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MAP OF THE LANDSCAPE UNITS AND GEOMORPHOSITES OF MONTE ARCI (SARDINIA)

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ABSTRACT: F. Di Gregorio & G. Piras, *Map of the landscape units and geomorphosites of Monte Arci (Sardinia).* (IT ISSN 0394-3356, 2005).
In the present paper a geomorphosites map is presented in which these sites are inserted in Landscape Units. The study area is the volcanic complex of Monte Arci in Central-West Sardinia.
By means of a detailed geomorphological mapping, performed with the aid of photo-interpretation and direct surveys in the field, different types of landscapes have been identified, according to their specific lithological, morphological and evolutive characteristics, that also have determined different types of landuse.
It has been possible to distinguish the *Landscape System* of the Pliocene volcanites of Monte Arci that has been further subdivided in the following *Landscape Units*:
- Landscape Unit of the acid lava's;
- Landscape Unit of the intermediate lava's;
- Landscape Unit of the alkaline trachites;
- Landscape Unit of the basic lava's.

The eastern flank is substantially very different and is characterised by the *Landscape System of the marine Miocene sedimentary deposits and the intra-Miocene volcanites*, with recurrent rounded hills in marly-sandy terrains with discontinuous and sporadic outcropping of infrasedimentary volcanic products mostly in relief.
The Western flank instead is characterised by the *Landscape System of the continental plio-quaternary sedimentary deposits*, with flat and downhill landforms such as glacis and alluvial mostly inactive cones.
Inside each of these *Landscape Units* several géomorphosites have been identified, mapped and classified according to their genesis, all with own specific scientific, didactic and cultural-tourist interests.
This type of analysis and cartographic representation allows to comprise inside these fundamental reference units (*Landscape Units* and *Systems*) single punctual geomorphologic elements, showing their genesis in a better way, their spatial distribution and density and the possible relation with their surrounding environment. This kind of Map constitutes a valid basic information that allows to evaluate the potential experience of the landscape as a fundamental instrument of knowledge in the territorial and landscape planning and in Environmental Impact Assessment Studies.

RIASSUNTO: F. Di Gregorio & G. Piras, Carta delle unità di paesaggio e dei geomorfositi del Monte Arci (Sardegna)*. (IT ISSN 0394-3356, 2005).*
Nel presente lavoro viene presentato un esempio di cartografia dei geomorfositi inseriti all'interno delle Unità di paesaggio che li contengono. L'area presa in considerazione è quella del complesso vulcanico del Monte Arci nella Sardegna centro-occidentale.
Tramite un dettagliato rilevamento geomorfologico, condotto con l'uso della fotointerpretazione e di rilevamenti diretti in campo, nell'area sono state identificate alcune tipologie di paesaggio in base agli specifici caratteri distintivi geolitologici, morfologici ed evolutivi, ai quali corrispondono anche ben definite tipologie di utilizzazione del suolo.
In sostanza, è possibile distinguere nel Monte Arci il Sistema di paesaggi delle vulcaniti plioceniche che, a sua volta, può essere classificato nelle seguenti Unità:
- Unità di paesaggio delle lave acide;
- Unità di paesaggio delle lave intermedie;
- Unità di paesaggio delle trachiti alcaline;
- Unità di paesaggio delle lave basiche.
Da questo si differenzia sostanzialmente il settore orientale, caratterizzato dal Sistema di paesaggi dei depositi sedimentari marini miocenici e delle vulcaniti intramioceniche, contraddistinto dalla ricorrenza di morbide forme collinari concave alla base e convesse verso l'alto, in terreni marnoso-arenacei con affioramento discontinuo e sporadico, generalmente in emergenza, dei prodotti lavici infrasedimentari.
Il settore occidentale è, invece, caratterizzato dal Sistema di paesaggi dei depositi sedimentari continentali plio-quaternari, con forme pianeggianti e pedemontane, quali glacis e conoidi alluvionali, per lo più inattive.
All'interno di ciascuna Unità di paesaggio sono stati identificati e cartografati i geomorfositi presenti distinti in base al processo genetico e al livello di interesse scientifico, didattico e turistico-culturale.
Questo tipo di analisi e di rappresentazione consente di ricomprendere all'interno delle unità fondamentali di riferimento (Unità di paesaggio e Sistemi di paesaggi) i singoli elementi geomorfici puntuali, lineari o areali, di esplicitarne meglio la genesi, la distribuzione e la densità nello spazio geografico. Questo metodo di analisi e rappresentazione costituisce una valida base conoscitiva per valutare il potenziale di esperienza del paesaggio, nella pianificazione territoriale e paesaggistica e negli studi di Valutazione di Impatto Ambientale (VIA).

Keywords: Geomorphosites, Landscape Units, Landscape Systems, Central-West Sardinia, Monte Arci, Valorisation.

Parole chiave: Geomorfositi, Unità di paesaggio, Sistema di paesaggi, Sardegna centro-occidentale, Monte Arci, Valorizzazione.

1. INTRODUCTION

In the present paper a géomorphosites map is presented in which these sites are inserted in *Landscape Units*. The study area is the volcanic complex of Monte Arci in Central-West Sardinia.

The *Landscape Unit* represents a fundamental taxonomic unit in a methodological approach of mapping of the resources of a territory based especially on its physical characteristics (Clemente, 1987; Di Gregorio, 1987; Piacente *et al.*, 2000; Poli *et al,* 1994; Romani, 1994; Turri, 1979); this allows to describe with greater detail the areas with a recurrent lithological, morphological and pedological pattern that are genetically related, or else geographical units with specific, distinctive and homogeneous characteristics of formation and evolution (Tricart & Kilian, 1979; Piacente, 1999; Romani, 1994; Sestini, 1963). This approach also permits to individuate significant elements of the landscape (Panizza, 1988), as has clearly been demonstrated by earlier experiences such as the Territorial Landscape Plan of the Emilia-Romagna Region (1987).

The *Landscape Units* are generally considered singularly or in association with other units forming *Systems* with peculiar genetic or evolutive connections; in other cases the *Landscape Units* are subdivided in single components depending on the complexity of the study area and of the desired cartographic detail (FAO, 1983).

The recognition of *Landscape Units* and *Systems* is possible by means of methods for the territorial analysis of vast regions, essentially based on remote sensing techniques or on aerial photo-interpretation. The principal fundament of validity of this type of approach relies on the fact that the landscape configuration, using geomorphologic analysing method, is the easiest characteristic of the physical attributes of a territory to recognise, classify and represent.

In particular, according to the lithologic-morphologic criteria it is possible to individuate different fundamental *Landscape Units* all of which give birth to spatial entities characterised by a distinct set forms and different from others on the base of the single constituting components. In this manner a classification of the geographic space is configured, principally based on the analysis of the geological constitution and the characterising landforms, considering that these are the expression of the evolution and of a dynamical earth surface that is realised by the interference of natural and human processes and phenomena.

Regrouping the *Landscape Units* with homogeneous genetic and evolution characteristics it is possible to define *Landscape Systems*.

Thanks to the recognition and the classification of these distinct litho-morphological units it is thus possible to make an easier reading of the territory and a more immediate and accurate qualification of the natural resources, in particular of those that constitute the peculiar physical traits because collocated in the same spatial context; in contemporary it is possible to individuate the situations of interference between natural and human factors, or a combination of these, for a more rational use and tutelage of the same resources and a better insertion in eventual settlements and infrastructures in the natural and human existing landscape (Clemente, 1987).

This methodology has been applied in the Monte Arci area, in central-west Sardinia, collimating particularly the attention on the relationship between geosites and géomorphosites, *Landscape Units* and *Systems* (Tab. 1).

2. GEOLOGICAL AND GEOMORPHOLOGICAL ASPECTS OF MONTE ARCI

Monte Arci is an important Tertiary and Plio-Quaternary volcanic complex characterised by a wide variety of effusive rocks and interesting structural or residual landforms derived from ancient palaeogeographic and palaeoclimatic events.

The products of the volcanic activity that can be found on Monte Arci are referable to two different chronological events, each of which have distinct precise volcanologic and geodynamic characters.

To the intra-Miocene volcanism, referable to the tectonic evolution of the Western Mediterranean (Cherchi & Montadert, 1982) are correlated mostly discontinuous outcrops intercalated in the marly-arenaceous Miocene sediments of Marmilla (Maccioni, 1969; 1974), constituted of basic rocks with calco-alcaline affinities, related to a submarine volcanism dated 19÷5 My (Savelli, 1975; Di Paola *et al.*, 1975). Such outcrops are constituted, from bottom to top, by submarine pillow lava's with infrasedimentary hyaloclasts and monogenetic breccia of pillow lava's with minor presence of hyaloclasts.

To the Late-Pliocene cycle the emission of the lava's that have originated the volcanic complex of Monte Arci during distensional phenomena of the continental Sardinian plate and the formation of the tectonic graben of Campidano are attributed, with basic, intermediate and acid rocks related to subaerial volcanism. Radiometric dating (Belluomini *et al.*, 1970; Belluomini & Taddeucci, 1970; Savelli, 1975; Di Paola *et al.*, 1975; Bigazzi *et al.*, 1976; Beccaluva *et al.*, 1985; Montanini, 1992; Montanini & Villa, 1990, 1993) has allowed to date the Pliocene volcanic activity between 5 and 2.6 My.

The succession of volcanic products recognised by several Authors (Di Paola *et al.*, 1975; Beccaluva *et al*., 1975, 1977; Assorgia *et al.*, 1975; 1976), from bottom to top is represented by:

- Acid lava's, constituted of rhyolite-rhyodacite flows with transition of lithoid facies to perlite-obsidian facies with associated pyroclastic levels;
- Intermediate lava's, mainly dacitic and subordinately andesitic, with evident slabby fissuring;
- Alcaline trachites, sometimes passing to vitrophyric facies;
- Basic lava's, separated in basaltic andesites, basalts with an alkaline chemistry and subalcaline basalts;

The Plio-Quaternary continental sedimentary deposits are mainly composed of:

- Conglomerates, sands and more or less compact clays, mainly composing alluvial cones and glacis (ancient alluvium Auct.);
- Recent and present alluvium along river beds.

Altogether Monte Arci has a typical form of elliptic ridge elongated in N-S direction that reaches its

Tab. 1 - Systems and Landscape Units of Monte Arci.
Sistemi e Unità di Paesaggio del Monte Arci.

Landscape System	Landscape Unit	Location	General Morphology	Summary of main physical features
1 Plio-Quaternary sedimentary-continental deposits	Recent and modern alluvium of main river beds	Riu Florissa, Riu Tumboi, Gora Tappoi	More or less V- or U-shaped enclosed valleys	- enclosed valleys - waterfalls
	Glacis and alluvial fans	Pranu Tiria, Pranu Forru, Madala, Mandronis, Sa Giara, Pira Inferta S'Argioledda	Largely inactive glacis and alluvial fans	- glacis - alluvial fans
2 Pliocene volcanic rocks	Basic lava flows	Pranu Terra, Pranu Mallu,Pranu Santa Lucia, Su Tasureddu, Campu Serrau, Apruna, Acqua Marzana, Arrideli, Benazzeddus, Corona Su Pardu, Pranu Murta, Pranu Pira, Pranu Sibiriu	Near horizontal or gently undulating basic lava plateaus and lava flows	- basalt plateaus - temporary wetlands - dykes - necks - lava domes - column jointing
	Trachytic lava flows	Punta Quebiois, Is Benas Serra Arruidroxiu, Punta S'Orziada, Punta Masoni Perdu, Rocce Su Colombariu	Rugged, porphyry and intensely honeycomb-weathered rock outcrops	- small cavities and tafoni - slightly enclosed valleys - near vertical walls
	Intermediate lava flows (andesite and dacite)	Costa Pisu, Braxelogu, Pranu Piccinu, Cuccuru Mattivi, Conca Mraxi, Bruncu su Copiu	Gently inclined lava flows often fractured and slab-like, surrounded by near vertical rock walls	- lava flows - fractures with slab like geometry - near vertical rock walls - enclosed valleys - pseudo-karst cavities - waterfalls
	Acid lava flows (rhyolitic, rhyolitic-rhyodacitic) often in perlite-obsidian facies, sometimes associated with pyroclastic strata	Punta Laccu Sa Vitella, Genna Spina, Perdas Urias, Punta Nicola Pani, Conca S'Ollastu, Punta Su Cantareddu, Mt. Sparau	Rugged landforms with steeply inclined slopes, sharp breaks of slope and enclosed valleys	- enclosed valleys - pyroclastic sequences - obsidian deposits - tafoni - perlite quarries
3 Miocene sedimentary marine deposits and intra-Miocene volcanic rocks	Marly-sandy sediments intercalated with submarine basic pillow or brecciated lavas, with associated hyaloclastites	Cea Pedrixi, Sa Spendula, Truncheddu, Cannisone, Pranu Espis, Serra Craboni, Pala Sa Murta, Su Entosu, Santa Maria, Corona Fraus	Repetitive, gently rolling hills on marly-sandy terrains with discontinuous and sporadic outcrops of intrasedimentary lava products	- repetitive rolling hills - enclosed valleys - pillow lavas - waterfalls

highest altitude at the neck named Trebina Longa (812 m a.s.l.). The Western sector that overviews the Campidano is composed of volcanic flows, mostly rhyolite, deeply cut by valleys that flow into the plain. The Eastern sector is characterised by a morphology of plateau with different almost horizontal plains limited by rocky cliffs and steep surfaces that form a clear contrast with the sweet hills of the Marmilla.

3. THE LANDSCAPE SYSTEMS AND UNITS OF MONTE ARCI

To facilitate the individuation of the géomorphosites, according to the definition given by Barca & Di Gregorio (1991) and by Panizza & Piacente (1989), on Monte Arci firstly the territory has been subdivided in *Landscape Units* and *Systems* (Fig. 1). In more detail, using lithological and morphological criteria the main

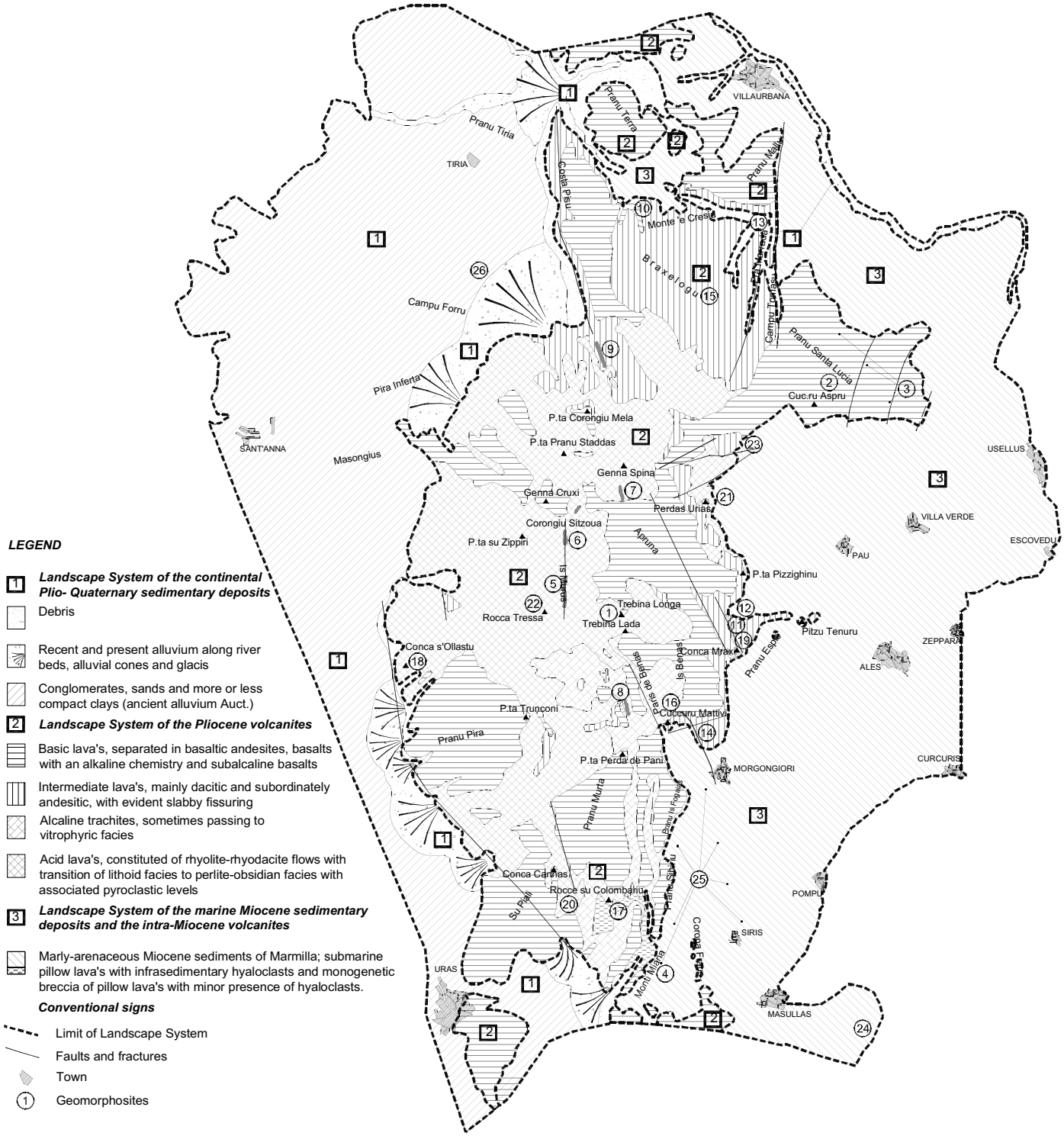

Fig. 1 – Map of the Landscape Units and Systems of Monte Arci
Carta dei Sistemi e Unità di paesaggio del Monte Arci.

geomorphological units have been identified, all of which give rise to a landscape with precise, distinctive and homogeneous genetic and evolutive characters. Following these criteria the *Landscape Systems* have been recognised and, for each of these, have been distinguished the *Landscape Units* and also the single physiographic components present in them. Practically, from the performed research using detailed field work and photo-interpretation, it has been possible to distinguish the *Landscape System of the Pliocene volcanites* of Monte Arci that has been further subdivided in the following *Landscape Units*:

- *Landscape Unit of the acid lava's*, characterised by an articulated and uneven morphology especially where massive rhyolites crop out, with steep sides and clear breaks of slope where the less resistant perlite-obisian facies are surfacing and the presence of a well developed fluvial network, typical of the Western flank;
- *Landscape Unit of the intermediate lava's*, characterised by a plateau morphology on the lava flows recognisable by the slabby fissuration of the rocks;
- *Landscape Unit of the alkaline trachites* with landforms prevalently related to meteoric subaerial processes with hollows and tafoni;
- *Landscape Unit of the basic lava's* characterised by table-like morphologies bordered by vertical cliffs or steep slopes.

From these units the Eastern flank is very different, characterised by the *Landscape System of the marine Miocene sedimentary deposits and the intra-Miocene volcanites*, characterised by recurrent rounded hills in marly-sandy terrains with discontinuous and sporadic outcropping of infrasedimentary volcanic products mostly in relief.

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4. THE GEOMORPHOSITES

Inside the *Landscape Units* of Monte Arci many géomorphosites have been identified (Tab. 2) that represent a high didactic and scientific value, as testimonies of particular past and still ongoing evolutive geological and geomorphological processes (Barca *et al.*, 1997; Di Gregorio & Piras, 1997). Some of these géomorphosites can be considered as single or isolated elements (*Sa Perda Sperrada*, the columnar fissuring of *Is Aruttas Santas*, the andesitic *Megapillow of Gutturu Forru* and the isolated outcrops of pillow lava's, the volcanic *necks* of *Trebina Longa* and *Trebina Lada*, the waterfalls of *Sa Spendula* and *Su Fustiolau*) others are better identified as linear morphotypes (the cliffs of *Conca Mraxi* and the pyroclastic levels at their foot, the river *Riu Tumboi* and its tributaries, the emerging basaltic dykes of *Is Murus*, *Corongiu Sitzoua*, *Acquafrida*, *Paris de Benas*, *Sa Dispensa*) or as aerial more or less relevant sites (the basaltic plateau of *Pranu Santa Lucia* and the temporary wetlands called *paulis* on its summit, the tafoni of *Is Benas*, *Rocce su Colombariu* and *Conca s'Ollastu*, the steppe-like environments of *Campu Forru* and *Pranu Tiria*).

Some of these sites (the hypogean Neolithic burial of *Su Segretu de sa Conch'e s'Omini*, the nuragic hypogean temple of *Sa Grutta de is Coambus*, the obsidian sites of *Perdas Urias*, *Conca Cannas* and *Tzipaneas*) have a great archaeological interest, as testimonials of the life and the artefacts of the ancient populations that have lived in this territory, founding the seam of the Nuragic culture started with the industry of the obsidian that took up the confront with many other Mediterranean cultures.

5. CONCLUSIONS

Geomorphosites are among the multiple and complex environmental components of the landscape that need to be studied and on which whatever Territorial and Environmental Planning should be based, occupying a fundamental role for their value as a non renewable resource, sometimes unique for their intrinsic characteristics.

Possible risks for the integrity or the complete destruction of this heritage can be avoided only by a detailed territorial analysis founded on the impact assessment of the projects regarding the occupation of the soil, the use of the natural resources and the urbanisation.

By means of a detailed geomorphological mapping, performed with the aid of photo-interpretation and direct surveys in the field, different types of landscapes have been identified at Monte Arci (Central-West Sardinia), according to their specific lithological, morphological and evolutive characteristics, that also have determined different types of landuse. Inside each of these *Landscape Units* several géomorphosites have been identified, mapped and classified according to their genesis, all with own specific scientific, didactic and cultural-tourist interests.

This type of analysis and cartographic representation allows to comprise inside these fundamental reference units (*Landscape Units* and *Systems*) single punctual geomorphologic elements, showing their genesis in a better way, their spatial distribution and density and the possible relation with their surrounding environment. This kind of Map constitutes a valid basic information that allows to evaluate the potential experience of the landscape as an fundamental instrument of knowledge in the territorial and landscape planning and in Environmental Impact Assessment Studies.

The cartographic work of recognition of the *Landscape Units* and *Systems* has allowed to identify various géomorphosites. The adopted analysis and the evaluation of these géomorphosites inside a physiographic reference unit permits to reveal a predominance of sites in the *Landscape Units* of the Tertiary volcanic rocks, showing a more relevant geodiversity and a higher Multiple Value (Di Fidio, 1990) of landscape elements that can be used for e recreational experience of the landscape by Geotourism.

Tab. 2 – Geomorphosites of Monte Arci.
I Geomorfositi del Monte Arci.

Landscape System of the Pliocene volcanic rocks						
Name	*Municipality*	*Location*	*I.G.M. reference*	*Genetic Classification*	*Rock type*	*Genetic definition*
Basalt flows *landscape Unit*						
1 - Trebina Longa - Trebina Lada	Morgongiori	Porteddu Murus	539 IV MK78300288	Volcanic	Basalt	Volcanic *necks*
2 - Pranu Santa Lucia	Villav. - Usellus	Pranu Santa Lucia	529 III MK82450798	Volc.-Struct.	Basalt	Volcanic *plateau*
3 - *Paulis* del Pranu Santa Lucia	Villav.- Usellus	Pranu Santa Lucia	529 III MK83050950	Lacustrine	Basalt	Temporary basins
4 - Sa Perda Sperrada	Masullas	Perda Sperrada	539 IV MJ79039546	Struct.-Meteoric	Basalt	Morphosculpture
5 - "Is Murus" dyke	Marrubiu	Is Murus	539 IV MK76930385	Volcanic	Basalt	Outcropping dyke
6 - "Corongiu Sitzoua" dyke	Marrubiu	Corongiu Sitzoua	539 IV MK76930495	Volcanic	Basalt	Outcropping dyke
7 - "Acquafrida" dyke	Ales	Acquafrida	529 III MK78200593	Volcanic	Basalt	Outcropping dyke
8 - "Paris de Benas" dyke	Morgongiori	Paris de Benas	539 IV MK78340113	Volcanic	Basalt	Outcropping dyke
9 - "Sa Dispensa" dyke	Palmas Arborea	Sa Dispensa	529 III MK77810878	Volcanic	Basalt	Outcropping dyke
10 - Is Aruttas Santas basalt columns	Villaurbana	Is Aruttas Santas	529 III MK78631228	Volc. – Struct.	And.– basalt.	Columnar jointed basalt
Intermediate lava flows *landscape Unit*						
11 - "Cliffs" at Conca Mraxi	Ales - Pau - Morgongiori	Conca Mraxi	539 IV MK80750245	Struct. - Slope	Rhyolite - Dacite	Sheer volcanic walls
12 - "Sa Spendula" waterfall	Ales	Cadresa	539 IV MK80250338	Fluvial – Struct.	Dacite	Waterfall
13 - Riu Tumboi and affluents	Villaurbana	Riu Tumboi	529 III MK80051245	Fluvial – Struct.	Dacite – And.	Small fluvial valleys
14 - *Sa Grutta de is Coambus*	Morgongiori	Punta Santu Marcu	539 IV MK79950093	Anthropogenic	Dacite	Natural cavities hypogeum temple ipogeo
15 - Su Segretu de sa Conch'e s'Omini	Villaurbana	Braxelogu	529III MK80101043	Anthropogenic	Dacite	Natural cavities hypogeum
Alkali trachitic lava flows *landscape Unit*						
16 - Is Benas	Morgongiori	Is Benas	539 IV MK79250150	Meteoric	Trachyte	Honeycombed rock
17 - Rocce su Colombariu	Masullas	Rocce su Colombariu	539 IV MJ77989695	Meteoric	Trachyte	Honeycombed rock
Acid lava flows *landscape Unit*						
18 - Conca s'Ollastu	Marrubiu - Morgongiori	Conca s'Ollastu	539 IV MK73550217	Meteoric	Rhyolite	Honeycombed rock
19 - Layers of pyroclastic rock	Ales - Morgongiori	Conca Mraxi	539 IV MK80750245	Volcanic	Pyroclastic	Pyroclastic rock sequences
20 - Conca Cannas obsidian deposit	Masullas	Conca Cannas	539 IV MJ77389713	Volcanic	Rhyolite	Obsidian deposit
21 - Perdas Urias obsidian deposit	Pau	Perdas Urias - Sennixeddu	529 III MJ80360621	Volcanic	Rhyolite	Obsidian deposit
22 - Tzipaneas obsidian deposit	Marrubiu	Tzipaneas	539 IV MK76530371	Volcanic	Rhyolite	Obsidian deposit
***Landscape System* of the Miocene marine sedimentary deposits and IntraMiocene volcanic rocks**						
23 - "Fustiolau" waterfall	Pau	Truncheddu	539 IV MK80930684	Fluvial – Struct.	Marl – Aren.	Waterfall
24 - *Megapillow* at Gutturu Forru	Masullas	Gutturu Forru	539 III MJ83509418	Volcanic	Andesite	Andesitic *megapillow*
25 – Outcrops of pillow lava	Masullas - Siris - Morgongiori	Santa Maria - Pala Sa Murta	539 IV MJ79089557	Volcanic	Basalt – And.	Pillow lava
***Landscape System* of the Plio-Quaternary continental sedimentary deposits**						
26 – Steppe environments at Campu Forru and Pranu Tiria	Palmas Arborea - Oristano	Campu Forru - Pranu Tiria	529 III MK76111039	Fluv. – Anthrop.	Alluvia	Steppe environments and lakes in hills

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