

THE GEOSITES OF THE CILENTO-VALLO DI DIANO NATIONAL PARK (CAMPANIA REGION, SOUTHERN ITALY)

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ABSTRACT: N. Santangelo *et al.*, *The geosites of the Cilento-Vallo di Diano National Park (Campania region, southern Italy)*. (IT ISSN 0394-3356, 2005).

The Cilento-Vallo di Diano National Park, located in the southern part of the Campania region, preserves a geological heritage characterized by a high degree of diversity: it includes coastal and mountain areas modelled on both mesozoic carbonate successions and terrigenous successions, that give rise to a landscape alternating between steep mountainous districts and hilly areas.

The purpose of this work is to present a preliminary identification and inventory of the main geosites of the Cilento-Vallo di Diano National Park.

On the basis of literature analysis and the authors' knowledge, more than one hundred sites were selected and mapped using a geographical information system. Different categories of geosites were distinguished (stratigraphical, palaeoenvironmental, palaeontological, structural, geomorphological, hydrogeological), according to the scheme proposed for the global site inventory of geosites.

Geomorphosites are surely widely represented. The hinterland of the park, with its karst features, superimposed gorges, cuesta-like ridges, fault scarps and fault-line scarps offers valuable resources for the teaching of main topics relative to karst and structural geomorphology; especially when we think of the singularity of the selected sites, due to the rarity or scientific interest of the preserved situations.

Along the coastal sector the most important geomorphosites are represented by marine quaternary terraces (Camerota, Palinuro, Licosa capes), fossil dunes and coastal caves, many of which also preserve important geoarchaeological records.

It is to be hoped that this wide territory will soon become well known and highly appreciated and that this study can be the first stage towards the achievement of such aim.

RIASSUNTO: N. Santangelo *et al.*, I geositi del Parco Nazionale del Cilento - Vallo di Diano (Campania, Italia meridionale). (IT ISSN 0394-3356, 2005).

Il Parco nazionale del Cilento-Vallo di Diano, localizzato nella porzione meridionale della Regione Campania, conserva un patrimonio geologico molto vario: esso comprende infatti aree costiere e montuose, modellate sia su terreni carbonatici di età mesozoica che su successioni prevalentemente terrigene, ed è caratterizzato da un paesaggio che passa dagli aspri rilievi montuosi delle zone interne alle zone collinari costiere.

La varietà dei litotipi affioranti e le particolari forme del rilievo generate dai diversi processi sedimentari ed erosivi, hanno creato i presupposti per la formazione e la conservazione di numerosi geositi di notevole valenza scientifica, inseriti, tra l'altro, in un contesto di eccezionale bellezza naturalistica, ricco di valenze botaniche, zoologiche, architettoniche, e storico-culturali.

Lo scopo di questo lavoro è stato quello di evidenziare, per la prima volta, le numerose emergenze geologiche di questo territorio attraverso l'individuazione ed il censimento dei principali geositi.

La selezione è stata realizzata sulla base dei numerosi dati di letteratura e su conoscenze personali degli autori che da diversi anni svolgono ricerche nell'area del Cilento; sono stati individuati e cartografati, utilizzando un GIS, più di 200 siti. Essi sono stati differenziati in base alla tipologia (stratigrafici, paleoambientali, paleontologici, strutturali, geomorfologici, idrogeologici), seguendo lo schema proposto in letteratura per l'inventario mondiale dei geositi.

Tra i vari siti a valenza geologica i "geomorfositi" sono senz'altro fra i più rappresentativi; le zone interne del Parco infatti, con le loro morfologie carsiche, le forre, le forme a controllo strutturale (scarpate di faglia, cuesta) costituiscono delle "palestre" naturali per l'insegnamento e la divulgazione di discipline quali il carsismo e la geomorfologia strutturale.

Molte altre località, inoltre, presentano requisiti di rarità od un elevato interesse scientifico. Nel settore costiero i geomorfositi più importanti sono rappresentati da lembi di terrazzi marini (promontori di Camerota, Palinuro e Licosa), dune fossili e grotte costiere, alcune delle quali conservano riempimenti con particolare interesse geoarcheologico.

Il lavoro effettuato rappresenta un primo passo verso la conoscenza, la divulgazione e quindi la valorizzazione di questo prezioso patrimonio geologico.

Keywords: Geosites, Geomorphosites, GIS, Cilento-Vallo di Diano National Park, Southern Italy.

Parole chiave: Geositi, Geomorfositi, GIS, Parco Nazionale del Cilento-Vallo di Diano, Italia meridionale.

1. GEOLOGICAL SETTING

The area of the park is delimited in the North by the Sele Plain, in the NE by Diano and Tanagro Valleys, in the South by Policastro Gulf and in the West by the Tyrrhenian sea. (Fig.1). In this area a geological heritage characterized by a high degree of diversity is preserved;

coastal and mountain areas made up both by carbonate and terrigenous successions give rise to a landscape alternating between steep mountainous districts and hilly areas.

According to Guida *et al.* (1980), the Cilento region can be defined as a "Morpho-structural Province", sensu Tricart (1965), which represents a

sub-unit of the larger Campanian-lucanian Tectonic Region.

This area belongs to the Southern Apennines fold-and-thrust belt, which developed between late Cretaceous and Pleistocene ages as a consequence of the interaction between the European and the African plates and of the spreading of the Tyrrhenian oceanic basin (D'argenio *et al.*, 1975). Due to the long-time and complex lithogenetic and orogenetic history, several litho-stratigraphical units, in form of nappes and/or irregular sequences can be distinguished (Fig. 1).

- INTERNAL UNITS

In this group the Sicilide Units and the North Calabrian Units (Mesozoic-Tertiary) were included (Bonardi *et al.*, 1988; Cammarosano *et al.*, 2000); they are made up prevalingly of marly calcarenites, calciluti-

tes, clay, often siliceous, sandy clays, sandstones and conglomerates which were deposited in terrigenous basinal domains. At present, the main outcrops of those lithological successions are located in the hilly coastal area at the back of the Ascea village and along the Alento, Mingardo and Bussento river valleys.

- EXTERNAL UNITS

The main units of this group are represented by the Bulgheria unit, the Alburno-Cervati Unit and the Foraporta Maddalena Unit. They are made up of carbonate sediments of Mesozoic and Tertiary age which show sedimentation environments going from the shallow water carbonates with back-reef facies to the deep water carbonates with external margin of carbonate platform facies.

These units form the main mountainous massifs

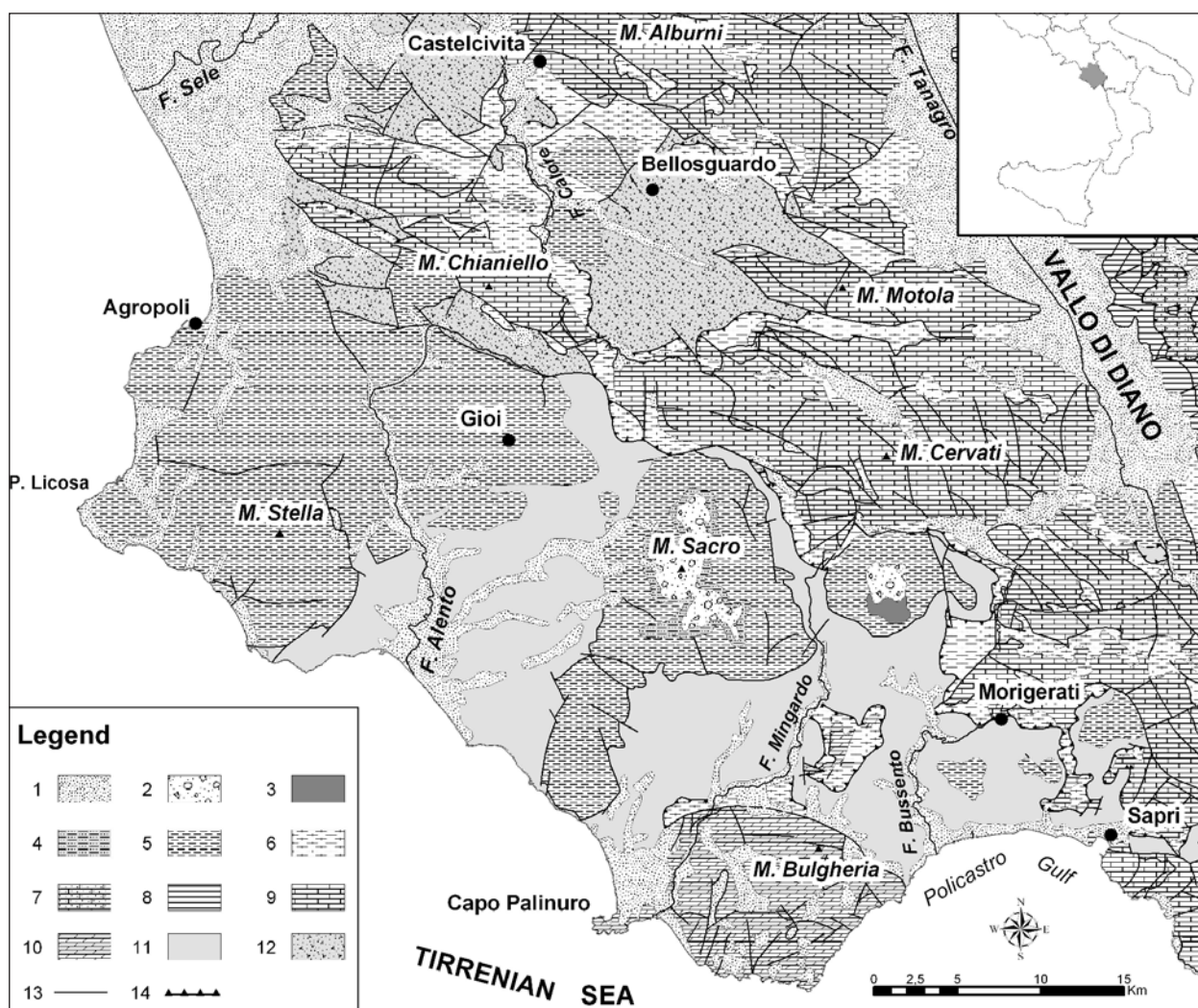


Fig. 1 - Geological map of the Cilento-Vallo di Diano National Park. 1) Quaternary sedimentary deposits. Miocene lithostratigraphic units: 2) Monte Sacro Formations; 3) Ophiolitic olistolites (Centaurino Mount); 4) Monte Sacro Olistostrome; 5) Albidona, Pollica, San Mauro Formations; 6) Piaggine-Raganello Formation. Meso-Cenozoic lithostratigraphic units: 7) Lagonegro Units; 8) Maddalena Units; 9) Alburno-Cervati Units; 10) Bulgheria Units; 11) North-Calabrian Units; 12) Sicilide Units. 13) Fault; 14) Overthrust.

Carta geologica del Parco Nazionale del Cilento-Vallo di Diano. 1) Depositi quaternari. Unità litostigrafiche di età miocenica: 2) Formazione di Monte Sacro; 3) Olistolite ofiolitico (Monte Centaurino); 4) Olistostroma di Monte Sacro; 5) Formazioni di Albidona, Pollica, San Mauro; 6) Formazione di Piaggine-Raganello. Unità litostigrafiche Meso-cenozoiche: 7) Unità di Lagonegro; 8) Unità della Maddalena; 9) Unità Alburno-Cervati; 10) Unità Bulgheria; 11) Unità Nord-Calabresi; 12) Unità Sicilidi. 13) Faglia; 14) Sovrascorrimento.

of the Park located both in the internal (Cervati Mt., 1898 m a.s.l. Alburno; Mt., 1742 m a.s.l.) and in the coastal area (Bulgheria Mt. 1225 m a.s.l.). The Lagonegro Units instead, cropping out mostly at the north-eastern boundary of the Park (Maddalena M.ts), are made up mainly of terrigenous sediments which changed their facies from terrigenous sediments of shallow-water facies during Later Triassic, to pelagic sediments and clastic carbonate deep-sea sediments during Cretaceous and Tertiary times.

- NEOGENIC SINOROGENIC UNITS

This group is represented by several formations of Miocene age (the Raganello Formation, the Piaggine Formation and the Cilento Group) which are made up of clays, sandstones and conglomerates with wild-flysch facies, generally lying in disconformity on the previously cited units.

The most widespread unit is that of the Cilento group (Amore *et al.*, 1988) which crops out mainly in correspondence of the coastal mountainous massif of Stella Mt., Gelbison Mt. and Centaurino Mt.

- QUATERNARY POSTOROGENIC UNITS

In this group were included all the continental and marine sediments, the deposition of which took place after the final emersion of the area (Late Pliocene-Early Pleistocene). They are represented by conglomerates, lacustrine deposits, conglomerate, slope breccias and travertine along the main river valleys that were formed in the area (Tanagro, Calore, Alento, Lambro, Mingardo and Bussento rivers), while ancient eolian sands and marine deposits (Early to upper Pleistocene in age) are widespread along the coast.

The present structural setting of the Cilento region is that of a duplex structure resulting from the NE-vergent thrusting of the above mentioned lithostratigraphical units from the Middle Miocene to the Middle Pleistocene age. In particular, during the Upper Miocene era, the Internal Units overthrust the External ones; in the resulting foredeep the thick turbiditic sequences of the Cilento Group were deposited. Successive tectonic phases, which occurred up to Early Pleistocene, were responsible for further eastward translation of the previous formed thrust sheets (Patacca *et al.*, 1990).

Since then, only transpressive movements and vertical uplift have occurred (Cinque *et al.*, 1993).

The formation of the Cilento landscape took place mainly during Quaternary times and was strongly influenced by that complex tectonic history together with the action of geomorphic processes upon the main climate variations.

The main geomorphological units (De Vita *et al.*, 1994; Cinque & Romano, 2001) that can be recognized in the area are:

- Carbonatic mountainous massifs, with summit karst landscapes, bounded by deep structural slopes and wide piedmonts areas;
- Terrigenous mountainous massifs, with sharpest crests and deeply incised ravines;
- Marly-clayey hills, with gentle slopes and dendritic drainage pattern;
- Intermontane basins, alluvial and coastal plains.

2. GEOSITES INVENTORY

The Cilento-Vallo di Diano National Park was founded in 1991 on the basis of the law n. 394/91 while the Park Corporation was established in 1995. It encloses 80 municipalities with about 256.000 citizens and an extension of about 1800 square kilometres.

It was also the only Park in the Mediterranean area to be included in the UNESCO World Heritage List in 1998.

It was founded to preserve an environmental estate that is unique for its biodiversity, both from a floristic and faunistic point of view. As far as the abiotic component is concerned, the wide geological and geomorphological estate present in the area was illustrated in the previous paragraph.

This work represents a first attempt to describe the main geosites of the Park starting from a site-list produced by Santangelo *et al.* (2000) within a convention established between the Park Corporation and the CUGRI (InterUniversity Great Risk Center) for the planning of the abiotic component of the Park..

The problem of the individuation and of the inventory of geosites has been faced both at international and national level starting from the 1990 (Panizza, 1992; Carton *et al.*, 1994; Bertacchini *et al.*, 1999; Harley, 1999; Wimbledon, 1999; Wimbledon *et al.*, 1999; Massoli-Novelli, 2001; D'Andrea & Di Leginio, 2002).

In this paper, according to the outline proposed for the global site inventory of geosites (Wimbledon, 1999; Wimbledon *et al.*, 1999), various categories of sites were distinguished including the most common ones (stratigraphical, geomorphological, palaeoenvironmental, structural, hydrogeological, paleontological) together with those with particular panoramic (scenic sites) or economic (ancient mine for example) value. On the basis of literature analysis and the author's knowledge, 263 geosites were identified and selected (Fig. 2); among them 34 % have stratigraphical and palaeontological interest while 32% can be considered as geomorphosites (subdivided in general, karstic and gorges). The palaeoenvironmental sites are well represented too (16%): in this category all the localities where particular sedimentary structures or palaeoclimatic indicators are well exposed, were included.

Obviously it is impossible to describe all the sites listed in the study, therefore only the most singular ones will be mentioned here, whilst geomorphosites, which were the object of the workshop organized by IAG in Cagliari (Italy) on September 2003, will be analysed thoroughly.

2.1 Stratigraphical and paleontological geosites

The sites of stratigraphical and paleontological interest are located both in the mesozoic carbonate mountains and in the coastal hilly areas of the park that are prevalently made up of sandy-clayey successions of Miocene age.

In the first zone, the sites which better illustrate the history of "Campano-Lucana" mesozoic carbonate platform, with all its facies variations (reef, inner reef, transition) were selected.

Among the fossiliferous sites, the outcrops of calcilutites with *Lytoceras* and *Hyldoceras* located in the

area surrounding the Licusati and Scario villages of the Mt. Bulgheria should be mentioned. They represent in fact a unique example of Jurassic Ammonite in the whole Campania region.

Another site, particularly significant for its rarity, is the fossiliferous level of Petina (Mts. Alburni) which is a *Plattenkalk* level of middle Albian age (lower Cretaceous) with a *macrofauna* of fishes and *Decapoda Crustacea* (Bravi & Garassino, 1998), that represent a unique example (together with that of Pietraroia in The Matese Mountains) in an extra-alpine region. Other important *plattenkalk* levels of a more recent age (upper Cretaceous and Paleocene) are located in the Mt. Vesole area (Scorziello & Sgroso, 1965; Bravi, 1995; Bravi *et al.*, 1999; Barone Lumaga *et al.*, 2000).

In the coastal hilly area of the Miocene park, basinal terrigenous sequences are well represented (Mt. Gelbison and Mt. Stella) and the selection concerned the sites where the

sedimentary structures and the facies associations of turbiditic successions ("Bouma sequence" strata, slumping, olistostrome, locally containing ophiolites,) are better presented (Cocco *et al.*, 1978; Critelli & Le Pera, 1990).

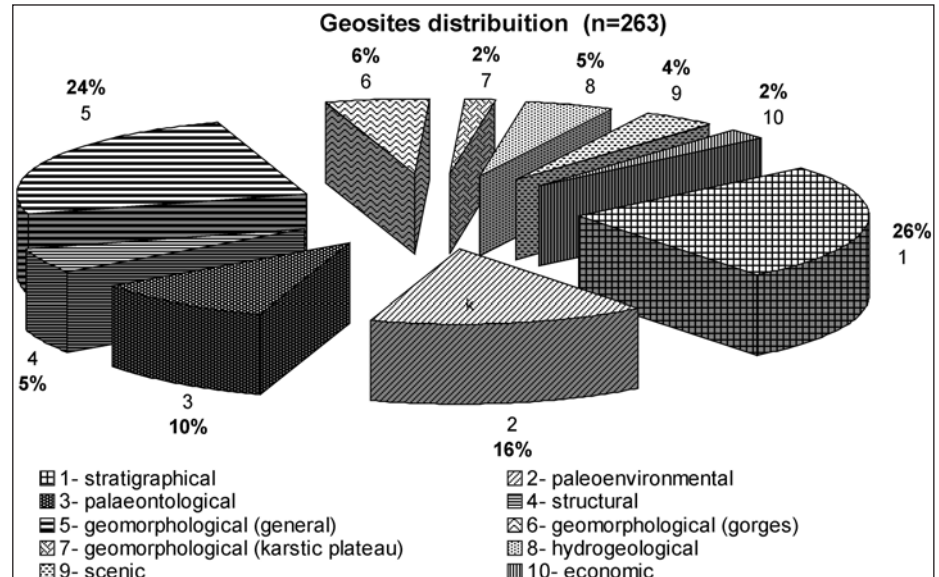


Fig. 2 - Distribution of the main geosites of the Cilento-Vallo di Diano National Park.
Distribuzione dei principali geositi del Parco Nazionale del Cilento-Vallo di Diano.

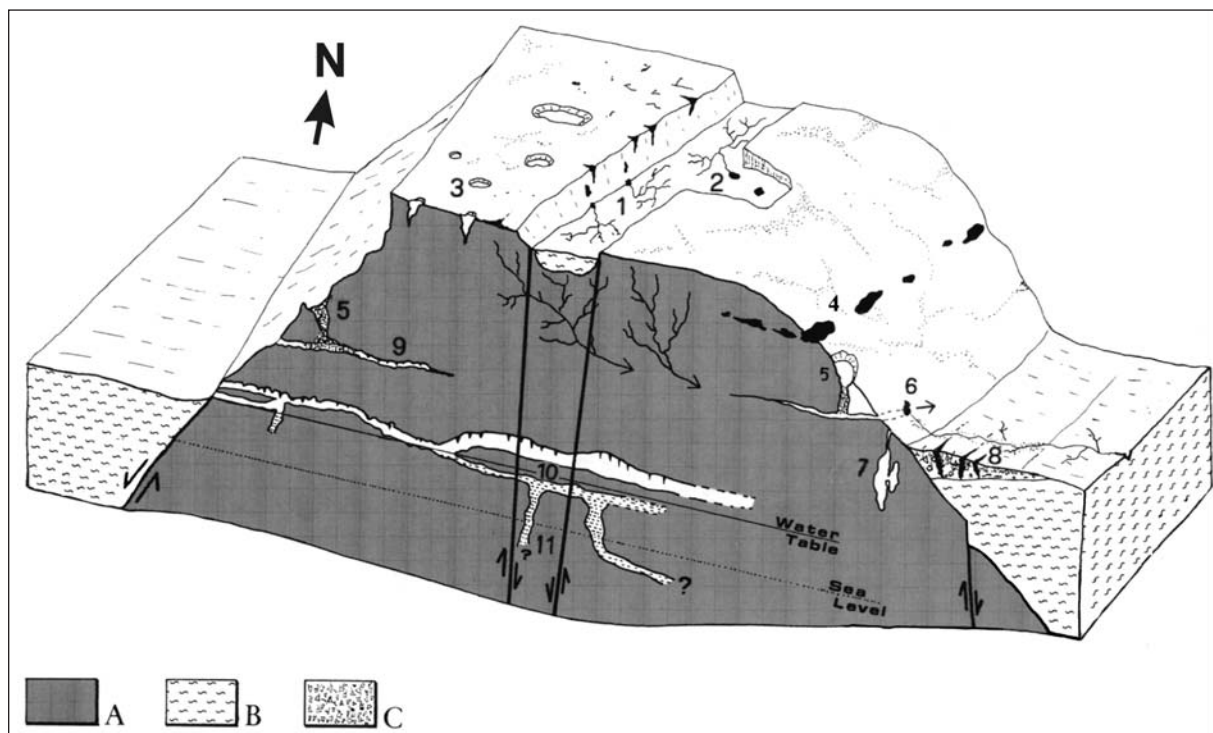


Fig. 3 - Sketch cross section of the Alburni Mountains massif. A) limestones; B) flysch; C) slope breccias; 1) ponor located along fault-line scarp; 2) ponor located at the bottom of the valleys; 3) doline; 4) bedding plane caves; 5) sinkhole; 6) resurgence; 7) fissure vertical cave; 8) cave due to lateral spreading; 9) fossil phreatic cave; 10) active phreatic cave; 11) active phreatic cave located below present sea level (from Santangelo & Santo, 1997).

Sezione schematica attraverso il massiccio dei Monti Alburni. A) calcari; B) flysch; C) brecce di versante; 1) inghiottitoio su scarpata di linea di faglia; 2) inghiottitoio su fondo valle; 3) dolina da dissoluzione; 4) cavità da interstrato; 5) dolina da crollo; 6) risorgenza; 7) grotta verticale su frattura; 8) cavità dovuta ad espansione laterale; 9) grotta freatica fossile; 10) grotta freatica attiva; 11) grotta freatica attiva localizzata sotto il livello del mare attuale (da Santangelo & Santo, 1997).

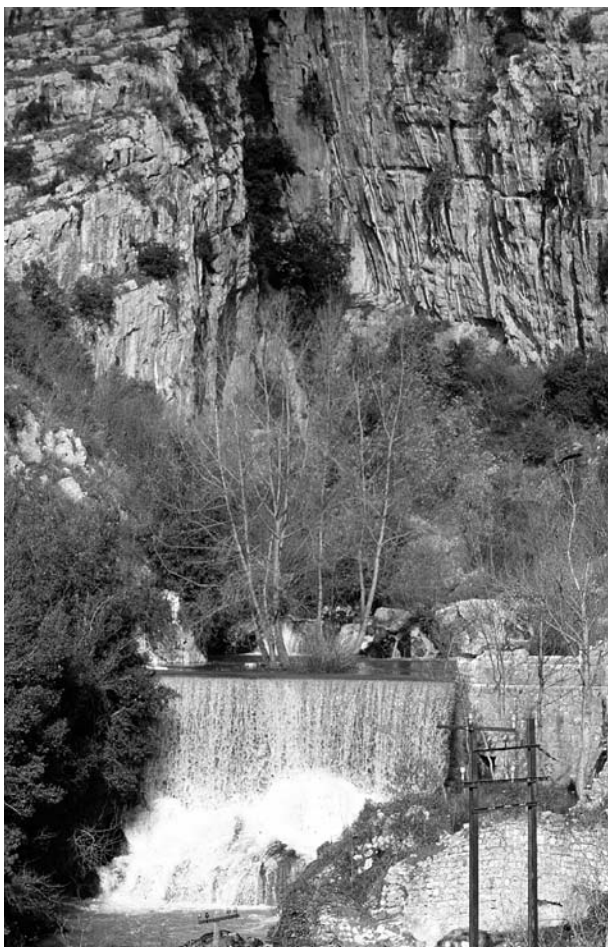


Fig. 4 - The Auso spring is a spectacular karst resurgence located at the base of the Alburni Mountains Massif (from Santangelo & Santo, 2001).

La sorgente dell'Auso: una spettacolare risorgenza carsica ubicata al piede del massiccio dei Monti Alburni (from Santangelo & Santo, 2001).

Among the Quaternary deposits of the park, the continental lacustrine succession of Vallo di Diano preserves an important paleoclimatical and tephro-stratigraphical record for the Middle Pleistocene (between 600 and 400 ky), that represents a unique example in Southern Italy (Karner *et al.* 1999; Russo Ermolli *et al.*, 1995) and probably also in the Mediterranean area.

Other sites were included in the inventory for their hydrogeological or economical value; a good example is represented by the Capaccio springs located at the foot of the Vesole mount. These waters, highly mineralized, during Pleistocene times produced the deposition of a wide travertine body; the rocks were then utilized during the Greek era for the building of temples in the ancient town of Paestum. At present, in the area surrounding the spring, the travertine formation is still active so the site can be used for lectures on this particular natural phenomenon, too.

3. MAIN GEOMORPHOSITES

Different kind of geomorphosites are present in the area of the Park. The hinterland of the park, with its karst features, superimposed gorges, cuesta-like ridges, fault scarps and fault-line scarps offers valuable resources for the teaching of main topics relative to karst and structural geomorphology. Not less important for their singularity or their scientific value are the coastal landforms or the morphologies due to gravity and fluvial processes. In this paragraph the best representative ones among them will be discussed.

3.1 Karstic geomorphosites

Due to the abundance of mesozoic carbonate successions, karst processes have produced widespread epikarst and ipokarst morphologies most of which can be considered sites of particular geological interest for their didactic and scientific value or for their rarity.

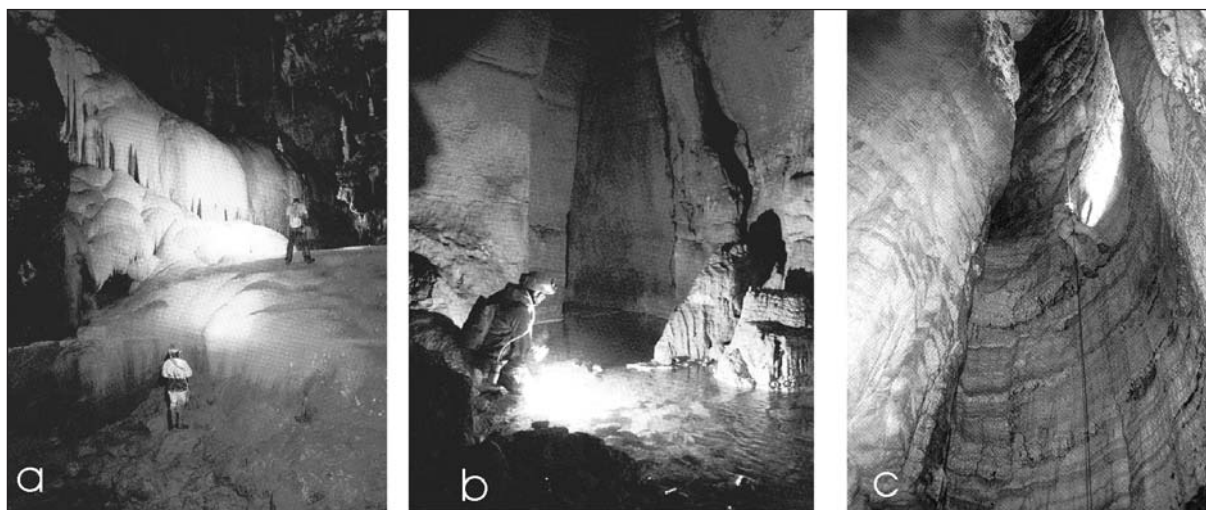


Fig. 5 - a) Particular dripstones in the "Castelcivita Cave"; b) underground lake in the "Inverno Cave"; c) a vertical shaft in the "Fra Gentile Cave" (from Bellucci *et al.*, 1995).

a) Concrezioni nella grotta di Castelcivita; b) lago sotterraneo nella grava d'Inverno; c) un profondo pozzo verticale nella Grotta di "Fra Gentile" (da Bellucci et al, 1995).

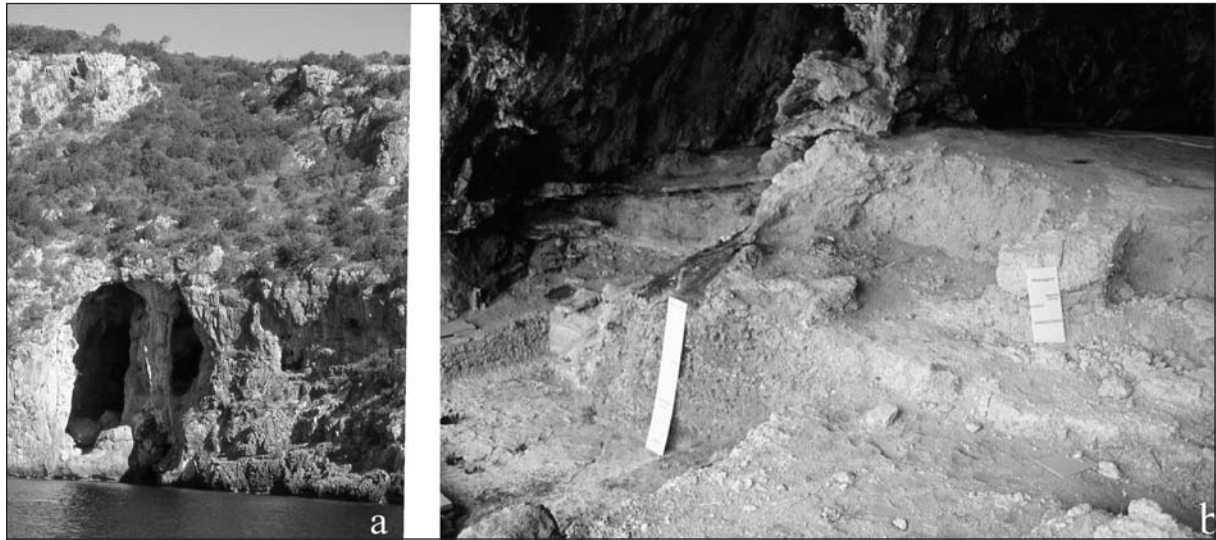


Fig. 6 - a) The entrance of the coastal Noglio cave near Marina di Camerota village; b) archaeological trench in the Cala Cave, near Marina di Camerota village.

a) L'ingresso della grotta costiera del Noglio, lungo la costa di Marina di Camerota; b) scavo archeologico nella grotta della Cala, nei pressi dell'abitato di Marina di Camerota.

The Alburno and Cervati Mt. massifs surely represent the most important karst areas in southern Italy; more than 500 caves are known, some of which with an extension wider than 6 kilometers.

The Alburni massif karstic area for instance (Fig. 3; Fig.13), was selected for its richness in different typology of ipokarst morphologies: active and fossil phreatic caves, together with ponors are the best represented and their genesis and evolution is strictly connected with the morphostructural evolution of the massif (Santangelo & Santo, 1997). The area can also be considered as an important example of the influence of karstic channels on the groundwater circulation within a carbonate massif (Bellucci *et al.*, 1991; 1995; Celico *et al.*, 1994; Santangelo & Santo, 1997; Santo, 1991; 1993) (Fig.4).

Some caves, like Pertosa and Castelcivita, have an important tourist and didactic value: spectacular dripstones, subterranean lakes and rivers have been enchanting thousands of visitors and brought them in touch with the fascinating underground world (Fig. 5).

Otherwise, many caves were selected among geomorphosites because of the important archaeological records preserved in them. It is the case of both coastal (the Cala and Serratura caves, near Marina di Camerota village; Fig. 6) and internal (Castelcivita-Ausino, Pertosa, Polla, Sassano, Vallicelli) caves. The human frequentation in some places took place ever since the Palaeolithic age, while in other cases it occurred during the Bronze and the Iron ages (Bachechi & Revedin, 1993; Benini *et al.*, 1997; Bertolini *et al.*, 1996; Boscato *et al.*, 1997; Martini, 1978; 1981; 1993; Gambassini & Ronchitelli, 1997; Guide Archaelogique, 1996; Piperno & Pellegrini, 2000; Piperno, 2001).

Another geomorphosite, peculiar for its rarity is also preserved in the southern part of the national park. As a matter of fact, in the karstic area of Mt. Pannello flows the sole example of underground river present in Southern Italy: the Bussento river, which, after running

in a subaerial path with a drainage basin area of about 315 km², suddenly sinks into a spectacular ponor (Fig. 7) located at the base of the northern hill slope of Mt. Pannello to resurge subsequently, after about 2 kilometers, on the opposite slope of the mountain, near the Morigerati village. (Laureti, 1960; D'Elia *et al.*, 1987).

3.2 Structural geomorphosites

Within this group, superimposed gorges, fault-line scarp and monoclinical structures will be mentioned. During the Plio-Quaternary time the reliefs of Cilento experienced repeated phases of the drainage network

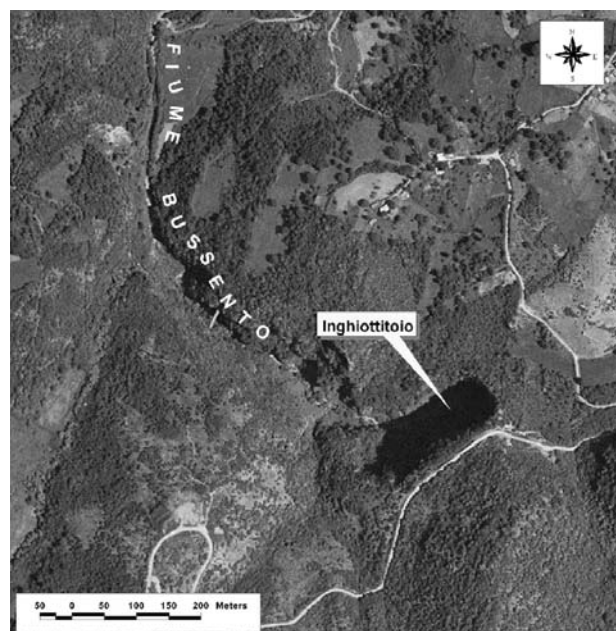


Fig.7 - The Bussento river sinks into the "La Rupe" ponor.
Il fiume Bussento scompare nell'inghiottitoio "La Rupe".

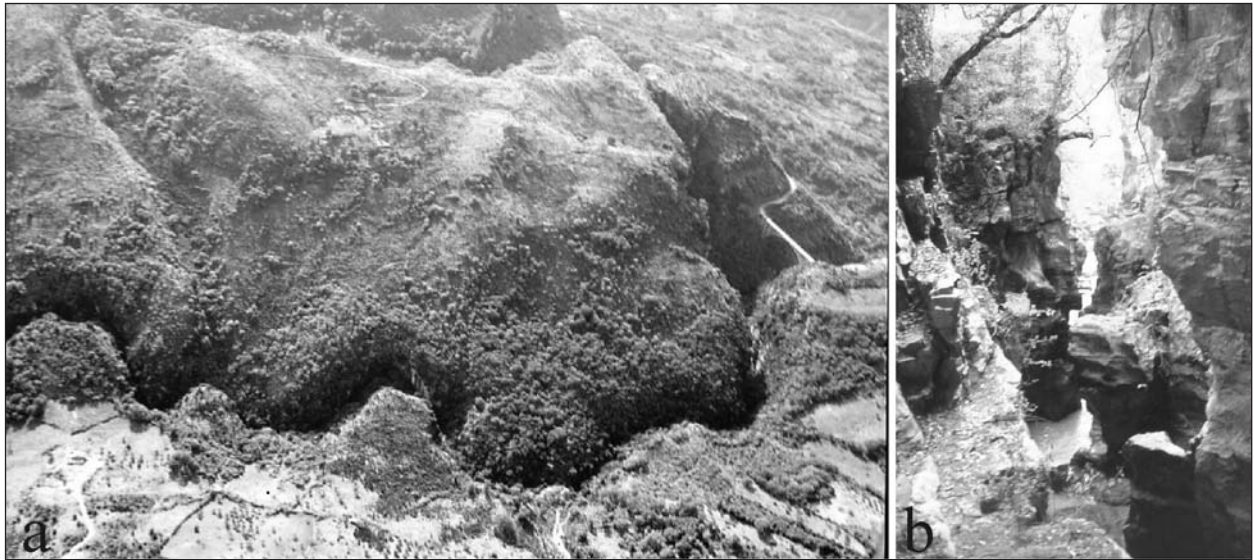


Fig. 8 - a) Aerial view of the entrenched meanders of the Sacco gorge; b) a particular of the Bussento gorge.
 a) *Visione aerea dei meandri incastrati della Forra di Sacco*; b) *un particolare della forra del Bussento*.

deepening (Ascione & Cinque, 1999) that often resulted in the superimposition of gorges cutting across previously buried and/or levelled resistant structures. Spectacular examples are to be found along the Calore river, in the calcareous hinterland of the Park, such as the Sacco gorge (Fig. 8; Fig.13) with its entrenched meanders (Brancaccio *et al.*, 1978; Amato *et al.*, 1995; 1997). The same circumstances cause the formation of fault-line scarps, where soft terrigenous units are in contact with the hard Mesozoic limestones: it is the case of the southern slope of Alburni and Cervati massifs (Fig. 9) or the northern slope of Mt. Bulgheria. (Ascione *et al.*, 1992; Ascione & Cinque, 1999).

The Vesole-Chianello Mts. (Fig. 10; Fig. 13) and Motola Mt. ridges, on the other hand, are good examples of asymmetrical ridges with a monoclinial structure that locally show well preserved flatirons along the dipping slope.



Fig. 9 - The Rupe delle Camere Fault line scarp (Alburni Mountains Massif).

La scarpata di linea di faglia di "Rupe delle Camere" (Massiccio dei Monti Alburni).



Fig. 10 - The Calore river gorge and the dip slope of Vesole Mount.

La forra del F. Calore e il versante di strato di Monte Vesole.

3.3 Coastal geomorphosites

The coastal sector of the park is characterized by the alternating between rocky promontories and sandy beaches. In the northern sector of the coast the most significant geomorphosites are located along the Licosa cape, a little promontory made up of sandstones belonging to the Pollica flysch formation. Approaching to the promontory from the sea, at the foot of its northern and southern slopes, a wide terraced surface can be observed. Such surface, that becomes wider than 500 metres in certain areas, is a polycyclic wave-cut terrace (Fig. 11a) formed during middle and late Pleistocene times due to repeated eustatic oscillations (Cinque *et al.*, 1994). In particular, along its southern external rim are preserved covers of marine deposits (Fig. 11b) that were ascribed to OIS 5c by means of U/Th datings on *corallinae algae* (Iannace *et al.*, 2001). Along the northern rim instead, near S.Marco village, Middle Pleistocene arenites with peculiar sedimentary structures crop out (Fig. 11c).

The southern coast of the park, on the contrary, is made up mainly of carbonate promontory (Palinuro and Infreschi capes) delimited by vertical sea cliffs, with several coastal caves, alternate with little pocket beaches. Active and inactive coastal morphologies like natural arcs and marine terraces (Fig. 12) are well documented. Fossil dunes, marine deposits, bioerosive notches testify the main sea level eustatic variations during the late Quaternary age (Esposito *et al.* 2003). The most representative sites (Fig. 13) in regard with a didactic, tourist or scientific value were inserted in the inventory.

4. GEOSITES DATABASE AND MAPPING

The Data Base of the Geosites of the Cilento-Vallo di Diano National park was built following the Geological Data Base Model of Geological Survey of Italy (GSI), proposed by Cara *et al.* (1993), Bonfatti & Monari (1995), Cara & Giovagnoli (1995).

In fact, since 2000 the GSI, within the limits of the project "Protection of the Italian geological heritage" has been determined to match the following objectives: 1) propose guide-lines for geosites inventory; 2) constitute a digital database of geosites; 3) supply methods and criteria in geosite mapping and geo-referencing on medium or small scale.

The work was organized keeping in consideration the standard methods and criteria for geosites inven-

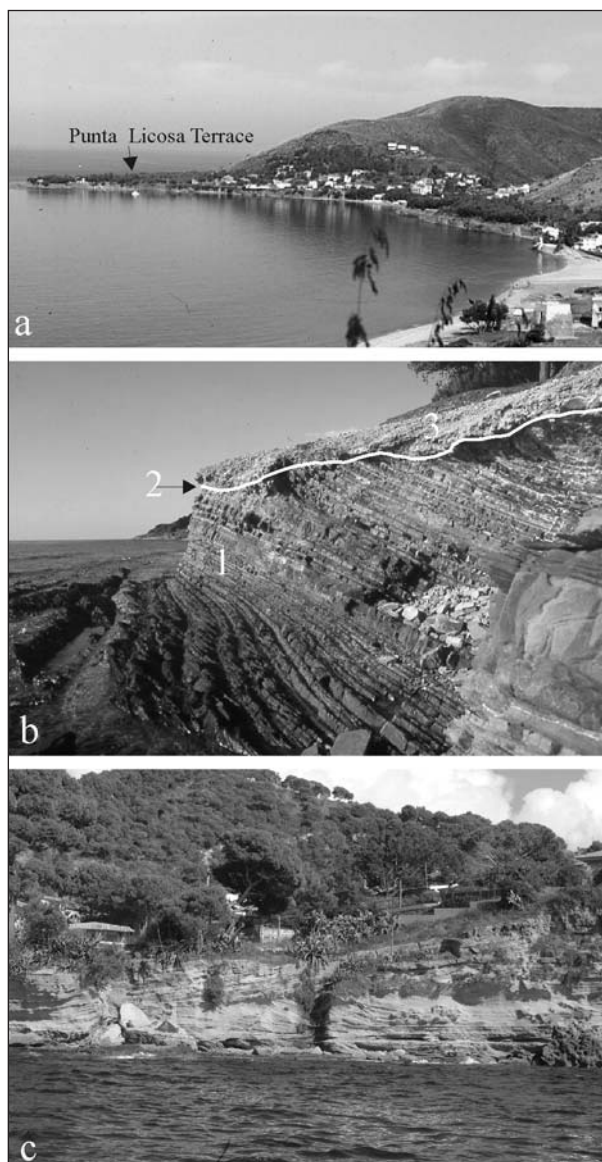
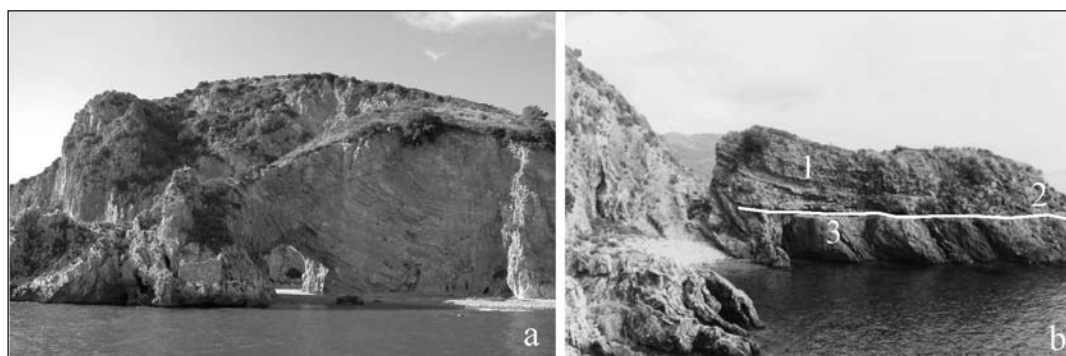


Fig. 11 - a) The marine terrace of Punta Licosa; b) Particular of the marine deposits that cover the terrace: 1) Pollica Formation (Miocene); 2) Buried wave-cut surface; 3) Marine deposits (Upper Pleistocene). c) The "San Marco di Castellabate" sandstones (Middle Pleistocene).

a) Il terrazzo marino di Punta Licosa; b) Particolare dei depositi marini che coprono il terrazzo nel settore meridionale: 1) Formazione di Pollica (Miocene); 2) Superficie di abrasione sepolta; 3) Depositi marini (Pleistocene superiore). c) Le areniti di S. Marco (Pleistocene medio).

Fig.12 - a) The Palinuro natural arc; b) An upper Pleistocene buried wave-cut terrace (2) carved on the Ascea miocenitic formation (3) and covered by slope breccias and pyroclastic of wurmian age (1).

a) L'arco naturale di Palinuro; b) Terrazzo di abrasione marina sepolto (2) del Pleistocene superiore, intagliato sulle calcilutiti della formazione di Ascea (3) e ricoperto da brecce di versante e piroclastiti di età wurmiana (1).



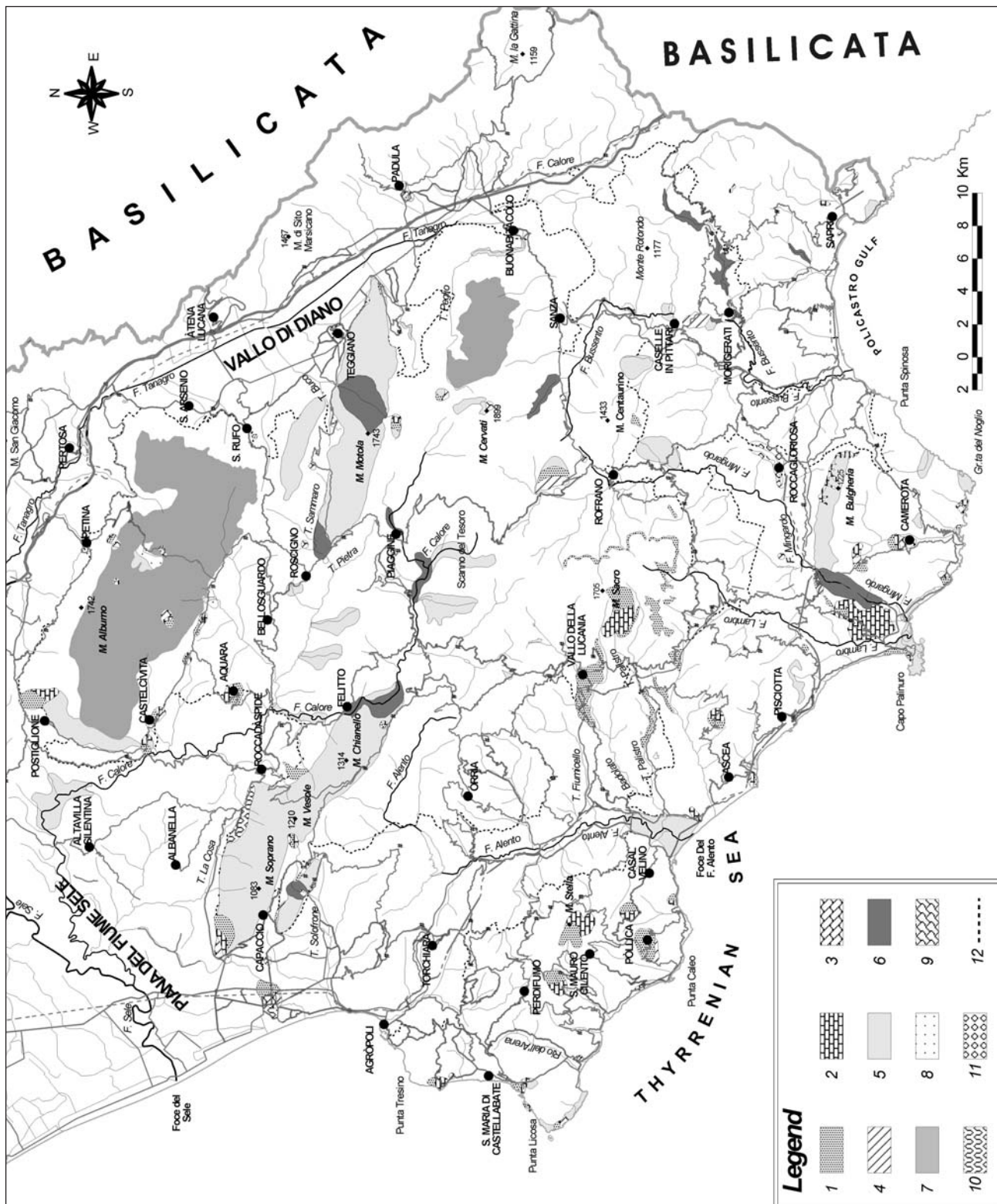


Fig. 13 - Index map of geosites. Sites typology: 1) stratigraphical; 2) palaeoenvironmental; 3) palaeontological; 4) structural; 5) geomorphological (general); 6) geomorphological (gorge); 7) geomorphological (karstic plateau); 8) hydrogeological; 9) scenic; 10) economic; 11) multiple; 12) boundaries of the Park.

Carta indice dei geositi. Tipologia dei siti: 1) stratigrafico; 2) paleoambientale; 3) paleontologico; 4) strutturale; 5) geomorfologico (generale); 6) geomorfologico (gorge); 7) geomorfologico (altopiano carsico); 8) idrogeologico; 9) panoramico; 10) economico; 11) multiplo. 12) limiti del Parco.

tory, data processing and mapping; it can be summarized in the following six steps: 1) Field geosites identification; 2) Geosites geo-referencing on medium (1:50.000) and large (1: 5.000) scale maps; 3) Compilation of cards according to the sketch proposed on the SGI website; 4) Geosite Non-graphic Data Base construction in MS-Access® software program; 5) Multiscale and multithematic Graphical Data Base construction in ESRI-ArcView® GIS program; 6) Linking of the Geosite Non-graphic Data Base with the Graphical Data Base.

For each geosite, a single SGI "testing card" was compiled, subdividing information into two main categories: Surface Geosites and Subterranean geosites.

Basic information was stored and structured into table mdb.* files of MS-Access® program, with the following main topics: ID number, Main geomorphological unit (Carbonate massifs, Marly-clayey hills, Intermontane basin, coastal plain), Place-name, Coordinates, Geosite typology (geological, geomorphological, stratigraphical, palaeo-etnological, palaeontological, etc.), short description.

Regarding the geosites mapping, a multiscale and multithematic Arcview® project with raster and vector structure was applied.

The geo-referencing was carried out on topographic base-map IGM at 1:50.000 scale and the cartographic projection adopted is the UTM 33N zone.

Two different levels of information were foreseen: the first one is a general level on a 1: 50.000 scale, containing the basic data, that can be considered as an "index map" sensu Carton *et al.*, (2003) (Fig. 13). The second one, on a 1:5.000 scale, contains more detailed information like simplified geological or geomorphological sketches, depending on the sites typology. A tool of queries, allows the browsing among multithematic maps starting from simple key words (like geology, geomorphology, hydrogeology, pedology and climate) to finish with exchange-interchange of graphical data. Finally, the link between the Geosite Non-graphic Data Base and the Graphical Data Base provides an interactive computer tool system for the planning and management of the geological estate of the park.

5. CONCLUSIONS

The data listed so far can help the reader to get an idea of the high degree of the "geodiversity" preserved in this wide territory. In fact, the very important sites preserved in the park area allowed the scientific reconstruction of paleogeographic and sedimentary history of the Southern Apennine chain, thanks to their stratigraphical markers, sedimentary structures or fossiliferous levels. Furthermore, very interesting geomorphosites are located both in the hinterland and in the coastal areas; the carbonate massif of the Alburno and Cervati Mts for example, surely represents a unique karstic estate for its dimension, variety and beauty as well as for its being one of the most important supply of groundwater in the Campania region. Human frequentation since the Stone Age was recorded in many of the caves, which are rich of precious geoarchaeological records.

Along the coast, the presence of ancient erosional

and depositional coastal morphologies allowed the reconstruction of the main sea level eustatic oscillations during the Pleistocene and the Holocene.

In conclusion, it must be outlined that even if all the area is already protected, much still needs to be done in order to exploit the environmental estate better; very few in fact are the divulgating papers and the multimedia materials (VHS film, CD-rom) produced about the area, while completely absent are the didactic excursions, and the tourist itineraries that take into account the geological component of the territory.

The coastal area, for example, is an important tourist attraction of the Campania region both for its wonderful sea and its archaeological sites (like Paestum and Velia) but the richness of its geological heritage is completely unknown. On the other hand, the hinterland of the Park, generally left out from the main tourist itineraries, would greatly benefit from the discovery of its environmental estate.

It is to be hoped that this wide territory will soon become well known and highly appreciated and that this study can be the first stage towards the achievement of such aim.

REFERENCES

- AMATO A., CINQUE A. & SANTANGELO N. (1995) - *Il controllo della struttura e della tettonica Plio-Quaternaria sull'evoluzione del reticolo idrografico dell'Appennino campano-lucano* - Studi Geol. Camerti, Vol. Spec.
- AMATO A., CINQUE A. & SANTANGELO N. (1997) - *Le forre dell'Appennino meridionale: caratteri, genesi ed implicazioni tettoniche* - Riassunti Convegno sul tema "Tettonica quaternaria del territorio italiano: conoscenze, problemi ed applicazioni", Parma 25-27 Febbraio 1997.
- AMORE F.O., BONARDI G., CIAMPO G., DE CAPOA P. & PERONE V. (1988) - *Relazioni tra "Flysch interni" e domini appenninici: reinterpretazione delle formazioni di Pollica, S. Mauro e Albidona e il problema della evoluzione inframiocenica delle zone esterne appenniniche* - Mem. Soc. Geol. It., **41**, pp. 285-297.
- ASCIONE A. & CINQUE A. (1999) - *Tectonics and erosion in the long term relief history of the Southern Apennines* - Z. Geomorph. N.F., Suppl-Be **118**, pp. 1-16.
- ASCIONE A., CINQUE A., SANTANGELO N. & TOZZI M. (1992) - *Il bacino del Vallo di Diano e la tettonica trascorrente plio-quaternaria: nuovi vincoli cronologici e cinematica* - Studi Geol. Camerti, Vol. Spec. (1992/1), pp. 201-208.
- BACHECHI L. & REVEDIN A. (1993) - *Il Gravettiano di grotta Calanca a Marina di Camerota (Salerno)* - Rivista di scienze preistoriche **XLV**.
- BARONE LUMAGA M.R., BRAVI S., CIVILE D. & MARTINO C. (2000) - *Ritrovamento di Sapindopsis sp. FONTAINE (SAPINDACEAE) in sedimenti del Cenomaniano superiore di M. Chianello (Appennino meridionale)* - Abstract 95° Congr. Soc. Bot. It., Messina, 28-30 Settembre 2000.
- BELLUCCI F., GIULIVO I., PALELLA L. & SANTO A. (1991) - *Carsismo ed idrogeologia del settore centrale dei*

- M. Alburni (Campania) - Geol. Tecnica, 3, pp. 5-12.
- BELLUCCI F., GIULIVO I., PALELLA L. & SANTO A. (1995) - *Monti Alburni: ricerche speleologiche* - De Angelis Ed. 302 pp.
- BENINI A., BOSCATO P. & GAMBASSINI P. (1997) - *Grotta della Cala (Salerno): industrie litiche e faune uluziane ed aurugnaziane* - Rivista di scienze preistoriche XLVIII, pp. 37-41.
- BERTACCHINI M., GIUSTI C., MARCHETTI M., PANIZZA M. & PELLEGRINI M. (1999) - *I beni geologici della Provincia di Modena* - Artioli Ed., Modena, 104 pp.
- BERTOLINI M., FEDOZZI S., MARTINI F. & SALA B. (1996) - *Late glacial and Holocene climatic oscillations inferred from the varying in the micromammal association at Grotta della Serratura (Marina di Camerata, Salerno, Italy)* - Il Quaternario 9 (2).
- BONARDI G., AMORE F.O., CIAMPO G., DE CAPOA P., MICONNET P. & PERRONE V. (1988) - *Il Complesso Liguride Auct.: stato delle conoscenze e problemi aperti sulla sua evoluzione pre-appenninica ed i suoi rapporti con l'arco calabro* - Mem. Soc. Geol. It., 41, pp. 17-35.
- BONFATTI F. & MONARI P.D. (1995) - *La modellazione concettuale: strumento di organizzazione della conoscenza geologica*, in "Carta Geologica d'Italia 1:50.000, Guida all'informatizzazione" - Quaderni SGN, Serie III, 3, pp. 13-21.
- BOSCATO P., RONCHITELLI A. & WIERER U. (1997) - *Il Gravettiano antico di Grotta della Cala a Marina di Camerota: Paleontologia e ambiente* - Rivista di Scienze Preistoriche XLVIII.
- BRANCACCIO L., NICOLETTI E. & PATTI O. (1978) - *La forma epigenetica del T. Sammaro (Cilento). Un problema geomorfologico e sue implicazioni antropogeografiche* - Boll. Soc. Nat. In Napoli, 87, pp. 1-18.
- BRAVI S. (1995) - *Studies on old and new meso-cenozoic "plattenkalk" in Southern Italy* - Il Inter. Symp. On lithographic limestones, Lleida-cuenca (Spain) 9-16 July 1995.
- BRAVI S. & GARASSINO A. (1998) - *Plattenkalk of the lower Cretaceous (Albian) of Petina, in the Alburni Mounts (Campania, Southern Italy), and its decapod crustacean assemblage* - Atti Soc. It. Sc. Nat. Museo Civ. stor. Nat., 138/1997 (I-II), pp. 89-118.
- BRAVI S., COPPA M.G., GARASSINO A. & PATRICELLI R. (1999) - *Palaemon vesolensis n.sp. (Crustacea, Decapoda) from the plattenkalk of Vesole mount (Salerno, Southern Italy)* - Atti Soc. It. Sc. Nat. Museo Civ. Stor. Nat., Milano, 140/1999 (II), pp. 141-169.
- CAMMAROSANO A., DANNA M., DE RIENZO F., MARTELLI L., MIELE F. & NARDI G. (2000) - *Il substrato del Gruppo del Cilento tra il M.te Vesalo e il M.te Sacro (Cilento, Appennino Meridionale)* - Boll. Soc. Geol. It., 119, pp. 395-405.
- CARA P., CHIARINI E., SPAZIANI A., STAMPAGNONI G., VENTURA F. A., VENTURA R., & VISICCHIO F. (1993) - *Il disegno logico della base informativa territoriale del Sistema Informativo Geologico Nazionale* - Boll. Serv. Geol. d'Italia, CIX (1991), pp. 15-46.
- CARA P. & GIOVAGNOLI (1995) - *Scheda per la raccolta di dati relativi a campioni geologici in "Carta Geologica d'Italia 1:50.000, Guida all'informatizzazione"* - Quaderni SGN, Serie III, 3, pp. 77-130.
- CARTON A., CAVALLIN A., FRANCAVILLA F., MANOVANI F., PANIZZA M., PELLEGRINI G.B. & TELLINI C. (1994) - *Ricerche ambientali per l'individuazione dei beni geomorfologici. Metodi ed esempi* - Il Quaternario, 7 (b), pp. 365-372.
- CARTON A., CORATZA P. & MARCHETTI M. (2003) - *Nota preliminare sulla cartografia dei geomorfositi* - In: S. Piacente & G. Poli (eds.), *La memoria della Terra la Terra della memoria*, Regione Emilia Romagna Ed., pp. 114-121.
- CELICO P., PELELLA L., STANZIONE D. & AQUINO S. (1994) - *Sull'idrogeologia e la geochimica dei M. Alburni (Sa)* - Geol. Rom., 30, pp. 687-689.
- CINQUE A., PATACCA E., SCANDONE P. & TOZZI M. (1993): *Quaternary kinematic evolution of the Southern Apennines. Relationship between surface geological features and deep lithospheric structures* - Annali di Geofisica, 36, n. 2, pp. 249-259.
- CINQUE A., ROMANO P., ROSSKOPF C., SANTANGELO N. & SANTO A. (1994) - *Morfologie costiere e depositi quaternari tra Agropoli e Ogliastro Marina (Cilento - Italia Meridionale)* - Il Quaternario, vol. 7, fasc.1., pp. 3-16.
- CINQUE A. & ROMANO P. (2001) - *Evoluzione geomorfologica della Campania e caratterizzazione oro-idrografica della Regione*, In: A. Vallario (ed.), *L'ambiente geologico della Campania*, CUEN Ed., pp. 59-90.
- COCCO E., DE MAGISTRIS M.A. & DE PIPPO T. (1978) - *Sedimentologia del flysch del Cilento. 1: le arenarie di Serramezzana (Cilento, Appennino meridionale)* - Geol. Rom., 17, pp. 289-302.
- CRITELLI S. & LE PERA E. (1990) - *Litostratigrafia e composizione della Formazione di Pollica (Gruppo del Cilento, Appennino meridionale)* - Boll. Soc. Geol. It., 109, pp. 511-536.
- D'ANDREA M. & DI LEGINIO M. (2002) - *Progetto SGN: Conservazione del patrimonio geologico italiano. I censimenti sui siti d'interesse geologico in Italia* - Geologia dell'Ambiente, anno X, 2, pp. 9-13.
- D'ARGENIO B., PESCATORE T. & SCANDONE P. (1975) - *Structural pattern of the Campania-lucania Apennines* - Quaderni de "La Ricerca Scientifica" CNR, n. 90.
- D'ELIA G., GUIDA M. & TERRANOVA C. (1987) - *Osservazioni sui fenomeni di deformazione gravitativa profonda nel bacino del F. Bussento (Campania)* - Boll. Soc. Geol. It. 106, pp. 253-264.
- DE VITA P., GUIDA D., GUIDA M., LANZARA R., LAURIA M. & VALLARIO A. (1994) - *Proposte metodologiche e procedurali di pianificazione del territorio in aree protette: l'Unità Territoriale di Riferimento* - Geologia Tecnica & Ambientale, n. 3.
- ESPOSITO C., FILOCAMO F., MARCIANO R., ROMANO P., SANTANGELO N., SCARCIGLIA F. & TUCCIMEI P. (2003) - *Late quaternary shorelines in southern Cilento (Mt. Bulgheria) morphostratigraphy and cronology* - Il Quaternario 16 (1), pp. 11-22.
- GAMBASSINI P. & RONCHITELLI A. (1997) - *Due ami preistorici nella grotta della Cala a Marina di Camerota (Salerno)* - Apollo, Bollettino dei Musei Provinciali del Salernitano.
- GUIDA D., LUISE D., SALZANO G. & VALLARIO A. (1980) -

- Ricostruzione di sequenze morfoevolutive pleistoceniche nell'area ad W di Monte Sacro* - Geol. Appl. e Idrogeologia, **15**, pp. 1-22.
- GUIDE ARCHEOLOGICHE (1996) - *Il Paleolitico dell'Italia centro-meridionale* - n° 1, XIII Congresso UISPP, Forlì.
- HARLEY M. (1999) - *RIGS un progetto regionale per la salvaguardia dei siti geologici/geomorfologici* - In: G. Poli (ed.), *Geositi Testimoni del Tempo*, Regione Emilia Romagna Ed., pp. 52-64
- IANNACE A., ROMANO P., SANTANGELO N., SANTO A. & TUCCIMEI P. (2001) - *The OIS 5c along Licosa cape promontory (Campania region, Southern Italy)* - Z. Geomorph. N.F. **45**, pp. 307-319.
- KARNER D., JUVIGNÉ E., BRANCACCIO L., CINQUE A., RUSSO ERMOLLI E., SANTANGELO N., BERNASCONI S. & LIRER L. (1999) - *An early middle-Pleistocene tephrostratotype for the Mediterranean basin: the Vallo di Diano, Campania, Italy* - Global and Planetary change, **21**, pp. 1-15.
- LAURETI L. (1960) - *Nuovi contributi alla conoscenza del corso sotterraneo del Bussento (Cilento)* - Boll. Soc. Geogr. It., **11-12**, pp. 1-15.
- MARTINI F. (1978) - *L'Epigravettiano di Grotta della Cala a Marina di Camerata (Salerno)* - Rivista di scienze preistoriche XXXIII.
- MARTINI F. (1981) - *L'Epigravettiano di Grotta della Cala a Marina di Camerata (Salerno)* - Rivista di scienze preistoriche XXXVI.
- MARTINI F. (1993) - *Grotta della Serratura a Marina di Camerata. Culture ed ambienti dei complessi olocenici* - Ed. Garlatti e Razzai, Firenze.
- MASSOLI NOVELLI R. (2001) - *Inventari di geositi in Italia: stato dell'arte* - Geologia dell'Ambiente, **1**, SIGEA, Roma, pp. 10-13.
- PANIZZA M. (1992) - *Sulla valutazione dei Beni Ambientali* - Mem. Descr. della Carta Geol. d'It., **42**, pp. 479-484.
- PATACCA E, SARTORI R. & SCANDONE P. (1990) - *Tyrrhenian basin and apenninic arcs: kinematic relations since late Tortonian times* - Mem Soc. Geol. It., **45**, pp. 425-451.
- PIPERNO M. & PELLEGRINI S. (eds.) (2000) - *Recenti risultati delle ricerche alla Grotta del Pino (Sassano, Salerno)* - Boll. Paleont. Italiana, **91-92**, pp. 121-206.
- PIPERNO M. (2001) - *La preistoria alle falde del M. Cervati* - Parco Nazionale del Cilento Vallo di Diano Ed., 12 pp.
- RUSSO ERMOLLI E., JUVIGNE E., BERNASCONI S., BRANCACCIO L., CINQUE A., LIRER L. & SANTANGELO N. (1995) - *Les premier stratotype continental de quatre stades isotopiques successifs du Pleistocene moyen pour le bassin méditerranéen septentrional: le Vallo di Diano (Campanie, Italie)* - Comptes rendues de l'Académie des Sciences, Paris, t. **321**, série II a, pp. 877-884.
- SANTANGELO N. & SANTO A. (1997) - *Endokarst processes in the Alburni massif (Campania, Southern Italy): evolution of ponors and hydrogeological implications* - Zeitschrift für Geomorphologie, **41**, 2, pp. 229-247.
- SANTANGELO N. & SANTO A. (2001) - *Le risorse delle aree carsiche*. In "L'ambiente Geologico in Campania" a cura di Vallario A., CUEN Ed. Napoli, pp. 253-285.
- SANTANGELO N., SANTO A. & GUIDA D. (2000) - *I geositi del Parco Nazionale del Cilento-Vallo di Diano*. Piano del Parco 2000: Relazione di settore nell'ambito della Convenzione "CUGRI-Parco del Cilento", Vallo della Lucania.
- SANTO A. (1991) - *Karst processes and potential vulnerability of the campanian carbonatic aquifers: the state of the knowledge* - Proceedings of the International Conference on Environmental Changes in Karst areas, I.G.U.- U.I.S.- Italy 15-27 Sept. 1991, Quaderni del Dipartimento di Geografia, n. **13**, pp. 95-107.
- SANTO A. (1993) - *Idrogeologia dell'area carsica di Castelcivita (M. Alburni -SA-)* - Geol. Appl. e Idrog. **28**, pp. 663-673.
- SCORZIELLO R. & SGROSSO I. (1965) - *Segnalazione di crostacei decapodi nel Paleocene di M. Vesole* - Boll. Soc. Nat., **74**, pp. 4-5.
- TRICART J. (1965) - *Principes et méthodes de la géomorphologie* - Ed. Masson, Paris.
- WIMBLEDON W.A.P. (1999) - *L'identificazione e la selezione dei siti geologici, una priorità per la geoconservazione*. In G. Poli (ed.), *Geositi, testimoni del Tempo*, Edizioni Pendragon, Bologna.
- WIMBLEDON W.A. (1999) - *L'identificazione e la selezione dei siti geologici, una priorità per la geoconservazione*. In "Geositi testimoni del tempo" a cura di Poli G., Regione Emilia Romagna Ed., pp. 52-63.
- WIMBLEDON A.P., ANDERSEN S., CLEAI C. J., COWIE J.W., ERIKSTAD L., GONGGRIJP G.P., OHANSSON C.E., KARIS L.O. & SUOMINEN V. (1999) - *Geological World Heritage: GEOSITES - a global comparative site inventory to enable prioritisation for conservation* - Memorie descrittive della Carta Geologica d'Italia **54**, pp. 45-60.