

GEOSITES AND LANDSCAPE EVOLUTION OF THE TACCHI: AN EXAMPLE FROM CENTRAL-EAST SARDINIA

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ABSTRACT: J. De Waele *et al.*, *Geosites and landscape evolution of the Tacchi: an example from central-east Sardinia*. (IT ISSN 0394-3356, 2005).

The Tacchi area is a landscape unit located to the south of the Gennargentu mountains in the central-eastern part of Sardinia, mainly characterised by table-like carbonatic Mesozoic mountains, locally named "Tacchi", unconformably overlaying a Paleozoic peneplain constituted of Cambro-Silurian silty and sandy shales. The Tacchi are the result of a complex geologic history, deriving from a unique and widespread Jurassic carbonatic cover that was split up in clods due to epigenetic movements, faulted, uplifted or lowered and successively eroded and isolated by fluvial processes. The palaeo-geography and the evolution of this landscape can be explained using several different geosites of the area, such as the San Giorgio Gorge, the Su Marmuri cave and the Monte Tisiddu Tacco that, united in a network of geosites, can bring to an improvement of the tourist offer of this interesting area. Besides these geosites many other places of geological interest such as the Riu Pardu river and its abandoned villages of Gairo vecchio and Osini vecchio (partially destroyed by phenomena of hydrogeologic hazard during the XXth century and especially following an exceptional rainfall in October 1951), several waterfalls and travertine deposits can be mentioned, completing an already rich and varied landscape.

The Project aims to the conservation of the geodiversity and the multiple valences present in the territory, and comprises the valorisation of the sites of geological interest in line with the principles of a sustainable development. This valorisation foresees the realisation of a local network of geosites connected to the system of Natural Monuments instituted by the Regional Law 31/1989, the arrangement of equipped pathways, the elaboration of explicative documents and panels in which geology, geomorphology, karst landscape, biology, archaeology and human settlements and processes are described. Some panels will be focalised on the reading of the landscape and its evolution (Lecture du paysage) in which geological, geomorphological and environmental aspects collimate to form an educational model of great suggestion.

This proposal of valorisation of these geosites, grouped in a network, could well be applied to other areas, and the Authors hope that the regional and local stakeholders will, in the near future, participate in the geo-environmental preparation of their territory, giving an important service to the many tourists that come and visit the Tacchi area.

RIASSUNTO: J. De Waele *et al.*, *Geositi e evoluzione del paesaggio dei Tacchi: un esempio dalla Sardegna centro orientale*. (IT ISSN 0394-3356, 2005).

L'area dei Tacchi è un'unità di paesaggio situata a Sud del massiccio del Gennargentu (Sardegna centro-orientale), caratterizzata dalla presenza di altipiani carbonatici Mesozoici, conosciuti con il nome locale di "Tacchi" o "Tonneri", che coprono in discordanza il peneplano Paleozoico costituito da metarenarie e metasiltiti di età Ordoviciano-Cambriana. I Tacchi sono il risultato di una complessa evoluzione geologica e derivano da un'unica ed estesa copertura carbonatica Giurassica suddivisa in vari frammenti a seguito di movimenti epigenetici Plio-Pleistocenici dai quali vennero fratturati, sollevati o abbassati e successivamente erosi e isolati da processi fluviali, gravitativi e meteorici. La paleogeografia e l'evoluzione di questi paesaggi possono essere spiegate in maniera eloquente osservando diversi geositi di questa regione, quali la Gola di San Giorgio, la Grotta di Su Marmuri e il Tacco di Monte Tisiddu che, collegati a rete possono creare un forte motivo di richiamo per un turismo naturalistico e culturale per questa regione dell'interno della Sardegna.

Oltre a questi geositi il territorio contiene altri validi temi di interesse geologico e geomorfologico come la Valle del Riu Pardu e i suoi villaggi abbandonati di Gairo ed Osini Vecchio (parzialmente distrutti da frane avvenute nel XX secolo e soprattutto dopo le forti piogge nell'ottobre del 1951), diverse cascate temporanee e depositi di travertino o di terre rosse di decalcificazione e valli sospese che completano il richiamo verso questo paesaggio di per sé già ricco e vario.

La presente ricerca ha come obiettivo la conservazione della geodiversità e delle molteplici valenze di questo territorio e si propone la valorizzazione dei geositi di maggiore interesse in linea con i principi dello sviluppo sostenibile. Tale valorizzazione prevede la realizzazione, d'intesa con le Autorità locali, di una rete locale di geositi connesso con il sistema dei Monumenti Naturali istituiti dalla Legge Regionale 31/1989, la costruzione di sentieri equipaggiati, l'elaborazione di cartografia tematica e pannelli esplicativi nei quali geologia, geomorfologia, paesaggio carsico, fauna, flora ed archeologia vengono illustrati in forma chiara ed accessibile secondo i criteri di una corretta divulgazione scientifica. In particolare alcuni di questi pannelli saranno focalizzati alla lettura del paesaggio nella quale gli aspetti geologici, geomorfologici ed ambientali collimano a delineare un modello evolutivo di notevole interesse per l'educazione ambientale e nello stesso tempo di grande suggestione dal punto di vista percettivo.

La proposta di valorizzazione di tali geositi, raggruppati in una rete, è concepita per integrarsi con l'insieme dei beni geografico-fisici presenti nelle aree limitrofe. Tutto questo potrà contribuire a fornire un servizio importante ai numerosi turisti che visitano le coste e che possono trovare nei paesaggi dei Tacchi itinerari geotematici di grande interesse.

Keywords: Tacchi, Karst, Jurassic, Dolomitic limestones, Geosites, Ogliastro.

Parole chiave: Tacchi, Carso, Giurese, Calcarei dolomitici, Geositi, Geoturismo, Sardegna.

1. INTRODUCTION

In this study, performed in the framework of the National Project on Geomorphological sites, the Authors describe the three most important geosites of

the area of Ulassai and Osini, in the central-eastern part of Sardinia. The three chosen sites are the *San Giorgio Gorge*, the *Su Marmuri* show cave and the *Monte Tisiddu Taccu* (Fig. 1).

Aside the description of these geological monu-

ments the Authors propose the conservation of the multiple valences present in the territory, comprising the valorisation of the sites of geological interest in line with the principles of a sustainable development, also through the realisation of a local network of geosites connected to the system of Natural Monuments instituted by the Regional Law 31/1989.

This proposal of valorisation of these sites of geological and geomorphological interest, grouped in a local network, could well be applied to other areas ending up with the realisation of a Regional System of Geosites, and the Authors hope that the regional and local stakeholders will, in the near future, participate in the correct geo-environmental management of their territory, giving an important service to the cultural education of the local people and to the many tourists that come and visit the *Tacchi* area and the central-eastern coast of Sardinia.

2. METHODOLOGY

Geosites and geomorphosites have in some way been recognised as cultural heritage by the “Convention of the Protection of World’s Culture and Nature” signed by almost 160 countries and adopted by UNESCO during the general conference of Paris in 1972. This Convention gave also birth to the World Heritage List of those sites that have “exceptional universal value” from a historical, artistic or scientific point of view.

From the end of the 70’s beginning of the 80’s the first inventories of “naturalistic sites” are produced in Italy. In this first phase, that can easily be defined preliminary, the study and the cataloguing of geological sites does not have well defined and univocal rules. In 1991 the first European meeting on Geosites is held at Digne-les-Bains (France) during which the “Declaration of Rights of the Earth’s Memory” is presented. In the same occasion the methodology for the systematic survey of geological and geomorphological sites on a regional scale is also proposed by Barca & Di Gregorio (1991) with the aim to assure a uniform study and evaluation of such sites. At this scope a file sheet is proposed that is subdivided in four sections: 1) identification, 2) main and integrative parameters of evaluation, 3) degree of scientific and historic-cultural importance, 4) state of use and tutelage. The file sheet is also characterised by the presence of an extract of topographical map and further information on the geographical location. The Authors suggest to arrive at a objective way of survey that do not take too much into account the aesthetic criteria normally used in describing natural sites. Contemporary Casto *et al.* (1991) produce a type of sheet file used for the cataloguing of geosites and geomorphosites in the provinces of Rome and Rieti. This sheet file, even though containing a precise location of the described sites and containing also two new elements, such as photographs of the site useful to evaluate modification and or destruction, and a brief description, seems to be too subjective and too dependant on the surveyor (Marchetti, 1999; Poli, 2003).

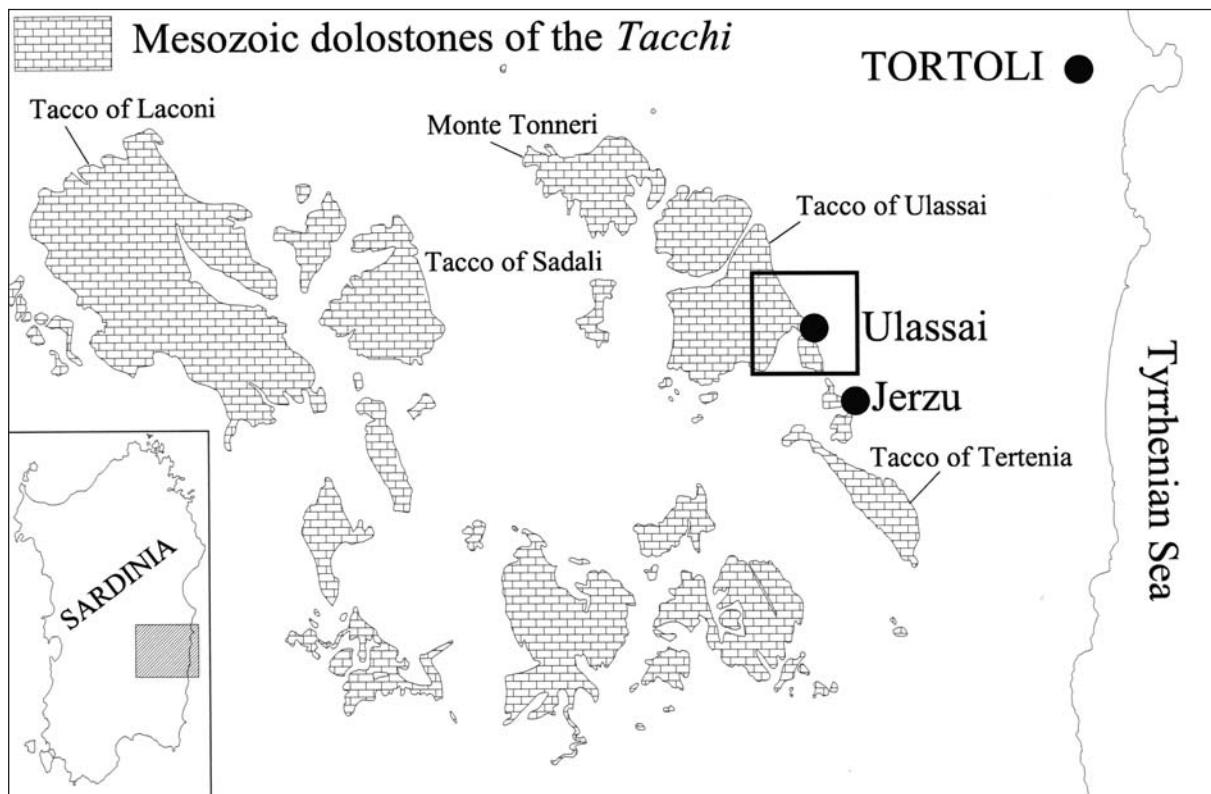


Fig. 1 - Site orientation.
Area di ricerca.

From the second half of the 90's the studies and the methodologies continuously improved and also on a national level starts to form the idea of making a uniform methodology and to construct a sheet file based on the positive earlier experiences made in various Italian regions. The new sheet files for identification and classification are conceived and realised in order to be inserted in GIS systems, in the framework of regional, national and international projects for geosites census.

Since 1996 the International Union of Geological Sciences (IUGS) started the GEOSITES research program in the framework of UNESCO (Wimbleton, 1996). Finally, in august 2001, during the IVth International Conference of the International Association of Geomorphologists, the Working Group "Geomorphological sites: research, assessment and improvement" has been instituted, taking experience from the Italian national COFIN Project "Geosites in the Italian Landscape: research, evaluation and valorisation". It is in the framework of all these activities that the term "geomorphosites" has been coined (Panizza, 2001) and that new methodologies for cataloguing have been proposed (Carton *et al.*, 2003).

A sheet file elaborated by the Agency for the Protection of the Environment and Territory (APAT, former National Geological Service) and by the Centre for Documentation of Geosites of the University of Genoa, still under experimentation, has been used in this paper. This sheet file is subdivided in fourteen sections further subdivided in sub-sections, and accompanied by a second so-called "specialistic" sheet file. The presence of sub-sections in most of the sections enhances the comprehension of the geosites giving a more detailed information. This new type of sheet file, a part of being the most recent and most developed one, is also the one the better satisfies the requirement both for the analysis and the input of geomorphosite data, and has also been adopted for the surveying of sites in Sardinia.

3. GEOLOGY OF THE TACCHI REGION

The *Tacchi* area is a landscape unit located to the south of the *Gennargentu* mountains in the central-eastern part of Sardinia. This unit is mainly characterised by table-like carbonatic Mesozoic plateaus, locally named "*Tacchi*", overlaying with

an unconformity the Palaeozoic basement constituted of Middle Cambrian-Ordovician quartzitic-micaceous metasediments, quartzites, quartzitic phyllites and metasilstones (Gennargentu Formation) peneplained during Permian-Triassic (Fig. 2). This long continental period is clearly identified by the local presence of ferruginous phyllites with limonite nodules generally named "*Ferro dei Tacchi*", in the past cultivated for the iron content (Marini, 1984).

The beginning of the Jurassic succession is characterised by a more or less well preserved succession of continental fluvial, delta and lacustrine sediments composed of a quartzite conglomerate, sandy and clayey lenses and, in some places, containing lignite seams or clays with vegetal remains (Barca & Palmerini, 1973; Fazzini *et al.*, 1974). According to Dieni & Massari (1985) these sediments are comparable to the complete succession described at Genna Selole and attributed to Bajocian-Bathonian (Genna Selole Formation). Palynological studies of these sequences also suggest the age of the black clays with plant remains to be Bajocian-Bathonian (Del Rio, 1985). This continental

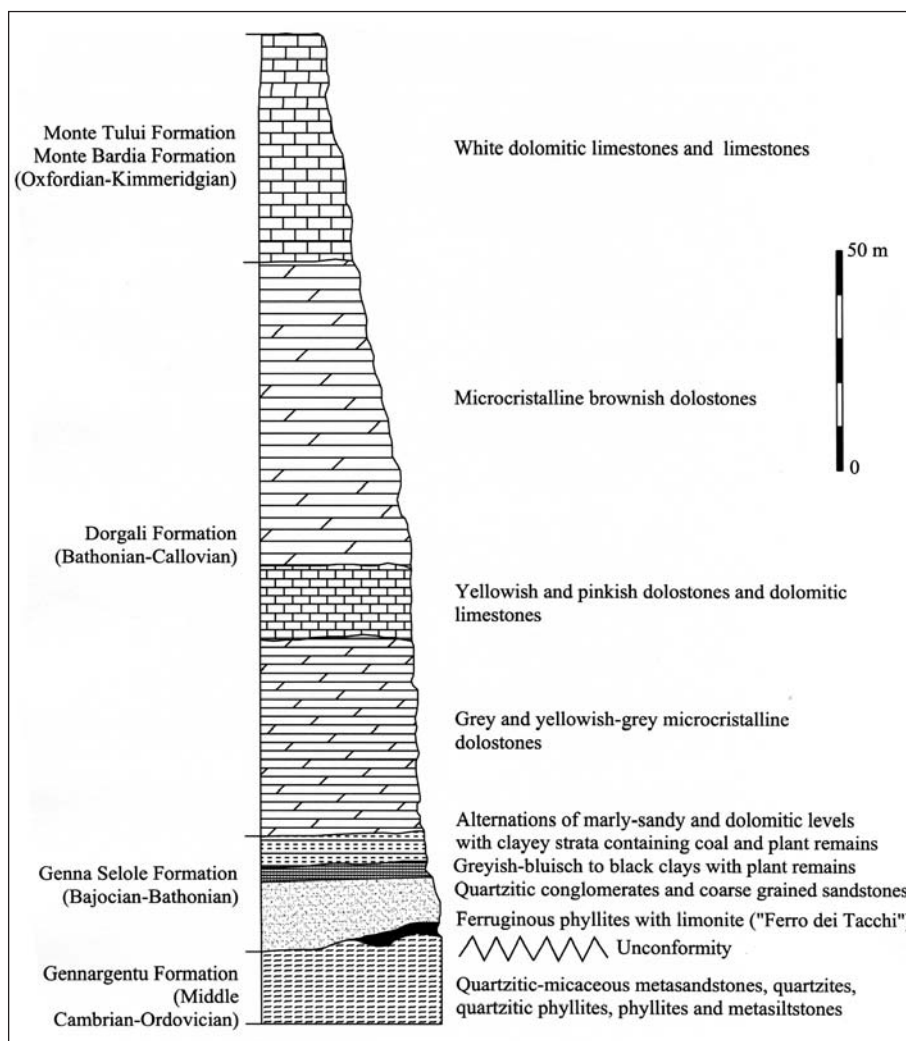
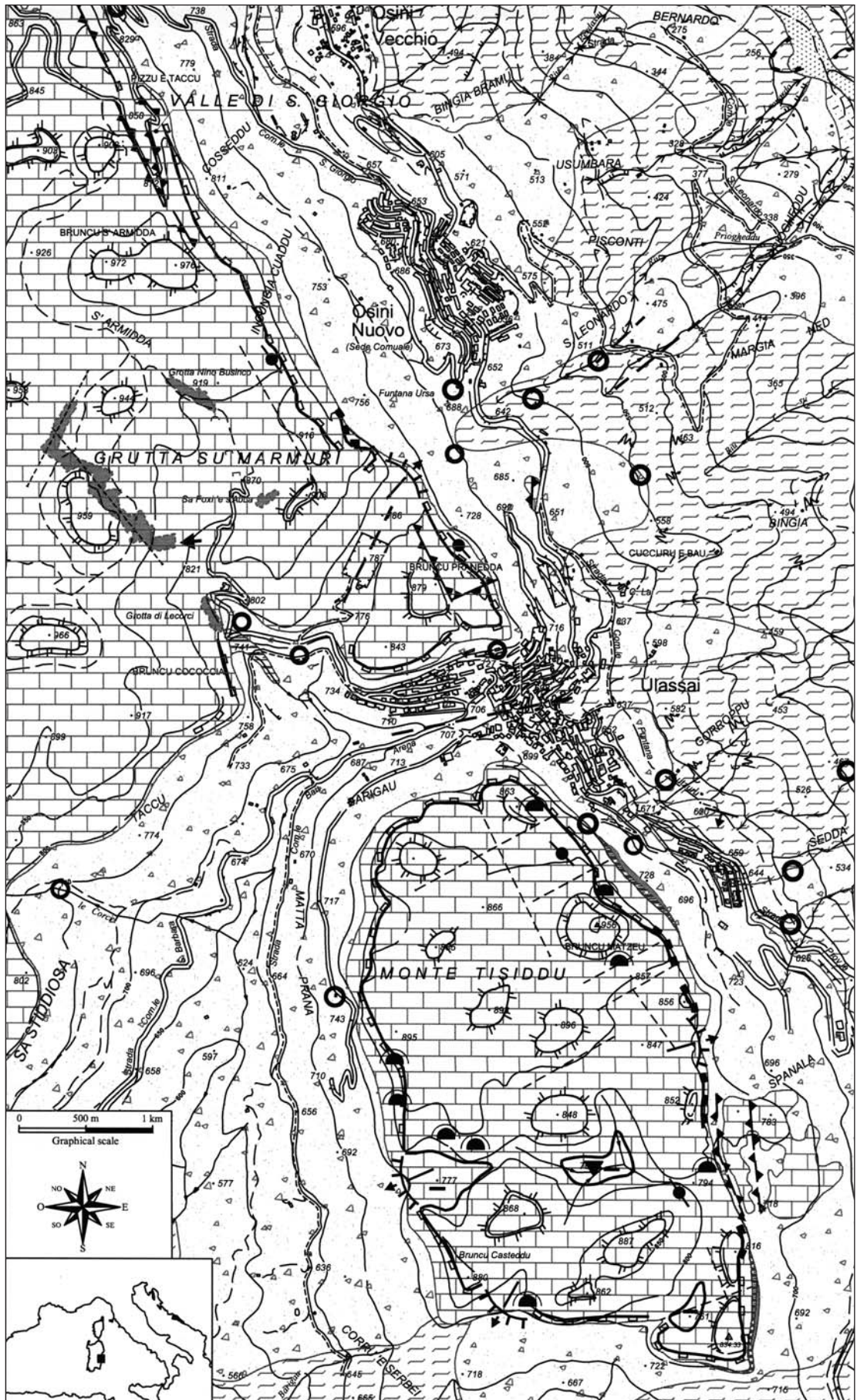


Fig. 2 - Stratigraphic column of the sedimentary sequence of the Tacchi in Central-East Sardinia.

Colonna stratigrafica della sequenza sedimentaria dei Tacchi nella Sardegna centro-orientale.






Fig. 3 - Geological and geomorphological map of the study area with the three geosites.

Carta geologica e geomorfologica dell'area di studio con i tre geositi.




LEGEND

QUATERNARY



-  Heterogeneous weakly cemented or incoherent slope wash *HOLOCENE*
-  Present alluvial bottom valley deposits constituted of sands and pebbles *HOLOCENE*
-  Travertine
-  Quaternary terraced alluvial heterometric weakly cemented reddish deposits mainly composed of metamorphic pebbles *UPPER PLEISTOCENE?*
-  Chaotic ancient and recent landslides and rockfalls, sometimes remobilised, constituted of calcareous-dolomitic more or less cemented materials derived from the toppling or from the falling of big rock masses from the borders of the *Tacchi LOWER-MIDDLE PLEISTOCENE.*

TERTIARY


-  Conglomerate with quartz and subordinately metamorphic well rounded pebbles deriving from an ancient hydrography *EOCENE?*

MESOZOIC

Dorgali Formation

-  Well stratified dolo- and dolomitic limestones with *Brachiopods* and rare *Bivalves* *MIDDLE JURASSIC.*
-  Brown marly limestones, dolomitic limestones, marls with *Charophyta* and thin lenses of lignite *MIDDLE JURASSIC.*


Genna Selole Formation

-  Monogenetic quartzite conglomerates, claystones and greyish siltstones with plant remains *MIDDLE JURASSIC.*







PALAEOZOIC

HERCYNIC METAMORPHIC BASEMENT

Gennargentu Formation



-  Irregular alternation of decimetric to metric levels of quartzite and mica metasandstones, quartzites, quartzite phyllites *CAMBRIAN? - LOWER ORDOVICIAN.*

CONVENTIONAL SIGNS




- | | |
|---|--|
|  Certain and presumed faults |  Horizontal strata |
|  Main fractures. |  Dip of stratification between 10° and 30°. |
|  Tension cracks |  Dip of stratification > 30°. |

Geomorphological scheme of the geosites




HYDROGRAPHY

-  Streams
-  Important spring











GRAVITATIVE FORMS

-  Landslide niche
-  Instable slopes or cliffs with possible rock falls
-  Tectonically controlled slope or cliff

KARSTIC FORMS

-  Cave entrance
-  Sinkhole (Doline)
-  Sinkhole (Ponor)

FLUVIAL AND SLOPE FORMS RELATED TO SURFICIAL FLOW

-  Surface with diffuse erosion forms
-  Surface with concentrated erosion forms
-  Gully caused by concentrated flow
-  V-shaped valley
-  Flat trough valley
-  Trough valley
-  Suspended valley
-  Deepening valley bottom
-  Eroding border of stream
-  Residual relief

sequence is immediately followed by a marine succession of dolomitic limestones, in the lower part disposed in well stratified decimetric and metric beds and upwards becoming more massive, upon which are locally preserved about 30 meters of white coralline and oolitic limestones for a total thickness of over 300 meters. Recently the lower dolomitic succession has been attributed to the Dorgali Formation, mostly of Bathonian-Callovian age, while the uppermost more calcareous part represents sediments of the Monte Tului and Monte Bardia Formations of Callovian-Kimmeridgian age (Barca & Costamagna, 2000, Barca *et al.*, 2000a; 2000b).

This unique and widespread Jurassic carbonatic cover emerged from the sea at the end of Mesozoic and during Tertiary the landscape started evolving with the formation of valleys with prevalent direction NNE-SSW that eroded the surrounding Palaeozoic mountains. These palaeo-valleys are still recognisable on top of many *Tacchi* where large closed depressions contain remnants of fluvial deposits with metamorphic and quartzite elements (e.g. *polje* of San Giorgio) and suspended valleys occur along the borders of the *Tacchi*. Towards the end of Tertiary the fluvial erosion of the Palaeozoic metamorphosed sediments, enhanced by the epirogenetic movements of the Alpine orogeny, started cutting the dolomitic limestone plateau in several separated blocks along the major tectonic directions (NNW-SSE, NNE-SSW and E-W), causing an inversion of relief. From this period to now the individual *Tacchi* started evolving separately and the karst features show slight differences even between neighbouring table-mountains. From a geomorphological point of view the *Tacchi* of Osini and Ulassai are mainly characterised by multiple karstic forms such as sinkholes, dry valleys, larger depressions (macrodolines), caves, stone forests and other spectacular ruin-like erosional karstic forms; grykes, solution pans, karren and other minor karst phenomena are less developed (Marini & Ulzega, 1973; Bianco & De Waele, 1992; Ardaud & De Waele, 1999; Bartolo *et al.*, 1999).

The valleys that divide the *Tacchi*, some of which have rapidly evolved since Pliocene (Ulzega & Marini, 1977), are characterised by unstable flanks where landslides have repeatedly occurred in concomitance with heavy rainfalls (e.g. *Riu Pardu*) (Maxia *et al.*, 1973; Ciccu *et al.*, 1994; Ginesu, 1999).

4. THE GEOSITES

The most typical landform of the region is the so-called *Taccu* or *Tonneri*, table-like car-

bonatic mountain being the result of the geomorphologic processes that have changed the landscape since Tertiary. These geomorphic testimonies constitute the remains of a continuous dolomitic limestone platform that covered most part of central-east Sardinia, cut in many independent outcrops situated at varying heights by tectonic movements and erosion and forming a typical example of inversion of relief.

At the basis and along the borders of these mountains, in some places, the Jurassic transgression sediments of the Genna Selole Formation can be observed and the traces of the ancient excavations for lignite can still be seen along the path that runs at the basis of *Tisiddu*. On the contact of dolomitic limestones and Palaeozoic basement many karst springs are situated, most of which are used for the orchards or for public fountains (Ardaud *et al.*, 1993). In figure 3 a geological and geomorphological map of the region is given in which the three geosites are clearly reported.

One of the most typical *Tacchi* is *Monte Tisiddu* near Ulassai; this carbonatic plateau, with a surface of about 1.5 km² and walls of 50 to 100 m height, is controlled by the Forestry Department, and shows interesting and spectacular karstic landforms such as sinkholes, caves etc. (Bianco & De Waele, 1992) (Fig. 4).

There are only four pathways that allow to ascend the carbonatic plateau, while along almost the entire perimeter of *Tisiddu* vertical walls form a natural inaccessible barrier. These ancient tracks can be followed by hikers and allow to make walks of scientific and didactic interest in a mostly uncontaminated nature and with diversified and unusual panorama's on the underlying *Riu Pardu* and *Riu Ulassai* valleys and on the villages of Ulassai and Jerzu. Once on *Tisiddu* the land-



Fig. 4 - *Monte Tisiddu Tacco*: A panoramic view from *Bruncu Cococcia* towards the Northwest: on the first plan to the left the vertical walls of *Bruncu Casteddu* (*Monte Tisiddu*) and in the background the other smaller *Tacchi* of Jerzu, all covering the Palaeozoic basement profoundly incised by the Tertiary and Quaternary valleys (Photo Jo De Waele).

Tacco di Monte Tisiddu: Vista panoramica da *Bruncu Cococcia* verso Nordovest; in primo piano sulla sinistra si vedono le pareti verticali di *Bruncu Casteddu*, mentre sullo sfondo si notano gli altri piccoli *tacchi* di Jerzu, che coprono anch'essi il basamento paleozoico intensamente inciso da valli terziarie e quaternarie (Foto Jo De Waele).

scape is dominated by karstic landforms such as dolines, dry valleys, caves and karst pinnacles. From the highest top of the mountain (*Brunco Matzeu*, 957 m a.s.l.) a spectacular and widespread view stretches from the Tyrrhenian Sea to the *Gennargentu* mountains, while the nearby *Tacco* of Ulassai dominates the *Riu Pardu* valley.

The river *Pardu* flows along a NW-SE alpine fault and deeply cuts the Palaeozoic basement. This rapid deepening by erosion is related to the Plio-Quaternary uplifting of the whole area that also caused the capture

of *Riu Pardu* approximately 3 km downstream of Ulassai. This capture determines an abrupt change of direction from NW-SE to NE-SW. The rapid geomorphologic evolution of the valley has caused mass movements, mainly along tension cracks, provoking a whole generation of Quaternary landslides (Ulzega & Marini, 1977; Arisci *et al.*, 2000). The most impressive of these tension cracks is the *San Giorgio* Gorge, across which passes a road that connects the village of Osini with the carbonatic high plateau rich in karst forms, interesting endemic flora and archaeological remains

(Fig. 5). The *San Giorgio* Gorge forms the natural gateway to the plains of the karstic *Tacco* of Ulassai and is one of the Island's Natural Monuments instituted by the Regional Law n°31/1989. In this narrow gorge, wide only 8 m in some places for a height of 40 m, have been found archaeological remains of a roman settlement. Some pathways lead up into the mountain to the eastern flank of this tension crack from where the panorama dominates the entire *Riu Pardu* valley with its abandoned villages of Gairo and Osini (partially destroyed by landslides during the XXth century and particularly after exceptional rainfalls in October 1951), the reconstructed new villages and ancient and recent landslides and rockfalls. A couple of hundreds of meters to the north, along the high dolomite walls of the *Tacco*, a suspended valley testimonies an ancient Late-Tertiary hydrography.

But the most important proof of an ancient drainage basin on the *Tacco* is the enormous sinkhole and underground river passage of the *Su Marmuri* cave near Ulassai, open to public from April to October and accounting for more than 20,000 visitors/year (Fig. 6). The cave entrance is characterised by a collapse *doline* which has uncovered a very big natural tunnel. After a descent of almost 40 meters along a stairway constructed in the late 50's the cave passage becomes horizontal and is characterised by an angular development caused by the intersection of fractures along which the underground river has eroded forming this gigantic tunnel. The enormous natural underground river passage of *Su Marmuri* ends deep into the carbonatic plateau after



Fig. 5 - San Giorgio gorge: Spectacular view of the dolomite peak at the centre of the gorge, isolated by tension cracks, around which the tarmac road that connects the village of Osini with the karstic plateau of *Tacco* of Ulassai turns (Photo Jo De Waele).

La gola di San Giorgio: Vista spettacolare del picco dolomitico che si erge al centro della gola, isolato da tension cracks, attorno al quale gira la strada asfaltata che collega l'abitato di Osini con l'altopiano carsico del Tacco di Ulassai (Foto Jo De Waele).

a total length of almost 900 meters. In the median part of the cave the floor is constituted of thousands of rimstone pools (Fig. 6), followed by a giant room with impressive flowstones, stalagmites and stalactites. Close to the entrance lay two fresh-water lakes nearby which hibernate more than 10,000 bats (*Miniopterus schreibersi* NATT.) during winter. Besides this colony of bats, among the greatest known on the island, the cave

is very important for its cave dwelling fauna with rare endemic Arthropods such as the Beetle *Ovobathysciola gestroi* FAIRMAIRE (the first troglobius animal discovered by Raffaello Gestro in Sardinia at the end of the 19th century) and the Chilopod *Lithobius doderoi* SILVESTRI, both of which are typical of the *Tacchi* region (Bartolo et al., 1983; De Waele, 1996; Bartolo et al., 1999).

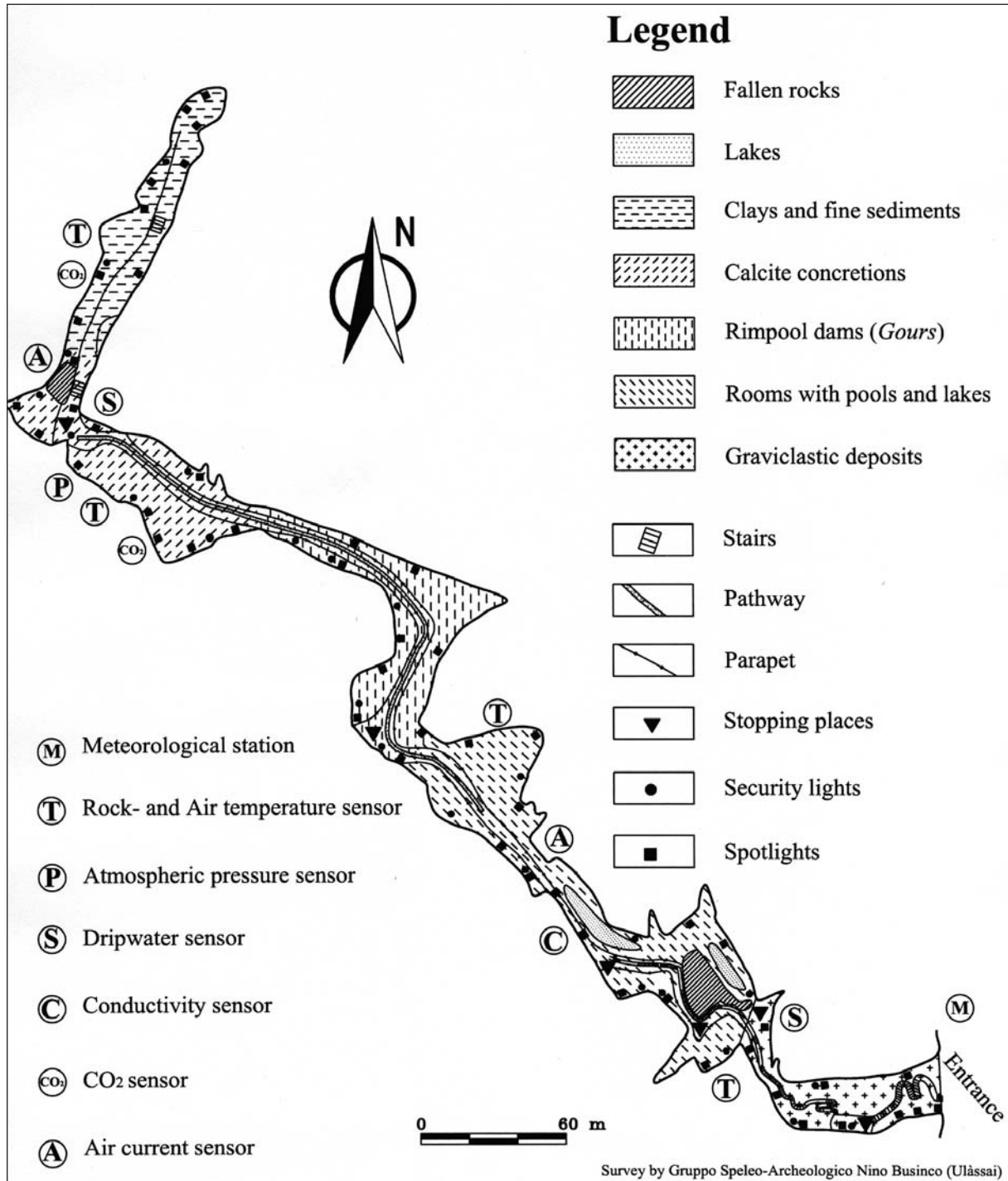


Fig. 6 - Plan of the Su Marmuri cave that takes its name from the characteristic concreting (marble), with the environmental monitoring system proposed by Ardaud & De Waele (1999) (Survey by Gruppo Speleo-Archeologico Nino Businco Ulàssai).

Pianta della grotta di Su Marmuri con il sistema di monitoraggio proposto da Ardaud & De Waele (1999): la grotta prende il nome dall'abbondante e massiccio concrezionamento. (Rilievo dal Gruppo Speleo-Archeologico Nino Businco Ulàssai).

5. PROPOSAL OF CONSERVATION AND VALORISATION

Monte Tisiddu, the gorge of *San Giorgio* and the *Su Marmuri* cave constitute all together an extraordinary example of the Tertiary-Quaternary landscape evolution of the Mesozoic carbonatic platform that characterise the central eastern part of Sardinia: the first,



Fig. 7 - Su Marmuri cave: "Galleria delle Vaschette"(Passage of the Gours) in the central part of the cave has developed along a NW-SE fracture, is characterised by vertical and rectilinear walls widened by underground fluvial erosion processes, and its floor is at present completely covered with thousands of *gours* filled with water, some of which still contain cave pearls (Photo Gabriela Pani).

La grotta di Su Marmuri: "Galleria delle Vaschette", nella parte centrale della cavità è impostata su una frattura NO-SE e si caratterizza per le pareti rettilinee e verticali allargate da processi d'erosione fluviale. Il pavimento è completamente ricoperto da migliaia di vaschette riempite d'acqua, alcune delle quali contengono perle di grotta (Foto Gabriela Pani).

with its dolines, the dry valleys and the karst pinnacles as a testimony of a well developed and mature surface karst; the second representing the tectonic and gravitational phenomena and correlated to the fragmentation of the borders of the forming carbonatic plateaus and the third emblematically testifying the underground karst evolution that started before the fragmentation of the emerged carbonate platform.

To protect and to valorise these three geosites

the Authors propose the creation of a local network of geological monuments, connected to a regional System that was started with the institution of the Regional Natural Monuments of the Regional Law 31/1989. For these purposes a program of detailed geological-stratigraphical and geomorphological survey has been foreseen that aims to put in evidence their intrinsic characteristics, essential for their appropriate valorisation and a management compatible with their effective carrying capacity, in particular for the *Su Marmuri* cave where a meteorological study will monitor the subterranean environment.

After this phase, in collaboration with the local Authorities, illustrative material will be prepared (booklets, CD Rom, synthetic thematic maps, etc.) in order to document the elements of interest of these geological landscapes and geosites and, ultimately, a series of explicative panels, containing the educational information, and signals will be positioned to enable their correct utilisation.

Aside these initiatives, anyhow, for some of these geosites (*Monte Tisiddu*, Gorge of *San Giorgio*) it will be necessary to enforce the measures of protection of the territory and the landscape, and also the formation of local guides that are prepared to explain the interest and the importance of these sites and of the network of geomorphological sites in a regional and in a national context.

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