

## GEOLOGY AND GEOMORPHOLOGY OF THE “ROSANDRA” VALLEY FOR A CULTURAL ENHANCEMENT

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**ABSTRACT:** F. Cucchi *et al.*, *Geology and Geomorphology of the “Rosandra” Valley for a Cultural Enhancement*. (IT ISSN 0394-3356, 2005).

The Rosandra Valley is located near Trieste (Italy), on the border of Classical Karst, and is a canyon-like depression excavated in tertiary limestone. The origin of the valley is mainly due to presence of faults and overthrusts and different attitude to erosion between limestone and marls, which makes it a beautiful example of lithological and structural control on morphogenesis. Furthermore, its slopes are interested by extended and mature underground karst phenomena that contribute to making the whole hydro-structure more interesting. The valley is also remarkable for its local vegetation, due to its particular climatic conditions, and to its prehistoric and historical value, stemming from its geographic location.

**RIASSUNTO:** F. Cucchi *et al.*, *Geologia e Geomorfologia della Val Rosandra per una sua valorizzazione culturale*. (IT ISSN 0394-3356, 2005).

*La Val Rosandra è ubicata in provincia di Trieste, al confine del Carso Classico, ed è una valle profondamente incisa in calcari terziari. La sua origine è principalmente legata alla presenza di faglie e di sovrascorrimenti ed all'erosione selettiva dovuta alla presenza di litotipi diversi come calcari e marne; tutto ciò ha creato un esempio spettacolare di forme influenzate dalla litologia e dalla tettonica. Inoltre i suoi rilievi sono interessati da estesi e maturi fenomeni carsici ipogei così da creare una singolare idrostruttura. La valle è anche attraente per la vegetazione locale, condizionata dalle particolari condizioni climatiche, e per l'interesse preistorico e storico dovuto alla posizione geografica.*

Key words: Rosandra Valley, Karst, Geomorphology, Geology, Geopark.

Parole chiave: Val Rosandra, Carso, Geomorfologia, Geologia, Geopark.

### 1. INTRODUCTION

"The Valley" – as the Triestines call it – opens onto the Western side of the Trieste Classical Karst plateau: it is constituted by the intermediate and the final stretch of a creek – the Rosandra creek – that originates from the confluence of two water streams – the T. Botazzo and the Rio Griza – whose springs are located in Slovenia, a few miles away from the Italian border.

The initial stretch, now in the Slovenian territory, consists of a normal wide verdant valley that, at one point, deeply engraves white bare limestone rocks. After some miles, it results in a plain overlooking the Gulf of Trieste.

The whole area, and in particular M.te Stena on the right, is characterised by surface and underground karst. 100 cavities have been surveyed, some of which cover many hundred metres. Among them one of the most beautiful cave can be found (the Gualtiero Savi Cave, point 1, Fig. 2): it has rich speleothemes (no important concretions dating back to later than 300,000 years ago have been found), an interesting morphology of corrosive and sedimentary origin, and extends over approximately 4,000 metres, thus testifying to the complex geomorphologic and hydrogeological evolution of the “Classical Karst”.



Fig. 1 - Location map.  
Ubicazione.

On the left side, the valley was delimited by the so-called "Via del Sale" ("Salt Road"), used in Roman times and in the Middle Ages to transport salt to the inland villages. The tracks of the first railway line connecting the Hapsburg port of Maria Theresa to Vienna and Ljubljana (1887), have now been converted into a cycle track, which means that the old path is still used nowadays (point 3, Fig. 2). Caves with prehistoric remains, ruins of castles and hill forts, mills, country churches, ruins of the Roman aqueduct and abandoned quarries prove the intense and ancient settlements in the area (Fig. 2).

The Valley's peculiar climatic and geomorphologic conditions (closeness to the sea, swift passage from the sea level to an altitude of over 400 metres) and its geographical location (the farthest Northern limit of the Adriatic Sea still belonging to the European continent) provide the Valley with utterly peculiar fauna and vegetation. The valley, which has been long regarded as "special" for its outstanding naturalistic value, also presents an important and unique geological and geomorphologic heritage and is worth becoming an interesting Geopark.

## 2. GEOLOGICAL CONSIDERATIONS

As far as the lithostratigraphic succession is concerned, the following items can be found (going from the most ancient to the most recent one): the limestone rocks of the "Opicina member" (Thanetian-Ilerdian), belonging to the informal "Limestone Formation of Trieste Karst" (Cucchi *et al.*, 1989a), the "fucoidi" marls (Lower Eocene), the Flysch (Lower and Medium Eocene) and Quaternary deposits.

As can be observed from the viewpoint of S. Lorenzo (point 4, Fig. 2), the most abundant and characterising lithotype is the "Opicina member" limestone. It includes compact limestones, usually of light grey but also of black colour, fetid when struck, presenting highly fossiliferous migrated oils (foraminifers, among which alveolinids and nummulites, gastropods and echinoids) sometimes spathized with fracturing from scale-like to pseudo-conchoidal.

Limestone stratification is usually sharp and on a decimetre scale but metre-thick limestone banks with indistinct stratification are not infrequent. Consequently, karstifiability ranges from high to very high and erodibility from low to very low. According to recent studies (Drobne, 2003, *in press*), the above-mentioned limestones were deposited in an "intermediate photic zone" environment (Hottinger, 1997), i.e. with bathymetries ranging between 40 and 80 metres.

These limestones mainly testify to coastal marine settings. Marly limestones characterize the upper-most part of the member, showing an increasing occurrence of planktonic foraminifers. These limestones indicate an increasing depth and the decline of previous taxa, prior to the drowning of the carbonate platform in relation to terrigenous turbidites (Flysch).

At the top, the increase in terrigenous materials progressively modifies the lithology, to reach facies of grey and hazel marl-limestone with decimetre-scale thickness (Cucchi *et al.*, 1989b), thus testifying both to the carbonate platform drowning and to a sharp change

in regional paleogeographical conditions.

From a stratigraphic point of view, Eocene "fucoidi" marls follow: they are basically lamellar argillites whose colour varies from grey to bluish (Fig. 3). They reach their maximum 10-metre thickness on M.te Stena hillsides along the cycle-track built on the ancient train tracks (point 5, Fig. 2).

If thickness is definitely modest, remarkable instead are geomorphologic conditionings: due to its plasticity, the horizon is often characterised by low-angle reverse faults, in acts as non-kastifiable level, is impermeable and shows rather high erodibility.

At a higher-contact level, the flysch that outcrops is constituted by alternation of marl levels and sandstones with variable thickness. Marl thickness ranges from millimetre- to centimetre-scale; sandstone thickness from centimetre- to decimetre-, sometimes metre-scale. Sandstones, which are usually predominant, are moderately sorted, with average grain size being approximately 0.1 mm.

As they are carbonate-cement quartzo-feldspathic sandstones, they can be defined graywackes. On average, they are composed by minimum 50% silicon oxide (containing 43÷53% quartz and 6÷11% flint) and by feldspars (18÷26%), mainly plagioclase and mica feldspars (4÷6%) with chlorite and muscovite predominating over biotite, carbonates (16÷20%, both cement and often highly altered clasts), and a series of other minerals present in minimum quantities (iron oxides, glauconite, tourmaline, garnets, zircon, rutile: cumulative percentage between 1 and 3%). These mineral constituents are practically sterile, even though some jellyfish rests have been found, alongside rare globigerinae.

Marls, whose mineral composition is fairly similar to that of graywackes, but for a higher percentage of carbonates than of other mineral constituents, are not very rich in organic residues. The most abundant organic elements are plankton foraminiferans such as Globigerinae and Globorotaliae. The fossiliferous fraction of basal marls dates back to the middle-high Cuisian age (Onofri, 1982).

This alternation confirms the progressive platform drowning and the appearance in the basin of elements deriving from the Alpine orogenesis in European and Balkan regions. Sedimentary structures such as flutes and burrow casts are frequent.

Due to its plasticity, flysch presents low-range folds giving it a good level of erodibility, plasticity and substantial impermeability.

Quaternary deposits are constituted by sometimes-cemented scree slope, by alluvial deposits and by eluvial-colluvial coverings.

In the case of slope debris, clasts are elements mainly of limestone nature, belonging to the Opicina member: they are sharp-edged and vary in size. Only rarely do sandstone clasts, whose shape is more rounded, appear; in the breccias, the cement is calcitic and of reddish-grey colour. Its cementation level highly varies from point to point and it sometimes affects the surface layers only: consequently, also permeability and erodibility can vary.

Some landslide displaced materials are present: they are generated by collapse and rolling of large breccia blocks slid due to undermining to the foot of

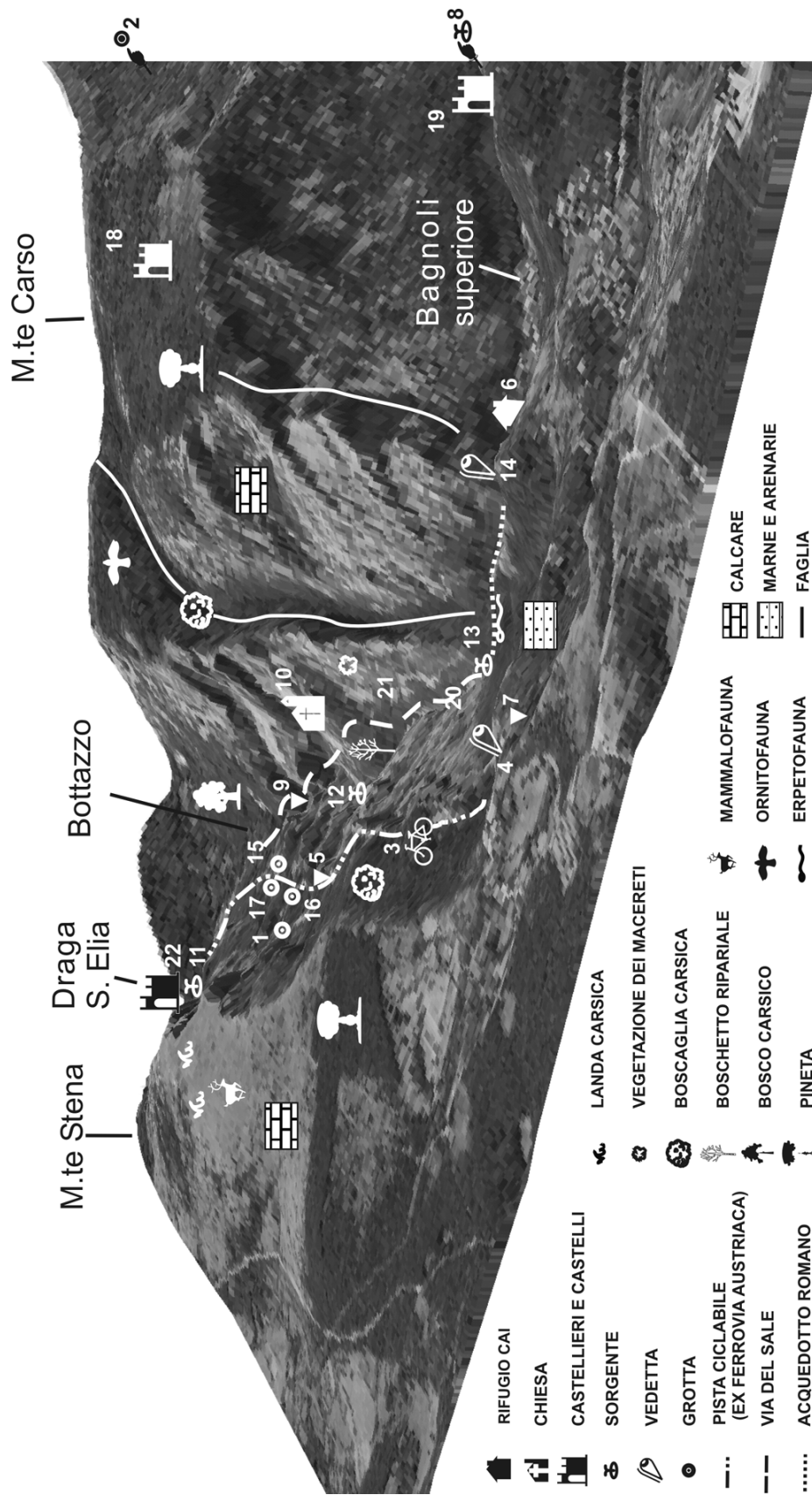


Fig. 2 - Location on three-dimensional model of Val Rosandra peculiarities: 1 - Gualtiero Savi Cave; 2 - Orsi Cave; 3 - Old Austrian railway line, now converted into a cycling track; 4 - Viewpoint near S. Lorenzo; 5 - "Fucoidi" marl outcrop; 6 - Premuda Mountain Shelter; 7 - Tectonic limit; 8 - Antro di Bagnoli spring; 9 - Waterfall; 10 - S. Maria in Siatris Church; 11 - Sturk spring; 12 - Antro delle Ninfe; 13 - Oppia spring; 14 - Viewpoint near Moccò; 15 - Martina Cucchi Cave; 16 - Galleria Cave; 17 - Fessura del Vento Cave; 18 - M.te Carso hillfort; 19 - M.te S. Michele; 20 - Roman aqueduct; 21 - Salt road; 22 - Draga castle.

Ubicazione su modello tridimensionale delle peculiarità della Val Rosandra: 1 - Grotta Gualtiero Savi; 2 - Cavema degli Orsi; 3 - Tracciato vecchia ferrovia austriaca, ora pista ciclabile; 4 - Vedetta di S. Lorenzo; 5 - Marne a fucoidi; 6 - Rifugio Premuda; 7 - Contatto tettonico; 8 - Antro di Bagnoli; 9 - Cascata; 10 - Chiesa di S. Maria in Siatris; 11 - Fonte Sturk; 12 - Antro delle Ninfe; 13 - Fonte Oppia; 14 - Vedetta di Moccò; 15 - Grotta Martina Cucchi; 16 - Grotta delle Gallerie; 17 - Fessura del Vento; 18 - Castelliere del M.te Carso; 19 - Castelliere del M.te S. Michele; 20 - Acquedotto romano; 21 - Via del Sale; 22 - Castello di Draga S. Elia.

the side cemented on the surface, and by planar sliding on stratum levels of sometimes-thick and wide limestone banks.

The alluvial deposits present along the Rosandra torrent are polygenic alluviums, with scarce fine-grained fraction, locally interbedded with sandy or sandy-silt lenses. Pebble size – pebbles are often rounded in shape and of mainly arenaceous and secondly calcareous nature (calcitic speleothems also) – varies from centimetre- to decimetre scale. A coarse diversely interbedded polygenic-alluvium escarpment, located opposite the “Rifugio Premuda”, bears witness to phases of intense transport (point 6, Fig. 2).

The eluvial-colluvial coverings are generally silty and clayey, mostly deriving from degradation of sandy-marly formations and, limitedly, of carbonate formations. This red clayey soils, rich in iron oxides and known under the name of “red soils”, constitute a thin and discontinuous veil on the karst surface.

From a structural point of view, the Rosandra Valley is part of the “imbricate structure of Čičarija”, characterised by thrust wedges in a sequence of reverse faults and overthrusts that follow the Dinaric trend (Placer, 1981).

An excellent panoramic view onto the tectonic structure of the area can be enjoyed from the viewpoint of S. Lorenzo (point 4, Fig. 2), located at 377 metres above sea level in proximity of the village of the same name.

If we assume a geological section oriented N-S, from here the monocline imbricate structure can be observed (M.te Stena on the orographic right of the creek): it first follows an apparently synclinal trend, along the axis where the valley has formed, and a clearly anticlinal trend afterwards, thus conditioning M.te Carso hillsides (on the orographic left of the creek). The compression stresses coming from the North-eastern sector gave rise to three main overthrust-



Fig. 3 - “Fucoidi” marl outcrop.  
*Affioramento di marna a fucoidi.*

sts among the rigid limestone masses and the plastic flysch deposits (Fig. 4): the reverse-fault set located on the orographic right of the Rosandra creek, on the hillsides of M.te Stena; the overthrust known as the “Crinale fault” (Ridge fault); the “M.te Carso overthrust”, low-angle fault stretching towards S-E and originating the tectonically imbricate structure of the Cicarija region (Slovenia and Croatia).

The first is a case of a small overthrust family generally connecting Palaeocene-Eocene limestones on “fucoidi” marls of Eocene age. Degradation and fracturing (ranging from millimetre to centimetre scale) of the latter lithotype makes this tectonic contact along the route from the viewpoint of S. Lorenzo to the village of S. Antonio in Bosco (point 7, Fig. 2) particularly evident. Here it is also possible to find flysch sandstones enclosed in the underlying marls.

The “Crinale fault” and the “M.te Carso overthrust-

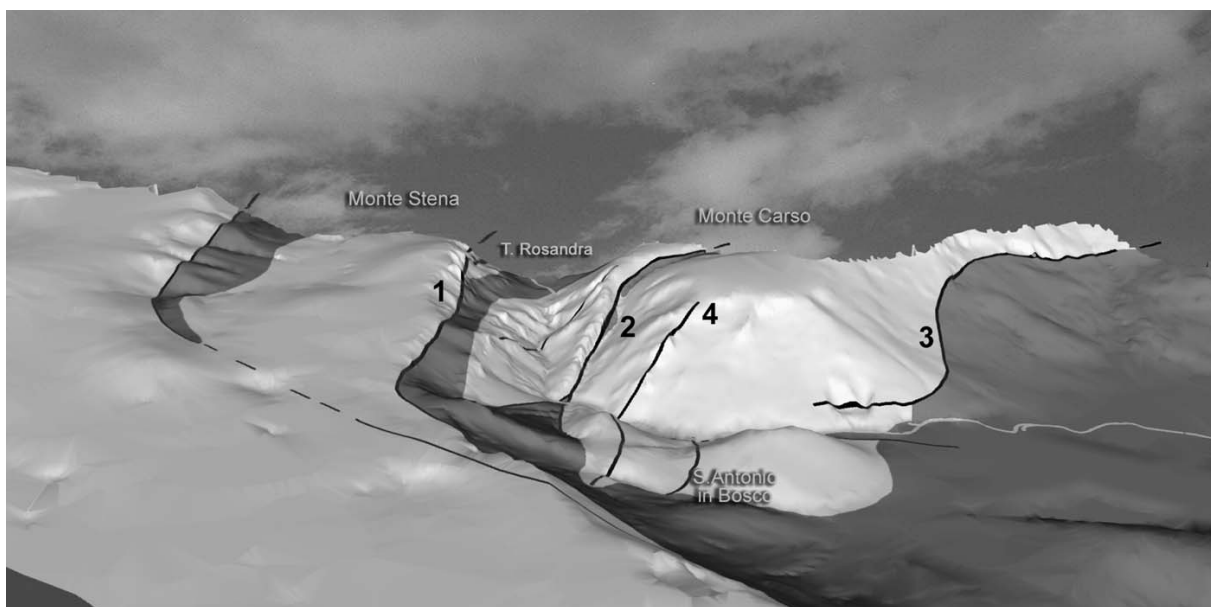


Fig. 4 - Lithological and structural scheme: 1- Reverse thrusts; 2- Crinale fault; 3- M.te Carso overthrust; 4- M.te Carso fault. Lithology: Light grey = Limestone; Dark grey = Fucoidi marl and flysch.

*Schema litologico - strutturale: 1- Faglie inverse; 2- Faglia del crinale; 3- Sovrascorrimiento del M.te Carso; 4- Faglia del M.te Carso. Litologie: Grigio chiaro = Calcari; Grigio scuro = Marne a fucoidi e flysch.*

st”, both advancing towards WSW, identify three well-outlined structural areas.

The first block, the main one, is constituted by the lithoid mass underthrust in the “M.te Carso overthrust”. This block presents numerous deformation structures due to hanging walls, many of which are brilliant study cases, such as the hook-pattern of marls and sandstones in vertical contact with the limestones, as the case that is clearly visible in the Antro di Bagnoli Spring (point 8, Fig. 2).

The second block is constituted by a thrust wedge located between the “M.te Carso overthrust” and the “Crinale fault”. Its main features can be found in two distinct sub-areas: the Northern one, mostly characterised by generally reverse faults and corresponding with M.te Carso culmination, where the hinge of “M.te Carso anticline” has been preserved (Martinis, 1971), stopping at another fault located SW – called “M.te Carso fault” – oriented SW and with dip direction E, thus identifying the Southern sub-area (Fig. 4).

The third block is delimited by the “Crinale fault”, structure with axis NW-SE, whose top shows a high level of limestone-rock tectonisation.

To summarize, the area is characterised by rigid limestone masses that are either overthrust, or raised on reverse faults on flysch and on plastic marl rocks, with NE dip-direction fault surface, an aspect that is clearly visible from the numerous panoramic viewpoints the valley is rich in.

### 3. GEOMORPHOLOGICAL CONSIDERATIONS

The Rosandra Valley is a rare example of Karst

river valley with surface hydrology.

The Rosandra creek originates from the confluence (occurring in the Slovenian territory) of two water streams – the T. Botazzo and the Rio Griza – whose springs are located in Slovenia, a few miles away from the Italian border. Its basin extends over approximately 21 km<sup>2</sup>, of which 8 upstream of the confluence, 6 from the point of confluence to the plain. Its main course extends over 13 km from the sources to the sea, 5.5 before the confluence and 4 between the point of confluence and the access to the plain.

Along their course, they first erode the flysch sili-con-clastic sediments; only afterwards, in proximity of the village of Draga S. Elia, do they erode the limestones of the Opicina member and, finally, the flysch marl-sandstone alternations (Potleca, 1997).

The first stretch erodes a relatively erodible formation, substantially impermeable. Its structure presents a wide undulating syncline with upstream dip direction, in whose core the confluence between T. Bottazzo and Rio Griza occurs.

Downstream of the village of Botazzo, near the State border, the passage from turbidites to marls and to the underlying limestones is made apparent by an over 30-metre-high picturesque waterfall (point 9, Fig. 2) that constitutes the mouth of the Valley.

The hillsides become steeper (with wide berms on the right and structural hillside on the left), the creek flows on the rocks, the first seepage phenomena occur and we can see the formation of a deep canyon-like depression of karst origins into the rock, rich in rapids, pot-holes, small waterfalls, enclosed meanders and basins (Fig. 5).



Fig. 5 - Enclosed meandering.  
*Meandri incassati.*

On the left, the creek is occasionally fed by a tributary flowing along a reverse fault that borders the North side of the M.te Carso anticline.

The riverbed is subject to constant diversions along the main discontinuity-set families up to Bagnoli della Rosandra, where the slopes decrease and the torrent flows on its ancient alluvial deposits until it reaches its mouth into the sea beyond the Zaule plain.

Noteworthy is again the ancient and massive landslide displaced material due to planar sliding over which the small country church of S. Maria in Siariis rests (point 10, Fig. 2; Fig. 6). On the right, scattered in the woods, massive breccia blocks can be seen: they testify to the undermining process at the basis of the scree slope, cemented in proximity of the river's sharp bend towards SW before reaching the village of Bagnoli, and conditioned by the local tectonics – if not neo-tectonics – and by a paleo-landslide.

A system of springs contribute to feeding the torrent: the Zroček spring, on the Slovenian territory, the Šturk spring (point 11, Fig. 2), nearby Botazzo village, the Zaniér spring (point 12, Fig. 2), flowing from the Antro delle Ninfe, the Oppia spring (point 13, Fig. 2) located by the overthrust of the “Crinale” (Ridge) and the Antro di Bagnoli spring (point 8, Fig. 2) in proximity of the village of Bagnoli della Rosandra.



Fig. 6 - The paleo-landslide with the Church of S. Maria in Siariis on the orographic right of the Rosandra creek.

*La paleofrana con la chiesa di S. Maria in Siariis in sinistra orografica del Torrente Rosandra.*

The viewpoints of Moccò (point 14, Fig. 2) and S. Lorenzo (point 4, Fig. 2) offer a privileged view on the slopes overlooking the Rosandra creek. These slopes are all characterised by rocky cliffs, overhanging rocks, aiguilles and mighty scree slopes, expressing a faceted lithology and complex tectonics.

The “grize”, karst gravel areas, are the hallmark of the top of the mountains, alongside the rare rocky outcrop and a poor and scarcely developed soil.

The small landforms caused by superficial corrosion are widely extended over the whole limestone area, characterised by medium to medium-high “karstifiability”, and particularly on Monte Carso hillsides, where the outcrop of limestone banks is more continuous and extended, and originates massive solution runnels (Rinnenkarren).

Underground phenomena are equally developed: 100 caves have been discovered so far, and some of them belong to the some of the most widely extended Trieste karst systems. M.te Stena, in particular, hosts a comprehensive net of articulated and diversely shaped cavities, basically organised on four levels, which stretches totally over 7,000 metres, thus bearing testimony to ancient geological and hydro-geological origins. The best-known cave is the Gualtiero Savi Cave (point 1, Fig. 2; Fig. 8), which covers an area of almost 4,000 metres and is the widest underground system in the Rosandra Valley, thus being the second cave for extension in the whole Italian sector of the Classical Karst. It is a series of sub-horizontal galleries, structural gullies and large chambers located at 350 metres above sea level, and of a set of meanders, smaller caves and smaller galleries to be found at a lower level, approximately 50 metres above sea level (Cucchi *et al.*, 1998).

Surveys conducted via air-tracing methodology have ascertained that the Gualtiero Savi Cave is connected to other cavities such as the Martina Cucchi Cave (point 15, Fig. 2), the Gallerie Cave (point 16, Fig. 2), the Fessura del Vento Cave (point 17, Fig. 2), and numerous minor ones, whose entrances open at different levels on the hillsides of M.te Stena. This is one of the most complex and interesting karst drainage systems of the “Classical Karst”, thus being a privileged observation point on the spelological development not only of the Rosandra Valley, but also of the entire karst region.

Caves present highly remarkable chemical and physical fillings. Among them, the polygenetic conglomerates that often obliterate galleries can be mentioned; they also bear witness to intense transportation phases along water streams originating from flysch-facies basins present to the East (clasts, mainly of marly and arenaceous origin, frequently present fragments of speleothems). Also speleothems are very interesting: some of them are now practically fossilized and date back to over 300,000 years ago but numerous active specimens – through which it is possible to trace recent climate changes – still exist.

It should also be noted that on the left side of the Rosandra creek we can find the Orsi Cave (point 2, Fig. 2), a fossil gallery whose filling deposits are still covered by concreted prehistoric animal remains (*Ursus spelaeus*, Rosenmuller & Hinroth) dating back to at least 120,000 years ago.

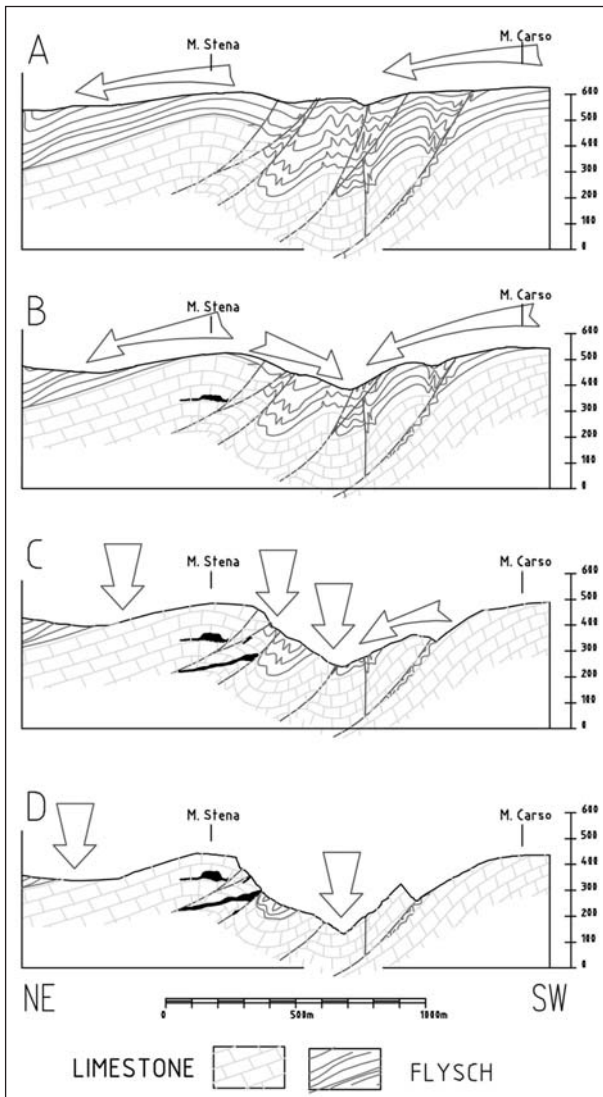


Fig. 7 - Evolution study of the Rosandra Valley (taken from Cucchi *et al.*, 1998) highlighting selective corrosion and karstification conditioned by lithology, tectonic corrosion and karstification conditioned by lithology, tectonic structures and general geomorphologic evolution.

B: beginning of the speleogenesis, conditioned by fault and stratum planes.

C: development and expansion of the G. Savi Cave and of the Gallerie Cave, while the underlying Fessura del Vento Cave starts to form. The Valley deepens and the "Solco del Vallone" starts to form on the left of the torrent

D: current situation with the high-level cavities visible. The karst now evolves with prevalent diffused sub-vertical percolation due to the wideness of the limestone surfaces exposed to atmospheric agents.

*Schizzo evolutivo della Val Rosandra (tratto da Cucchi et al., 1998) con erosione selettiva e carsificazione condizionata da litologia, lineamenti tettonici ed evoluzione geomorfologica e paleo-ambientale generale. In B, si ha l'inizio della speleogenesi guidata da piani di strato e di faglia. In C, la grotta G. Savi e la Grotta delle Gallerie si sviluppano e si ampliano mentre inizia a formarsi la sottostante Fessura del Vento. La Valle si approfondisce e si imposta il "Solco del Vallone" sul fianco del M. Carso in sinistra del torrente. In D, si ha la situazione attuale con le cavità pensili e con prevalente percolazione ipogea sub-verticale diffusa data l'ampiezza delle superfici calcaree esposte agli agenti atmosferici.*

#### 4. CLIMATE CONSIDERATIONS

Karst climatic conditions are peculiar due to its geographic position. Karst has, in fact, a transition climate between the Atlantic and the Continental regime. A similar transition exists between the Mediterranean and the Alpine climate. As happens in all areas characterised by contact between different climatic regimes, here too local topographic influences acquire the utmost intensity (microclimate), thus contributing to the plant landscape diversification. The Rosandra Valley is a clear example of this phenomenon, as it features particular microclimate and plant conditions. The upper part of the Valley (from Klanec, 415 metres above sea level, to Bottazzo, 186 metres above sea level) has a prevailing Continental climate, both due to its altitude and to the distance from the sea. It is marginally exposed to the "bora" wind, and is mostly covered by trees. Two hill slopes with different morphological characteristics form the lower part of the Valley (from Bottazzo to Bagnoli, 72 metres above sea level): they have, in fact, different exposure to the "bora" wind and to solar radiation, which leads to a still higher microclimate diversification. The windward left hill slope (SW) is cha-

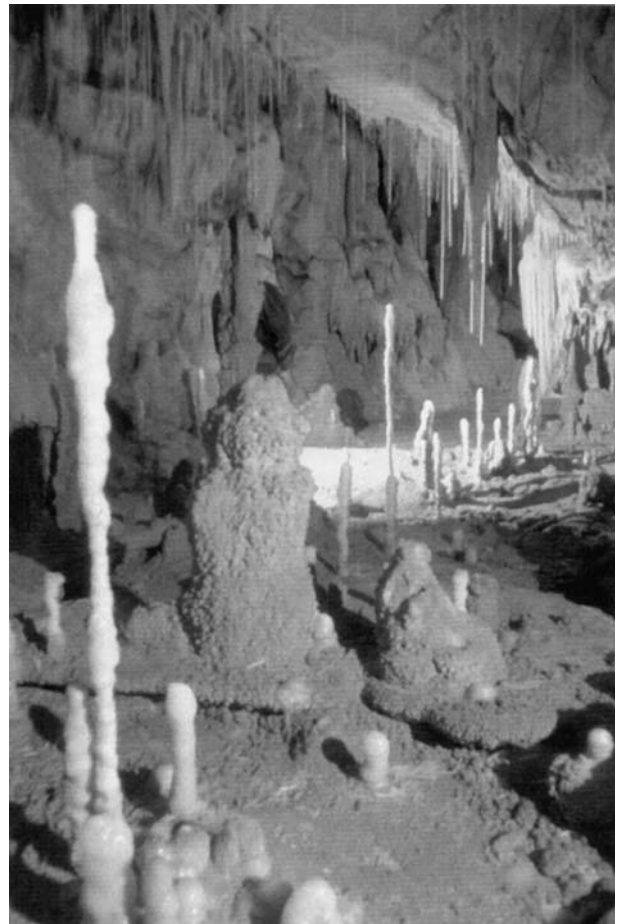


Fig. 8 - Enchanting concretions in the Gualtiero Savi Cave (photograph by Umberto Tognoli, taken from La grotta dei sogni, RAFVG & CAI).

*Incantevoli concrezioni nella Grotta Gualtiero Savi (foto di Umberto Tognoli, tratta da: La grotta dei sogni, RAFVG & CAI).*

acterised by a brief period of direct insolation; it has a particularly rigid Continental climate, due to its limited altitude, with a consequent delay of the beginning of spring and earlier start of winter. The right hill slope (NE) is made up of series of vertical walls, is always leeward and exposed to the sun and, during most of the day, it is characterised by Mediterranean climate conditions. When it is not lashed by the wind, the rock heats up, to the point that the air can reach maximum temperatures of 40°C in summer and of 30°C in winter. The temperature difference between the two hill slopes can reach 10°C.

## 5. CONSIDERATIONS ON VEGETATION

The Rosandra Valley is characterised by different types of vegetation, due to the interaction between diverse environmental factors (geomorphology, lithology, microclimates) and flora: scree vegetation, karst heath, steppe vegetation, karst scrub forest, karst wood, riparian vegetation and pinewood.

The vegetation that prevails in the Rosandra Valley is referred to as the North-Adriatic “Dripeto” (rich in *Drypetes* plants), from the presence of *Drypis spinosa* ssp. *jacquiniana*, which forms large pulvini scattered on the scree slope. This cenosis is mainly present on the left hillslope, where the scree slope reaches its maximum accumulation: “from a naturalistic point of view, it is probably the most valuable association of the whole valley, if not of the whole Trieste Karst” (Poldini *et al.*, 1978). “Another distinctive feature of the North-Adriatic “Dripeto” is the extremely high percentage of endemic Iliric-Balkan species, which makes it rank first among all other Karst associations in this respect, with a record of 53.3%” (Poldini *et al.*, 1980). Furthermore, given the severe microclimate conditions characterising this hill slope of the Rosandra Valley, scree cenosis shows a particularly high presence of Orophytes (plant species that grow in mountain areas) at exceptionally low altitudes, probably the lowest recorded in their diffusion area. The presence of Alpine elements is highly significant in the Rosandra Valley, because it bears witness to the past phyto-historical events that occurred in the valley itself. According to the experts, during the Quaternary climate oscillations, a penetration of the Alpine flora (in cold periods) and of the Mediterranean flora (in hot periods) occurred, whose traces were almost completely cancelled by the local Illyrian flora that constitutes the current Karst vegetation. Many of them managed instead to survive in the Rosandra Valley thanks to its high microclimate variety, thus enhancing the cultural value of the studies on and the protection of the Valley.

The karst heath develops on Monte Carso and Monte Stena banks, where the slope is gentler and rocks appear next to the scree slope. It is a discontinuous herbaceous formation growing between the outcropping rocks, a typically zoogenous association due to the century-long pasturing activity on deforested areas. Its origins probably date back to the Brass Age (approximately 1800-900 BC), which saw the insurgence of pasture farming on the karst territory. Given the constant presence of *Centaurea rupestris* and of *Carex humilis*, this pasturing cenosis has been called

“Cariceto-centaureto”. Besides these species, the heath presents the most typical karst elements, among which numerous endemic species can be found, mainly of Illyrian origin (such as *Genista tergestina*, *Pulsatilla montana*, *Jurinea mollis*, etc.). Where the iron-debris nappe becomes particularly abundant, the heath also features *Sesleria juncifolia*, a Gramineae plant with rigid thin leaves and large clumps, particularly suitable to resist to the ice-cold gusts of winter bora. Where rocks combine with particularly dry soils, some elements of *Stipa eriocaulis* can be found, an elegant Gramineae plant of Mediterranean origin with long plumes fluttering in the wind (from which the vulgar Italian name of “Lino delle Fate” (Fairy Flax).

Under conditions of exposure to the South, marked steepness and strong substrate permeability, the heath gives way to a steppe-like grass formation, where the Illyrian elements decrease in favour of Mediterranean species. This association reaches its maximum flowering period between late summer and autumn, and thrives on the rocky hill slopes over the old stone laundry in Moccò and, on the hill slope on the orographic right, on the slope dominating the rail tracks at the entrance of the first gallery. The presence of different species of Mediterranean origin is highly valuable, because these plants, as the Alpine ones, have witnessed past climatic conditions.

The typical karst scrub forest is mainly constituted by low-stemmed *Ostrya carpinifolia* and *Fraxinus ornus* trees and, despite being the most frequent cenosis in the Trieste Karst, in the Rosandra Valley it acquires some new peculiarities. First of all, it is of primary origin (Poldini *et al.*, 1978), whereas on the rest of the Karst territory it developed after the cutting down of the great Oak forests (which began during hillforts times, approximately Brass Age). This association is precious for the consolidation of unstable slopes, thanks to the development of rooting apparatuses, and is enriched by the presence of elements that are typical of fresh and humid habitats where it declines towards the Rosandra canyon-like depression. It is worth noticing the presence of abundant blooming of *Galanthus nivalis* and the frequency of *Polypodium interjectum*, species typical of humid and shadowy rocky habitats.

The karst wood is a tree formation characterised by the presence of Sessile Oaks and Turkey Oaks (*cerri*) next to the highly developed oak wood that probably covered the karst soil in prehistoric times, prior to its destruction at the hands of Man. This association develops in the coolest and most humid small valleys, where colluvial soils accumulate. The fresh habitat, also enhanced by the tree-crown closure, enables the growth of woodland species typical of Central Europe (such as *Erythronium dens-canis*, *Hepatica nobilis*, *Asarum europaeum*, etc.). This oak wood is mostly developed in the higher part of the Valley, on a marly-arenaceous substratum.

The Rosandra Valley is furthermore enriched by the presence of riparian spinneys, which are a rarity for karst soils, poor in surface hydrography. The most abundant species are *Salix purpurea*, *Alnus glutinosa* e *Populus nigra*, as regards trees, and *Petasites hybridus* e *Viola alba* as far as the undergrowth is concerned.

The plateau of S. Servolo (Monte Carso) and Monte Stena are characterised by Austrian Black Pine



(*Pinus nigra*) pinewood. These reforestation processes began in the second half of the XIX century, when almost the whole Karst area was completely bare due to the deforestation started during the Brass Age with a view to acquiring new pasturelands. In the Rosandra Valley, pinewoods are now formed by trees of advanced maturity, which are progressively being substituted by the pressing Karst scrub forest that has been developing inside the pinewood in the last decades.

Worth mentioning is also the presence of species that are either rare or scarcely widespread in the adjoining areas: *Lilium bulbiferum*, *Lilium carnioolicum* (two out of the three lily regional species), *Moehringia tomasinii* (endemic species, that is species that grow spontaneously only in the area they are native to), *Asplenium lepidum* (most rare fern of Mediterranean distribution), *Digitalis laevigata*, *Platanthera chlorantha*, *Dactylorhiza maculata*, *Gymnadenia conopsea*, the most rare *Genista januensis* and *Genista holopetala*.

## 6. CONSIDERATIONS ON FAUNA

As far as the local fauna is concerned, the Rosandra Valley presents almost all the species that populate the Karst area. It is furthermore enriched by some of the species that are usually found in humid ecosystems, particularly rare in the Karst environment.

As for the mammal fauna, the Roe Deer is quite widespread, so that it can also be directly sighted during the day. This ungulate mammal frequents the Karst scrub forests and clearings. Another mammal belonging to the Cervidae family that can sometimes be found in the Valley is the Red Deer (*Cervus elaphus*), coming from nearby Slovenia. Near to water ponds, it is possible to find traces of the presence of the Wild Boar (*Sus scrofa*). Among the rodents, it is worth mentioning the Edible Dormouse (*Glis glis*), the Red Squirrel (*Sciurus vulgaris*), which regularly frequents the pinewoods, the Water Vole (*Arvicola terrestris*) and the Yellow-necked Mouse (*Apodemus flavicollis*). Also two hedgehog species can be found: a Western (*Erinaceus europaeus*) and an Eastern one (*Erinaceus concolor*), probably competing with each other because they share the same diffusion area in the Karst environment. The hare (*Lepus europaeus*), once common, is now threatened by the introduction of the common European Rabbit (*Oryctolagus cuniculus*) and by the shrubs spreading in the Karst area. As far as the Carnivores are concerned, one of the most widespread species is the Red Fox (*Vulpes vulpes*), particularly precious from an environmental point of view because it also feeds on carrion, thus contributing to preventing the onset of various diseases. The Badger (*Meles meles*), the Beech Marten (*Martes foina*), the Polecat (*Mustela putorius*) and the Weasel (*Mustela nivalis*) are the Mustelids present in the Rosandra Valley: they are difficult to sight, though, because of their nocturnal habits. During the last years, the sporadic presence of Great Carnivores has been noted. Traces and sighting prove the presence, or at least the passage, of the Brown Bear (*Ursus arctos*) and of the Lynx (*Lynx lynx*), whereas during the last ten years the presence of the Golden Jackal (*Canis aureus*) has been ascertained.

As far as bird species are concerned, the valley

hosts a few Blue Rock-Thrush (*Monticola solitarius*) couples. The Blue Rock Thrush is a strongly territorial bird belonging to the Turdidae family, a rocky species whose diffusion area is limited to the three European peninsulas - the Iberic, the Italian and the Balkan Peninsula - and whose males have a metallic-blue plumage colour. The Rock Partridge (*Alectoris graeca*) is a blue-greyish member of the Phasianidae family that perfectly camouflages itself thanks to its colour being quite similar to that of limestone rocks. It is a typical species of the Karst heath, once largely widespread and now only rarely present, which can be considered on the verge of extinction due to the spontaneous reforestation of the abandoned pasturelands. The progressive disappearance of the species usually associated with grass formations goes hand in hand with the simultaneous diffusion of the species that nest inside low-stemmed trees, such as the Rock Bunting (*Emberiza cia*), a quite common species, easy to observe. In the winter months, also the Wall Creeper (*Tichodroma muraria*) and the Crested Tit (*Parus cristatus*) find shelter in the Rosandra Valley. In particular, the presence of this tit and of the Coal Tit seems to be ascribable to the black-pine pinewood reforestation process, which leads species normally nesting on the Alps at an altitude of over 800 m to nest at lower altitudes. As far as the diurnal birds of prey are concerned, the following species can be sighted: the Common Buzzard (*Buteo buteo*), the Northern Goshawk (*Accipiter gentilis*), which nests in the pinewoods close to clearings, the Common Kestrel (*Falco tinnunculus*), which nests on the rocky walls above the old railway line, and the Sparrowhawk (*Accipiter nisus*), which, though only 20-30-centimetre tall, hunts small birds in the thick Karst scrub forest. Till some years ago, also the Eagle Owl (*Bubo bubo*), the largest member of the Strigiformes order, used to nest on the Valley walls. Still present now are the Barn Owl (*Tyto alba*), the Scops Owl (*Otus scops*), the Little Owl (*Athene noctua*) and the Tawny Owl (*Strix aluco*), which frequent and nest by the entrance of cavities.

The Rosandra Valley is also populated by a rich herpetofauna, constituted both by definitely Mediterranean species and by Illyrian-Balkan and Mediterranean ones. As happens for the vegetation, in fact, Karst is respectively the Eastern and Northern expansion threshold of their diffusion area. The different species of Reptiles and Amphibians spread in the diverse Valley habitats according to their trophic and/or reproductive needs. The most turbulent stretches of the Rosandra creek are not suitable for the survival of Amphibians eggs and larvae, whereas the calmer coves host the larvae of black and yellow Fire Salamander (*Salamandra salamandra*), Common Toad adults (*Bufo bufo*), Yellow-bellied Toad (*Bombina variegata*), Agile Frog (*Rana dalmatina*) and Edible Frog (*Rana esculenta*). Along the torrent banks, it is possible to find the Grass Snake (*Natrix natrix*), species that feeds on Amphibians larvae, and the Minnow (*Phoxinus phoxinus*). Terrestrial Amphibians such as the Black and Yellow Fire Salamander, the Common Toad, the Edible and the Agile Frog can populate riparian scrub forests; as far as snakes are concerned, it is possible to find the Grass Snake, the Aesculapian Snake (*Elaphe longissima*) and the Western Whipsnake (*Coluber viridiflavus carbona-*

rius). The most humid areas of Karst scrub forests host the Green Lizard (*Lacerta viridis*), the Aesculapian Snake, the Western Whipsnake and, rarely, the Bulgarian Viper (*Vipera ammodytes*). Away from the torrent, more thermophilous Reptiles can be found, such as the Green Lizard, the Dalmation Algyroides (*Algyroides nigropunctatus*) and the Bulgarian Viper. Karst woods are characterised by the presence of the Green Lizard, the Slow Worm (*Anguis fragilis*), the Aesculapian Snake, the Western Whipsnake, the Smooth Snake and the Bulgarian Viper, though the latter species is not particularly abundant due to the excessive insolation and the scarcity of preys.

## 7. HISTORICAL CONSIDERATIONS

Anthropogenic use of the Rosandra Valley is linked with environmental, geomorphologic and geological factors. The valley is a natural link between the sea and the inland, and has thus been always exploited for commercial traffic. The remains and antiquities found in the caves demonstrate that Man had been present since Prehistoric, Mesolithic and Neolithic Ages. These and other peculiarities contributed to its exploitation both at the hands of prehistoric Man and of the tourists-excursionists today.

The whole area, and in particular M.te Stena on the right, is characterised by both epigeal and underground karst phenomena: approximately twenty cavities are quite interesting from an archaeological point of view. In this respect it is probably worth mentioning the Orsi Cave (point 2, Fig. 2) and the Gallerie Cave (point 16, Fig. 2; Fig. 9) (Catasto, 2003). The first one is located on Monte Carso and consists of a single gallery that stretches over a total area of 135 m. The cave name comes from the finding – during exploration – of some ten skulls, jaws, femoral bones and vertebrae belonging to the Cave Bear species (*Ursus spelaeus*), besides skulls and other bones of smaller-size animals. A particularly surveyed cave is the Gallerie Cave or Finestre Cave (point 16, Fig. 2), located at the bottom of M.te Stena, where archaeological excavation, started during last century by the pioneers of Karst prehistoric studies, is still ongoing today at the hands of unauthorised researchers and antiquity collectors with no higher aspirations. The quantity of terracotta artcrafts discovered here is higher than that found in any other Karst cave, thus demonstrating that the cave had always been frequented by large human settlements throughout all Prehistoric ages, thanks to the favourable environmental conditions. Some specific ceramics findings suggest that vase-making activities were probably carried out in a chamber of the cave, probably the Camino Cave.

Two prehistoric constructions have also been recovered. They are two “hillforts”: one is located under Monte Carso top (point 18, Fig. 2), where the ruins of the enclosing wall – probably ascribable to the Iron Age – are still visible today; the other is located on the top of Monte S. Michele, and dates back to Protohistoric times too (point 19, Fig. 2). The first (Marini, 1985) appears to be the most widely extended hillforts in the area of Trieste, and it also reaches the Slovene territory. Its safe and easily defendable geographic location

made the complete building of the enclosing wall unnecessary, because the area was already partially protected by the impervious nature of the environment. From the hypothetical reconstruction of the hillfort of S. Michele (Canarella, 1989), it can be argued that three defensive concentric walls surrounded it; the only wall that is still visible today is the one enclosing the top of the mountain. The place is likely to have been frequented also during Roman times, as the recovering of fibulae belonging to that period demonstrates.

At the mouth of the Valley, once left the settlement of Bagnoli Superiore, it is possible to walk along the line of the ancient Roman aqueduct for approximately 700 m (point 20, Fig. 2). This aqueduct is the only one present in the Region: stretching over 14 Km, it used to supply the town of Tergeste with drinking water. It fed from the Fonte Oppia (Oppia Spring, point 13, Fig. 2), a spring of water once flowing from the foot of a rock mass located along the Rosandra creek, and now flowing from “stone ruins” located below the torrent level, as the British made the ancient rock mass explode during the occupation of Trieste.

Also the “Via del Sale” (Salt Road) dates back at least to Roman times: its path can still be walked along today on the orographic right of the torrent (point 21, Fig. 2). The road was functioning above all during the Hapsburg Reign, and it served as a link between Zaule salt marshes, near the village of Muggia, and the towns and the inland villages. The road followed the ridge and also reached the Church of S. Maria in Siariis (XII cen-



Fig. 9 - Gallerie Cave.  
Grotta delle Gallerie.

tury), which was completely restored in 1955, and which is still interesting today for the peculiarity of its location and for the panoramic view: on the orographic right, it is in fact possible to see the viewpoint of Moccò (point 14, Fig. 2), which rises on the remains of the Medieval castle with the same name. Built before 1100, it entirely dominated the Rosandra Valley and enjoyed the beautiful scenery of the Gulf. According to the popular tradition, the castle is supposed to have had a gloomy and threatening atmosphere: it was built on a square plan and enriched by a gallery with merlons dominated by a smaller-size construction and by a tower. The location of the ancient castle, which offered an excellent viewpoint on the surrounding valley, made it a most coveted stronghold, above all during the conflicts waged by Venice and Trieste for the supremacy on commercial traffic. In 1511, the bishop Pietro Bonomo succeeded in conquering the castle, seizing it from the hands of the Venetians; after a short time, the Triestines themselves destroyed it to avoid re-conquering by the enemy. In the XVII century, the materials used for the construction of the castle were re-used to build the New Castle, always on a square plan, which was seriously damaged immediately afterwards, during World War Two and then irreparably destroyed by a fire: today only the foundations can be seen.

Another castle present in the valley is the Draga Castle (point 22, Fig. 2), initially belonging to the Vincumberg family and whose edification began in 1200 and continued until 1400. After passing from the hands of the Venetians to the Triestines, it was completely abandoned and destroyed in 1600. The castle, linked with the Karst ridge through a drawbridge, was certainly connected with the Salt Road but the successive excavations and the building of the railway obliterated the initial course. Today its ruins can be seen on the rocky spur in Slovenia.

Thinking of recent times, the layout of the old railway line needs mentioning (point 3, Fig. 2). The old railway line connected the Hapsburg port of Maria Theresa times to Vienna and Ljubljana; it was started in 1887 and used until 1959. Located on the orographic right of the Rosandra creek, it is today a classical and beloved path to walk along, offering a wonderful view of the whole valley and leading from S. Antonio in Bosco and from S. Lorenzo both to the villages of Draga S. Elia and Bottazzo. This path is currently being re-evaluated, also thanks to its conversion into a cycle-track linking Trieste with Draga S. Elia and with Slovenia as far as Erpelle. At present, both the Rosandra Valley stretch (as far as the border between Italy and Slovenia) and part of the Campanelle - S. Antonio in Bosco stretch have already been completed, whereas the town and the Slovene stretches will take longer to complete.

To conclude this brief but not exhaustive digression on Man and the Valley, what still needs to be mentioned is the second CAI mountain shelter at the lowest altitude in Italy: the "Rifugio Premuda" (point 6, Fig. 2). Located at the entrance of the Rosandra Valley, it was opened in 1940, as a legacy of the Mountaineering School founded in the Thirties by Emilio Cornici. The valley is still today an important destination for excursionists and nature-lover tourists, for speleologists and mountaineers.

## 8. CONCLUSIONS

The physical and environmental peculiarities of the Rosandra Valley were officially recognised by Law in 1996, with the Regional Law no. 042 of 30/9/1996, Chapter II, concerning parks and reserves, which declares "the establishment of the Regional Natural Reserve of the Rosandra Valley", defined by Art. 2 as "... a territory characterised by a high-level natural and environmental quality, whose conservation aim prevails over other objectives..."

In parallel, in compliance with 79/409 and 92/43 EEC directives, put into force by the Ministerial Decree of 3/4/2000, the area is included both in the Special Protection Areas and in the Sites of Community Interest.

Special Protection Areas, disciplined in compliance with 79/409/EEC directive, are those areas that are suitable – due to their extension and/or geographical location – for the protection of the endangered bird species as referred to in the Annex I of the aforementioned directive concerning the protection of bird wildlife.

Sites of Community Interest are defined as follows by 92/43/EEC directive: "... sites that, within the bio-geographical area/areas they belong to, significantly contribute to the adequate conservation or restoration of natural habitats as described by Annex I, or of a species as described by Annex II, and that can furthermore significantly contribute to the coherent approach stated by Nature 2000 as referred to in Art. 3, and/or that significantly contribute to the protection of biodiversity in the pertinent bio-geographical area/areas".

So far, the Rosandra Valley has always been attached "special" importance, due to its high environmental value. As previously stated, its park is also a valuable and unique geological, historical and geomorphologic heritage.

This is the reason why the Valley can be considered a suitable candidate for the Geopark status, according to the definition provided by the 29<sup>th</sup> UNESCO General Conference (Paris, October 24 – November 12, 1997): "a *Geopark* is an area that has a peculiar geological heritage and a sustainable territorial development strategy... It ought to include a certain number of extremely important geological elements, in terms of scientific quality, rarity, aesthetic characteristics or educational value. The majority of the areas included in a European *Geopark* are supposed to be part of the abovementioned geological heritage, but their interest can also reside in archaeological, environmental, historical or cultural values".

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