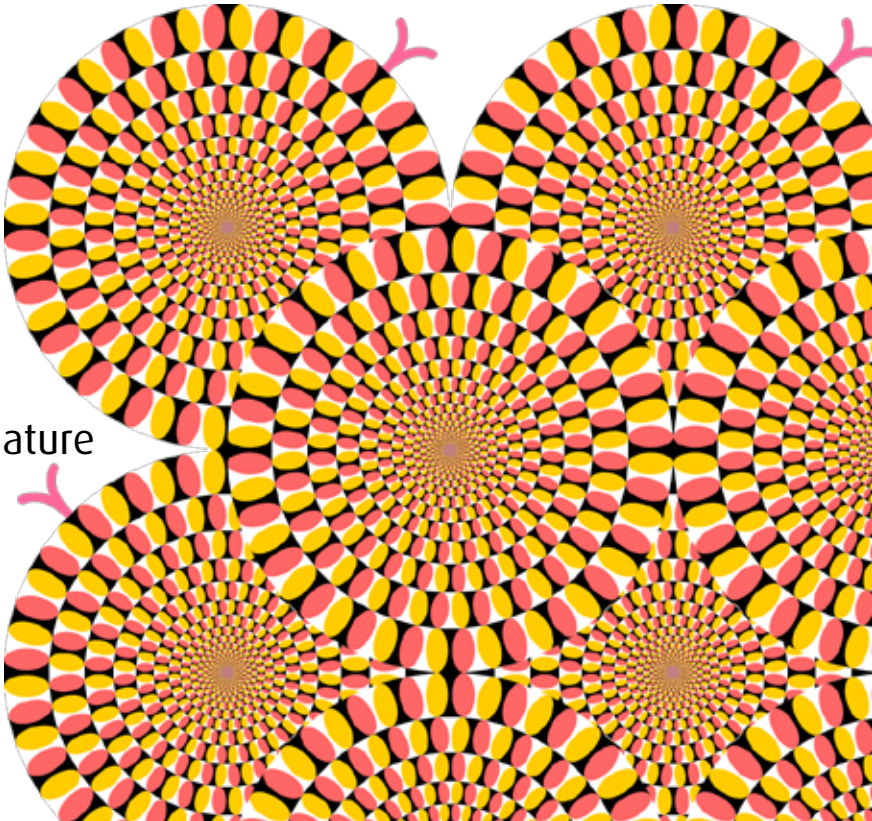
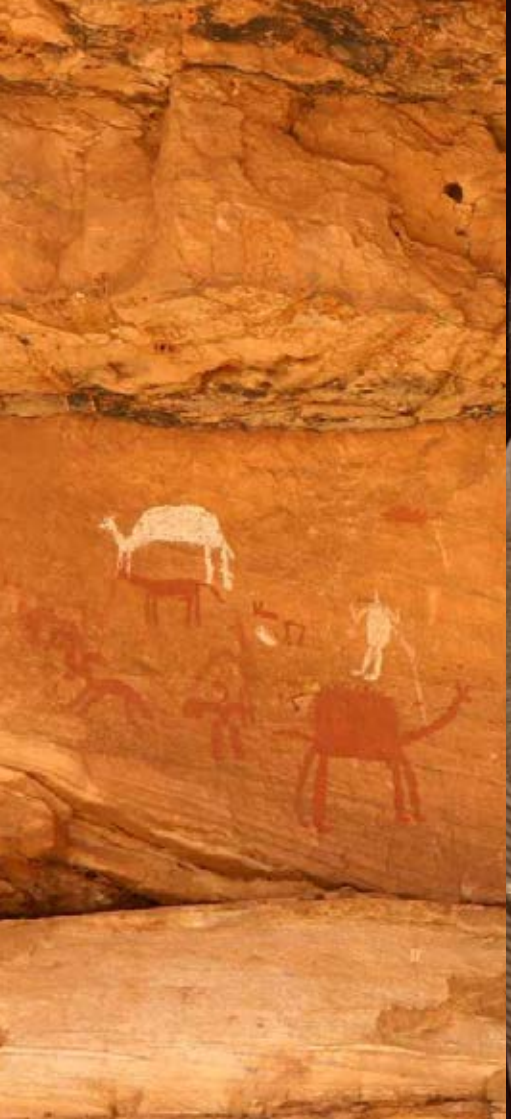
# MUSEO GIARDINO GEOLOGICO

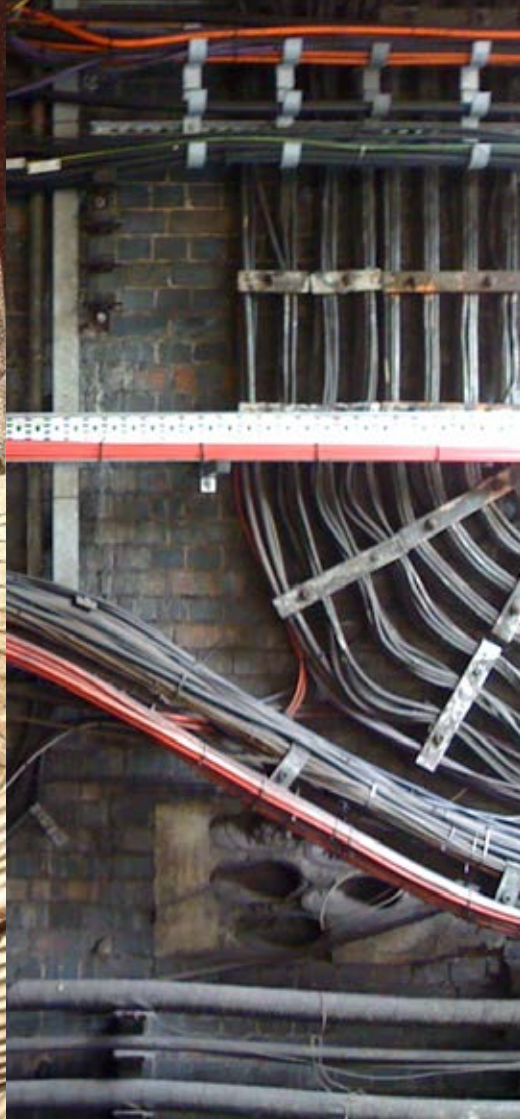
Sandra Forni



## MEMORANDOM

for those who are curious by Nature





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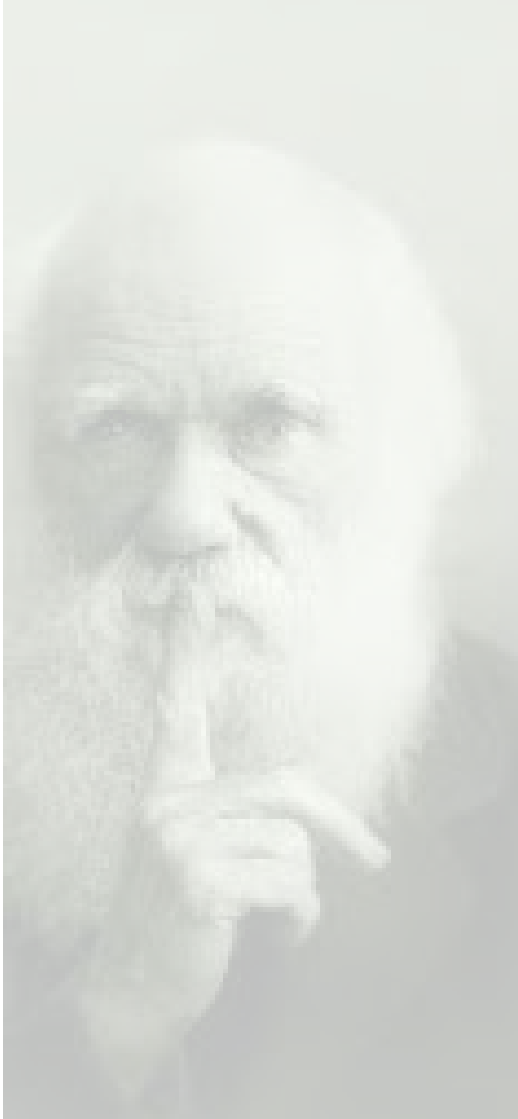

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The Geological Garden Museum is dedicated to the memory of Sandra Forni,
a colleague and friend who died prematurely in 2005.

# Summary

Each visit to a museum creates expectations that can be unfulfilled to some degree if we are unclear of the original premise and aims of the exhibition in question. Sometimes we focus our attention on a specific exhibit which we see as representative of the exhibition and the reason that prompted our visit in the first place. In other cases it is the sheer quantity or spectacular nature of exhibits that plays a primary role.

**This is not the case with our exhibition.**

The aim of the exhibition is to provide a concise and detailed framework of the distinctive traits of our region and to facilitate a clear understanding of the role played in our society by such precious assets as the soil and subsoil. Aside from any aesthetic appeal, which is naturally of interest, it is the material itself that is central to the exhibition.

**The problem is how to interpret it.**

So just as in architecture a monument may be beautiful yet unable to convey any message to us if we have no knowledge of history of art, so nature becomes intelligible and fascinating only if we are able to understand and interpret the meanings, symbols and stories. However, the pathway to understanding is often anything but straightforward.

There is a certain degree of knowledge which is taken for granted and considered indisputable, but which in truth, especially today, is actually diminished, impoverished and devoid of content. This guide endeavours to reclaim the meanings and origins of that knowledge.

Raffaele Pignone

*Chief of Geological, Seismic and Soil Survey of Emilia-Romagna*

# Prologue

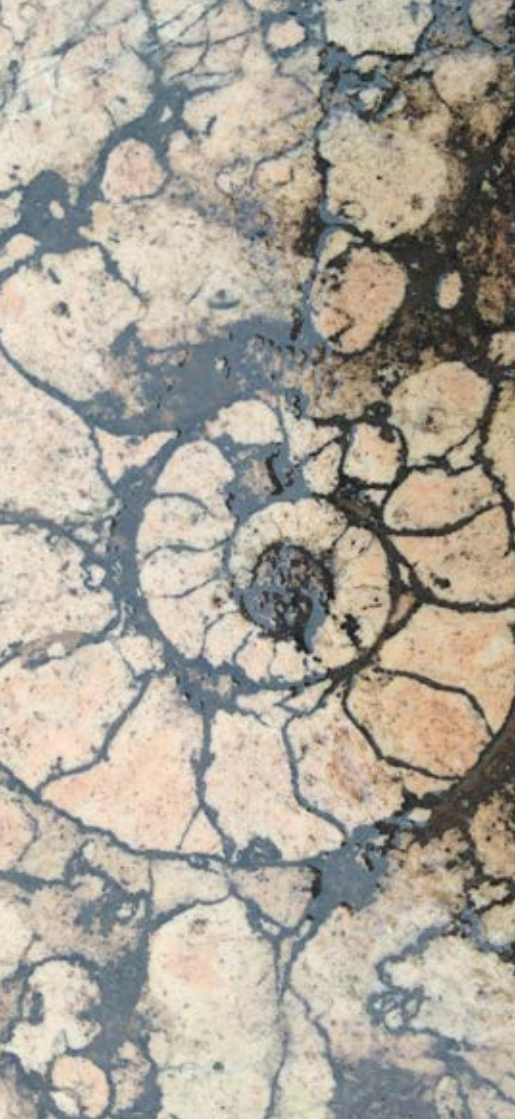
He who never made a mistake never made a discovery
*(Samuel Smiles)*

*"In Africa, a group of ethologists had travelled to a lakeside area to study monkeys that lived in the forest. The ethologists decided to attract the monkeys to the shore of the lake by placing sweetcorn on the sand. The monkeys ate the sweetcorn and then quickly retreated to the forest where they felt safe. The ethologists decided to mix the sweetcorn in with the sand in order to hinder the monkeys in their activity, allowing the scientists more time to observe the primates' behaviour. The monkeys did indeed encounter some difficulty in separating the sweetcorn from the sand and thus remained on the beach for longer. At one point one particular monkey, frustrated by the difficult task, picked up a handful of sand and sweetcorn, tossed it into the lake and made a discovery: the sweetcorn floated while the sand fell to the bottom. Brilliant! In a short space of time, a structure emerged whereby the monkey who had conducted the experiment in the first place taught the others how to separate the sweetcorn from the sand. Some monkeys gathered up sweetcorn and sand, others threw it into the water, and others still collected the floating sweetcorn. The older monkeys, however, refused to learn the new method, preferring to collect the sweetcorn in the traditional way."*

I don't know if this story is true but it certainly shows that knowledge and therefore progress involves action, experimentation, curiosity and teaching. The mind needs exercise to stay nimble and young. Our collection can, in this sense, provide a bit of a mental workout.

## Are you ready to explore?

The Sandra Forni Geological Garden Museum comprises two spaces - museum and garden – featuring exhibits that testify to particular moments in the Earth's past. It's like a photo album that immortalises key moments in the life of a family. It can be "looked at", therefore, as a chronological history or as a series of independent objects, a set of events that are intrinsically linked.

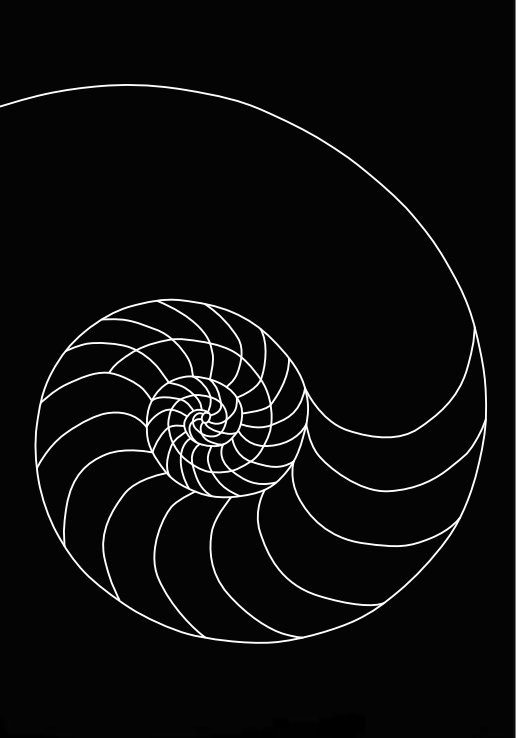


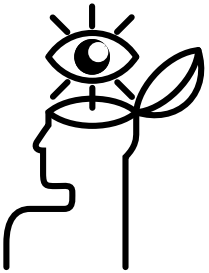
# The fossils

Learning is experience. Everything else is just information
*(A. Einstein)*

Fossils are a testimony to the past: they are, or they reproduce, what remains of a living being. From a historical point of view, their discovery has always aroused wonder and bewilderment. On the one hand, they led ancient peoples like the Egyptians to question the meaning of life and its perpetuation (mummification was a way of preserving, rather like a fossil, human and animal bodies). On the other hand, the variety of shapes, gigantism (the remains of dinosaurs), deviations from existing forms, created and fuelled many of the stories of Greek-Roman mythology. Even manifestations linked to the presence of fossil fuels in the ground, such as fires triggered by seepage of natural gas and petroleum, added to the legend and mystery of the regions where they occurred, prompting the first questions on what might lie beneath the ground we tread on. Travel, the exploration of distant lands, as well as direct observation of the presence of entirely similar species in different environments (for example the discovery of marine fossils in the mountains), raised doubts and reflections over the centuries with far-reaching philosophical and religious implications that only in relatively recent times have been considered and accepted. The theory of continental drift, formulated in 1912 and supported by fossil evidence, was only substantiated in the 1950s.

It was difficult to accept concepts such as evolution, timescales so long as to be inconceivable, intangible, and to realise that we know so little of life. A life that began in environments we considered extreme, evolving slowly towards our everyday normality. A normality that exists alongside the same extreme environments in which organisms continue to live today. Fossilization transforms an object into a simulacrum: it mimics itself but is, in reality, something else. A fossil is a testimony of what no longer exists but lingers on like a fingerprint. For example, large animals were trapped in tar sands and eventually fossilized, in a sort of triumph of past life over more recent. While we may view fossils as evocative, of scientific interest or sensational, the importance of their contribution to our civilization is less obvious. Fossil evidence inadvertently became an instrument of war and civilization from the Babylonian era onward, used as bitumen to make roads passable and the hulls of ships waterproof. Meanwhile pitch, a mixture that would later be called Greek Fire, was used to burn enemy ships during naval combat. But true systematic use was to come with the industrial revolution in Great Britain at the end of the 1700s. Coal, oil and gas suddenly began to affect socio-economic and political situations. The use that least testifies to fossils' ancient origin has become that which affects the present and the future, perpetuating the triumph of the recent past in a spasmodic process of ever-growing dependence. Fossils in their static, unchanging nature contain the energy we need to fuel our lives and affirm our existence as a living species.





## Fossilization

The museum illustrates the main types of fossilization and fossils. There is no chronological order, the intention being to provide an overview to help visitors understand how an organism can undergo a process of fossilization and how this happens. The time factor is an extremely important aspect for the encapsulation of the organism in sediment and the gradual replacement of organic matter with mineral or in any case inorganic material. The exhibition includes specimens that have undergone processes of isomorphous substitution, like silicification in the case of plants, inclusion phenomena with the creation of both the external and internal prints of the animal, as in the case of trilobites and ammonites, and carbonization phenomena resulting from a sudden burial that permits no exchange with the external environment. Fossilization involves a tiny portion of the organic matter equal to approximately one percent (1%), and for this reason the discovery of an artefact is quite rare. One of the things that most amazes visitors and prompts reflection, is the variety of shapes and in some cases the relatively recent age of finds. For example, the Pliocene, a period strongly represented in the lithology of the Emilia-Romagna region, yields species of shells and fish that are still found today.

What becomes clear to see is the continuity of life and its tenacious manifestation, plus evolution as the successful adaptation to a given environment. The rate of discovery is testimony to this success.

The classification of life forms following explorations to South America, Asia, Africa and Australia between the eighteenth and nineteenth centuries, and comparative studies with fossil forms, led to a comprehensive understanding of habitats and the development of theories such as the evolution of the species and natural selection. Another aspect that attracted considerable interest in science was the discovery of living fossils: forms that have continued to exist through to the present day only in microsystems that survived natural catastrophes and changes on Earth. Their discovery has allowed us to better understand the processes of adaptation of species to their environment and also how this constitutes an improvement in terms of chances of survival and a weakening in terms of adaptive ability.

# The soils

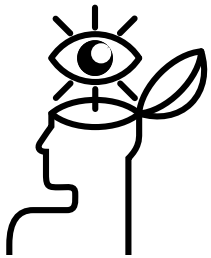
Land! land!
*(Cristoforo Colombo - 1492)*

Colours, smells, tactile sensations: this is what we instinctively perceive when we talk about soil. Life is inextricably linked to it throughout its whole life cycle, from beginning to end, which is why we call it 'earth', identifying it with the planet on which we live. Soils are the product of interaction between chemical, physical and biological factors linked to the substrate, morphology, exposure, climate, living organisms, and human activity too. Aerobic and anaerobic bacteria, fungi, plants of the most disparate shapes and degrees of evolution, plus animals all share it in the most varied forms of symbiosis and competition strategies. What is most striking is the density of life which inhabits it (just a handful of earth contains a hundred billion tiny living organisms, mostly bacteria and small insects). The complexity and variety of its structure and chemical composition is largely known, but even today some aspects of elementary exchanges in organic components are misunderstood. A mystery that has been perpetuated over the centuries, the mystery of life itself. From it stems the great respect that people's traditions have always had for the soil. Agricultural civilizations laid the foundations of progress, transforming Man from a nomadic hunter-gatherer to a methodical, more settled existence.

The land dictated the pace of growth and human population increase. It allowed people to contemplate a future that went beyond a precarious day-to-day existence thanks to sowing, tending and patient waiting, before

harvesting the fruits of their labour. This radically changed the approach to life, introducing a time dimension dictated by the changing seasons and the ability to improve results obtained time after time. The very character of a civilization is shaped by the soil: the productivity of the land is mirrored in the enterprising nature, coarseness or hospitality of a people. The fruits of the earth bear witness to the marriage between the generosity of the soil and the work of man, a friendship that is perpetuated according to age-old customs.

Over the past century, technology has profoundly changed land management: the systematic introduction of specific crops and synthetic products coupled with intensive farming methods also changed man's respect for the soil, and only in recent times have we begun to see a return to natural methods and the intrinsic value of this precious resource.



## Man and the soil

In Emilia-Romagna pedology (the study of soil) is of great importance since many of the Region's economic activities require a profound understanding of the distinctive characteristics of the soil. One aspect often overlooked is certainly the typicality of the soil. Locally, man has tried to improve and optimize agricultural production through targeted and rational choices, which may sometimes even appear romantic, like the planting of a rose bush at the end of each row of vines as an effective early warning system against parasites. The soil strongly conditions agricultural production and animal husbandry, emphasizing the uniqueness of certain food products. Parmigiano Reggiano cheese is a prime example.

The morphology of the soil can also be seen as a memory of the past and a history book of events. Places that were once home to the *Terramare* civilizations and Roman centuria, which have geometrically characterized the lands on the plain for 2000 years, still retain traces of past civilizations and reveal these traits rarely subject to the recurrent flooding of the rivers of the Apennines.

The museum exhibits the different varieties of soil present in our region and the tools for identifying and classifying the soil. It is amazing to note how such a thin layer of soil can contain so much potential and how the latter can drive wealth and prosperity. The soil ecosystem is silent but it is a cornucopia which, season after season, following precise natural rhythms, gives us nature and the agricultural crops that sustain life on earth. And only by respecting this soil ecosystem can we perpetuate this vital life cycle.

# Mineral and rocks

You cannot be free of think if you do not have knowledge
*(italian graffiti)*

Minerals and rocks have always marked the time evolution of man. First flint, then metals played a fundamental part in the evolution of knowledge and progress.

Obsidian and flint, both consisting of silica, were the first materials used by man.

And 4000 years ago it was again silica, in the form of glass, which was the first material to be obtained artificially by lighting a fire on a beach, and then used for the construction of

containers and artistic objects. Silica remains essential in today's modern manufacturing industries, the key element in countless different electronic items. The material remains the same, in actual fact. What has changed is our attitude towards it. The growth of knowledge and awareness generates development and civilization.

Similarly clay, derived from mud, was transformed into *objets d'art*, building bricks, vases, tablets on which to write symbols and later an alphabet, or a tool for counting in the case of the Babylonians. The Greeks and Romans learned to bake clay, making water pipes, roof tiles, heating pipes and kilns. Then, over the centuries, it was exploited to produce earthenware pottery and china and later, with the advent of new ceramic materials, it became a component both in aerospace technology and engine mechanics.

The limitation of having at one's disposal, in a given environment, a single resource in great abundance (be it a mineral, a rock or other material) is, historically, the condition which has spawned new ideas. These have allowed civilizations to make great advances, to evolve. It is significant that in everyday language we say "I got an idea". It is a turn of phrase that suggests a revelation, an idea came to me. So something that does not belong to me, namely knowledge, revealed itself to me, lifting the veil that had previously made it invisible to my eyes. Revelation, which is the restoring of the veil once the knowledge is acquired, necessarily entails a learning process. Education, in its Latin sense *(educere)* 'to extract', is the action of revealing but it also has a profound metallurgical connotation.

The use of materials affects on our senses, either directly or indirectly. Stone is perceived by artists as already possessing a form even before it is

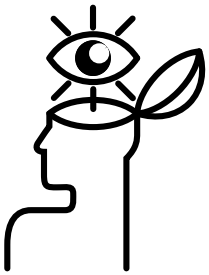
modelled. Michelangelo spoke about this at length in his writings. He asserted that the sculptor's task is to liberate the figures that already exist in a block of stone being worked. So must a new idea behave towards a material.

Rocks and minerals are the protagonists of civilization's development. Copper, for example, started to be used for tools, replacing stone artefacts and allowing man to make great advances. As an alloy, it was used to make bronze, weapons, armour, writing styluses, surgical instruments and coins. It was eventually replaced by iron, only to reappear for cannons and bullets at the end of the Middle Ages. Again as copper, it returned to the fore in the nineteenth century as a tool for conducting and controlling electricity.

With regard to minerals, there is another aspect that has influenced our culture at every level: their outward form. The crystal is the geometrical symbol of perfection. For centuries, Platonic solids represented the absolute and beauty. The duality of form and content drives us to attain further understanding of reality, taking on a philosophical meaning, the same meaning behind the Greek thinking upon which our Western concept of reality is based.

Each time history takes a new look at minerals and rocks, it makes great technological, economic, artistic and intellectual advances, thanks to which the material appears as no-one would ever have expected.

The short journey of exploration through minerals and rocks that we propose is based on the idea that no matter how familiar a subject may be to us, our knowledge of it is never sufficient.



## Precious Minerals

Let's start with the story of a metal which, in the past, was considered to be of no value: platinum. Its name comes from Spanish and means little silver (*plata* = silver). In actual fact, although already known to the Egyptians and the pre-Columbian civilizations, platinum was considered an impurity of silver and thus discarded. It was only at the end of the 16th that it began to be valued and it became a prized material from 1700 onwards. So we can see that the notion of preciousness is not related to the rarity or beauty of a material, but to its commercial demand or the symbolism associated with it. So man is the measure of preciousness.

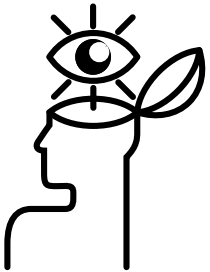
Value is not necessarily the product of a specific need, but may also be the result of a trivial convention: such is the case with gold.

Gold represents the reference point of our economy but its significance lies in its chemical characteristics: it is relatively abundant, incorruptible by acid or atmospheric agents, it has a unique colour and its symbolism makes it the protagonist and key to its own success. At least in the beginning. Over the centuries, some of its meaning has been lost, yet its monetary symbolic value remains and that is what has carried its success into the modern economic system. Today it is a simple reference system, in the same manner as a unit of weight or length.

Still on the subject of precious metals, a little-known fascinating fact is that the term 'blue blood' used to describe royalty, derives from the bluish

tint that affected those suffering from argyria (from *Argyros* which in Greek means silver). This is an alteration of the skin, which takes on a bluish-grey tinge due to the ingestion of silver (in the form of powder or compounds). The condition was caused by contamination of food eaten with silver cutlery. Various cases of argyria were studied mostly in the late twentieth century: mine workers were among those most often affected.

Sometimes form dictates value. This is the case with precious stones: absence of impurities, idiomorphic shape and size are the parameters used to grade preciousness. However, these stereotypes tend to come at the expense of the originality and uniqueness of specimens; it is a system that obliges conformity for an underlying commercial purpose.

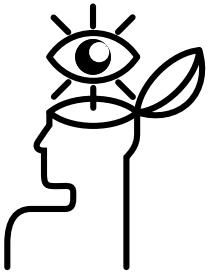


## Useful Minerals

The museum's collection includes a number of minerals and metal objects produced from minerals. These are everyday artefacts, historical or in any case well-known. The use of minerals has been partly superseded by the introduction of plastics and polymers. Numerous metals present and commonly used in everyday life can be highly toxic to humans, but the real risk lies only in prolonged exposure, and under particular conditions.

For example, lead continues to enjoy widespread use in many different fields of application. It is extracted from minerals such as galena, cerussite and anglesite. It was commonly used from Roman times until very recently

for the construction of water pipes and never posed a threat. It became a danger during the Roman era when it was suddenly fashionable to use lead barrels for the fermentation of wine, to make it sweeter. The Roman emperors Tiberius, Caligula, Domitian, Commodus and, some believe, even Nero, suffered from lead poisoning (Saturnism is the name given to the disease). This serious form of lead poisoning was also widespread among the Roman upper classes, leading to mental disorders as well as severe damage to vital organs, so much so that lead has even been blamed for the fall of the empire. So it is not the metal that is the problem, but how we use it. Sometimes detailed knowledge and a few clever measures can be of great use.



## Minerals around the world

Today mineral extraction is concentrated in many developing countries, where cheap labour costs and the abundance of such resources make it extremely profitable. In Europe, these resources are nowadays limited and environmental concerns have led to the retention of only certain sectors of the mining industry.

The museum's collection is varied and the exhibition criterion is based simply on qualities of colour, shape, beauty and variety. Clearly, an aesthetic criterion is not a systematic scientific method, but despite the subjective nature of the choice, it allows an instinctive reaction to the charm of the exhibits on show without necessarily having to attribute monetary or utili-

tarian value. Indeed, we are often prompted to make quantitative or concrete evaluations of the things around us, but this often results in us attributing false or irrelevant value to items. Objectivity in observations, including scientific ones, is only possible where there is no defined cultural path or preconceptions. In the exhibition, colour and shape are probably the most immediately perceived aspects that are assimilated by the visitor. It is important to bear in mind that when a mineral is discovered, these impressions are often even more arresting, given the element of surprise and, frequently, it is simply aesthetic taste that inspires a collection and the act of collecting. Nature reveals itself in its most unexpected and beautiful to those who are less expert but no less sensitive. An exhibition is made up of a combination of these experiences and the desire is to convey and pass on this emotion. Undeniably, there are scientific rules which an exhibition ought to follow, but the common thread is still the morphology (crystal habit when present) and the geometric arrangement of the crystals, which can be very surprising.

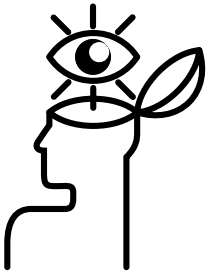
The formation of a mineral is the result of certain thermodynamic conditions and a characteristic chemistry. This is what determines a particular mineral association. There are still gaps in our understanding of exactly how minerals crystallize. In the case of crystalline forms, which can also occur together as, for example, with pyrite: cube, octahedron, pentagon, dodecahedron, etc.. we are still studying the mechanism that induces crystallization in one particular form as opposed to another.

In nature it is very rare to find a single mineral species. In general, most species are associated minerals: in this case we talk about paragenesis. The concept is similar to that by which a rock is defined as an aggregate of minerals. The specificity of the paragenesis, however, lies in the simultaneous

presence of minerals in a limited portion of space. We talk about paragenesis of rock when observing a small portion of an outcrop because the simultaneous presence of minerals could also be random. A rock sample is unquestionably the result of a chemical and physical equilibrium. These mineral phases compete for the same condition of stability, a mineral balance that is frozen under formation conditions.

This concept is formalized in the so-called principle of local equilibrium, as set out by De Donder: according to this principle, in any randomly selected small portion of rock there exists a condition of equilibrium between the minerals found there. The visitor and the surrounding environment, in contrast, are in strong disequilibrium with the sample. Only a slow process of alteration will bring the sample into equilibrium with the visitor, but that will happen in geological time. The process is extremely slow but irreversible.

Therefore, although a balance exists between the minerals, these are generally in disequilibrium with the museum environment and therefore with the visitor.



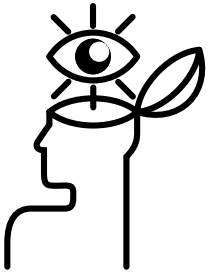
## Italian Minerals

In the past, Italy was a country with a strong mining tradition. Since prehistoric times, the presence of rock complexes from three orogenic cycles (Hercynian, Alpine and Apennine) led to intense mining activity to locate, extract and process first copper, and later iron. The intensive extraction of metals and many raw materials ended in the 1970s in the face

of excessive costs and the discovery of large deposits in African countries and in Eastern Europe. Through the specimens on display, the museum illustrates the types of minerals found and the principle Italian mining sites of historical importance. In chronological order, the last major Italian mineral prospecting took place around 1950, when widespread exploration was undertaken to locate radioactive minerals. It is worth remembering that Italy boasted the largest European deposit of iron (on the island of Elba and surrounding areas) and the world's most important mercury mine (Mount Amiata). The Etruscans, Greeks and Romans founded their economic and military power on these resources. Little more than striking vestiges of this great past remain, and memories of the more recent industries and mines are also vague and confused. The past has been forgotten and a whole mining tradition has been deleted. Mining, as well as the exploitation of energy resources (including geothermal energy), began thanks to technologies developed in our country. We record all this rather haphazardly in our museums, forgetting once again that it is intellectual value that distinguishes material.

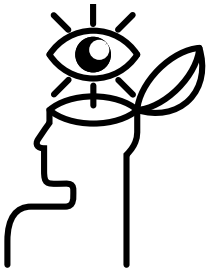
Among the many minerals present in the collection, I want to focus on one that is little-known: antimony. The reason is connected to its name. Legend has it that during the Middle Ages, near Cerreto in southern Tuscany, there was a monastery where, despite the peaceful natural setting, the monks inexplicably became sick, and many died. No doctor could understand why. A Bolognese scholar, observing that the monastery's cutlery and dishes were made of a locally produced metal which gave food a particular flavour, thought that this might be the cause of the illness and so prohibited the use of those utensils, at which point the monks stopped dying. The metal was called antimony, which means "against the monks". In more recent times

antimony was highly sought after as it was used, from the Renaissance up to the last century, as a hardening agent in type metal in printing, when the latter was still hand set.



**Rocks** Whether igneous, sedimentary or metamorphic, rocks can arouse strong emotions. The impression of power and absoluteness when we gaze upon mountains, the most majestic expression of rock; the physical pain of a pebble in a shoe; the rigour and spiritual anguish of a tombstone in a cemetery; the strength of the distorted veins of gneiss; the calmness and simplicity of a slab of sandstone all evoke everyday life, but their vitality and the explosion of shapes and colours are the result of human intervention on the rock. The mosaics, statues and multicoloured floors that adorn our monuments all endow the raw material with meaning, a significance that goes beyond the stone or rather reinterprets it, exalting it and casting it in a new, more precious light. Rocks are bearers of the most important messages of civilizations, ambassadors of art, culture, science, literature, beauty and magnificence. However, in its apparently fixed state, rock is above all a testament to passing time. Not surprisingly, an hourglass is precisely the measure of time through sedimentation. Sand is the driving force of time and sand is a form of rock. We perceive time differently from how it is measured because it is coloured by our emotions: a day can fly by without us noticing it, while one particular moment can seem endless. Yet rocks can represent this too. Lava

can be generated quickly by a sudden volcanic eruption. The same rock may disintegrate very slowly through weathering. For humans as for rock, it is the environment that conditions events, their evolution, their speed and the outcome. In this sense, rock is a silent but reliable witness to the sequence of events and a portion of the history of our planet.



## Ice and rock

On this subject, there is an interesting story relating to an event that occurred many years ago. As we know, in correspondence to divergent boundaries (called ridges), the sea floor is characterized by volcanic activity and the presence of basalts, while the earth's crust is characterized by the presence of granite cratons. Many years ago during an Antarctic oceanographic expedition, while scientists were dredging in the vicinity of a ridge, they came across a large amount of granitic rock. This discovery aroused amazement and wonder because there was no reason why granite ought to be found there. This sparked a whole series of theories and speculations in an attempt to justify this anomaly. A few days later when a large block of striated granite was found, everything finally became clear and all the scientists laughed. The streaks were due to the action of a glacier. What had happened? In Antarctica during the summer, icebergs break away from the continental glaciers, floating away from the coast and then slowly melting until they are completely dissolved. The bottom part of the iceberg, which originates from a glacial moraine, still contains numerous pieces of continental crust, granite to be precise. As the icebergs melt, the sea floor is positively

bombarded with granitic rocks. Each year the process is repeated, so that the granite continues to build up. Samples collected during dredging comprised ocean floor rocks (basalt) and allochthonous material (granite). The explanation is simple but the rock is a silent witness. We should always try to understand what evidence it might disclose.

# Mineral resources

I see what I Know
*(Federico Zeri)*

Emilia-Romagna, in contrast to regions such as Piedmont, Sicily, Sardinia and Tuscany, is not particularly rich in mineral deposits. There are modest mineral resources of copper and sulphides in the Apennines and the only significant mining activity relates to the sulphur mines of Romagna which were exploited from the 16th century. In contrast, Emilia-Romagna has considerable potential in the field of hydrocarbons, particularly gas, so much so that prospecting was promoted throughout the region from the 1920. The first drilling for oil in Italy was carried out in 1860 by Achille Donzelli. The company drilled two wells in Ozzano, 32 and 45 metres deep with a daily production of 25 kg. In the same period the Marquis Guido Della Rosa drilled a 308 m deep well in Salsomaggiore which produced 3750 kg of oil daily. Despite massive exploration campaigns, it was not until 1949 that just a few minor deposits were located in Cortemaggiore and Pontenure (Piacenza province). The disappointing results in terms of oil

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AD LECTOREM.

Qui cœlum, terras, æquor, genus omne animantum
Omne exors animæ, quid ferat omnis ager
Inuentus rerum uarios, Artesq; Metalla
Marmora cum gemmis, quid iuuet, aut noceat
Denig naturæ qui cuncta adoperta reuelat
Plynion integrum. Candide Lector habes
Atq ita q̃ priscum præferuat fronte nitorem
Lima uiri docti præstitit Hermoleo
Cui fere' te tantum (dicam) debere fatendum
Authori quantum secula debuerant.

resources for the Po Valley were, however, offset by the discovery of numerous deposits of natural gas. The first extraction of natural gas in Italy in 1938 was in Podenzano (Piacenza province). In 1944 the Caviaga gas field was discovered, at the time the largest discovery in Western Europe. In 1952 the Ravenna field was identified at 1250-1960 metres below ground (30 production wells), and numerous wells have been drilled in the Adriatic since the 70s. In 2009 the natural gas extracted on the Po plain met 15% of Italian demand.

We have known about the presence of gas since ancient times. Pliny the Elder in his monumental work *Naturalis Historia* recounts the presence in Emilia-Romagna of fires related to the seepage of methane from underground.

*... In Nymphaeo exit e petra flamma, quae pluviis accenditur. Exit et ad aquas Scantias. Haec quidem invalida, cum transit nec longe in alia materia durans. Viret aeterno hunc fontem igneum contegens fraxinus. Exit in Mutinensi agro statis Vulcano diebus. ....*

*Pliny the Elder, Book II Chapter 107*

In Nymphaeum there cometh a flame out of a rock, which is set a-burning with rain. There is the like at the waters called Scantiæ. But this is but feeble when it passeth, neither endureth it long in any other matter. There is an ash tree covering this fiery fountain, which notwithstanding is always green. In the territory of Mutina, there riseth up fire also, upon days devoted to Vulcan.

It is also interesting to note how accidents have also come about in the past.

In Barigazzo in the province of Modena, Lazzaro Spallanzani (born 1729 Scandiano; died 1799 Pavia) , in an attempt to get a closer look at the area's

famous "flaming fountain", entered a pit known to emit flammable gases and ordered one of his companions to drop in a lit match, with the consequences thus described:

*The moment it touched the ground a massive flame rose up, filling the middle of the pit and exposing me to such terrible heat that instantly my legs, hands and face were all burned, as well as my eyelashes and hair, despite my rapid retreat through the bottom aperture of the pit."*

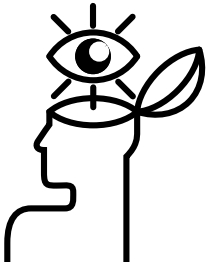
*(Travels in the Two Sicilies, p. 555)*

Natural resources, however, are not limited to metal and gas, but also raw materials for the building industry such as sandstone, clay, arkose sand, lignite and gypsum. And we mustn't overlook the saline, acidulous, ferruginous and sulphurous waters which constitute a precious heritage of low-temperature thermal spa waters, attracting a specific kind of tourist in search of health and wellbeing.

# The geological garden

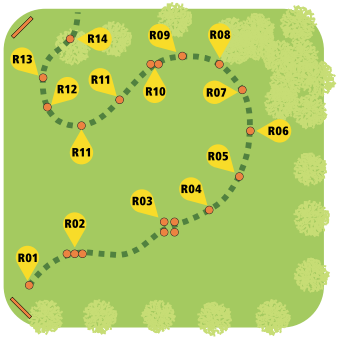
Space and time are two familiar concepts, or at least we consider them so. We measure them with great precision, we employ them in our every activities, but our senses are unable to perceive them objectively. One of the most obvious examples is the discrepancy between linear distance and topographic elevation. Three thousand meters is a short journey over land, but represents a considerable altitude. Similarly, the measurement of time can be related to the age of the individual and in particular to life lived. A young child views 5 years as a huge amount of time, a teenager as a very long time, while an adult sees it as a reasonably long period of time. Our senses, despite the objectivity of measurements, provide us with a perception adapted to our physicality. For this reason, while on the one hand, when talking about geology we acknowledge and accept concepts of geological time, the evolution of continents and paleogeography, on the other hand we cannot truly perceive what these mean because they are beyond our comprehension. This indicates that what we consider to be objective and true actually lies beyond the reach of our rational thinking. Biological cycles are attributable to linear concepts of space and time, but their rhythmical and /or cyclical nature is not perceived as such by what is involved and this is precisely to guarantee the survival of the species. For this reason, when we are confronted with geology, we find a past that somehow contradicts our everyday life. Yet it is precisely the past that is the

driving force behind our future choices. The geological garden is an extrapolation of these ideas. The spatial dimension has been reduced to the physical dimension of the boulders, and time has become the space that separates one boulder from another.

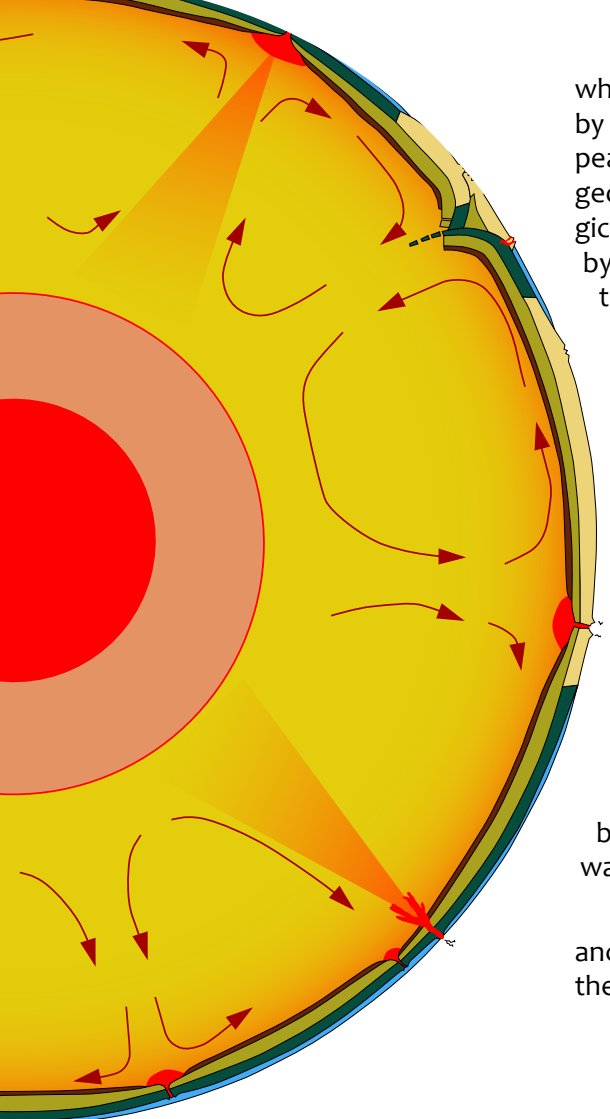


## The boulders in the garden

From an architectural point of view, a garden is a space found in all historic buildings converted into archaeological museums. Generally this is an atrium or courtyard (*peristilium*) which typically houses a *lapidarium*, a collection of inscriptions, tombs and particularly large artefacts. This type of arrangement is, however, unusual for a geological museum. The geological garden, in terms of a green space, does not have a specific geometric shape because, although it is part of an urban setting, it attempts to evoke a natural feel, rejecting symbolic schemes. Even as regards the species of trees, there are no hidden meanings and / or specific plant choices. The garden features a number of large boulders, metric and submetric in size, that represent the different lithological types present in the Emilia-Romagna region, plus some specimens that testify to other lithologies present in Italy. Geometrically, the boulders from the region are placed in a circle, arranged in chronological order, like a clock whose hands turn in an anti-clockwise direction. The other rocks are placed to the side of the clock in a random arrangement. The chance to see the different lithological types of the region grouped together constitutes a unique example of space and time as one. Those




- **R01** Paleozoic Granite
- **R02** Triassic Gypsum
- **R03** Ophiolites
- **R04** Palombini Limestone
- **R05** Salti del Diavolo Conglomerates
- **R06** Helmintoides Flysch
- **R07** Groppo del Vescovo Limestone
- **R08** Monte Modino Sandstone
- **R09** Marnoso Arenacea
- **R10** Bismantova and San Leo Sandstone
- **R11** Messinian Gypsum
- **R12** Monte Adone Sandstone
- **R13** Castell'Arquato Sandstone
- **R14** Spungone Sandstone



who have already chance of walking in the region may have been left puzzled by the fact that geological units had the chance to go walking frequently appear stratigraphically inverted with respect to the proposed sequence. The geometry of the Apennines is the result of a mechanism that shaped geological formations, overlapping successive folds, like a carpet being shortened by lateral thrusts. The fold first, the main one which is also closest to the thrust front, appears folded over on itself so that the lower surface becomes the core of the fold itself: the upper surface is visible on both flanks. It is an impressive display but congruent with the geological evolution.

The boulders provide a snapshot of the progressive evolution of two successive events: first the oldest event, linked to a period of time stretching from the Paleozoic (300 My: Millions of years) to the tertiary (200 My), and the second more recent event, which describes the evolution of a divergent boundary interrupted by the Apennine orogeny. The story from 150 My is that of a seafloor that evolves from submarine volcanism, characterized by accumulation of fast-cooling lavas, and from a subsequent establishment of processes linked to biological activity and the accumulation of sediments through to the total drainage of the basin as a result of tectonic activity, resulting in the deposition of evaporites. The type of sediments in the various formations represented by the boulders are of particular interest. Overlapping like the pages of a book of stone, they represent landslides and underwater currents, shallow waters, erosion and deposition in a never-ending sequence.

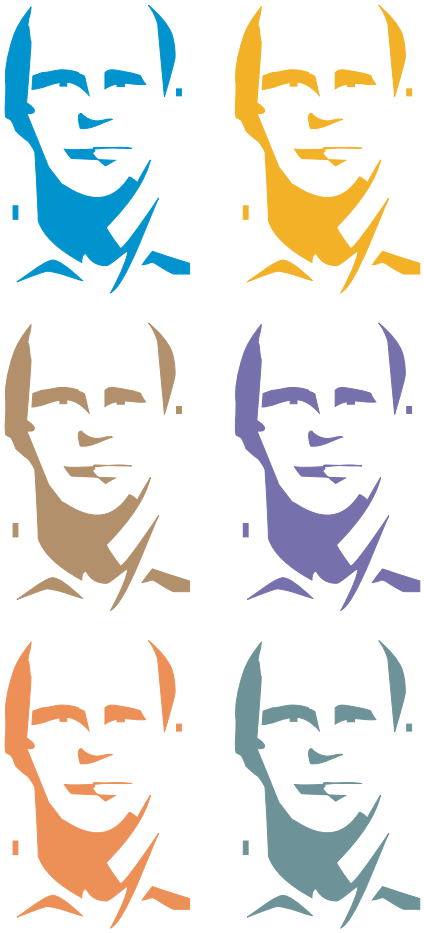
Just as the prehistoric megaliths bear witness to the awakening of an ancient civilization, in the same way the boulders in the garden bring to light the knowledge of a profound past.

# Note by the author

A man is the books he read,
the paintings he saw,
the music he listened to and forgot,
the roads he travelled
*(Sergio Pitol)*

We have reached the end of our journey. Although much has been said, so much remains to be told, but the pages available to us are limited and I am grateful for the time you have dedicated to reading this short guide. I want to leave you with a short story that demonstrates how geology is an effective tool that should be used intelligently. In the 1960s a university professor was offered a large sum of money to find a uranium mine in an area the size of Spain, but he was only given one week to do so. The professor accepted the challenge. The next day, armed with a Geiger counter, he went to the museum of natural sciences in the capital. He tested all the specimens exhibited until the Geiger counter emitted a beep. He then carefully read the label of the specimen that had triggered the device, noting its place of origin. The professor travelled to the location in question and found the largest deposit of uranium that had ever been found in that country. Of course, things do not always pan out that way, but a museum can be very helpful. Perhaps geology's greatest quality, in spite of all the technology, is that its naturalistic approach keeps our feet firmly on the ground. The world needs common sense.

Pier Francesco Sciuto



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