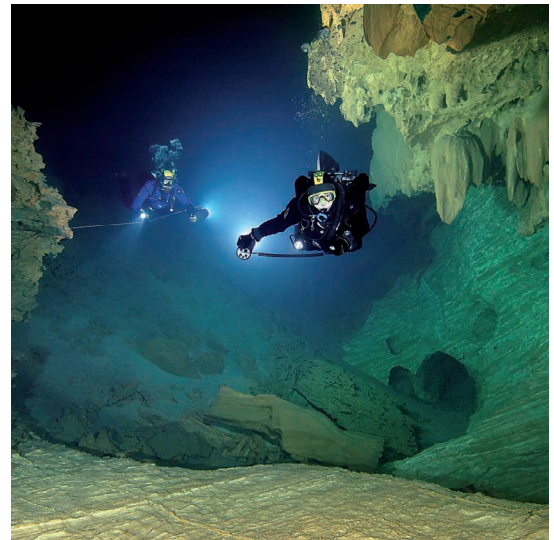


16th INTERNATIONAL CONGRESS OF SPELEOLOGY

Proceedings

VOLUME 2



16th INTERNATIONAL
CONGRESS OF SPELEOLOGY



WHERE HISTORY MEETS FUTURE



Edited by
Michal Filippi
Pavel Bosák

16th INTERNATIONAL CONGRESS OF SPELEOLOGY

Czech Republic, Brno

July 21–28, 2013

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Cover photos (some photos were adjusted/cropped)

Top left – A gallery along the “Rio de los Venezuelanos” in the Imawari Yeuta Cave system in quartz sandstones, Auyan Tepui, Venezuela. Photo V. Crobu. For details see the paper by Sauro et al.

Top right – The 15th siphon of Ramo Nord in the Grotta del Bue Marino, Sardinia. Photo by R. Husák. For details see the paper by D. Hutňan.

Bottom left – Using an Xbox Kinect equipment to survey a cave. Photo by J. Gulley. For details see the paper by Covington et al.

Bottom right – Inclined workings of the Voskresenskyi Mine, Ural Mountains, Russia. Photo by A. Cunko. For details see the paper by A. Cunko.

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WORKSHOPS AND SURVEY RESULTS IN THE CHRIMA CINP PROJECT (EU PROGRAMME CULTURE 2007–2013)

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The activities carried out under the project activity of Crhima-cinp, an acronym standing for “Cultural Rupestrian Heritage in circum Mediterranean Area. Common Identity-New Perspective” is described in this paper. It has been financed with funds from the Culture Programme 2007–2013, Budget 2010, Strand 1.1 Multi-annual cooperation projects, Strand 1.2.1 – Cooperation measures. The project responds to the unitary purpose of the invitation Culture 2007–2013: contribute to enhancement of a cultural area shared by Europeans, the development of cooperation between the creators, operators, and cultural institutions of the countries participating in the Programme. The activities have promoted a new interest in the rediscovery of the rupestrian villages that characterize many countries of Europe and of the Mediterranean, populated until the last century, memory of layers tangible and intangible of great interest that is likely to be permanently compromised or destroyed. The project increased the exchange of information between the various Mediterranean countries by producing monographic studies on different sites, publishing new studies of little-known areas, and contributing with new materials at the scientific deepening of topics and at the dissemination of information. The report summarizes the experiences of the workshops carried out in some centers chosen as the site of the work, (Massafra in Italy, Saumur in France, Santorini in Greece and Ortahisar in Turkey). The work summarizes the major activities in the area with drawings and photographs that illustrate the differences and similarities of rupestrian settlements of each region under study.

1. Introduction

1.1. CRHIMA-cinp project

Theme of the project is the Rupestrian Heritage, a distinctive feature of the Mediterranean landscape.

The works show how the rupestrian culture is widespread an across the Mediterranean area, a heritage developed over time with environmental, architectural and artistic emergencies that are known only to scholars and enthusiasts of the subject, still though without having an overall picture of this cultural event.

The project, with the various activities organized, presents a synthetic framework of the influences and events that have contributed to the diffusion of the phenomenon and the arts that characterize it. It favored a greater awareness about the extension of the different features present in the sites chosen as study areas. It also encouraged interdisciplinary knowledge, which contributes to the understanding of a complex heritage, lasted over time, responding to practical needs, spiritual and contingent of everyday life for many

people. The project supported the transnational mobility of cultural operators who, through their activities, have strengthened the knowledge of the known territories and focused the attention of the authorities and the local population on the value of the indigenous patrimony, often not fully known. New operators educated to the respect for cultural diversity that enriches the regions of the same country or of countries of the Union were also formed.

The partnership CRHIMA-cinp project. Project Coordinator: (coordinator): (IT) Università Di Firenze – Department of Architecture dsp – Project manager Prof. Carmela Crescenzi. Project co-organiser (co-organiser): (EL) Dep of Energy Physics National, NKUA – Project manager: Prof. Assimakopoulou Margarita (ES) Dep. De Expresión Gráfica Arquitectónica, UPV – Project manager: Prof George Llopis; (FR) Dep. of Sciences Humaines and Department of Science and Techniques for Architecture ENSAP “La Villette” – Project manager: Prof Edith Crescenzi; (IT) Archeogruppo “E. Jacovelli” onlus Project manager: Avv. Giulio Mastrangelo; (TR) “Kadir Has” University Of Istanbul – Virtu Art Faculty Project manager:



Figure 1. Palagianello. Troglodyte village.

Prof. Mehemet Alper. Additional partners (IT): Centro Studi Sotterranei – Genova, Museo del Territorio di Palagianello e Centro Unesco di Firenze Onlus.

1.2. Rupestrian culture

Man has excavated structures in the rocks from the Anatolian highlands to the Egyptian deserts, from the Balkans to Italy, from France to Spain. In this anthropological and ethnographic context, the cave is the “common house” of Mediterranean cultures. Medieval caves – rupestrian houses and churches – massively characterize the landscape of the plateau of Cappadocia in Turkey, several regions of Spain, Greece and the Loire Valley in France, and many other places in the Mediterranean area and in other regions the world.

All these settlements are the micro cells of the wider Mediterranean rupestrian habitats that encompasses diversity but also many common aspects. The rupestrian civil structures were considered an expression of inferior classes, since UNESCO included Cappadocia (Turkey) and the rupestrian districts of the city of Matera (Italy), in the World Heritage list. From that moment, the valley of the Loire and other centers, have considerably increased scientific studies on the rupestrian structures and the preservation of monuments and environmental contexts.

The cultural unity of rupestrian settlements was, in some cases, damaged or destroyed, but their relevance as open air eco-museums has never been underestimated, despite anthropogenic deterioration caused by weather conditions.

Recently, the attention was focused on urban settlements, on the typologies and on subterranean shelters. These structures are certainly less monumental than churches, but they are more numerous and more ancient.

2. Geography and geology

The geology of the five examined sites has geologic and morphologic characteristics which allowed the excavation of rocks to create spaces for daily activities. These places developed mainly because of volcanic eruptions, which deposited soft materials (as tuffs) that could be excavated with rudimental tools. This was the case, for instance, for Turkey and Greece. In Cappadocia, Turkey, volcanic eruptions formed plateaus. The water and wind erosion created the characteristic valleys of the area.

Santorini, in Greece, is constituted by a crater, which was destroyed by a prehistoric earthquake. Later, it has been



Figure 2. Geological materials of studied areas.

eroded by external agents and then covered by the sea. The building activity has always been based on the different rocks of the island. The different mechanical and chemical characteristics of the rocks offered different solutions.

In Italy and France, on the other hand, the bedrock is represented by different types of limestone rocks, from calcarenite deposits (Italy) to chalk (France).

The water and wind erosion in the area of Massafra, Palagianello and Mottola (Italy) have eroded the calcarenite on the Ionian coast, creating ravines. Many rupestrian settlements were realized in these ravines.

The geological constitution of the cliffs in the Loire Valley, France, has been influenced by the typical chalk of Turonian age. The Lower Turonian chalk is the most typical, whilst the Upper Turonian has a greater content in sands.

3. Troglodyte Settlements

The man has always responded, according to historical periods, with “built form” to its security, defense and spiritual needs. The original “rock shelter” and natural cavities were transformed into dwellings functional to daily life. The provisions of natural shelters were transformed with additional excavations or expanded with the construction of spaces extended outward. He decorated the caves with wall art (graffiti, paint dry, frescoes, etc.), satisfying the need to tell great, superhuman and mystical events.

The adaptation of the needs is expressed by simple interventions in the natural setting to create a troglodyte site included: the natural caves are enriched by a hearth; the rock shelters are protected by a wall, in cracks between rocks are built homes, a village situated protection and backed by a natural wall. Cave builders were able to combine different solutions, adapting and improving technical construction and different materials to the natural features of the sites.

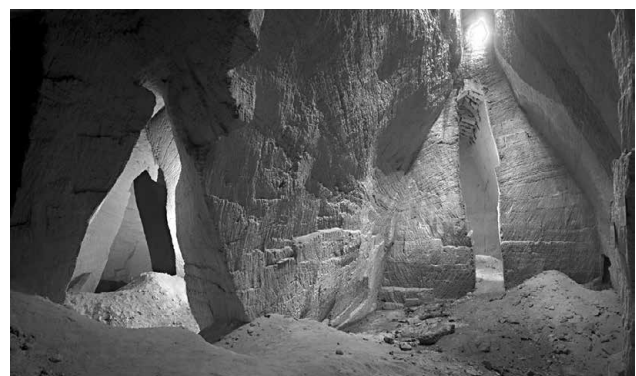


Figure 3. France, “carrière de falun”.

3.1. Hollowing out settlements

The realizations of the underground volumes are obtained by subtraction of materials. There are two methods of excavation:

1. Horizontal excavation in the sides of valleys and cliffs: there are rupestrian dwellings.
2. Vertical excavation in the plateau, originating hypogean settlements.

Each of these solutions confirm the versatility of the troglodytic architecture to the geological, climatic and anthropogenic settings.

3.2. Typology of troglodytes settlements:

1. *Rocky villages in terraces or on the wall.* It is the most common settlement system. The number of households is variable and takes full advantage of the valley slopes. These architectures are usually carried out with particular attention to insolation during the different seasons.

Important achievements of this kind are in the complex linear in France in dwellings carved into the cliffs of the Loire Valley; in Spain, in the many buildings that characterize Andalusia; in Turkey where one example is the village of Zelve or the valley of Selime; in Puglia with the villages in the ravines of Massafra and Ginosa; in the districts of Caveoso and Barisano at Matera, Basilicata; in the villages of Santorini Votonos and Finikia.



Figure 4. Wall village, Bocairent, Valencia, Spain.

2. *Villages on the surface.* They are found in Cappadocia; these villages are carved into the cones, called “fairy chimneys”, pyramids of rock (tuff, silt or volcanic boulders), showing a caprock consisting of a more compact slab of the same material, which protects the underlying rock from erosion.

The rock cones are distributed in a natural setting that reproduces, in fact, the village’s structure. These villages, having the buildings excavated in rock blocks, are considered surface settlements.

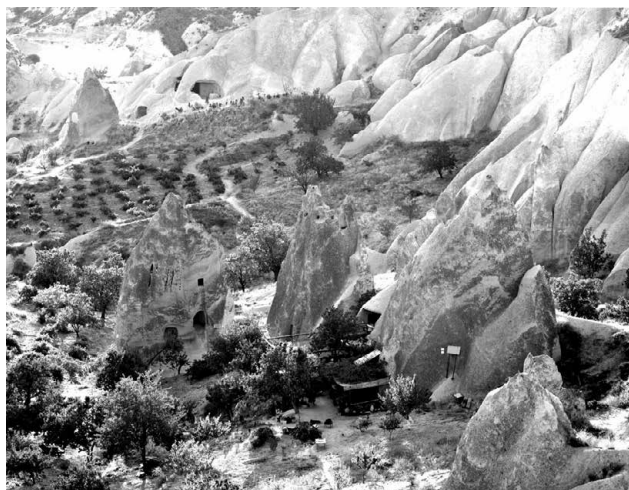


Figure 5. Ortahisar, Villages on the surface.

3. *Hipogean villages.* The residential units are organized around wells drilled vertically and called courts or patios or vicinanza. The courts are connected to each other through underground passages or at the surface. Common areas of aggregation and distribution to homes and their annexes, the courts regulate the entry of sun, light and heat, and ensure, with fireplaces, the ventilation. Typical of settlements in North Africa, the emblematic example is the village of Matmata, Tunisia. The court system or “neighborhood” was imported in Massafra in the fifth century. In the Comuniad of Valencia is known the settlement of Paterna; in Turkey an example of these structures is the Gümüşler Monastery, in the province of Niğde; finally, in Santorini, there are small groups of villages on the plateau of Oia.

4. *Underground villages.* In some cases, the imperatives of defense led to totally conceal the urban structure. The communication with the outside are limited to few accesses and outlets required for ventilation. The cities of Derinkuyu and Kaymakli (Turkey), on several levels, are representative of this underground villages. In France it is known the city of Naours.

4. Documentation

The heterogeneity of the public to involve requires different tools for the graphic and multimedia description, to understand both. It is the most common settlement system. The number of households is variable and takes full advantage of the valley slopes employing his good orientation. In the continuity of living in a cave, and representation of the architecture and the environment.

The representation, in all its modalities, is one of the most useful tools for the documentation of monuments already ruined by the passing of time and that are destined to destroy.

The acceleration of degradation is clear: in the environments of the monastery of Hallach (Hortahisar – Cappadocia), in a few years, there has been a loss of quality of the drawings (Fig. 5) and the integrity of the rock appears heavily compromised. In 2007 the village of Zelve was accessible, while in 2010 it was closed to the public.

Failing to safeguard and restore the abundance of cave sites, any form of documentation, even if only photographic or aimed at a simple survey, it would be desirable in order not to lose the memory of the legacy left to us over the centuries.

It is nowadays possible to use softwares to recreate the three-dimensional reality of the caves, in order to let people appreciate the environmental and architectural features with sure effect and involvement. Furthermore, the softwares, with the data processing, are able to produce models from which the site can be quantitatively measured and analyzed.

The same places require several readings and the main instrument for this documentation is represented by photographs. It is necessary that the photos are shot in peculiar ways, according to the used software. Therefore,

the effectiveness and efficiency of data acquisition must be supported and integrated with the data processing, in order to effectively produce integrate geometric information, attribute of matter, excavation techniques, state of decay, etc. Further, the difficulties in classification and processing of the amount of data that may contribute to the knowledge of the sites have not to be underestimated.

The major activities carried out within the CHRIMA-cinp consisted in analysis of different rupestrian sites.

Through experience, different operating modes and methodological approaches have been tested, aimed at identifying the most proper conceptual data collection plan, and the related cartographic products. The critical analysis of the project results, conducted with basic documentation, has tested the critical importance of a fast survey to obtain satisfactory results to document the rupestrian heritage.

4.1. Methods and data survey of some heritage.

4.1.1. *Traditional survey.* Surveying in France contributed to collection of data at Bourg-Neuf, Saumurois.



Figure 6. Bourg-Neuf, plan.

Bourg-Neuf is a town in the municipality of Dampierre-sur-Loire. Its origin dates back to the fifteenth century, when the ligerians dug dwellings into the tufa creating a small village away by the floods of the Loire. More and more modest families inhabited these houses until the 60s of the twentieth century, finally abandoning them for newer and more comfortable spaces.

The village of Bourg-Neuf develops along the winding path of “Rue Haute” located half way up the cliff. At the entrance of the village, the Rue Haute divides into two paths that serve all the houses in the village and is part of the old mining tunnels of tuff, serving other houses and gardens overlooking the valley. Sixteen of the private homes in Bourg-Neuf have real possibilities for restructuring despite the decay: one has already been renovated and upgraded to “holiday home”, two are in the process of restructuring, the remaining thirteen are abandoned. The houses are troglodytic and partly semi-troglodytic. Bourg-Neuf differs from the typical wall troglodytic settlements of the area: it has the characteristics of rock settlements but has some of the characteristics of the underground settlements, such as underground galleries opening into courts. All homes have at least one fireplace, some have a “potager” or a bread oven; all have a small green space; some of them consist of a single large compartment, other have multiple rooms and levels.

4.1.2. *Speditive survey.* The experiment carried out on Hallac highlighted some issues about facing cameras like as daylight factor, definition and dept of field and the quality of metric reading of homologous points. It is highlighted the need, in critical location such as the aisles

of building basilican Allac, of a traditional topographic survey (closed profile of plan or section) and sufficient measures for the development of the third dimension.

In Allach (2010) metric measurements in the courtyard of the church, in the hall with a dome and in the basilica were carried out, together with the photographic survey for the construction of a tridimensional model and a panoramic view. The textual description of the court highlighted the architectural features, revealing decorative elements that cannot be appreciated in the short time of the survey.

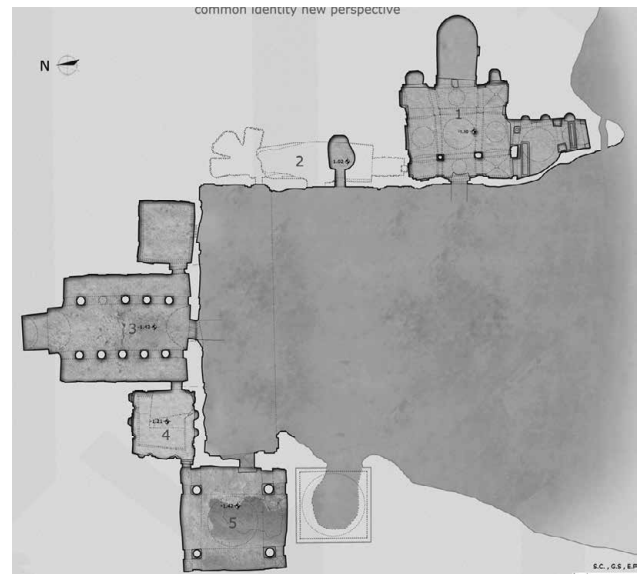


Figure 7. Hallac Monastery, the top.

Hallac Monastery is located to the north-northeast of the Ortahisar village, in the area between the road connecting Nevshehir to Urgup and Yolu and that connecting Ortahisar to Nevshehir. The complex has an open courtyard on the south side (Pic. 2) on which seven rooms open on the ground floor and others on a second level. The court has partially oxidized pink and cream walls and it is cut into a spur limited by a crown of brown cones. The original core was probably a closed court, accessed by a narrow passage on the SE edge; the southern front was probably closed by small cones eroded by time. The original ground level of the courtyard is covered by a 1–1.5 m pile of debris.

Today, the court disengages four entrances: at north there is a three-room complex, which is located at the bottom (no. 2, 3, 4), while at the top there are openings of unvisited rooms. A church is located at east with an inscribed cross plan church with a funerary narthex; on the eastern side, at the top, there are entrances to the house of the monks, which were successively used as pigeon house (no. 7); at west, there are an inscribed cross plan large square room (no. 5) and a second room, probably used as kitchen (no. 6).



Figure 8. Hallac Monastery, the front-section.

The photogrammetric survey was also applied to the Chapel of S. Pietro and Paolo in Balkan monastery (Ortahisar – Turkey). Despite the photographic documentation was heterogeneous and not aimed at the photogrammetric restitution, it was possible to obtain relevant data to an understanding of its architecture.

The same technique was applied to survey of some caves in the territory of Casabona in Calabria (Italy). Casabona has three rupestrian villages. The first is Valle Cupa, located in the ravine of the Malolacco valley, and contains about 250 rupestrian environment developed along linear terraces with an extensive network of trails. Then, there is the site of Timpa Tallarico and the Rione Croce with 80 caves; in the site of Montagna Piana, moreover, there is a village with 15 caves.

The cave with spirals presents in Valle cupa is very interesting: spirals, concentric circles and moon are carved into the sandstone.

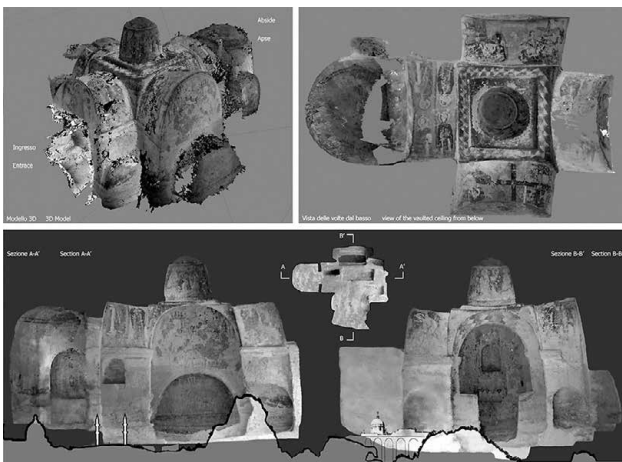


Figure 9. Chapel of S. Pietro and Paolo in Balkan monastery.

4.1.3. 3D scanner survey. Different architectures, religious and civil, have been object of 3D survey in Spain and Italy (Massafra and Ginosa).

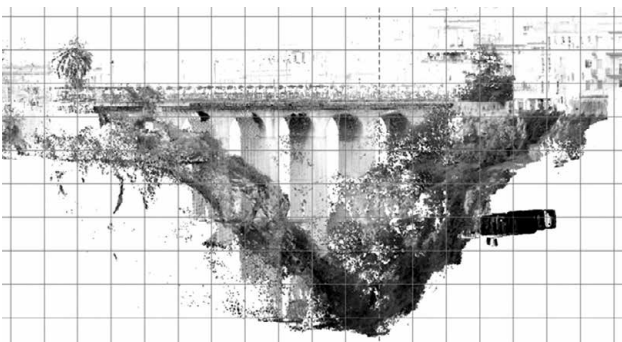


Figure 10. The San Marco ravines, 3DS architectures and hosting environment survey.

The San Marco Ravine is north of Massafra, and originates near the Masseria Pantaleo. It is on the east side of the old town, dividing it in two parts. It is part of the town, and is named after the rupestrian church of San Marco.

In the past it was called (the Greek word *paradeisos* means garden), because Paradise cliffs and terraces are covered with blooming spontaneous vegetation, gardens, orange gardens. The suggestive view from the Ponte Vecchio shows terraces, cliffs, caves and cactuses. Many of these caves were inhabited in the Middle Age; were important crypts are San Marco, the Candelora and Santa Marina.

Other important caves are the Hegumen's house and the anonymous crypt in Vico III Canali, used as an oil mill until few decades ago. The ravine is surmounted by the severe and majestic Castle from the 16th century (but founded before), with a square plan, three cylindrical towers and one octangular tower.



Figure 12. Ginosa, top the ravine.

4.1.4. Virtual Tour – 360° photos. Different architectures, religious and civil, and the hosting environment have been object of these analysis in Turkey and Italy.



Figure 13. Gravina di Trovanza, environment virtual tour.

In Massafra, was detected the little “gravina” of Trovanza, in Mastropaolo area. Some caves were part of the settlement, on two levels, used as residence and outbuildings; one of the caves has a rectangular plan and it has one wall entirely covered by small square niches arranged in parallel rows (dovecot/herbarium). The common interpretation describes it as a room for the conservation of medicinal herbs, hence the popular name of “pharmacy”.

Faced with this cave is a small rupestrian church with a rectangular plan (about 4.60 x 3.20 m, height 2.30 m) and a single orthogonal basis (2.75 x 1.20 m) to the east, with an altar against the wall. There are some frescos (in fair condition). The canal system is well conserved.

5. Annotations

In Cappadocia, from surveys made in some places with rupestrian sites in terraces like Ortahisar, the structural decay of the sites has accelerated with the change of the population during the first half of the twentieth century.

The conservative wisdom and culture of land hard rock has been lost; the necessity to build on the surface prevailed though lacked the technical bases of support for good land management. The voussiors for new homes quarried from the rock on which he was edified: emptying of the rock, and the overhead of the underlying structures are contributing factors of the collapse.

These collapses were further favored by lack in water management that, taking advantage of the network of collection and distribution, found new paths seeping into the rock, thus causing erosion. In many countries, the lack of a network of wastewater collection, together with the excavation for the restoration of some houses, continues to heavily contribute to the collapses.

The villages were abandoned in the wall, and the lack of care led to the loss of many settlements of considerable architectural value.

Presumably, the same phenomena have occurred in previous eras in rupestrian sites of the different states; negligence over the time and the ignorance of the value of cultural and environmental rupestrian heritage contributed to the loss of the cultural heritage of living in a cave.

In various countries restoration and environmental rehabilitation are ongoing for cultural needs or, more often, for economic interests related to tourism activity. For instance, significant interventions are occurring at Saumoirs and Matera. However, in several sites it is not yet clear the bioarchitectonical value of the rock; therefore, the rock is coated with plastic and anti-perspirants fabrics and then laid in plaster supported by wire mesh. In other countries, the exposed rock is an aesthetic value required by tourists, but is completely ignored the need for ventilation systems for the health of the environment and of the same rock.

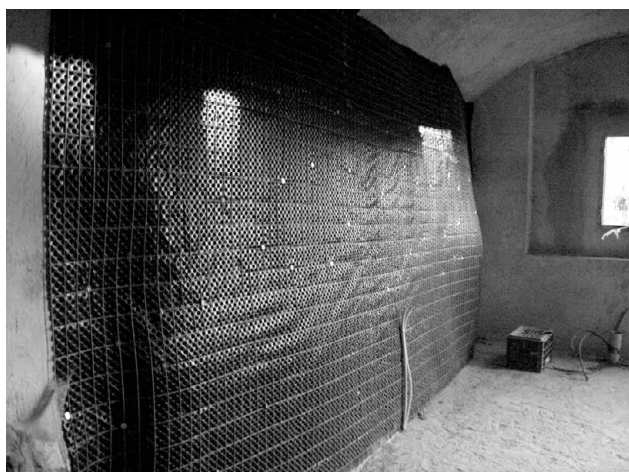


Figure 14. Restoration of a cave. Finikia Oia.

6. Results of the project Chrima-cinp

The activities of the partnership were intense and continuous; the specific activities of the partners are published in the:

- *The rupestrian settlements in the circum-Mediterranean area*, published by DAdsp, typ. Il David, Florence, September 2012. isbn: 978-88-96080-09-2. The texts discuss: historical and cultural features; studies of some settlements with unpublished drawings of the architectural emergencies; thematic studies on the rupestrian culture.
- CD documentary *Journey through the rupestrian cultures*. The CD contains a video presenting the three territories of the Workshop: Puglia, Santorini and Cappadocia; 3D virtual video of the rupestrian environments with architectural and landscape values in Cappadocia and

Puglia. It collects photographic material representing the qualities of the territories: rupestrian settlements, humanized villages, architectural emergencies; moments of socialization and activities of Crhima-CINP.

- CD “Music for bagpipes in the Mediterranean Area”, with sounds and music of the Mediterranean area;
- Web site www.rupestrianmed.eu. The site is an important data source that promotes the activities of the Crhima-CINP project, collects drawings and papers developed during its activities, as also the data from the censuses that have been carried out or are still in progress.

The results of the project activities, including the works on the rupestrian heritage by the participating students, are published in:

- *Days of Study on the Jonica Earth. Rupestrian habitat in the Mediterranean. From archeology to new practices for its protection and recovery*. Massafra 29–31 October 2010. Antonio Dellisanti publisher, May 2012. isbn: 978-88-89220-92-4
- *Days of Study on the Jonica Earth. Rupestrian habitat in the Mediterranean. From archeology to new practices for its protection and recovery*. Massafra April–May 2011 published by DAdsp, typ. Il David, Florence, June 2012. isbn: 978-88-96080-06-1.
- *Crhima Cultural Rupestrian Heritage in the Circum-Mediterranean Area, Conference Firenze 21–23 Giugno 2012, Abstracts*, published by DAdsp, typ. Il David, Firenze June 2012. isbn: 978-88-96080-07-8.
- Exhibition: Massafra 2010, Massafra 2011, Ortahisar 2011, Mustafapasha 2011.
- Final exhibition: Firenze 2012, Sorano 2012.
- *Rupestrian Landscapes and Settlements Chrima Cinp Project Workshops and Survey Results*. published by DAdsp, typ. Il David, Florence September 2012. isbn: 978-88-96080-08-5. The volume contains descriptive graphic papers of the Crhima-CINP project; general information about the rupestrian sites of the partner countries; general information about the rupestrian territories and emergencies.

Credits

Figure 6. <http://www.pixelistes.com/.../souterraine-t24158.html>

Figure 6. *Bourg-Neuf, plan* – by Giovanni M.Vampa, Nicola Pacini.

Excerpt from the thesis: Studi e riqualificazione della Loira troglodita. Il bourg-neuf: “La Loire a velo” elemento di riqualificazione. *Relatore*: Carmela Crescenzi, *Correlatore*: Bernard Tobie. *Laureandi*: Giovanni M.Vampa, Nicola Pacini.

Figure 9. *Chapel of S. Pietro and Paolo in Balkan monastery* Fotogrammetry Survey by Simone Beneventi, UniFI.

Figure 10–12 M. Manganaro, A. Altadonna, G. Martello, A. Nastasi, N. Siragusa. DiSIA. UniME.

THE AUGUSTEAN AQUEDUCT IN THE PHLEGRAEAN FIELDS (NAPLES, SOUTHERN ITALY)

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Romans built the 96 km long Campanian Augustean Aqueduct to bring fresh water from Southern Italy mountain springs to the densely populated areas of *Puteoli* and *Baiae* in the Phlegraean Fields. In the XVI and XIX centuries the ancient aqueduct was investigated in order to restore it to bring water to Naples, with no result. The section after Naples was never seriously investigated. From 2010 we are performing researches about underground hydraulic systems in the Phlegraean Fields. The paper reports about several findings in the area. Up to now, only few hundred meters of aqueduct are documented, out of more than 22 km. However, the little information gained already contributes to the comprehension of a very important ancient settlement area.

1. Introduction

The Phlegraean Fields are an active volcanic caldera, composed by several craters in an area of about 65 Km² in the surroundings of the town of Naples (Campania, southern Italy). Presently, the volcanic activity is limited to fumaroles and thermal springs but in 1538 a new crater erupted and destroyed a large area. Main eruptions are dated at 39/35 ky b.p. and 15 ky b.p., while several minor volcanoes erupted in pre-historical times (Rosi and Sbrana 1987; Orsi et al. 1999; Fedele et al. 2011; Scarpati et al. 2012). The area is affected by bradiseismic effects: a long-period raising and lowering of the land, related to variations in the underlying magmatic chamber. In Roman times the land was at higher elevation than today, so many coastal structures, villas, palaces and harbour plants are presently underwater.

In ancient times the presence of safe harbours, thermal springs and a temperate and fertile land raised attention by Greeks and Romans. In the last years of the first century B. C. the area was fully exploited with leisure establishments, fisheries, storehouses and with the Navy harbour plants. Many caves were opened in Roman times, as tunnels, aqueducts, water tanks, hot water catchments, steam tubes to warm spas. A major drawback in the Phlegraean Fields was its lack of fresh water. The volcanic land produced just thermal salt springs. In order to support a growing population and the demanding military and commercial fleets, the Romans designed a long aqueduct, tapping important springs in the calcareous Appennines. The aqueduct course was largely underground. Side branches reached the ancient cities of *Pompeii*, *Nola*, *Atella*. The main branch skirted *Neapolis* (the present Naples) and reached the important commercial harbour of *Puteoli* (today Pozzuoli), the *Portus Julius* Navy harbour, the wealthy settlement of *Baia* and the *Misenus* harbour, after leaving a side branch to the ancient Greek city of *Cuma*. Total length was about 96 km (De Feo and Napoli 2007).

The ancient aqueduct ceased functioning at an undetermined date in the Middle Age. In the XVI century, the city of Naples required more water to support its growing population, so the Spanish viceroy Don Pedro de Toledo appointed the Neapolitan architect Pietro Antonio

Lettieri with the task to investigate the ancient aqueduct in order to restore it. Lettieri research lasted four years but the restoration effort proved too large. We are just left with a hand written relation (Lettieri, ab. 1560) describing the course from the springs to Naples, with some hints about the course after Naples in the Phlegraean Fields. The same happened between 1840 and 1880, when architect Felice Abate performed a similar research (Abate 1864). Finally, in 1885 a modern aqueduct was completed, tapping the same sources as the Roman aqueduct.

2. Aqueduct explorations in the Phlegraean Fields

Since the restoration of the Phlegraean Fields section held no special interest, the ancient aqueduct was neglected in the area. Even the dating was uncertain. In 1938 a celebration stone was found at the springs, which attributes the aqueduct to Augustus (Sgobbo 1938). Finally, in the XX century second half a wall inscription was found in a tunnel at Scalandrone, between Pozzuoli and Baia, bearing a date corresponding to 10 A.D. for the opening of a water catchment from the Augustean Aqueduct (Camodeca 1997).

Very few bibliographic references to aqueduct sections in the Phlegraean Fields were found. We began research on the aqueduct in 2010, with the support of the Special Superintendency for Archaeological Heritage of Naples and Pompeii and of the Phlegraean Fields Regional Park. The following sections will report briefly about the first results of these studies. Sections are reported in flowing progression, from Naples to the aqueduct end in Miseno (Fig. 1).

The ongoing research aims at providing a small contribution to the Italian map of ancient underground aqueducts (Parise et al. 1999).

2.1. Crypta Neapolitana

The *Crypta Neapolitana* is a 709 m long tunnel which in Roman times connected *Puteoli* with *Neapolis*. The aqueduct runs parallel to the *Crypta*, few meters deep within its north wall (Amato et al. 2002). The *Crypta* pavement