The ArtRisk project builds on the following considerations.

- Landscape organization and management in Europe has always had a direct relationship to Cultural Heritage, not only because soil disturbance may threaten Heritage conservation, but because Heritage remains are embodied in the landscape, defining its identity, and thus the identity of local populations;
- Architectural and Artistic remains from all periods are the core elements of the Heritage built in the landscape; they enable the establishment of routes and clusters that may condition the development and sustainability of those territories, Heritage remains are often considered as isolated features, but this diminishes their value, since they are the material link between past and future;

In less-favoured regions, namely those facing problems of depopulation, monuments and past artistic remains may act as structural elements for the reorganization of the management of landscape resources; this is so in many regions, but those regions face the danger that they may lose their foundations completely if there is a catastrophic destruction of the Heritage; this has been the case where massive areas have been flooded by artificial lakes, been affected by seismic activity or been devastated by fires.

Every year, the impact of major catastrophes destroys or conceals vast areas of Heritage. All partners involved in the project have extensive experience in rescuing and monitoring such impacts.

The aim of the current project is to establish a common European strategy to face those perils, both at predictive and rescue levels. In order to do so, a first area of intensive attention has been selected: the Tagus valley, where, over 30 years ago, a dam flooded the greater part of the largest Holocene rock-art complex in the Iberian Peninsula, one of the largest in Europe. A portion survives in the area of Miração, a region dominated by the exploitation of forest resources, and it forms the core of the Prehistoric Art Museum. This art, together with other monumental remains, is a crucial element for the region’s development in terms of both identity and economy (tourism).

The context is not a new one, but the present project addresses the need to establish a set of procedures in similar cases. It does so by defining a series of activities and by exploring, in several contexts, the relationship of Heritage to fire and water: an ambivalent relationship, since fire and water are major menasces to current Heritage remains, but also had a major impact on most of them in the past.

Planned activities follow different and complementary strategies: portable material products (exhibition, guide) that may act as starting points for discussions with Heritage management agents in various countries; virtual products that may be used for further monitoring exercises elsewhere in Europe (GIS, web-site) and a specific concentrated application of procedures, involving conservation and dissemination (Pego da Rainha-Ocreza).

As a result of this network, several tools have been prepared.

1. An itinerant exhibition on the impact of natural catastrophes (fires, earthquakes and floods) on European major Heritage remains, based on selected sites in Portugal (Tagus), Spain (Guadiana), Italy (Alps and Naples), and Romania (Danube Delta) - this exhibition will address, in particular, the relevance of this Heritage for the identity and development of those regions;
2. this folder, that you may use and to which you may add new files;
3. a GIS application designed for monitoring endangered areas in Europe, associated with a permanent exhibition on the role of the art related to the origins of agro-pastoralism;
4. a web-site to disseminate the project’s results (www.paamt.pt/ArtRisk);
5. the study and conservation of affected prehistoric art sites, including a documentation centre, by international teams involving all partners, within the framework of a strategy designed to make them accessible to the wider public;
6. the establishment of a European Network on the control of risk and damage to landscape Heritage, to be open to any institution outside the current partnership.

If you are interested in this argument we invite…
WHY A EUROPEAN NETWORK FOR NATURAL HAZARDS AND ARCHAEOLOGICAL HERITAGE?

Nowadays Europe is the territory of contrasts and economical globalization. Inside this territory, culture stands out as the key element which can link people thoughts and feelings, which can make people conscious about their double identity - as European citizens and as their distinct countries citizens. Only culture can promote the equality between the diverse values, true values in their different forms, the general truth contained in every value. Culture means the past melted in the present, the reason of today’s action and the seed of tomorrow’s dreams.

And this is enough to demonstrate the importance of keeping alive the culture’s different forms. It is possible, from a reason or another, in the whirl of life, to forget some of our defining features. Then we have only to look at the impressive number of silent and immobile witnesses of the past and we shall be ourselves again. But if there is no witness, there is no memory to get back. No matter how immaterial is the result, the start is a material one. This material side of our memory has to be protected for ourselves and for those who will come. To preserve these traces which tell the history of our continent and explain our very nature is our task. It is not easy but it has to be done. By everyone and by all together. Using everyone intelligence and the capacity of all. Using every one skills and the capacity of all. That means working inside an extended network, a European Network. Among the elements which have a strong impact on the material heritage, natural hazards are the most destructive. Among all the representatives of the immobile heritage, the most exposed is the archaeological one. This is why the connection among many cultural European institutions in a European Network for Natural Hazards and Archaeological Heritage is so urgent and useful. A network linking cultural institutions with great experience and similar problems means more effective results. It means also an increase of the specialists’ mobility which result is the collaboration and successful implementation of those projects orientated to the lasting development of the European integrated system.

And the last but the most important target of such a network is to enlarge the horizon for every citizen, to make them conscious about their roots, about their identity and about the importance of keeping the past alive in order to have a future.
The fires in 2003 in Central Portugal have affected in a severe way the region of Alto Ribatejo. Out of the c.450,000 ha of the region, 162,000 have burned (36%), having a dramatic impact in daily live of the local populations. People lost houses, jobs and other assets and, among his, hundreds of archaeological sites were also affected.

To face the impact of such fires on the Heritage implied, first of all, to approach the issue of priorities: how to discuss the protection of sites when other more relevant catastrophes were occurring? The regional network of NGOs, scholars (Polytechnic Institute of Tomar) and municipalities that form the “Archaeological and Environmental Park of the Middle Tagus” has, first, stressed the importance of recognising that those sites were attached to the memories and identities of the region, their destruction having cultural, moral and economic implications.

It was explained that the material memories of the landscape (settlements, rock art, necropolis, irrigation systems, field systems, etc.) once lost would potentially accelerate the processes of depopulation of the rural areas. Deprived of economic resources and of moral reasons to recognise their identities, people, specially young people, would tend to abandon land. Therefore, there would be an impact not only on tourism (loss of places to visit) but also in the other dimensions of regional socio-economics. The conclusion was that, in times of major stress as those, it was crucial to validate the role of cultural heritage in the re-construction of the landscape in a process respecting its cultural traditions and diversity.

There was a perception that the fires, having destroyed the vegetation, would have two main physical effects on the sites: the destruction of surface layers (namely detaching layers of rocks by thermal action) and the crawling of structures (previously sustained by the vegetation).

A third, indirect, effect would be the destruction of sites by machines having to clean and replant the burned forest. In
all cases, mid-October was considered a key deadline, since it would precede both the cleaning of the forests and the arrival of Fall rains, that would accelerate the erosion processes.

The preliminary diagnosis couldn't be more severe: over 60% of the known heritage had been affected. In the end, over 500 new sites were discovered. As a conclusion, the experience indicated that, to face this kind of threat, the following resources are chiefly needed:

- highly trained archaeology surveyors,
- with the experience of working in burned land and with a good knowledge of local geomorphology;
- involvement of conservation experts;
- involvement of GIS experts, to process the field records;
- use of 4WD vehicles to survey, systematically, a sample of 20% of the land;
- use of helicopters to survey the rest of the area (this last part was not implemented, for lack of requested support from the Ministry of Culture).

(Portuguese abstract)

Os incêndios de 2003 destruíram cerca de 36% da superfície da região (1 620 000 ha). Uma metodologia inovadora, envolvendo equipes de campo treinadas para a prospecção pós-incêndio, apoiadas por um sistema simples de registo geo-referenciado, posteriormente transportado para uma plataforma SIG, permitiu o registro de centenas de novos sítios.

Fig. 2. Collapsed structures, as a secondary effect of the fire.
Fig. 3. Burned structures from the Caratão hillfort in Mação (Portugal).
Fig. 4. Bronze age rock art damage after the fire (Cobragança, Mação, Portugal).
Fig. 5. Detail of the thermoclastic effect of fire, detaching parts of the carved rock.
Seismic Risk in Campania

Seismic activity in the region derives from two main sources:
- tectonic earthquakes in the Appenine Mountains
- the volcanic activity of Vesuvius and the Phlegrean Fields

In the past, many earthquakes of tectonic origin have occurred in Campania. Pliny the Younger emphasizes in his letter to Tacitus that seismic shocks “were noted phenomena” in the area, so much so that people were not “much frightened when the earth trembled” (Epistolarum, VI, 20).

Everyone remembers the 1980 Irpini earthquake which affected an extensive area in Campania and part of Basilicata, devastating about a hundred towns and villages and damaging many archaeological sites, both inland (Conza) and on the Tyrrenhian coast (including Pompeii and Stabiae).

Today, a large portion of Naples is exposed to medium level of seismicity. Earthquakes associated with volcanic phenomena may also cause damage and history records notable examples. Most famous is the case of Pompeii which from AD 62 onwards felt a series of quakes, precursors to the great AD 79 eruption, that caused serious damage to the Roman towns around Vesuvius with long-lasting effects on trade and the economy (fig. 1).

Other Risks

To these phenomena must be added the risk of landslides, mudslides and flooding which frequently strike the hilly parts of the region.

The recent (5 May 1998) landslips on the slopes bordering the Pizzo d’Alvano mountains are still fresh in our memories; they took the form of mud-flows, devastating Sarno, Siano, Bracigliano and San Felice a Cancello and killing over 160 people (fig. 2).

The archaeological area of Sarno, a protohistoric and classical site, was also damaged. In the early bronze age, consequently to the eruption of Avellino pumice stones, a mudflow destroyed a hut village in Nola (fig. 3).

The Vesuvius Volcanic Risk

The recent eruption history of the Somma-Vesuvius volcano started after a huge eruption which produced the Campania ignimbrite (about 39,000 years ago) which buried some prehistoric sites (Faicchio and Guardia Sanframondi). 25,000 years ago, the volcano began to produce large explosive eruptions, known as “Plinian”.

About 3,500 years ago, the Somma volcano gave rise to the “Pomici di Avellino” eruption, with fatal consequences for many of the Early Bronze Age settlements in the area.

It is estimated that a future Vesuvian eruption would be of high intensity and wide extension. Coping with it would require extraordinary measures.

An Evacuation Plan has been drawn up, which assumes the occurrence of an eruption similar to the Sub-Plinian (strongly explosive) event of 1631.

The Maximum Expected Event

This scenario does not represent the most probable event, but rather the maximum to be expected in the short to medium term. The dimensions regarding the Maximum Expected Event (velocity, height, density, temperature of the eruptive column, etc.) have been calculated from studies of the volcano and data concerning the most frequent wind speeds and directions in the upper atmosphere.

Using this information, computer simulations have been made of the various eruption phases and risk maps prepared on the basis of the type and strength of the volcanic phenomena to which areas might be subjected. (Red Zone: area exposed to most severe risk; Yellow Zone: lower risk area. A portion of the Yellow Zone is subject to
a high level of hydrogeological risk, this is defined as the Blue Zone and coincides with the “Nola Basin”.

The Phlegrean Fields Volcanic Risk

The entire Phlegrean Fields area (from Phlegraean, “burning”) has been involved in volcanic eruptions and the secondary effects of these.

Volcanic products from the Phlegrean zone (pumice and pyroclastic flows) have interfered with human settlement and land use in distant areas, south of the Regi Laghi and (with regard to pumice clouds) as far as localities to the east of Vesuvius (Avella, Nola, etc).

The effect of the eruptions from the Astromini, Agnano-Monte Spina and other volcanoes is evident in many Copper Age sites, for example the current excavations in the Gricignano zone and along the old course of the Clanio.

The last large event – the Monte Nuovo eruption – occurred in 1538.

Today only the Solfatara volcano is still active, but the bradyseismic phenomena which have affected the coastal area over the centuries (and also recently) subject the buildings there to a sort of “slow earthquake.”

The most recent bradyseismic crisis occurred in 1983–84, when the ground in the central part of the Phlegrean caldera rose by more than 1.80 cm.

During this crisis, preparations were made for the evacuation of the local population in three days, with the forecast of a week’s warning before an event.

The emergency plan was based on two eruptive scenarios differing in level of explosive strength estimated on the basis of the area’s recent volcanic history.

- Minimum Event: Plinian eruption of Agnano Monte Spina (4,400 years ago) with total destruction of an extensive area covering about 80 km, between Posillipo, the Campidoli, Cuma and Baia.

- Maximum Event: Monte Nuovo eruption (1538) with total destruction limited to an area of 15 km around the eruptive vent located in the centre of the caldera, corresponding to Pozzuoli harbour.

The scientific community is currently elaborating a more precise zoning of volcanic hazard in the Phlegrean area.

**Fig. 2. The Sarno mud-flows - Source: Fire Service.**

**Fig. 3. Nola excavation. In the foreground, Hut of the Early Bronze Age.**
The dryness of the air, due to drought, and its wetness, due to rainstorms, are the causes of earthquakes

Thales

Water and rock art: a balanced relation

The relation between water and rock art could be considered as indissoluble. A love-hate relation, where one side, rock art, depends on the other side destructive action (water), but can not break this relation because in certain occasions, its conservation depends on it as well. Water is, certainly, one of most destructive elements for rock art. Its negative effects have two different origins:

- Natural origin
- Human origin

In first place we will focus in natural originated effects that attack rock art located at caves and open air. Destruction caused by water could respond to three types:

- By erosion
- By precipitation
- By deposition

A. Affections caused by erosion

Those affections are due to water dragging itself. We can distinguish two different types of erosion:

A.1. Chemical erosion by dissolution: It affects mainly rock art located on limestone supports, normally at caves. Water in contact with limestone produces the progressive dissolution of stony supports and the total lost of any artistic manifestation located at the affected areas.

A.2. Mechanical erosion by dragging: It is the most usual and affects rock art at open air and cave locations, and all kind of stony supports.

Water flow increase and its floating particles produce progressive erosion that finally erases any kind of rock art manifestation existing at stony supports. Affection is not limited to the depictions but to the stone surface itself. Constant exposure to water dragging causes in many occasions the total destruction of stone surface.

B. Affections by precipitation

In this case, although precipitation can contribute to hide rock art manifestations, not necessarily may cause its total destruction. In some cases depictions remain preserved under floe calcite due to precipitation.

This kind of affection is mainly documented in caves and at limestone surfaces but it may affect also open air rock art manifestations and other supports as quartzite and slate. Floe calcite has a double origin:

B.1. By lamination: the more or less continuous flow of a water thin film produces calcium carbonate precipitation over cave walls, generating the consequent floe calcite or even spalothems that hide totally or partially the painting or engraving depictions.

B.2. By Vapor Partial Pressure variations: caves exclusively. At caves normally exists atmospheric water vapor saturation derived of the environmental humidity conditions. Temperature variations inside the cavemay increase the Vapor Partial Pressure, CO2 as well as H2O, producing the calcium carbonate precipitation over cave’s stony supports that finally turn opaque the cave walls and hide rock art manifestations.

C. Affections by deposition

This last type of affection neither causes necessarily art manifestations total destruction, but evidently, produces its definitive hiding. Deposition affection is usually located at riverside complexes. It is produced by the art complexes periodical immersion under close river waters during freshet periods. Those periods of maximum flow go accompanied with massive sediment contribution dragged by water, that is progressively deposited over depictions areas during flows decrease, when the dragging capacity of water diminishes as well.

However, the relation between water and rock art, as we have explained at the beginning, is indissoluble. Although water action may produce the rock art destruction, the absence of water could incise as well in the preservation conditions, and contribute to the progressive destruction of art depictions.

This kind of affection is documented

Fig.1. Destruction of stone surface by mechaerical erosion. Molino Manzín (Alconchel, Chelas, Badajoz, Spain).

Fig. 2. Stone with rock art affected by flood. Presa de Alqueva. Portugal.
mainly at caves where the balance of environmental conditions influences in the good preservation of rock art. But caves environment conditions are very unstable and are quite habitual variations in those conditions that produce, as we explained in the case of the V. P. P., irreversible harms over the graphic elements documented at caves.

In other way, an accused decrease of the humidity level inside the cave provokes the progressive desiccation of stone supports that serves as basis to the artistic motifs.

At extremes conditions the environmental dryness could generate the stone surfaces scaling, destroying any artistic representation painted or engraved at the mentioned surface. The other main origin of rock art affection caused by water is related to human activity. The most usual is the construction of big hydraulic substructures that cause the lost of the original riverbeds located at the affected areas, and also the lost of all rock art manifestations depicted at the stone surfaces of the river banks.

In this case the lost is irreversible, because normally the characteristics of the supports impede the removal of the depictions, and even if is possible to preserve them (removing stone surfaces from their original place), archeological and geographical context will be lost and with them any possibility of interpretation.

Indirectly, big dam construction generates a notorious increase of the environmental humidity conditions at the affected areas. It is usual that those big water zones provoke as well the increase of fog periods and a higher precipitation ratio. This increase in the environmental humidity conditions, although does not affect directly rock art, it does affect the parasitical vegetation (lichen and moss) that are usually located over the painted and encarved motifs at stone supports. This increase in humidity and precipitation levels, helps their development and expansion, producing finally the total destruction of art depictions that are completely swept aside by the vegetation advance.

Fig. 3. Rock art affection by parasitical vegetation. Molino Manzanez (Alconchel, Chelas, Badajoz. Spain).

Fig. 4. Rock art affection by mechanical erosion. Molino Manzanez (Alconchel, Chelas, Badajoz. Spain).
Air is the nearest to an immaterial thing, for since we are generated in the flow of air, it is necessary that it should be infinite and abundant, because it is never exhausted.

Anaximenes

Air (Aer in Latin) is the ocean we breathe. Air supplies us with oxygen which is essential for our bodies to live. Air is 99.9 per cent nitrogen, oxygen, water vapour and inert gases. Human activities can release substances into the air, some of which can cause problems for environment, humans, plants and animals.

There are several main types of pollution and well-known effects of pollution which are: smog, acid rain, the greenhouse effect, and "holes" in the ozone layer. Each of these problematic effects has serious implications for our health and for the whole environment, and particularly for Cultural Heritage.

Cultural Heritage

Cultural Heritage includes the traces of human activity in the natural environment. These are irreplaceable sources of information on men's evolution, and on the development of material and spiritual life. Because cultural environments, as monuments and sites, are non-renewable resources, their conservation and management must be based on a long-term project, and present society can benefit from the preservation and active knowledge of its past.

The value of cultural heritage cannot always be measured in monetary terms.

Rock art sites

Rock Art sites, petroglyphs and paintings, are the oldest traces left by people on his non material history: every year, a lot of these are lost or damaged. The ArtRisk project has been started to ensure that atmospheric corrosion is an universal process that knows no geopolitical boundaries; it is determined by climatic parameters such as relative humidity, temperature and precipitation.

Sulphur dioxide has a strong accelerating effect on certain material's degradation. Increasingly, the synergistic effect of multi-pollutants is cause of acidification of soil and water due to long-range transboundary transport of air pollution. Several attempts to calculate cost of material damage due to acidification have been made in the world; many developing countries are located in warm regions with high relative humidity and a high frequency of precipitation which increa-
sees the potential of acidifying pollutants on Cultural Heritage. Moreover, a high proportion of the population is at times exposed to concentrations of air pollutants that increase the risk of health problems.

**Air pollution and acid rain effects on rock art**

The reduced thresholds and critical loads for air pollutant exposure, the synergetic effects occurring between pollutants, particles and aerosols with rocky surfaces, determine the necessity to establish a ranking of air pollutants causing harmful effects on cultural heritage materials. Protection of Rock Art Cultural Heritage consider air pollution effects, conservation treatments, global change effects and impacts of mass tourism.

Acid rain is still one of Europe's most serious environmental problems, even though reductions in emissions have reduced the extent of acidification. Acid rain is caused by emissions of sulphur and nitrogen compounds to the atmosphere. Here, sulphur and nitrogen react chemically with water vapour to form sulphuric acid and nitric acid. The most serious damage caused by acid rain today is acidification of water; in addition to this effects on ecosystems, acid rain damages buildings, sculptures, rock art and other structures of our Cultural Heritage. Air pollution has serious consequences for Mankind as a whole.

![Image of rock art](https://example.com/image1.jpg)

**Fig. 2.** Ponte Raust, Pinerolo, Italy. Studied by CeSMAP since the 1960s, the 'Rock of the Fairy' was the unique example of Alpine Prehistoric paintings in Italy till the discovery - 1979 - of the Neolithic paintings of the Cavour Rocca. The surfaces are exposed to the acid rains aggression. (Photo Mauro Cinquetti, CeSMAP).

**Fig. 3.** Torre Pellice, Pinerolo, Italy. The “grids” are the more evident motifs of the composition present in the Balma di Mondoni shelter. The rocky surface is affected by whitish mineral percolations caused by acid rain, obliterating the prehistoric paintings. (Photo Mauro Cinquetti, CeSMAP).
For it is by earth that we see earth, and by water water, and by air glorious air; so, too, by fire we see destroying fire, and love by love, and strife by baneful strife. For out of these all things are fitted together and their form is fixed, and by these men think and feel both pleasure and pain.

Empedocles