

STUDY OF THE GEOMORPHOLOGICAL AND ARCHAEOLOGICAL ASPECTS OF SINTRA AREA (PORTUGAL) AS CONTRIBUTION TO ITS TOURIST APPRAISAL AND PROMOTION

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Abstract: The Portuguese town of Sintra is an UNESCO world heritage site for its cultural and environmental aspects. The town is located 30 km from Lisbon and 15 km from the Atlantic Ocean, and is a touristic site in every seasons mainly for its architectural qualities. This work describes the geomorphological and archaeological aspects of the town and the surrounding Serra de Sintra in order to give an added value to tourist appraisal and promotion of the area. Serra de Sintra is an elliptic igneous massif 10 km E-W and 5 km N-S, 300-500 m above sea level. The geological structure is complex but it can be simplified as a core of sienites surrounded by granites intruded in a limestone plateau. The morphogenetic processes, beside common landforms such as narrow valleys, scarps and ridges, shaped a variety of particular granite morphologies such as round block fields, inselbergs, castle koppies, etc.... The most spectacular ones have been described and classified as geosites in a data-base. The oldest archaeological remains dates to the Mesolithic, but the area has been extensively occupied during the Neolithic/Calcolithic, Bronze and Iron Ages. In historical times Romans, Visigots and Arabs left some interesting architectural and linguistic marks. All the archaeological sites have been classified according to bibliographic, museal data and field surveys. They are also all included in a data-base. GeoArchaeo-Tourist maps at 1:25,000 and 1:10,000 scales of the Serra de Sintra and Sintra town are the information results collected in the geomorphological and cultural data-bases. The maps have been implemented, by means of an ArcGIS computer programme, integrating geological, geomorphological, archaeological and historical aspects with the tourist infrastructures (information points, parking areas, accommodations, panoramic points, etc.) in order to obtain documents readable,

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simple, clear but scientifically accurate also for non-expert users. This study could be suitably simplified and summarized in a guide book, with enclosed GeoArchaeo-Tourist maps, as a contribution to improve the knowledge and appraisal of the Sintra territory also for its landscape and archaeological aspects.

Key words: geomorphology, archaeology, tourism, maps, Sintra, Portugal

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INTRODUCTION

The town of Sintra is known in Portugal as well as all over the world for being an UNESCO world cultural heritage site. Thousands of tourists from all over the world visit the town and the vicinity areas, mainly the castle (Mouros Castle) and the palaces and gardens (Vila Palace, Regaleira Houses and Gardens, Monserrate Park and Palace, Pena Palace, etc.). So the tourists only visit the central part of the town and some of the most attractive cultural monuments located within a range of few km, following the guided tours established by the local entity responsible for the tourism promotion.

This work describes the research carried out on the geomorphological and archaeological aspects of Sintra town and the surrounding Serra (Serra de Sintra in portuguese language) in order to implement GeoArchaeo-Tourist maps, at 1:25,000 and 1:10,000 scales, to provide a new tourist document for the appraisal and promotion of the overall area also under other aspects.

The aim of this work was to realize a document, easily readable by tourists, about cultural as well as environmental aspects.



Figure 1. Location of the Sintra area (Portugal) (Source: viaggi.globopix.net)

The studied area is located in the southern sector of the historic region of Extremadura between Lisbon (30 km to West) and the Atlantic Ocean (15 km to East), (figure 1).

Sintra is a town that grows on the northern slopes of the homonymous Serra and is characterized by the tall conical chimneys of the Palácio Nacional or Palácio da Vila, which are also the symbol of the town; it was known in the Ancient World as Lunae Mons (mountains of the Moon) and was the legendary retreat of Diana the Huntress (Cynthia to the Romans, hence Çintra).

Geographical Geological and Geomorphological Setting of the Studied Area

The Serra de Sintra belongs to six Municipalities (Sintra, Colares, São Martinho, São Pedro de Penaferrim, Sta. Maria and São Miguel) and cover an area of about 50 km²; the altitudes range between 300 and 500 m.a.s.l.

The climate of the area depends from two main factors: the proximity of the Atlantic Ocean and the fact that the Serra de Sintra acts as a condensation barrier. In detail, the ocean has a temperate influence, mitigating the thermal amplitudes and controlling the elevated level of atmospheric humidity. The Serra de Sintra, functions as a condensation barrier to the clouds and the maritime fogs, establishing a contrast climate on its slopes.

The mean annual temperatures in the studied area range from about 9°C in winter to about 20°C during the summer. Precipitation range between a maximum of about 160 mm/month in March and a minimum of 5 mm/month in July with a total amount of about 800 mm/year (Baltazar and Martins, 2006). Another important phenomenon in the area is the frequent occurrence of fog which acts as a kind of hidden precipitation causing condensation on the plants leaves (Alcoforado, 1984).

From a geological viewpoint the Serra de Sintra is an elliptic igneous relief (figure 2) with 10 km E-W and 5 km N-S dimensions, which has a dome structure resulting from a slow and continuous growth of a magmatic massif (Kullberg M. C. and Kullberg J. C., 2000).

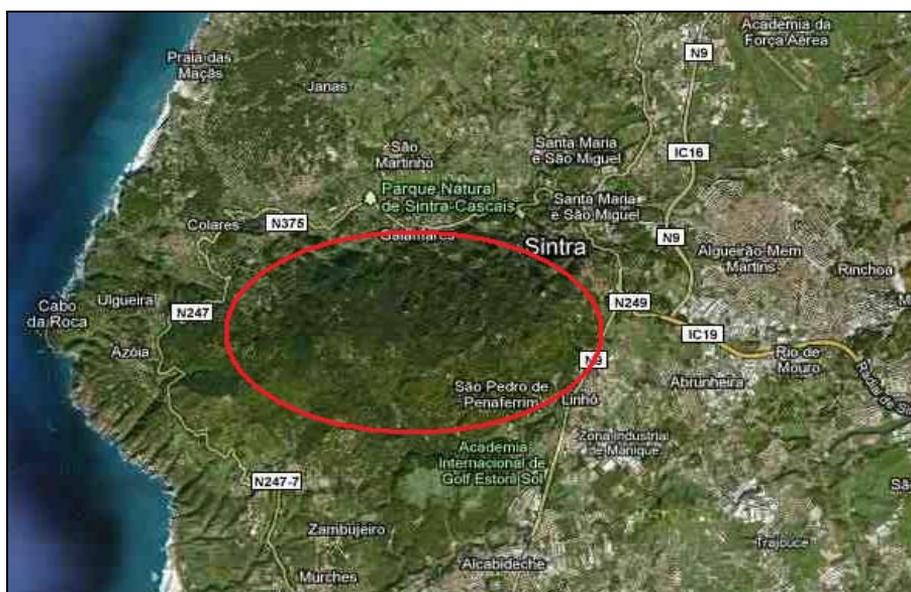


Figure 2. Location of Sintra and the surrounding Serra de Sintra (Portugal) on a satellite image (Source: Google maps)

The Sintra massif forms an approximately arcuate area, in which, in a very general sense, granite surrounds a smaller core area of syenite; there are also small, discontinuous areas of other igneous rocks such as diorite-gabbro, mafraite and igneous

breccias. The magmatic massif is surrounded by limestone plateaux constituted by sedimentary rocks of Jurassic and Cretaceous age (the southern plateau is the platform of Cascais with altitude near 200 m and the northern one is the platform of São João das Lampas with altitude near 300 m); the magmatic massif and the limestone plateaux are cutted by numerous igneous veins (figure 3).

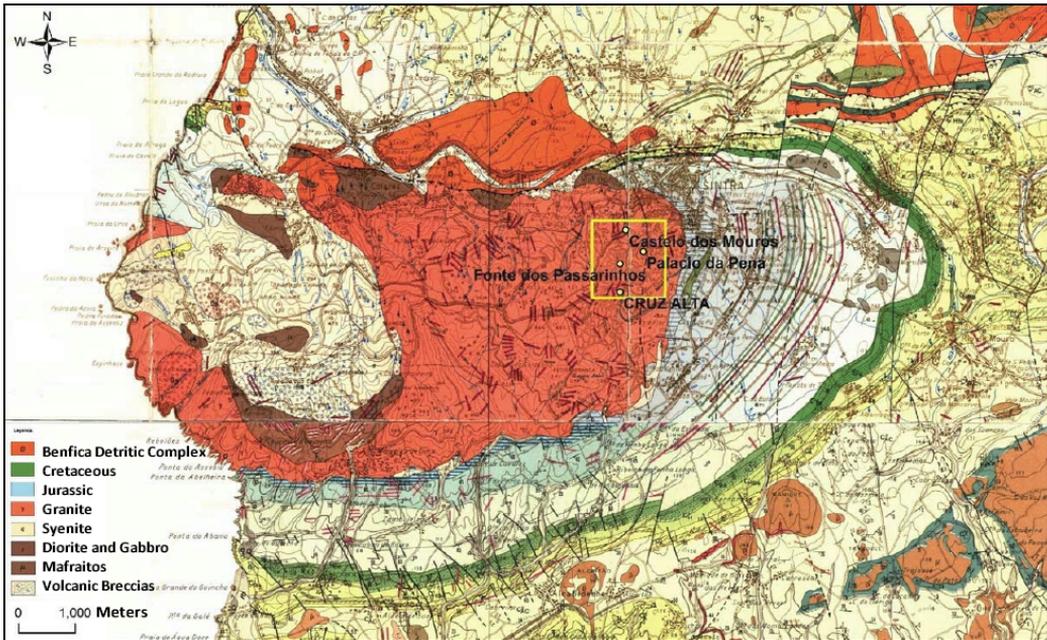


Figure 3. Geological map of the Serra de Sintra magmatic intrusion and surrounding sedimentary rocks, The yellow square corresponds to the area represented in the GeoArchaeo-Tourist map at 1:10,000 scale (figure 12) (Source: Serviços Geológicos de Portugal, Carta Geológica de Portugal, 1:50.000, folhas nº 34-A,1991, and 34-C, 1999)

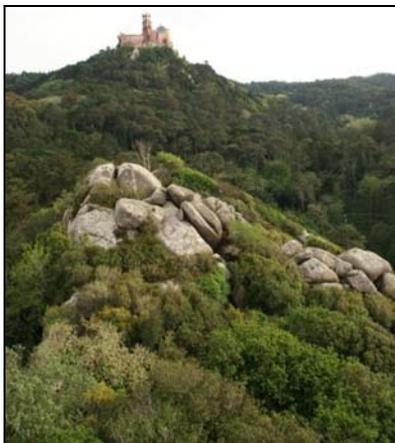


Figure 4. Granite boulders and, in the back ground, an inselberg with the Pena Palace on the top (Photo S. Levratti)

In spite of this complex outcropping rocks, the lithology is dominated by the granites, which are normally greatly weathered and fresh surfaces are hard to find; on the southern slopes of the Serra de Sintra there are several quarries, but even in these sites, the rock is normally weathered and soft (Ferreira, 1979).

Because of the bedrock and the weathering processes the characteristic geomorphological landscape of the Serra de Sintra is represented by masses, blocks and boulders, that can be seen almost everywhere; in some places also landforms such as nubbins, castle koppies and inselbergs are visible (figure 4).

Boulders can be found in many touristic places and people who is walking on the trails, have to pay attention because these big rocks can fall down from the slope; this rockfall hazard is indicated in some panels (figure 5).



Figure 5. Indication of rockfall hazard along a tourist trail of the Mouros Castle (Photo D. Castaldini)

ARCHAEOLOGICAL SETTING

The study area has been inhabited since prehistoric times: the oldest records date to the Mesolithic, with the site of the Penha Verde; many claims are attributable to the Neolithic/Chalcolithic; some examples are: Tholos do Monge, Rua Padaria, Bela Vista, remnants below Moorish Castle, etc. Important sites of the Bronze Age and even Iron Age (St. Euphemia, Monte Sereno, Santo Amaro, remnants below Moorish Castle) have been found (Ribeiro C., 1880; Simões, 1993).

Romans, Visigoths, Arabs, remained long in the area, leaving deep scars: influenced architecture, the system of collecting water etc...



Figure 6. Quinta da Regaleira (Photo S. Levratti)

The main part of Sintra develops since medieval age, dominated by the Palácio Nacional and other monuments; even if the most majestic buildings are attributable to the Romantic period, with the building of the Palácio da Pena, other small palaces (Monserrate, Quinta da Regaleira, figure 6) and the creation of lush gardens (botanical museums, Parque da Pena and de Monserrate).

METHOD OF STUDY

The research in the Sintra and Serra de Sintra areas has been carried out making studies on archaeological, geomorphological and touristic aspects which have been finalized to the implementation of GeoArcheo-Tourist Maps at 1:25,000 and 1:10,000 scales.

A GeoArcheo-Tourist map is a thematic map where geological-geomorphological and archaeological aspects are integrated with the tourist infrastructures (information points, accesses, accommodations, excursion trails etc). The level of information has to be readable, simple, clear and scientifically accurate also for not specialist users.

As concern the basic topographical maps, the 1:25,000 and 1:10,000 scales are available, but the resolution of the 1:10,000 scale map is not better, because both have contour lines with an interval of 10 meters. Moreover the 1:10,000 scale map has in the background the vegetation cover, that it is not particularly important for this study, and prevent us to use the background of the map to implant the geological-geomorphological and archaeological aspects as well as the tourist information. So, for the implementation of the larger scale GeoArcheo-Tourist map we decided to use the enlargement of the Military Topographic Map of Portugal at the scale 1:25,000 (415-416 sheets) instead of the original 1:10,000 map.

From the practical point of view, has been applied the study method used at Otricoli (central Italy) by Bertacchini et al., 2007, with some modifications (figure 7).

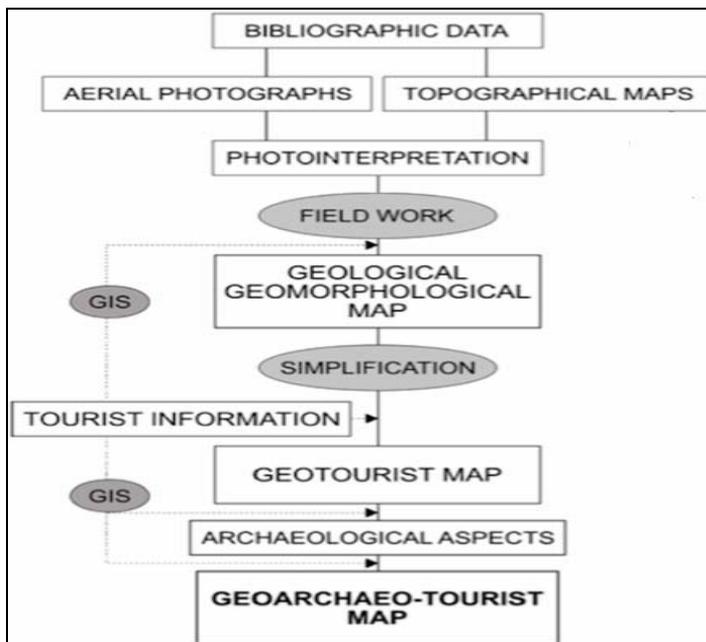


Figure 7. Scheme of elaboration of the GeoArcheo-Tourist map
(Source: Bertacchini et al., 2007, modified)

According to this premise, the GeoArcheo-Tourist Maps of Sintra, has been elaborated following the steps synthesized as follows.

The geological - geomorphological aspects of the study area have been illustrated in geomorphological maps at 1:25,000 and at 1:10,000 scales produced from bibliographic research, analysis of aerial photographs and field survey. Geotourist maps were derived (with appropriate simplifications and integrations) from the geomorphological maps.

A geotourist map combines the most evident geological and geomorphological aspects with basic tourist information (for example parking areas, panoramic points, picnic areas, etc.). The aim was to produce maps that could be easily interpreted by tourists to help them understand the landscape.

The last step of the GeoArchaeo-Tourist Maps implementation was to add the archaeological aspects to the geotourist maps (e.g. archaeological sites and their chronology, museums and churches, etc.).

The implementation of these data with the ArcGIS computer techniques have facilitated, on the one hand, the reading of several detailed information about the physical landscape of the study area, and on the other hand, their simplification, especially for the elements of difficult identification or understanding. On the contrary, the ArcGIS computer programme has emphasized the basic aspects of landscape perception.

Study on archaeological aspects

The information on archaeological aspects are numerous and for their study bibliographic and cartographic researches have been carried out at the Municipality (Câmara Municipal) of Sintra, at the Archaeological Museum (Museu Arqueológico de São Miguel de Odrinhas) of Sintra and in the Lisboa University Library.

In particular, as concern the location and the history's site, the analysis of the various sources carried out through a meticulous selection of the information led to the implementation of a reliable and accurate data base for the "*Inventory of the archaeological sites*". The inventory data sheets give information on site number and name and on its chronology, typology, accessibility, present day location (table 1).

Table 1. An extract of the "*Inventory of the archaeological sites*", Abbreviations: MASM-Museu Arqueológico de São Miguel de Odrinhas; CM-Câmara Municipal de Sintra; IPA-Inventario do Património Arquitectónico; MNA-Museu Nacional de Arqueologia

Nº	Site name	Chronology	Typology	Accessibility	Present day location
23	Penha Verde	Mesolithic/Calcolithic		Interdict	
33	São Pedro de Canefarrim	Neolithic	Village	Free	MASM & CM Sintra
28	Rua das Padarias	Neolithic	Village	Interdict	MASM
27-30	Castelo dos Mouros	Neolithic		Free	MASM
40	Monte do Sereno	Neolithic		Interdict	MASM
47	Penedo dos Ovos	Calcolithic		Conditioned	MASM
16	Vale de São Martinho	Calcolithic	Necropolis	Conditioned	MASM
29	Parque das Merendas	Bronze Age	Village	Free	MASM
10	St. Amaro	Bronze Age	Necropolis	Interdict	MASM
41	S. Eufémia da Serra	Bronze Age	Village	Free	MASM
2	Lugar do Marcador	Bronze Age	Country house	Interdict	IPA
1	Mucifal	Iron Age	Buried remains	Interdict	MASM
12	Sao Romão	Roman Period			MASM & MNA
25	Rua da Ferreira	Roman Period	Street and necropolis	Free	

Overall, in the study area, 47 sites have been found, but for only 29 of them detailed inventory sheets has been compiled, whereas 18 sites are missing for lack of information. In detail were found: 1 Mesolithic site, 10 Neolithic/Calcolithic sites, 5 Bronze and Iron age sites, 4 Roman age sites, 4 Arab period sites and 5 Medieval age sites. For the elaboration of

the inventory sheets (figure 8) has been utilized as example the “Atlas of Archaeological Heritages of the Modena Province” (Cardarelli and Malnati, 2003 and 2006).

Castelo dos Mouros

Nº IN THE MAP: 34

LOCATION: freguesia de Santa Maria e São Miguel

SITUATION OF CLASSIFICATION: classified

ACCES: condizionated

DESCRIPTION: the irregular plan of the castle, but adapted to the soil, more or less than 450mt. perimeter and area of about 12,000 m², is situated on a rocky cliff and take advantage of the natural defense side in NO and NO. The scholars agree that the Muslims were the perpetrators of the original fort, between the eighth and ninth centuries, with the aim of controlling strategically overland routes that connected the villages near Sintra (Mafra, Caçóis and Lisbon).



Sintra view from the castle



The castle
(Da: Cruz C.L., 2008)



The flag: the city name in Islamic language

CONSERVATION PLACE: Museu Nacional de Arqueologia e no Museu Arqueológico de São Miguel de Odrinhas, Camera Municipal di Sintra e DGEMN.

REFERENCES: Câmara Municipal de Sintra, 1996; CARVALHO S.L., 1987.

Figure 8. An example of a data sheet of the Inventory of the archaeological sites

In order to better understand the occupation of the study area during the different periods, a “Table of the settlement continuity” was implemented (table 2). From table 2 is clear that the studied area has been inhabited since the Neolithic period and in some sites (e.g. Nafarros, São Romão) there is a long continuity through the several centuries.

Table 2. Extract of the table of the settlement continuity

Site	Mesolithic	Neolithic	Calcolithic	Bronze age	Iron age	Roman age	Arab period	Medieval age
Mucifal								
Marcador								
Quinta da Areia								
Nafarros								
Morelinho								
Carrascal								
Ribeira de Sintra								
St. Amaro								
Sao Romao								

The data base of the archaeological settlements represents a clear state of the art of the Serra de Sintra archaeological aspects.

Considering the location of the archaeological settlements and their chronology (see figure 11 - GeoArchaeo-Tourist map at 1:25,000 scale and its legend in figure 10) it is clear that the sites from Mesolithic to Iron ages are mainly found on the higher parts of the Serra de Sintra igneous relief while the roman age sites have been built in the lower part of the territory constituted by a limestone plateau. The Arab and Medioeval sites are located in the magmatic massif as the older ones.

These different locations highlights different strategies of control and use of the territory through the times.

Geomorphological study

The geomorphological study was based on aerial photographs and field surveys for mapping the main landforms of the studied area (scarps, ridges, granite block fields, major granite landforms, lakes etc).

The most spectacular landforms (mainly the landforms due to granite weathering) have been described and classified as geosites in a data-base. For each of these has been compiled an inventory sheet (figure 9). The inventory sheet was implemented considering as examples those by the Italian National Institute for Protection and Environmental Research (ISPRA) and by Rodrigues (2009).

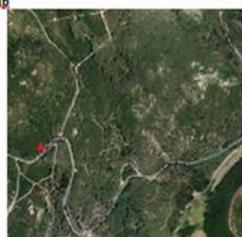
Identification code in the map: F		Map 	Photos: 	
Study area: Serra de Sintra				
Location: Lungo la strada EN 9-1 Km 6				
Survey date: 29 /04 /2010				
Position: Rising out <input checked="" type="checkbox"/> Submerged <input type="checkbox"/> Subterranean <input type="checkbox"/>		Accessibility: by foot <input type="checkbox"/> by car <input checked="" type="checkbox"/> others <input type="checkbox"/>		
Type of Geosite: Geomorphologic <input checked="" type="checkbox"/> Geologic <input type="checkbox"/> Hidrologic <input type="checkbox"/> Pedologic <input type="checkbox"/> Others <input type="checkbox"/>		Scale: Local <input checked="" type="checkbox"/> Regional <input type="checkbox"/> National <input type="checkbox"/> International <input type="checkbox"/>		
Description: Il geosito in questione è ottimo esempio di pedestal/ tafone, che potrebbe rientrare in una classificazione geomorfologica.		Degree of conservation: Good <input checked="" type="checkbox"/> Discreet <input type="checkbox"/> Bad <input type="checkbox"/>		
		Vulnerability Raised <input type="checkbox"/> Medium <input checked="" type="checkbox"/> Non-existent <input type="checkbox"/>		
		Notes Considerando la particolare forma zoomorfa di questo granito, assomigliante ad un camello, potrebbe prendere il nome di "Testa di Cammello"		

Figure 9. Example of the Geosites Inventory sheet: "The camel head" geosite

The geomorphosites were identified and classified in what concerns their type, the diversity of observed elements in the field, the accessibility, the degree of conservation of the geosite and its scale of importance (local, regional, national or international). In order to assess their value were also gathered information about the importance of the scientific value (rarity, representativity and integrity), as well as about the additional values such as cultural or historical ones, economic, ecologic and aesthetic values.

The inventory sheet of the geomorphosite includes also information about potencialities of each one regarding use and management values or insufficiencies, as well as actual and potential threats to the geosite and special needs of protection and geoconservation related with problems of natural and/or human vulnerability.

The created data base of geomorphosites can be improved with other researches developed in zones surrounding the study area and, in the near future, it would be possible to have a complete picture of the geomorphosites present in the whole Serra de Sintra area.

The geoarchaeo-tourist maps

As stated before, a GeoArchaeo-Tourist map can be defined as a thematic map which combines the most evident geological/geomorphological and archaeological aspects, with touristic informations (Bertacchini et al., 2007). The aim of this work was to produce a document that could be easily interpreted by tourists of average education to help them to recognize and appreciate the main features of the studied areas.

The GeoArchaeo-Tourist maps of Sintra area have been implemented at 1:25,000 and 1:10.000 scales.

To make easier the reading of the maps, a clear, essential and easily distinguishable symbology was implemented (it is the same for both scale maps); the legend was subdivided into three different sectors: in the first one the symbols representing geological-geomorphological aspects are indicated, whereas the second one shows the archaeological and architectural aspects and the third one is dedicated to tourist information (figure 10).

GEOLOGICAL – GEOMORPHOLOGICAL ASPECTS	ARCHAEOLOGICAL – ARCHITECTURAL ASPECT:	TOURIST INFORMATION
 Granite rock	Archaeological sites and its chronology	 Information point
 Sedimentary rock	 Arab period and Medieval Age	 Parking area
 Stream	 Roman Age	 Bus stop
 Pond	 Iron Age	 Panoramic point
 Granite blocks field	 Bronze age	 Picnic area
 Main ridge	 Neolithic – Calcolithic	 Fountains
 Main scarp	 Mesolithic	 Bar, restaurant
 Geosites and its classification	 Architectural sites	 Hotel
	 Museum	 Service station
	 Church	

Figure 10. Legend of GeoArchaeo-Tourist map at 1:25.000 and 1:10.000 scales

In detail, as concern the main geological and geomorphological aspects, in the maps are indicated the rock types (granite and sedimentary rocks), streams and ponds, granite block fields, main ridges and scarps and geosites with their identification made in the Geosites inventory sheet (e.g. figure 9).

The archaeological and, above all, architectural elements constitute the main attraction of the zone and, consequently, they have been shown with evident symbols, in order to be immediately recognized by the tourists. In particular the archaeological sites are indicated in different colours according to their chronology, moreover architectural sites, museums and churches are also indicated.

The tourist information have been shown with the conventional symbols used in the tourist maps. Like that, the tourist can know the location of information points,

parking areas, bus stops, panoramic points, picnic areas, fountains, bar/restaurants, hotels, service stations.

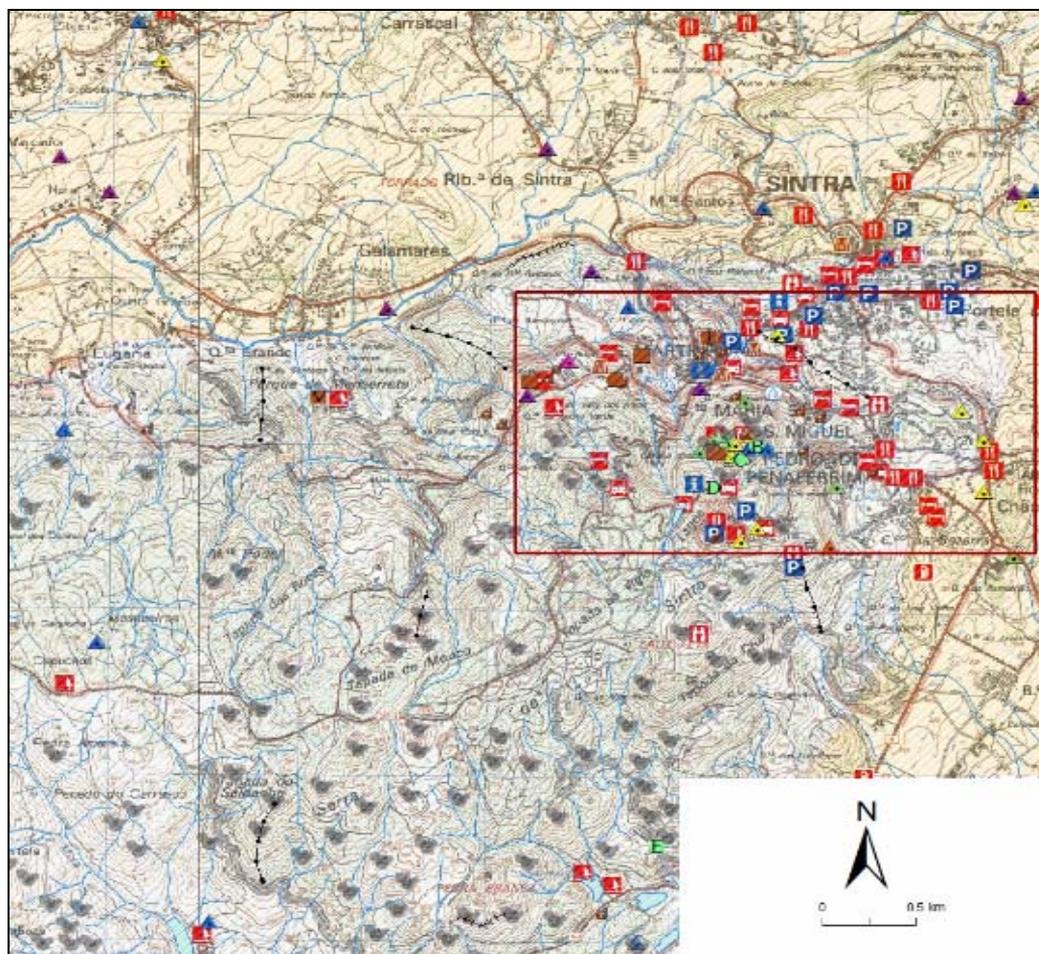


Figure 11. GeoArchaeo-Tourist map at 1:25,000 scale. The red line indicates the boundary of the GeoArchaeo-Tourist map at 1:10,000 scale

Examining the GeoArchaeo-Tourist map at 1:25,000 scale (figure 11) it is clear that the main archaeological and architectural attractions, geosites and tourist facilities are concentrated in the Sintra zone.

Anyhow outside the Sintra zone, several picnic areas, bar/restaurants can be found. A panoramic point is located on the top of Cruz Alta (the higher peak South-West of Sintra) from where is possible to have a beautiful view of the Sintra zone. Archaeological sites, of Neolithic-Calcolithic and Roman age, are present mainly in the northern sector of the Serra de Sintra where sedimentary rocks outcrop. The southern sector of the Serra de Sintra, where granite rocks outcrop, shows a landscape characterized by granite block fields.

This map, taking into account its scale, can be considered as an “*outline map*” of the Serra de Sintra, that can help the tourist to choose his kind of tour to discover the Serra for seeing the landforms and to feel the nature, or to discover the history and the architecture of Sintra town.

Examining the GeoArchaeo-Tourist map at 1:10,000 scale (figure 12) it is evident that in the southern area, close to Sintra, the tourists have a wide choice of archaeological and architectural attractions to visit (e.g. Mouros Castle, Pena Palace, Convento dos Capuchos, Quinta de Regaleira, figure 6) as well as of geosites, which are concentrated in the Mouros Castle zone (e.g. figure 9), to appreciate.

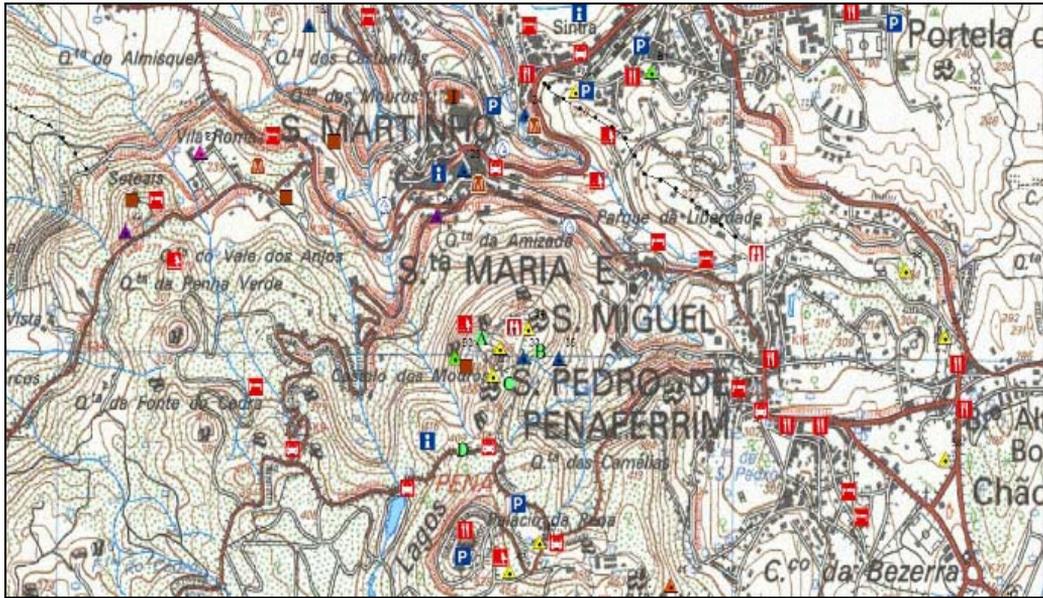


Figure 12. GeoArchaeo-Tourist map at 1:10000 scale

The tourist facilities are quite developed; for instance there are numerous bar/restaurants and hotels, information points, parking areas and it is easy to find bus stop stations, also linked to the Câmara Municipal touristic tours.

CONCLUSIONS

This research is the first integrated study on geological/geomorphological, archaeological and tourist aspects of Sintra district.

In detail, the work has led to: i) an unified and detailed inventory of archaeological sites which previously were set out and described in various sources in generic and dishomogeneous documents; ii) the implementation of the first data base for inventory of geosites of the studied area; iii) the elaboration of GeoArchaeo-Tourist maps, at at 1:25,000 and 1:10,000 scales of the Serra de Sintra area which are the first maps of this type elaborated in Portugal.

This work could be suitably simplified and summarized in a guidebook, with enclosed GeoArchaeo-Tourist maps as a contribution to improve the knowledge and appraisal of the Sintra territory.

The GeoArchaeo-Tourist maps at 1:25,000 and 1:10,000 scales could be prepared as a foldable, pocket-size, map printed on both sides (on the front side the map at 1:25,000 scale and on the back side the map at 1:10,000 scale respectively) which the tourists can consult in the field while visiting the Serra de Sintra area. The map at 1:10,000 scale could be improved with the indication of the rockfall hazard points (Aringoli et al., 2007, Pelfini et al., 2009) mainly located along the tourist trails in the Morish Castle (figure 5).

The material currently available for the tourists in this area is restricted only to the historical and architectural aspects and therefore the guidebook suggested in this paper could be an important contribution for tourists to discover the Sintra's area also for its landscape and archaeological aspects.

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