

**Annex no. 1**



# **Apuane Geopark**

**Description of the most important Geosites  
in the Apuan Alps Regional Park**



**Massa (Italy)  
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## INTRODUCTION

The Application Dossier describes the geological uniqueness and richness of the Apuan Alps, with several cases of a certain importance. The Regional Park (aspiring Geopark) identifies the geosites as indicators of territorial geodiversity and elements of geological and geomorphological interest.

The main criteria applied in the choice of these geosites were as follows: uniqueness within the regional area/national territory; representativeness or exemplarity of a specific process; scientific importance and contextual interest; conservation status and risk of deterioration (natural/anthropogenic); educational and tourist importance; landscape, historical, cultural and ecological values. In particular, I.S.P.R.A. (Italian Institute for Environmental Protection and Research) survey methodology has been adopted. The criteria for the census and the filing have identified 253 geosites. All geosites are represented in the cartographic annex: *Geosite Map of the Apuan Alps Regional Park* with a scale ratio of 1:50.000 .

In order to focus on the geological and geomorphological peculiarities, twenty-nine relevant categories of geosites representing the main processes (responsible for the genesis and the evolution of the territory) have been identified: tectonic window, tectonic unconformity, tectonic interference, isolated peak, ridge, natural arch, cuèsta, great wall, gorge, embedded meander, old river-bed, pothole, U-shaped valley, glacial cirque, overdeepened basin, glacial saddle, roche moutonnée, moraine ridge, cemented moraine, erratic block, karren field, doline field, doline, karst cave, ice cave, spring, thermal spring, mineral site, paleontological site. Attention was paid to those elements testifying, in a clear and illustrative way, to a past event of the geological history, helping understand the territorial evolution of each sector of the Park.

The full list of 253 geosites is inserted in the following pages and a detailed analysis of 55 main geosites of the area proposed as Geopark is also present. The sites of higher geological value, representing one or more processes for every main category are identified. Each selected geosite has an inventory card with a description of the level of interest and a geological and environmental explanation. Their location is referred to sixteen Park sectors, as shown in figure no. 1.

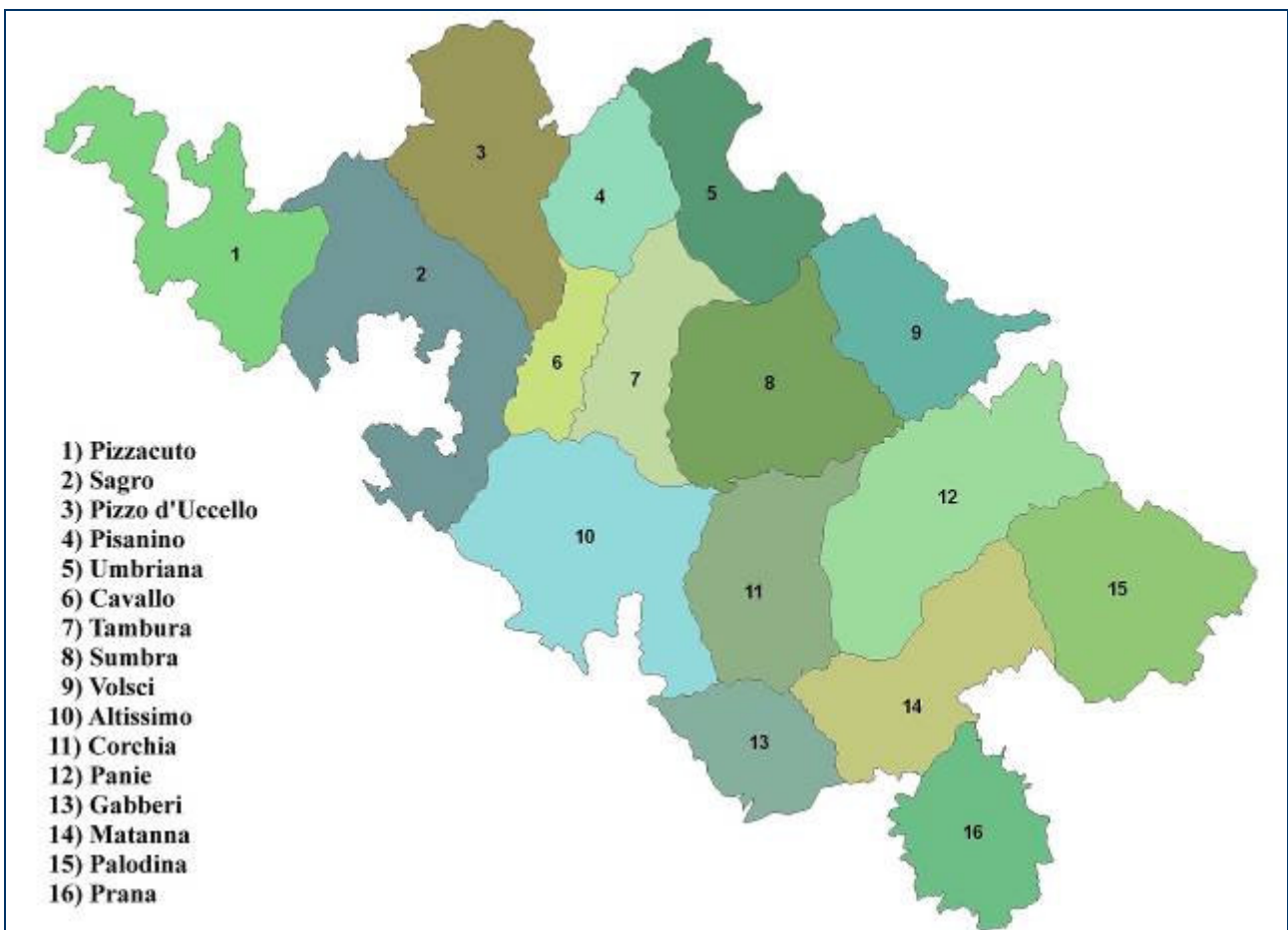
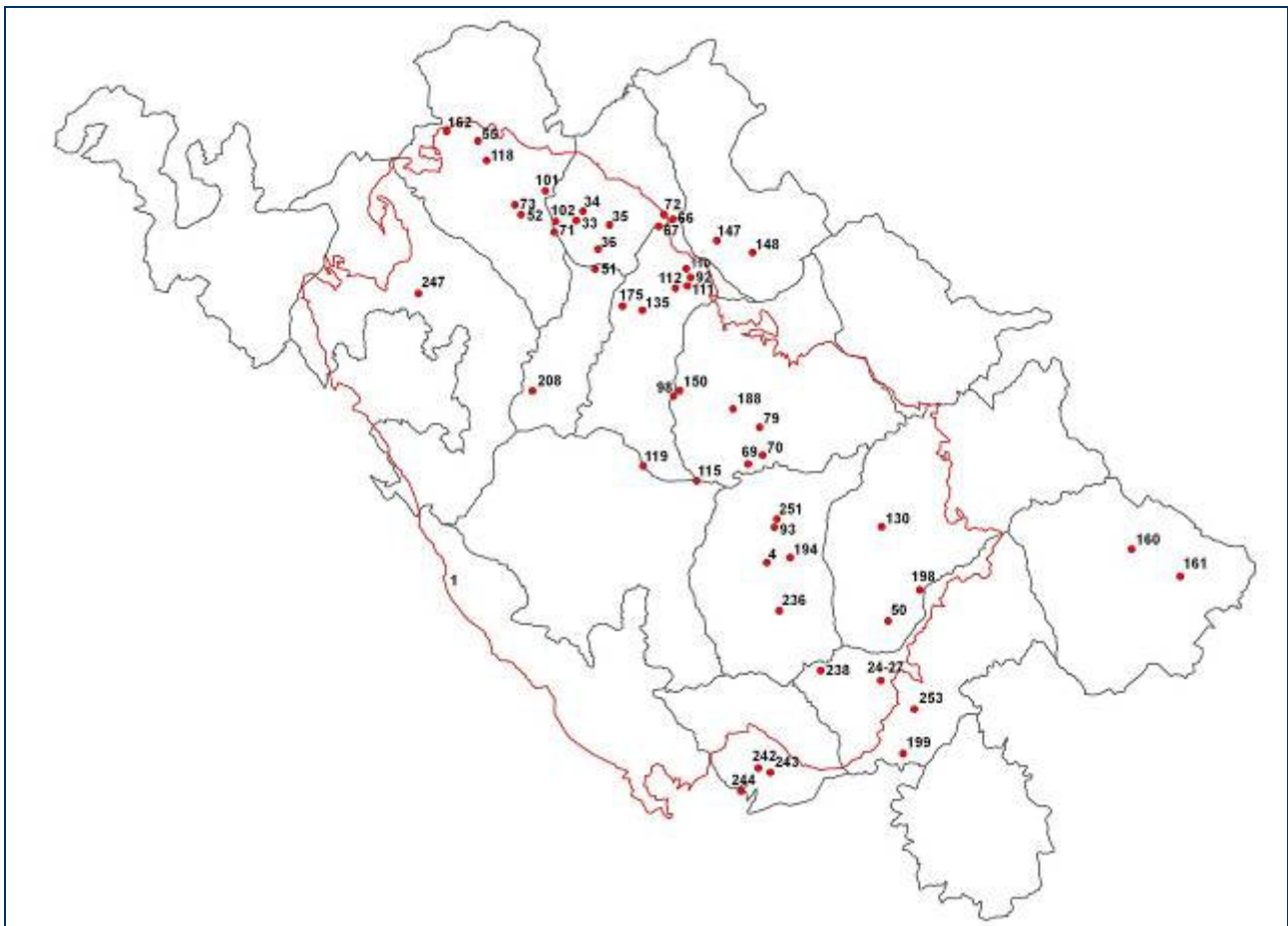
The location of each selected geosite is referred to sixteen Park sectors, as represented in the figure no. 1.a. Each Park sector's name in the figure no. 1.b is indicated. The sectors' name corresponds to the most important Mount here located.

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figures: 1.a (up) The location of the main geosites in the Park areas – 1.b (down) The name of the Park areas

**List of the Geosites identified and registered in the aspiring Geopark's territory, ordered by typology and indicating their location (Park sector)**

<b>typology</b>	<b>n.</b>	<b>geosite</b>	<b>park sector</b>	
<b>tectonic window</b>	1	Apuan Alps	Apuan Alps	
	2	Tenerano	Sagro	
	3	Sant' Anna	Gabberi	
<b>tectonic unconformity</b>	4	Corchia ( <i>west and south</i> )	Corchia	
<b>tectonic interference</b>	5	Pizzo d'Uccello	Pizzo d'Uccello	
<b>isolated peak</b>	6	Guglie della Vaccareccia	Pizzo d'Uccello	
	7	Torre Val d'Alberghi	Pizzo d'Uccello	
	8	Torrione Figari	Pizzo d'Uccello	
	9	Punta Quèsta	Pizzo d'Uccello	
	10	Torre di Monzone	Sagro	
	11	Puntone della Piastra	Sagro	
	12	Pizzo del Cottonificio (Pizzacuto)	Sagro	
	13	Punta Carina	Cavallo	
	14	Punta Graziosa, Sicilia, Ferro	Cavallo	
	15	Guglia di Piastramarina	Cavallo	
	16	Torre dei Campaniletti	Tambura	
	17	Torrioni di Passo Croce	Corchia	
	18	Torre di Corchia	Corchia	
	19	Guglia di Pietreto	Corchia	
	20	Torre occidentale	Corchia	
	21	Rocchette	Panie	
	22	Torre Oliva	Panie	
	23	Torrioni del Pizzo delle Siette	Panie	
	24	Procinto	Matanna	
	25	Torrione Bacci (Bimbo)	Matanna	
	26	Piccolo Procinto	Matanna	
	27	Bimba	Matanna	
	28	Pietralunga del Gabberi	Gabberi	
	<b>ridge</b>	29	Nattapiana	Pizzo d'Uccello
		30	Capradossa	Pizzo d'Uccello
		31	Pizzo d'Uccello ( <i>south</i> )	Pizzo d'Uccello
		32	Garnerone-Grondilice	Pizzo d'Uccello
		33	Bagola Bianca	Pisanino
34		Forbice	Pisanino	
35		Mirandola	Pisanino	
36		Pisanino-Zucchi	Pisanino	
37		Contrario-Cavallo	Cavallo	
38		Cresta Botto	Cavallo	
39		Coda del Cavallo	Cavallo	
40		Focoletta-Macina	Tambura	
41		Vestito-Pelato	Altissimo	
42		Altissimo	Altissimo	
43		Cresta degli Uncini	Altissimo	
44		Rovaio-Spigolo del Gesù	Panie	
45		Pania della Croce-Pizzo delle Siette	Panie	
46		Omo morto	Panie	
47		Pania Secca ( <i>north</i> )	Panie	
48		Gran Pilastro ( <i>south-east</i> )	Panie	
49		Gialunga	Panie	
<b>natural arch</b>	50	Forato	Panie	
<b>cuèsta</b>	51	Pizzo Altare	Pisanino	
<b>great wall</b>	52	Pizzo d'Uccello ( <i>north</i> )	Pizzo d'Uccello	
	53	Altissimo ( <i>south</i> )	Altissimo	
	54	Nona ( <i>west</i> )	Matanna	

typology	n.	geosite	park sector
<i>gorge</i>	55	Solco d'Equi	Pizzo d'Uccello
	56	Serchio di Gramolazzo	Pizzo d'Uccello-Pisanino
	57	Canale dell'Inferno	Volsci
	58	Valle Alberghi	Pizzo d'Uccello-Cavallo
	59	Fosso Tambura	Tambura
	60	Torrente Serra	Altissimo
	61	Canale Levigliese	Panie
	62	Fosso Apraia	Sumbra-Volsci
	63	Rio Lombricese	Matanna-Prana
<i>embedded meander</i>	64	Le Tagliate	Sumbra-Corchia
	65	Turrite-Anguillaja	Sumbra-Corchia
<i>old river bed</i>	66	Piano di Gorfigliano ( <i>north</i> )	Pisanino
	67	Piano di Gorfigliano ( <i>south</i> )	Pisanino
<i>pot-hole</i>	68	Valle Alberghi	Pizzo Uccello-Cavallo
	69	Fosso del Fato Nero	Sumbra
	70	Fosso dell'Anguillaja	Sumbra
<i>U-shaped valley</i>	71	Orto di Donna-Serenaia	Pizzo d'Uccello-Pisanino
	72	Piano di Gorfigliano	Pisanino-Umbriana
<i>glacial cirque</i>	73	Pizzo d'Uccello ( <i>north</i> )	Pizzo d'Uccello
	74	Grondilice ( <i>north-east</i> )	Pizzo d'Uccello
	75	Cavallo ( <i>north-west</i> )	Cavallo
	76	Spallone-Foce di Pianza	Sagro
	77	Catino del Sagro	Sagro
	78	Roccandagia	Tambura
	79	Sumbra ( <i>south</i> )	Sumbra
	80	Grotta Giuncona	Altissimo
	81	Altissimo ( <i>south</i> )	Altissimo
	82	Cervairole	Altissimo
	83	Retrocorchia	Corchia
	84	Corchia ( <i>south</i> )	Corchia
	85	Pizzo delle Saette ( <i>west</i> )	Panie
	86	Pizzo delle Saette ( <i>north</i> )	Panie
	87	Pania Secca ( <i>north</i> )	Panie
	88	Pania Secca ( <i>south-east</i> )	Panie
	89	Canale dell'Inferno	Panie
	90	Prati di Valli	Panie
<i>overdeepened basin</i>	91	Pianellaccio	Pisanino
	92	Camlocatino	Tambura
	93	Fociomboli	Corchia
	94	Mosceta	Corchia
<i>glacial saddle</i>	95	Passo Giovo	Pizzo d'Uccello
	96	Foce di Pianza	Sagro
	97	Passo della Focolaccia	Cavallo-Tambura
	98	Passo Sella	Tambura-Sumbra
	99	Passo del Vestito	Tambura-Altissimo
	100	Foce di Mosceta	Corchia-Panie
<i>roche moutonnée</i>	101	La Tecchiarella	Pizzo d'Uccello
	102	Val Serenaia	Pizzo d'Uccello-Pisanino
<i>moraine ridge</i>	103	Foce Rifogliola	Pisanino
	104	Canale Libardo	Pisanino
	105	Fosso Sirchia, Pianellaccio ( <i>north</i> )	Pisanino
	106	Fosso Sirchia, Pianellaccio ( <i>south</i> )	Pisanino
	107	Gorfigliano	Pisanino
	108	Pesciola	Umbriana
	109	Case Walton	Sagro
	110	Camlocatino ( <i>north</i> )	Tambura
	111	Camlocatino ( <i>south</i> )	Tambura
	112	Camlocatino ( <i>west</i> )	Tambura
	113	Vagli Sopra	Tambura

typology	n.	geosite	park sector
<i>moraine ridge</i>	114	Arni	Tambura-Sumbra
	115	Campagrina ( <i>Stoppani's moraine</i> )	Altissimo-Sumbra
	116	Puntato	Corchia
	117	Pianiza, Alpe di S. Antonio	Panie
<i>cemented moraine</i>	118	Valtredi, Solco d'Equi	Pizzo d'Uccello
	119	Gobbie	Altissimo
	120	Val Terreno	Corchia
<i>erratic block</i>	121	Rondinella	Tambura
	122	Pastificio Vagli	Tambura
	123	Valle dell'Edron	Tambura
<i>karren field</i>	124	Catino del Sagro	Sagro
	125	Orto di Donna	Pizzo d'Uccello
	126	Cavallo ( <i>north</i> )	Cavallo
	127	Valle di Arnetola	Sumbra
	128	Passo Sella	Tambura-Sumbra
	129	Sumbra ( <i>south</i> )	Sumbra
	130	Vetricia	Panie
	131	Valle dell'Inferno	Panie
	132	Prana	Prana
<i>doline field</i>	133	Mirandola	Pisanino
	134	Foce di Cardeto	Pisanino
	135	Carcaraia	Tambura
	136	Bergiola Foscalina	Sagro
	137	Penna	Palodina
<i>doline</i>	138	Castri	Pisanino
	139	Calamaio	Pisanino
	140	Bandita	Sagro
	141	Caporinella	Sagro
	142	Alpe di Burla	Sagro
	143	Ballerino	Sagro
	144	Catino del Sagro	Sagro
	145	Spallone	Sagro
	146	Campaccio di Carcaraia	Tambura
	147	Tontorone	Umbriana
	148	Corona	Umbriana
	149	Torre	Sumbra
	150	Passo Sella	Sumbra
	151	Fiocca ( <i>north-east</i> )	Sumbra
	152	Sumbra ( <i>north-west</i> )	Sumbra
	153	Pian della Fioba	Altissimo
	154	Corchia ( <i>north</i> )	Corchia
	155	Montalto	Corchia
	156	Bucaccia di Grottorotondo	Panie
	157	Tre Corna	Matanna
	158	Catino d'Àleva	Matanna
	159	Matanna	Matanna
	160	Pian di Lago-Pian di Corte	Palodina
	161	Penna	Palodina
<i>karst cave</i>	162	Buca e Tecchia d'Equi	Pizzo d'Uccello
	163	Buca delle Ombre	Pizzo d'Uccello
	164	Buca Nuova	Pizzo d'Uccello
	165	Abisso Olivifer	Pizzo d'Uccello
	166	Speluca della Fanaccia	Pisanino
	167	Complesso Pannè-MC5-Pannino	Pisanino
	168	Tecchia di Tenerano	Sagro
	169	Complesso della Rocca di Tenerano	Sagro
	170	Abisso dello Smilodonte	Sagro
	171	Tanone di Torano	Sagro
	172	Complesso della Carcaraia	Tambura

typology	n.	geosite	park sector
<i>karst cave</i>	173	Abisso Perestroika	Tambura
	174	Abisso Mani Pulite	Tambura
	175	Abisso Roversi	Tambura
	176	Complesso della Tambura	Tambura
	177	Cavit� relitte del Sella	Tambura
	178	Abisso Guaglio	Tambura
	179	Abisso Pozzi	Tambura
	180	Abisso Coltelli	Tambura
	181	Abisso Mandini	Tambura
	182	Buca di Renella	Cavallo
	183	Buca dell'Onice	Cavallo
	184	Abisso Eunice	Sumbra
	185	Complesso Simi-Pelegalli-Mamma Ghira	Sumbra
	186	Complesso Gnomo-Giardino	Sumbra
	187	Buca Go Fredo	Sumbra
	188	Abisso dei Draghi Volanti	Sumbra
	189	Buca Grande del Pelato	Altissimo
	190	Complesso Pelato-Astrea-Generatore	Altissimo
	191	Abisso Zuffa-Gomito-Ribaldone	Altissimo
	192	Abisso dei Fulmini	Altissimo
193	Abisso Milazzo	Altissimo	
194	Complesso del Corchia	Corchia	
195	Buca dell'Osso	Corchia	
196	Abisso Revel	Panie	
197	Buca del Vento del Trimpello	Panie	
198	Tana che Urla ( <i>Vallisneri's cave</i> )	Panie	
199	Grotta all'Onda e Buca del Tasso	Matanna	
<i>ice cave</i>	200	Foce di Cardeto	Pisanino
	201	Valle dell'Inferno	Panie
<i>spring</i>	202	Equi (Buca-Barrila)	Pizzo d'Uccello
	203	Lucido di Vinca	Sagro-Pizzo d'Uccello
	204	Carbonera	Sagro
	205	Torano	Sagro
	206	Tana dei Tufi	Sagro
	207	Cartaro	Sagro
	208	Frigido	Cavallo
	209	Aiarone	Sumbra
	210	Renara	Altissimo
	211	La Polla di Altagnana	Altissimo
	212	La Polla dell'Altissimo	Altissimo
	213	La Pollaccia	Corchia
	214	Chiesaccia	Panie
	215	Polla dei Gangheri	Panie
	216	Fontanacce	Matanna
	217	Botronchio	Matanna
	218	Grotta all'Onda	Matanna
	219	Mulinette	Gabberi
220	Mulini di S. Anna	Gabberi	
<i>thermal spring</i>	221	Equi	Pizzo d'Uccello
	222	Acqua Salata di Monzone	Sagro-Pizzo d'Uccello
	223	Acqua Nera di Monzone	Sagro-Pizzo d'Uccello
<i>mineralogical site</i>	224	�iola	Pizzo d'Uccello
	225	Fondone	Pizzo d'Uccello
	226	Gorfigliano	Pisanino
	227	Foce Tambura	Tambura
	228	Bascugliani	Sumbra
	229	Nocchia	Sumbra
	230	Col di Beteto	Sumbra
231	Fiocca-Faniello	Sumbra	

typology	n.	geosite	park sector
<i>mineralogical site</i>	232	Scortico-Ravazzone	Sagro
	233	Frigido	Sagro
	234	Colle Panestra	Panie
	235	Trimpello	Panie
	236	Levigliani	Corchia
	237	Tana-Pruno	Corchia
	238	Buca della Vena	Matanna
	239	Canale della Radice-Mulina	Gabberi
	240	Bottino-Gallena	Gabberi
	241	Argentiera-La Rocca	Gabberi
	242	Buca dell' Angina	Gabberi
	243	Arsiccio	Gabberi
	244	Valdicastello-Pollone	Gabberi
	<i>paleontological site</i>	245	Grondilice ( <i>north-east</i> )
246		Poggio Troncone	Sagro
247		Foce di Pianza	Sagro
248		Ponte Storto	Pizzacuto-Sagro
249		Cima d'Uomo	Sagro
250		Fatonero	Sumbra
251		Fociomboli	Corchia
252		Ceto	Corchia
253		Alto Matanna	Matanna



*figure 2 – Eastern slope of Mt. Matanna (1318 m): wide outcrop of “red ammonitiferous Limestone”*



**location**

region	Tuscany
province	Lucca-Massa Carrara
municipality	various
sector	North-western Tuscany
toponym/locality	Apuan Alps

**interest**

scientific interest	structural geology geo-history
contextual interest	landscape, historical botanical, faunal, etc.
interest evaluation	representative
level of interest	international

**conservation status**

characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

The inner part of the Apuan Alps is characterized by a large tectonic window with the shape of an irregular ellipsis. It is a typical geological structure formed by the erosion of the thrust system, which exposes the deepest structural units of the Northern Apennines made of a metamorphic complex originated during the Alpine orogeny. The Apuan tectonic window is one of the best examples of direct overlapping of high-crustal tectonic units over a metamorphic complex deeply deformed at mid-crustal level. Consequently, the Apuan Alps are a key to the interpretation of the Northern Apennines' tectonic evolution during the Cenozoic. The rocks of the tectonic window belong to the Metamorphic Sequence of the Tuscan Domain, generally divided into: a) the Massa Unit (Paleozoic and Triassic formations) outcropping in the south western edge of the massif; b) the Autochthon *Auct.* (Hercynian Basement and Mesozoic-Tertiary Alpine Cover), located in the central and north-eastern sectors of the tectonic window and including the deepest part of the Metamorphic Complex. Allegedly, the deformation structures of the tectonic window were formed by two main tectonic-metamorphic regional events – phases 'D1' and 'D2' – which took place 27-20 Ma and 14-11 Ma, respectively. The first ductile compressional deformation (D1) was caused by the continental collision between the Corsica-Sardinia plate and the Adria microplate (Paleogene). The basement and the cover of the metamorphic complex are deformed and metamorphosed (greenschist±biotite±cyanite facies) in a NE-verging ensialic shear belt and are overlapped by the Tuscan Nappe and the Ligurian Units *s.l.* The ductile extensional deformation phase (D2) leads to the gradual isostatic re-equilibration of the thickened crust by tectonic denudation and erosion (Neogene). The latest stages of the Apuan Alps deformation are linked to the development of brittle structures associated with vertical movements locally exceeding 4 km.

**description of the level of interest**

The Apuan tectonic window was already pinpointed by proGEO (1996) as an important element of the European geological heritage, as it is a peculiar geological structure at international level in the field of Earth Sciences. Since the origin of modern geology the Apuan Alps have always been a key area to study and understand complex geodynamic processes leading to the formation of the Apennines range. This territory is a large structural geosite of European importance, not least owing to its historical contribution to the development of geological knowledge.

**Corchia Hercynian unconformity****location**

region	Tuscany
province	Lucca
Municipality	Stazzema
sector	Corchia
toponym/locality	Passo Croce

**interest**

scientific interest	stratigraphy geology
contextual interest	landscape hiking
interest evaluation	representative
level of interest	international

**conservation status**

characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

The Mesozoic-Tertiary cover of the Apuan Alps is angularly discontinuous with regards to the Paleozoic basement previously involved in the Hercynian deformation and metamorphism (greenschist facies). Despite the small number of fossils, the Pre-Triassic sequence of the Autochthon *Auct.* has been reconstructed mainly thanks to its close lithological-petrographical similarities with the well-known fossiliferous sequence (Lower Cambrian-Devonian) of Central Sardinia.

The regional angular unconformity at the basis of the Alpine cover, (Mesozoic-Tertiary) stratigraphically lying over Paleozoic formations, is more evident on the western side of Mt. Corchia, near Passo Croce (1149 m). This area is characterized by a well-exposed typical Upper Cambrian-Silurian/Devonian section of the Tuscan basement. The Hercynian discontinuity is located between the graphitic-lydite phyllites (Silurian?-Devonian) and the basal siliciclastic rocks of “Verrucano” (Triassic).

From bottom to top, the sequence of the Paleozoic basement is composed of: a) lower phyllites and quartzites (?Upper Cambrian-Lower Ordovician); b) porphyroids and porphyritic schists (?Middle Ordovician); c) metasandstones, quartzites and phyllites (?Upper Ordovician); d) graphitic phyllites and lydites; Orthoceras-bearing dolostones (Silurian?-Devonian).

The Pre-Carboniferous sequence is discomformably topped by metaparaconglomerates called “Anagenites” (Upper Ladinian-Carnic), belonging to the Alpine cover. In particular, lower phyllites (?Upper Cambrian-?Lower Ordovician) enables the reconstruction of the entire complex tectonic history of the Paleozoic basement. These rocks have relict deformation structures, which cannot be found in the Alpine cover and are ascribed to the Hercynian orogeny. The upper part of the lower Phyllites is characterized by a discontinuous level of paraconglomerates, which might be evidence of a Caledonian discontinuity. Finally, metavolcanites (porphyroids and porphyritic schists) have been linked to effusive and intrusive volcanic arc products, present in much of the southern European Basement (Middle Ordovician).

**description of the level of interest**

The Hercynian discontinuity of Mt. Corchia is a very important geosite already indicated in the international list by proGEO (1996). This valuable element of the geological heritage is often visited during fields trips by Earth Sciences Departments. The itinerary was proposed during the 32nd International Geological Congress (Florence, 2004) in the guidebook entitled “*The Paleozoic basement through the 500 Ma History of the Northern Apennines*”.

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## Procinto's crags and aiguilles

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Matanna
toponym/locality	Mt. Procinto e Bimbi
<b>interest</b>	
scientific interest	geomorphology
contextual interest	landscape, hiking botanical
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Mt. Procinto (1173 m) is the highest landform of the homonymous mountain range, a series of well-aligned rocky crags and isolated pinnacles made of Norian “Grezzoni” Dolomite. Mt. Procinto resembles a quadrangular “monolith” and has no vegetation covering its perpendicular slopes, which rise about 150 m above an almost vertical cylindrical base, approximately a hundred meters high. The top of the landform – called “il Giardino” (the Garden) – is cone-shaped and covered with thick timber vegetation (beeches and European hop-hornbeams). This “roof botanical garden”, just a hectare wide, hosts almost 200 vegetable species, among which many endemic, relic and significant species of the Apuan flora.

A more articulated ridge is found to the west of the regularly shaped Mt. Procinto. It has lower crags and aiguilles and two of its sides are crossed by grooves and chimneys, collectively called “Bimbi” (*Kids*). Torriane Bacci, Piccolo Procinto and Bimba follow one another, separated by small fissures.

In particular, Torriane Bacci is a small aiguille, also known as “the swaddled baby”, which has a height difference of about 80 m on its southern side. Piccolo Procinto (Small Procinto) is named after the resemblance with “big” Procinto. It is quadrangular-shaped and has a narrow vertical slope to the north, about 150 m high. Finally, Bimba (Little Girl), also known as “ignorante” (ignorant) is a bold crag with a characteristic profile, whose overhanging and bare slopes contrast with the underlying wood and grass lawns. The origin of these isolated rocky pinnacles, partially detached from the slope, is probably linked to the slow erosion of lower resistance zones under favourable structural conditions, as happens at the intersection of different fracture systems.

The geosite is rather easily accessible. Visible afar off from several panoramic viewpoints, it can be easily reached on foot. Furthermore, accommodation facilities (mountain huts, B&B, holiday homes, etc.), a climbing training area and a “historical” via ferrata (“iron way”) to the highest mountain peak are found nearby.

**description of the level of interest**

The Procinto range is one the most characteristic orographic structures in the Apuan Alps, resembling, in small scale, the distinctive dolomite landforms. In this almost unique place in the Northern Apennines, the selective erosion of carbonate formations shaped the most known and representative examples of “gothic” natural architecture.

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## Pisanino's ridges

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Minucciano
sector	Pisanino
toponym/locality	Mt. Pisanino
<b>interest</b>	
scientific interest	geomorphology
contextual interest	landscape hiking
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Mt. Pisanino's (1947 m) orographic knot is characterized by three main rocky ridges, whose planar angles measure about  $120^\circ$ , and which meet on the summit of the Apuan Alps's highest peak. This unusual morphology is situated beyond the same mountain range main watershed, along the joint with Mt. Cavallo's (1882 m) second peak. The secondary watershed, running northwards, divides Orto di Donna Serenaia's valley (west) from Acqua Bianca's valley (east).

Pisanino's rocky ridges, at times sharp and with significantly steep slopes, overhang the already high thalwegs of the Apuan Alps northern sector, with abrupt height differences, close to 900 m. Pisanino's western slope is particularly steep and degrades following the dip direction of the rocky outcrops main schistosity plane.

The relief great energy is linked to structural factors, largely depending on the ductile tectonics of the first compressive phase of the Metamorphic Complex and concretely affected by composite post-Miocenic fragile deformations.

The ridge running in north-east direction from Pisanino's peak to Mt. Mirandola (1566 m) and beyond corresponds to the hinge line of a second order isoclinal anticline (called "Pianellaccio"), whose core is made of Marble *s.s.*, cropping out for about a kilometre, almost all along the ridge. A second ridge, diverging northwest toward Bagola Bianca (1807 m) and La Forbice (1680 m), is aligned with an important structural escarpment, 600 m long and 250 m high. It may be a sin-metamorphic tectonic contact within the Diaspri formation, although clear sub-vertical fracture planes (north west-south east) are visible on its face. The third ridge, which runs in north-south direction and links Pisanino to Mt. Cavallo through Zucchi di Cardeto, has a more complex structure. The final tract of Pizzo Altare (1747 m) is characterised by monoclinical landforms resembling *cuèstas*, with high asymmetric sections, facing eastwards and backing westwards.

Simple and complex morphogenetic processes, linked to quaternary glacialism, cryoclastism and epigeic karst phenomena, played a role in the medium- and small-scale moulding of rocky ridges.

**description of the level of interest**

Mt. Pisanino's ridges are unusually sharp for the Tusco-Emilian Apennines, where the diffusion of arenaceous and marly-arenaceous Flyschs along the ridge results in rounded outlines and not in sharp and aerial outlines as in the carbonate and radiolarian formations of the Apuan Alps. With respect to the Apennines, Pisanino's rocky ridges are interesting at regional level, at least for their rareness. They are also interesting with respect to the Apuan Alps (despite the large number of ridges found in the area), essentially for the representativeness of the geosite, characterised by an extreme steepness of the slope and a significant height difference.

**location**

region	Tuscany
province	Lucca
municipality	Stazzema
sector	Matanna
toponym/locality	Mt. Forato

**interest**

scientific interest	geomorphology
contextual interest	landscape hiking
interest evaluation	representative
level of interest	national

**conservation status**

characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

It is a rock arch placed beneath Mt. Forato's north and south forked peaks, which reach an altitude of 1208 and 1230 m respectively. The place belongs to the Panie mountain range and is situated in the Apuan Alps south-central sector, along the divide of the same range. This natural architecture has considerable dimensions: a 32 m span and a maximum height of 26 m, whereas the minimum rock thickness of the arch measures between 8 and 12 m both in horizontal and vertical cross sections.

The ridge dividing the two Forato's peaks, with the natural arch at the centre, is made of three different carbonate rock formations of the Autochthonous *Auct.*: "Grezzoni" dolomites, dolomite Marbles and Marbles s.s. This "orographic window" is a secondary form of land moulding, deriving from the landform selective deterioration. Several factors contributed to the natural arch morphogenesis: first of all the erosion caused by rainwater and currents, then the chemical dissolution of the carbonate rock slopes and the role played by wind and cryoclastism.

There is also a theory on the arc being what is left of a deep karst river basin, surfaced after the Apuan area upthrust and then degraded by erosion. Accordingly, the rock arch may be the result of two fractures, perpendicular to the pre-existent basin.

Mt. Forato's arch is clearly visible from both Versilia and Garfagnana. In certain days of the year, sunrise may be seen from the Tyrrhenian coast through the natural opening, while sundown is visible from the town of Barga.

In the Middle Ages and in the Modern Era, the mountain was known by the name of "Pania forata" (perforated Pania). The origin of this morphological singularity is the subject of folk tales. In Garfagnana, the legend goes that it was formed when the devil, flying after being slapped by the hermit St. Peregrinus, crashed against the mountain. In Versilia, instead, the arc is a miraculous passage which opened up in the rock to let the Holy Family cross the Apuan Alps and escape from Herod's soldiers after the flight to Egypt.

**description of the level of interest**

The natural arch is one of the largest in Italy. Its great visibility from afar, thanks to the absence of visual obstacles in the nearby area, contributes to its scenic-aesthetic value. It is a particularly representative geosite, characterised by an unusual morphology and therefore of great scientific interest, at least at national level.

52, 73

**Pizzo d'Uccello northern side**

<b>location</b>	
region	Tuscany
province	Massa Carrara
municipality	Casola Lunigiana-Fivizzano
sector	Pizzo d'Uccello
toponym/locality	Pizzo d'Uccello
<b>interest</b>	
scientific interest	geomorphology
contextual interest	landscape hiking
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Pizzo d'Uccello northern side (1782 m) is the most impressive and majestic side in the Apuan Alps. Its maximum height difference amounts to almost 700 m, whereas its inclination measures an average of 70° and almost reaches 90° underneath its summit. The north-western ridge, stretching towards Punta Nattapiana (1403 m), plunges to the bottom, whereas the steepness of Capradossa ridge, towards Poggio Boldozzana (1338 m), to the north of Pizzo d'Uccello summit, is more modest.

The face mainly consists of “Grezzoni” dolomites from the Norian age and, to a lesser extent, of Marmi a Megalodonti formations from the Rhaetian and dolomite Marbles from the Early Lias. The mighty Triassic rocky wall is situated on a basement made of carbonate formations, which are more recent than the Autochthon *Auct.* (Metamorphic Succession of the Tuscan Domain). The overturned stratigraphic sequence outcrops on the reverse side of a first-order isoclinal fold, called Vinca anticline. The sides of this ductile deformation are complex second-order tectonic structures, such as Pizzo d'Uccello anticline and syncline, whose hinge lines are situated along the northern side, going from north-west to south-east.

The relief morphology at the bottom of the northern side, especially underneath Capradossa ridge, is characterized by small cirques and glacial exaration cirque-like formations. They are the upper extreme limits reached by the Solco d'Equi würmian glacier. During the late Pleistocene, the long and high Pizzo d'Uccello northern side offered a shelter and, therefore, guaranteed the conservation of huge glacial masses along the relief northern slopes. Thus, the glacier was kept in the shade for most part of the year and reached low-altitude areas with its ablation zone. Snowfields lasting until late summer at the bottom of the northern side testify to glacial vocation in this area. For example, Cantonaccio (also called Cantoni di Neve vecchia, that is “Corners of old snow”, on the maps of the Italian Military Geographical Institute, IGMI), situated at 1100 m a.s.l., owes its name to the accumulation of snow fallen during winters and persisting throughout different seasons. In the same place there are also small snow-moraine ridge and cryoclastic deposits.

**description of the level of interest**

Large sub-vertical sides, as those of Pizzo d'Uccello, are not found anywhere else in Tuscany and are very rare along the whole Apennines. Regional, if not interregional, interest is therefore foregone in terms of the relative rarity of the phenomenon, which, on the contrary, is more widespread in the Alps. Hence, the impossibility to acknowledge a national interest in the geosite. Yet, the climbing contextual interest, which has contributed to the definition of the mountain as “the Apuan Matterhorn (Cervino)”, gives an added value, difficult to quantify but very important. Finally, the geosite representativeness with regards to interest assessment is referred to the Apuan context.

55, 118

**Solco d'Equi's fluvio-glacial fissure**

<b>location</b>	
region	Tuscany
province	Massa Carrara
municipality	Casola Lunigiana-Fivizzano
sector	Pizzo d'Uccello
toponym/locality	Solco d'Equi
<b>interest</b>	
scientific interest	geomorphology
contextual interest	landscape
interest evaluation	illustrative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Solco d'Equi is a narrow gorge in the Apuan Alps northern sector, where the relief is characterised by a high level of energy and slopes overhanging the thalweg. This deep fissure, which follows a sinuous course, is almost 1.5 km long and is found at the end of a small valley, sloping down from the northern face of Pizzo d'Uccello (1782 m). Solco d'Equi is carved in the Marbles *s.s.* and cherty Limestones of the Apuan Alps Metamorphic Complex, coherently with the structural alignments of folds (especially Pizzo d'Uccello's anticline). The attractive morphology is a consequence of separate and combined river and glacial moulding processes, in combination with cryoclastic degradation and karst dissolution processes.

During the last Glaciation, a small glacier sank along Solco d'Equi, thanks to its favourable north exposure. During its maximum expansion, the ablation zone reached a minimum altitude of 475 m, the lowest in the entire Apuan area. Glacial deposits and formations are now visible in the U-shaped cross section of the valley's upper walls and in scattered morainic deposits. In particular, Valtredi's cemented moraine have been attributed to a pre-Würm glaciation, since they are placed below typical melted glacial sediments, without gradual transitions.

In the Post-Glacial period, the valley's basic crack deepened further due to a renewed river erosion, partly caused by karst shaping, but especially stressed by the Apuan Alps late tectonic uplift. As the linear thalweg fissure spread, the river left along the mountainsides, at different altitudes, visible signs of the turbulent flow of running water, e.g. smoothing and semihelicoidal hollows.

**description of the level of interest**

The geosite hosts an interesting superimposition and coexistence of different forms and deposits, originated by different morphogenetic agents and simple meteoric degradation processes of the relief. In this geosite the overall effects and the landscape contrast between the Apuan tectonic window's carbonate mountains and the modest arenaceous and shaly landforms of the Non-Metamorphic Succession of the Tuscan Domain (Macigno and "red" Scaglia) are appreciable.

The regional interest of the geosite lies in its being a geographic limit and home to valuable geomorphological elements, starting from the cemented morainic outliers.

66-67, 72

**Gorfigliano fluvio-glacial plane****location**

region	Tuscany
province	Lucca
municipality	Minucciano
sector	Pizzo d'Uccello
toponym/locality	Solco d'Equi

**interest**

scientific interest	geomorphology
contextual interest	landscape
interest evaluation	illustrative
level of interest	regional

**conservation status**

characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Piano di Gorfigliano is a large thalweg, 1.5 km long and 500 m wide, where the Torrent Acqua Bianca, right tributary of Serchio di Gramolazzo river, runs through. The large area is located between Mt. Tontorone north-eastern slopes (1100 m) and Mt. Calamaio south-eastern side (1040 m), at an altitude comprised between 650-700 m a.s.l.

During Würm, a glacier, descending from Pisanino-Cavallo-Tambura-Roccandagia high sides, enlarged the valley rift in an unusual way for the Apuan Alps and created a U-shape profile. Upon the ablation zone retreat, a small morainic barrier lake formed, as meltwater was stopped from flowing to the valley by some glacial ridges. Piano di Gorfigliano original glacial morphology was partly modified by fluvial and gravitative processes in the Post-Glacial. Its hydrography too was strongly affected by morpho-climatic vicissitudes occurred between the Late Pleistocene and Olocene. Acqua Bianca torrent does not flow along the valley central axis any longer, but it runs close to its south-eastern side. This was caused by a larger accumulation of the alluvial fans of north-eastern side tributaries, which progressively pushed the main watercourse toward the opposite margin. Traces of Acqua Bianca torrent translation are found in the remarkable old river beds in Piano di Gorfigliano central area, if they have not been moulded by left tributaries.

The area hydrogeological structure is difficult to understand, as the thalweg deposits various origins and granulometry often create complex underflows. There are numerous springs along Piano di Gorfigliano, whose aquifer seems to consist of fluvial, fluvio-glacial and glacial deposits, situated on an impermeable substrate made of sericite Schists from the Early Cretaceous-Oligocene.

Stagnation and weakly-flowing water contribute to the formation of small humid areas, home to flora and vegetation of high geobotanical interest.

**description of the level of interest**

Piano di Gorfigliano is an almost unique geosite within the Apuan and Tuscan context, as it preserves, in terms of exemplarity, rather than representativeness, a vast array of forms and deposits deriving from the separated or combined, synchronic or dychronic actions of glacial, fluvial and gravitative morphogenetic processes.



69-70

**Pot-holes of Anguillaja and Fatonero's ditches**

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Sumbra
toponym/locality	Anguillaja e Fatonero
<b>interest</b>	
scientific interest	geomorphology epigean karst phenomena
contextual interest	hiking landscape botanical
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

The ditches of Anguillaja and Fatonero are Turrice Secca's left tributaries, flowing down along the southern slope of Mt. Sumbra (1765 m) and Mt. Fiocca (1709 m), at a linear distance of about 650 m. The two streams are intermittent. During heavy rains they temporary flow over a substrate mainly constituted by Marbles *s.s.* and (in a lower proportion) cherty Limestones. In the streambed, channelled and whirling water dug large, quite regular pot-shaped cavities, known as "Giants' pot-holes", with extremely smooth walls and a cap-shaped bottom.

Anguillaja and Fatonero's pot-holes have been moulded directly into the rock and their dimensions may vary from a few centimetres until reaching a diameter of 6.6 m and a deepness of 1.6 m. Quantifying them is not easy, not least because sometimes smaller pot-holes are contained in larger ones. Considering only the latter, thirty is probably the total number in both streams.

"Giants' pot-holes" are often formed as a consequence of the abrasive action of rotating pebbles. Many factors, not least the stream whirling movement and a consistent and homogeneous rock substrate (as Marble in Mt. Sumbra's southern side), contribute to their development. Anguillaja and Fatonero's pot-holes seem to follow this traditional model, as presumably demonstrated by the regular signs left by mechanical erosion on the internal borders of a number of these pot-shaped cavities. In certain cases, their formation might have been favoured at first by chemical leaching (superficial karst phenomena), but then the hydrodynamic action was either prevalent or exclusive.

However, other Authors hypothesised that the pot-holes formed as a consequence of water forcedly flowing through subglacial tunnels, which were probably found under the glaciers formed during the last Glaciation. Indeed, Sumbra and Fiocca's southern side is characterised by spread forms of glacial, glaciokarst and cryonival origin, which testify to the presence of glacial masses during Würm and of small ephemeral ice and snow masses during Late-Glacial and Post-Glacial.

**description of the level of interest**

Despite the diffusion of these erosion products in the Apuan Alps' gorges, especially on a outcropping carbonate substrate, the Anguillaja and Fatonero's geosite stands out for the unique density, regular form and dimensions of the pot-holes, not found elsewhere at regional level. The place is a frequent destination for excursions and climbing along the riverbeds.

71, 101-102

## Orto di Donna-Serenaia's glacial valley

**location**

region	Tuscany
province	Lucca
municipality	Minucciano
sector	Pizzo d'Uccello-Pisanino
toponym/locality	Serenaia

**interest**

scientific interest	geomorphology
contextual interest	landscape
	hiking
interest evaluation	representative
level of interest	regional

**conservation status**

characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Serchio di Gramolazzo's upper valley is surrounded, to its southern head, by the Apuan Alps highest ridges arranged in a horseshoe-shape, where Mt. Pisanino (1947 m) reaches the maximum peak. The average altitude of the ridges is 1700 m and it is never lower than 1497 m (Foce di Giovo). During Würm, the longest and widest Apuan glacier originated from here. Its ablation zone reached the current town of Gramolazzo, at an altitude of about 640 m. Together with minor glaciers on the northern slope of Mt. Pisanino (along the Libardo and Sirchia ditches), it covered an area of almost 12 km<sup>2</sup> and its major stream was slightly longer than 6 km.

Gramolazzo's glacier left erosion forms and deposits all along its course, both in the advance and retreat phases. The wide and flat thalweg, almost 1 km long, between Serenaia and Orto di Donna (1000-1100 m of altitude), is of particular geomorphological importance, not least for its dimensions. In this part of the Serchio di Gramolazzo's upper valley, a rare example of glacial valley in the Apuan Alps may be seen; it is characterised by a typical U-shaped cross section and a number of modest steps. Its morphology is marked by two opposite plateaus, delimited by escarpments and situated along the opposite sides of the valley. Their symmetric course and longitudinal development, at the same altitude, are related to a stasis of glacial mass movements, which resulted in greater erosive activity.

In Orto di Donna-Serenaia's valley, detrital filling and deposits prevail, today fed by small alluvial fans and cryonival processes (snow avalanches) especially on the hydrographic right and on the eastern side. At the inferior edge, there is a sharp morphological gap in the valley, maybe due to a resumption of linear erosion of Serchio di Gramolazzo in the Post-Glacial. Below the step, slopes get steeper and resemble river incisions, contrasting with the upper part's glacial profile. The step threshold withdrawal, caused by river erosion, has progressively isolated a relic of roof glacial valley on the left slope near Tecchiarella (1031 m), where there are roches moutonnées.

**description of the level of interest**

The U-shaped Orto di Donna-Serenaia's valley is characterised by a significant concentration of forms and deposits produced by the largest Apuan Würm glacier, unique at regional level. The post-glacial morphological re-adaptation modified some features, but did not cancel the main glacial features, which are still there despite the action of five other morphogenetic systems.

79, 188

## Sumbra's glacial cirques and karst landforms

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Vagli Sotto
sector	Sumbra
toponym/locality	Sumbra
<b>interest</b>	
scientific interest	geomorphology hypogean karst phenomena
contextual interest	landscape hiking
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Mt. Sumbra (1765 m) rises in the centre of the Apuan Alps, along a secondary watershed running from west to east. Its morphology is characterised by four differently coalescent glacial cirques, located on the southern slope, which open up below the ridge as sub-circular amphitheatres, forming impressive vertical slopes, more than 250 m high.

The sharp southward-looking slopes are characterized by rounded grooves originated by cryonival processes, confirming the presence of perpetual snowfields or small ephemeral ice masses toward the same ridge during the Late-Glacial. Furthermore, glacial karst phenomena shaped both slopes, with deeply carved grikes and marvellous potholes along the southern face (e.g. Anguillaja and Fatonero Ditches). The northern mountainsides, on the other hand, are characterised by epigean karst formations, such as large flat bottomed or funnel-shaped dolines, well developed above structural morphological plateaus.

Mt. Sumbra is mainly constituted by Marbles *s.s.* and cherty Limestones. These carbonate lithotypes and the absence of continuous wood covering enabled the good conservation of glacial and karst morphosculptures in their most characteristic forms.


Finally, in the subsoil there are particularly developed karst cavities of speleological and hydrogeological interest. To the north-east of Sumbra's peak, at about 1430 m of altitude, there is the entrance to Abisso dei Draghi Volanti (Abyss of the Flying Dragons), which has a height difference of about 880 m and reaches the bottom almost at the same level of its emerging point, located at Pollaccia's spring (545 m a.s.l.). The large geological section formed by this karst cavity – belonging to Mt. Sumbra's anticline – shows the geometrically lowest known point of the Apuan folded structure, which sees Marbles *s.s.* cropping out and "Grezzoni" dolomite in the final part of the Abyss.

**description of the level of interest**

The geomorphosite of Mt. Sumbra's southern slope is extremely remarkable for both the Apuan Alps and Tuscany, even in relation with similar formations present in Apennines sites within the same Region. Relatively to the aforementioned territorial context, it is the best example of coalescent Würm glacial cirques.

92, 110-112

**Campocatino's moraine ridges and glacial hollow**

<b>location</b>		
region	Tuscany	
province	Lucca	
municipality	Vagli Sotto	
sector	Tambura	
toponym/locality	Campocatino	
<b>interest</b>		
scientific interest	geomorphology	
contextual interest	landscape, hiking	
	didactic, architectural	
interest evaluation	representative	
level of interest	regional	
<b>conservation status</b>		
characteristic/condition	good	
risk of natural deterioration	non-existent	
risk of anthropogenic deterioration	medium	

**geological and environmental description**

It is a complex glacial geomorphosite, modelled by a small Würm glacier. The morphogenetic agent formed in Mt. Roccadaglia (1708) and Mt. Tombaccio (1372) and spread eastwards for almost two kilometres, reaching the current town of Vagli Sopra.

The most important relict of Late Pleistocene glacial action is the overdeepened basin of Campocatino, today completely filled with lake and river-lake deposits. The hollow (about 500 m long and 250 m wide) is situated at the foot of Roccadaglia's vertical walls, where scree accumulates in large quantity resembling many coalescent cryoclastic cones, at different levels of activity.

Campocatino's hollow is limited by an articulated and well defined morainic amphitheatre, typically arched in the front part, made of several evident concentric rings and numerous isolated morainic outliers. The threshold, slightly reverse, is situated at the convergence point of the ridges, at an altitude of around one thousand metres, where the glacial deposit is partially gutted due to the erosive action of channelled water.

Five main morainic ridges have been identified on the northern side, five on the southern side and two on the western side, within which numerous other bank parts, both lateral and frontal, are visible and mark the glacier retreat and stasis phases. The highest outlier (160 m long) is situated at an altitude of 1245, marking perhaps the last stage before the glacier definitive disappearance. All of Campocatino's morainic deposits are almost exclusively made of marble elements incorporated in a scarce matrix.

Glacial traces in the area were first reported in 1872 by Igino Cocchi (1827-1913), who identified a "morainic ring" near Campocatino's mountain pasture.

**description of the level of interest**

The erosion and glacial deposit forms on the eastern slope of Mt. Roccadaglia, along with Campocatino's overdeepened basin and morainic ridges, are the most significant and best preserved example of glacialism in the Apuan Alps and of its fluctuations. The area is located in the north-eastern part of the Apuan massif, where the Würm glacial moulding had its major effects.

Campocatino's geomorphosite is of significant didactic and educational interest. The place is even more attractive thanks to a small pastoral village, built on the glacial banks and characterised by small stone-built houses, which are a consequence of northern morainic ridges terracing and agricultural layout works. The seasonal settlement was the summer domicile of shepherds, migrating between Vagli's pastures and "Maremma lands" in the areas of Lucca and Pisa.

The area is particularly interesting with regards to flora too, since it is home to rare and endemic species. An important faunal species in the area is the wallcreeper (*Tichodroma muraria* L.), which lives around Roccarandaglia's walls. Since 1991 the area is protected by LIPU (Italian Society for the Protection of Birds).

93, 251

## Fociomboli's glacial hollow and bog

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Corchia
toponym/locality	Fociomboli
<b>interest</b>	
scientific interest	geomorphology
contextual interest	botanical
	hiking
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

During Würm, the northern slope of Mt. Corchia (1678 m) was characterised by several ice tongues, merging downwards. The accumulation zone of Retrocorchia's glacier originated from the large glacial cirque near the mountain ridge, while the ablation limit allegedly reached, in its greatest expansion, the current Tùrrite Secca's river bed, near Isola Santa, for a total length of about 3 km.

In Retrocorchia, the area of "Paduli" (wetlands) in Fociomboli is a glacial overdeepened basin, well moulded in the porphyritic Schists of the Paleozoic basement. The morainic deposits, even though irregularly cropping out along the valley's slopes, did not form here visible arcs, festoons and glacial banks.

At the external edge of the geosite there is a small threshold of *Orthoceras*-bearing schistose Dolomites which, thanks to their greater resistance to exaration, created a counterslope during glacial retreat. Behind the threshold, a small periglacial lake formed on an area of about a hectare, but it was progressively filled in by fine detritus and is now a swampy plateau.

The loamy and bog sediments of the hollow's most depressed part are 4 m deep and contain, almost all along the sequence, fossil pollens from a large period of the Post-glacial. The pollen diagram of Fociomboli identified two periods: the first, with a continental climate, saw the prevalence of Scots and mugo pines, whereas the second, with an oceanic climate, was characterized by beeches and a modest and rather constant diffusion of silver firs.

"Paduli" di Fociomboli's flora is noteworthy too, since it is characterised by species of particular geobotanical interest [*Eriophorum angustifolium* Honcheny, *Dactylorhiza incarnata* (L.) Soð, etc.], among which the orchidaceous plant *Herminium monorchis* (L.) R. Br. stands out: it is a significant glacial relict, which can only be found here in the whole Apennines ridge. The area also sees the outcrop of schistose Dolomites of the glacial threshold, which, in the past, had given numerous Silurian *Orthoceras* fossils.

**description of the level of interest**

The geosite/biotope of Fociomboli, characterized by a high level of geo-biodiversity, is the largest bog in the Apuan Alps and one of the most important in Tuscany. Its morphology and flora recall the progressive evolution, from lake to swamp, of a typical wetland, formed in an overdeepened basin following glacier retreat. The place is a preferred destination for excursionists and campers because of the amenity of its landscape and the presence of flat areas, crossed by numerous weakly flowing streams, regularly fed by several springs where "Grezzone" Dolomite and porphyritic Schists touch.

98, 150

**Passo Sella's glacial saddle and dolines**

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Vagli Sotto
sector	Tambura-Sumbra
toponym/locality	Passo Sella
<b>interest</b>	
scientific interest	geomorphology epigean karst phenomena
contextual interest	landscape hiking
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

A secondary watershed of the Apuan Alps, which reaches its lowest altitude (1496 m) near Passo Sella, goes from Mt. Sella (1735 m) to Mt. Fiocca (1709 m). The place, as suggested by the toponym ("Sella" means saddle), is a gentle and grassy saddleback with morphostructures and morphosculptures deriving from several morphogenetic agents. Passo Sella is crossed by the hinge line of an anticline, which has a Marble *s.s.* core and is called, not casually, Passo Sella anticline. In the medium-scale moulding, glacio-karst processes combined and followed one another, perhaps with a time gap in their respective morphological effects.

The geosite is mainly a glacial transfluence saddle between Arnetola and Arni's valley. Furthermore, dolines line up coherently with structural elements and, in particular, with the axial-plane schistosity. Along the Apuan ridge, the presence of dolines in ridge areas or near saddlebacks is not extremely rare. Their unusual morphological collocation renders their genesis and evolution hard to explain under current conditions. These epigean karst forms are probably signs of a now changed landscape, whose steepness was probably less pronounced.

Karst processes affected the area both superficially and in depth. On the western slope of Mt. Sella, at about 1600-1650 m of altitude, there are the entrances to Buca dei Morti and Buca di Piastreta. They are relicts of cavities with a pronounced high-altitude palaeo-phreatic morphology, containing truncated segments of once wider systems of horizontal galleries, whose traces of scallops and dissolution domes are typical of a full-load circulation. The same situation is found in the highest branches of Abisso dello Gnomo (Gnome Abyss), whose five entrances are located on the eastern slope of the Sella range, slightly below the Passo, at about 1400 m of altitude. Clear signs of phreatic circulation are visible here too, although with a greater litho-structural control. These ancient cavities may be linked to a large endorheic basin, which spread out in the central part of the Apuan complex during late and early Pleistocene.

**description of the level of interest**

Sella Pass is a regionally emblematic and representative geosite for what concerns the complex combination of morphogenetic, glacial and karst processes on carbonate outcrops, situated on not very steep internal slopes at rather high altitudes, compatible with the formation of glacial masses during Würm.

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Seravezza-Stazzema
sector	Altissimo-Sumbra
toponym/locality	Arni-Campagrina
<b>interest</b>	
scientific interest	geomorphology geohistory
contextual interest	cultural
interest evaluation	illustrative
level of interest	national
<b>conservation status</b>	
characteristic/condition	precarious
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



### **geological and environmental description**

Near the town of Arni di Stazzema (Campagrina), there are visible signs of the extreme expansion of a medium-sized glacier which, during Würm glacial stage, was probably spread over the whole Canale delle Gobbie's valley, to the north of Mt. Altissimo. After it merges into Tùrrite Secca, beyond the river banks, well-visible and wide glacial deposits crop out, even to the side of the main riverbed. They are partly carved and have been partly removed by watercourses. In particular, a morainic ridge can be seen to the hydrographic left, at about 785 m a.s.l. It is transversal to the valley and partially modified by the construction of ancient and more recent buildings in the small Arni-Campagrina village. A similar, but less pronounced, geomorphology is found on the opposite bank of the river, near St. Mary Magdalene church in Arni, beyond the bell tower separated from the religious building.

The glacial deposit consists of a chaotic mass of heterogeneous clasts, especially Marble s.s. and secondarily "Grezzoni" Dolomite and porphyritic Schists, immersed in a medium-fine granulometry matrix. Some elements present the typical striations caused by the mechanical erosive action of a moving glacier.

### **description of the level of interest**

Beside the general scientific interest toward this glacial geomorphosite, its fame is linked to the history of geology. It was here that, on 13<sup>th</sup> June 1872, the famous geologist and palaeontologist Antonio Stoppani (1824-1891) detected the first signs of the Quaternary Glaciation outside the Alps, more or less at the same time as Igino Cocchi (1827-1913). Until that moment, no evidence had been found along the whole Apennines ridge.

In *Il Bel Paese* (1876) – a didactic text widely spread after Italian unification – Stoppani recalls the discovery of Campagrina's glacial deposit in the Arni's Valley: "*that moraine suddenly showed to my imagination the Apuan range covered with snow, like the summits of Mt. Blanc and Mt. Rosa. I imagined that large cirque, closed to the south-west by Mt. Altissimo (...). That double glacier disappeared, but its façade is still there, moulded by the moraine, a heap of stones, almost all made of white marble, which seem to block the entire Arni's valley (...)*".

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Seravezza
sector	Altissimo
toponym/locality	Campo delle Gobbie
<b>interest</b>	
scientific interest	geomorphology
contextual interest	cultural didactic
interest evaluation	rare
level of interest	regional
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	medium
risk of anthropogenic deterioration	medium



### **geological and environmental description**

Small outliers of glacial and fluvioglacial deposits outcrop in Retroaltissimo, where Canale delle Gobbie (Gobbie's Channel) flows through. Most of these sediments were produced by a glacier which occupied the whole valley during the maximum würmian expansion and retreated to the valley head of Grotta Giuncona cirque in the Late-Glacial. The morainic outcrop at 1040 m, on the hydrographic right of Canale del Buro tributary, flowing southward from Passo del Vestito diffluence saddle, is particularly interesting. The geomorphological element is visible from the provincial road, where it runs near the eastern side of Mt. Pelato (1325 m), in the area called Campo delle Gobbie.

The glacial deposit here has two different and separated aspects, without gradual transitions. Typical loose deposits coexist with cemented, conglomerate deposits. The first have been attributed to the Würm, whereas the latter are thought to belong to a previous glacial expansion. The signs of a pre-würmian glaciation in the Apuan Alps, probably the Riss of the Alps, is in line with what was discovered in some areas of the Apennines in the second half of the 19th cent., after a long period in which the phenomenon had been denied. In the Apuan Alps, melted glacial deposits are usually situated over cemented deposits, along surfaces showing signs of exposure. The reverse seems to happen in the area of Vestito, with melted deposits at lower quote respect to cemented ones. The seemingly anomaly may be explained with the pre-würmian glacier being thicker than the subsequent.

A stalactite and stalagmite concretion, formed within a “pocket” of Gobbie cemented glacial deposit, enabled the first conglomerate radiometric dating (U/Th). Despite contaminations, the result (not published yet) seems to suggest a pre-würmian formation of the moraine, thus attributable to Riss with a certain reliability margin.

### **description of the level of interest**

Cemented glacial deposits outcrop in very few areas of the Apuan Alps: Solco d'Equi (Pizzo d'Uccello northern side) and Val Terreno (Retrocorchia). That is why Gobbie's pre-würmian moraine represents a rare value and interest, at least at regional level. In this context it is necessary to recall that the only certain traces of the Riss glaciation in the northern Apennines are limited to heterogeneous and disorganized deposits on Mt. Navert summit, in the Province of Parma.



<b>location</b>	
region	Tuscany
province	Lucca
municipality	Molazzana
sector	Panie
toponym/locality	Alpe di S. Antonio
<b>interest</b>	
scientific interest	epigean karst phenomena
contextual interest	hiking archaeological
interest evaluation	representative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent



### **geological and environmental description**

Vetricia (1300-1500 m of altitude) is a karst plateau situated between Pizzo delle Saette massif (1720 m) and Pania della Croce-Pania Secca ridge, below Omo morto grass lawns and the C.A.I. (Italian Alpine Club) mountain hut "Enrico Rossi". The area is characterised by large superficial and deep karst phenomena, caused by heavy rain and snowfalls and especially by the rock substrate's carbonate nature and intense fracturing.

The prevailing lithology consists of more or less dolomitised Hettangian metalimestones, therefore, after chemical degradation processes, the landscape is now characterised by epigean karst macroforms. The various karst phenomena and their evolution level suggest that the karstification process probably started during the Quaternary Glaciation and then developed through the widening by dissolution of the rock substrate's discontinuities and fractures. In Vetricia, karren fields prevail, together with clefts and abysses based on two main joint systems with very deep grikes along the north-south direction and less evident fissures along the east-west direction. Macroforms include dolines, which are found along major fractures, although not in a significant number. Almost all of them are typically bowl-shaped, with a round opening.

Epigean microforms include gouges and linear and/or meandering grikes, excavated in smooth and slightly sloped bedrocks. There are also deep parallel grikes, solution runnels and rock tanks ("kamenitze"). Furthermore, here there is the entrance to several hypogean cavities, mainly vertically developed (Abisso Revel, Buca Larga, Buca del faggio di Vetricia, ecc.). In Vetricia's karst plateau, at least six different areas with rock incisions of uncertain origin, perhaps even protohistoric, have been identified. Among them "Pietra tonante" (a slab come off the rocky slope) and "Masso erratico" (a large erratic block moved by glaciers).

### **description of the level of interest**

Vetricia's karst geomorphosite is at least of regional interest, because both in the Apuan Alps and in Tuscany not many places host such a variety of epigean macro and microforms, often absolutely complete. Most superficial forms of karst morphology can be found here, except for major elements (uvula and polje), which are partly compensated in value by remarkable hypogean elements.

**location**

region	Tuscany
province	Lucca
municipality	Minucciano-Vagli Sotto
sector	Tambura
toponym/locality	Carcaraia

**interest**

scientific interest	epigean karst phenomena
contextual interest	hiking didactic
interest evaluation	representative
level of interest	national

**conservation status**

characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Carcaraia is situated on Mt. Tambura's (1895 m) northern slope and is limited to the west by Cavallo's mountainsides and to the east by Rocchandaglia-Tombaccio's secondary ridge. The area is almost entirely made of dolomitic Marbles and crystalline Dolomites from Early Lias and presents one of the highest thickness of the Apuan Alps (Tambura's anticline). The presence of carbonate lithotypes and a high precipitation rate (more than 3,000 mm/year) are ideal conditions for the development of karst phenomena, both epigean and hypogean.

Considering only superficial formations, the distinctive feature of Carcaraia is the large extension of its doline field, situated on its rather steep slope and covering about 1,2 km<sup>2</sup>. The dolines are rarely isolated, more often clustered together with a high concentration, unusual for the Apuan Alps (and beyond). Dolines are depressions formed by dissolution, whose dimensions may vary from metres to decametres and whose depth is remarkable in comparison to the diameter. Their forms are very heterogeneous; they may be dish-, bowl-, funnel- and even well-shaped.

Carcaraia is also characterised by karren fields, concentrated at high altitudes, where snow cover persists and the rock mass is more fractured, thus resulting in a karst landscape made of grikes and clints. There are many microforms, such as gouges, linear or meandering solution runnels, jagged ridges and basins, situated both on outcropping rocks and detached large carbonate blocks. There is a high concentration of karst cavities too, among which the Abissi Paolo Roversi, Perestroika and Manipulite and the entrances to Carcaraia's karst Complex (Saragato-Aria Ghiaccia-Squisio). Coloured tracers showed that water circulating here flows out at Frigido's spring, near Forno di Massa.

**description of the level of interest**

Carcaraia is, therefore, the place in the Apuan Alps with the highest concentration of superficial karst forms. Dolines are the distinctive morphological elements of the landscape, with an average density of 320 elements per km<sup>2</sup>. It is an extremely unusual value in comparison with the average density of the entire Apuan massif (about 0.5 dolines/km<sup>2</sup>) or of other Italian karst areas (between 50 and 100 dolines/km<sup>2</sup>). The geosite is therefore interesting at national level, not to mention the added value of karst cavities linked to epigean formations, which are very large (the hypogean Complex of Carcaraia measure 35 km) and have great height differences (1350 m, Abisso Roversi).

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**Dolines on Garfagnana plateaux**

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Vagli Sotto, Galliciano
sector	Umbriana, Palodina
toponym/locality	Tontorone, Corona Pian di Lago, Penna
<b>interest</b>	
scientific interest	epigean karst phenomena
contextual interest	botanical didactic
interest evaluation	illustrative
level of interest	regional
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Despite a large hypogean extension, superficial karst phenomena in the Apuan Alps are not particularly remarkable on large and middle scale, but are more evident in smaller forms, in 'karrens' which often creates karst landscapes with grikes. The uneven orography, especially near the main ridge, is the most important reason for the relatively high number of dolines and the almost absolute lack of poljes, blind valleys and closed basins. These plateaux are rare near the highest Apuan summits. Some of them can be found in places which have been moulded by Würmian glaciers. It is not a coincidence that dolines are almost exclusively found to the north of the main ridge, where slopes are the result of glacial morphogenetic activity.

Nevertheless, epigean karst forms are relatively widespread along the secondary ridges of the Apuan Alps, on the inland side sloping towards Garfagnana. River Serchio right tributaries flow in sub-parallel valleys, separated one from the other by higher watersheds. Moreover, they do not slope towards Camporgiano, Castelnuovo and Galliciano bottom valley as gently as torrents. The Garfagnana mountainside is, therefore, characterized by the alignment of structural highs, levelled towards the crest, which are far from the main ridge. These landforms are to be interpreted as horsts of the Serchio' tectonic ditch (graben), into which they suddenly sink, along the valley Apuan margin. These plateaux with a rather smooth morphology create favourable conditions for medium scale epigean karst phenomena, especially where Tuscan Nappe carbonate formations outcrop. Dolines of remarkable dimensions, mainly flat dish-shaped, may be found on non-metamorphic limestones and dolomites. Their inner part is characterized by a layer of detritus with various degrees of thickness, differently from similar depressions originated in the tectonic window's carbonate formations.

Dolines in Garfagnana are sometimes characterized by water stagnation in correspondence of argillitic intercalations or repellent internal deposits of gravitative origin. Remarkable hygrophilous flora and vegetation can be found in these humid areas with a seasonal surfacing of the aquifer.

**description of the level of interest**

The dolines on the Apuan inland side plateaux are of regional interest for their quality and quantity, compared to the dimension of the territory. It is noteworthy to recall that 44 karst areas have been registered in Tuscany. They spread over a surface totalling 1,100 km<sup>2</sup>, that is to say 5% of the entire Region. These areas are not very large considering that almost 1/3 of karstifiable lands, 350 km<sup>2</sup>, are located in the Apuan Alps, especially on their inland side of the Garfagnana.

<b>location</b>	
region	Tuscany
province	Massa Carrara
municipality	Fivizzano
sector	Pizzo d'Uccello
toponym/locality	Equi Terme
<b>interest</b>	
scientific interest	hypogean karst phenomena hydrogeology palaeontology
contextual interest	archaeological cultural
interest evaluation	representative
level of interest	national
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



### **geological and environmental description**

The karst complex of Equi Terme's caves comprises two different elements: "Buca" and "Tecchia", situated not very far one from the other, where Fagli valley flows into Lucido's valley. "Buca" di Equi opens up at 258 m a.s.l., to the hydrographic left of Fagli stream, almost at the same altitude. The karst cavity is about 850 m long, parallel to a fault running in north (north-west)-south (south-east) direction, and it spreads into the cataclases formed by friction between cherty Limestones and dolomite Marbles. It follows a mainly horizontal course, therefore the height difference is scarce (48 m). The cave is ramified into tunnels, corridors and halls, which at their end, rise to over 60 m. Karst galleries are embellished by stalactites and stalagmites, which often resemble columns, limestone flows, curtains and lace-like forms.

"Buca" di Equi is a perpetual karst spring of underground water, whose average flow rate is estimated around 250 l/s. During floods, spectacular and violent water outflows occur, reaching a maximum of 15 m<sup>3</sup>/s. Slightly to the north there is a second spring, called Barilla, which is the Buca's upper floodway and has an average flow rate of 200 l/s. The hydrogeological basin of Equi Terme's springs has not yet been identified precisely. It includes Pisanino massif and probably parts of Orto di Donna and Acqua Bianca's valleys, situated beyond the watershed. The catchment area probably measures 15 km<sup>2</sup>, with a linear underground water course about 8 km long until the spring and a height difference of almost 1600 m.

Finally, Equi Terme's Tecchia is a hydrologically speaking neutral cavity which opens up in cherty Limestones, at 305 m a.s.l., to the left of Fagli stream. The cave resembles a rock shelter and is home to significant deposits of palaeontological, palaeoethnological and archaeological interest. Excavations, started in the 19<sup>th</sup> cent., brought to light stone tools from the Mousterian to the Neolithic, together with Würm and post-glacial faunas (wolf, dhole, jackal, leopard, lynx, ermine, marmot, beaver, ibex, chamois, etc.). The remains of *Ursus spelaeus* (Rosenmüller & Heinroth), which probably inhabited the cavity in alternation with Neanderthal hunters, are particularly numerous.

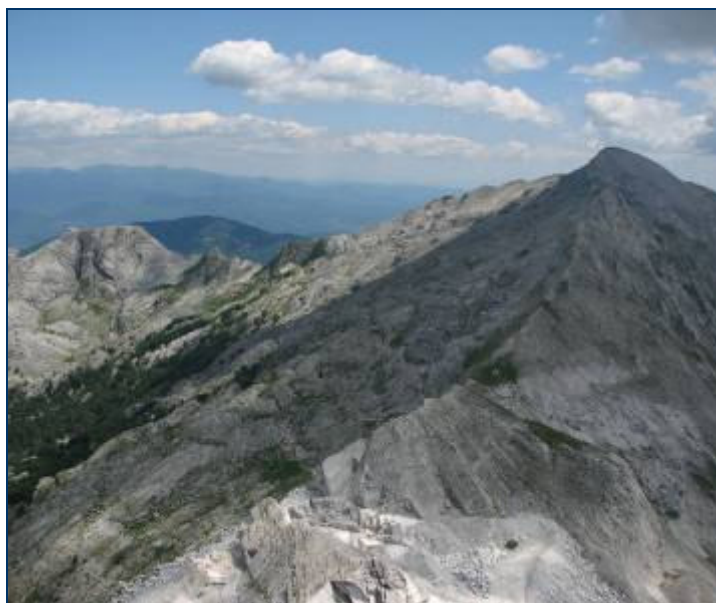
### **description of the level of interest**

Several scientific interests are concentrated in Equi Terme's karst cavities complex, known as "Buca" and "Tecchia", starting from geomorphological, hydrogeological and palaeontological interests, not to mention the area's historical and archaeological value. Their importance is already significant when they are taken separately, but their synergic effect renders them highly interesting, at least at national level.

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**Abisso Roversi's cave**

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Minucciano
sector	Tambura
toponym/locality	Carcaraia
<b>interest</b>	
scientific interest	hypogean karst phenomena hydrogeology
contextual interest	hiking (speleology)
interest evaluation	representative
level of interest	international
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent

**geological and environmental description**

Abisso Paolo Roversi belongs to the karst area of Carcaraia, situated on Mt. Tambura (1895 m) northern side. Hypogean phenomena are concentrated in this area of the Apuan Alps, characterized by more than 150 explored cavities and some complex karst Systems, for an overall length of underground passages of more than 50 km.

Abisso Roversi outer opening is situated at 1710 m a.s.l., at the core of a doline-like depression. It is located near the mountain range main watershed, in the stretch between Mt. Tambura peak and Passo della Focolaccia (about 1645 m). Abisso Roversi has a linear extension of 4200 metres, but its main feature is the remarkable height differences, amounting to 1350 m a.s.l. (100 m of positive difference and 1250 m of negative one). In particular, the abyss vertical wells reach terminal siphons at the bottom, at 460 m a.s.l. not far away from the phreatic base level, situated at around 350 m. Most of the cavity has a vadose origin, with wells following vertical fractures inside the dolomite Marble formation. These descending elements are also characterized by a single vertical 310-m deep environment (black hole or Mandini well), which is one of the largest in the world. The cave has also elements with a horizontal course allegedly evolved from ancient tunnels of phreatic origins. These elements are characterized by cave-in and rooms of remarkable dimensions (the largest measures 50 x 80 x 50 m).

The colours of the torrent flowing inside Abisso Roversi testify to the link between the cave and the source of the river Frigido in Forno di Massa. In other words, Mt. Tambura underground water emerges after flowing underground for about 4.5 km (beeline distance).

**description of the level of interest**

The level of international interest in this karst cavity stems especially from its huge height differences. Abisso Roversi is the deepest cave in Italy and ranks twentieth in the world list (data updated in September 2010).

An added value is given by underground water flowing towards superficial watershed, linking inland side recharge areas to coastal side karst springs.

<i>location</i>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Corchia
toponym/locality	Mt. Corchia
<i>interest</i>	
scientific interest	hypogean karst phenomena
contextual interest	hiking (speleology) didactic
interest evaluation	representative
level of interest	international
<i>conservation status</i>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



### *geological and environmental description*

Mt. Corchia (1678 m) is different from the other Apuan landforms, because it hosts a large karst Complex, collectively called Antro del Corchia (Corchia's Cave). The geosite's complex morphology and pre-Quaternary origin, enable a deep study on the Apuan Alps' post-orogenic vicissitudes and morphotectonic history. Furthermore, recent studies on the Antro's speleothems radiometric dating showed the presence of one of the longest and most continuous Earth climate archives, which has been able to record climate variations in the Mediterranean area in the past million years.

The exploration history of the karst complex has ancient origins, since it dates back to 1840. Since then, thousands of Italian and foreign speleologists have explored the numerous underground ramifications of Antro del Corchia. It is thanks to them that the different explored parts are now joint, starting from the 14 natural entrances known so far.

The karst Complex consists of four different levels of large galleries. The upper three levels have a palaeophreatic origin (I, 1350-1500 m of altitude; II 1050-1250 m; III 800-1000) and the lowest is currently active (IV 450-650 m). Their origin dates back to stasis moments of the basic hydrological area and therefore to periods of relative isostatic balance of the Apuan Alps. The gallery levels of Antro del Corchia are superimposed one over the other and mainly linked by wells, predominantly of vadose origin. Unlike the galleries, they formed during rapid upthrust stages of the Apuan massif, occurred during the Quaternary (I-II, Early Pleistocene; II-III, Early-middle Pleistocene; III-IV, Middle Pleistocene).

The Antro's gallery dimensions, especially around 1200 m of altitude, required significant water income, incompatible with the current morphological structure. In the early development phases of the hypogean karst phenomena, Mt. Corchia probably collected most of Apuan water resources, acting as drainer. Between Late and Early Pleistocene, a large hanging internal basin, measuring 30 km<sup>2</sup> formed. It run parallel to the Apuan ridge axis, and it acted as the allogenic catchment area of Corchia's karst System. Witness to this ancient hydrographic/hydrogeological situation the conglomerate deposits of the upper galleries, where "exotic" non-metamorphic sandstone pebbles, coming from far allochthonous units, were found.

### *description of the level of interest*

The importance of Antro del Corchia's karst Complex geosite transcend the national level, especially with regards to the geological and climate archive preserved in its intricate network of galleries and wells; not to mention the absolute value of its dimensions, measured both in length (about 53 km) and deepness (1187 m), and the historical contribution of the site to the development of speleological exploration.

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## Tana che Urla (“Vallisneri’s cave”)

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Vergemoli
sector	Panie
toponym/locality	Fornovolasco
<b>interest</b>	
scientific interest	hypogean karst phenomena hydrogeology geohistory
contextual interest	hiking (speleology) didactic
interest evaluation	representative
level of interest	national
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Tana che Urla (Screaming Den) is a 400 m long karst cavity with a height difference of 48 m. It opens up in the eastern slope of the tract comprised between Pania della Croce (1858 m) and Mt. Forato (1230 m), to the hydrographic left of the Tùrrite di Gallicano at 615 m of altitude. The cave consists of a single gallery with a basically horizontal course, carved in “Grezzone” Dolomite, almost touching the impermeable lower Phyllites. Its morphology is typically phreatic and is characterised by a wide entrance, from which a stream flows out (average flow rate: 30 l/s).

The most inner tract of the gallery has a long active siphon (220 m). During waterfloods, water pours out violently from the cavity’s entrance and flows into the stream below with an impressive waterfall, which may reach a maximum of 3 m<sup>3</sup>/s.

Tana che Urla is one of the best known and most frequented cavities in the Apuan Alps, because it is easily accessible and walked through and there is no need of fixed equipment along the way. As a matter of fact, it is frequently used as a didactic excursion for speleological tours or classes.

**description of the level of interest**

The prevailing scientific interest, beside that linked to the hypogean karst phenomena, is mainly of geohistorical nature, since the cave suggested to Antonio Vallisneri *senior* (1661-1730) the perpetual water cycle. The observations made here in 1704 inspired him his famous *Academic Lecture on the origin of springs* (1715), where the Italian scientist confuted the so-known “sea theory”, also advocated by René Descartes (1596-1650). In particular, the official science believed that spring water was generated by sea water seeped into the depths, evaporated within rocks because of the Earth internal heat and condensed in underground caves by distillation, according to the alembic principle.

Thanks to the experience made in Tana che Urla, involving direct observation and the study of Apuan mountains’ morphology and lithology, Vallisneri *senior* was able to demonstrate the meteoric origin of springs. According to his explanation, water seeps into permeable rocks until it finds an impermeable geological stratum enabling it to spring out. Vallisneri also explained the geosite’s peculiar name: “because, bringing the ear to the cave’s mouth, one can always here a strange din, a rumble coming from afar, like a men, yelling and shouting”.

The well-known naturalist Lazzaro Spallanzani (1729-1799) came here in 1783 attracted by the fame of this cave, to delve into further hydrogeological subjects.

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Camaiore
sector	Matanna
toponym/locality	Grotta all'Onda
<b>interest</b>	
scientific interest	hypogean karst phenomena hydrogeology
contextual interest	archaeological, cultural hiking
interest evaluation	rare
level of interest	national
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



### **geological and environmental description**

Grotta all'Onda is located at the bottom of a morphological crag at 708 m a.s.l., in an area particularly rich in karst springs, fed by the overlooking carbonate formations of Mt. Matanna southern side (1318 m). The cavity formed on a permeability threshold at the border with a very small tectonic window of sericitic Schists of the Authochthon *Auct.* The window is completely surrounded by Tuscan Nappe cavernous Limestones *s.l.* interlayered with polygenic breccias with mainly metamorphic clasts.

The cave entrance is characterized by a wide ogival cleft, 30 m. wide and 2-3 m high. The upper edge of the outer vault resembles a large sea wave. Hence the name of the geosite (Wave Cave). Small cascades flow from the overhanging calcareous wall rendering the geosite particularly pleasant and evocative.

The cavity consists of a large 40 x 60 m room, scattered with huge blocks fallen from the vault. Its inner deposits testify to remarkable sedimentologic and paleoclimatic vicissitudes occurred since 0.17 Ma. This site – explored for the first time in 1865 – testifies human presence until recent times. Its most ancient Mousterian stone tools date back to 40,000 years ago, as shown by a recent speleothems radiometric dating. Hunters of the Paleolithic used the cave for their seasonal settlements and lived in its outer part. Lastly, the Neolithic layer preserves materials dating back to 5,000 years ago, testifying to agro-pastoral activities in small permanent settlements.

Another cavity of palaeoethnological and palaeontological interest, Buca del Tasso (the Badger's Hole), is situated near Grotta all'Onda, on Mt Prana (1221 m) western side. Remarkable remains of late-Pleistocene animals (mammoths, Merk's rhinoceros, leopards, cave bears, etc.) have been discovered in this area and are largely linked to the activities of hunters-gatherers in the last phase of the Middle Paleolithic (40,000 years ago). The small cavity, located at 415 m near Metàto di Camaiore, has also preserved an exceptional anthropological find, very rare in Italy: a femur of a child of *Homo neanderthalensis* King.

### **description of the level of interest**

From the hydrogeological point of view, Grotta all'Onda is a rare example of a neutral cavity characterized by an uplifted karst palaeo-level which is responsible for the formation of the underground environment. The combined prehistoric and geological interest renders this site one of the most important geosites in Italy, especially for the value of its geo-archaeological remains.



<b>location</b>	
region	Tuscany
province	Massa Carrara
municipality	Massa
sector	Cavallo
toponym/locality	Forno
<b>interest</b>	
scientific interest	hydrogeology
contextual interest	historical
interest evaluation	representative
level of interest	national
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	non-existent



### **geological and environmental description**

Frigido's spring flows out from a cavity in the rock, at 235 m a.s.l., on the western slope of Mt. Castagnolo (1003 m), near the village of Forno di Massa. It is a karst spring of underground water, situated where two formations with different permeability levels touch; the "Grezzone" Dolomite is superimposed on Ordovician porphyroids. Furthermore, the cavity is linked to a second entrance ("Bucone": Big Hole), about 500 m to the north, which may originate spectacular waterfalls during heavy storms if the cavity is "too full".

Frigido's spring is the largest in the Apuan Alps, with an average flow rate of 1550 l/s and peaks of 8 m<sup>3</sup>/s. The spring catchment area allegedly comprises most of the Apuan massif northern sector, including wide areas beyond the main watershed. Indeed, the hydrogeological basin (34,5 km<sup>2</sup>) is significantly different from the superficial hydrographic basin (20,0 km<sup>2</sup>), since it affects the high north-eastern slopes of Grondilice, Pisanino, Cavallo, Tambura, Sella e Macina, including most of Carcaraia and Arnetola's valley.

In the past, the spring was harnessed as driving force for an important cotton mill – Cotonificio Ligure – which was built approximately in 1890, almost in the shelter of the karst landform. Today, the buildings and machinery of the former Filanda di Forno (Forno's spinnery) are sites and goods belonging to industrial archaeology, even though hydroelectric energy is still produced through the old factory's pipes.

### **description of the level of interest**

Frigido's spring is the best example in the Apuan Alps (and beyond) of underground water capture by coastal basins to the detriment of internal ones, as evolutionary consequence of the progressive erosion of impermeable thresholds in sea slope. The high average flow rate of the karst spring, the greatest in Tuscany and remarkable in Italy, contributes to conferring an interest of national level to the geosite.

The spring was at the centre of numerous hydrogeological studies, which still attract scholars and researchers. Lazzaro Spallanzani (1729-1799), who expressly went to Forno, was among the first to describe the place. During his visit in 1783, he was the first to realize that spring water came from beyond the Apuan Alps' main watershed.

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Corchia
toponym/locality	Levigliani
<b>interest</b>	
scientific interest	mineralogy
contextual interest	historical cultural
interest evaluation	representative
level of interest	national
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



#### **geological and environmental description**

The mercury mines of Levigliani are situated in Riseccoli, to the hydrographic left of the channels Canale del Bosco-Canale delle Volte, at 500-550 m of altitude. In the same valley to the west, near Cansoli, there is a similar but smaller mine.

Levigliani's mineral resources are encased in the Paleozoic basement of the Apuan Alps Metamorphic Complex, where they are disseminated or incorporated in quartz-carbonate veins. The veins, narrow but continuous along the entire deposit, are parallel to the axial-plane schistosity (or main metamorphic foliation). There is an interesting and rare paragenesis of mercury sulphides, zinc, iron and bismuth. Mercuriferous minerals (cinnabar, metacinnabar, sphalerite, etc.) are completely incorporated in Ordovician volcano-sedimentary rocks (green phyllites associated with metabasites), metamorphosed during the Hercynian and Alpine orogenesis. The diffusion in the deposit of native mercury, easily findable in metallic drops along quartz veins, is particularly significant.

Furthermore, other rare, if not unique, minerals are found here; e.g. leviglianite (a zinciferous variety of messelite) and especially calomel (a mercury chloride, which rendered the mine famous). A new mineral species was recently discovered: grumiplucite, a mercury and bismuth sulfosalt mineral, found in the form of metallic grey coloured and longitudinally striped prismatic acicular crystals.

The date when mining activity started in Levigliani is uncertain, though it probably occurred in the Middle Ages. Certainly, the extraction of "minium" or cinnabar, used to make pigments for the miniatures found in Florentine handwritten codes, started toward 1470. Thereafter, the history of Levigliani's mines alternates between tentative exploitations and hasty abandonments, either for exploiters' inability or for the scarce quantity of mineral obtained. Unsuccessful attempts were made by Cosimo III de' Medici at the beginning of the 18<sup>th</sup> cent. and by several foreign entrepreneurs during the 19<sup>th</sup> cent. (Morel de Beauvine, Ponyatowski, Rogerius). Extractions continued in a discontinuous way until 1970. Today, the mines are geoturistic resources and frequent destinations for scholars and researchers.

#### **description of the level of interest**

The geosite is appreciated because it offers the opportunity to observe rare minerals along mining tunnels, thanks to the conservation and recovery works in the underground mineral complex. The presence of different mineral elements, which are rare or absent elsewhere in Italy, confers to the geosite an interest of national level; an example is native mercury, anciently called "quicksilver" for its colour and fluidity during its liquid state.

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Matanna
toponym/locality	Buca della Vena
<b>interest</b>	
scientific interest	mineralogy
contextual interest	historical cultural
interest evaluation	representative
level of interest	international
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium



### ***geological and environmental description***

Buca della Vena's mine belongs to the metalliferous area of Upper Versilia, in the Apuan Alps central-southern sector. The area sees a concentration of major mineralisation and deposit types, which led, in different eras, to intense extraction activities. Mineralisation is found between Paleozoic basement's tourmalinized phyllites (Fornovolasco Schists) and the triassic carbonate cover ("Grezzone" Dolomite) of the Apuan Alps Metamorphic Complex. It is sub-parallel to the schistosity of the compressive tectonic phase (D1, therefore coherent with the general evolutionary picture of the mountain range).

In the past decades, more than 80 mineral species were identified in Buca della Vena, 10 of which completely new [allanite-(La), apuanite, dessauite, marrucite, pellouxite, pillaitite, rouxelite, scainiite, stibivanite-2O and versiliaite]. Most of them have not yet been found in other parts of the world. Among new minerals, the most important certainly are apuanite and versiliaite, which belong to the group of antimony and iron oxysulphides. Another distinctive feature of Buca della Vena is the presence of lead and antimony acicular sulfosalt minerals, containing chlorine and oxygen. Beryl concentrations in calcite veins and the presence of numerous and extremely rare minerals, containing vanadium as their main element (carelianite, derbylite, stibivanite, etc.), are also unusual.

Mining activities in Buca della Vena were firstly reported during the Middle Ages, precisely at the end of the 14<sup>th</sup> cent. During the 16<sup>th</sup> cent., when the land passed under the dominion of the Florentine Seignior of the Medici family, extractions resumed. Rediscovered in 1845, after a long period of abandonment, the mine was definitively closed in 1987-88, after a reduction in the demand of barium minerals (Ba) containing pyrite and magnetite. Important signs of industrial archaeology are still visible on the field.

### ***description of the level of interest***

Buca della Vena's mine is the most important mineral geosite in the Apuan complex, since it hosts numerous rare, extremely rare and unique species. The place also stands out for the presence of complex mineral phases with an unusual chemical composition generated under particular chemico-physical crystallization conditions, rarely found in nature. Thanks to these unique characteristics, the geosite is interesting at international level and recognised by the world scientific community.

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## Valle Buona's Mine (Pb-Zn-Ag)

<b>location</b>	
region	Tuscany
province	Lucca
municipality	Stazzema-Pietrasanta
sector	Gabberi
toponym/locality	Sant'Anna-Valdicastello
<b>interest</b>	
scientific interest	mineralogy
contextual interest	historical, architectural cultural
interest evaluation	representative
level of interest	national
<b>conservation status</b>	
characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

“Valle Buona” (Good Valley) comprises the mines of Buca dell’Angina, Monte Arsiccio and Pollone. Already in the 13<sup>th</sup> cent, the toponym referred to the veins richness in minerals, cropping out in different points of the valley and useful and precious for the economy of the time. The three mines are located in the hydrographic basin of Baccatoio stream, between Sant’Anna di Stazzema and Valdicastello Carducci, on the south-western slope of Mt. Lieto (1019 m) and Mt. Gabberi (1109 m).

Angina, Arsiccio and Pollone, which host deposits of baryte, pyrite and lead, silver and zinc sulphides, are all located within the small Sant’Anna’s tectonic window and have the same relations between mineralization and enclosing rocks. The mining tunnels exploited lenticular deposits, situated where paleozoic Phyllites and quartzite touch the overlaying “Grezzone” Dolomite. Usually, the mineralization zoning, going from top to bottom, is as follows: “Grezzone” (top) - hematite and compact magnetite, iron oxides mixed with finely crystallized baryte, massive baryte, baryte mixed with pyrite; pyrite - Phyllites (bottom).

The geometry and the presence of carbonate rock blocks within the mineral, when in contact with Norian age Dolomites, confirm the metasomatic nature of mineralization, which probably formed along late movement planes of the first tectonic phase occurred the Apuan Alps. The conformation of Angina mine, where natural and artificial cavities coexist, is absolutely peculiar. In this area there is a system of karst caves made of halls and galleries, which were found while digging tunnels for the deposit exploitation. In particular, geocronite crystals (lead and antimony sulfosalt mineral) of unique beauty and dimensions (up to 15 cm long and several kilos in weight) have been found in Pollone’s mine. They are exhibited in important Italian and foreign museums and still unequalled at international level.

The exploitation of Valle Buona’s ferrous minerals began in the Middle Ages (or earlier), continued during the Renaissance and the modern era and was resumed at industrial levels in the 19<sup>th</sup> cent., when Italian and foreign companies mined veins of hematite, magnetite and manganese-bearing limonite. In the second post-war era, the company EDEM exploited the mine for one last time, extracting baryte until 1989.

**description of the level of interest**

Angina, Arsiccio and Pollone’s mineralogical and mineral geosites are important at national level for the historical continuity in extraction activities and for their relatively well-preserved mineral sites and goods. Valle Buona’s area is potentially apt to develop geoturistic enhancement initiatives and recovery projects of industrial archaeology sites and facilities.

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**Fossils in marble banks in Foce di Pianza**

<b>location</b>	
region	Tuscany
province	Massa Carrara
municipality	Carrara-Fivizzano
sector	Sagro
toponym/locality	Foce di Pianza
<b>interest</b>	
scientific interest	palaeontology
contextual interest	didactic cultural
interest evaluation	rare
level of interest	regional
<b>conservation status</b>	
characteristic/condition	fair
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

Foce di Pianza's marble banks are among the rare places within the Apuan tectonic window still conserving visible palaeontological signs, despite the effects of metamorphism. The geosite is found at about 1300 m of altitude, to the west of the glacial transfluence saddle, toward Mt. Borla (1465 m). It was discovered in 1945 by Enzo Beneo (1903-1988), who described a level of gastropods, with the same structure as marble, which called "*lumachelle*" (small snail) owing to their richness in tower-like formations. Subsequent studies identified ammonites, crinoids and fossilised algae.

Notoriously, Apuan Alps' metalimestones were subject to high temperature and pressure, which almost completely destroyed sedimentation levels and fossils in all known outcrops. Therefore, fossiliferous areas are rather rare in the Apuan Alps Metamorphic Complex and even rarer in Marbles *s.s.* of Autochthon *Auct.* Its attribution to the Hettangian, based on the few reliable and recognizable fossils, generated a period of confusion, uncertainty and discussions in geological literature.

**description of the level of interest**

Foce di Pianza's palaeontological geosite is interesting at regional level, especially considering its rareness within the geographical area. Moreover, the level of interest of this geosite is increased, indirectly, by scientific importance always attributed by geological studies to the Metamorphic Succession of the Tuscan Domain.

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## Alto Matanna's "red ammonitiferous Limestone"

**location**

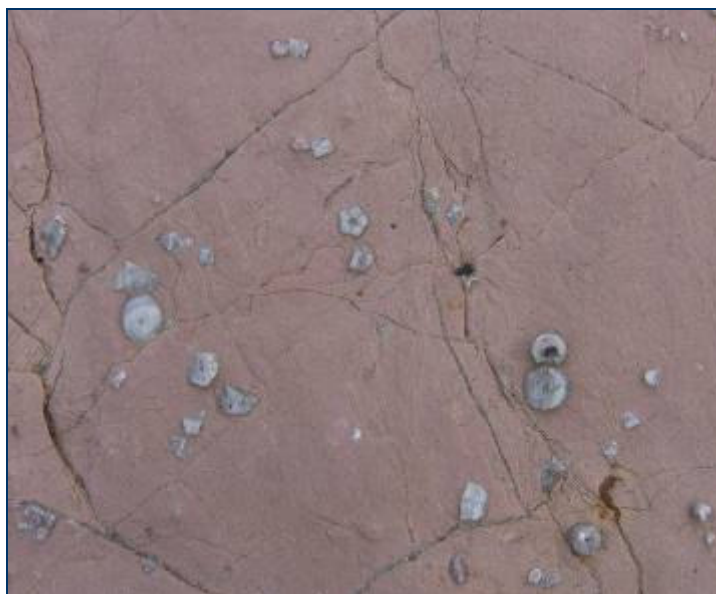
region	Tuscany
province	Lucca
municipality	Stazzema
sector	Matanna
toponym/locality	Alto Matanna

**interest**

scientific interest	palaeontology
contextual interest	didactic historical
interest evaluation	representative
level of interest	regional

**conservation status**

characteristic/condition	good
risk of natural deterioration	non-existent
risk of anthropogenic deterioration	medium

**geological and environmental description**

The outcrops of Mt. Matanna's (1318 m) "red ammoniteferous Limestone" are apparently larger than elsewhere, because landform morphology follows the rock line. They are characterised by a modest thickness, which, in the entire Apuan complex, never measures more than 50 m between the massif base level and the stratified facies above.

The substrate looks like a pale-pink entrochal nodular limestone, mainly on Mt. Matanna's eastern slope, just below the ridge. Small quarries, already abandoned at the end of the XIX cent., produced an ornamental stone known as "*Roseo di Matanna*" (Matanna's pink) or "*Mischio carnicino*" (flesh-coloured).

In general, the yellow, pink and red nodular limestones of the non-Metamorphic Succession of the Tuscan Domain (Tuscan Nappe) have fossiliferous levels containing ammonites, which won them the ancient denomination of "*Arietites Limestones*". A typical Sinemurian cephalopod of this area is *Plesechioceras doricum* (Savi & Meneghini), often associated to other species of ammonites and crinoids.

**description of the level of interest**

The presence of fossilised fauna in Alto Matanna's "red ammoniteferous Limestone" was first reported in 1864. The discovery was made by the naturalist Emilio Simi (1820-1875), who provided the geologist Iginio Cocchi (1827-1913) with the materials found. The latter attached significant value and importance to the finds, in comparison with other red Limestones outcrop in the northern Apennine: "*(the) beautiful red limestone, and here you have some ammonites, whose importance is second only to Sassorosso*".

This geohistorical evaluations and annotations confer an interest of regional level to Mt. Matanna's palaeontological site.