unchanged compared to their ancestors (such as *Heterobrissus, Hypsoclypsus* and *Echinolampas*). On the contrary, others have modified their aspect but kept just some original features, such as *Faorina*.

THE VOLCANO AND THE TROPICAL ENVIRONMENT

The volcanic activity continued throughout the Early Miocene, alternating standstill periods; it was characterized by the production of huge quantities of submarine basaltic lavas, until the first summits of the volcano emerged. The submarine magmatic activity produced the typical pillow-lavas while, up to the present, it hasn't been possible to find rocks ascribable to the subaerial activity of that time. However, some present environments, such as the Hawaii area, reveal that a similar activity must have occurred on our volcano too, when it was in full eruptive activity. Scenes of predation (such as the one depicted by the present diorama) weren't infrequent since the particular tropical environment developed in this area was characterized by a rich fauna and flora. The sea waters surrounding Monte Arci were peopled by marine mammals, fishes and reptiles as much as the current tropical environment of the Indonesian archipelago; also the tropical vegetation didn't differ too much and was characterized by thick coastal forests, bombax, palm trees and magnolia. After the Langhian age, the heart of biodiversity moved towards East, developing similar environments always linked to the volcanic activity.

FISHES OF THE ARCI AREA

As documented by this museum, the finding of an accumulation of fish remains is considered an exceptional case in Sardinia. The fossilized fishes plates exhibited in the Volcanic Hall contain remains belonging to the *Clupeidae* family (more commonly called herrings), probably ascribable to the *Alosa* genus. The thanatocoenosis exhibited here shows the remains of a group of shads hit by a violent murky stream followed by a submarine landslide, occurred around 18-20 million years ago in these waters. Landslides like that weren't infrequent; proves of that have been found in the Masullas and Pompu areas. The fishes hit by the blast wave were partly disarticulated and carried away for a long distance and then covered by the sediments of the landslide. Generally, the parts of the fishes that firstly fossilize are the hardest ones, like bones, teeth, opercula and scales; on the contrary, the remains shown here still preserve parts of mineralized soft tissues.

MIOCENIC SARDINIAN FAUNA

In different fossil deposits dating back to the Early Miocene, such as in the Laerru and Oschiri areas, it has been possible to find copious amounts of plants and animals remains. Among them it's worth mentioning the remains of primitive ruminant mammals, such as suidae, as well as rodents, insectivores, crocodiles, turtles and birds. In the other areas of the Island, remains of big cetacean predators (squaliformes such as *Carcharocles megalodon*) along with primitive cetaceans and marine mammals (such as the *Metaxytherium*, exinct genus of Asian dugong) have been found together with remains of reptiles such as the *Tomistoma*, a crocodilian related to the current Indonesian gharial and particular freshwater "soft shell" turtles. During the Serravallian stage, Sardinia and Corsica probably approached the coasts of what is now Tuscany, sharing the same fauna and flora. This new shared fauna included typical savannah animals, characterized by small deers, antelopes and tiny giraffes, suidae, small rodents and the *Oreopithecus bambolii*, which was a primate quite similar to the current gibbon, able to move in a bipedal manner.

MIOCENIC SARDINIAN FLORA

The most recent paleobotanical and paleoecological studies about the West Proto-Mediterranean have defined the climate and the flora characterizing Sardinia at the beginning of the Aquitanian stage until the achievement of the "Climatic Optimum" at the end of the Burdigalian stage. Although the average temperature was progressively rising, there were still recurring cold periods (estimated 100,000 years each) and the flora adapted to it. However, once reached the "Climatic Optimum", for many millions of years, the Sardinian and Proto-Mediterranean flora was characterized by a typical subtropical-tropical biodiversity. *Bombacoxylon* (tropical tall tree plants which resemble to the current *Bombax* of the semi-submerged plains of the South-East Asia and India areas), used to cover the forests. Different species of palm trees, some quite similar to the current Mediterranean dwarf palm trees, were common but not prevalent. During cold periods, conifers (not *Pinus*) characterized by Podocarpaceae and Cupressaceae were quite abundant. Although any mangrove (which means a group of plants typical of the coastal tropical environments) hasn't been observed in the Island, the presence of some specimen of the same group (belonging to the *Meliaceae* and *Avicennia* families) has been observed along the Spanish and French coasts suggesting they were quite widespread also in Sardinia.

THE CLIMATE CHANGED

Starting from the Serravallian stage (13.6 million years ago) the global climate gradually cooled down, due to the expansion of the polar ice sheet. As a consequence, in the Island, climate became strongly seasonal. However, in the South Mediterranean and in Sardinia, a subtropical fauna and flora managed to survive. As a consequence of the expansion of the Antarctic ice sheet, the global sea level dropped and the sea begun to recede from the Mediterranean, causing the salinity crisis of the west Mediterranean sea.

THE SALINITY CRISIS

When, at the beginning of the Messinian Age, the convergence movements pushed the Moroccan coasts against Spain, the connection between the Mediterranean sea and the Atlantic Ocean, already reduced, totally closed. As a consequence our sea became isolated and, over millions of years, the waters progressively evaporated and the overall salinity level raised, provoking the extinction of many animal species. Once emerged, Monte Arci was then attacked by a superficial erosion which reduced its summits and dig deep valleys, contributing in the sedimentation of a huge quantity of rubbles in the Sardinian   in the Campidano area.

FORMATION OF THE CURRENT LANDSCAPE

At the end of Miocene and during the Plio-Pleistocene epoch, the new tectonic forces re-opened the old fractures along the Sardinian graben (ditch) and, as a consequence, the Campidano area collapsed further, sharpening the existing hollow. The Arci western side collapsed, followed, to a lesser extent, by the eastern side. The result was a thin and tall relief with precipitous sides, similar to the current one, but much higher. About Around 5 million years ago, when the volcanic activity restarted, the old mountains already eroded were covered by the huge succession of acid rhyolitic, intermediate and alkaline lava flows. Finally, about 1.8 million years ago, in the old Marmilla area, huge basaltic lava flows poured out and formed the current basaltic shelves.