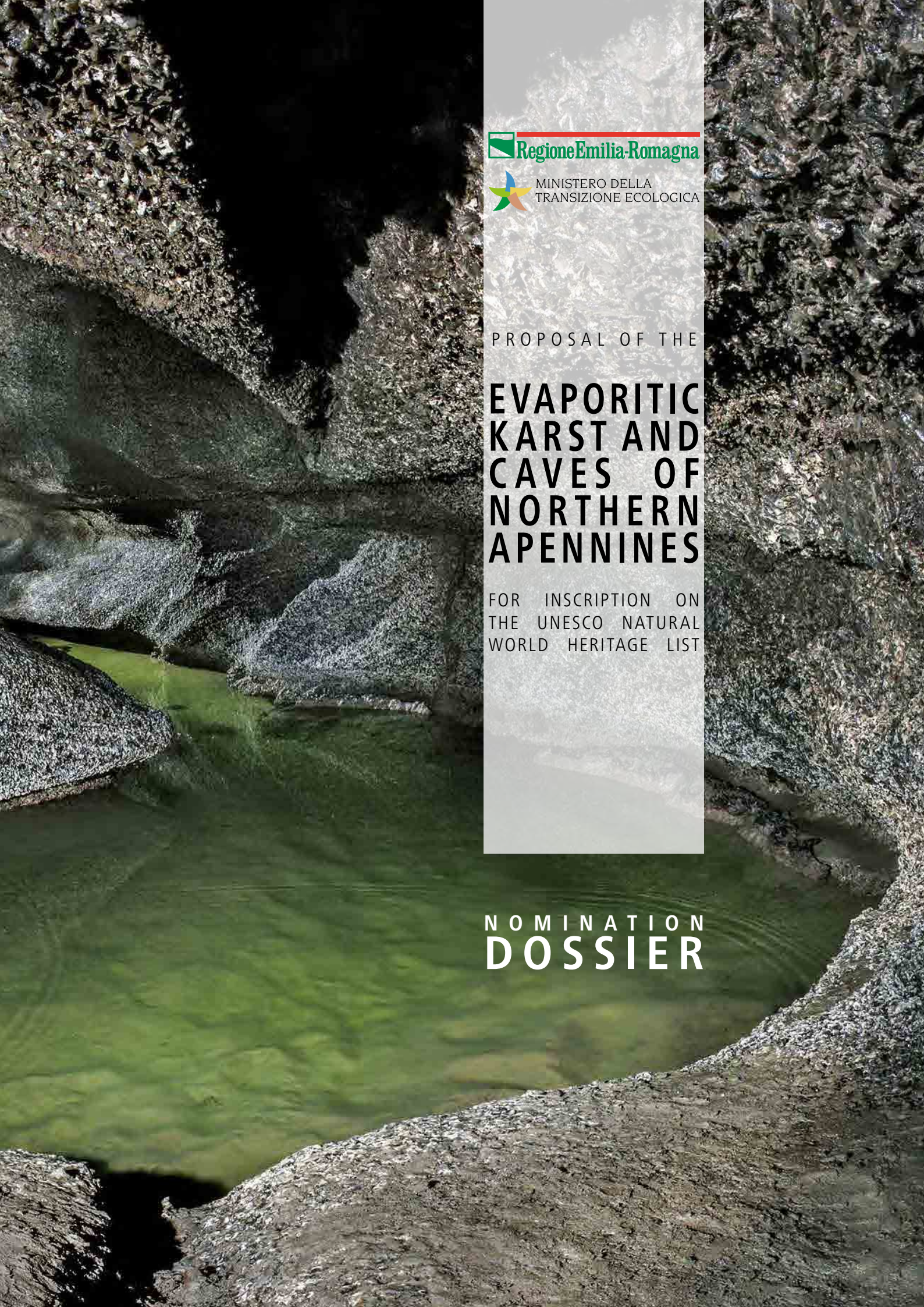


RegioneEmilia-Romagna

MINISTERO DELLA TRANSIZIONE ECOLOGICA

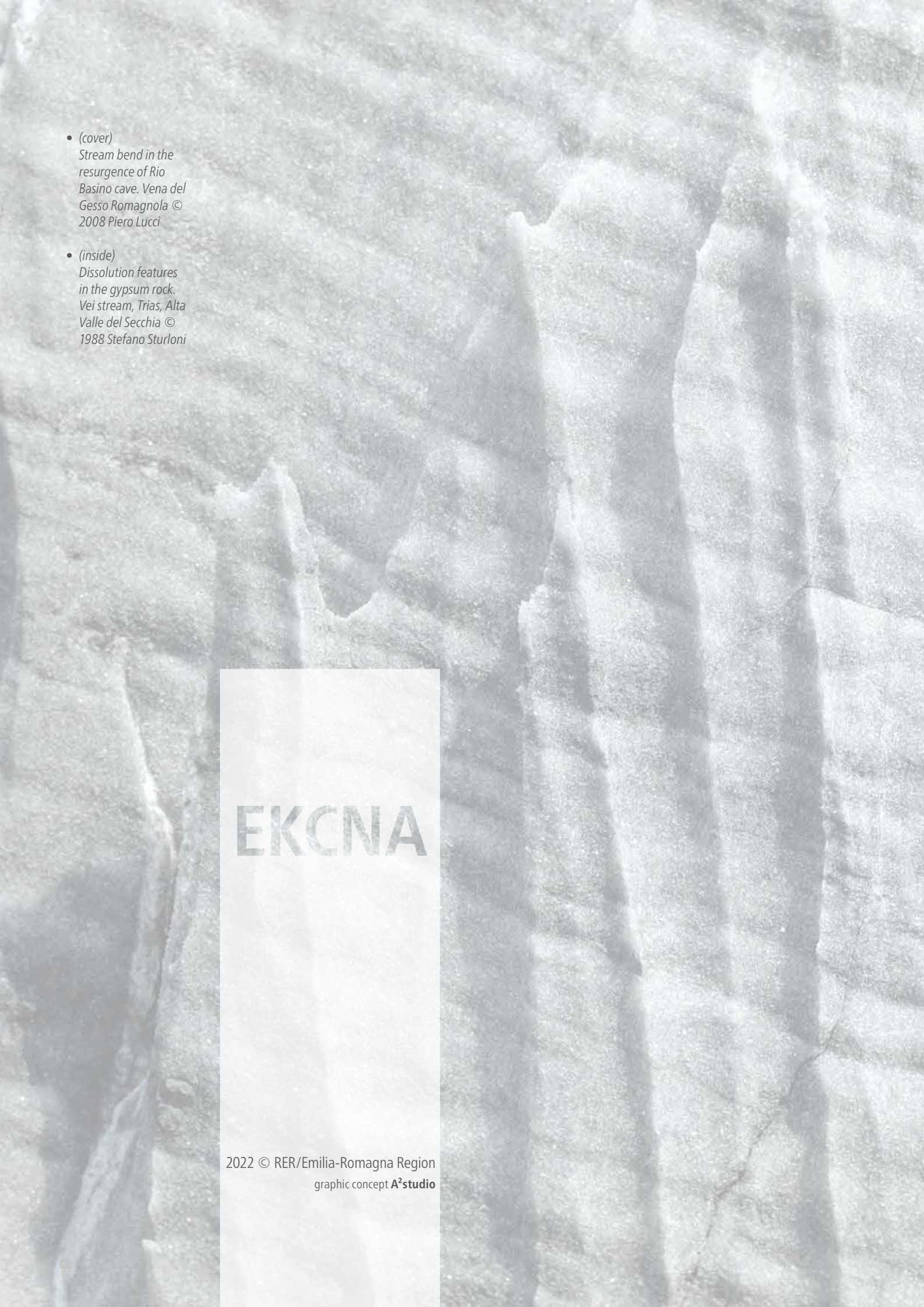
PROPOSAL OF THE

EVAPORITIC KARST AND CAVES OF NORTHERN APENNINES

FOR INSCRIPTION ON THE UNESCO NATURAL WORLD HERITAGE LIST

NOMINATION

DOSSIER



- *(cover)*
  Stream bend in the resurgence of Rio Basino cave. Vena del Gesso Romagnola © 2008 Piero Lucci

- *(inside)*
  Dissolution features in the gypsum rock. Vei stream, Trias, Alta Valle del Secchia © 1988 Stefano Sturloni

EKCNA

graphic concept **A²studio**

RegioneEmilia-Romagna

MINISTERO DELLA TRANSIZIONE ECOLOGICA

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EKCNA

NOMINATION

DOSSIER

Ministry of the Ecological Transition /
Ministero della Transizione ecologica
Emilia-Romagna Regional Administration - Department for mountains, internal areas, spatial planning, equal opportunities /
Regione Emilia-Romagna - Assessorato alla montagna, aree interne, programmazione territoriale, pari opportunità

Specialized coordination
Stefano Furin,
Cesare Micheletti & Loredana Ponticelli

Nomination editing, management strategy, web-GIS and cartography, layout & graphic design
A^{2}studio srl, Trento (TN) - I
Dolomiti Project srl, Feltre (BL) - I

Date
January 2022

Acronym Legend

RER	Emilia-Romagna Region
MITE	Ministry of the Ecological Transition
FSRER	Speleological Federation of Emilia-Romagna Region
GSPGC	Speleological and Paletnological Group "G. Chierici" (RE)
GSB USB	Speleological Group & Union of Bologna
IUCN	International Union for Conservation of Nature
WH	World Heritage
c.s.	component site (or *component part* of the serial site)

Cover photo
Stream bend in the resurgence of Rio Basino cave. Vena del Gesso Romagnola © 2008 Piero Lucci

Photo credits
P. Lucci, S. Lugli, G. Filippucci, G. Belvederi, P. Gualandi, F. Facchinetti, G. Bianchini, G. Bertolini, M. Chiesi, P. Ferrari, S. Sturloni, S. Piastra, H. Artoli, F. Grazioli, G. Agolini, A. Pumo, D. Victorini, R. Simonetti, G. Bartolini

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IMPRESSUM

General Coordination

Emilia-Romagna Regional Administration - General directorate for territorial and Environmental Care

- Paolo Ferrecchi (General Director)
- Sergio Monti (Director of Department for geology, seismic and soil survey)
- Gianni Gregorio (Director of Department for Protected areas, Forestry and Mountains development)
- Marco Pizziolo, Giovanna Daniele, Mauro Generali, Alberto Martini e Silvia Messori (organizing secretariat)

Technical-scientific Working Group

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Dipartimento di Scienze Biologiche, geologiche e ambientali;

- Paolo Forti, with contributions of Jo De Waele – Karst
- Federico Fanti - Paleontology

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Soprintendenza Archeologia Belle Arti e Paesaggio Province di Ravenna, Forlì-Cesena, Rimini

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- Alessandra Curotti, Stefano Furin - Parks, maps, laws and planning

Regione Emilia-Romagna

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Servizio aree protette, foreste e sviluppo della montagna

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Servizio innovazione digitale, dei dati e della tecnologia

- Giovanni Belvederi – Maps

Servizio attrattività e internazionalizzazione

- Maura Mingozzi - Laws and planning

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- Massimiliano Costa – Coordination , Biology, parks, laws and planning

Ente di gestione per i parchi e la biodiversità - Emilia orientale

- David Bianco - Biology, parks, laws and planning

Ente di gestione per i parchi e la biodiversità - Emilia centrale

- Valerio Fioravanti, Fausto Minelli - Parks, laws and planning

Ente di gestione per i parchi e la biodiversità – Romagna

- Nevio Agostini, with contributions of Lorenzo Cangini, Oscar Zani - Parks, laws and planning

Federazione Speleologica Regionale dell'Emilia-Romagna

- Massimo Ercolani, with contributions of Piero Lucci, Paolo Grimandi, William Formella (†), Garibaldi Sansavini, Federico Cendron, Veronica Chiarini, Luca Parisi - Karst

With contributions of:

- Fausto Bonafede, Michele Vignudelli - Biology
- Marco Sami - Paleontology

PREAMBLE

The nomination project of **Evaporitic Karst and Caves of the Northern Apennines** was born in the framework of the close and historical collaboration between the **Regional Speleological Federation** (FSRER) and the **Universities of Emilia-Romagna territory**.

Professor **Paolo Forti**, Honorary President of the *Union Internationale de Spéléologie* (UIS), is one of the first scientists to understand the worldwide relevance of the evaporitic karst phenomena of this part of the Apennine chain. Professor Paolo Forti, already head of the Chair of Speleology at the University of Bologna, President of the Italian Speleological Society, and Director of the Italian Institute of Speleology, has explored and researched hundreds of caves and cavities in dozens of countries around the world and is thus considered one of the leading international experts in this field.

He pointed out the opportunity to start the nomination process for inclusion in the World Heritage List, highlighting, together with many other international scientists, the absence of properties of this kind in the UNESCO World Heritage List.

At the end of 2016, FSRER formally invited Region Emilia-Romagna to promote its gypsum karst sites for inclusion on the UNESCO World Heritage List.

By a formal act of the Regional Council (Act No. 2273 of 21/12/2016), the Region was therefore committed to involve all public administrations of the territory concerned, through an *Memorandum of Understanding (MoU)*, containing the objectives, actions, timing, specific responsibilities, and mutual commitments to implement the nomination project.

The technical-scientific documentation necessary to apply for inclusion in the Italian Tentative List, the first step of the nomination, has been prepared in 2017. The request was submitted to the Italian National Commission for UNESCO (CNIU) on January 17, 2018 (note n. PG/2018/0028872) and, on January 31, 2018, the site "*Evaporite karst and caves of Emilia Romagna Region*" (this was the draft name of the nomination) was included in the **Italian Tentative List of UNESCO World Heritage** (**Ref.: 6317**).

Therefore, the Emilia-Romagna Region has set up a **Technical Scientific Working Group** (executive act no. 12029 of 25/07/2018 and renewal act no. 17425 of 22/08/2021). The Working Group tasks are to contribute to the in-depth study of all technical-scientific issues related to the nomination, to prepare the documentation to be submitted to the competent Ministry of the Ecological Transition and to effectively accompany the process.

The Working Group, which is still active, includes experts from the Universities of Bologna and Modena and Reggio Emilia, technical staff of the Ministry of Culture - Regional Secretariat for Emilia-Romagna and of the Emilia-Romagna Region, representatives of the Park Authorities within the candidate area, and FSRER members. The Working Group also made use of the specialized technical contribution of professionals with proven experience in nomination processes.

To support the nomination process, the Region has promoted a **participatory process to engage all the institutional stakeholders** of the entire nominated property. Public Authorities that signed the *Memorandum of Understanding* to support the nomination to listing the ***Evaporite Karst and Caves of Northern Apennines*** on the WHL (registered on 27/04/2020, with Emilia-Romagna Region Repertoire n. 149) are the following :

- **Emilia-Romagna Regional Administration**
- **Appennino Tosco-Emiliano National Park**
- **Management Authority for Parks and Biodiversity - Emilia Orientale**
- **Management Authority for Parks and Biodiversity - Romagna**
- **Metropolitan City of Bologna**
- **Province of Ravenna**
- **Province of Reggio Emilia**
- **New District of Imola**
- **Union of Municipalities Savena-Idice**
- **Union of Romagna Faentina**
- **Mountain Union of the Municipalities of Appennino Reggiano**
- **Municipality of Castelnovo ne' Monti (RE)**
- **Municipality of Ventasso (RE)**
- **Municipality of Villa Minozzo (RE)**
- **Municipality of Borgo Tossignano (BO)**
- **Municipality of Casalfiumanese (BO)**
- **Municipality of Fontanelice (BO)**
- **Municipality of Pianoro (BO)**
- **Municipality of San Lazzaro (BO)**
- **Municipality of Zola Predosa (BO)**
- **Municipality of Brisighella (RA)**
- **Municipality of Casola Valsenio (RA)**
- **Municipality of Riolo Terme (RA)**

During the nomination development emerged the opportunity to extend the nomination to portions of the regional territory not previously considered, to complete the series and reinforce the integrity of the property. Thus, the karst gypsum areas outcropping near Reggio Emilia (Bassa Collina Reggiana) and near Rimini (Gessi di San Leo, Gessi di Onferno) were also included, increasing the number of components of the serial property from 3 to 7.

In this context it was agreed that the name of the nominated property should be changed to **Evaporitic Karst and Caves of the Northern Apennines,** to better represent the phenomenon from a geographical point of view.

The *MoU* was therefore signed also by the bodies affected by the new extension:

- **Management Authority for Parks and Biodiversity - Emilia Centrale**
- **Union of Colline Matildiche**
- **Union Tresinaro - Secchia**
- **Municipality of Albinea (RE)**
- **Municipality of Scandiano (RE)**
- **Municipality of Vezzano sul Crostolo (RE)**
- **Municipality of Viano (RE)**
- **Union of Reno Lavino Samoggia Valleys**
- **Municipality of Sasso Marconi (BO)**
- **Province of Rimini**
- **Union of Municipalities Valmarecchia**
- **Union of Municipalities Valconca**
- **Municipality of Gemmano (RN)**
- **Municipality of San Leo (RN)**

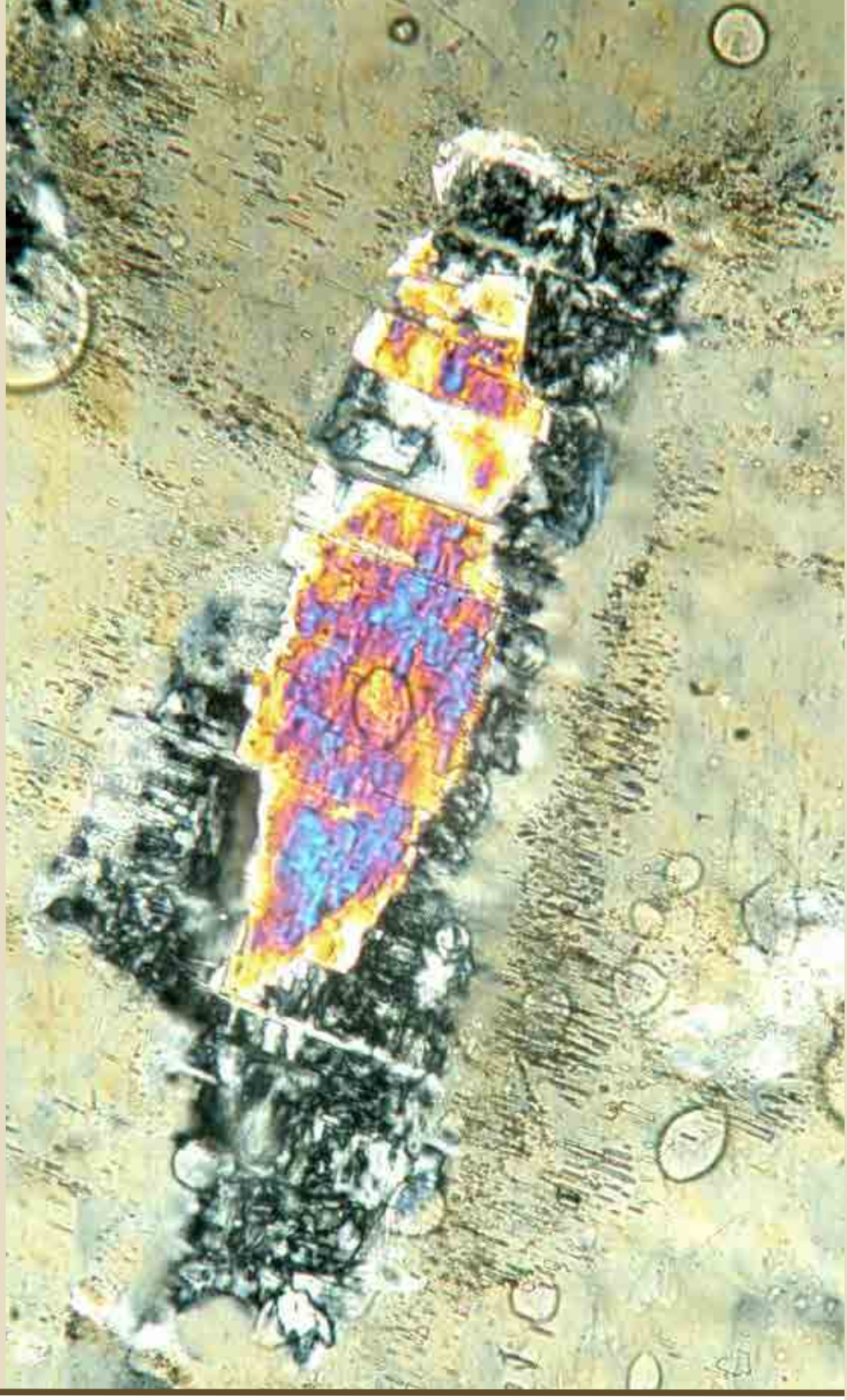
Between the end of November and December 2021, all the territorial bodies involved have committed to approve the expanded *Memorandum of Understanding* through their political bodies. The MoU manifests the undersigned entities commitment to support and sustain the nomination in every phase, cooperating and harmonizing their actions in the territory. It also commits the signatories to work together, according to their role and their area of competence, to promote actions, projects, programs, and strategies towards:

- *The protection of the environmental balance and safeguard of the epigean and hypogean ecosystems;*
- *The protection and conservation of geological sites and specific geological landscape of the Gypsums;*
- *The enhancement of the historical, cultural, social, and archaeological aspects of the territories; environmental education of the local people and visitors to the protected and adjacent areas;*
- *A sustainable development of the territory through best practices and promotion of compatible economic activities.*

The MoU also foresees the creation of an **Institutional Committee** (see par. 5.e), composed by representatives of the subscribing bodies and chaired by the Councillor for mountains, internal areas, territorial planning, equal opportunities of the Emilia-Romagna Regional Administration. In case of inscription into the WHL, the Institutional Committee has agreed to establish an adequate governance, capable to accomplish the objectives of the management strategy according to standards and conditions that will be established with UNESCO during the approval phase.

In addition to the scientific community and local institutions, the nomination process was also supported by the **Italian Alpine Club (CAI)** at national level and by four local sections (**Forlì, Parma, Imola, Ravenna**) which, thanks to its role as main manager of the trail network (law no. 91/1963), constantly carries out surveys and maintenance activities of the paths in the nominated property.

Further support came from associations (**The International association of Lions Clubs**) and cultural organisations (**Scuola Comunale di musica Giuseppe Sarti** in Faenza, **Scuola Angelo Pescarini Arti e Mestieri** in Ravenna), as well as from leading figures in the artistic world (the international popstar **Laura Pausini**). They all expressed their support for the nomination, testifying to the identitary value of these sites and the importance of the protection and aware use of natural heritage.



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➔ All Digital Documents of the nomination form can be found in the DVD
(see annex "Maps and plans of the nominated serial property & Digital Nomination Files")

• *(facing page) Anhydrite crystal (center) partially hydrated into gypsum (gray) seen under to optical microscope © S. Lugli*

EXECUTIVE SUMMARY

STATE PARTY

Italy

STATE, PROVINCE OR REGION

Emilia Romagna Region, Province of Reggio Emilia, Bologna, Rimini and Ravenna.

NAME OF PROPERTY

Evaporitic Karst and Caves of Northern Apennines.

GEOGRAPHICAL COORDINATES TO THE NEAREST SECOND

The geographical coordinates of the nominated property, considered as a whole, are:

The entire nominated serial property	Latitude	Longitude
centroid	44° 13' 59" N	11° 27' 38" E
north-west vertex	44° 36' 09" N	10° 18' 53" E
south-eastern vertex	43° 51' 48" N	12° 36' 23" E

The areas and the coordinates of the centroid of each component site are as follows:

ID	Name of the component part	Latitude of the central point	Longitude of the central point	Area of nominated component part (ha)	Area of the Buffer Zone (ha)
c.s.1	Alta Valle Secchia	44° 21' 41" N	10° 23' 10" E	1596 ha	1294 ha
c.s.2	Bassa Collina Reggiana	44° 35' 06" N	10° 35' 56" E	274 ha	1385 ha
c.s.3	Gessi di Zola Predosa	44° 27' 40" N	11° 13' 13" E	57 ha	128 ha
c.s.4	Gessi Bolognesi	44° 26' 15" N	11° 24' 00" E	237 ha	325 ha
c.s.5	Vena del Gesso Romagnola	44° 15' 07" N	11° 38' 38" E	1313 ha	4775 ha
c.s.6	Evaporiti di San Leo	43° 55' 05" N	12° 20' 45" E	119 ha	165 ha
c.s.7	Gessi di Onferno	43° 52' 30" N	12° 32' 51" E	84 ha	276 ha
				3 680 ha	**8 348 ha**

Coordinate Reference System: International ellipsoid - World Geodetic System 1984 (WGS84, also called EPSG: 4326). The values are expressed in sexagesimal degrees (degrees, minutes, seconds) rounded to the nearest second.

TEXTUAL DESCRIPTION OF THE BOUNDARY(IES) OF THE NOMINATED PROPERTY

The nominated property extends over a territory consisting of 7 component sites. It surrounds the entire straight ridge of evaporite outcrops that emerges on the northern slopes of the Apennines, from the "Vena del Gesso Romagnola" to the Secchia River Valley , which exposes, by erosion, some older evaporite deposits. The boundaries of the nominated property extend also underground, to include the cavities produced by karst phenomena.

• *(facing page) Dissolution pendants in the selenite rock of the Tanaccia cave, Vena del Gesso Romagnola © P. Lucci*

MAP OF THE NOMINATED PROPERTY SHOWING THE BOUNDARIES AND BUFFER ZONE

The candidate area extends over a territory consisting of 7 component sites. It surrounds the entire straight ridge of evaporite outcrops that emerges on the northern slopes of the Apennines, from the "Vena del Gesso Romagnola" to the Secchia River Valley , which exposes, by erosion, some older evaporite deposits. The boundaries of the candidate property extend also underground, to include the cavities produced by karst phenomena. All the major known caves in evaporites are included in the nominated property and

are protected by Regional, National and International laws. The boundaries take into account the extension of the whole karstic system, including the hydrogeological circulation and alimentation basin. A particular attention has been posed to include all the historical study areas, due to the relevance that these places had in the development of evaporite speleology, mineralogy and hydrogeology disciplines.

12°0'E
Reno
Idice
Sillaro
Reno
Lamone
Senio
GNA
Ravenna
Imola
Santerno
Faenza
Montone
Ronco
Savio
Forlì
Cesena
Adriatic sea
CS 5
VENA DEL GESSO ROMAGNOLA
PENNINES
Rimini
Rubicone
Marecchia
44°0'N
EVAPORITI DI SAN LEO
CS 6
San Marino
Conca
Savio
CS 7
GESSI DI ONFERNO
12°0'E
Foglia

CRITERIA UNDER WHICH PROPERTY IS NOMINATED

The **Evaporitic Karst and Caves of the Northern Apennines** represent a natural system of a unique record of evaporitic karst phenomena. The proposal for inscription is under **criterion (viii) :**

"be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features."

The nominated property hosts a density of superficial karst forms, caves, saline springs, minerals, speleothems, and palaeontological contents that has no equal in the world, thanks to its peculiar geological and climatic context. For this reason, the phenomena have been studied here since 16th century and this has been the place where many of modern scientific theories about evaporitic karst are born.

DRAFT STATEMENT OF OUTSTANDING UNIVERSAL VALUE

A. Brief synthesis

The **Evaporite Karst and Caves of Northern Apennines** serial property constitute the most complete, outstanding and accessible examples of the karst phenomena in gypsum and anhydrite at sub-tropical wet climate conditions. Located in northern Italy, this serial site unites together the most internationally studied areas with regard to hydrogeology, mineralogy and speleology in evaporitic karstic systems since 16th century: the explorations and discoveries that took place in this area are considered as milestones in the development of the respective disciplines. As highlighted by the comparative analysis, many speleothems and minerals are unique to this area, due to a complex relationship between rocks, geological evolution and climate. The serial property includes all the deposits that host different type of mineralogical evolution of gypsum, including its transformation in anhydrite and alabaster as well as all the historical study areas described in the pioneer speleological publications.

In fact, despite evaporite karst is generally considered unspectacular, in this area it constitutes a prominent feature of the landscape and crystals over one meter in height can be observed in some localities. In a very narrow belt made of vertical cliffs emerging from the surrounding clays it is possible to study the evolution of Mesozoic and Cenozoic evaporitic deposits, with the same easiness of access that led to their exploration since the pre-scientific era. Actually, caves have been explored since prehistorical times, and they became one of the first excavation areas of lapis specularis, the stunning transparent crystals, which could replace glass during Roman times. Excavation in the nominated area is strictly regulated in order to preserve the caves and the landscape. The standards of protection, management (including specific hypogean protection measures) and monitoring ensure that the Evaporite Karst and Caves of Northern Apennines phenomena and the ecosystems that are linked to them will be preserved and continue to evolve naturally.

For these reasons this area can be considered an unicum on the entire planet, that collects, protects, documents and makes available to scientists from all over the world the set of karst forms and phenomena that develop in evaporites in subtropical-humid climates.

B. Justification for criteria

Criterion (viii): The nominated serial property comprises one of the most complete evaporitic karst systems in the world. By an exceptional combination of humid sub-tropical climatic conditions and a peculiar geological setting, the candidate area is a one of his kind in the world. It constitutes one of the best places where karst in gypsum and anhydrite deposits can be observed and studied. In a relatively small area over 900 caves (amongst the largest, deepest and most complex of this type in the world) allow an easy access to most of the phenomena observable in evaporitic karst, a geological setting not yet represented in the World Heritage List.

• *The Secchia river flowing through the Triassic gypsum outcrops (view from Mt. Duro). Alta Valle del Secchia*
© S. Sturloni

An uncommon richness of rare speleothems and minerals, sometimes unique to these caves, have attracted naturalists and scientists since the 16th century. In these places the discipline of speleology in evaporites was born, and tens of phenomena have been described here for the first time.

Nowadays the rocks and caves of the Northern Apennines represent the best scientifically documented sulfate-halite karst in the world from the geological, speleological and hydrological points of view. These features can be easily accessed and explored, making this area a leading evaporitic karst research location.

C. Statement of Integrity

The seven component sites of the nominated serial property involve approximately 90% of the entire evaporitic rocks of the northern Apennine ridge. They represent the whole karst phenomena in gypsum and anhydrite, including all the outcropping and underground karst areas, all the main karst aquifers, and all their recharge areas. They also include a complete collection of epigean and hypogean karst morphologies from the dissolution surfaces in vertically exposed gypsum cliffs to the speleothems in the abysses of the caves.

From the environmental integrity point of view, the quality of the karst systems is excellent. The continuity of the karst hydrological system, above and below ground, is well preserved in all the component sites. The fruition of the few caves open to the public takes place with speleological modalities, without alterations of the natural cavities and their habitats.

From the development pressures point of view, settlement pressures are absent, although some component sites fall within the range of influence of intensely settled areas, agriculture – if present - is very limited and extensive, and the management of the existing woods is conservative, aimed at increasing their wilderness. The mining exploitation of gypsum for local use, which has affected these areas since Roman times, is now prohibited in the nominated property. As a whole, the natural property is essentially perceived also as a site of scientific and cultural interest and therefore the

human use and intervention are very limited.

D. Statement of authenticity for properties nominated under criteria (i) to (vi)

Not relevant as this nomination is submitted under criterion (viii).

E. Requirements for Protection and management

All evaporitic karst areas of the nominated property are specifically identified and strictly protected by a specific geological and speleological heritage protection act, in accordance with European, national and regional regulations.

The great majority (96%) of the nominated property is protected by European Community directives and is part of the Natura 2000 network. Most of the nominated property (71%) is protected by a national park and by two regional parks. The remaining areas are nature reserves and protected landscapes, preserved by law. The land adjacent to the nominated property is subject to the territorial and landscape planning of the Emilia-Romagna Region that establishes the rules for the management of the territory and is one of the most effective tools to implement the protection measures.

The management system consists of two management bodies. The component site 1 is managed by the Appennino Tosco-Emiliano National Park. The component sites from 2 to 7 are under the control of the the Emilia-Romagna Region which directly supervise the management bodies of the regional protected areas. These management body have a management plan, a specific budget and a dedicated staff (technical and administrative) to manage and control the respective areas.

Key management issues include the protection of the attributes and values of the geological heritage, conservation measures for habitats and species of Community interest, knowledge and communication of the natural environments. The karst hydrological system is also a very relevant management topic in these highly dynamic environments. Other management themes include education, enhancement, the quality of visitor experience, and finally the environmental restoration and conversion of abandoned and disused quarries for educational purposes.

A long-term monitoring system has been set up, using ground- and underground-based observations, for improved evaluation of the chemical and ecological state of karst aquifers, seismo-tectonic movements, and climate cave conditions. Key aspects of the nominated property's flora and fauna are also monitored.

NAME AND CONTACT INFORMATION OF OFFICIAL LOCAL INSTITUTION/AGENCY

RER	**Emilia-Romagna Region**
name 1	**Barbara Lori**
	Councillor for mountains, internal areas, spatial planning, equal opportunities
address	Regione Emilia-Romagna, viale Aldo Moro 30
city	40127 Bologna (BO) - ITALY
tel.	+39 051 527 3804
e-mail	asspianificazione@regione.emilia-romagna.it
website	https://www.regione.emilia-romagna.it
name 2	**General Directorate for Territorial and Environmental Protection**
	Secretariat of nomination process
address	Regione Emilia-Romagna, Viale Aldo Moro, 30
city	40127 Bologna (BO) - ITALY
tel.	+39 051 527 3711
e-mail	dgcta@regione.emilia-romagna.it
website	https://ambiente.regione.emilia-romagna.it/en

- *Guided speleological tour at the Canyon One, Onferno Caves. Gessi di Onferno © P. Gualandi*

IDENTIFICATION
OF THE PROPERTY

1

1.A COUNTRY

Italy.

1.B STATE, PROVINCE OR REGION

Emilia-Romagna Region, Provinces of Reggio Emilia, Bologna, Rimini and Ravenna.

1.C NAME OF PROPERTY

Evaporitic Karst and Caves of Northern Apennines.

The name of the nominated Property has been defined to be representative of the site and to offer easy and immediate geographical identification, on the basis of the following reasons:

- ***Evaporitic Karst and Caves**: it clarifies in an immediate way the emblematic values and characteristics of the geological phenomenon of the nominated Property, specifying what kind of geological phenomenon it is and with which morphologies it manifests itself;*
- ***of Northern Apennines:** the term Apennines provides a geographical location, globally recognisable since it is a mountain chain that from a geological point of view is identified and studied at an international level.*

1.D GEOGRAPHICAL COORDINATES TO THE NEAREST SECOND

The geographical coordinates of the candidate Property, considered as a whole, are:

The entire nominated serial property	Latitude	Longitude
centroid	44° 13' 59" N	11° 27' 38" E
north-west vertex	44° 36' 09" N	10° 18' 53" E
south-eastern vertex	43° 51' 48" N	12° 36' 23" E

The coordinates of the centroid of each component site are as follows:

ID	Name of the component part	Latitude of the central point	Longitude of the central point	Area of nominated component part (ha)	Area of the Buffer Zone (ha)
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c.s.7	Gessi di Onferno	43° 52' 30" N	12° 32' 51" E	84 ha	276 ha
				3 680 ha	**8 348 ha**

Coordinate Reference System: International ellipsoid - World Geodetic System 1984 (WGS84, also called EPSG:4326). The values are expressed in sexagesimal degrees (degrees, minutes, seconds) rounded to the nearest second.

- *(in front) The room of the little lake of the Tanaccia cave, Vena del Gesso Romagnola © P. Lucci*

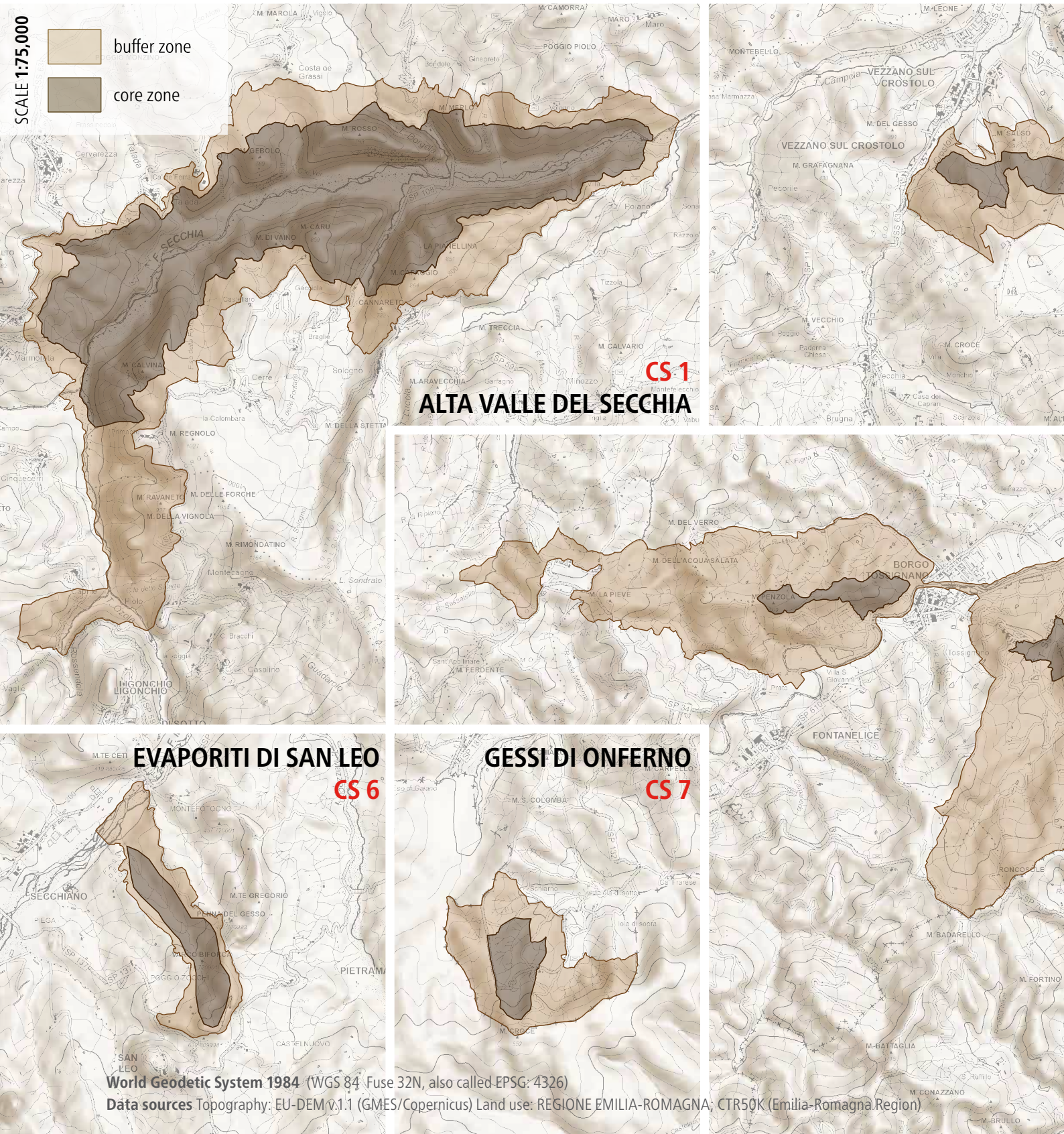
1.E MAPS AND PLANS, SHOWING THE BOUNDARIES OF THE NOMINATED PROPERTY AND BUFFER ZONE

See detailed topographic maps of all component parts and their buffer zones in the Annex 1. The candidate area extends over a territory consisting of 7 component sites. It surrounds the entire straight ridge of evaporite outcrops that emerges on the northern slopes of the Apennines, from the "Vena del Gesso Romagnola" to the Secchia River Valley , which exposes, by erosion, some older evaporite deposits. The boundaries of the candidate Property extend also underground, to include the cavities produced by karst

phenomena. The boundaries take into account the extension of the whole karstic system, including the hydrogeological circulation and alimentation basin. A particular attention has been posed to include all the historical study areas, due to the relevance that these places had in the development of evaporite speleology, mineralogy and hydrogeology disciplines. All the major known caves in evaporites are included in the nominated property and are protected by Regional, National and International laws.

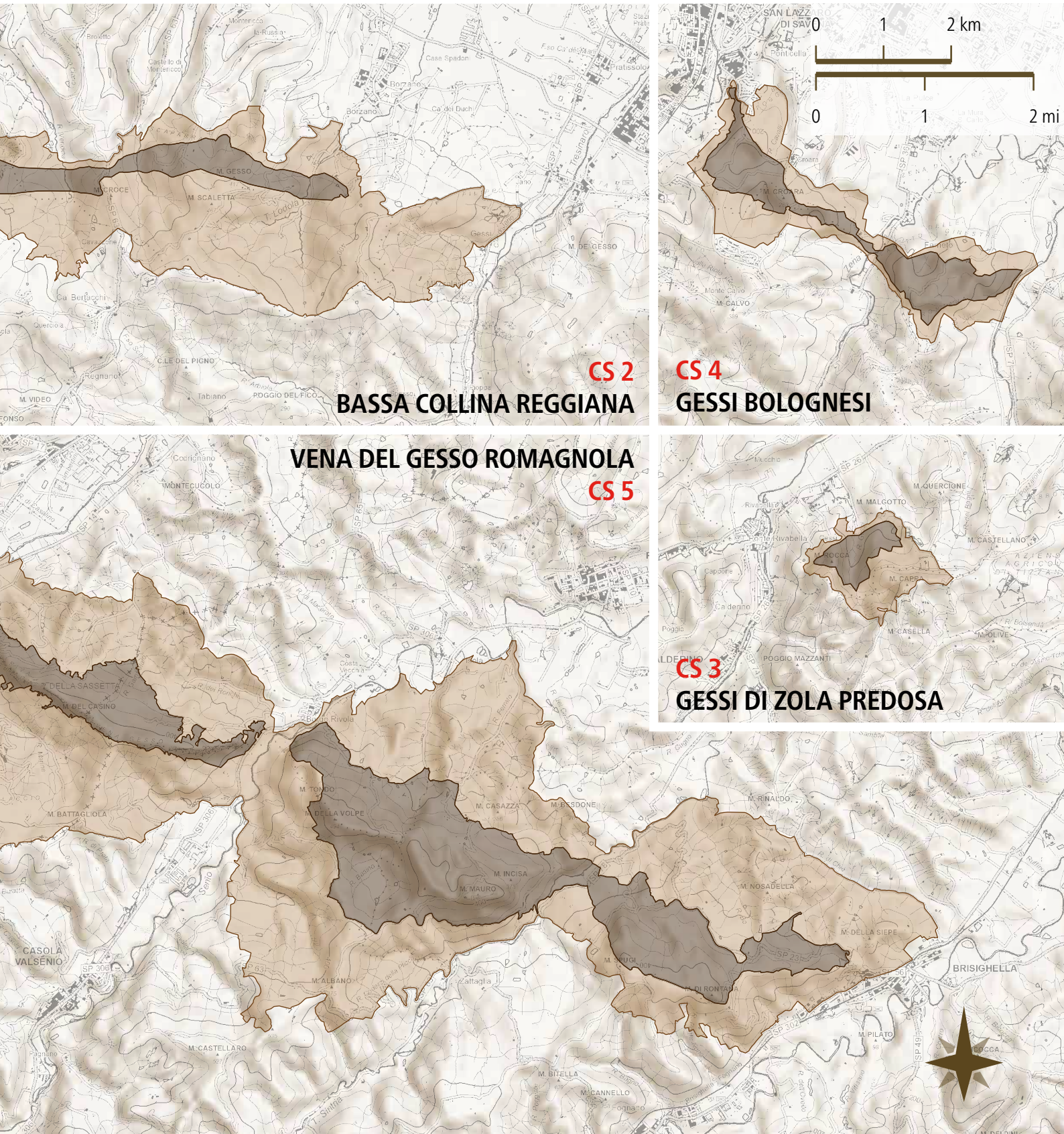
1.F AREA OF NOMINATED PROPERTY (HA.) AND PROPOSED BUFFER ZONE (HA.)

ID	Name of the component part	Area of nominated component part (ha)	Area of the Buffer Zone (ha)
c.s.1	Alta Valle del Secchia	1596,001	1292,320
c.s.2	Bassa Collina Reggiana	273,680	1384,753
c.s.3	Gessi di Zola Predosa	57,349	127,706



World Geodetic System 1984 (WGS 84 Fuse 32N, also called EPSG: 4326)
Data sources Topography: EU-DEM v.1.1 (GMES/Copernicus) Land use: REGIONE EMILIA-ROMAGNA; CTR50K (Emilia-Romagna Region)

ID	Name of the component part	Area of nominated component part (ha)	Area of the Buffer Zone (ha)
c.s.4	Gessi Bolognesi	237,225	325,109
c.s.5	Vena del Gesso Romagnola	1313,015	4774,837
c.s.6	Evaporiti di San Leo	119,350	164,990
c.s.7	Gessi di Onferno	84,460	276,126
	total surface	**3681,080**	**8345,841**



DESCRIPTION

2

2.A DESCRIPTION OF PROPERTY

The Northern Apennines are part of the of **the Apennines chain** and divide the northern part of the Italian peninsula into two main sectors: the Po Plain to the north and the Ligurian coast/ Tuscany hills and plains to the south. The Northern Apennines form an arc oriented approximately NW-SE. They extend from the conjunction with the Alps on the west to the Marecchia river on the east.

Evaporitic deposits have been laid from seawater during two major geological events: the opening of the **Tethys Sea** during the breaking up of the **Pangea** supercontinent in the Late Triassic, and during the Late Miocene "salinity crisis" related to the reduction of the connection between the Mediterranean Sea and the Atlantic Ocean at Gibraltar, which turned the **Mediterranean Sea** into a giant salina. The geologic evolution of this area led to the development of both gypsum and halite deposits, generically known as evaporitic rocks due to their genesis.

The evaporitic areas hosted in the Northern Apennines are of relatively limited extension, compared to other evaporitic sites, and are mostly spotted across the northern side of the mountain range, facing the Po Plain and the Adriatic Sea. Despite the reduced extension, however, here is concentrated a great wealth of geological phenomena, including karst surfaces and hypogeal ones: more than 900 caves are known from this area, extending over more than 100 km in length.

Due to the scattered nature of the outcrops, the **Evaporitic Karst and Caves of Northern Apennines** are a serial site nomination. The component sites of the nominated property are seven, including almost all the areas where gypsum and anhydrite deposits crop out in the Northern Apennines and develop hypogean and epigean karst phenomena. Together they offer a unique opportunity to understand the evolution of karst systems in warm-humid environments from many points of view, including the peculiar morphologies that form in this climatic regime, the role of surface and subterranean waters, the development of minerals accompanying gypsum, anhydrite and halite.

Thanks to their morphological, bioclimatic and biogeographic features, the evaporite karst systems of the northern Apennines host some exclusive species in Italy and some very rare nationally; typical species of higher altitudinal bands; species at the limit of range or disjunctions. Therefore, the evaporite deposits influenced the evolution of the landscape, the habitats and the ecosystems, the economic and cultural development of the area. Finally, karst in the evaporites of Emilia-Romagna is by far the most studied in the world: it was the first to be investigated, starting from the 16th century and it is still absolutely the best known and described in the highest number of scientific papers, over 1650.

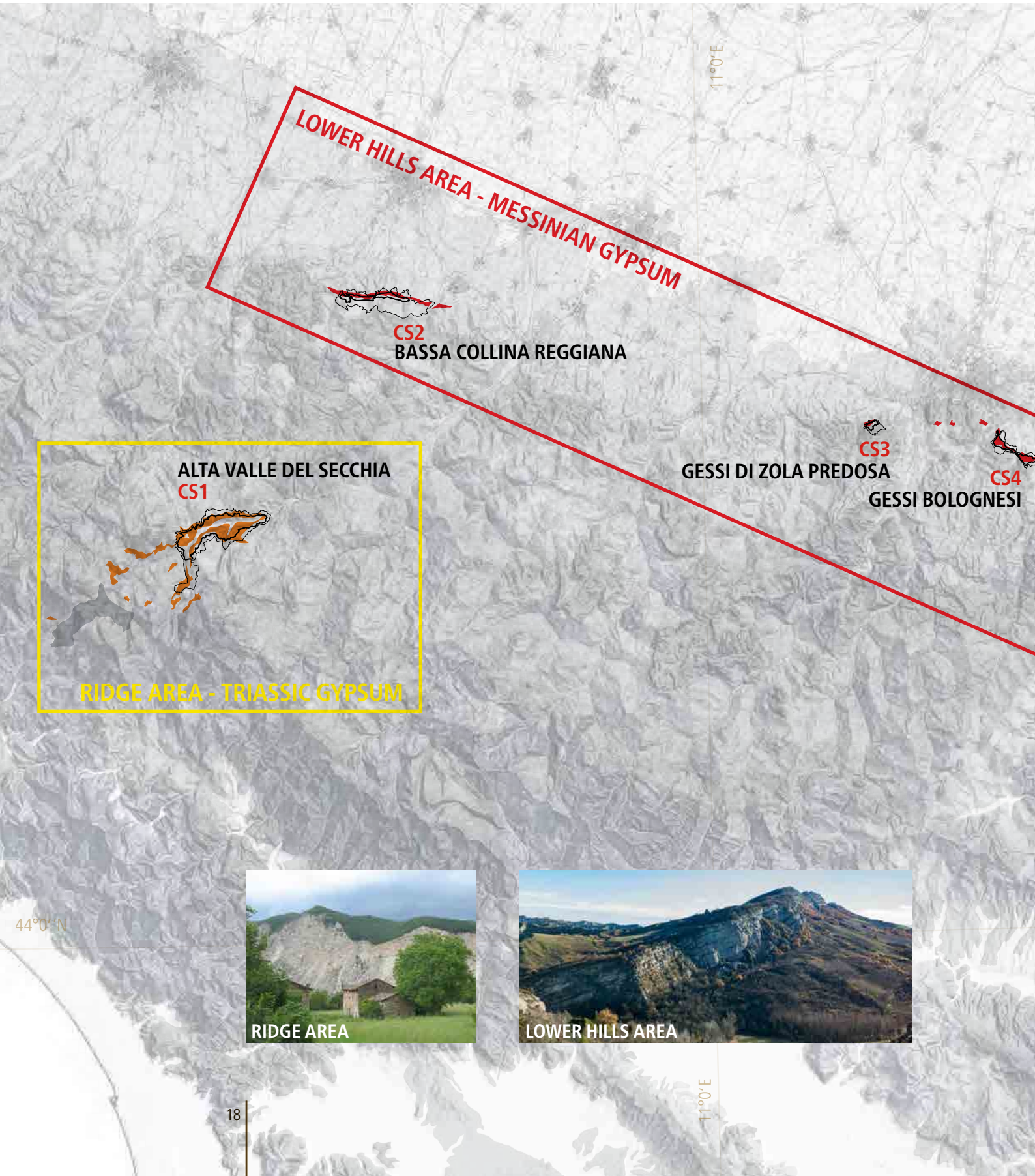
- *(in front) The Secchia valley evaporite cliffs with a view over the Pietra di Bismantova is one of the most iconic images of the entire Apennines chain. The Miocene calcarenite of the blocky plateau stand as a superb imposing background for the 200 m-high dizzy cliffs, where the whitish Triassic gypsum is wildly exposed along a nearly vertical wall above the Secchia River, Alta Valle del Secchia*
  © P. Lucci

2.A.1 GEOGRAPHY

In order to offer an overview of the characteristics of the **Evaporitic Karst and Caves of Northern Apennines** it may be opportune to initially group the component sites into three main areas.

Main areas	Component site name	c.s. #
Ridge area	Alta Valle del Secchia	1
Lower hills area	Bassa Collina Reggiana	2
	Gessi di Zola Predosa	3
	Gessi Bolognesi	4
	Vena del Gesso Romagnola	5
Eastern area	Evsporiti di San Leo	6
	Gessi di Onferno	7

This subdivision can ease the understanding of each component site contribution to the serial nominated property. The component sites in each area share common landscape features, climate and geological history and can be thus described as a whole. Each "main area" contributes to the completeness of the phenomenon described by the property: the development of karst systems in evaporites at temperate-humid climate.



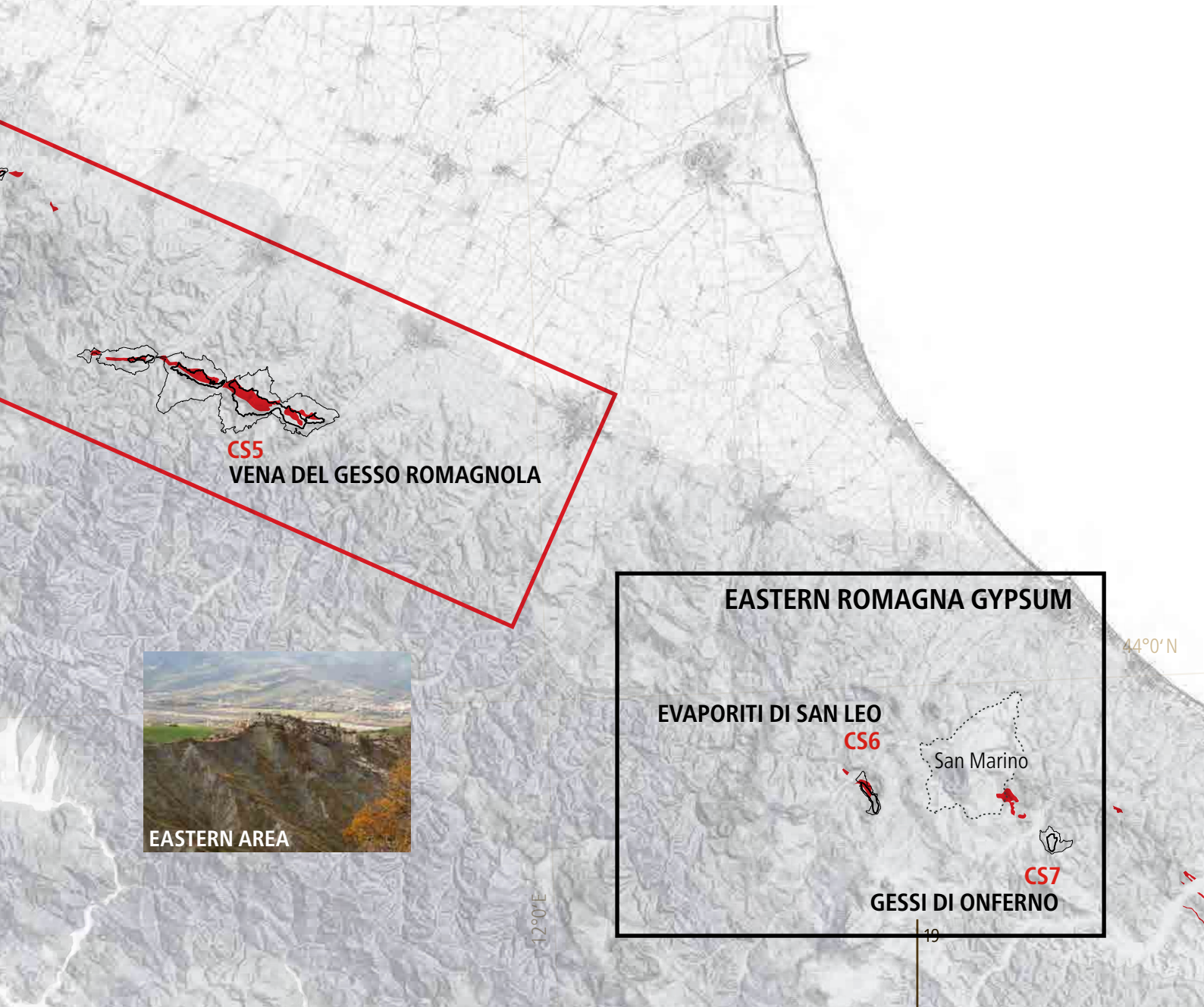
RIDGE AREA

LOWER HILLS AREA

The **Ridge area** is located in the central part of the Apennine chain, mainly in the Reggio Emilia Province. Evaporitic rocks crop out at an elevation of 700-800 m.; the landscape shows classic features and elements of the Apennine mountains; the degree of wilderness is high. The evaporitic deposits are located along the Secchia river, forming an impressive valley whose bed is embanked, on both sides, between "curtains" of gypsum mountains, sectioned by erosion.

The **Lower hills area**, on the contrary, is spread in a narrow belt from the Reggio Emilia to the Rimini Provinces. The mountain range that characterizes this area is oriented NW-SE, perpendicular to the Apennine valleys, parallel to the direction of the Apennine chain and facing the Po Plain and the Via Emilia. The impact of evaporitic rocks on the landscape is high, because of the selective erosion of the weaker formations above and below the gypsum ones. The elevation is here approximately between 500 and 200 m , so significantly lower than in the Ridge area. The linear gypsum outcrop, locally named **Vena del Gesso** (Gypsum Vein) is usually considered, by an historical point of view, a physical demarcation, which divides the foot of the Apennine from the medium-high Apennine.

The **Eastern area** is the less prominent: the epigean impact on the landscape is limited to the development of gorges interspersed with badlands hosted in clays. The hypogean features are far more impressive, with complete karst systems including sinkholes, caves and resurgences. The elevation, like in the lower hills area, is generally below 300 m.



The present-day landscape of the nominated property is generally characterized by a low human density and pressure. Among the residents, the ageing index is high; a large number of rural houses located on gypsum areas is abandoned or ruined; urban settlements are rare and in demographical decrease; infrastructures, such as railways or highways, are generally absent. These features or trends reach their maximum intensity in the Triassic gypsum area and in the turbidite deposits area, whereas the Messinian gypsum area shows the highest level of anthropization: here the short distance from the cities along the Via Emilia implied, in the last decades, the restoration of some old buildings or the construction of new ones used as secondary houses. In general, however, as a consequence of the depopulation and marginalization, which started mainly after the Second World War, forests currently prevail on cultivated lands. Also, breeding is not attested because, once again, woods occupied the former grasses.

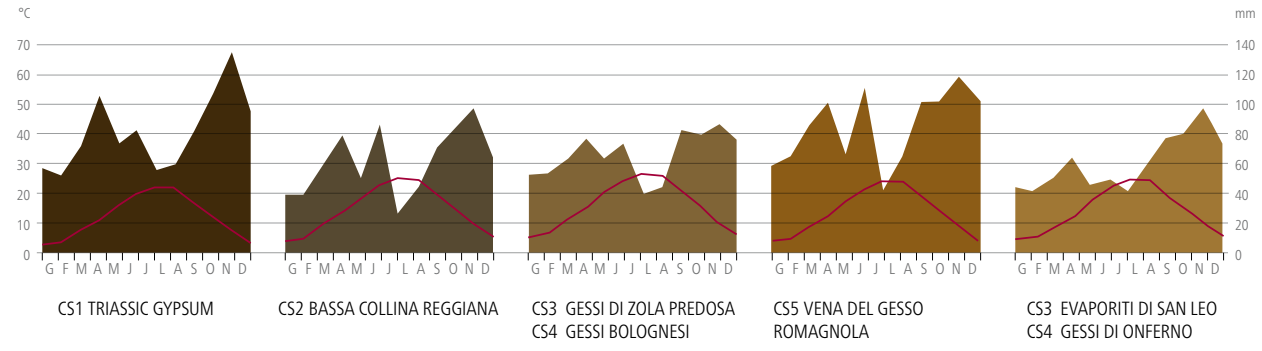
Vice versa, dolines and blind valleys – in chronological order the last cultivated lands to be abandoned – are not usually covered by woods, and look like "empty depressions" surrounded by vegetation. In particular, in the Messinian gypsum areas, woods cover the northern slope of the outcrops, while the southern side shows a sub vertical rock wall, where the gypsum strata are visible. Currently, forests have covered also most of the pre-industrial mining sites, while the industrial ones (late 19th–20th centuries), whose dimensions were significantly larger, still have a strong impact on the landscape.

2.A.2 CLIMATE

From a climatic point of view the Triassic gypsum area is characterized by a **temperate oceanic climate** (*Cfb*, according to Köppen and Geiger Climate Classification). July is the warmest month of the year with an average temperature of 19.9° C. The coldest month is January with an average temperature of 1.0° C. Average annual rainfall is 900 mm. The elevation ranges between 417 m and 894 m (average 600 m). The mountain range section of the Secchia Valley has a W-E course along high sub-vertical walls with opposite exposures: The south-facing side is characterized by a warm, arid and sunny microclimate, while the north-facing side has a cool and shady microclimate. The karst environment produces a strong variability especially along the slopes of the dolines, with a quick transition from arid and sunny rupicolous environment at the top, to the damp and fresh bottom. The considerable microclimatic condition change at very short distances is one of the factors favouring the high biodiversity of this area.

The climate of the Messinian gypsum areas and of the turbiditic deposits on the eastern part of the nominated property is **humid-subtropical** (*Cfa*, Köppen and Geiger Climate Classification). The average temperature of the warmest month is 23,1° C (July), while during the coldest ones it is about 2.9° C (January). The mean annual precipitation is 739 mm, recorded at an elevation of 115 m. The Vena del Gesso ridge is extending from the north-east to the south-east and the high cliffs are under the sun effect all day long on the south side and always in shadow on the north side.
This structural situation induces two different microclimate conditions over a very short distance: The southern side is dominated by a dry and warm microclimate, typical of Southern Italy, while the

- *The hydrometric and thermometric regime of the component sites, grouped by main areas.*



northern side is affected by wet and fresh conditions, similar to those at elevation between 800 and 1000 m. As a result, the habitats and species are very different on the two slopes of the gypsum ridge, determining a high biodiversity.

Since the gypsum outcrops are mainly aligned in an NW-SE direction, the cliffs are exposed to the south on one side and to the north on the other. This generates a particular warm and arid microclimate on one side, fresh and moist on the other, with very different environmental conditions, even at a distance of a few meters. In addition, because of the structural control of stratification, the south-facing slopes are "anti-dip sloped" and, therefore, much steeper and arid than the (often woody) "dip-sloped" north-facing slopes. The presence of deep depressions of karstic origin (dolines, blind valleys) greatly amplifies the cold microclimate thanks to the very special conditions created here, with regional temperature records. The temperatures are very cool even in summer, especially near the foot of the karst depressions, at the entrance to a long cave, such as the doline of Spipola and the homonymous cave or in a deep and narrow gorge, like in the *Rio Basino* area. Cool temperatures at the foot of the sinkhole, even during heat waves (up to 10° C lower than the edge of the sinkhole at a distance of less than 100 meters), are a decisive factor for the survival of microthermal species.

- Another stunning iconic view is the Messinian "Vena del Gesso" (Gypsum Vein), the gypsum ridge stretching across a large part of the northernmost Apennine chain. The gypsum/shale layers are superbly exposed emerging from the argillaceous sediments cut by badlands laying above the gypsum ridge. © P. Lucci

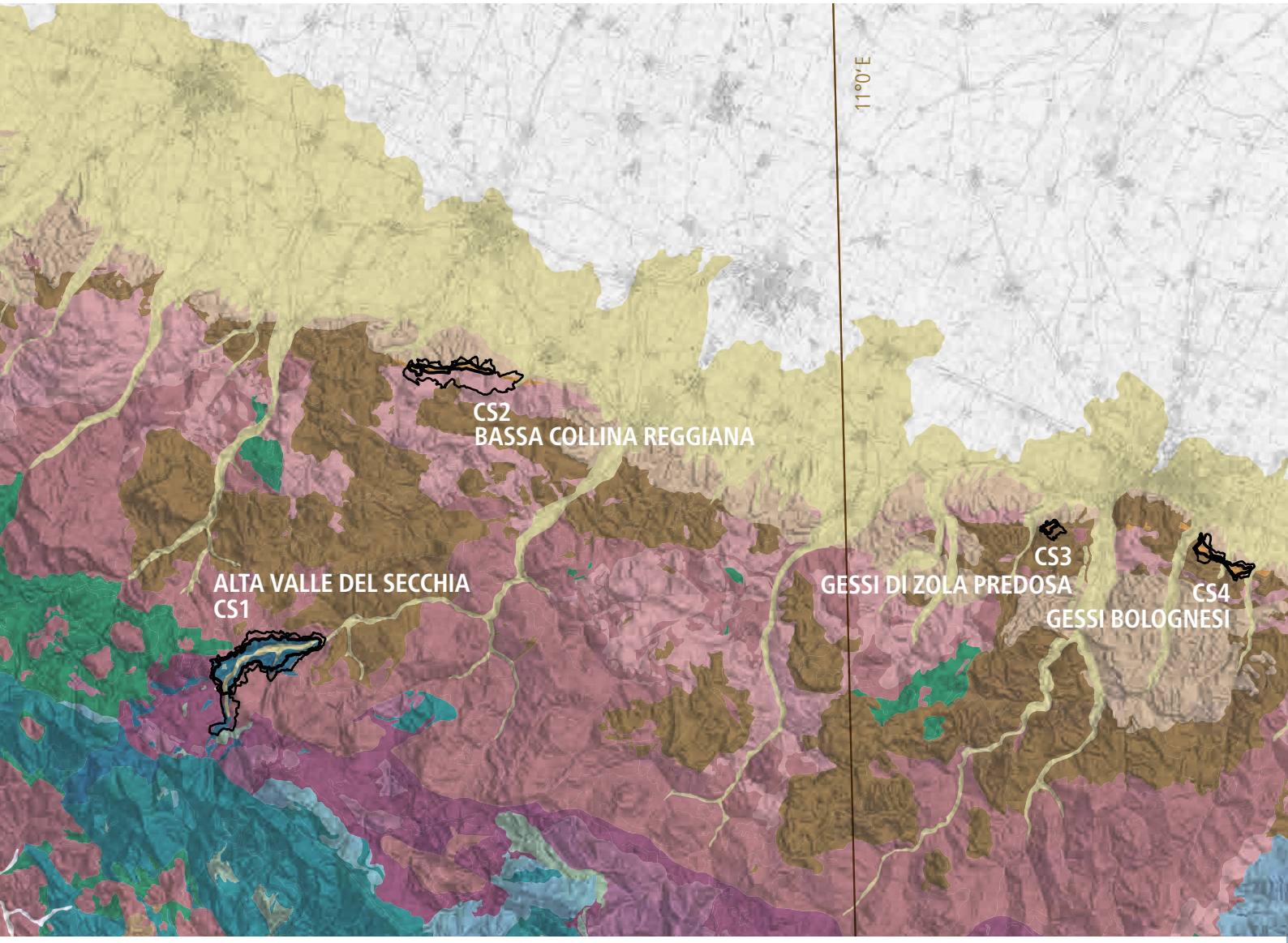
2.A.3 GEOLOGY

The nominated property is located in the Northern Apennines range, a complex fold-thrust belt formed during the Cenozoic and the Quaternary by the interplay of the African and the European plates. The mountain arc is the result of the eastwards migration of the European plate with respect to the Adria plate (northern sector of the African plate) in the middle Eocene. This plate motion induced the closure of the Ligurian-Piedmont Ocean and the subsequent continental collision resulted in the over-thrusting of the Ligurian units above the Tuscan-Umbria units.

The **Ligurian units** are remnants of the Ligurian-Piedmont Ocean, which was part of the Tethys Sea formed by the breaking up of the supercontinent Pangea. The **Tuscan-Umbria units** consist of the Hercynian basement and its Permian-Mesozoic to Cenozoic sedimentary cover deposited on the continental margin of the Adria plate. The counter-clockwise rotation of the Corsica-Sardinia plate, along with back arc processes caused the eastward migration of the belt chain, which was dissected by back-arc rifting. These late phenomena (Tortonian) led to the extension in the Tyrrhenian Sea and in the Northern Apennines, and the migration of the subduction zone and the extensional tectonics toward the east.

The core of the Northern Apennines consists thus mainly of terrigenous rocks (sandstones, marls, clays, alternating with each other and with limestones) and subordinately limestones, and radiolarites. The most ancient rocks are conglomerates and sandstones, **gypsum** and dolomites of the Upper Triassic (lower part of the Mesozoic - about 200-220 million years ago), deposited in a continental and shallow environment in the initial stages of the opening of the Tethys Sea.

From the Late Eocene to the Miocene marine sediments belonging to the **Epiligurian wedge-top basins sediments** deposed over the Ligurian units. In particular between 5,970,000 and



Umbro-Marchean-Romagnan Domain

The outermost of the orogenic wedge. They lie below the Tuscan units, are less deformed and non-metamorphic; They consist mainly of calcareous- marly sediments, hemipelagic marls, siliciclastic turbidites.
Late Triassic-early Messinian.

Calcareous-marly succession. Cretaceous-Miocene

Siliciclastic succession of intra-Apennine minor basins and external basins.

Siliciclastic succession of internal basins.

Apenninic Epiligurian Succession (pre-evaporitic)

Sedimentary succession that non-conformably covers only the Ligurian Units.

Mainly breccia and turbiditic sandstones deposits of a shallow marine environment. Oligocene -late Serravallian.

Miocene-Pleistocene marine deposits of the Tirrenian margin

The deposits mark the Miocene-Pleistocene transgressive-regressive cycles, formed by .
They infill typical graben-type basins.

Shallow marine fossiliferous clays, sandstones, conglomerates and bioclastic limestones

Syn- and post-evaporitic Miocene to Pleistocene deposits of the Adriatic margin

Gypsum and clay.
Messinian Mediterranean evaporitic phase.

Post-evaporitic reworked gypsum, gypsarenite, dolomiti limestones, bituminous clays.

Post-evaporitic conglomerates, sandstones, clays, breccias.
Pliocene-Pleistocene

Thrust-slices

Thrust-slices with Ligurian affinity

Thrust-slices from arenaceous units

Shear zones and thrust-slices with Tuscan affinity

Shear zones with cataclastic dolomite, limestone, gypsum and anhydrite, shales, amphibulites, quarzites.

Shear zones and thrust-slices from Fiumalbo Clays and Marmoreto Marls

Continental and coastal deposits from the Quaternary

Conoids and alluvial terraces

Ligurian Domain

The Ligurian Domain is referred to the Ligurian-Piedmont Oceanic Basin.
It is subdivided in internal and external subdomains, the latter close to the Subligurian Domain.

Internal Ligurian Domain

Ophiolitic terms of oceanic crust, as serpentinites, gabbros and basalts, and the respective sedimentary cover, as ophiolitic breccias, cherts, limestones, shales and turbiditic siliciclastic sandstones.
Middle Jurassic to the Paleocene.

External Ligurian Domain - Internal succession

Classical Helmintoides calcareous flysch deposits, containing ophiolitic breccias and huge ophiolitic olistostromes.
Cretaceous to Middle Eocene in age.

External Ligurian Domain - External succession

Ophiolitic breccias, pelagic limestones and shales, turbidite calcarenites, marlstones and marly limestones.
Cretaceous to Middle Eocene in age.

Subligurian Domain

Transitional domain, between the continental Apulia microplate and the oceanic Ligurian Basin.

Shales, limestones and volcanic-bearing turbidite sandstones and conglomerates.
Paleocene to Oligocene in age.

Tuscan Domain

The continental margin of the Apulia microplate.

Cervarola Unit

Shales, limestones and volcanic-bearing turbidite sandstones and conglomerates.
Paleocene to Oligocene.

Mt. Modino Unit

Turbiditic sediments deposited during the collisional and post-collisional stages of the Northern Apennines fold-and-thrust belt.Age: middle Eocene-lower Miocene.

Rentella Unit

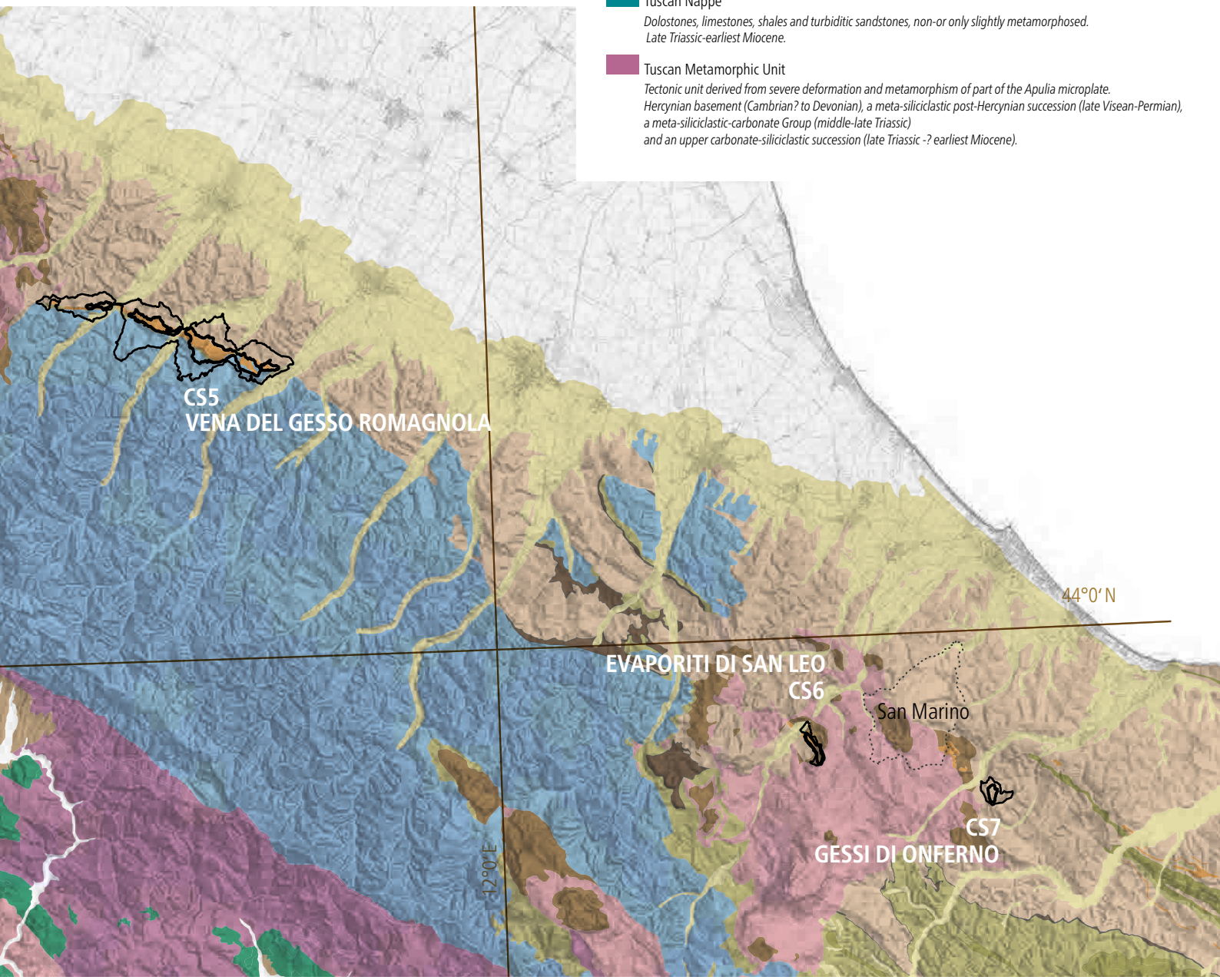
Pelagic and emipelagic sediments transitioning to foredeep turbiditic sediments.
Upper Oligocene-lower Miocene.

Tuscan Nappe

Dolostones, limestones, shales and turbiditic sandstones, non-or only slightly metamorphosed.
Late Triassic-earliest Miocene.

Tuscan Metamorphic Unit

Tectonic unit derived from severe deformation and metamorphism of part of the Apulia microplate.
Hercynian basement (Cambrian? to Devonian), a meta-siliciclastic post-Hercynian succession (late Visean-Permian), a meta-siliciclastic-carbonate Group (middle-late Triassic)
and an upper carbonate-siliciclastic succession (late Triassic -? earliest Miocene).



5,330,000 years ago, within the geological time frame defined as Messinian (Upper Miocene), the Mediterranean has first turned into a giant salina and later into a sort of huge brackish lake (*Lago Mare*). The origin of this salinity crisis is due to a drastic change in the connection with the Atlantic Ocean related to the tectonic movements of convergence of the African plate towards the European one. These movements have repeatedly changed the geography of the Strait of Gibraltar and the most spectacular result was a further restriction of the oceanic connections, which induced the increase in salinity of the Mediterranean waters, turning them into inhospitable brines, where only some groups of bacteria could live. The particular conditions, led to the deposition of gypsum, in the form of crystals that constitute the main rock of the *Gessoso-Solfifera Fm,* or the "selenite" also called "moonstone".

In the eastern part of the Northern Apennines, a huge allochthonous body known as **Val Marecchia Nappe**, consisting of stacked slices of Ligurian and Epiligurian rocks overthrusting Tuscan-Umbria units, hosts some re-sedimented evaporitic units. The gypsum strata of the *Gessoso-Solfifera Fm* were eroded and redeposited forming spectacular sedimentary structures in the eastern part of the property, which was the deeper part of the basin, the Apennine foredeep. This section of the basin underwent burial and oil migration leading to the transformation of gypsum into anhydrite and then alabaster and the late bacterial sulphate reduction of the evaporites to form ore-grade sulphur mineralization.

It is evident that the general subdivision of the property, introduced in the previous section is then related to the genesis of the evaporitic deposits.

A. Ridge area

The **Ridge area** hosts the so-called Ligurian Units, in particular the oldest evaporite rocks (Gessi di Sassalbo Fm) registered the breaking up of the supercontinent Pangea about 200 million years ago and the dramatic tectonic deformation induced by the collision of the European and the African plates, which formed the Northern Apennine chain. The spectacular cliffs created by the erosion and dissolution of the Secchia river are sculptured by twisted and convoluted fragmented strata juxtaposed by the selective dissolution of former halite layers.

The subvertical cliffs along the river exhibit an extremely convoluted structure, which is the direct consequence of the role played by the evaporites as the main detachment horizon for the evolution of the Northern Apennines thrust and fold chain. Here the cave systems do not cross the core of the mountains, where soluble but impermeable anhydrite is prevailing, but are confined only at the outer rim of them, where gypsum is dominant. The results are that the karst conduits are "bending" around the evaporite massifs following the more soluble outer rim, which is also cut by tensional release fractures.

• *The Triassic gypsum outcrop at Sassalbo. © Stefano Lugli*

The *Gessi di Sassalbo Fm* (216-203 million years ago) was deposited in a system of marine lagoons during the ingression of the Tethys Sea along the rift system progressively cutting the Hercynian orogen and its European foreland during the breaking up of the supercontinent Pangea. Later, after the Tethys Sea was progressively consumed by the convergence of the African and Eurasian plates, the Gessi di Sassalbo Formation acted as the main detachment horizon for the Tuscan Nappe during the NE directed build-up of the Northern Apennines chain.

The evaporite sequence is exposed along the Secchia river valley structure, which has been interpreted as a transpressional system running transverse to the major tectonic lineaments of the Northern Apennines chain. The evaporite unit is dissected into thrust slices, which are tectonically included into younger allocthonous units.

The evaporite thrust slices were detached from the base of the Tuscan Nappe by formation of megatension gashes. These thrust slices were then incorporated into the migrating overlaying Ligurian units during a post-Burdigalian-Langhian deformation phase.

The evaporite deposit is mainly composed of meter- to decametre-scale alternating gypsum ($CaSO_4 \cdot 2H_2O$)-anhydrite rocks ($CaSO_4$) and dolostones ($MgCa(CO_3)_2$) with minor halite (NaCl), which were affected by severe post-depositional modifications and strong tectonization. The inferred maximum total thickness reaches 2200 m.

Anhydrite is a minor constituent and can be found mostly at depth, whereas gypsum prevails in the outcrops. The anhydrite rocks show tectonic flow structures, such as centimetric pseudo-laminations consisting of transposed tight isoclinal folds outlined by comminute dolostone fragments. The gypsum rocks show the same general structures as the anhydrite rocks; they are formed at expenses of pre-existing anhydrite by migration of sharp hydration fronts propagating from fractures and strata boundaries.

- *Folded anhydrite rock (gray at center) partially hydrated to gypsum (white), Secchia valley. © Stefano Lugli*

As a consequence of the strong contrast in competence and "mobility", the carbonate layers frequently appear as *megaboudins* within a sulfate groundmass. The carbonate rocks are mainly massive dolomitic mudstones rarely showing cross-stratification and lamination. The Gessi di Sassalbo Fm were affected by thermal events probably related to the development of the greenschist facies Alpi Apuane metamorphic complex, located to the SW of the nominated area.

The sulfate rocks contain spectacular idiomorphic quartz crystals up to a few centimetres across, which grew at relatively high temperatures (260 to 305°C) at deep tectonic burial conditions during the flow of the host anhydrite rock. These conditions could be related to the evaporites acting as detachment horizon for the Tuscan Nappe during the Oligocene-Miocene development of the Apuane greenschist-facies metamorphic complex. The same conditions were responsible for the Mg-metasomatic replacement of dolostones by magnesite ($MgCO_3$) induced by hydrothermal circulation (275° to 310°C).

- *Black quartz crystals within the gypsum rock. © Enrico Borghi*

Although minor halite is only sparsely distributed at depth, as suggested by boreholes and salt springs, widespread and thick caprock-like sulfate megabreccias suggest the former presence of thick salt deposits in the northernmost zone.

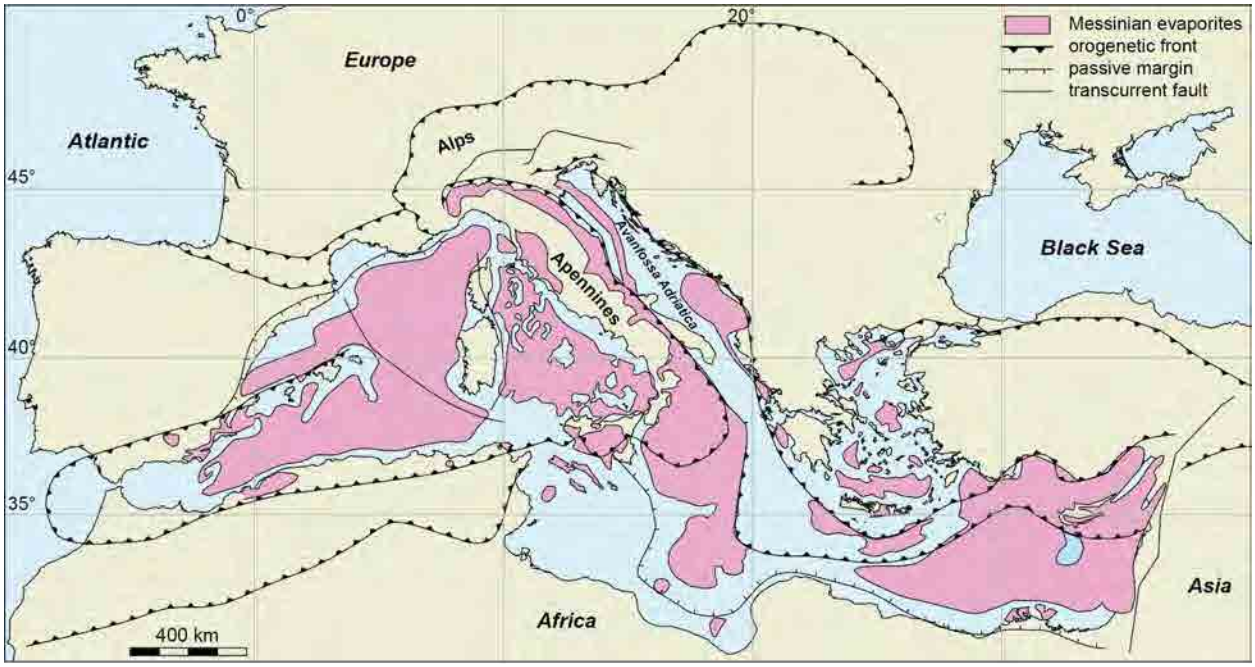
The role of the *Gessi di Sassalbo Fm* during the Apennines tectogenesis can be depicted as follows: a) prevalent deposition of gypsum in the Upper Triassic; b) gypsum dehydration at burial conditions to form anhydrite (Cretaceous); c) syn-tectonic flow of anhydrite rocks, brecciation of dolostones; syn-tectonic growth stage of quartz euhedra at deep burial conditions possibly related to the development of the Oligocene-Miocene greenschist facies Apuane metamorphic complex; d) hydrothermal deposition of magnesite and partial Mg-metasomatic replacement of dolostones by magnesite; e) sub-surface dissolution of halite to form thick matrix-supported residual caprock-like anhydrite megabreccias; f) complete gypsification of anhydrite at sub-surface conditions; g) evaporite dissolution at surface exposure producing dolostone breccias with partial calcitization and removal of most clasts ("*Calcare cavernoso*").

- *The spaghetti-like bacterial filaments included within the gypsum selenite crystals seen under the optical microscope, natural light © S.Lugli*

B. Lower hills area

The **Lower hills area** differs both in age and rock composition: the youngest evaporite rocks (*Gessoso-Solfifera Fm*) outcropping in the central part of the nominated property are the spectacular results of the ecological catastrophe that struck the Mediterranean Sea about 6 million years ago, when the basin was transformed in a giant *salina* and all the marine life forms, with the exception of specialized bacteria, were completely wiped out from the sea. The impressively large gypsum crystals formed during the so-called Mediterranean "salinity crisis" contain the fossilized remains of these residual of life forms visible as "spaghetti-like" strands.

The *Gessoso-solfifera Fm* (also defined as Primary Lower Gypsum) was the result of the first phase of this dramatic hydrological and ecological crisis, which in the deep Mediterranean settings



• *The evaporites in the Mediterranean basin deposited during the Messinian salinity crisis. © Stefano Lugli*

(around Cyprus), induced the deposition of a more than 2 km-thick evaporite succession in less than 640,000 years.

In the nominated area the evaporite sediments were deposited in two distinct sectors of the Northern Apennines chain. In the shallower *Gessoso-Solfifera Fm* (Vena del Gesso) thrust-top basin, the Primary Lower Gypsum unit formed during the first stage of the crisis (5.97 - 5.60 million years ago). Conversely, the main foredeep was characterized by the deposition of euxinic shales and the accumulation of evaporites started only during the second stage of the crisis, when the primary evaporites were tectonically uplifted, eroded and resedimented in the deeper parts of the basin. A subsequent phase of tectonic dormancy and the general subsidence allowed the development of a transgressive succession, with the deposition of the *Lago Mare* brackish sequence, culminating with the Pliocene marine ingression (*Formazione a Colombacci, Marne di Cella, Argille Azzurre*).

• *Sketch of the geological features of the Vena del Gesso looking east from Tossignano. ©Stefano Lugli*

In the Vena del Gesso area a total of 16 layers of gypsum were deposited rapidly in less than 350,000 years, forming a sequence more than 200 m-thick. The gypsum layers are separated by thin layers of shale. Each of these gypsum/shale pair of layers has been deposited in about 23,000 years and records the climatic variations of the arid/wet cycles induced by the perturbations of the planet's orbital parameters known as precession of the equinoxes. The clay is the wet phase characterized by heavy rains, when the continental areas were subject to heavy runoff and the finer particles were transported in suspension into the basin. The gypsum, on the other hand, formed in the dry phase, an indispensable condition for the development of effective evaporation of seawater.

The gypsum crystals of the Vena are famous for their twinned crystalline habit with "*arrow head*" or "*swallow tail*". One of the most striking features of the selenite layers is that the crystals are all vertically oriented with the re-entrant angle of the twin pointing upward and the tip downward, as a result of the competition for space of bottom growth crystals which favoured only the growth of the crystals oriented upwards, the only free space possible. This orientation of the crystals favoured

the trapping of bacterial filaments, the only life forms surviving the high salinity of the brines, which are perfectly preserved into the crystal cores.

• *Arrow head gypsum crystals from Monte Tondo. ©Stefano Lugli*

The Messinian gypsum was deposited during the first phase of the "salinity crisis", when the Mediterranean Sea was transformed into a giant *salina*. The ways in which this extreme event has developed have ignited a strong international controversy. According to some scholars, the Mediterranean would have totally dried up, while other data indicate a drastic reduction in connections without a significant drop in sea level. The long-standing controversy continued to these days due to the paucity of direct information on the rock record from the deep offshore successions, where a more than 2 km-thick sulfate and halite sequence was deposited.

Today, a large consensus has been reached about the general architecture and chronostratigraphy of the "salinity crisis", but a debate is still active on how to successfully correlate the onshore and offshore sequences.

With its gypsum-shale layer alternations, the Messinian gypsum is one of the best examples in the world of climate cyclicity studied by astrochronology: the use of the geologic record of climate oscillations to measure the passage of time from rhythmic layers (Astronomical Time Scale). As Earth and the Sun, Moon, and other planets interact, cyclic oscillations in the eccentricity of Earth's orbit and in the tilt and precession of Earth's axis cause variations in solar radiation reaching the surface, inducing climatic variations (Milankovitch cycles). In the Mediterranean basin, the results for high-frequency astronomically forced climate variations are arid-humid climate cycles spanning about 23,000 years (precession).

Being gypsum an evaporite mineral, it formed only during the arid part of the cycle, while shales were deposited during the humid time frame. Because the solar insolation variations are calculated from the astronomic parameters, it follows that each of the 16 gypsum beds is accurately dated using astrochronology.

C. Eastern Area

The caves of the **Eastern area** are privileged sites where all these spectacular geological features are visible, even better than at outcrop exposures. The cave cut through gypsum turbidite strata. Pristine native sulfur nodules can be observed at the base of the sequence, where organic-rich shales lie directly in contact with the overlaying clastic gypsum. These caves show at a small scale all the features responsible for the genesis of the ore-scale sulfur deposits, which were exploited in the large mines of the area.

• *Alabastrine gypsum with swallow tail crystal pseudomorphs © Stefano Lugli*

Some of the caves expose spectacular sedimentary and diagenetic structures in the clastic gypsum deposited by turbidity currents. The sedimentary sequence is made of alternating gypsrudite, gypsarenite and mudstone strata displaying load casts, megaripples and displacive nodules. The rarity of these structures within evaporite caves makes the caves in clastic gypsum a unique environment at international scale.

Together, the component sites contain one of the best scientifically documented sulfate-halite karst in the world from the geological, speleological and hydrological point of view.

Continental and coastal deposits from the Quaternary

Conoids and alluvial terraces

Ligurian Domain

The Ligurian Domain is referred to the Ligurian-Piedmont Oceanic Basin. It is subdivided in internal and external subdomains, the latter close to the Subligurian Domain.

Internal Ligurian Domain

Ophiolitic terms of oceanic crust, as serpentinites, gabbros and basalts, and the respective sedimentary cover, as ophiolitic breccias, cherts, limestones, shales and turbiditic siliciclastic sandstones. Middle Jurassic to the Paleocene.

External Ligurian Domain - Internal succession

Classical Helmintoides calcareous flysch deposits, containing ophiolitic breccias and huge ophiolitic olistostromes. Cretaceous to Middle Eocene in age.

External Ligurian Domain - External succession

Ophiolitic breccias, pelagic limestones and shales, turbidite calcarenites, marlstones and marly limestones. Cretaceous to Middle Eocene in age.

Subligurian Domain

Transitional domain, between the continental Apulia microplate and the oceanic Ligurian Basin.

Shales, limestones and volcanic-bearing turbidite sandstones and conglomerates. Paleocene to Oligocene in age.

Tuscan Domain

The continental margin of the Apulia microplate.

Cervarola Unit

Shales, limestones and volcanic-bearing turbidite sandstones and conglomerates. Paleocene to Oligocene.

Mt. Modino Unit

Turbiditic sediments deposited during the collisional and post-collisional stages of the Northern Apennines fold-and-thrust belt.Age: middle Eocene-lower Miocene.

Rentella Unit

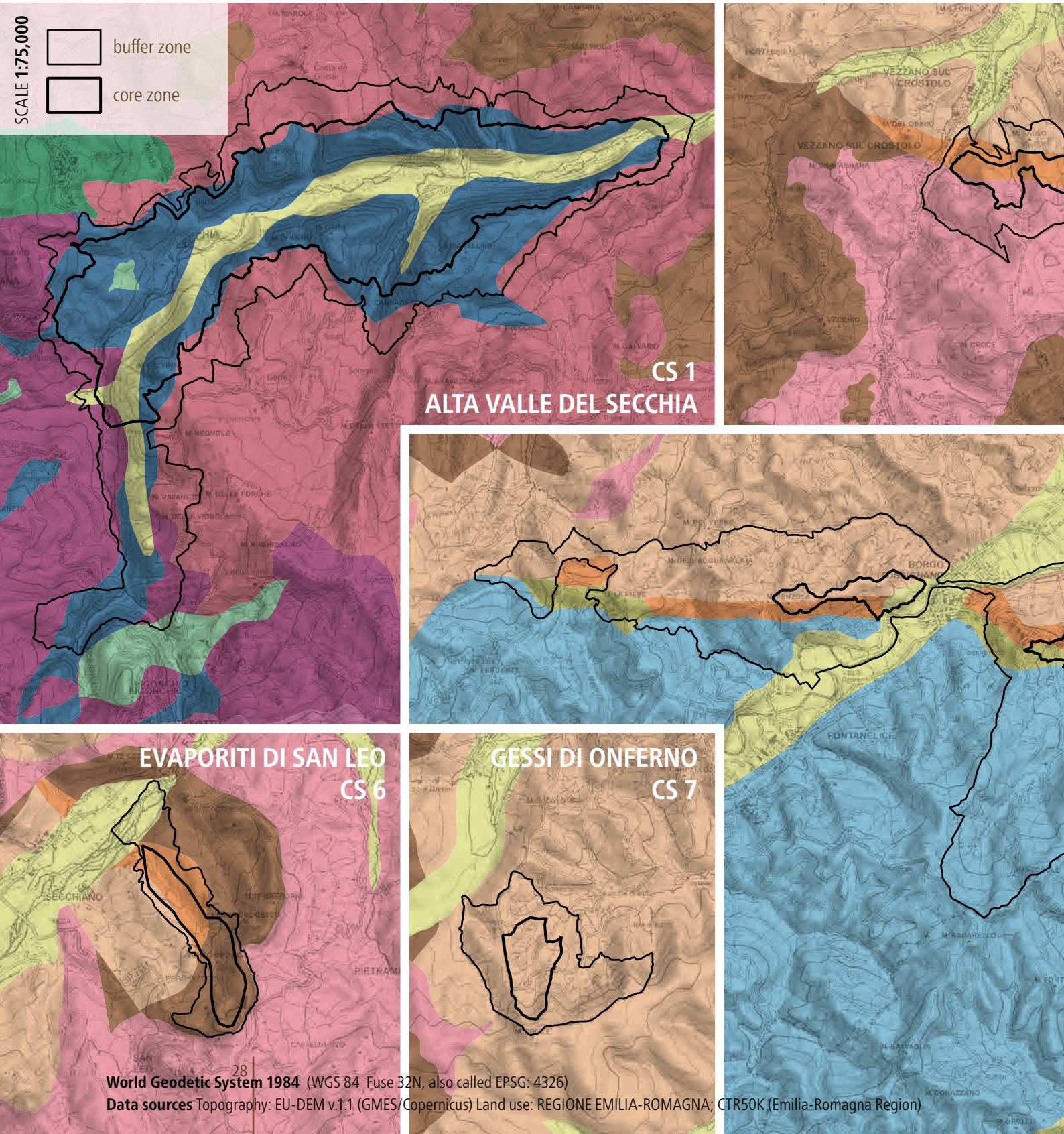
Pelagic and emipelagic sediments transitioning to foredeep turbiditic sediments. Upper Oligocene-lower Miocene.

Tuscan Nappe

Dolostones, limestones, shales and turbiditic sandstones, non-or only slightly metamorphosed. Late Triassic-earliest Miocene.

Tuscan Metamorphic Unit

Tectonic unit derived from severe deformation and metamorphism of part of the Apulia microplate. Hercynian basement (Cambrian? to Devonian), a meta-siliciclastic post-Hercynian succession (late Visean-Permian), a meta-siliciclastic-carbonate Group (middle-late Triassic) and an upper carbonate-siliciclastic succession (late Triassic -? earliest Miocene).



World Geodetic System 1984 (WGS 84 Fuse 32N, also called EPSG: 4326)

Data sources Topography: EU-DEM v.1.1 (GMES/Copernicus) Land use: REGIONE EMILIA-ROMAGNA; CTR50K (Emilia-Romagna Region)

Umbro-Marchean-Romagnan Domain

The outermost of the orogenic wedge. They lie below the Tuscan units, are less deformed and non-metamorphic; They consist mainly of calcareous- marly sediments, hemipelagic marls, siliciclastic turbidites. Late Triassic-early Messinian.

Calcareous-marly succession. Cretaceous-Miocene

Siliciclastic succession of intra-Apennine minor basins and external basins.

Siliciclastic succession of internal basins.

Apenninic Epiligurian Succession (pre-evaporitic)

Sedimentary succession that non-conformably covers only the Ligurian Units.

Mainly breccia and turbiditic sandstones deposits of a shallow marine environment. Oligocene -late Serravallian.

Miocene-Pleistocene marine deposits of the Tirrenian margin

The deposits mark the Miocene-Pleistocene transgressive-regressive cycles, formed by . They infill typical graben-type basins.

Shallow marine fossiliferous clays, sandstones, conglomerates and bioclastic limestones

Syn- and post-evaporitic Miocene to Pleistocene deposits of the Adriatic margin

Gypsum and clay. Messinian Mediterranean evaporitic phase.

Post-evaporitic reworked gypsum, gypsarenite, dolomiti limestones, bituminous clays.

Post-evaporitic conglomerates, sandstones, clays, breccias. Pliocene-Pleistocene

Thrust-slices

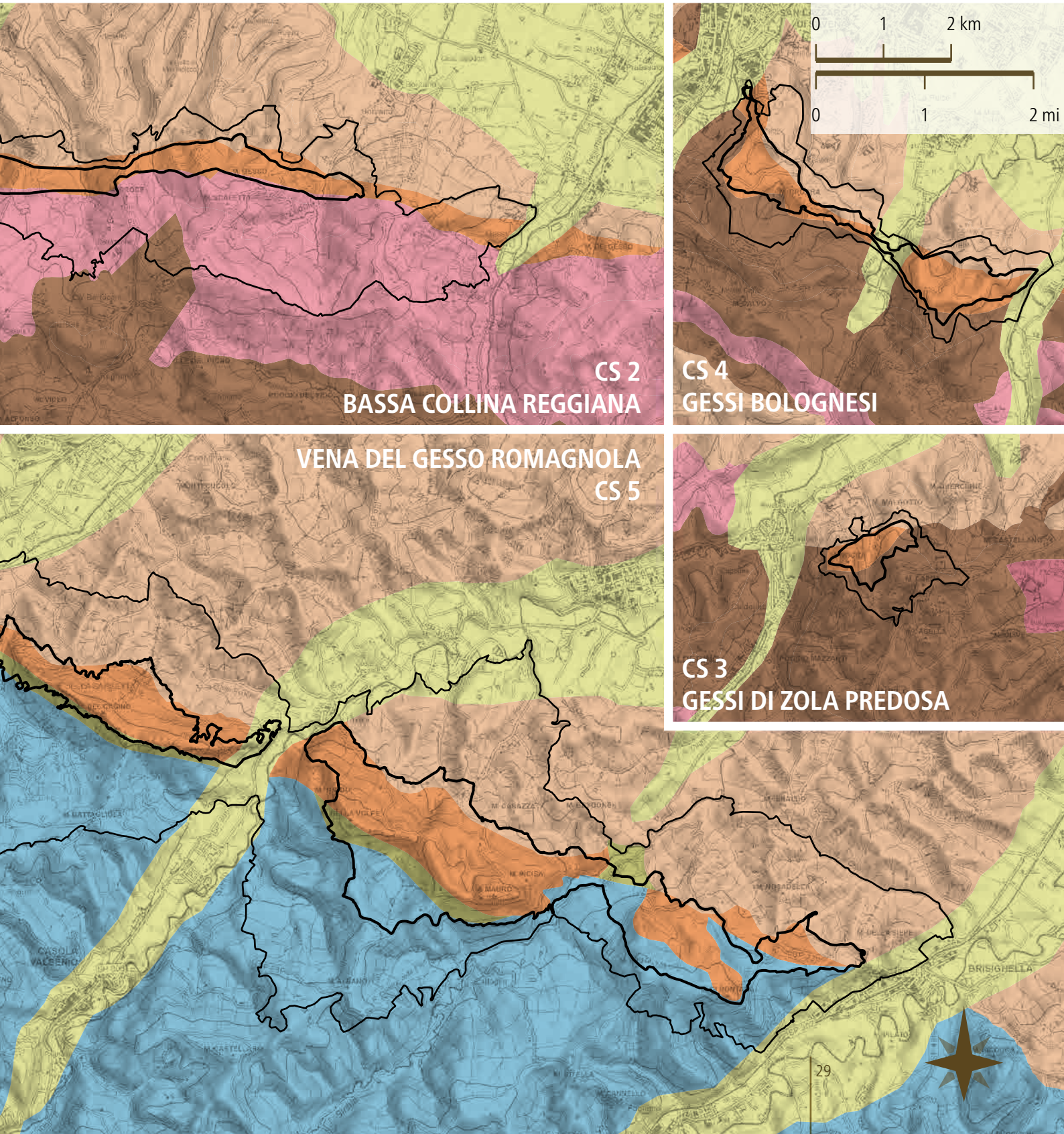
Thrust-slices with Ligurian affinity

Thrust-slices from arenaceous units

Shear zones and thrust-slices with Tuscan affinity

Shear zones with cataclastic dolomite, limestone, gypsum and anhydrite, shales, amphibulites, quarzites.

Shear zones and thrust-slices from Fiumalbo Clays and Marmoreto Marls



2.A.4 MINERALOGY

The actually known sulfate (gypsum and anhydrite) caves in the world host only 11 cave minerals and 10 of them are present in the *Gessi di Sassalbo Fm* of the Upper Secchia Valley karst area, among them 8 are restricted to this environment (brochantite, clinochlore, devillina, ice, magnesite, opal and undifferentiated Fe and Mn oxides), while two of them (clinochlore and devilline) are minerals never reported from other cavern environment in the world being restricted to just one cave in the Upper Secchia Valley.

Gypsum caves in the world host some 32 different cave minerals and 17 of them are present in the gypsum areas of Emilia-Romagna Gessoso-Solfifera Fm, the most important mineralogical karst site in the world hosting a number of cave minerals which is over the double that of any other gypsum karst area.

Moreover, no other gypsum cave in the world hosts the following minerals: chloromagnesite, epsomite, mirabilite, hematite, lepidocrocite, opal, quartz, sulphur. Finally, one of these minerals (chloromagnesite) was never reported from others cavern environment in the world, being restricted to just one cave of the Gessoso-Solfifera Fm in the Bologna area.

The first mineralogical studies in the world within a gypsum cave were performed in the karst area of Bologna (Laghi 1802), where epsomite was found. Later three completely new minerogenetic mechanisms, until present restricted in the gypsum areas of the Emilia-Romagna, were discovered and described: the first causing the deposition of complex aggregates of opal and iron-manganese oxides-hydroxides inside the Pelagalli cave, the second allowing the development of euhedral quartz crystals over corroded gypsum rock, and the third inducing the development of sulphur crystals over gypsum stalactites. Finally, the gypsum caves of the property host an incredible variety of gypsum crystals, which is by far higher of that observed in any other gypsum karst area in the world.

• *Gypsum crystals growing on carbonate concretions in the Risorgente del Rio Basino cave. © Piero Lucci*

2.A.5 GEOMORPHOLOGY AND KARST

The main geomorphological features of the nominated property are strongly influenced by two main factors:

a. *the solubility of the sulfate formations, and*

b. *the presence of argillaceous sediments around the evaporite outcrops*.

The sulfate formations, although very soluble, are less erodible than the argillaceous sediments, which are also sliding downslope through wide landslides. The result is that the evaporite mountains are superbly sticking out in respect to the surrounding areas.

Epigean and hypogean landforms are particularly common; some of these features are unique worldwide (e.g. the "hypogean bends" in the Triassic gypsum), whereas others were first observed, studied and described in the nominated property (e.g. gypsum "candles" and "tumolos", paragenetic galleries, calcite blade, etc.). Notably, a peculiar feature of Messinian gypsum is the simultaneous presence of two karst cycles: the intra-Messinian and the recent one. From a mineralogical point of view, the evaporite caves of the nominated property present a variety of chemical deposits wider than any other gypsum karst area in the world. Indeed, almost all known evaporite cave minerals can be found in Emilia-Romagna. Furthermore, regional caves host a vast collection of gypsum crystallizations, most of which are truly confined and peculiar of this environment. Therefore, it is reasonable to declare that knowledgeably karst phenomena in Emilia-Romagna evaporites are the most various and most complex in the world both from a morphological and a mineralogical point of view.

The Triassic gypsum of the *Gessi di Sassalbo Fm* is cut by the Secchia river and is exposed along outstanding cliffs with vertical walls showing the tormented evaporite layers. The faces of the cliffs are striped by recent rockfalls as the river is continuously eroding their foot. Mudflow deposits, originated in the argillaceous formations cropping behind the gypsum walls, are fanning downslope in between the evaporite mountains reaching the base level of the Secchia riverbed. Fluvial terraces remain consisting of gravels, now resting 25 m above the Secchia river, testify that ancient landslides dammed the river channel creating lakes, which were progressively filled by fluvial sediments.

- *Sinkole in the gravel bed of the Secchia river. © Stefano Lugli*
- *Geo resurgence. © Daniel Bulgarelli*

The cave systems do not cross the core of the mountains, where soluble but impermeable anhydrite is prevailing, but are confined only at their outer rim, where gypsum is dominant. The results are that the karst conduits are "bending" around the evaporite massifs following the more soluble outer rim, which is also cut by tensional release fractures. These "hypogean bends" are a unique karst feature, never described elsewhere in the world.

Because the mudslide fans seals in places the vertical fractures cutting the edges of the mountains at the riverbed base-level, the observation of the karst hydrology map illustrating the underground

- *The Tana della Mussina cave ©Hendrix Artioli*

- *Ceiling channels in the Spipola cave. © G. Agolini*

- *Spiaggia del sole cave. © Paolo Ferrari*

water movements may give the wrong impression that locally the water flow may be moving uphill.

The tormented geologic evolution of the evaporite formation since more than 200 million years ago and the strong tectonic deformation induce a relatively rapid evolution by rock falls and landslides of the caves. New caves are opening and old caves are disappearing in an impressively dynamic evolution.

The Messinian *Gessoso-Solfifera Fm* of the "Vena del Gesso" stand as a superb ridge running parallel to the Northern Apennines front. The gypsum ridge is actually the result of the juxtaposition and embrication of large mountain-size blocks, encircled by mud sediments, which are the result of huge submarine mass-waste phenomena triggered by the intra-Messinian tectonic phase. These overthrusts formed by gravity slides are spectacularly exposed at Monte Penzola and Monte Mauro. At Monte Mauro, three mountain-size gypsum blocks are overlapping one over the other.

Another spectacular feature formed as a consequence of the mass-waste phenomena is the graben structure of the Riva di San Biagio section of the "Vena del Gesso". Here the gypsum ridge is dissected by faults forming an extensional feature truncated at the top by the Messinian erosional surface. The mass waste deposits and the Messinian erosional surface were subsequently sealed by the Pliocenic *Argille Azzurre Fm*, which are nowadays remodelled into deep badlands.

2.A.6 PALAEONTOLOGY

The older evaporite rocks (Upper Triassic) of the nominated property are virtually devoid of fossil remains, but the younger gypsum rocks (Latest Miocene) retain a very important paleontological significance for several reasons:

Gypsum crystals contain remains representing a world-famous example of a very rare kind of fossilization. During their growth at the bottom of the sea, the crystals trapped "spaghetti-like" filaments of possible cyanobacteria and/or sulfide-oxidizing bacteria. These filaments are the direct evidence of the ecological catastrophe that struck the Mediterranean Sea about 6 million years ago, when the basin was transformed in a giant salina and all the marine life forms were completely wiped out from the sea. Only specialized bacteria, were able to survive the extremely salty environmental conditions. The successful attempt of extracting the organic matter preserved within the gypsum crystals allowed the identification and sequencing of the most ancient cyanobacteria DNA ever analysed (Panieri et alii, 2008).

• *skull of* Plioviverrops faventinus*, a small hyaenid described for the first time after the findings in the Monticino Quarry. Vena del Gesso Romagnolo*

In many sites of the Vena del Gesso basin (mainly Tossignano and Monte Tondo) the shale layers separating the selenite beds commonly contain fossil remains of fishes, insects and leaves of Messinian age. The shale testifies the cyclical flooding of the evaporite basin by undersaturated continental waters. The fish fauna is strongly dominant by *taxa* belonging to the estuarine residents guild (*Aphanius crassicaudus, Atherina boyeri, Gobius ignotus*), including marine species that reside and can complete their life cycle in brackish biotopes. The co-occurrence of *taxa* from different ecological categories, as the leerfish *Lichia* aff. *amia* and Scombridae gen. et sp. indet. (marine adventitious) and the cichlid *Oreochromis lorenzoi* or *Lates* cf. *niloticus* (freshwater migrant) could indicate that the lagoons were periodically connected with the sea. In particular, the occurrence of african taxa of Nilotic-Sudanian affinity (*O. lorenzoi* and *L. cf. niloticus*) is indicative of warm conditions and is particularly significant from a biogeographic point of view, supporting the hypothesis of faunal exchange between Eurasia and African during the Miocene.

The fossil flora includes more than 70 *taxa* of vascular plants, with 10 conifers and 63 angiosperms (59 dicots, 3 monocots, 1 plant incertae sedis). Several fossil-species, well known in the Miocene of central Europe and Italy, have been detected. The most frequent are *Taxodium dubium, Sequoia sp.*, *Laurophyllum sp. A* and *B, Daphnogene polymorpha, Fagus gussonii, Platanus leucophylla, Quercus pseudocastanea, Quercus roburoides, Ailanthus pythii*. The general palaeovegetation structure corresponds to the vegetation transect of swamp, riparian vegetation and zonal "subtropical humid forest". For the last one, the results of IPR vegetation analysis indicate a transitional (ecotone) vegetation type between "Broad-leaved Evergreen Forest" and "Mixed Mesophytic Forest", under tropical climatic conditions.

The Monticino mammal fossil community represent one of the first association revealing the existence of an Italian peninsula fully connected with the European continent. The fossil remains were found in a quarry near the town of Brisighella now turned into a geo-park, where a spectacular angular unconformity between the gypsum and latest Messinian (Colombacci Formation) and Pliocene fine-grained sediments (Argille Azzurre Formation) is visible. This is the only place in the entire Mediterranean where evidence of subaerial exposure is present in the gypsum layers and one of the few sites where a macro- and micro-vertebrate fauna can be clearly dated by biostratigraphy, magnetostratigraphy and astrochronology. The subaerial exposure happened at the end of the

deposition of the entire Messinian gypsum sequence and before the Lower Pliocene marine transgression, and this allow to chronologically pinpoint the faunal assemblage between 5,61 and 5,33 million years ago. As a consequence of the exposure to rainwater, fractures in the gypsum were enlarged by karst and birds of prey accumulated food boluses rich in micro-vertebrates, while some of the karst features acted as natural traps for larger vertebrates. The fossil assemblage is very rich and comprises 78 species of continental vertebrates: 34 *taxa* are amphibians and reptiles (frogs, crocodiles, lizards, snakes, worm lizards), 4 *taxa* are birds, 40 *taxa* are mammals (monkeys, aardvarks, equids, rhinoceros, proboscideans, rodents, rabbits, hedgehogs, shrews, bats). Five mammal species are completely new to science: the hyaenid *Plioviverrops faventinus*, the primitive dog *Eucyon monticinensis*, the bovid Oioceros occidentalis, the rodents *Stephanomys debruijni* and *Centralomys benericettii*. The Monticino paleofauna clearly indicates warm-temperate to subtropical climate conditions.

- *Remains of the cave bear (Ursus spelaeus), Vena del Gesso Romagnola © PRVDGR*

An interesting Late Pleistocene fauna, dated between 44,000 and 20,000 B.P., has been found at several sites in the gypsum formation of the Bologna area. The fauna is composed of cold adapted birds at I.E.C.M.E. quarry (*Alectoris graeca*) and Serafino Calindri Cave (*Lyrurus tetrix, Lagopus sp.* and *Corvus cf. C. corax*) together with cold adapted large ungulates as *Bison priscus* and *Equus sp.*, recorded in other localities. These are accompanied by the auroch (*Bos primigenius*) and the giant deer (*Megaloceros giganteus*) at I.E.C.M.E. quarry, by the wolverine (*Gulo gulo*) and the marmot (*Marmota marmota*) at Fiorini quarrry, by the cave hyaena (*Crocuta crocuta spelaea*) at Serafino Calindri Cave and wolf (*Canis lupus*) at Cava a Filo quarry. Some mammals of more temperate-forested environment as the wild boar (*Sus scrofa*) could come from Lateglacial or Holocene deposits. Few Late Pleistocene macromammal remains were found in some Vena del Gesso caves: although more fragmented and scattered than those found in the Bologna area. They testify to the presence of some carnivorans as cave bear (*Ursus spelaeus*), lynx (*Lynx cf. lynx*), probably leopard (*Panthera cf. pardus*) and the steppe rhino (*Stephanorhinus cf. hemitoechus*).

2.A.7 FLORA AND FAUNA

In the Northern Apennines the most common and widespread woodland formations are dominated by three species: *Quercus pubescens* (dominant in the sunniest slopes), *Ostrya carpinifolia* (dominant on the north side) and *Fraxinus ornus*; these species are associated with *Acer campestre, Sorbus domestica, Sorbus torminalis, Quercus cerris*.

In the candidate property the presence of evaporitic soils and the peculiar morphologies associated to them lead to the development of three unique habitats. Gypsum outcrops in fact develop morphologies very different from the surrounding areas and they can both amplify or mitigate extreme microclimatic conditions, leading to the colonization of species of colder and more humid climates (microthermal, sub-Atlantic, orophytic), of warmer climates (macrotherm, Mediterranean), or of colder and dry climates (para-steppic conditions). In these habitats live species listed in the criteria IX of the IUCN threatened species list, and many others protected by the Directives 92/43/EEC and 09/147/EC.

The most characteristic habitat is without doubt **the underground habitat of caves**. Many endemic troglobite invertebrate (listed in criteria IX) live in these gypsum caves: molluscs, mites, insects.

The second habitat is the bottom of the sinkholes, which open in the northern slopes and, due to the phenomenon of thermal inversion that stratifies the cold air in the bottom, they present a vegetation and a fauna of cold climates, at very low altitudes: ferns, mosses, liverworts, molluscs, insects and amphibians. The north-facing cliffs present various species of moss (among whose *Tortula revolvens* living only on gypsum rocks) and lichens, associated with many ferns, including the common *Asplenium ceterach*, the rare *Asplenium scolopendrium, Polypodium vulgare, P. cambricum, Asplenium trichomanes* and the very rare *Polystichum lonchitis*; in these stations grows also the rare *Staphylea pinnata*. In some cases, in particularly fresh and deep dolines and ravines, there are small woods typically of mountain (on hill elevation); in these habitats there are herbaceous species always linked to fresh and humid microclimates, such as *Galanthus nivalis* threatened by climate change and global warming, because here the extreme peaks of heat and aridity are almost totally mitigated by the influence of the air and the humidity of the subsoil. The northern hillsides are home of *Isopyrum thalictroides, Scilla bifolia, Mercurialis perennis, Cystopteris fragilis, Asplenium scolopendrium, Allium ursinum, Convallaria majalis*. In some cases, on the northern slopes, the woods have been replaced by fruit chestnut trees, with centuries-old arboreal specimens rich in cavities and, therefore, very important from an ecological point of view.

The third habitat are the rocky cliffs, exposed to the south, hosting a particular flora, composed of Mediterranean species and loving gypsum substrate, such as the moss *Tortula revolvens* (exclusive of gypsum rock) and fauna, with the rare cricket Saga pedo, the beautiful butterfly *Phengaris arion* and the strictly Mediterranean *Sylvia undata*; at the foot of these cliffs, in the meadows and vineyards that extend between the gypsum landslides, the very rare and endemic hyacinth, already cited, *Bellevalia webbiana*. More in general, the south-facing slopes have thermophilic (of warm climates) and xerophilous (of arid climates) features in which there are typically Mediterranean elements. Here we can distinguish two prevailing habitats: the rupicolous populations and the garrigue. On the most inaccessible cliffs live, directly clinging to the gypsum rock, many species adapted to these extreme, arid and inhospitable environments; among them there is the botanical emblem of the Vena del Gesso, the very rare Allosorus persicus (the Messinian gypsum component site "Vena del Gesso Romagnola" is the only Italian site, at the extreme West distribution limit; it is a distinctly gypsophilous species in Italy); moreover, different species of Sedum; *Alyssum alyssoides; Helichrysum italicum; Helianthemum apenninum; Onosma echioides; Onosma helvetica; Fumana procumbens; Thymus striatus; Ruta graveolens; Artemisia alba* and, only in Alta Valle del Secchia (c.s.1), *A. pedemontan*a (another gypsophilous species in Italy). Where a thin layer of soil is formed, thanks to the lower slope, the typical Mediterranean garigue is asserted, with evergreen shrubs alternating with dry meadows, partly constituted by the same species present on the cliffs, together with *Brachypodium rupestre* and some orchids as *Anacamptis morio*; among the shrubs there are many Mediterranean species, such as *Pistacia terebinthus, Rhamnus alaternus, Viburnum tinus, Phillyrea latifolia, Juniperus oxycedrus, Quercus ilex*.

At the foot of the cliffs there are *Quercus pubescens* forests or shrubs, with J*uniperus communis, Rosa canina, Prunus spinosa* and, where the soils are even more arid and poor, compact spots of *Spartium junceum*. In the meadows and at the edges of the vineyards extending beyond the foot of the cliffs, there are the rare and endemic *Bellevalia webbiana, Himantoglossum adriaticum* protected by the European Union, and many other species of orchids.

The fauna of the candidate property is of extraordinary interest, due to the great environmental and microclimatic diversity, but also to the presence of an ancient, stable and rare ecosystem of great scientific and conservation importance in the caves in gypsum. The fauna of the caves presents organisms of ancient marine origin, witnesses to the evolutionary history of the planet, trapped in these underground environments protected for millions of years. In the caves there are troglobite, troglophile and troglossene species: the first are of greatest interest, strictly and inextricably linked to the underground cavities. Over 150 invertebrate species are known within the caves of the Emilia-Romagna gypsum areas, about half of which are troglophile species, 25% are troglossene species and as many troglobite species (about 35 species).

Some annelids oligochaetes of ancient marine origin are endemic of the Triassic Gypsum area and, being new species for science, are in the nomenclature phase (C*oralliodrilus sp., Abyssidrilus sp., Cernosvitoviella sp.*). Among the molluscs the most interesting species is *Islamina piristoma* (*Gastropoda, Hydrobiidae*), endemism of the Northern Apennines which lives exclusively in Vena del Gesso Messinian gypsum.

Among the arachnids, several species of mites are very interesting, such as *Medioppis melisi* (endemic of Vena del Gesso and Gessi Bolognesi areas), *Ramusella caporiacci* (endemic of Vena del Gesso), *Trichouropoda schreiberi* (discovered and described in the Vena del Gesso and Gessi Bolognesi areas) or *Parasitus loricatus, Uroobovella rackei, Trichouropoda schreiberi*. There are also many troglobitic and endemic crustaceans, such as the ostracode *Pseudolimnocythere sp.* of Triassic Gypsum (new for science) or the amphipods *Niphargus gr. longicaudatus* and *Niphargus gr. speziae* (both Italic), *Niphargus poianoi* (endemic of the Upper Secchia Valley, in the Triassic Gypsum area) and other more widespread such as the isopod *Androniscus dentiger* or the copepod *Diacyclops paolae*. Some interesting hexapods are first of all two springtails (*Collembola*): one new for science, *Deuterophorura pieroluccii* (endemic of Vena del Gesso), and the more widespread *Mesachorutes quadriocellatus*; moreover, some insects, such as the rove beetle (*Staphylinidae*) *Lathrobium maginii subsp. mingazzinii* (endemic of Vena del Gesso), the round fungus beetles (*Leiodidae*) *Choleva garganona* (Italic) are known from the evaporitic areas. Very interesting is also the abundant presence of an endemic Italian orthopteran, typical of the caves, very showy: the beautiful *Dolichopoda laetitiae*.

In the caves of the Messinian Vena del Gesso (c.s.5) and in San Leo (c.s.6) there is also an endemic amphibian of the Apennines, *Speleomantes italicus* (NT), while in the Triassic gypsum caves (c.s.1) there is the endemic *Speleomantes strinatii* (NT).

But, most of all, in the caves we find very important colonies of bats (*Chiroptera*). There are 23 species in the candidate property, some of which in large reproductive or hibernation colonies. Among the reproductive species in caves there are three species of horse-shoe bats (*Rhinolophidae*): *Rhinolophus euryale* (NT) with 450-750 females (in the Lucerna and Onferno caves and in the Monte Tondo galleries), *R. ferrumequinum, R. hipposideros*; moreover, some *Vespertilionidae* such as *Myotis myotis, Myotis blythii, Myotis nattereri* and a *Miniopteridae*: *Miniopterus schreibersii* (VU). They are all also present during hibernation and, in particular, Miniopterus schreibersii is present with over 30,000 individuals (18,000 at Monte Tondo, 3,500 in Onferno, 7,000 in Eastern Romagna and 2,000 at the Croara caves). There are also interesting wood bats, such as *Barbastella barbastellus* (NT) and *Myotis bechsteinii* (NT), besides all the more common anthropophilous species.

The resurgence streams are home to some rare insect species, including, in particular, the damselfly *Coenagrion mercuriale ssp. castellanii* (NT) which has in Romagna one of the most important populations in Italy. Moreover, there are some endemic Amphibians: T*riturus carnifex, Bombina pachypus* (EN), *Rana italica* and one endemic fish resistant to sulphurous waters and rich in dissolved salts: *Rutilus rubilio* (NT).

Many other endemic or sub-endemic fish are, most of all, in the Secchia river: *Barbus plebejus, Barbus meridionalis* (NT), *Cobitis bilineata, Protochondrostoma genei, Padogobius bonelli*; there is also a very rare freshwater crayfish: *Austropotamobius pallipes* (EN).

The southern cliffs have many Mediterranean animals, such as the rare cricket *Saga pedo* (VU), the beautiful butterflies *Phengaris arion* (NT) and *Iolana iolas* (NT). Among the vertebrates, the snake *Coronilla girondica*, some passerines, such as *Sylvia moltonii* and the rare *Sylvia undata* (NT) and mammals such as *Hystrix cristata*.

In general, in the forests there are all the large and medium mammals of the Apennines: *Canis lupus* (about 5-6 family herds), *Vulpes vulpes, Felis silvestris* (only in Vena del Gesso), *Meles meles, Martes foina, Martes martes* (only in Vena del Gesso), *Mustela putorius, Cervus elaphus, Capreolus capreolus, Sus scrofa*. Among the small mammals there are other interesting species, such as the endemic *Sorex samniticus* and the rare *Eliomys quercinus* (NT). There are totally 58 species of mammals.

On the rocky cliffs two birds of prey are nesting: *Falco peregrinus* (6 pairs) and *Bubo bubo* (1 pair); there are also many other nesting diurnal and nocturnal raptors, among which *Pernis apivorus, Circus pygargus, Circaetus gallicus. Altogether*, over 150 species of birds are known, of which almost 100 are nesting. Other interesting nesting birds are *Streptopelia turtur* (VU), *Caprimulgus europaeus, Lullula arborea, Anthus campestris, Sylvia hortensis, Certhia brachydactyla, Lanius collurio, Passer italiae* (VU), *Emberiza hortulana*. There are two species often wintering at the entrance of the caves: *Strix aluco* and *Tichodroma muraria*. Many insect species are widespread in the nominated property, some rare and protected, such as *Lucanus cervus* (NT), *Cerambyx cerdo* (NT), *Osmoderma eremita* (NT), *Lycaena dispar* (NT).

• *Myotis myotis and Miniopterus schreibersii*

Among mammals, the gypsum outcrops are "high biodiversity isles", thanks to the great geomorphological and environmental diversity. The underground karst systems host the most important Italian populations of bats, with 23 species and large reproductive and hibernation colonies of rare species such as *Rhinolophus euryale* (VU) with over 600 females, *Miniopterus schreibersii* (NT) with over 25,000 wintering individuals. There are two endemic Amphibians living in caves: *Speleomantes italicus* in Messinian Gypsum (Vena del Gesso Romagnola), *Speleomantes strinatii* (NT) in Triassic gypsum of the Secchia Valley. In the resurgent streams there are other three endemic Amphibians: *Triturus carnifex, Bombina pachypus* (EN), *Rana italica* and one endemic fish resistant to sulphurous waters and rich in dissolved salts: *Rutilus rubilio* (NT). But among the Invertebrates, we found the most interesting species linked to the karst habitats and that originate in hypogeum environments extraordinary faunal cenoses, in perfect equilibrium; just to name a few of them: some species new to science and in the nomenclature phase (*Coralliodrilus sp., Abyssidrilus sp., Cernosvitoviella sp., Pseudolimnocythere sp.*, all endemic of Triassic gypsum in the Alta Valle del Secchia; *Deuterophorura sp.*, endemic of Vena del Gesso; *Islamina piristoma* (endemic of Northern Apennines); *Medioppis melisi* (endemic of Vena del Gesso and Gessi Bolognesi); *Ramusella caporiacci* (endemic of Vena del Gesso), *Niphargus gr. longicaudatus* and *Niphargus gr. speziae* (both Italic), *Niphargus poianoi* (endemic of Triassic Gypsum); *Dolichopoda laetitiae* (Italic); *Lathrobium maginii subsp. mingazzinii* (endemic of Vena del Gesso); *Choleva garganona* (Italic). There are more than 1.200 species of plants, some of them linked to the karst habitats, such as the ferns (22 species) with rare species such as *Allosorus persicus* (Vena del Gesso is the only Italian site, at the extreme West distribution limit), *Asplenium sagittatum, Asplenium scolopendrium, Cystopteris fragilis*; more than 35 species of orchids, with *Anacamptis morio* (NT) and *Himantoglossum adriaticum. Bellevalia webbiana* (EN) is an endemic species of Tuscany and Romagna, with one of the most important world population in the Vena del Gesso Romagnola.

A targeted research on the most important blind valley-resurgent karst system, the Rio Stella-Rio Basino system, showed the presence of the following microbial groups, all naturally present in water and not attributable to polluting sources of anthropic origin: *Bacillus spp.* (*B. firmus, B. megaterium*), *Pseudomonas spp., Sarcina spp., Chromatium/Halochcromatium, Roseospira, Actinomycetes*. The same is in the caves of the Gessi Bolognesi, where are known the following naturally present microbial species: *Bacillus thuringensis, B. sphaericus, B. pumilus, Aeromona salmonicida, A. hydrophila, Serratia marcescens, Acinetobacter lwoffii*.

C.S.1 ALTA VALLE DEL SECCHIA

The **Alta Valle del Secchia** (*Upper Secchia Valley)*, from the Poiano springs to the Ozola stream confluence, is characterized by huge Triassic evaporites outcrops of the *Gessi di Sassalbo Fm*.

On an overall surface over than 22 km^2, it represents the most extended karst area in the Emilia-Romagna region, and shows unmatched forms in the Apennines landscapes, also thanks to the place's almost pristine nature. In this area, 10 km long and 1 to 3 km large, the landscape forms escape from the typical medium Apennine morphology, generally marked by extended and gentle clay slopes, producing very steep and impressive landforms. Here the curved forms of the mountain's top, shaped from the slow water and frost wearing, intersect the sharped lines of slopes and valley bottoms, drawn by the tectonic deformations.

It seems like a fantastical location, to a certain extent disturbing, and man seems to shy away from it: "*on gypsum it is not to live*". Rare scattered buildings, abandoned and ruined, seems to confirm this unwritten law.

The very scarce anthropization, the exceptional variability of the slope exposure, the presence of salt springs, the dryness and the nature of soils, cause one of the highest levels of floristic biodiversity in the Emilia-Romagna region, with rarities and endemic species of international interest.

To an overall view these areas show all their contrasts. The gypsum rocks seem to be "*pushed upwards*" by an underlying force. Few streams are deeply engraved in along strongly straight lines, which recall a tectonic origin. Colours add strength to these contrasts too: the blinding white of the gypsum cliffs slowly alternates with the dark green of the woods and the light green of the lawns. Finally, on this all, the Pietra di Bismantova stands like a sentinel: so different yet inseparable from the Triassic Gypsum landscape.

The area between the Secchia river and two of its right tributaries, Sologno and Lucola streams, extended about 4 km^2, host the "**Fontana Salsa**" (*salty spring*), to date known as Poiano Springs. This is the most copious karst spring in the Emilia-Romagna region, with an average flow rate greater

• *the Secchia valley with the cliff of Monte Rosso (2015)*
© G.Bianchini

than 400 l/s, and a strong salinity, subject, starting from the last period of the nineteenth century, of hydrogeological, hydrochemical and biological studies. Thanks to these studies further endemics have been identified, and new species have been described.

In this component site, the karst features are strongly influenced by the complex phenomena induced by the anhydrite hydration to gypsum in the subsurface, which is still active today.

Because of these peculiar characteristics the caves show a relatively rapid evolution by rock fall and landslide. New caves are opening and old caves are disappearing in an impressively dynamic evolution.

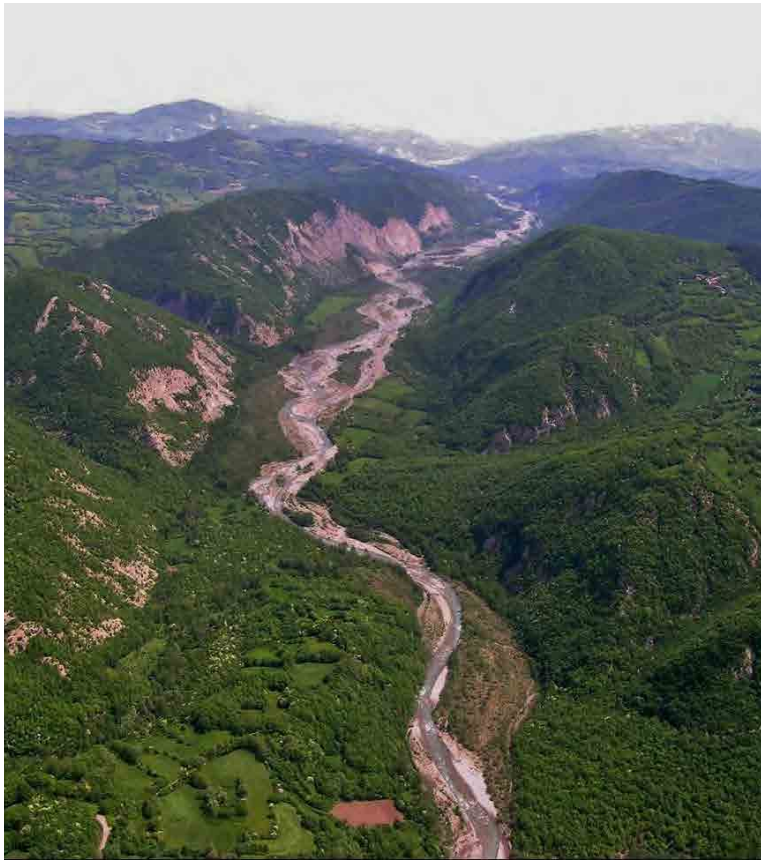
The evaporite mountains consist of a core of anhydrite which is unstable at surface exposure and is actively hydrated to form gypsum by rainwater and groundwater.

The high vertical cliffs, the strong tectonic deformation of the rocks, and the presence of the highly soluble salt halite, create the conditions for a unique karst feature not described anywhere else in the world, the so-called "*hypogean bends*". Here the area shows the usual dissolution macroforms, such as dolines and sinkholes, but in depth it is caracterized by a peculiar karst circulation, the "*hypogean bends*".

The streams penetrate into the evaporitic strata and then come back, after a more or less extended journey underground, into their own, or even another surface riverbed.

The extreme tectonization and the karst speed development often cause collapses or flood filling of the conduits, forcing to continuously update the cave registry; this one counts more than 80 natural significant caves. Among these ones, the **Tanoni della Gacciolina** karst system is the most developed (over 2000 m), while the **Monte Caldina** karst system is to date the evaporitic cave with the deepest drop in the world (-265 m).

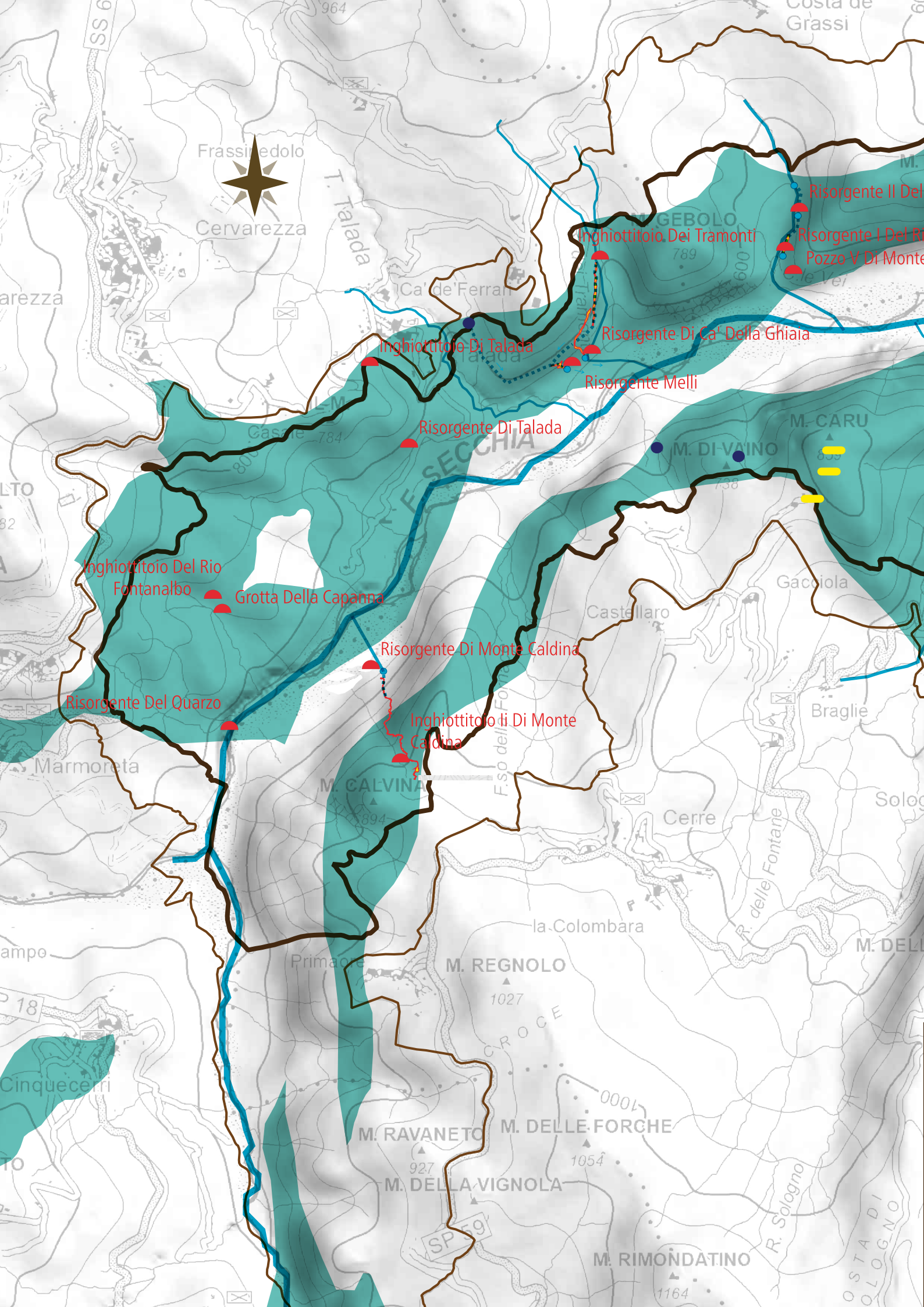
Among the mineralogical peculiarities, it must certainly be mentioned the presence of 10 out of 11 accessory minerals currently known in evaporitic caves all over the world .

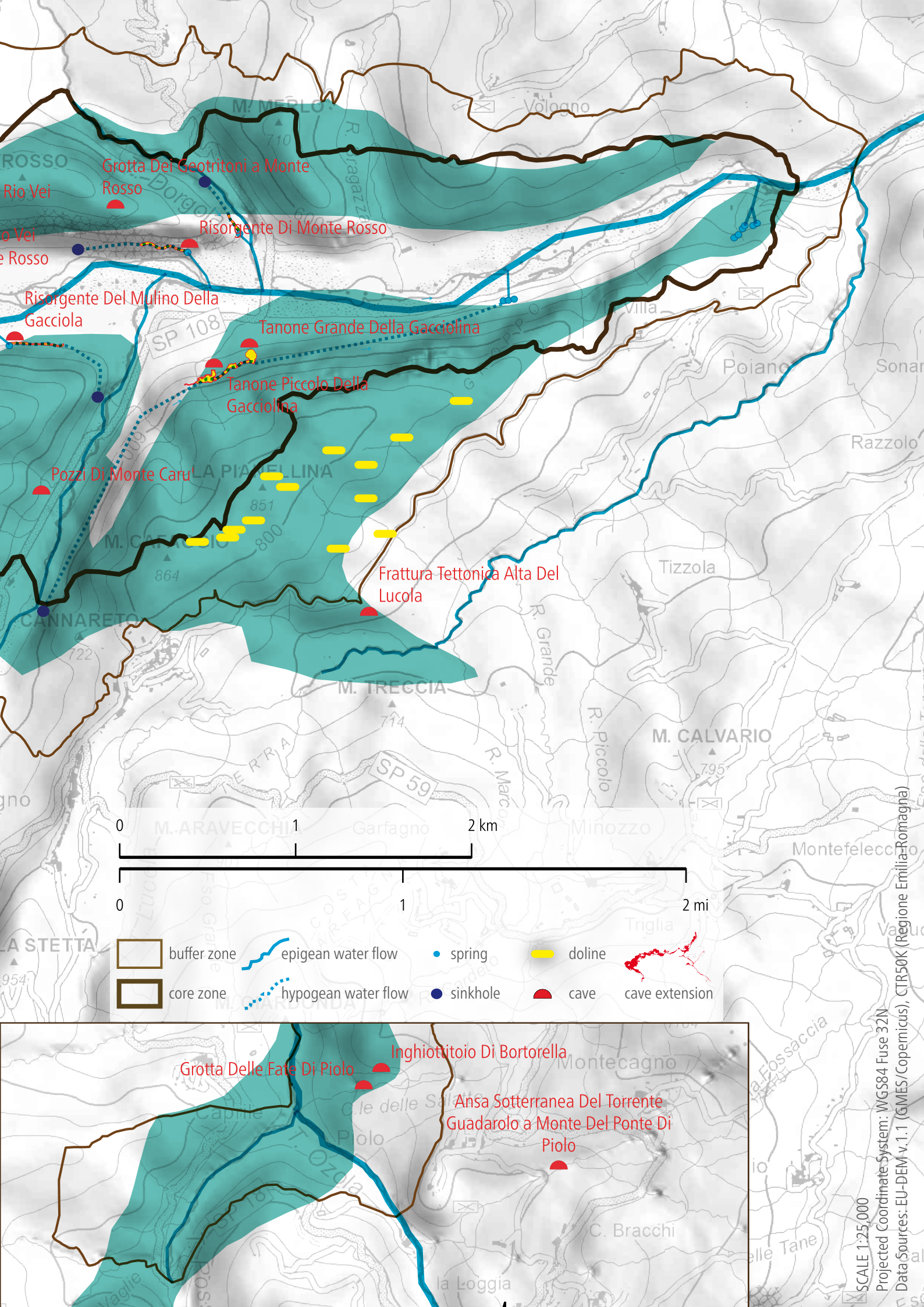


The first news about the high Secchia valley karst dates back to the beginning of the 17th century and is about the "**Fontana salsa di Pojano**" (*salty spring of Poiano*). Starting from the first description, the springs had amazed because of their waters saturated in sodium chloride, as it can be inferred from a letter sent in 1612 to the Duke of Modena (Bottegari, in Valdrighi, 1891).

Shortly afterwards, between the end of the 17th and the beginning of the 18th century, the great scientist **Antonio Vallisneri** accurately described the sub-aerial karst morphologies of the area. In the following centuries other scholars were interested in the phenomenon, and they analysed the Poiano waters by scientific methods (Doderlein, 1861; Spallanzani, 1906).

- *Tanone Grande della Gaggiolina cave (2019) © S.Sturloni*
- *Aerial view of the Secchia river (2017) © GSPGC*


Inghiottitoio Dei Tramonti
Risorgente II Del
Risorgente I Del Ri
Pozzo V Di Monte
Inghiottitoio Di Talada
Risorgente Di Ca' Della Ghiaia
Risorgente Melli
Risorgente Di Talada
Inghiottitoio Del Rio Fontanalbo
Grotta Della Capanna
Risorgente Di Monte Caldina
Risorgente Del Quarzo
Inghiottitoio Ii Di Monte Caldina
Cervarezza
Ca' de' Ferrari
M. CARU
M. DI VAINO
M. CALVINA
M. REGNOLO
M. RAVANETO
M. DELLE FORCHE
M. DELLA VIGNOLA
M. RIMONDATINO
Castellaro
Cerre
Braglie
la Colombara
Primaore
Marmoreta
Cinquecerri
T. Talada
F.so delle Fontane
R. Sologno


Grotta Dei Geotritoni a Monte Rosso
Risorgente Di Monte Rosso
Risorgente Del Mulino Della Gacciola
Tanone Grande Della Gacciolina
Tanone Piccolo Della Gacciolina
Pozzi Di Monte Caru
Frattura Tettonica Alta Del Lucola
Inghiottitoio Di Bortorella
Grotta Delle Fate Di Piolo
Ansa Sotterranea Del Torrente Guadarolo a Monte Del Ponte Di Piolo
0
1
2 km
0
1
2 mi
buffer zone
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25.000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v.1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)

The geological phenomena and the caves of the Triassic evaporite formation were described since the beginning of the 19th century, but have been systematically explored and surveyed since 1938 and 1945. The results of these early studies were published in 1949 as one of the most evocative and pioneering integrated work on an evaporite karst area, covering all scientific aspects from geology, botany, hydrology, hypogean meteorology to toponymy, and served as a model for scientific studies elsewhere.

One of the major active processes today is the formation of **karst sinkholes**. The largest one is about 50 m in diameter and opened in 2017 in the detrital cover of the gypsum next to the village of Sassalbo. Minor sinkholes, just a few meters across, are documented since the 1970s and continuously open in the fluvial deposits of the Secchia river and are then filled and buried by fluvial gravels.

These sinkholes testify for the rapid dissolution of gypsum and halite by karst underflow at the valley bottom. New large sinkholes may be expected to open along the Secchia river valley in the next future as a natural evolution of the karst phenomena.

This part of the nominated property escaped the industrial exploitation of gypsum as raw material, which was rather widespread in the last century in many other areas, such as the Messinian gypsum. Here only local, minor quarries were opened to supply the building needs for the traditional housing and chestnut drying facilities. The local production turned out with special characteristics. Due to

- *Aerial view of the Fonti di Poiano salt springs along the Secchia river valley (2008) © G.Bertolini*
- *The Tanone Grande della Gaggiolina cave (2010) © P.Lucci(*

the relatively high iron minerals content of the raw gypsum, the setting of mortars and plasters creates a distinct pink colour. Only another example is known in the world for pink gypsum mortar and plaster production (the Spanish town of Albarracin).

Today the remains of the ancient kilns for mortar and plaster production are visible along the tracks crossing the gypsum outcrops next to the main villages. The kilns are small and structurally very simple and represent open-air witnesses of the traditional local use of raw material for the preparation of this peculiar gypsum plaster. The traditional pink plaster dressing and decoration is visible on the walls of many old houses and of the church in the Sologno village.

- *Monte Rosso along the Secchia river valley (2007) © S.Sturloni*
- *The Tanone Grande della Gaggiolina cave, Bertolani room (2017) © H.Artioli*

• *The Tanone Piccolo della Gaggiolina cave. (2009) © P.Lucci*

C.S.2 BASSA COLLINA REGGIANA

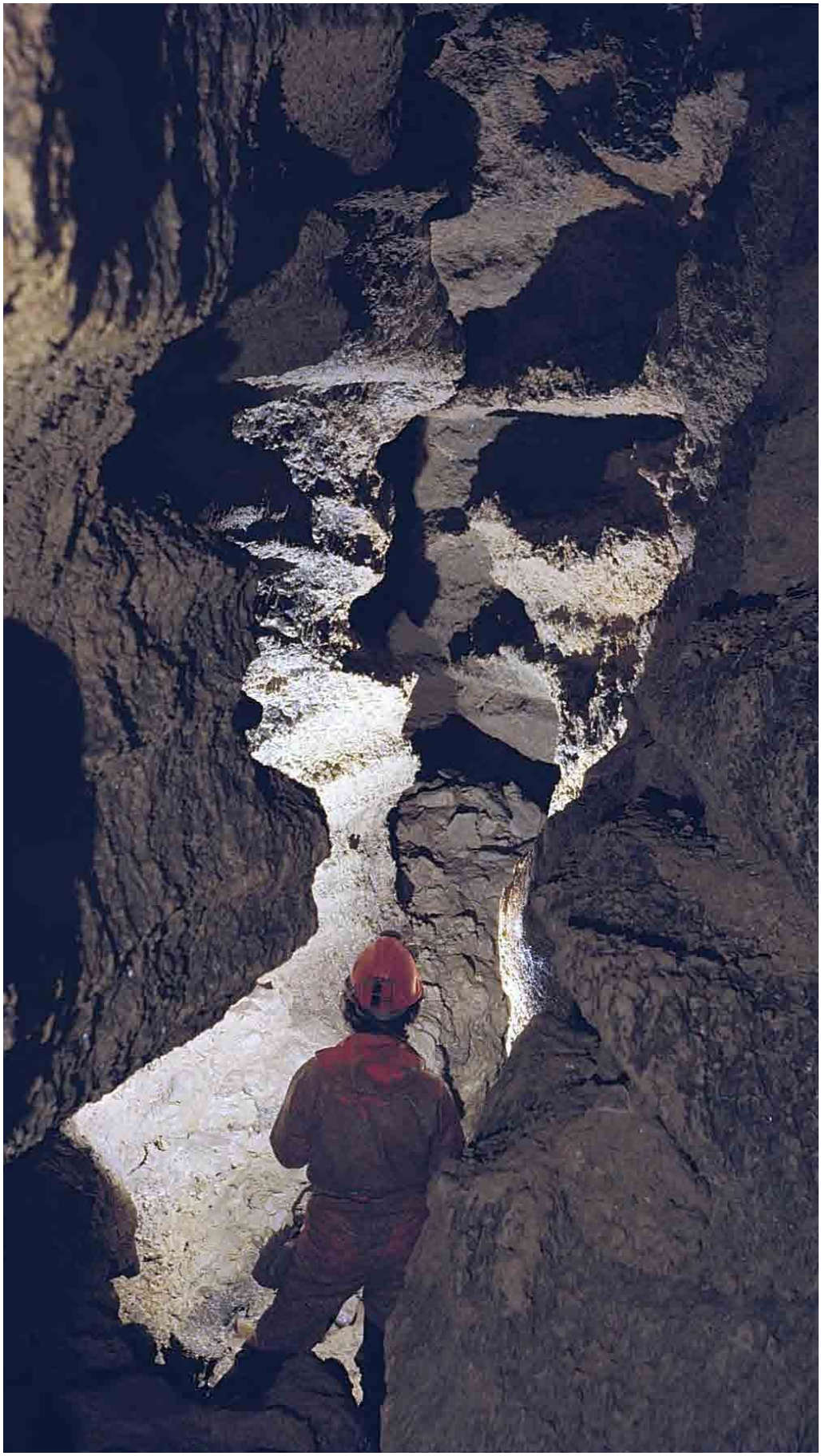
The Messinian gypsum outcropping in the **Reggio Emilia lower hill area** is characterised by a thin ridge developed in a northwest-southeast Apennine direction, with a series of discontinuous gypsum outcrops located between the Campola and Tresinaro streams. Set in a clayey matrix and commonly in a vertical orientation, the gypsum banks rarely emerge from the profile of the foothills, so only along the torrential incisions the presence of gypsum can be perceived on a large scale. In the Reggio Emilia area, therefore, there is no *gypsum line* distinguishable from the landscape, neither from the plain nor from the argillaceous ridges above it. However, to a close look the woodland cover of these areas following a pattern congruent with some of the intra-hill ridges is clerly visible, ultimately contributing to emphasise their modest elevation.

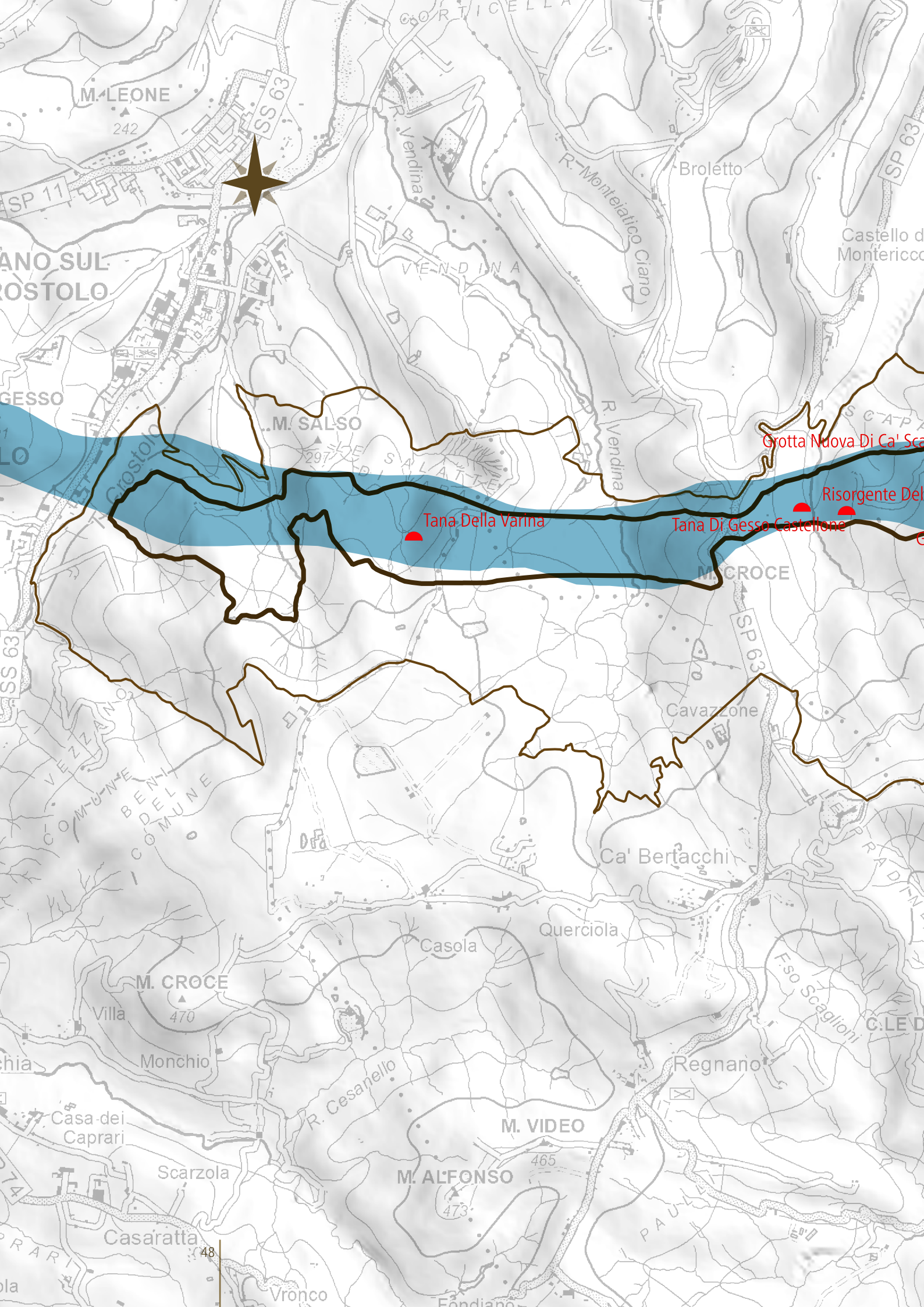
Sinkholes are widespread at the bottom of the numerous dolines; they are almost always occluded by mudslides, which drain the surface waters and feed small and medium-sized karst systems generally arranged parallel to the gypsum outcrop. The most important of these is the **Ca' Speranza-Mussina karst system**, which collects most of the water from the area to the south of the Borzano village. The waters rise at the **Tana della Mussina di Borzano**, a cave also famous for the excavations carried out in 1872 by **Gaetano Chierici**, a pioneer of palaeoethnology in Italy.

The area is also one of the cradles for the use of gypsum as ornamental stone and plaster-stucco production with the famous *scagliola carpigiana*, created as imitation of semi-precious stone panels for church altars starting from the 17th century.

- *The Borzano castle built over the selenite strata (2018) © S.Sturloni*

- *The entrance to the Tana della Mussina cave (2018) © P.Lucci*
- *The grand canyon of the Ca'Speranza cave. (1981) © M.Chiesi*




M. LEONE
242
SS 63
SP 11
R. Vendina
R. Montelatico Ciano
Broletto
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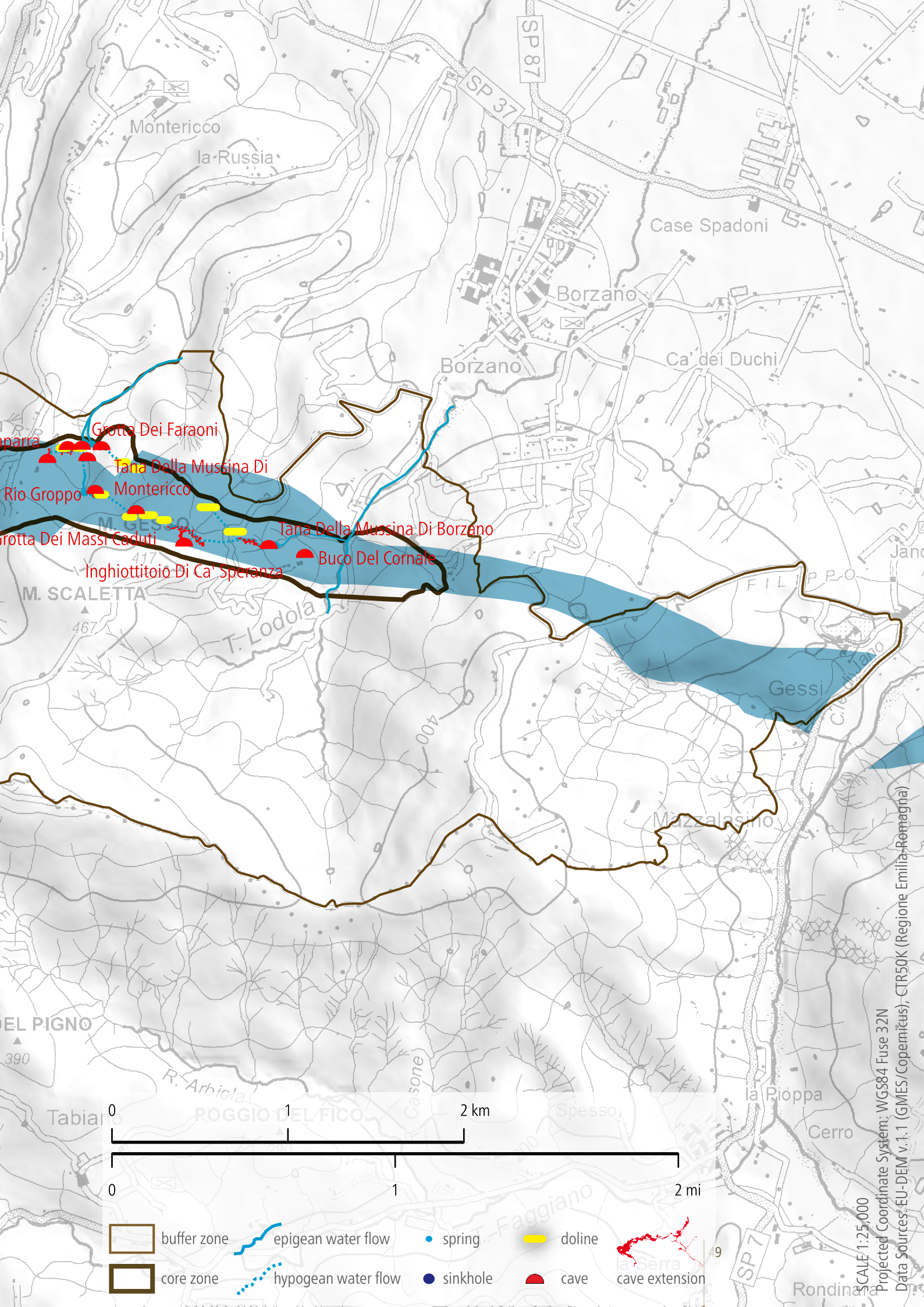
Castello d
Montericco
VE N DI NA
ANO SUL
ROSTOLO
GESSO
LO
M. SALSO
297
Crostolo
R. Vendina
Grotta Nuova Di Ca' Sca
Risorgente Del
Tana Della Varina
Tana Di Gesso Castellone
M. CROCE
SS 63
SP 63
Cavazzone
COMUNE BENI DELLE COMUNE
Ca' Bertacchi
Querciola
Casola
M. CROCE
470
Villa
Monchio
Fso Scaglioni
Regnano
R. Cesanello
Casa dei
Caprari
M. VIDEO
465
Scarzola
M. ALFONSO
473
Casaratta
48
Vronco


Montericco
la Russia
SP 87
SP 37
Case Spadoni
Borzano
Borzano
Ca' dei Duchi
Grotta Dei Faraoni
Tana Della Mussina Di Montericco
Rio Groppo
Tana Della Mussina Di Borzano
Buco Del Cornale
Inghiottitoio Di Ca' Speranza
M. SCALETTA
467
T. Lodola
Gessi
Mazzalasino
la Pioppa
Cerro
Rondinara
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2 km
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buffer zone
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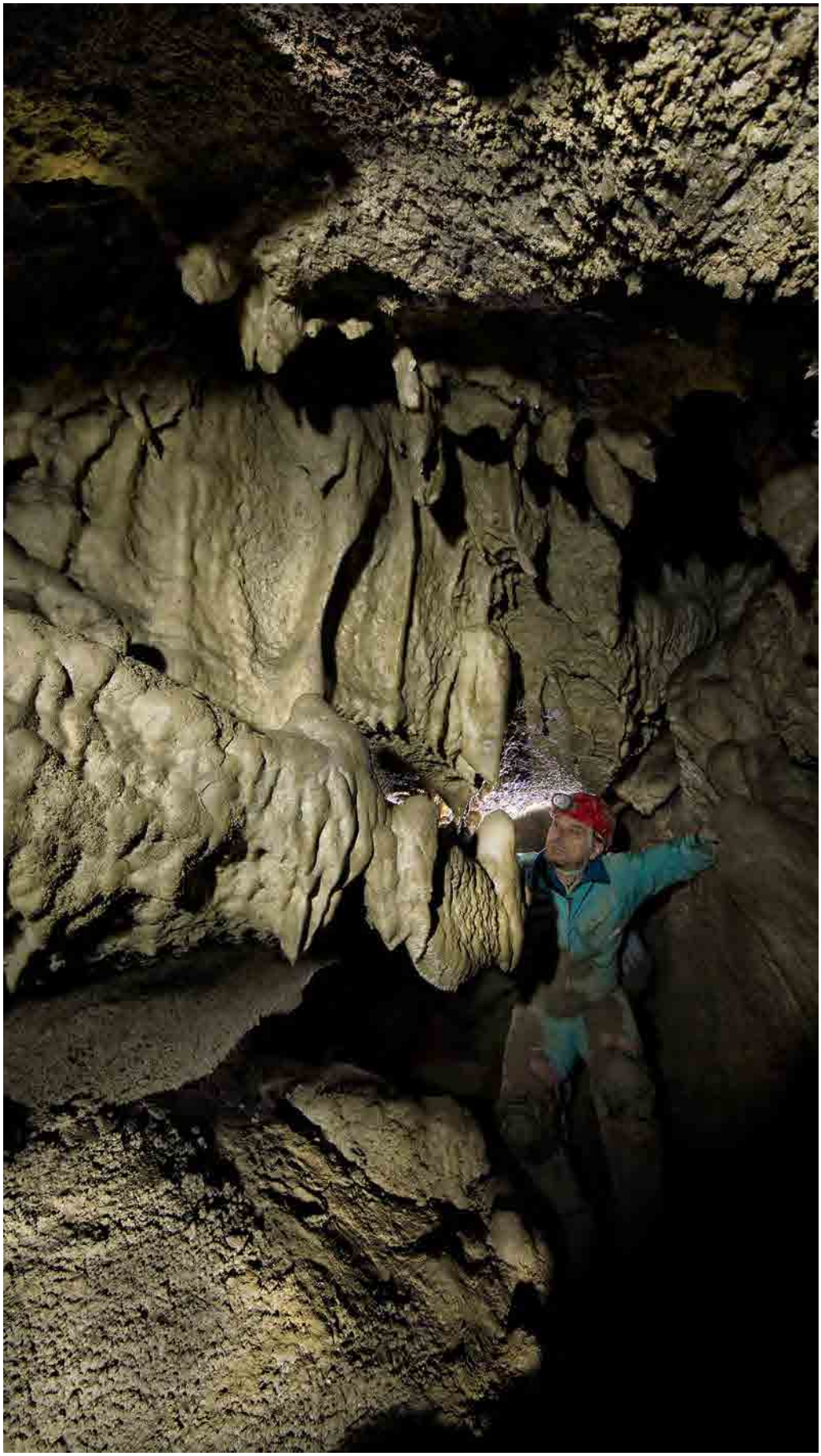
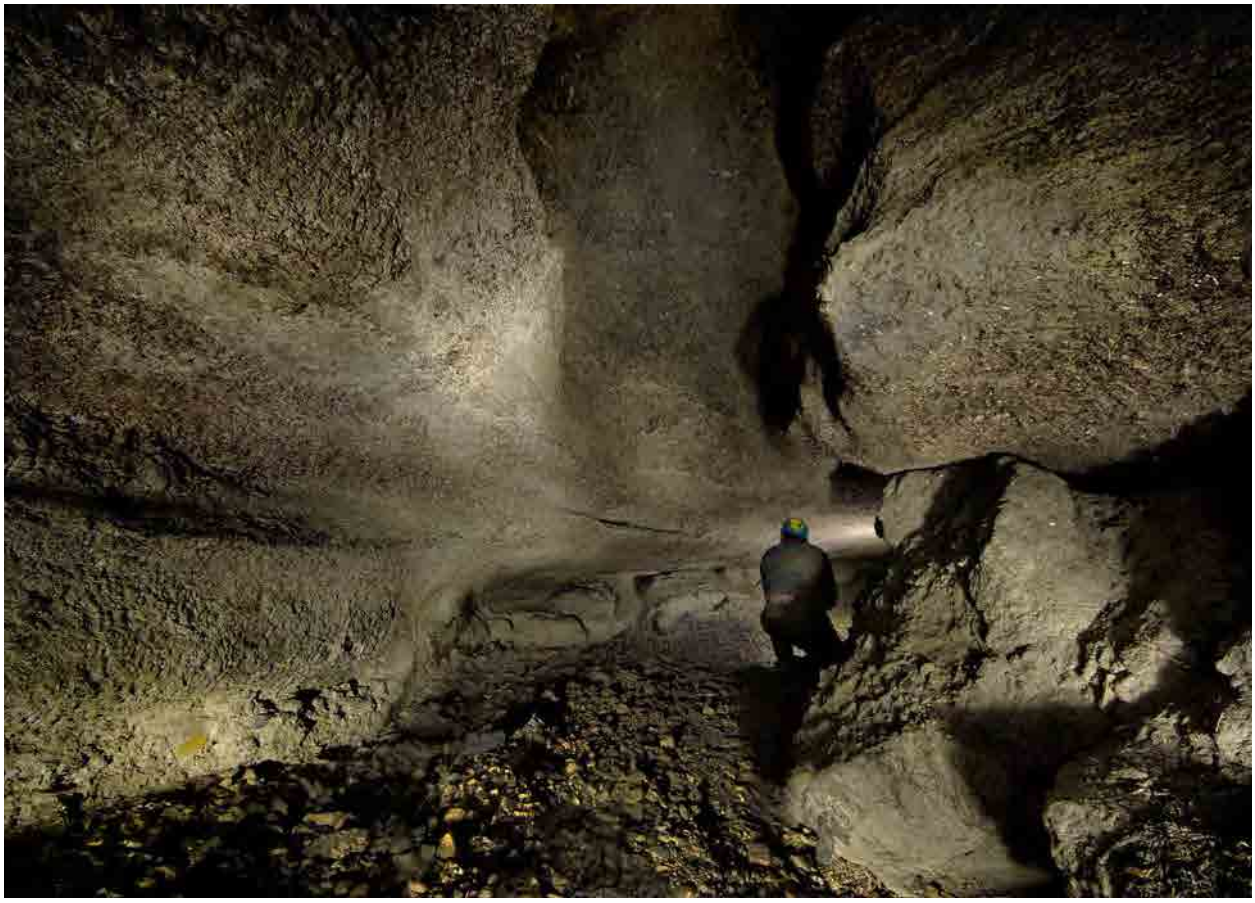
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25.000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v.1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)

- *The the Tana della Mussina cave. (2016) © H.Artioli*
- *Tana della Mussina cave (2018) © P.Lucci*
- *El capitain conduit of the Ca'Speranza cave. (1981) © M.Chiesi*



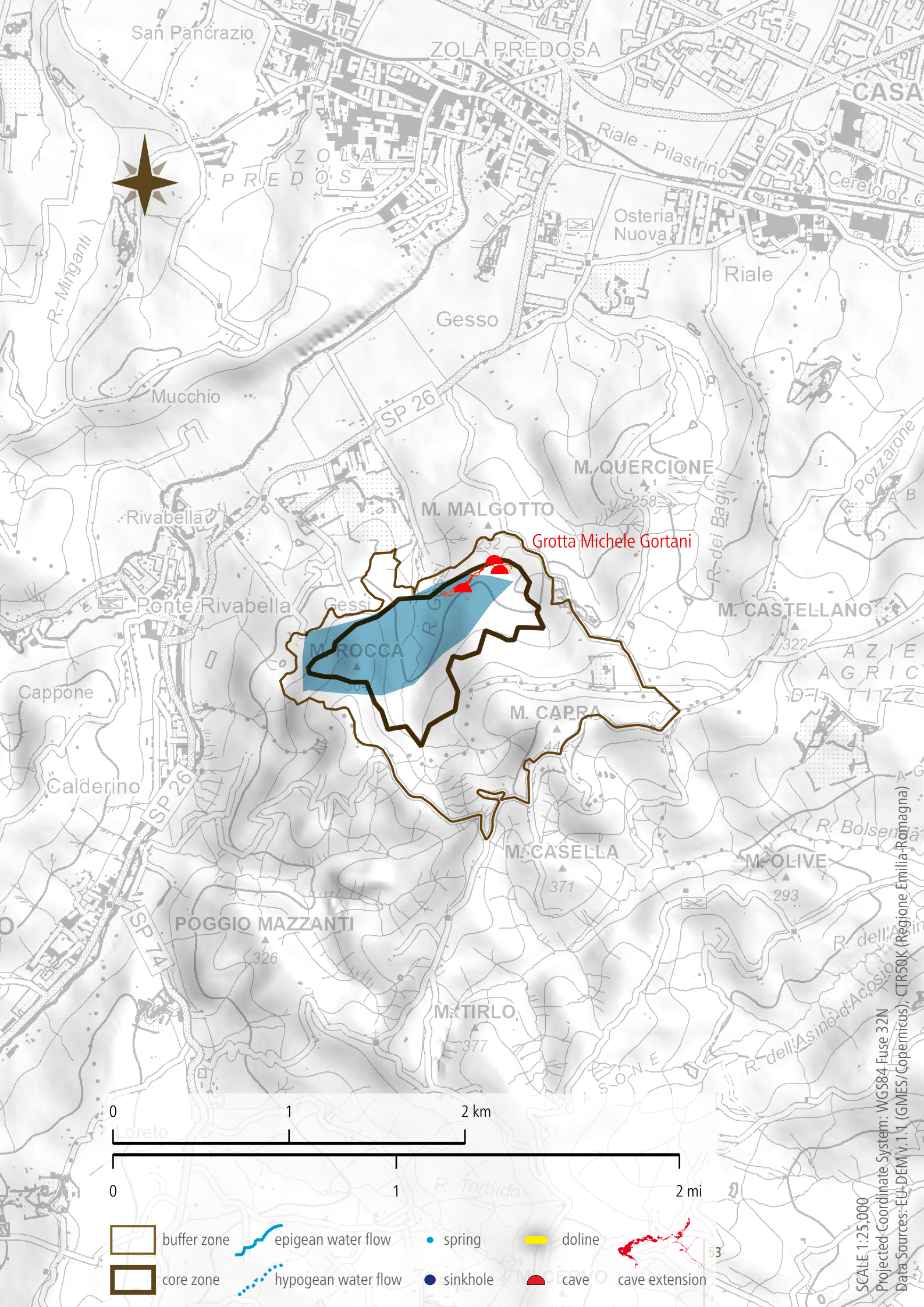


C.S.3 GESSI DI ZOLA PREDOSA

The **Gessi di Zola Predosa** appear as a series of outcrops along the Apennine margin, immediately south of Bologna. In this area karst takes place in a variety of surface forms, from blind valleys to dolines (up to 1 km in diameter), to singular dissolution phenomena such as candles and karren, and several detachment bubbles that pit the surfaces of the plateaus. Epigean forms, no less important, include some of the main regional karst systems, such as the **Michele Gortani Cave** in Gessi di Zola Predosa. This cave, with a planimetric development of more than 2 km, shows beautiful features of vadose deepening (canyons) and spectacular crystallization of satin-spar gypsum. However, the main attractiveness of this area is a widespread karst system, developed in a period of intra-Messinian exposure, characterized by groundwater tunnels and vault channels (paragenetic tunnels), displaced by the tectonic events that led to the final uplift of this area. To date, this cave is unique worldwide.

For quite a long time, the small karst area of the *Gessoso-Solfifera Fm* outcropping in Zola Predosa had been affected by mining and quarrying activities that permanently changed some sectors of the territory including the final part of the largest cave in the area, the Gortani Cave. The millennia-long interaction between the natural and anthropic elements has therefore shaped this territory and made it peculiar, with fortified medieval settlements, ancient parish churches and monasteries, characteristic villages and scattered rural settlements.

- *The signs left by the early exploreres of the Gortani cave in 1933 (2012) © F.Grazioli*
- *The vertical shaft at the entrance of the Gortani cave. (2012) © F.Grazioli*


San Pancrazio
ZOLA PREDOSA
CASA
Riale - Pilastrino
Osteria Nuova
Riale
Gesso
Mucchio
SP 26
M. QUERCIONE
M. MALGOTTO
Grotta Michele Gortani
Rivabella
Ponte Rivabella
M. ROCCA
M. CASTELLANO
Cappone
M. CAPRA
Calderino
M. CASELLA
M. OLIVE
POGGIO MAZZANTI
M. TIRLO
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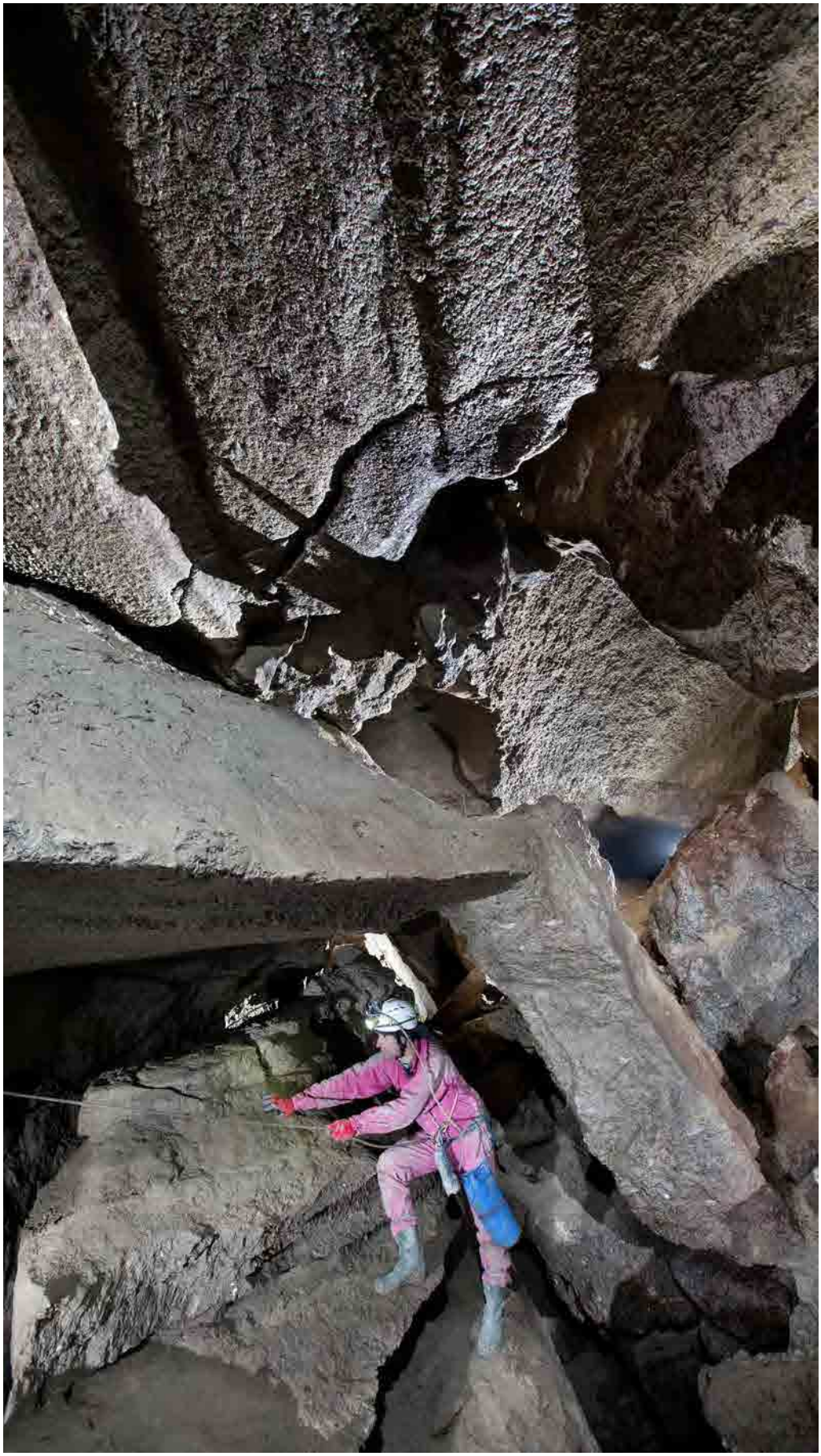
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25.000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v.1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)



- *Large selenite rockfall in the Gortani cave (2012) © F.Grazioli*
- *The "canyon" in the Gortani cave. (2012) © F.Grazioli*
- *The meander in the Gortani cave. (2012) © F.Grazioli*

C.S.4 GESSI BOLOGNESI

The landscape of **Gessi Bolognesi** is hilly, mostly gentle, with frequent alternations between woods (covering rock outcrops) and cultivated fields (sometimes within the dolines), although there are also more distinctly rocky and wild areas on the slopes where the gypsum beds rise steeply.

The most impressive surface karst phenomena in the *Gessoso-Solfifera Fm* are large depressions like the **Spipola doline**, which is 500 m wide and 100 m deep, the **Budriolo doline**, and further SE the **Inferno and Gaibola dolines** associated to the wide **Acquafredda** and **Ronzana blind valleys**. Remarkable epigean macro features are dissolution or cover-collapse secondary dolines, candle-like erosions (described in the 19th century; Cappellini, 1876), active sinkholes, and the "tumuli" or "creep bubbles", whereas in the Acquafredda blind valley the association of karst and tectonic phenomena laid bare, with impressive cliffs alternating layers of gypsum and shale.

Micro features (e.g. rillenkarren, kamenitze, etc.) are rare except for the SE sector, where their formation is directly influenced by the crystal texture. As a result of mining and quarrying activities, carried out in the area in the last century, the **Farneto "Sottoroccia"**, was discovered and the remains and ornamental funeral furnishings of about forty individuals of the Copper Age were exhumed.

In the **Croara area** (Mt. Croara and Mt Castello) the artificial dissection of paleo sinkholes filled with ancient sediments allowed the extraction of an exceptional osteological deposit of Pleistocene age with cold climate mammals (e.g. uri, bisons, megaloceros, groundhogs, wolverines, wolves, etc.) and avifauna.

For their extension and variety of forms, the hypogeous karst phenomena in the area between the Savena and the Idice streams are among the most significant and most important of the world as far as evaporite rocks are concern. Typical features are multi-level tunnels, wells, and vast

- *Aerial view of the Miserazzano plateau and the Spipola doline (2012) © G.Bartolini*
- *The Goibola doline (2012) © G.Bartolini*
- *Vertical dissolution pipes (wallkarren) at Buco delle Candele (2012) © G.Agolini*

collapsing rooms. Their evolution is due to the interaction among faults, fractures, and interlayers, which form a complex underground drainage. Few of these systems can be explored from the sinkhole to the resurgence, whereas most of them are interrupted by landslides, sediments, or siphons and only some significant sectors, experimentally connected by water tracking/tracers or by clear topographical evidence, are accessible.

In this area of the Gessi Bolognesi Park there are more than 160 caves with an overall length of 20 km; among these, a little less than 20 km can be ascribed to, or identified as being part of, distinct karst systems. The largest one is the Acquafredda-Spipola-Prete Santo System (11.5 km, the world largest epigenetic cave), a tributary of the Savena stream, followed in the Croara sector by the **S. Calindri-Osteriola Cave** System, which is currently accessible in its upstream segment for over 2 km.

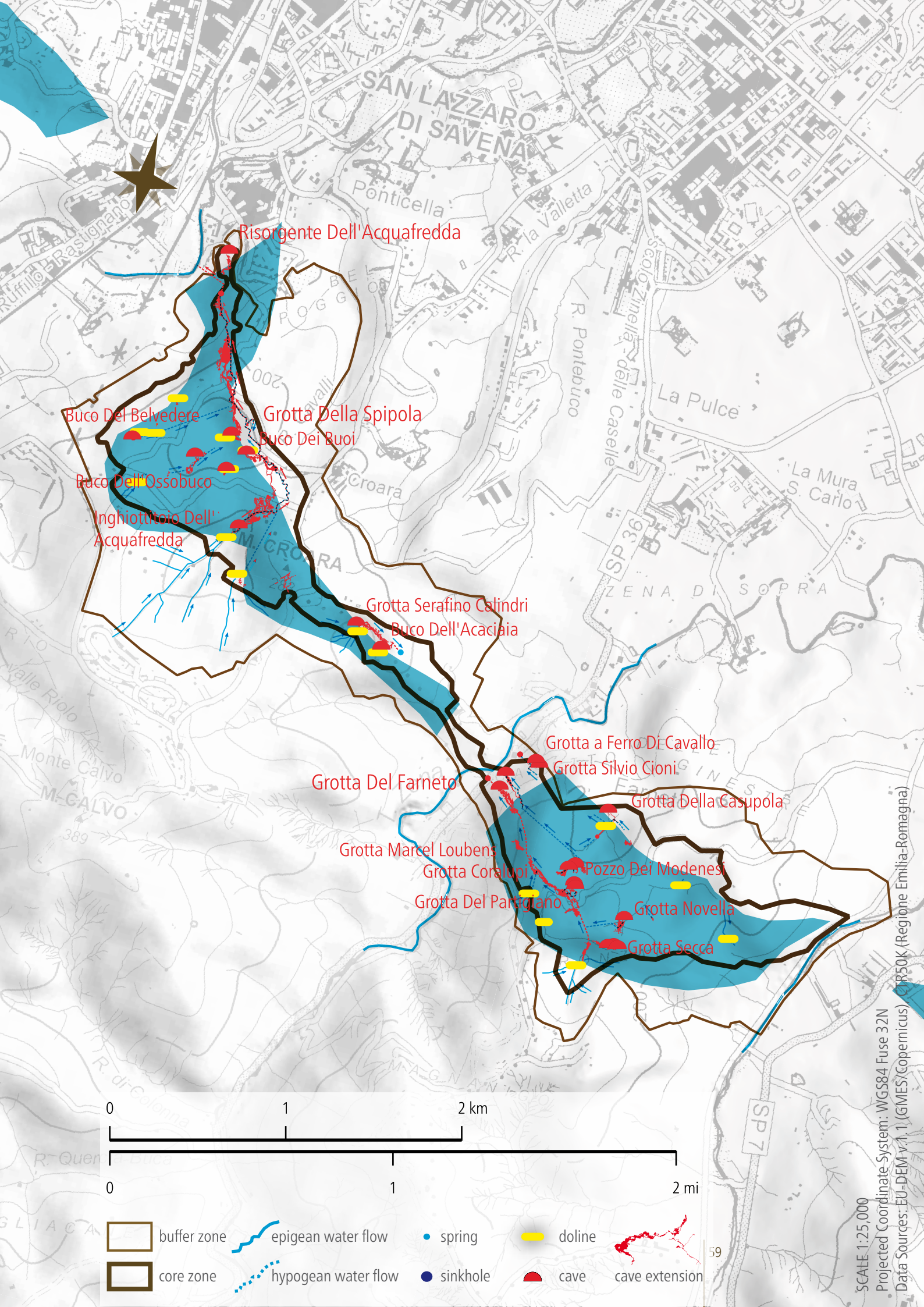
In the area between the Zena and Idice streams, the Partigiano-Modenesi System, still under exploration, is about 4 km long and is associated to minor systems like the **Cioni-Ferro di Cavallo** and the **Coralupo-Pelagalli Caves**. From a mineralogical point of view, the caves of this area are particularly rich of rare, and sometimes exclusive, mineralizations. In particular, it is worth remembering the **Pelagalli Cave**, closed to Farneto hamlet, for its

complex iron and manganese oxides and the **Buco dei Buoi Cave**, closed to Croara hamlet, for the presence of chloromagnesite, currently a unique finding for this type of context. The peculiar vertical karst features "candele" (wallkarren) developing in gypsum rocks were described here for the first time in the world by G. Capellini in 1876.

Finally, it is worth mentioning that two caves (the Farneto Cave and the S. Calindri Cave) show noticeable imprints and extensive evidence of human presence during the Bronze Age, whereas the sediments of many others preserve prehistoric human remains and ancient fauna.

- *Flat concretion terraces (gour) within the Spipola cave (2012) © G.Agolini*

- *Spipola cave, the inner doline (2012) © G.Agolini*


Risorgente Dell'Acquafredda
Buco Del Belvedere
Grotta Della Spipola
Buco Dei Buoi
Buco Dell'Ossobuco
Inghiottitoio Dell'
Acquafredda
Grotta Serafino Calindri
Buco Dell'Acaciaia
Grotta a Ferro Di Cavallo
Grotta Silvio Cioni
Grotta Del Farneto
Grotta Della Casupola
Grotta Marcel Loubens
Grotta Coralupi
Pozzo Dei Modenesi
Grotta Del Partigiano
Grotta Novella
Grotta Secca
SAN LAZZARO DI SAVENA
Ponticella
La Pulce
La Mura
S. Carlo
M. CROARA
M. CALVO
ZENA DI SOPRA
SP 36
SP 7
0
1
2 km
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1
2 mi
buffer zone
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
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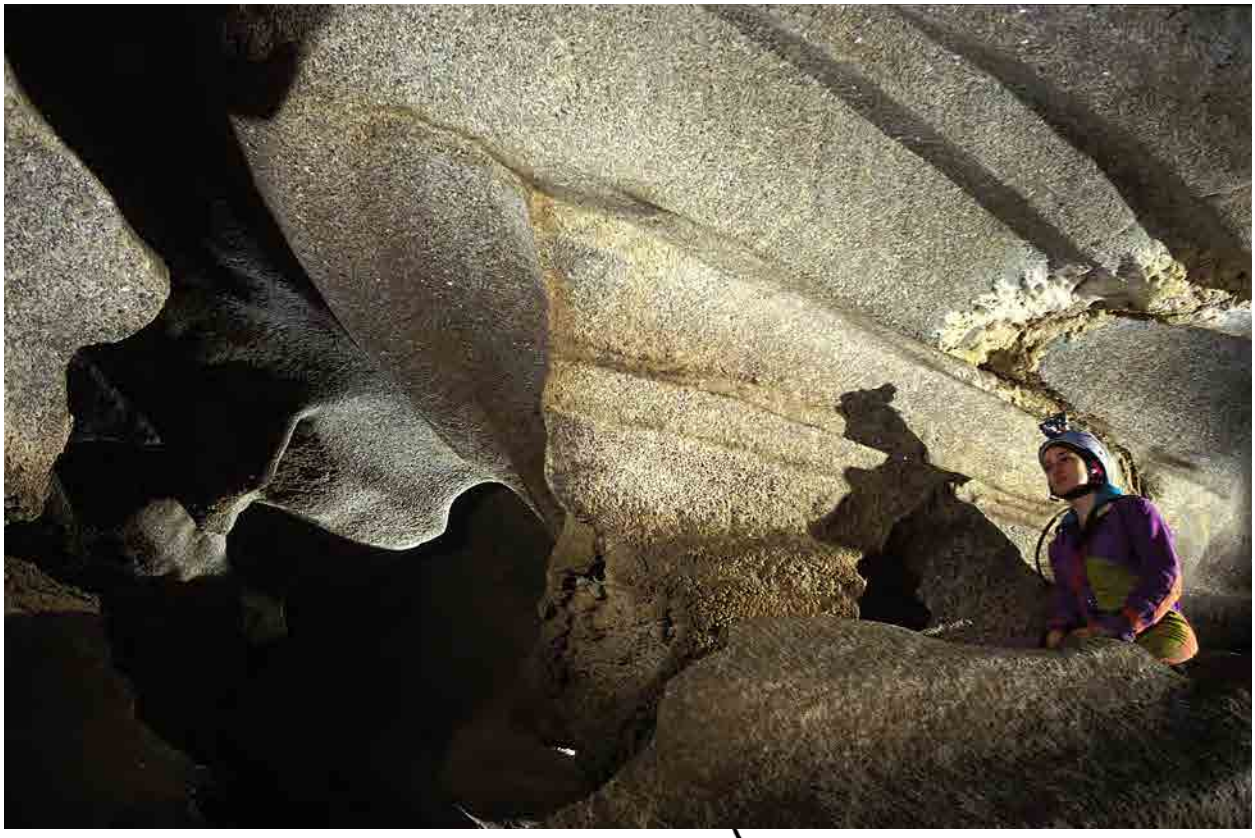
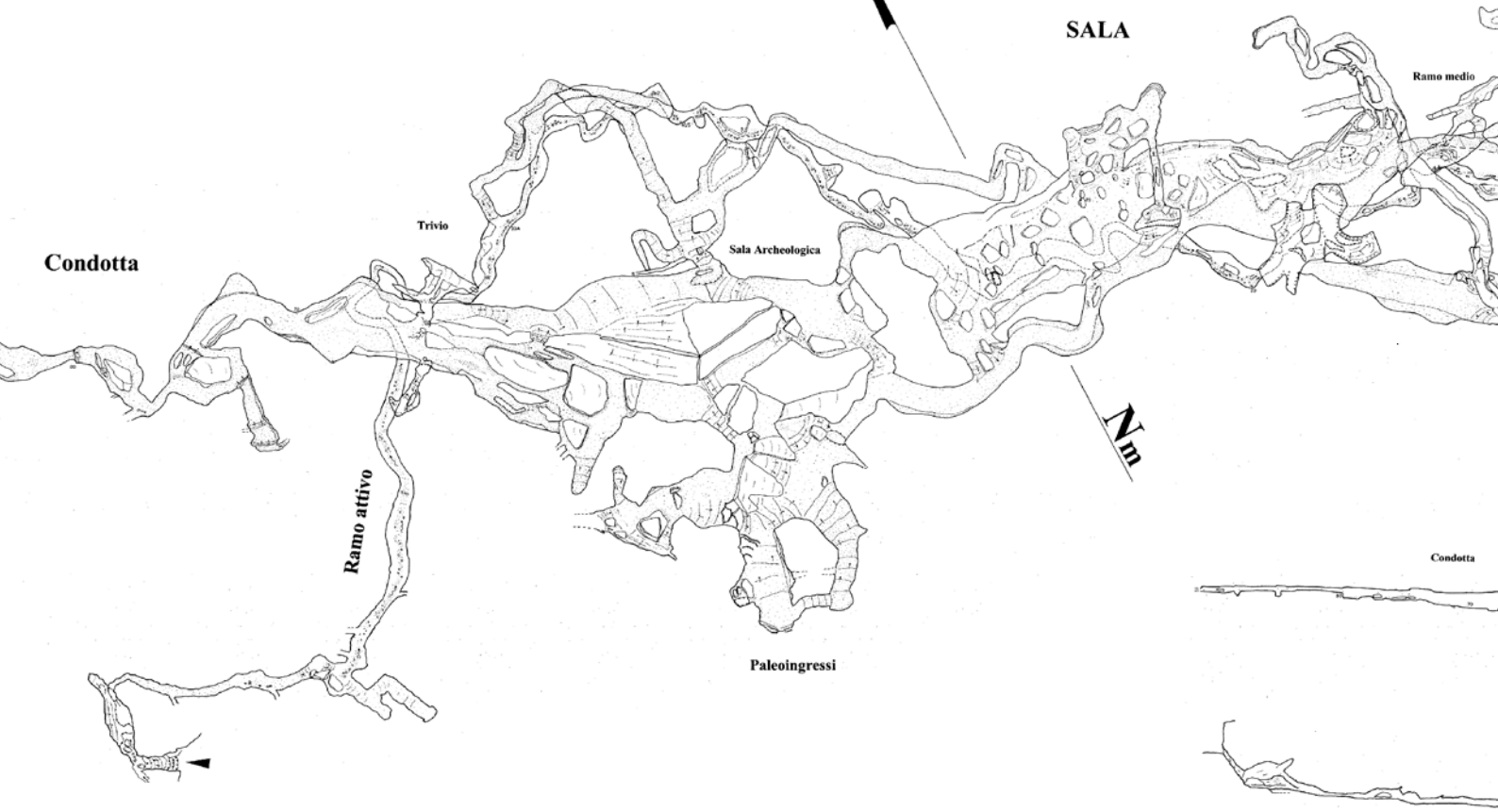
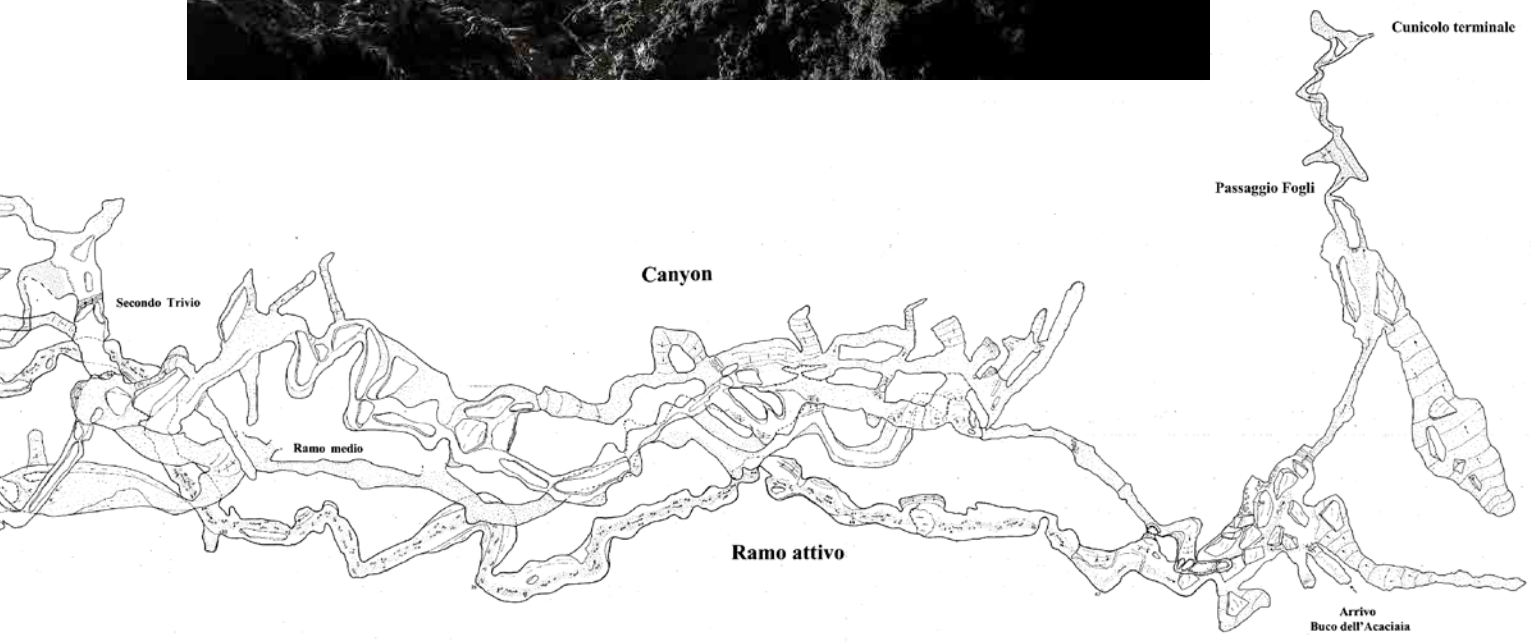
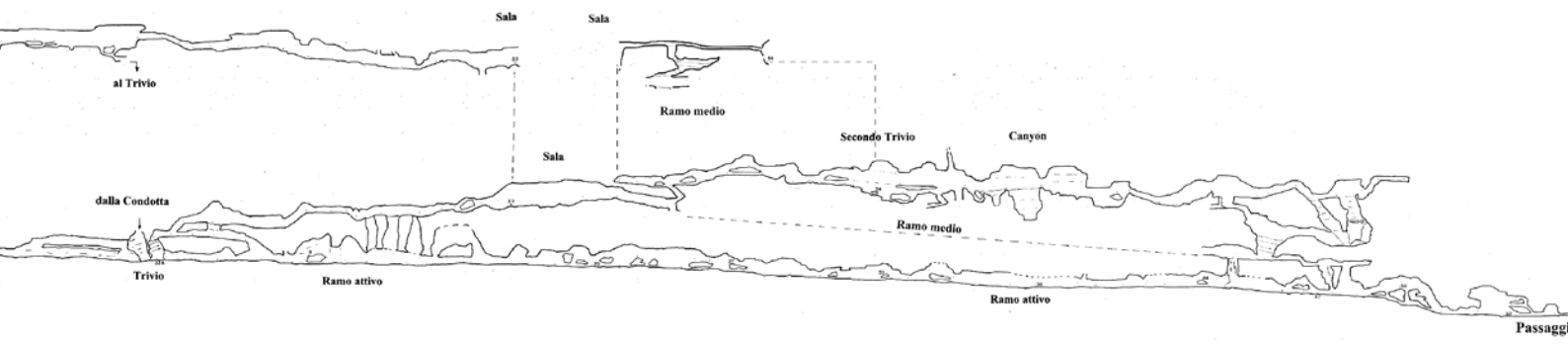



SALA
Ramo medio
Trivio
Sala Archeologica
Condotta
Nm
Ramo attivo
Condotta
Paleoingressi

- *The canyon in the S. Calindri cave (2012) © G. Agolini*
- *The "mammelloni" on the ceiling of the Buco del Belvedere cave (2012) © G. Agolini*
- *Metric survey of the S.Calindri cave (1964-2019). © GSB-USB*





• *Big room G.Giordani in the Spipola cave. (2012) © F.Grazioli*

C.S.5 VENA DEL GESSO ROMAGNOLA

The **Vena del Gesso Romagnola** (*Romagna gypsum vein*) is one of the most important geological formations in the entire Emilia-Romagna Apennines. The spectacular gypsum rampart with projecting walls over a hundred metres high is to be considered a true "geological monument" that indelibly characterises this part of the Apennines. Set between the more ancient *Marnoso-arenacea Fm* to the south and the more recent *Argille Azzurre Fm* to the north, the Vena del Gesso extends for a linear development of about 25 kilometres between the provinces of Bologna and

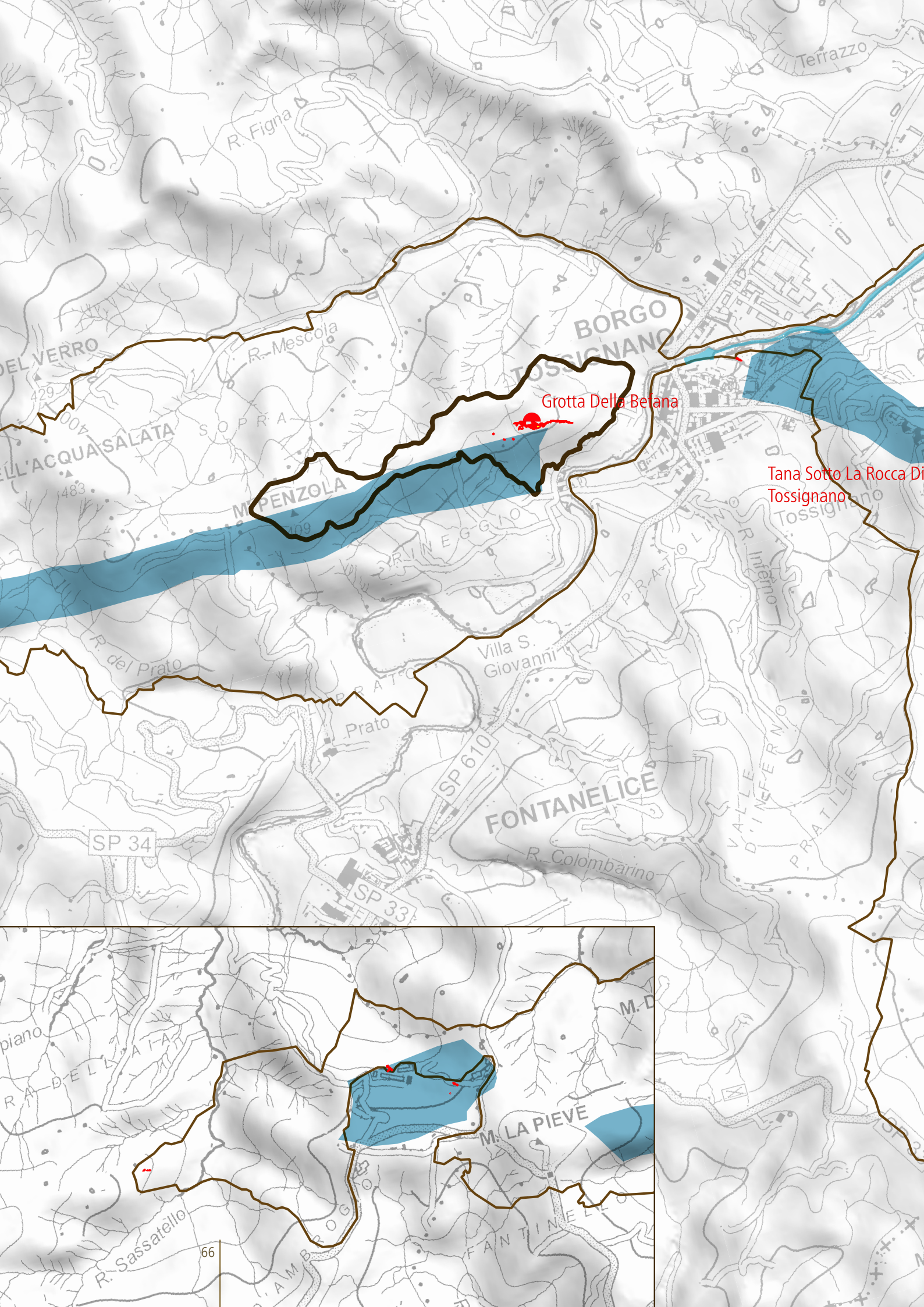
• *Gypsum cliff near Tossignano (2018) © P.Lucci*

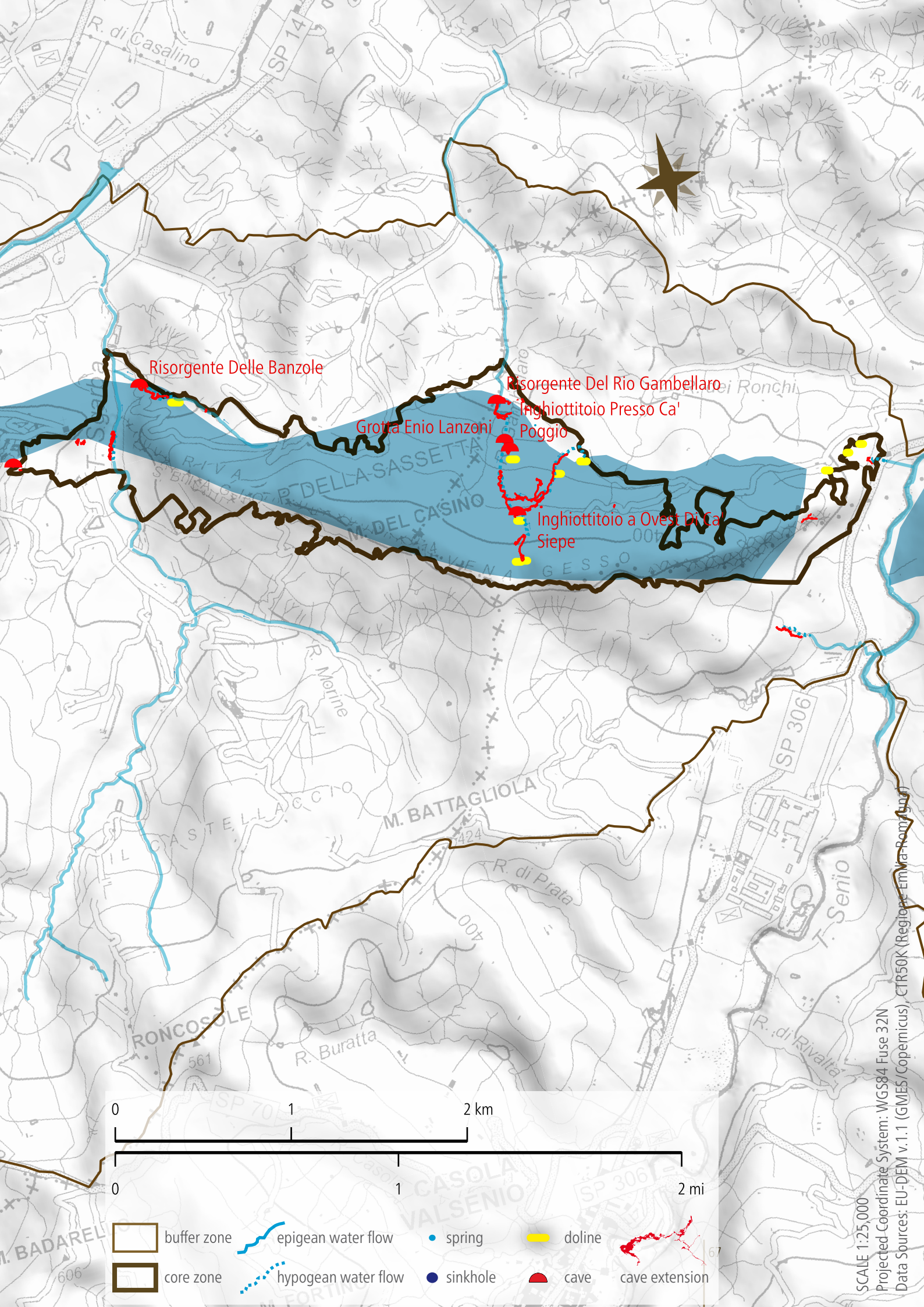
Ravenna. The entire surface of the gypsum outcrops does not exceed 10 square kilometres. Its uniqueness has always attracted man's attention and, for over a century, it has been the focus of research, studies and publications on geology, biology, palaeontology, anthropology, archaeology and, above all, speleology.

The landscape of the Vena del Gesso Romagnola *Gessoso-Solfifera Fm* is extensively shaped by superficial karst forms some of which of remarkable size like, for example, dolines, sinkholes and blind valleys; there are also other epigean phenomena due to rock dissolution and erosion such as "candles", karrens, and "tumuli". Caves are widely present; to date, over 200 cavities have been explored and mapped for a total length of over 40 km. There are also many large karst systems whose development exceeds 1 km and whose hydrogeology has been studied in detail. Along the left bank of the Senio stream, the large karst system of **Monte del Casino**, has a total length of 6 km. In the gypsums ridge of **Monte Mauro**, between the Senio and the Sintria Streams, stands a karst system, with an overall length of over 6 km, that is part of the famous **Re Tiberio Cave**, a place of archaeological interest today partially equipped for tourist visits. Unfortunately, the nearby quarry has intercepted and destroyed part of the cave system, irreparably altering the complex underground hydrology.

A few hundred metres to the south-east there is the **Stella-Basino-Bentini** karst system, one of the largest hydrogeological tunnels in gypsum on the entire continent. Fed, in part, by the water collected from an imposing blind valley, this system has a total length of over 7 km. In the Rontana and Castelnuovo Gypsums, along the right bank of the Sintria Stream, the **Rio Cavinale** karst system, comprises many of the most famous caves of the Vena del Gesso Romagnola like, for example, the **Luigi Fantini Abyss,** the **Mornig Abyss,** and the **Primo Peroni Abyss** for a total length of over 6 km. Finally, in the gypsum outcrop near Brisighella, along the left bank of the Lamone river, stands the karst system that includes, among other cavities, the **Tanaccia Cave**, of

- *Large selenite crystals in the walls of the Risorgente del Rio Basino cave (2008) © P.Lucci*
- *Secondary gypsum crystal (lapis specularis) in the Risorgente del Rio Basino cave. (2008) © P.Lucci*
- *Monte Penzola at sunset. (2017) © PRVDGR*


Grotta Della Befana
Tana Sotto La Rocca Di Tossignano
BORGO TOSSIGNANO
Tossignano
R. Figna
R. Mescola
R. Inferno
R. del Prato
R. Colombarino
Villa S. Giovanni
Prato
FONTANELICE
SP 610
SP 34
SP 33
M. PENZOLA
M. LA PIEVE
R. Sassatello
Terrazzo


Risorgente Delle Banzole
Risorgente Del Rio Gambellaro
Inghiottitoio Presso Ca' Poggio
Grotta Enio Lanzoni
Inghiottitoio a Ovest Di Ca' Siepe
M. DEL CASINO
M. BATTAGLIOLA
RONCOSOLE
R. di Casalino
R. Morine
R. Buratta
R. di Prata
R. di Rivalta
T. Senio
SP 14
SP 306
0
1
2 km
0
1
2 mi
buffer zone
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25,000
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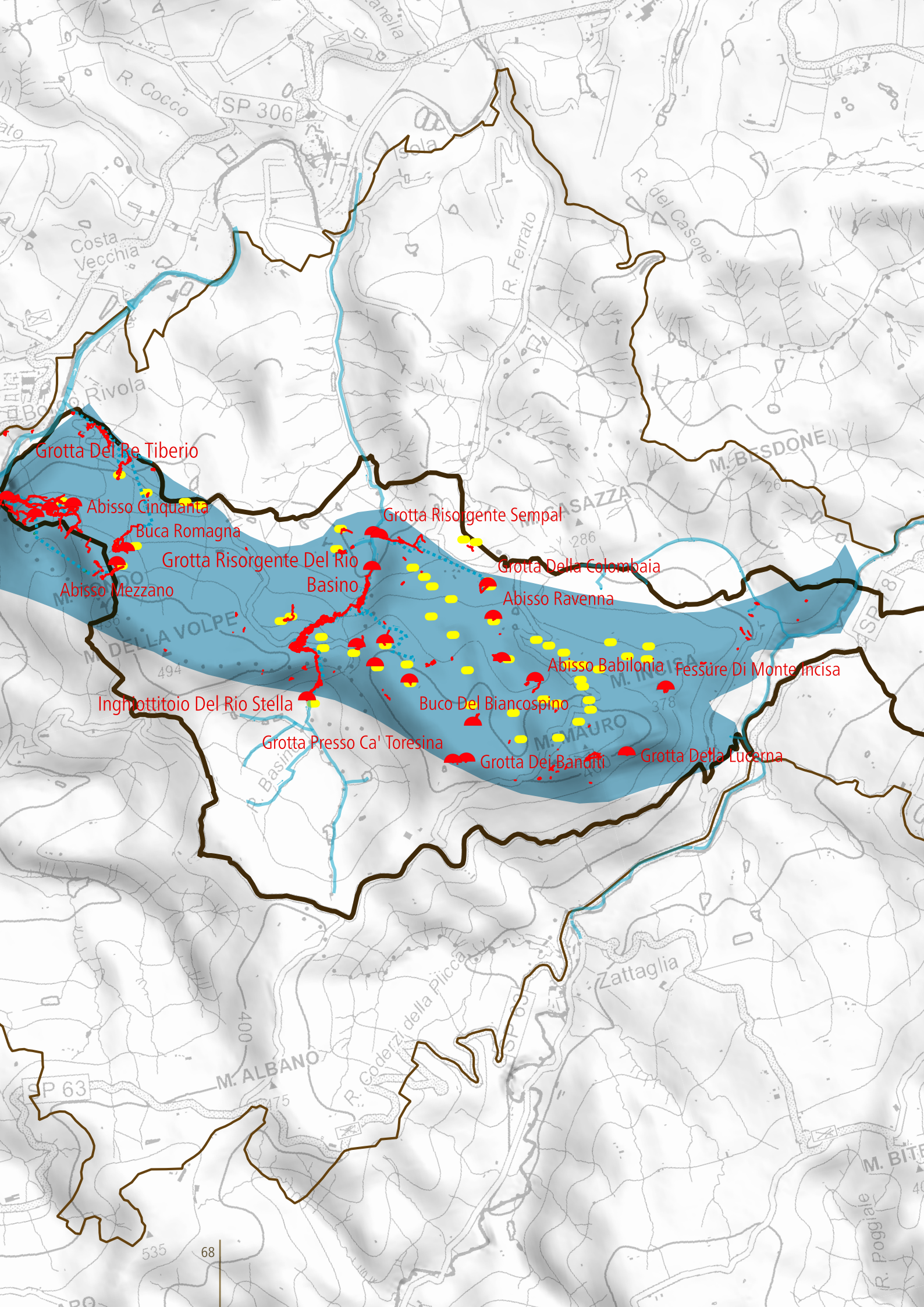
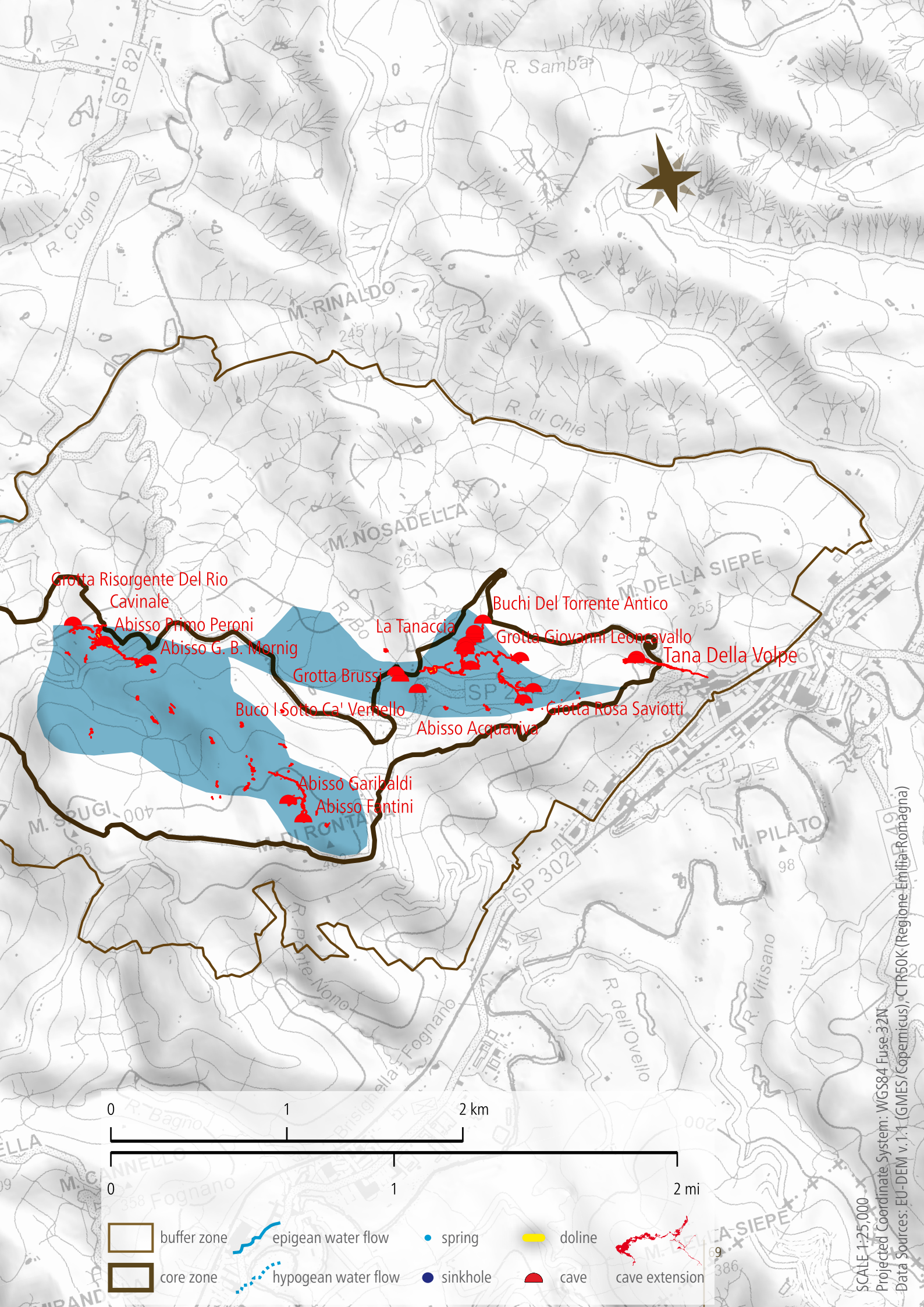
Data Sources: EU-DEM v.1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)


Grotta Del Re Tiberio
Abisso Cinquanta
Buca Romagna
Abisso Mezzano
Grotta Risorgente Del Rio Basino
Grotta Risorgente Sempal
Grotta Della Colombaia
Abisso Ravenna
Abisso Babilonia
Fessure Di Monte Incisa
Inghiottitoio Del Rio Stella
Buco Del Biancospino
Grotta Presso Ca' Toresina
Grotta Dei Banditi
Grotta Della Lucerna
M. DELLA VOLPE
M. CASASZZA
M. BESDONE
M. MAURO
M. ALBANO
SP 306
SP 63
Costa Vecchia
R. Cocco
R. Ferrato
R. del Casone
Zattaglia


Grotta Risorgente Del Rio
Cavinale
Abisso Primo Peroni
Abisso G. B. Mornig
La Tanaccia
Buchi Del Torrente Antico
Grotta Giovanni Leonesavallo
Tana Della Volpe
Grotta Brussi
Buco I Sotto Ca' Vernello
Grotta Rosa Saviotti
Abisso Acquaviva
Abisso Garibaldi
Abisso Fantini
M. RINALDO
M. NOSADELLA
M. DELLA SIEPE
M. PILATO
M. SPUGI
M. FRONTARA
SP 82
SP 2
SP 302
R. Samba
R. Cugno
R. di Chie
R. Bo
R. Vitisano
R. dell'Ovello
Ponte Nono
Fognano
0
1
2 km
0
1
2 mi
buffer zone
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25.000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v.1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)

- *The concretioned stream bed in the Risorgente del Rio Basino cave (2008) © P.Lucci*

- *Pisoid concretions in the Risorgente del Rio Basino cave (2008). © P.Lucci.*

great archaeological interest, that for some time now is also the destination of crowded tourist visits.

Particularly in recent years, many studies have been carried out about the Vena del Gesso Romagnola, most of which have original geomorphological, karst, and mineralogical implications. In the framework of projects concerning the study of speleogenetic phenomena in evaporitic areas, various carbonate speleothems have been sampled. The oldest speleothem is approximately 580,000 years old (near the **Banditi cave**). These results suggest that the first caves in the Messinian gypsum formed in the "cold phase" prior to the oldest concretion, i.e. about 640,000 years ago. As a result, it has been confirmed that climate and rainfall regime have a strong control over the nature and the forms of gypsum concretions. Hence, it was possible to elaborate a general model to reconstruct the climatic variations occurred in this area.

The presence of some well-developed subhorizontal levels in the **Grotta del Re Tiberio**, has allowed, for the first time, a correlation with the river terraces along the main waterway and therefore, to broadly define the temporal evolution of this karst system. The study has allowed to highlight how the speed of adaptation of underground karst forms to external climatic variations is very rapid and in particular, how the anti-gravitative tunnels can be correlated with the aggradation of the fluvial terraces in the period immediately following a "cold phase", of which they can be considered important indicators.

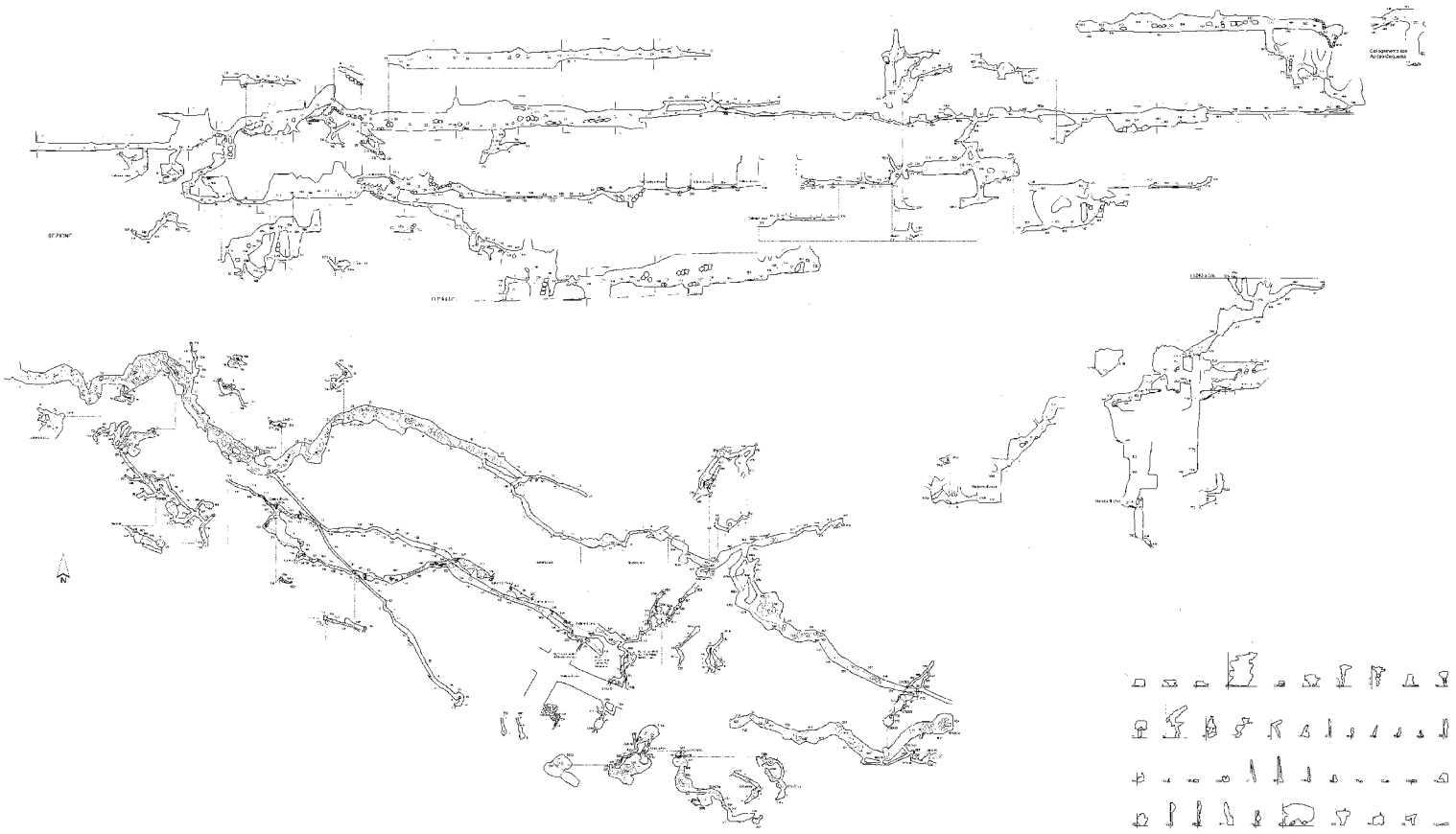
Finally, it is worth mentioning the numerous studies carried out on the physical and chemical deposits widely present in the cavities of the Vena del Gesso Romagnola, thus highlighting how some speleothems are currently restricted to this karst area like, for example, dendritic quartz on gypsum, calcite bubbles, and gypsum inflorescences of anthropogenic origin.

- *The canyon downstream the resurgence of the Rio Basino cave (2008) © P.Lucci*
- *The "gothic room" in the Re Tiberio cave (2009) © P.Lucci*
- *The shaft of the Acquaviva abyss. (2011) © P.Lucci*

- *Meander in the Re Tiberio cave (2012) © P.Lucci*

- *Metric survey of the Re Tiberio cave (1994-2003). © P.Lucci., M.Ercolani, B.Sansavini - Speleo GAM*

- *Conduit of the Ca'Castellina cave (2017) © PRVGR*



- *Metric survey of the Tanaccia cave (2010-2014). © R.Evilio, B.Sansavini - GSF*
- *Tanaccia cave, the room of guano. (2010) © P.Lucci*
- *Waterfall in the canyon downstream the resurgence of the Rio Basino cave (2009) © P.Lucci*
- *. The Grotta Grande dei Crivellari sinkhole. (2010) © P.Lucci*

The Vena del Gesso sequence is well exposed and show spectacular gypsum strata, which are up to 30 m-thick and are made up of some of the largest sedimentary gypsum crystals of the world reaching up to about 4 meters across. The gypsum beds are separated by thin shale layers, over which peculiar sedimentary features, the "nucleation cones" developed and are one of the most spectacular features inside the caves ("mammelloni").

Up to 16 gypsum cycles reveal the early stage of the so called "salinity crisis", which turned the entire Mediterranean Sea into a giant salina, wiping out most life forms from the sea at the end of the Miocene (5.9-5.3 million years ago). The "Vena del Gesso" ridge exhibits a spectacular monoclinal structure dissected into large blocks juxtaposed by huge mass waste gravitational phenomena during the Messinian. The large blocks were sealed by Late Messinian and Pliocene argillaceous deposits.

The gypsum strata were eroded and redeposited forming spectacular sedimentary structures in the Eastern Romagna area, which was the deeper part of the basin, the Apennine foredeep. This section of the basin underwent burial and oil migration leading to the transformation of gypsum into anhydrite and alabaster, and the late bacterial sulphate reduction of the evaporites to form ore-grade sulphur mineralization. The caves of the area are privileged sites where all these spectacular geological features are visible, even better than at outcrop exposures.

The Vena del Gesso ridge is the only place in the entire Mediterranean basin where the gypsum strata show the evidence of exposure with the development of ancient intra-Messinian karst features containing one of the most important Late Miocene continental faunae of the world. After this initial ancient karst phase sealed by Pliocene marine sediments, a second phase started over 500,000 years ago and is still going on today.

The caves of the Messinian evaporites contain prehistoric archaeological remains that were discovered and studied in the second half of the 19th century, creating one of the basal pillars for the birth of the Italian palaeoethnology. Some of the natural caves were transformed by the Romans into mines for the extraction of *lapis specularis*, the stunning transparent crystals of secondary gypsum, which were placed within windows frameworks instead of glass almost 2000 years ago. The Vena del Gesso gypsum show the largest concentration of **Roman *lapis specularis* quarries** in the Mediterranean basin outside of Spain.

Sparkling blocks of selenite crystals decorate the base of many medieval towers in the town of Bologna.

• *Large room in the Risorgente del Rio Basino cave. (2008) © P.Lucci*

C.S.6 EVAPORITI DI SAN LEO

In eastern Romagna the Messinian gypsum of **Evaporiti di San Leo** has unique characteristics, not found in other parts of the Region. Besides the macrocrystalline (selenite) gypsum similar to that of the Vena del Gesso, there are also microcrystalline gypsum (alabaster) in alternating layers of white and black colour.

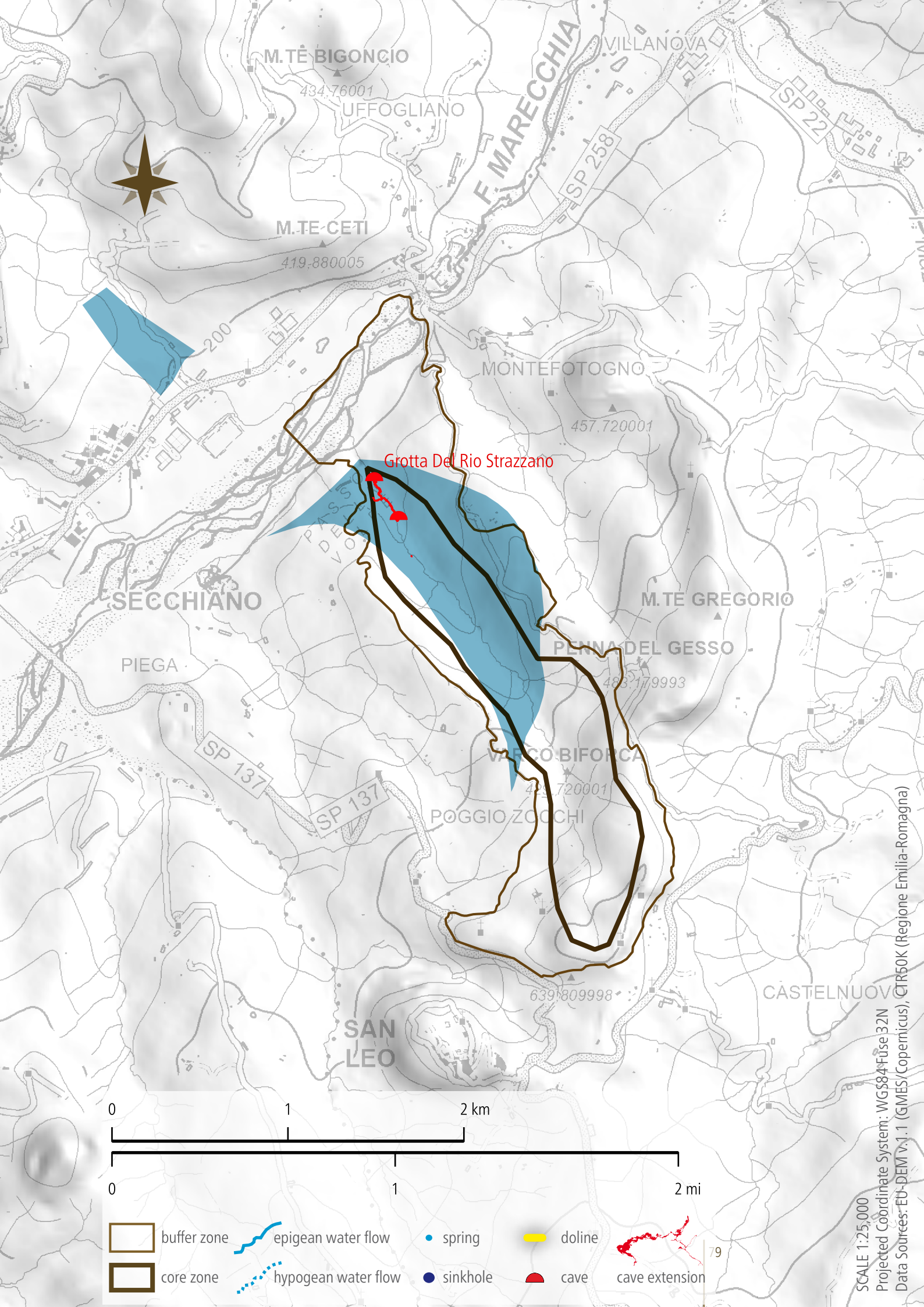
The pure microcrystalline gypsum has a typical white colour, while the layers of dark grey gypsum owe their colour to the clay and organic matter content. Their origin is linked to huge submarine landslides that affected the selenitic deposits in the Messinian, around 5.6 million years ago. The gypsum deposited in shallow waters slid down to the seabed and fragmented to form a sandy gypsum detritus that spilled out at depth (clastic gypsum, gypsum turbidites).

In the microcrystalline gypsum of the Strazzano stream, a small tributary of the Marecchia River located north of San Leo, there is an interesting karst system. Parallel to its external course the stream has generated karst conduits that today constitute the normal flow path. The external valley is suspended by about 1.5 m and is normally dry unless the underground system is completely flooded.

As far as we know the cave represent the only example in the world where karstic conduits cross alabastrine gypsum formed at the expenses of the selenite crystals. The shape of the crystals (pseudomorphs), which are up to 30 cm across, are beautifully exposed in the walls. The protected environment of the cave and the karst dissolution produced a unique exposure to observe the crystals in great details, which cannot be appreciated at surface outcrops.

• *Coarse gravel and scallops within the Rio Strazzano cave (2010) © P.Lucci*

• *Alabastrine gypsum outcrop in the Rio Strazzano valley (2015) © P.Lucci*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Grotta Del Rio Strazzano
SECCHIANO
PIEGA
M.TE GREGORIO
PENNA DEL GESSO
SP 137
SP 137
POGGIO ZOCCHI
639.809998
CASTELNUOVO
SAN LEO
0
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buffer zone
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25,000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v1.1 (GMES/Copernicus), CTR50K (Regione Emilia-Romagna)

- *Fractures and phreatic conduits in the alabastrine gypsum within the Rio Strazzano cave. (2010) © P. Lucci*

- *The alabastrine gypsum bed at Legnagnone (2009) © S.Lugli*

- *Phreatic conduits with scallops in the alabastrine gypsum of the Grotta di Rio Strazzano. (2010) © P. Lucci*

- *Conduits of the Grotta di Rio Strazzano. (2010) © F.Grazioli*

C.S.7 GESSI DI ONFERNO

The **Onferno Cave**, known since the 18th century, is by far the best-known cavity in eastern Romagna. It is a hydrogeological tunnel developing in an allochthonous block of selenite gypsum. This is a typical example of the development of karst in discontinuous evaporite formations.

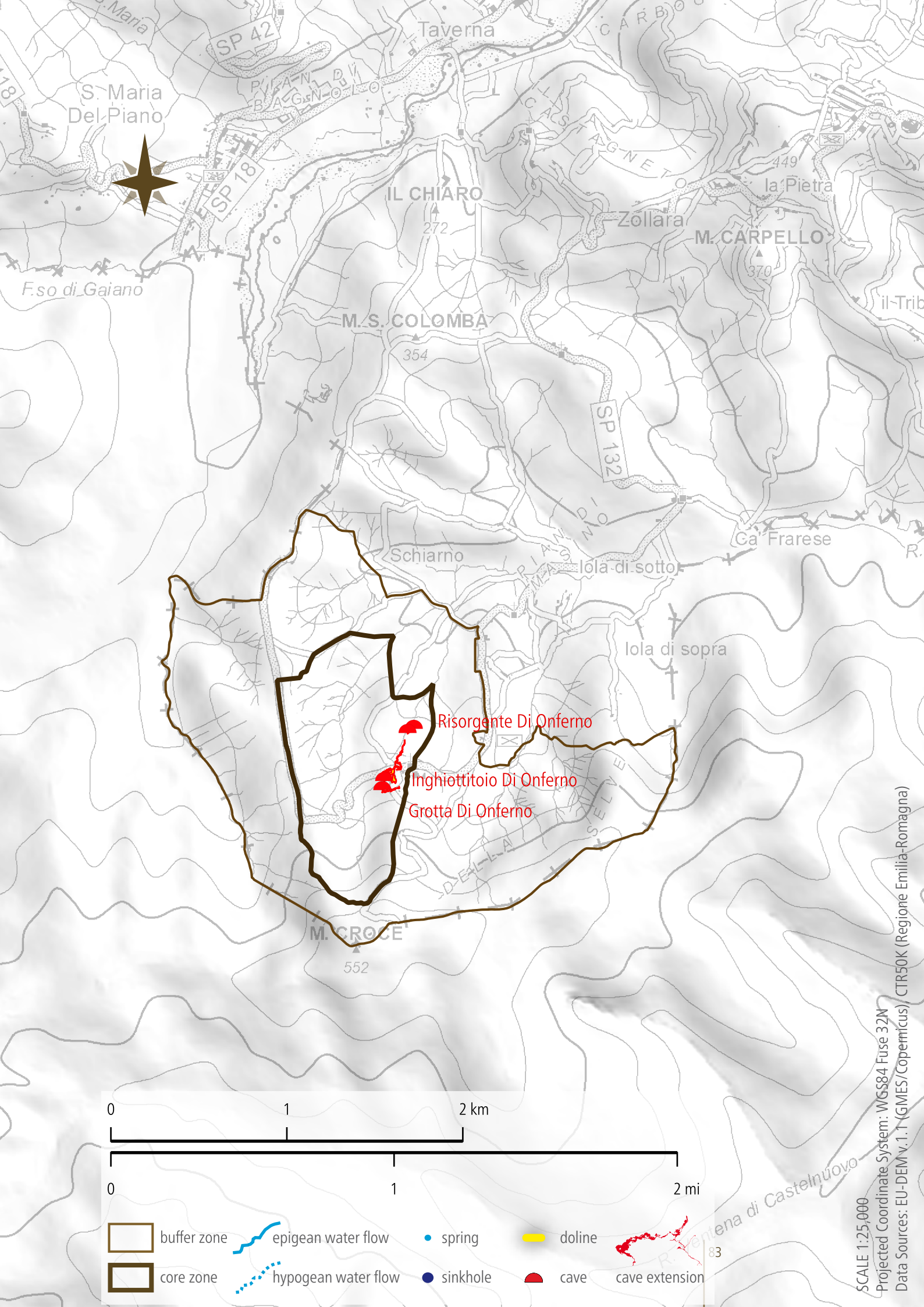
Where there is no outcropping gypsum, the streams flow for long stretches outside. When the torrential incisions themselves reach the gypsum bank, the water enters in depth and very rapid karst processes are immediately triggered which, in a short time (a few decades), lead to the formation of viable conduits. The cave consists of a high meander crossed by a stream with splendid erosive morphologies and powerful deposits of lithic, sandy and marly sediments.

• *Onferno castle (2016). Gessi di Onferno © P.Gualandi*

Here there is the largest mammelloni structure ever described in the world up to now for a natural cave. The structure is more than 2 m in diameter and protrudes from the ceiling for more than 2 m. The mammelloni structures formed by sinking in the underlaying mud of the very first selenite crystals formed at the beginning of every climatic cycle that formed the 16 strata of the Vena del Gesso.

At Onferno we can see also enormous blocks of selenitic gypsum not completely disintegrated by underwater landslides. Only in eastern Romagna and Sicily the interaction between gypsum and natural oil has allowed the formation of large accumulations of native sulfur. Remarkable is the presence of numerous sulfurous springs, which are quite rare in other gypsum caves in the region.

• *Quarina room (2015). Gessi di Onferno © P.Lucci*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Del Piano
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SP 18
IL CHIARO
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Zollara
la Pietra
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M. CARPELLO
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F.so di Gaiano
M. S. COLOMBA
354
SP 132
Schiarno
Iola di sotto
Ca' Frarese
Iola di sopra
Risorgente Di Onferno
Inghiottitoio Di Onferno
Grotta Di Onferno
M. CROCE
552
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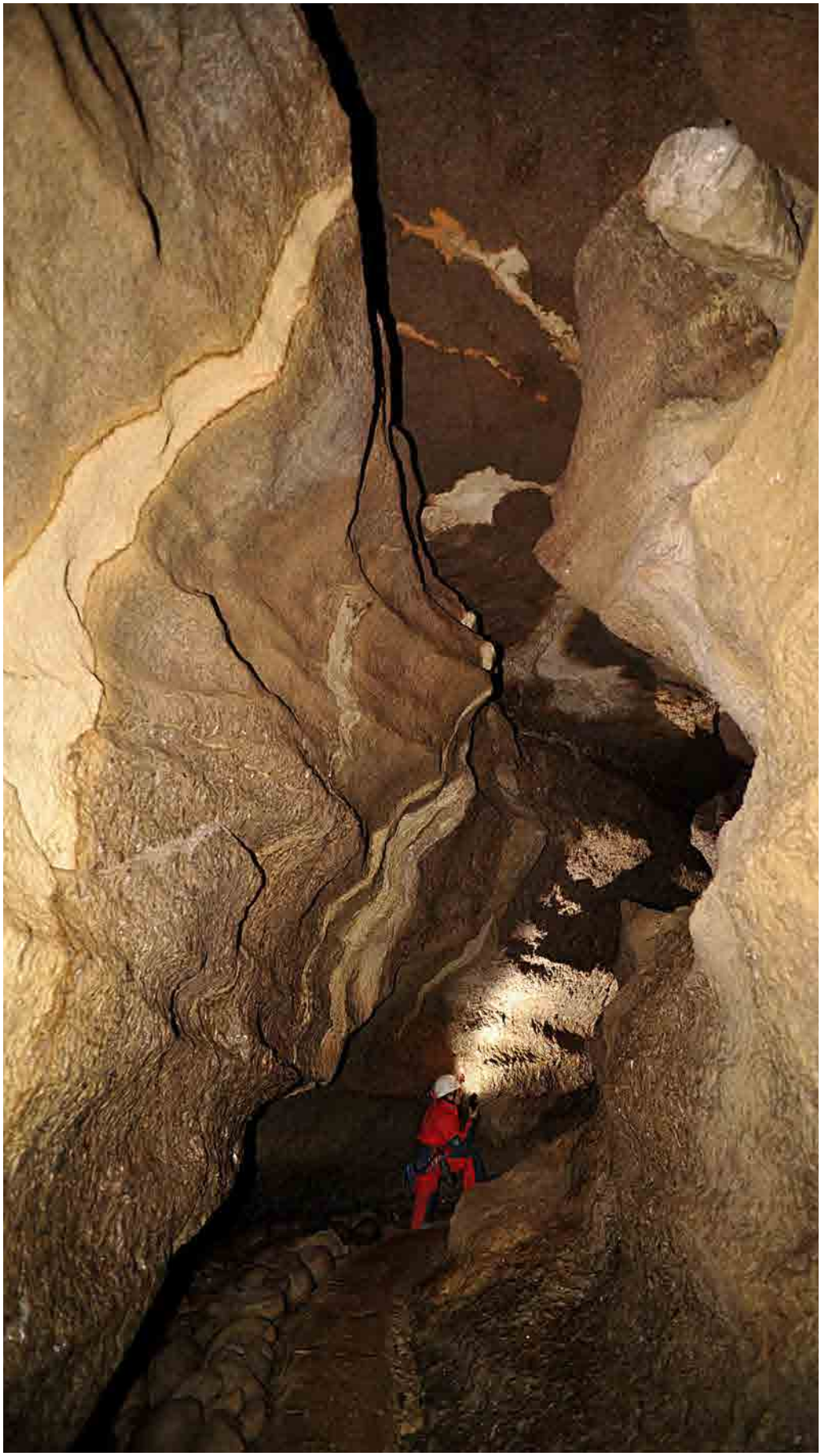
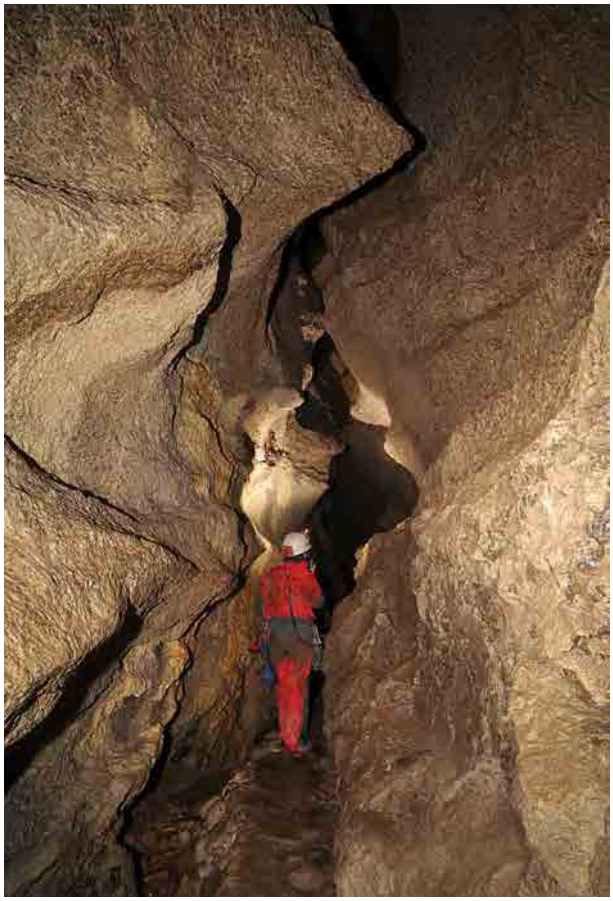
core zone
epigean water flow
hypogean water flow
spring
sinkhole
doline
cave
cave extension
SCALE 1:25,000
Projected Coordinate System: WGS84 Fuse 32N
Data Sources: EU-DEM v.1.1 (GMES/Copernicus); CTR50K (Regione Emilia-Romagna)

- *The great meander (2009) © G.Belvederi*
- *Onferno cave (2016) © P.Gualandi*
- *Searching for invertebrate fauna (2015) © P.Lucci*
- *Inside the Onferno cave (2021) © G.Filippucci*
- *The great meander (2009) © G.Belvederi*





2.B HISTORY AND DEVELOPMENT

2.B.1 MAN AND GYPSUM: ARCHAEOLOGY AND HISTORY

The Triassic and Messinian gypsum areas of the Emilia-Romagna Region influenced, in a long-term perspective, human settlement and dynamics. As a reflection of this, local communities adopted specific strategies of adaptation to this peculiar environment: these historical adaptations, in the broader context of man-environment interactions, have to be considered cultural facts and a cultural heritage. According to the residents, gypsum bedrock was historically perceived, at the same time, as an obstacle and a resource. Regarding the limitations connected to the gypsum, for example the absence of a subaerial hydrographical network drove agriculture in the direction of the development of non-irrigated cultivations; the soil infertility of the slopes implied a development of agriculture in the bottom of the dolines, where the cultivation was easier and the degree of fertility a bit higher; the high dissolved sulfate content of karst springs , meant an exploitation, for drinkable water, of springs located in other geological formations in the neighbourhood, or the use of rain water collected in cisterns. The last practice, geographically centred in the Mediterranean biome, is very unusual for a region as the Emilia-Romagna located on the border between Mediterranean and Continental biomes. With regard to gypsum as a resource, mining became one of the cores of the economy, and the selenite became the basis for a local type of rural architecture, entirely made up of gypsum blocks, mortar and plaster. All these elements or dynamics are currently residual or abandoned, attested only in historical architecture, historical documents, cartography and oral sources; in fact, the areas underwent an impressive depopulation process in the last 70 years.

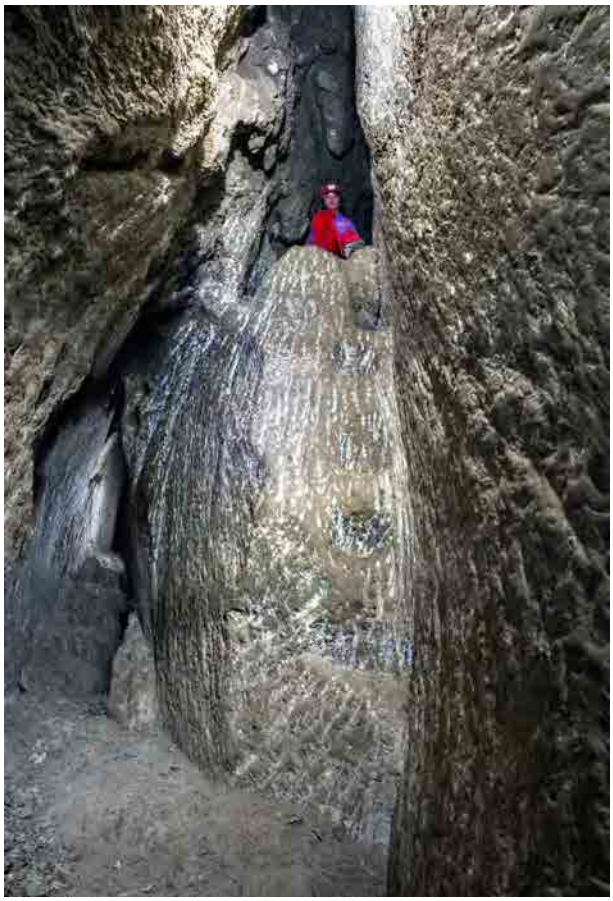
Prehistory and Protohistory

The very first data regarding a stable human frequentation of the gypsum areas of the property date back to Late Neolithic-Early Copper Ages. In this first stage, it is probable a use of the caves as seasonal settlement site (e.g. Tanaccia Cave, Vena del Gesso Romagnola). Between the Copper Age and the Early Bronze Age, the human frequentation became more systematic, and changed its aims: the natural cavities, in particular fossil karst springs, were mainly used as burial sites of the communities living in the neighbourhood. These are the cases of Farneto Cave (Gessi Bolognesi) and Tanaccia and Re Tiberio caves (Vena del Gesso Romagnola): in particular, the first and the last sites were among the very first gypsum caves to be investigated in a scientific perspective at the dawn of Prehistoric archaeology by a generation of high-level scientists (Giuseppe Scarabelli, Giacomo Tassinari, Gaetano Chierici, Giovanni Capellini, Edoardo Brizio). In the same chronological period, a minor number of caves experienced a different utilization: the Banditi Cave (Vena del Gesso Romagnola) was probably occupied for settlement purposes. Settlement uses perhaps prevailed, in all the caves just quoted, also during the Middle and the Recent Bronze Ages. A peculiar, and somehow unclear, frequentation regarded, between the Early and the Middle Bronze Ages, Serafino Calindri Cave in the Gessi Bolognesi area: it was probably a practical use (an underground warehouse?), in the framework of which the Protohistorical population exploited the gypsum of the cave, once calcined and grinded, to fix pottery to the floor or for other daily routine needs. After a hiatus in the Final Bronze Age, a new phase of human frequentation took place during the Iron Age: the Tanaccia and Re Tiberio Caves (Vena del Gesso Romagnola) became natural sanctuaries connected to sacred waters; artificial shelves were excavated in the walls of the caves to host miniaturist pottery, bronze rings and small anthropomorphous statues in bronze, as donations to the deities.

• *Globular cup with comb decoration dating from the Bronze Age, Tanaccia cave, Vena del Gesso Romagnola*

Roman Age and lapis specularis exploitation

During the Roman Age, the three gypsum areas were located far away from the economic and politic focuses of *Regio VIII,* whose borders were quite similar to the ones of the present-day Emilia-Romagna Region. As a consequence of the scarce fertility of gypsum soils, Roman farms and other rural settlements were rare in the Triassic and Messinian gypsum zones. On the contrary, the Roman presence in these areas was centred, from one side, to the continuation of the use of some cavities as natural sanctuary: it is the case of the Re Tiberio Cave, whose vocation as a sacred site related to waters, attested during the Iron Age, was continued by the Romans. From the other side, the Romans started to exploit gypsum as a mineral wealth. Large quarries to produce blocks as building materials were opened close to the city of Bononia (present-day Bologna), in Monte Donato (Gessi Bolognesi), Borzano (Reggio Emilia); other smaller quarries for the same purpose have been recently identified in Tossignano and Monte Mauro (Vena del Gesso Romagnola). At the same time, in the Roman Age there was a special development of a peculiar mining of gypsum. As witnessed by a quotation by Pliny the Elder regarding Bononia, thin cleavage fragments of secondary gypsum (known as *lapis specularis*) were used in windows as glass substitute: in the last 15 years ca., several underground quarries for such a utilization, dating back to the early Imperial Age, have been discovered in the Vena del Gesso Romagnola, in particular in Monte Mauro area. Probably, the most impressive site for the mining of lapis specularis is the **Lucerna Cave** (literally, 'Lamp Cave'): a fossil karst sinkhole named after the finding of a Roman lamp inside its deposits, whose walls were almost entirely excavated to exploit secondary gypsum, and later partially occluded by processing waste of the excavation (grinded gypsum, broken gypsum slabs, clay, etc.). This district of lapis specularis quarries in Monte Mauro is the largest ever found for the Roman world after the Spanish one (the most impressive is located close to the city of *Segobriga*).



- *Lucerna cave, Vena del Gesso Romagnola © P.Lucci*
- *The Roman lamp found inside the Lucerna cave.*

Middle Ages

In the Early Middle Ages, the general crisis (economic, environmental, demographic) which affected Italy had obvious reflections on the study-areas, where the human presence decreased significantly. It was during the Late Middle Ages that the situation changed, and human communities returned to settle and to exploit the gypsum zones.

The Middle Ages were a period of general political instability for Italy: so, defence through fortifications became a primary need for the communities. In this stage, the top of the gypsum outcrops, whose morphologies are so evident and towering because of the different resistance to erosion of the surrounding clays, hosted a number of Medieval castles, usually built on gypsum, with gypsum as building material. Also, caves returned to have a certain importance for human dynamics: they became sites of hermitage or shelter, or hosted outlaws and forgers. In the case of Re Tiberio Cave (Vena del Gesso Romagnola), it is attested the presence of forgers in the 14th-15th

centuries, who melted the anthropomorphic small statues in bronze put here, during the Iron Age, as donations for the Deities, to produce counterfeit coins. At that time, raw metals were in fact very expensive; an Iron Age archaeological site with bronze statues as Re Tiberio Cave was considered a convenient 'virtual mine', where melt and re-use the objects.

Regarding the mining exploitation, in this phase gypsum quarries experienced a first boom related to the construction sector. In particular, the Gessi Bolognesi provided the city of Bologna of an impressive amount of gypsum blocks and gypsum mortar: the classic Medieval architecture saw the use of bricks for elevations and selenite for bases or as ornamental stones.

Modern and Contemporary Ages

In the Modern Age, the human pressure over gypsum areas grew, with intensive occupation of the lands. Castles were abandoned, so the top of the gypsum mountains started to be re-naturalized. Caves were now used for practical purposes: 'natural' basement for rural houses located in the neighbourhood, 'natural' warehouses, seasonal shelters related to pastoralism.

In this phase, gypsum mining has a further development, as gunpowder started to be used in the excavation works. Moreover, besides blocks and mortar, in this stage gypsum saw new forms of utilization, such as artistic uses.

In the Contemporary Age, during the 19th century the population continued to grow, whereas starting from the 20th century a decrease trend was inset.

In this phase, the unusual landscapes of the gypsum outcrops inspired several artistic and literary works. In particular, the Gessi Bolognesi, located very close to the active cultural environment of the city of Bologna, were described by poets like Alessandro Albicini, Enrico Panzacchi and Giovanni Pascoli; the gypsum quarries of Monte Donato became the subjects of the paintings by Luigi Bertelli or Amleto Montevecchi.

Probably, it was during WWII that the gypsum of Emilia-Romagna Region (at least, the Messinian gypsum) experienced, for the last time until now in a chronological perspective, a primary role in human dynamics: as in the Middle Ages, also in those years the towering morphologies of the outcrops were exploited for military fortifications by the German side, to resist to the advance of the Allied Forces from the south; at the same time, natural cavities became temporary shelter for the local population escaping from the bombings. In particular, in the sector of the Vena del Gesso Romagnola between the Santerno and Senio valleys, and in the Gessi Bolognesi area, close to a large city like Bologna subject of heavy bombings, a number of gypsum caves were occupied for some months between 1944 and 1945 by thousands of people: these were the cases of the Re Tiberio, Sotto la Rocca di Tossignano, Ferrari and Sfollato Caves in the eastern sector and the Farneto, Acquafredda karst spring, Coralupi and Spipola Caves in the western area.

Starting from the post war time period, the gypsum areas saw a deep marginalization and depopulation: in the years of the "Italian economic miracle", the evaporitic outcrops seemed to be important only as a resource to be consumed through the large quarries opened in the meantime, adopting an industrial approach to mining.

Only starting from the 1980s, a new ecological awareness among the public opinion (locally sensitised by caving clubs and speleologists) formed the basis for the closing, driven by the Emilia-Romagna Region Authority, of most of the gypsum quarries (Monte Tondo quarry, Vena del Gesso Romagnola, excluded). A new paradigm arose, supporting the concept that gypsum was a heritage to be conserved, and not just a natural resource to be exploited. Eventually, after years of political debate, in 1988 the Gessi Bolognesi Regional Park was instituted; in 2001 the Appennino Tosco-Emiliano National Park was established; in 2005 the Vena del Gesso Romagnola Regional Park was created. Besides them, the other gypsum areas of the Emilia-Romagna Region are currently protected as Regional Natural Reserves or Nature 2000 Network Sites.

2.B.2 LAND USE AND DEVELOPMENT

Landscape evolution

The present-day landscape of the gypsum areas, today characterized by wilderness and depopulation, is the final result of a long-term evolution. During the Roman Age, the low number of rural settlements discovered in the gypsum outcrops is an evidence of a low density of settlements and underexploitation of these territories. In this phase, more than agriculture, one of the main vocations of the Gessi Bolognesi and the Vena del Gesso Romagnola was the mining of thin slabs of secondary gypsum crystals (the so-called lapis specularis in Latin) as a substitute of glass for windows. In the Early Middle Ages there was a further decrease of the population and a natural cooling of the climate, and forests became the main feature of the landscape: it was probably in this stage that many local phytonyms were originated (e.g. Gualdo, Bosco, Poggio Peloso, Farneto, etc.), whose meaning (from Latin, Italian or German languages; the last after the Barbaric invasions, Lombards mainly) is linked, directly or indirectly, to woods. In the Late Middle Ages, a period of warm climate and a stabilization of the political situation allowed a growth of the population, a decrease of forests and a symmetrical increase of agriculture, based mainly on vines and cereals, basis for the local food. Since the Late Middle Ages, farmers were not the owners of the land they cultivated, but they worked on the basis of a rent contract, called in Italian 'mezzadria': at the end of every year, the farmer shared 50%-50% the yearly harvest with the owner of the land, who was usually a nobleman living in the city. This situation had a clear reflection over the landscape: the sharing 50%-50% of the harvest pushed the farmers, in order to survive, to an intensive cultivation of the region, adopting a polycultural system, where lines of vines were connected to living trees (oaks, field elms, field maples), whose leaves were used as forage for cattle, hosting cereals between the lines. Such a landscape, named in Italian as *piantata*, aimed at maximizing and differentiating the agricultural production. In the Modern Age the human pressure in the gypsum areas continued to grow, and the quarry activity experienced a boom connected to the application of gunpowder to mining: quarries started to play an important role in the landscape of these areas and its perception; during the Modern Age we start to have detailed information regarding specific jobs linked to this sector, as the *gessaroli* (gypsum quarrymen) and *fornaciai* (workers in gypsum kilns), family-based jobs.

- *Olive trees in the Gypsum outcrop of Brisighella: Gypsum microclimate makes possible a Mediterranean cultivation in a Continental biome (2014) © Piero Lucci.*

It was also in this period that olive trees became a specific feature of the agricultural landscape of the Gessi Bolognesi and the Vena del Gesso Romagnola: the cooling of the climate in the broader framework of the Little Ice Age reduced the distribution of the olive trees (a Mediterranean cultivation) in the Apennine of the Emilia-Romagna Region, confining this production only in slightly warmer zones of the low Apennine as the Messinian gypsum areas, whose climate is warmer because of the nature of bedrock. In the Contemporary Age, in the 19th century the population reached its peak, while quarries started to adopt, in the context of the second industrial revolution, an industrial approach, with the use of machines. On the contrary, the 20th century saw the inset of the decrease of the population and the marginalization of these areas. In particular, the contract of *mezzadria* (sharecropping) was abolished, the fields were sold to the farmers (who became owners) and the related landscape of the *piantata* almost disappeared. Moreover, the Italian economic boom in the late 1950s meant huge migrations from the Apennines to the Po Plain, the new core of Italian economy. The gypsum areas were one of the very first zones of the Emilia-Romagna Apennine to be abandoned. The consequence of the depopulation process was a fast diffusion of the forests, which occupied the former fields.

- *In the chronicles of Giovanni Andrea Callegari (1527-1613) the Vena del Gesso area was described as:* "montagne di gesso, che cotto e pesto serve mirabilmente per fabbricare case [...]; et travagliandovi molta povera gente ne l'esercitio di cuocerlo al forno et ridurlo in polvere, ne tengono fornita non sola la valle, ma Faenza et Ravenna con altri luoghi circonvicini, con molto utile per chi lo porta a vendere. *[Mountains of gypsum, which cooked and crushed are used admirably to build houses [...]; and the work of many poor people who cook it in the oven and reduce it to powder keeps the valley, Faenza, Ravenna and other places nearby supplied with it, with large profit for those who sell it.]"*

Agriculture

The agriculture in the gypsum areas included in the nomination saw, in a long-term perspective, the usual cultivations of the region, historically developed here for climatic reasons. So, vines and cereals (wheat mainly) were, since the Roman times, the most common cultivations, and the regional food reflected this situation (wine, farinaceous food).

One cultivation only had a special history in the Messinian outcrops of the Emilia-Romagna (but not in the Triassic gypsum, whose high altitude, and consequent cooler climate, never allowed this product): olive trees. Olive tree adapts to warm climates; in particular, it historically adapted to the Mediterranean climate, whose warm winters are appropriate for this plant, which suffers ice, snow and humidity. In the Late Middle Ages, a period of warm climate made possible an impressive increase of olive trees even in the high Apennines or in the Po Plain. But starting from the late 16th century, a climate deterioration, the so-called Little Ice Age, implied a fast regression of this cultivations: the low temperatures and the frequent snow caused a high number of dead olive trees; also, the final production of olives decreased. Olive trees started to disappear from Emilia-Romagna Apennine, with the exception of the Gessi Bolognesi and the Vena del Gesso Romagnola: in the Messinian gypsum, the bedrock has got an effect of mitigation of low temperatures; moreover, the rock walls partially block winds. So, in the Gessi Bolognesi and the Vena del Gesso Romagnola the cultivation of olive trees survived to the climate crisis of the Little Ice Age: in the first area, the farming of olive trees continued until the 19th century; in the latter case, it is still present. The isolation of olive trees in the Vena del Gesso Romagnola, for some centuries an 'island' of olive trees cultivation, formed the basis for the origin, here, of a specific cultivar, the so-called *Nostrana* or *Nostrale*, located only between Santerno and Lamone valleys and characterized by high resistance to winter low temperatures, late ripening, low agricultural yield.

Besides agriculture in a strict sense, also sweet chestnut plantations were developed, in particular, for climatic reasons (cooler climate), in the northern slopes of the gypsum outcrops. Imported in Italy probably in proto-historical times, the chestnuts were used as a substitute of wheat to produce bread in the mountains, where wheat production was usually insufficient for the population (this is the reason way it was traditionally nicknamed *l'albero del pan*e, that is "the tree of bread".

Quarrying activities

Some characteristics of the selenite (a soft rock, whose processing was viable through basic instruments, whose crystals can be divided exploiting the natural cleavage and whose dehydration is possible at relatively low temperature, significantly lower than limestone) formed the basis for the mining exploitation through the centuries of the three gypsum areas of the property.

Quarries started to be opened since the Roman Age: in this period, we have records, both from written and archaeological sources of gypsum quarries in the *Gessoso-Solfifera Messinian evaporites* of the Gessi Bolognesi and the Vena del Gesso Romagnola. Gypsum was quarried in open air sites to obtain blocks to be used as building materials, or to obtain, once dehydrated in kilns and grinded, gypsum mortar. In particular in the Roman city of *Bononia* (present-day of Bologna), gypsum was largely used in construction or public works (e.g. late Roman walls). In the Roman Age, the cleavage of large secondary gypsum crystals were also exploited to produce gypsum thin slabs (lapis specularis), quarried in underground caves, to be used in the windows instead of glass. Impressive examples were found in Pompei, where stunning panels consisting of cleavage fragments as large as 30 cm and less than 2 mm-thick survived the destruction of the 79 CE eruption of the Vesuvius. The Romans turned natural caves into gypsum mines for the exploitation of these crystals and their tool marks are still visible along the cave walls. Outside the trenches and the cave-mines we can also see large accumulation of chips of sparkling crystal fragments, the waste left after the shaping of regular thin panels. The Vena del Gesso has the largest concentration of Roman quarries and mines of lapis specularis in the world outside of Spain. In this phase, until the Contemporary Age, the impact of these mining sites on the landscape was negligible.

The Early Middle Ages, a period of deep crisis, saw a regression in the quality of architecture, which then used timber, earth, perishable materials: in those years, gypsum was not used. It was during the Late Middle Ages that gypsum quarrying re-arose, involving in the exploitation, probably for the very first time, also the Triassic gypsum of the high Apennine. Again, it was the medieval urban environment of the city of Bologna to show the largest use of gypsum, for example as blocks used for the basis of medieval towers or load-bearing beams of the local arcades. The mining activity developed also in the Modern Age, during which gunpowder was introduced in the processing. Other prestigious use of the Messinian gypsum in art and architecture were stucco decoration, one of the distinguishing features of the exuberance of the Baroque and Rococo art (17th-18th century), and the *Scagliola carpigiana* handicrafts and panels impressively imitating semiprecious stone works (17th-18th century). The Contemporary Age meant the introduction, after the second industrial revolution, of the use of machines in the quarries. In the 20th century, during the Fascist Age, quarrying experienced a boom connected to the autarchic economy of Italy of that time and the large programs of public works instituted by the Fascist regime. A second, even larger, boom of the exploitation of gypsum took place starting from the 1950s in the context of the Italian "economic miracle", when the construction industry completed large urbanizations (in Emilia-Romagna Region, mainly along the coastline). In this period, together with the sector of construction, new uses of gypsum were implemented, as a component of fertilizers (ammonium sulphate) and cements. In those years, the quarries became larger, and underground works, together with open air excavations, were developed on a large scale. In this phase, gypsum quarries became not only an economic activity, but also an environmental problem: in fact, their impact on the landscape was significant and, in most of the cases, open air and underground quarries intersected karst systems; in some cases, these systems had an important cultural value as archaeological sites (Farneto and Re Tiberio cave). On the basis of an emerging ecological awareness, led mainly by regional caving clubs and academia, from the late 1980s almost all the gypsum quarries in the region started to be closed and to be involved in environmental restoration projects. In the same years, new quarry sites planned in the Triassic Gypsum were stopped before the inset of the excavations. In 1989 the Emilia-Romagna Region Authority, which held a primary role in territorial management, mines and quarries included, decided to close definitively all the gypsum quarries for natural and landscape conservation purposes in the broader framework of the protection of most of the gypsum outcrops. The only exception was the Monte Tondo quarry (Vena del Gesso Romagnola), designed as the only regional site where all the excavations related to gypsum had to be focused.

- *1920s: a local Primary class visiting a Gypsum quarry. Borgo Rivola (Riolo Terme). © Tonino Rivola Archive.*

Currently, the Monte Tondo quarry, located in the buffer zone is still in activity through open air excavation (while the underground tunnels are abandoned), and represents the largest gypsum quarry in the EU; the other quarries are experiencing renaturalization processes or have been recovered and reconverted in cultural and educational sites of industrial archaeology. The most outstanding example is the Monticino case (Vena del Gesso), where quarrying activity created the best exposed intra-Messinian angular unconformity of the entire Mediterranean. In the vertical walls of the former quarry, crystals up to 1.5 m-tall, the tectonic activity and the mass-waste sliding which re-shaped the Mediterranean area during the "salinity crisis" are very well exposed and can be easily recognized. The quarry brought to light paleokarst features containing vertebrate fossil remains of what is now one of the most important paleontological sites in Italy.

The Monticino quarry is one of the best examples in the world where a destructive exploitation activity has turned into a celebrated, easy to access, geo-park with outstanding fossil remains, crystals among the largest in the world and the spectacular exposure of the tectonic history of the Northern Apennine chain.

History of geological, geomorphological, paleontological, mineralogical researches

Pioneer studies

Karstic phenomena in the Emilia-Romagna evaporites were certainly the first in the world to be observed and partially described, long before the speleology became peculiar activity, at the end of 1800. Their systematic exploration began very early, anyway earlier than everywhere else in the world, and so we can maintain that karst phenomena in Northern Apennines are the most explored and studied in the world, as proved by the very copious existing bibliography (see Annexes, § 7.e).

• *Ulisse Aldovrandi (1522 - 1605)*

Researches on evaporite karst in Italy started very early, probably in the 16th century. The karst phenomena of the nominated area were the first to be described in a printed paper (Bottegari, 1612), namely the salt spring of Poiano in the Triassic evaporites of the Upper Secchia valley. From a cave near Bologna curious speleothems, called "**stelechiti**" (stalactites), were described and drawn by the world renown professor of the University of Bologna **Ulisse Aldrovandi** in the manuscript *Musaeum metallicum* written in the late 16th century, and printed, posthumous, in 1648. From the same area several authors, such as **Luigi Ferdinando Marsili** (1698), **Antonio Vallisneri** (1694 and 1715), **Lazzaro Spallanzani** (1762) and **Serafino Calindri** (1781) described respectively the petrography of gypsum, the gypsum areas of the lower Apennine of Reggio Emilia and in the Upper Secchia Valley, surface karst landforms from areas close to Bologna and from Onferno. Another geologist, **Tommaso Laghi** (1803), published a description of the cave mineral epsomite, found in a gypsum cave near Bologna. Another old description of gypsum karst landscape was given by the famous Swiss naturalist and mountaineer **H.B. De Saussure** in *Voyages dans les Alpes*, where he described the geomorphological phenomena of the Moncenisio area (De Saussure, 1796). **Giovanni Capellini** (1876) described and drew the famous gypsum candles near Bologna, giving a first scientific explanation for their formation.

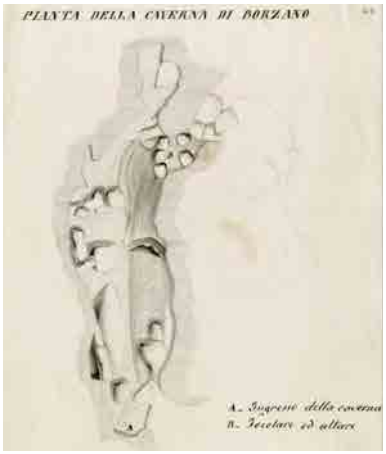
Year	Author	Subject
1612	Cosimo Bottegari	Poiano springs
1648	Ulisse Aldrovandi	Speleothems "stelechiti"
1693	Marco Antonio Melli	Description of Tana della Volpe Cave (Vena del Gesso)
1694	Antonio Vallisneri	Exploration and description of Borzano cave, Reggio Emilia Messinian Gypsum area
1698-1700 ca.	Luigi Ferdinando Marsili	Mining and property of gypsum
1715	Antonio Vallisneri	Hydrogeological researches, Triassic, Valestra cave
1762	Lazzaro Spallanzani	Hydrogeological researches
1762 ca.	Serafini Calindri	Description of the Onferno Cave

Year	Author	Subject
1756-1762 ca.	Tommaso Laghi	Property of gypsum
1781	Serafino Calindri	Karst landform description, Acquafredda sinking stream
1871	Francesco Orsoni	Discovery of the Farneto cave and subsequently its prehistoric site.
1872	Giuseppe Scarabelli	Description (1856) of Re Tiberio cave, first cave survey in gypsum
1876	Giovanni Capellini	Karst landscape, Buco del Belvedere, Buco delle Candele caves
1917	Olinto Marinelli	Italian gypsum areas

19TH – EARLY 20TH CENTURY

The first news about the Zola Predosa gypsum dates back to the middle of the 19th century, when Professor **Antonio Santagata** (University of Bologna), described for the first time the fibrous variety of gypsum, sericolite (satin-spar), in the karstic fractures of a gypsum cave.

Until the 19th century there are few reports on gypsum karst phenomena in the other Italian regions. The only worth citing are those by **Volta** (1786) and **Cozzaglio** (1893) regarding evaporite areas in Lombardy, and the works by **Gemmellaro** (1850) and **Baldacci** (1886) on the extensive Sicilian karst. It is in the early 20th century that researches on evaporite karst intensify, mainly in Sicily (Marinelli, 1899, 1910, 1911; Gemmellaro, 1915, see also Madonia et al., 2016), with the first monographic and comprehensive overview on the karst phenomena in Italian gypsum areas being published in 1917 (Marinelli, 1917). After this fundamental work, however, studies on this special kind of karst languished for over 50 years in most regions (also considering the occurrence of the World conflicts), excluding the description of karst phenomena and some caves in Romagna (Mornig, 1935) and the first real systematic multidisciplinary study on a gypsum karst area in Italy, in the Upper Secchia Valley, Reggio Emilia (AA. VV., 1949). It is however always near to Bologna that scientific research continued in the late 1960s and early 1970s, especially with the works on paragenesis and ceiling channels in the gypsum caves by Pasini (1967a, b, 1975) and the description of the Pleistocene fauna from a paleo-sinkhole (Pasini, 1969, 1970). Also, the role of CO_2 in the dissolution mechanisms of gypsum and the deposition of carbonate speleothems in these caves is based on observations in this area (Forti & Rabbi, 1981), as is the importance of condensation waters (Cigna & Forti, 1986). Furthermore, the possibility to use the deviation of speleothems' growth axes as indicators of past earthquakes, first detected in speleothems from Frasassi cave (in limestone, Marche), were also studied in a stalagmite of a gypsum cave (Buco dei Buoi) near Bologna (Forti & Postpischl, 1980).



• *Map of Borzano cave surveyed by Alberto Bernini, 1872*

Another noticeable increase in printed paper occurred from the beginning of the third Millennium, when the University of Bologna started to organize a specific PhD programme on Karst and Caves, which allowed also the publication of several important studies on the Evaporites of Emilia-Romagna in highly impact factor Journals.

At the end of 2018 the papers dealing with Evaporite karst and caves within the nominated property were over 1650, making these areas by far the most explored, described and studied of the whole planet.

Among them, we report here in chronological order just the few that may be considered **true *milestones* in the development of the karst studies** not only restricted to the relatively small field of the Evaporites, but sometimes also important for the general science.

1. First description of a salt spring with halite deposition in a gypsum/anhydrite outcrop (Bottegari 1612)
2. First description of a calcite stalactite from a gypsum cave (Aldrovandi, 1648)
3. First description of epsomite as cave mineral from a gypsum cave (Laghi, 1802)
4. First description of satin-spar as cave mineral from a gypsum cave (Santagata A., 1835)
5. First description of a surface karst erosional/corrosional morphology (candles) for a gypsum area (Capellini, 1876)
6. First description of cave fauna from a gypsum cave (Alzona, 1903)
7. First description of a new deep karst morphology (hypogean bend) from the gypsum/anhydrite karst of Emilia-Romagna (Malavolti, 1949)
8. First monography on the exceptional variety of the secondary gypsum crystals in the gypsum caves of Bologna (Tomba, 1957)
9. First general definition of the mechanisms allowing the evolution of paragenetic galleries in karst caves from a gypsum cave (Pasini, 1975)
10. First description of chloromagnesite as cave mineral, still unique to a gypsum cave of Emilia-Romagna (Cervellati et al. 1975)
11. Firt explanation of the genesis of the "mammelloni" structure during the Messinian deposition of gypsum (Vai & Ricci Lucchi, 1977)
12. First definition of a new speleogenetic process active in gypsum karst which allows also the development of a peculiar type of calcite speleothem (calcite blades) (Forti & Rabbi, 1982)
13. First description of 3 new cave minerals from gypsum/anhydrite caves (brochantite, devilline, penninite) two of which novel for the cavern environment (Chiesi & Forti, 1985)
14. First experimental paper on the relationships existing between earthquakes and speleothems based on observation made within gypsum caves of Emilia-Romagna (Forti & Postpischl ,1986)
15. First paper on the general speleogenetic role of condensation (Cigna & Forti, 1986)
16. First description of intra-Messinian important paleontological remains trapped within karst structures of Emilia-Romagna (De Giuli et al., 1988)
17. First description of a new minerogenetic processes giving rise to stalactites and stalagmites consisting of complex aggregates of different Fe-Mn minerals (Forti & Rossi, 1989)
18. First definition of a new speleogenetic mechanism which caused enhanced dissolution of gypsum and simultaneously the deposition of euhedral quartz (Forti, 1993)
19. First description of dolomite as cave mineral in gypsum karst (Forti et al., 2004)
20. First description of stygobiotic species (some of which new for science) of the gypsum-anhydrite karst of Emilia-Romagna (Stoch et al., 2009)
21. First description of a fossil cave developed during the intramessinian speleogenetic cycle (De Waele & Pasini, 2013)
22. First definition of a new mechanism allowing the development of peculiar calcite speleothems (calcite bubbles) inside gypsum caves (Ercolani et al., 2013)
23. First paleoclimate and paleoenvironmental study of a gypsum karst area (Columbu et al., 2015)
24. First description of the genetic mechanisms allowing the evolution of sulphur crystals over gypsum stalactites in gypsum caves (Forti & Lucci, 2016)

25. First detailed geochemical and microbiological survey on gypsum cave waters in the world (D'Angeli et al., 2017)
26. First regional evolution model on the gypsum karst landscape in Emilia-Romagna (Columbu et al., 2017)
27. First detailed geomorphological analysis of a gypsum cave and its morphologies using laser scanning and 3D photogrammetry techniques (De Waele et al., 2018).

The **study of the Upper Triassic and the Messinian evaporite Formations** of Northern Apennines provided significant milestones contributing to our understanding of the geologic history of our planet and of the genetic mechanisms for the formation of these peculiar sediments in extreme environmental conditions.

a) the Upper Triassic gypsum

1. first integrated study on the geology, botany, hydrology, hypogean meteorology and toponymy of a gypsum karst area (Malavolti, 1949).
2. first description of the hypogean bends in a karst system ("anse ipogee", Malavolti, 1949).
3. first description of the hypogean bends as controlled by anhydrite-gypsum transition (Lugli 1993).
4. first description of a metamorphosed evaporite sequence using fluid inclusions and stable isotope geochemistry (Lugli, 2001).
5. first description of a thick sulfate megabreccia originated by halite dissolution (Lugli, 2001).
6. first description of three different type of magnesite ($MgCO_3$) coexisting in the same evaporite Formation (primary, hydrothermal and Mg-metasomatic; Lugli et al., 2002).

b) the Messinian gypsum

7. first description of gypsum turbidites (Parea and Ricci Lucchi, 1972).
8. first description of fossilization into gypsum crystals: "spaghetti-like" filamentous bacteria (Vai and Ricci Lucchi, 1977).
9. first description of gypsified stromatolites (Vai and Ricci Lucchi, 1977).
10. first description of faunal remains preserved into a Messinian gypsum karst system (Costa et al., 1986).
11. first description of subaerial exposure features in the Messinian gypsum layers (Costa et al., 1986).
12. first description of giant mass-waste phenomena involving a gypsum sequence (Roveri et al., 2003).
13. first extraction of DNA from organic matter included into Miocene gypsum crystals (Panieri et al., 2010).
14. first Mediterranean Basin-scale correlation of the "Mediterranean salinity crisis" gypsum sediments (Lugli et al., 2010).
15. first description of an ancient lapis specularis quarry discovered outside Spain (Ercolani et al., 2015).
16. first high-resolution strontium isotope study on individual gypsum beds revealing climatic influence from precessional-scale orbital parameters (Reghizzi et al., 2018).
17. recognition of the Vena del Gesso area as the largest concentration of ancient *lapis specularis* quarries outside Spain (Lugli et al., 2019).
18. first description of the gypsum as belonging to the largest evaporitic marginal basin of the Mediterranean (Manzi et al., 2020).

Giuseppe Scarabelli described the Re Tiberio Cave in the Vena del Gesso Romagnola, publishing the first survey of a gypsum cave in the world in 1872. After the pioneering researches of Giuseppe Scarabelli and Giacomo Tassinari, Giovanni Battista De Gasperi, friulian geographer, in the first years of the last century starts the speleological researches in the Vena del Gesso Bolognese area: he explored the Re Tiberio Cave, the Banditi Cave, the Rio Stella sinkhole and the sinkhole after named "De Gasperi sinkhole", near the Rio Stella blind-valley (De Gasperi 1912; Bentini 1995a).

• *Sckech of Re Tiberia cave , by G.Scarabelli,1871..*

In the same years the first Italian national speleological association (**Società Speleologica Italiana**) was settled up in Bologna and from that time modern activities (like explorations, cave description and mapping) related to "modern" speleology started to be made on a rather regular basis. As a consequence, the number of printed papers on the Northern Apennines Evaporite karst became more frequent year by year. Giorgio Trebbi and Carlo Alzona, members of the society, devoted themselves to the exploration and study of cave morphology and hydrology and to speleo-biology research, respectively (Trebbi, 1903, 1926). In 1905 a complete overview of superficial karst phenomena was published by the geographer Olinto Marinelli.

In 1932 **Luigi Fantini** establishes the "Gruppo Speleologico Bolognese" that over a short period of time makes some important discoveries among which stand out the detection of the Spipola Cave near the Croara village and that of the Michele Gortani Cave near the Gesso village. In 1934 the caves of the Bologna area listed in the registry of the Italian Institute of Speleology in Postumia are 68, of which Fantini provides a first presentation in the publication "Le Grotte Bolognesi" (1934).

• *Exploration in the Spipola cave, 1936. © F. Malavolti.*

Thanks to Giovanni "Corsaro" (corsair) Mornig, from Trieste, the first systematic explorations begin, and between 1934 and 1935 he explores about 50 caves, mainly near Brisighella and Monte Rontana; among these ones, the Abisso Fantini, over 100 m deep, was the deepest cave known in the Emilia-Romagna region and one of the deepest in the world. His survey and filing works for the first time offered an overall overview of the Vena del Gesso karst phenomena.

The systematic speleological exploration of the Triassic evaporites area date back to 1938 and were managed by the **Scientific Committee of the Modena CAI** (Italian Alpine Club) section, which inspired the organization of heroic multidisciplinary research camps between 1945 and 1947. The accuracy of observations, analyses and surveys and the coverage of the investigated areas are still today a very high example of scientific research applied to the territory. The original description of a remarkable series of endemics, rarities and naturalistic details (AA.VV. 1949) showed the undisputed scientific interest of this areas.

The real improvement in the exploration, research and dissemination (and consequently in the number of yearly printed papers) on karst and caves occurred just after the Second World War, when several caving clubs were founded and few years later grouped within a Regional Federation (Federazione Speleologica Regionale dell'Emilia-Romagna).

Speleological researches in the Vena del Gesso Romagnola started in the fifties. Between 1953 and 1955 the "Pellegrino Strobel" Caves Group, from Parma, explored the first section of the Rio Basino Resurgent Cave and the Cà Poggio sinkhole. In 1956 the "Città di Faenza" and "Vampiro" speleologic groups were based in Faenza; in 1966 they merged creating the "Gruppo Speleologico Faentino". In the Brisighella gypsum the "Tana della Volpe" and, in 1958, the Tanaccia karst system were explored. In the Monte Mauro gypsum in 1957 continued the exploration of the Rio Basino Resurgent Cave and of the Rio Stella sinkhole: in 1964 these caves were eventually connected, allowing a crossing considered for decades one of the most difficult for this area.

In 1969 the Gortani Cave was discovered and explored, revealing interesting hypogean morphologies, but only in 2010 it was discovered and partially explored a very large ancient karst system intra-Messinian in age, absolutely unique in Italy for its morphologic features.

Starting from the 1980s new speleologic groups were founded dedicated to exploration and obstructions elimination; so that, in about 20 years, the caves number doubled, and their overall length rose from 10 to 40 km. The greatest discovery was the Luciano Bentini Abyss, first explored in November 1990 by the Faentino Speleological Group.

The role of speleological research in the protection of caves

The Reggio Emilian speleological group (founded in 1969), fearing the opening of gypsum quarries, increased its research and environmental activities to support the first proposal to establish a protected area. For this reason, the group encouraged the coordination of a new interdisciplinary study about the Poiano springs and the karst environment, and proposed a new analysis of all the natural caves in the area.

Thanks to the "Gruppo Speleologico Bolognese" (GSB) and to the "Unione Speleologica Bolognese" (USB), many scientific researches took place in collaboration with the University of Bologna. At the same time, the first measures for the protection of karst landscape threatened by mining, and quarrying activities and by urban expansion were put in place place in the Gessi Bolognesi area. These were the first steps of a long struggle that eventually led to the establishment of the "Parco dei Gessi Bolognesi" in 1988. The union of the two groups, GSB and USB, represents an important turning point for the development of cave exploration enhanced also by past experience, modern techniques, more efficient gears, and new equipment.

Caves previously interpreted as scattered and separate entities, were finally recognised as part of large karst systems. In the nominated property there are now 170 caves for an overall length of over 26 km. In this context, the most widespread karst system is that of the Spipola-Acquafredda-Prete Santo, which is 11.5 km long and 118 m deep, currently the largest gypsum cave in Western Europe. There are also other systems with an overall length of over 2 km, while the exploration of the Partigiano-Modenesi System, of which the Farneto Cave represents the final section, is still in progress and it may soon reach an overall length of 4 km, with an even wider potential development. In the Monte della Volpe gypsum, starting from 1990, the "Speleo GAM Mezzano" identified two large karst systems,

partly altered by the Monte Tondo quarry. The results of the explorations, the surveys and the studies promoted by the group were essential in safeguarding the karst phenomena in this area. In the Monte del Casino gypsum the "Ronda Speleologica Imolese" explored the Rio Gambellaro Resurgent karst system. During the new millennium the explorations in the Vena del Gesso concerned mainly the *lapis specularis* caves, after the discover of The Lucerna Cave by the Speleo GAM Mezzano in 2000. Between 2007 and 2010 the "Federazione Speleologica" of Emilia-Romagna promoted the "Stella-Basino Project", to which all the speleological groups contributed with several studies and investigations on one of the largest and most relevant karst system of the world. The "Stella-Basino Project" was part of a larger project, in order to offer a thorough and complete study of the Vena del Gesso. On this topic, in 2013 a multidisciplinary study of the Monte Tondo quarry was completed, and during 2015 and 2019 similar studies on the Brisighella, Rontana and Monte Mauro karst areas were also published in "*Memorie dell'Istituto Italiano di Speleologia*" monographs. The projects explored all aspects of structural geology, speleology, karst and surface hydrology , concretions, fills and paleontological, as well as flora and vegetation, epigean and hypogean invertebrates, vertebrates, especially bats. Also, palaeoethnology and archaeology, anthropic settlements, and relationship man-environment were studied. This series of books represent an unprecedented attept to combine scientific research and dissemination, in order to provide everybody, particularly the local authorities, with a thorough documentation of natural and cultural emergencies, useful elements for the proper planning and management of the territory.

In recent years, many projects have been designed, promoted and coordinated by the Società Speleologica Italiana and by the Federazione Speleologica Regionale dell'Emilia-Romagna. The "Trias Project", a complex research and educational project supported by Appennino Tosco-Emiliano National Park, produced a renewed impulse to scientific knowledges regarding the outstanding features of the Triassic gypsum karst area: thank to the use of the state-of-the-art continuous monitoring techniques, an accurate hydrological and hydrodynamic model of the Poiano Springs has been defined. The "Stella-Basino" project in 2010, the "I Gessi e la cava di Monte Tondo" (2013), "I gessi di Brisighella e Rontana" (2015) and the "Gessi e solfi della Romagna Orientale" project (2016) are other examples of international research activities promoted by the Federazione Speleologica Regionale dell'Emilia-Romagna. The projects, focused on Messinian gypsum in different areas of the nominated property, were characterized by a highly multidisciplinary approach, transversal to geology, speleology both in natural and artificial cavities, biology, history and geography.

Botanical researches

The bibliography on the flora and vegetation of the gypsum areas of Emilia-Romagna is very rich; a first group of founders was followed by a large and qualified group of other explorer botanists who highlighted the most diverse aspects of plant heritage: flora in general or single species or group of species, vegetation, relationships between environmental characteristics and flora or vegetation cover. The first studies date back to the XVI century.

The first to study the gypsum flora, not far from the University of Bologna where he taught, was Ulisse Aldrovandi (1522-1605). During the nineteenth century botanical investigations intensified, with the activity of Giuseppe Scarabelli (1820-1905) and Lodovico Caldesi (1821-1884).

In this century, to Giacomo Tassinari (1812-1900) we owe the discovery of one of the most interesting species of the candidate property, Allosorus persicus; in fact, in 1833, discovered a fern unknown to him, which he handed over to his botanical professor at the University of Bologna, another botanist of international fame: Antonio Bertoloni (1775-1869). Bertoloni classified the species as *Acrostichum microphyllum*, considering it new to science. This rare fern, to tell the truth at Bertoloni's time already identified in Persia, was later mistakenly considered extinct by the greatest researcher of the flora of the Vena del Gesso Romagnola, Pietro Zangheri (1889-1983). In 1980 the species was rediscovered, in new sites previously unknown, again by a professor of the University of Bologna, Francesco Corbetta and a professor of the University of Pavia, Graziano Rossi.

The same Giacomo Tassinari discovered in 1842 the rare *Asplenium sagittatum* in the Re Tiberio Cave (Vena del Gesso), with the only population in Northern Italy and in the northernmost site of its worldwide distribution area. The last record of presence dates back to 1964 and is due to Zangheri, who then denounced its extinction. Now in the Vena del Gesso is ongoing a reintroduction project of *Asplenium sagittatum*, carried on by the Park Vena del Gesso Romagnola, with WWF, the Speleological Federation of Emilia-Romagna and the University of La Tuscia.

In recent years, after the establishment of the three parks and the Onferno Regional Reserve, the research activities have intensified and dozens of investigations have been conducted to deepen the knowledge on the flora of the Emilia-Romagna gypsum. The number of known species has almost doubled: the total amount of different plants can now be esteemed in more than 1500 species.

Thanks to the significant activity of the park authorities, the state of conservation of the flora and vegetation in the candidate property can be considered, in general, optimal. In recent years, the Parks together carried out a LIFE project for the conservation of some habitats associated with the presence of gypsum cliffs and cave entrances and characterized by peculiar plant formations: the dry and sparse meadows that develop directly on the south-facing rocks and the chasmophytic vegetation covering the shady rocks.

Zoological researches

The history of zoological research in the Northern Apennines gypsum is quite recent. The area attracted the attention of botanists for centuries, but have been neglected by zoologists. The first faunal data date back to the nineteenth century, but are rather poor and fragmented. The most thorough research carried out in the first half of the 20th century includes the gypsum areas in research carried out on larger reference areas. However, interesting data were collected from the mid-19th century onwards.

The study of the hypogean fauna starting precisely from the exploration of the first caves in the late 1800s, and was the object of a targeted investigation. Later, many scholars dealt with the cave invertebrates and, finally, Pietro Zangheri (1889-1983) carried out his research between the 1950s and the 1970s. Then practically nothing, up to the in-depth investigations carried out by the Park and the Regional Speleological Federation in recent years: as a result the number of species rose from 45 up to 73. During the last 20 years the Vena del Gesso has been deeply investigated from the faunal point of view, under the coordination of Massimiliano Costa (2001-2020).

In all areas of the candidate property, research on the hypogean invertebrate fauna has allowed the discovery of species new to science and many are endemic, confirming the importance and uniqueness of the underground gypsum environments. For the most showy and best-known species of vertebrates, data are also available to analyse the population trend over the last 100-150 years.

Canis lupus has re-colonized the gypsum areas since the second half of the first decade of the 21st century, after almost a hundred years of absence; in that same period the presence of a species never previously reported, *Felis silvestris*, was discovered. *Hystrix cristata* has colonized the northern Apennines, for the first time, starting from Vena del Gesso Romagnola, in the mid-1980s.

Bubo bubo has been known since the early 20th century (Zangheri, 1938), but the number of couples has progressively decreased over the past 30 years. The causes of this decline are not known. On the contrary, Falco peregrinus, which nests in the same cliff environments, also reported in the early 20th century (Zangheri, 1938) as sporadic and then absent for decades, has now returned to nesting for about 20 years and is steadily increasing.

Many species of passerines related to the naked rocky environments are extinct as nesting, reflecting the progressive advance of the woods: *Monticola solitarius, Monticola saxatilis, Oenanthe oenanthe, Petronia petronia*. Other extinct species were linked to an extensive and sustainable agriculture, now disappeared: *Perdix perdix* (for which the Vena del Gesso Romagnola regional Park has a reintroduction project), *Lanius senator*.

JUSTIFICATION
FOR INSCRIPTION

3

3.1.A BRIEF SYNTHESIS

The nominated property is located in Northern Italy, along the Apennine chain and includes over 90% of the evaporitic rocks of the area. It is a serial property, composed by 7 component sites. Together, they host a unique array of evaporitic karstic landforms, caves and springs with an outstanding significance also for palaeontology, biology, archaeology and art history. The exceptional nature of this area is due to the unique combination of geological and climatic factors.

Two important phases of seawater evaporation during the opening of the Tethys Sea (over 200 million years ago) and the Mediterranean Salinity Crisis (about 6 million years ago) led to the deposition of significant volumes of gypsum in this region. The two evaporate formations underwent distinct exposure and karstification phases in this relatively narrow area enhanced by a peculiar combination of orogenic phenomena and humid sub-tropical conditions (according to Köppen classification). During the Roman age the natural caves in gypsum eased the mining of stunning transparent crystals to be used in windows frameworks instead of glass.

The proximity to the oldest University in the Western world and a thriving cultural environment at the end of 17th century favoured the early development in this area of various disciplines, such as evaporite mineralogy, hydrogeology and speleology. For this reason, a large part of the scientific discoveries concerning evaporite karstification owe their origin to these places, due to the evidence of the phenomena, their accessibility and the unique combination of geological and climatic factors.

3.1.B CRITERIA UNDER WHICH INSCRIPTION IS PROPOSED (AND JUSTIFICATION FOR INSCRIPTION UNDER THESE CRITERIA)

The **Evaporitic Karst and Caves of the Northern Apennines** represent a natural system of a unique record of evaporitic karst phenomena. The proposal for inscription is under **criterion (viii) :**

"be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features."

The proposal for inscription derives from the presence in the area of a unique record of evaporitic karst phenomena. The nominated property hosts a density of superficial karst forms, caves, salt springs, minerals, speleothems, and palaeontological contents that has no equal in the world, thanks to its peculiar geological and climatic context.

For this reason, the phenomena have been studied here since 16th century and this has been the place where many of modern scientific theories about evaporitic karst are born.

The nominated property, in fact, is the unique result of the deposition of gypsum-halite salts during two of the most impressive geological events of the Earth history: the break-up of the supercontinent Pangea about 200 million years ago and the ecological catastrophe that struck the Mediterranean Sea about 6 million years ago known as "Mediterranean Salinity Crisis". In the Northern Apennines the two evaporitic deposits crop out close to each other in a narrow area due to the Apennine orogenesis.

The exposure of the rocks, squeezed and tilted by the collision of Africa and Europe continents during the late Cenozoic allowed for a complex interaction with surface and subterranean waters, in a climatic regime classified as sub-tropical humid (according to Köppen–Geiger climate classification system). In the Northern Apennines area the peculiar emplacement of the rocks and the alternations of glacial and interglacial phases created the conditions for unique multi-phase karst features.

• *(facing page) The canyon in the S. Calindri cave. (2012) Gessi Bolognesi © G. Agolini*

The richness of epigean and hypogean karst forms, some of which described for the first time from this area, and the uncommon density of rare speleothems, some of them are unique in the world, contribute to the exceptionality of this area. Here in fact 26 different epigean karst forms have been identified, 2 of them are unique of this area: the hypogean bends and the gypsum and anhydrite protrusions. With 34 types of speleothems and 22 different cave minerals, this place is is one of a kind on Earth.

- The hosted epigenic caves, in pure gypsum and in gypsum-anhydrite formations, are amongst the largest, deepest and most complex in the world. The Messinian gypsum developed two different karst cycles, the oldest during the Mediterranean Salinity Crisis (intra-Messinian phase) and the last during the Holocene. In the present-day cycle the caves developed for over 500,000 years and the study of the hosted speleothems allowed the detailed reconstruction not only of the climate evolution over the last hundred thousand years, but also gave proxies for the understanding of the climate changes occurred in the last few decades.
- The hydrogeology of these karst areas is absolutely well known, with more than 50 international studies published so far. The large, complex karst aquifers have been studied and described in detail as, in particular, the one feeding the largest karst salt spring of Europe (Poiano Springs).

Geomorphological, mineralogical and hydrogeological features, however, are not the only outstanding aspects of the Northern Apennines evaporite karst and caves. Indeed, in these areas some rare and well-preserved paleontological remains of intra-Messinian and upper Pleistocene fauna were discovered.

The oldest karst system, contains a world-reference continental fauna dating back to the Late Miocene (5.6 million years ago) and prehistoric archaeological remains that contributed to shape the dawn of Italian paleethnology in the second half of the 19th century.

Furthermore, the area played a key role in the development of scientific disciplines, including speleology, mineralogy and hydrogeology and even before, to the empirical knowledge and peculiar uses of the evaporitic deposits as raw material.

Almost 2000 years ago some of the natural caves were transformed by the Romans into mines for the extraction of stunning transparent crystals to be used in windows frameworks instead of glass.

Due to the closeness to important communication routes since the Roman era, and to the cultural ferment that affected these territories also because of their proximity of eminent universities since 1600 ca., the evaporite karst and caves of the Northern Apennines are the first and the best studied in the world. Many speleogenetic theories on gypsum caves were conceived inside them and, just to mention a few, they involve:

a. the antigravitative karst evolution;
b. the role of CO_2 in the dissolution of gypsum and the deposition of carbonate speleothems;
c. the role of condensation in gypsum speleogenesis;
d. the possibility to use the deviations of the stalagmites growth axes to reconstruct the ancient earthquakes chronology;
e. the possibility to use calcite speleothems in gypsum caves as paleoclimate proxies;
f. the genesis of a karst feature, called "hypogean bends", unknown elsewhere in the world and testified by cave systems developed at the rim of the mountains.

3.1.C STATEMENT OF INTEGRITY

The evaporitic karst manifestations in the serial property represent the integrity of the phenomenon since the component sites combine all the typical processes in gypsum, anhydrite and in clastic deposits derived from these rocks.

The nominated property encompasses all the outcropping evaporitic karst areas that are under a protection regime for their geological and natural values. This comprise almost 90% of the whole evaporite rocks in the Northern Apennines and all of the areas that played a role in the development of scientific disciplines and contribute to the Outstanding Universal Value.

The integrity of a karst system is not only related to the preservation of the visible phenomenon but also to the factors that contribute to the development of it. For this reason, the proposed boundaries and the extension of the buffer zone have been developed taking in account all the main karst aquifers but also all their recharge areas, so that their future best preservation is assured.

Most of the property fall within the boundaries of the Appennino Tosco-Emiliano National Park and of two Regional Parks: the Gessi Bolognesi Park and the Vena del Gesso Romagnola Park.

The remaining areas are protected by a Regional Reserve (Onferno), European Community directives, national and regional laws - and they are part of the Nature 2000 network or identified as part of Protected Landscapes. All the properties are geosites officially catalogued by Emilia-Romagna Region, thanks to the Regional Law n.9/2006 "*Norme per la conservazione e valorizzazione della geodiversità dell'Emilia-Romagna e delle attività ad essa collegate*". Moreover, these three Parks are still expanding their boundaries by acquiring new private areas.

Water resources are monitored and protected: the environmental quality of the karst systems is excellent (see chapter 6), with particular reference to the karstic waters and the delicate underground ecosystems. Not even the very few caves devoted to the visits of the general public have been significantly altered and the tours take place with speleological modalities, without permanent walkways, lighting or other alterations of the natural environment.

Overall, after centuries of mining exploitation of gypsum for local uses, protection measures have triggered a striking restoration comeback in many of the historical excavation areas, leading to a progressive closure of many of them in the last 30 years. For the few remaining active quarries, the competent authorities are currently working to find the best solutions in terms of environmental, landscape and socio-economic terms.

Thanks to the Natural Parks administrations, two abandoned gypsum quarries were transformed into open air geological and paleontological museums and several thousand tourists visit the karst areas with the chance to enter one of the five show caves of our Region, mainly devoted to didactic activities on environmental protection for student of the primary and secondary schools. Moreover, most of the proposed properties, from 2010 to 2016, were interested by **LIFE Gypsum***, which increased protection and awareness of these areas. Furthermore, within the Project a Management Plan was developed to enhance preservation and to support the appointed authorities to keep high protection standards also for the future.

* ***LIFE** 08 NAT/IT/000369 project "**Gypsum**: protection e management of the habitats associated with the gypsum formations of Emilia-Romagna" http://www.lifegypsum.it*

3.1.D STATEMENT OF AUTHENTICITY (FOR NOMINATIONS MADE UNDER CRITERIA (I) TO (VI)

Not relevant as this nomination is submitted under criterion (viii).

3.1.E PROTECTION AND MANAGEMENT REQUIREMENTS

All component sites of the nominated serial property possess a strong legal protection framework. It consists of a coherent system of measures that link different levels of legislation (European, national, and local) protecting epigean and hypogean geological attributes of the candidate property and their natural habitats.

In particular, more than 96% of the nominated core areas correspond to karst and gypsum habitats belonging to the European Natura 2000 network (IUCN Protection Category IV) and 71% are included in five protected areas, established for the protection of epigean and hypogean evaporitic karst environments. These are:

- the Appennino Tosco-Emiliano National Park, established in 2001 (IUCN Cat. II),
- the Gessi Bolognesi and Calanchi dell'Abbadessa Regional Park, established in 1988,
- the Regional Park Vena del Gesso Romagnola, established in 2005,
- the Collina Reggiana Protected landscape, established in 2011 and the Onferno Regional Reserve established in 1991 (all IUCN Cat. IV).

With regard to the subsurface properties, all the phenomena of evaporitic karst and caves are punctually identified and catalogued by a specific regional law adopted in 2006 in accordance with Recommendation Rec(2004)3 of the Committee of Ministers of the Council of Europe on the conservation of the geological heritage and areas of special geological interest, as well as in implementation of the national law "*Code of Cultural Heritage and Landscape*" (artt. 136 and 142 of the Legislative Decree No 42/2004).

This regional law (L.R. no. 9/2006, Norms for the conservation and valorisation of the geodiversity of Emilia-Romagna and related activities) supports the valorisation of the geological and speleological heritage and promotes and supports the organisation of activities for the study, research and protection of caves and karst areas (IUCN Cat. III). In particular, in application of this law, a cadastre of caves, artificial cavities and karst areas has been established, which specifies for each catalogued site relevant information on specific features, values, protection status, and accessibility conditions. Together, all these protection measures form a consolidated system of environmental protection that has proven its effectiveness over time.

Overall, the nominated property is well managed. The component sites are under the control of just two managing bodies. The c.s.1 is managed by the Appennino Tosco-Emiliano National Park, which is directly supervised by the Italian Ministry for Ecological Transition. The c.s. from 2 to 7 are under the control of the Emilia-Romagna Region which directly supervise the management bodies of the regional protected areas. These management bodies (called *Managing Bodies for Parks and Biodiversity of Central Emilia, Eastern Emilia and Romagna*) are also responsible for implementing the specific conservation measures for the Natura 2000 sites that fall within their jurisdiction. Every management body owns a management plan, a specific budget and a dedicated staff (technical and administrative) to manage and control the respective areas. In addition, it's worth mentioning that the National Park is the coordinator of the Appennino Tosco-Emiliano Biosphere Reserve UNESCO, which entirely includes c.s.1 and part of c.s.2 of the nominated property.

The management of the 7 component sites of the nominated property will be ensured through an Overall Management Strategy coordinating enhancement actions and conservation measures (see chapter 5). Key management issues include the protection of the attributes and values of the geoheritage, conservation measures for habitats and species of Community interest, knowledge and communication of the environments, education and enhancement of the visitor experience.

A long-term monitoring system has been set up, using ground- and underground-based observations, for the improved evaluation of the ecological state of karst aquifers, seismo-tectonic movements and climate cave conditions. Key aspects of the property's flora and fauna are also monitored.

• *Meander exploration in the Grotta M. Gortani cave (2012). Gessi di Zola Predosa. © F. Grazioli*

3.2 COMPARATIVE ANALYSIS

The comparative analysis is the result of an original study carried out preparing the nomination document. It is based:

a. *on data published in international journals;*

b. *on congress proceedings held in the candidate area by virtue of its central role in the evolution of speleology in evaporitic karst areas;*

c. *on the direct experience of numerous speleologists who over the years have visited evaporitic karst sites in numerous areas of the globe, in very different climates and geological contexts.*

In order to provide a scientific validation to this analysis, a list of international scientific endorsement to the candidature provided by many eminent international researchers has been included, quoting some significant messages that prove the uniqueness of the candidate property.

The analysis was carried out through tables that compared the individual geological attributes. From these, two summary tables have been produced: in the first one the component sites of the candidate property are compared, in the second one the evaporitic sites of the whole world are compared to the nominated property.

In the summary tables the organization of the geologic attributes in macro-categories has been inspired by international publications that aimed to represent the evaporitic karst phenomena on a global scale (Klimchouk et alii, 1996): "*Gypsum karst of the World*" published on the International Journal of Speleology. Mineralogical aspects are presented following the analysis by Forti (2017): "*Chemical deposits in evaporite caves: an overview*", also published in the International Journal of Speleology.

This approach aims to follow the indications reported in the IUCN document "*World Heritage Caves & Karst*" published in 2008, where it was noted that: in order to evaluate the coverage of karst on the World Heritage List, each site needs to be reviewed in the context of three components:

I. *its climatic environment and karst style*
II. *the comprehensiveness of its karst system*
III. *its geology and landscape history.*

3.2.A COMPARATIVE ANALYSIS OF THE COMPONENT SITES OF THE NOMINATED SERIAL PROPERTY

Comparative analysis of the component sites of the nominated serial property has been carried out by the identification of three main groups of characteristics. The same group of characteristics, and the same evaluation classes have been also taken in account as the basis for a comparative analysis against other evaporite karstic zones in the world, described in the next chapters.

The first group of characteristics analysed is based on the criterion under which the property is nominated (VIII). "***Being a significant representation of evaporitic karst process***" requires to host a complete, rich set of epigean and hypogean features including:

- **epigean karst forms (karstic geomorphology)**
- **karstic salty springs**
- **salt diapiric phenomena**
- **physical and chemical processes that acted on evaporite deposits (a proxy for the diversity of minerals and observable rock characteristics)**
- **speleothems**
- **minerals**
- **mineral habits**

These attributes make it possible to identify the peculiar aspects of gypsum and anhydrite karst. On the one hand, they include morphological features perceptible on the surface such as karst forms and springs. These manifestations are particularly important precisely because of the rarity with which they occur in humid subtropical climatic conditions, when they normally undergo rapid dissolution and therefore tend to be obliterated by surface water circulation. In addition to surface morphologies, the attributes include all the unique aspects that characterise subterranean karstification in gypsum: the prevalence of ephemeral cavities, subject to collapse and variations that are perceptible even at the human scale, the various minerals with delicate crystalline habits that grow in these environments, the deformations induced by the tectonics of evaporites involved in orogenic contexts.

These attributes allow thus to easily identify the component sites that contribute more to the representativeness of the phenomenon.

The uniqueness and outstanding value of the nominated property, however, is not given only by an exceptional presence of speleothems and mineral phases. Additional attributes offer a unique opportunity to study the relationship of climate (average temperatures and precipitations) and karst – shedding light on the on-going processes affecting the property, in particular the ones relate to subterranean water circulation. Furthermore, the outcropping deposits can be classified according to their extension, or by their capability to represent major stages of Earth's history through the registration of the processes that took place in this area.

Finally, some characteristics have been taken in account in order to better represent the role that this area had in the past, and continues to have now, in the development of speleology, mineralogy and hydrogeology disciplines. The third part of the table tries to summarize the role that each component site played as an accessible study area for evaporite sciences, but also the influence that evaporite deposits have played on the human development of the area and the creation of specific habitats.

Given the heterogeneity of the characteristics described, the value of each attribute is listed through one of the following three classes:

★ *"present" if the category of attributes is visible in the component site but does not manifest exceptional characteristics (it is however an example of the process in the particular geological and climatic conditions of the site);*

★★ *"significant" if the characteristic is present with a high diversity of manifestations of relevant scientific interest*

★★★ *"very significant" if the characteristic is exhibited, in the component site, with manifestations of exceptional scientific or informative value.*

Each row in the table is thus a synthesis of the enumeration of each geomorphologic, speleologic, mineralogic, geologic feature observable in the area and described in chapter 2. Seven tables, provided as an attachment, describe in detail how the calculation have been carried out. They include:

- A list of **every geomorphologic feature** observable in each site, including some unique in the world;
- A list of observable **speleothems**;
- A list of **minerals** that have been identified in each site;
- A list of observable **mineralogenic mechanisms**;
- A list of **diagenetic processes** that affected the deposits of each site;
- The **age of the sediments** in each site
- The **thermometric and pluviometric regime** of each area;

They should be considered as separate component sites when addressing the type of protection and the role they play in the cultural accessibility of the phenomenon.

An internal comparison of the property reveals the wealth of attributes of the component sites. Each site contributes differently to the outstanding value .

COMPARATIVE ANALYSIS OF THE COMPONENT SITES

LEGEND

- = not present;
★ = present;
★★ = significant;
★★★ = very significant
Cfa, Cfb = Climate classes

ATTRIBUTES

CRITERION VIII	**main characters (attributes)**	**epigean**	karst forms / geomorphology
			evolutionary typology
			hydrology (salt springs)
		hypogean	speleothems
			minerals
			crystal habit
			diapirism
			hydrogeology
	associated characters	climate (Koeppen classification)	
		extent of visible phenomenon density (quantitative value)	
		geological history	evaporite age
			recording of significant post-depositional geological phenomena
			syn-depositional palaeontology
			post-depositional palaeontology
	other significant features	scientific context	history of geology / early studies
			level of current knowledge
			accessibility (caves of scientific importance)
			caving/geology study centres in the surroundings
		historical / geographical context	use of resources/interest in the phenomenon (Lapis specularis)
			historical landscape
			natural landscape (biodiversity/habitat)
			accessibility (caves of touristic interest)

	c.s.1 - Alta Valle del Secchia	c.s.2 - Bassa Collina Reggiana	c.s.3 - Gessi di Zola Predosa	c.s.4 - Gessi Bolognesi	c.s.5 - Vena del Gesso Romagnola	c.s.6 - Evaporiti di San Leo	c.s.7 - Gessi di Onferno
	★★★	★	★	★★★	★★★	★	★
	★	★	★★★	★★	★★★	★	★
	★★★	-	-	-	-	-	-
	★	★	★	★★★	★★	★	★
	★★★	-	★	★★★	★★	★	★
	★	-	★★	★★	★★★	★	★
	★★	-	-	-	-	-	-
	★★	★	★	★★★	★★	-	-
	Cfb	**Cfa**	**Cfa**	**Cfa**	**Cfa**	**Cfa**	**Cfa**
	★★★	★	★	★★	★★★	★	★
	★★★	★	★★	★★	★★★	★	★
	-	-	-	★★★	-	-	-
	-	-	-	-	★★★	-	-
	-	-	-	★★★	-	-	-
	★★	★★	★★	★★★	★★	★	★
	★★★	★★★	★★★	★★★	★★★	★★★	★★★
	★★★	★	★★★	★★★	★★★	★	★★
	-	-	-	★★★	★★★	-	-
	-	-	-	-	★★★	-	-
	★	★	-	★★	★★★	★★★	-
	★★★	★	-	★★	★★	★	★
	★★★	★	★	★★★	★★★	★	★★★

Component Site 1 is the only area where karst phenomena in gypsum-anhydrite occur and can be studied. It is also home to the largest salt spring in Europe, making it an extremely significant area for karst hydrogeology. The rocks are also of a different age compared to all the other component sites, representing events that occurred in the Triassic.

Component Site 2 was included in the candidate area because of the important role it has played in the history of karstic hydrogeology, being one of the first sites studied for this purpose, already in the 16th century. In it, as in the subsequent component sites, Miocene-age rocks crop out - considerably younger than those found in c.s.1.

Component Site 3 is a unique testimony to the evolution of karst systems in gypsum, as well as being a famous place for pioneering speleological studies, which is still accessible, even to a non-specialist public, thanks to its proximity to the centre of the city of Bologna. In addition to numerous speleothems in a cave of considerable extension, it is also known for its important mineralizations.

Component Site 4 is one of the places where modern speleology was born, thanks to the exceptional abundance of speleothems, minerals and an extremely extensive underground circulation (now known and mapped with extreme precision thanks to decades of exploration). It also records post-depositional biological and physical events that are unparalleled for the geological period and type of rocks involved.

Component Site 5 is similar in terms of richness of the speleothems, but unique in terms of the variety of crystalline habitats, and palaeontological content - this time syn-depositional - that make it one of the privileged sites in the world for the study of Messinian faunas during the Mediterranean salinity crisis. It is also the most extensive site, which clearly shows the importance of gypsum outcrops in this area, also in terms of landscape.

Component site 6 and 7 were included because they offer the evidence of the gypsum evolution in the geodynamic context of the Apennines. They contain important secondary rocks that were also used in the past as ornamental stones (gypsum alabaster) and caves that are accessible to the public.

3.2.B COMPARATIVE ANALYSIS WITH SIMILAR SITES INCLUDED IN THE WHL

As stated by P. Williams in his endorsement letter, as of today, no evaporite karst is included on the World Heritage List.

In 2008, in the IUCN document "*World Heritage Caves & Karst*" Recommendation 4 has been included stating that: *"States Parties whose territories include karst terrains situated on evaporite rocks consider the potential of their sites for natural World Heritage recognition"*.
In the recent revision of the framework for the application of criterion (viii) of the World Heritage Convention it was pointed out that *"there has been no progress regarding nominations in relation to gypsum karst"* (Mc Keever and Narbonne, 2021).
In 2008, IUCN undertook a global review of World Heritage Properties with internationally significant karst features of which 27 contained karst considered to be of outstanding universal value. Williams noted that in addition to these sites there were other WHS that containing karst of national or regional significance (Williams P., 2008). A new list by Williams, to be published by IUCN in the next years (according to Gunn J., 2021), comprises 54 WHS in 38 countries and includes 3 WHS with quartzite fluviokarst, one with conglomerate karst and one with vulcanokarst. All the remaining 49 WHS contain limestones, dolostones or marbles.
No World Heritage Site has included an evaporitic karst system as an outstanding universal value to be protected so far.

A provisional list of WHS with cave and/or karst interest circulated to members of the Cave and Karst Working Group in the IUCN World Commission on Protected Areas before 2020 and this resulted in several sites being added for which members had specific information. Most notable of these is the Wood Buffalo WHS in Canada, one of the world's great gypsum karstlands and it is clear that the site would have been recognized as such had it been nominated under criterion (viii). A more detailed analysis of this site is provided in the next chapter.

Other WHS may have local evaporite outcrops but their proportion against the size of the property is negligible and not representative of the phenomenon.

With regard to the national tentative lists, the "Salt Domes of Iran" have been included in 2017, but the country have not candidated it yet.

• *Stalactite curtain in the Buco dei Buoi cave (2011). Gessi Bolognesi*
© F.Grazioli

3.2.C COMPARATIVE ANALYSIS WITH OTHER SIMILAR SITES, NOT INCLUDED IN THE WHL

Several reviews of evaporite karst localities have been developed in recent years, focusing on speleological, mineralogical and environmental points of view. Many of these works predate this dossier and have been taken in account to summarise them into a general comparative overview of all the attributes that constitute the OUV. The holistic presentation of the state-of-the-art about gypsum karst provided in 1996 by Klimchouk, et al. in particular played a key role in the definition of the attributes,

Gypsum and, to a lesser extent, anhydrite formations are present in many areas of the World. Beside the Mediterranean area, these formations are particularly extensive in Russia, Ukraine and North America. Only few of them have been explored and studied yet.

Gypsum-anhydrite karst

Germany hosts hundreds of square kilometres of gypsum-anhydrite deposits, most of which buried below impervious formations (Kempe, 1966). Therefore, the epigenic karst phenomena are scarce and normally not impressive. Anyway, Germany is important because it hosts important anhydrite caves (Kempe, 2014, Kupetz M. & Knolle F., 2015). Even if relatively few epigenetic phenomena are known, most of the cavities developed in phreatic conditions (hypogenetic speleogenesis) therefore the resulted forms are few, while those in Emilia-Romagna are much more varied and complex. Many of these caves have been intercepted and partially destroyed by mining activities and few of them later transformed into show caves.

Gypsum karsts

Some of world gypsum karst areas have been at least partially explored and studied. In the following table the most important of them are considered in a comparative analysis carried out with the same approach mentioned in Chapter 3.b.1.

• *Location of other significant evaporitic karst sites*

COMPARATIVE ANALYSIS WITH OTHER SIMILAR SITES

LEGEND

nd = no data
- = not present;
★ = present;
★★ = significant;
★★★ = very significant
Cfa, Cfb = Climate classes

ATTRIBUTES

CRITERION VIII	main characters (attributes)	epigean	karst forms / geomorphology
			evolutionary typology
			hydrology (salt springs)
		hypogean	speleothems
			minerals
			crystal habit
			diapirism
			hydrogeology
	associated characters	climate (Köppen-Geiger classification)	
		extent of visible phenomenon density (quantitative value)	
		geological history	evaporite age
			recording of significant post-depositional geological phenomena
			syn-depositional palaeontology
			post-depositional palaeontology
	geo-diversity		diversity of geological context
			lithological diversity
			geomorphological diversity
	transmission of values		visibility of the geological phenomenon
			comprehensiveness of knowledge of the karst system (hydrogeology)
			site accessibility
			international scientific research (bibliometry)
			speleology / geology research centres in the surroundings
			pedagogic value

EVAPORITIC KARST AND CAVES OF NORTHERN APENNINES	SANTA NINFA - SICILY	VERZINO - CALABRIA	PODOLIA - UKRAINE	HARZ - GERMANY	SORBAS - SPAIN	PINEGA - RUSSIA	KUNGUR - RUSSIA	BIR AL GANHAM - ALGERIA	NEW MEXICO - USA	NEUQUÉN - ARGENTINA	PUNTA ALEGRE - CUBA	KAVAJA - ALBANIA
★★	★★	★	★	-	★★	★	★	★	★	★	★	★
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★★★	★★	★	★	★	★★	-	★★★	★	★★	-	★	nd
★★★	★	-	★★	★	★	★	★★★	★	★★	★		nd
★★★	★★	★	★★	-	★	★	★	-	★★	★	★	nd
★★★	★	★	★★	★	★	★	★	-	★	★	★	nd
Cfa Cfb	Csa	Csa	Dfb	Cfb	Bsk	Dfc	Dfb	Csa	Bsk	Bwk	Aw	Csa
★★★	★★	★	★★	★	★★	★	★★	★	★	★★	★	★★
★★	★★	★	★	★	★	★	★	★	★	★	★	★
★★★	★	-	★★	-	★	-	★	-	-	★	★	nd
★★★	-	-	-	-	-	-	-	-	-	-	-	nd
★★★	-	-	-	-	-	-	-	-	-	-	-	nd
★★	★★	★	-	-	★	-	★	★	★	★	★	nd
★★	★	★	-	-	★	★	★	-	★	★	-	nd
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Santa Ninfa, Sicily, Italy

The Santa Ninfa area hosts several surface and deep karst forms (Agnesi & Macaluso, 1989), most of them similar to those of the Northern Apennines area. The rocks are Messinian in age, coeval to the ones outcropping in component sites 2-7. The main differences with the candidate property are related to the variability of these forms and deposits, far wider in the Northern Apennines karst. Another difference is that in Santa Ninfa no paleontological remains are present.

Verzino, Calabria, Italy

The small Messinian gypsum outcrop hosts a single important and relatively long (a couple of km) karst system (Ferrini G., 1998). Presently this area has no specific safeguard.

Podolia, Ukraine

These maze caves are by far the longest gypsum caves of the world (Andreychouck, V. et al. 2009). Anyway, regarding criterion VIII, it must be stressed that morphologies and hosted speleothems of the Podolia caves exhibit, by far, less variability with respect to those of Emilia Romagna, moreover in Podolia a single karst cycle is present. According to our information Podolia gypsum karst still lacks of protection.

Harz Mountains, Germany

A belt of Permian and Triassic evaporite rocks provides discontinuous outcrops extending from central England to northern Germany. The best of the gypsum karst is in Germany's Harz Mountains (Kempe, 1996). Outcrops are scored by valleys dry since the early Pleistocene, are pitted with dolines, and have deeply pinnacled rockheads (bedrock surface on which unconsolidated sediment is deposited) largely mantled by soils of insoluble residues. Five caves reach lengths of 1500–2500 m, with drained phreatic passages and large breakdown rooms.
These caves generally developed along the interface where anhydrite is actively gypsified. Some of the features are similar to those of the Triassic gypsum-anhydrite of the Secchia valley with the exception of the hypogean bends, which are unique of the property area. Furthermore, no karst in younger evaporite rocks, such as the Messianian gypsum, is present in the Harz area.

Sorbas Gypsum Karst Almeria, Spain

This karst area is very similar to the gypsum properties of the Emilia-Romagna being developed in the same Messinian formations. Karst and caves are relatively well explored documented and studied (Calaforra J.M., 1998). In general, their dimension is smaller and only the actual karst cycle is represented. Moreover, they lack of several forms and speleothems as well as cave minerals present in the Emilia-Romagna properties. No paleontological remains are hosted in those caves.

Pinega, Russia

Permian gypsum is covered by thick fluvio-glacial deposits and occupies a large portion of territory (Malkov V.N. & Shavrina E.V., 1991). The Pinega gypsum karst is inserted in a Natural Park. Regarding the criterion VIII surface karst forms are rare and represented only by a few vertical sinkholes and by seasonal springs along the main river cutting the area. Caves are very recent (most of them developed after the last glaciation) and partially frozen all the year. The single hosted morphologies are related to the early summer floods. Only a very few speleothems and practically no cave minerals beside ice have been reported from these caves.

Kungur, Russia

The Permian gypsum hosts lot of sinkholes, several different small karst forms and a few caves, the most renown of which is the Kungur Ice Cave (Gorbunova, K. A. 1995). Regarding the criterion VIII the main characteristic is given by the huge ice deposits giving rise to formations and large

crystals while speleothems are restricted to few and small gypsum ones. This cave hosts also some ephemeral minerals segregated by the freezing lakes in the winter time. Kungur caves karst has scarce paleontological and/or archaeological value, and presently is subject to a poor protection policy. Moreover, the Kungur cave is open to the public with very few restrictions, therefore it is not well preserved.

Bir al Ganham, Algeria

The area hosts a rather large cavity (Bir al Ganham) (Calandri G. & Ramella L., 1987) with a few speleothems and cave minerals. At the moment no kind of safeguard exists for the whole karst area.

New Mexico, USA

The large peneplanar area of outcropping gypsum is characterized by flat extremely large dolines at the bottom of which sometimes sinkholes allow the access to even large caves (Peerman S. & Belski D., 1991). This karst area has been only partially explored and mapped but no specific analyses and studies have been performed until now. The absence of protection and the quite total lack of knowledge on their characteristics does not allow to develop an in-depth comparative analysis of this region.

Neuquén Mendoza, Argentina

There are several relatively small outcrops which host sparse dolines, karren-fields and some peculiar forms like small chimneys (Forti P. et al., 1993). Some gypsum caves are also known but their size is generally small. Only a minor part of these areas has been at least partially explored.

Punta Alegre, Cuba

The karst area of Punta Alegre is very small (Chiesi M. et al. 1993), consisting of a diapir in which few, very small, gypsum caves (never exceeding 20-30 m in length) are present. All the karst forms are controlled by the peculiar tropical climate, which allows also the development of a few interesting speleothems and cave minerals. A couple of caves (locally named Cuevas do Calor) host huge bat colonies during the breeding seasons. This area has no specific safeguard rules and the karst aquifer is hardly polluted by a factory of a traditional liquor from sugar can.

Somalia

Evaporite karst is unusual in sub-Saharan Africa but is well developed in gypsum and anhydrite on the northern Haud Plateau in Somalia. Shallow solution dolines up to 100 m in diameter are common, while many collapse dolines up to 50 m in diameter and 15m deep lead into caves 0.5–20 m below the surface, such as Ail Afwein (1275 m long) and Las Anod (1455 m long). Gypsum speleothems and crystals are common, and hyenas occupy many entrances. On the limestone Baidoa Plateau in southern Somalia there are several 1–3 km long structural/erosional basins with lakes including those at Ted, Moragavi, and Burdo. In the east, the plateau has a thick soil cover and some of the numerous shallow depressions contain perched water bodies.

Zeravshansky range (Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan)

There are many evaporite karsts in the Kyrktau Plateau (Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan), and it is the aridity that allows karst landscapes to survive on evaporites. Not many publications are available about this area. By direct observation, at least in Turkmenistan there is a scarce geodiversity with regard to epigean forms (small dolines, a few caves and wells) without any specific protection.

Wolf Creek, Australia

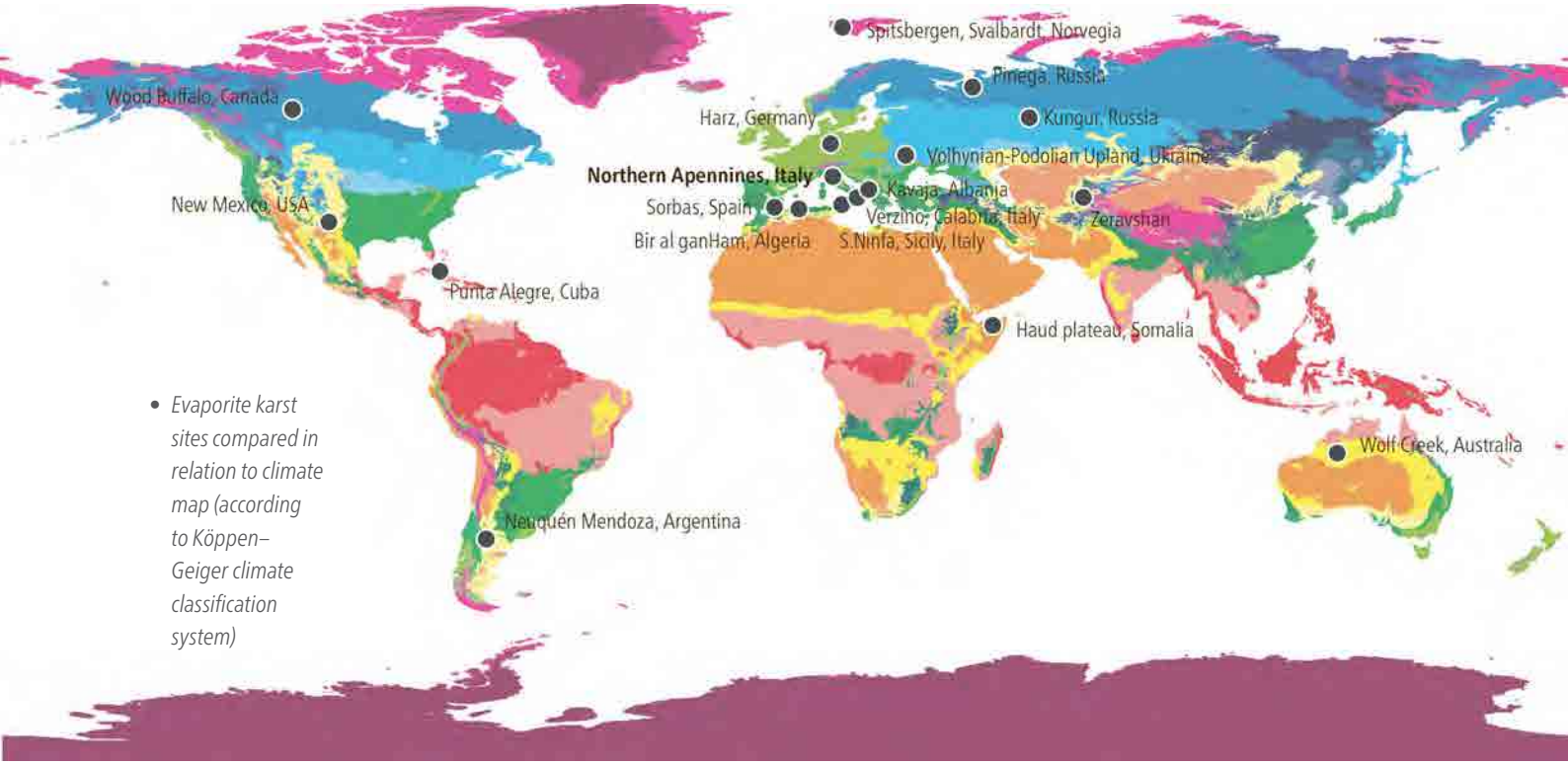
Little evaporite karst is known, apart from a few small gypsum caves in the Wolf Creek meteorite crater, Western Australia.

Wood Buffalo, Canada

Karst rocks are widely distributed around the central Precambrian Shield in Canada with 80,000 km^2 of evaporite rocks. "Outcrop" is something of a misnomer in much of the lowlands, because the karst bedrocks are buried under many metres of glacial till, outwash, etc. and are often hydrologically inert. However, in suitable conditions, glacial deposits may also preserve karst aquifers and enhance their productivity, while the most rapid rates of cave development anywhere probably occur around glacier margins during the melting stages. The combination of low relief and widespread burial by glacial deposits limits modern karst to narrow zones of higher hydraulic gradient, such as crests of escarpments or river gorges. Wood Buffalo National Park contains the most extensive gypsum karst in Canada, chiefly suffusion dolines where there is only glacial till on the gypsum, and larger collapse dolines with a thin cover of dolostone. Known caves are few, becoming water-filled or blocked by ice.

Scandinavia

Scandinavia contains only small areas of karst, and little outside the outcrops of the Lower Palaeozoic carbonates of Norland in Norway (Svalbard: west coast of Spitsbergen) and the island of Gotland in Sweden. Abundant Permian evaporites (anhydrite) give rise to high sulphate content of groundwater, and gypsum precipitates in icings. Although the karst is presently in a permafrozen state there are active sub- permafrost aquifers, fed from the underside of polythermal glaciers. Hence, the area serves as a modern analogue for subglacial karstification in northern Europe during the Pleistocene glaciations.



• *Evaporite karst sites compared in relation to climate map (according to Köppen–Geiger climate classification system)*

INTERNATIONAL SCIENTIFIC ENDORSEMENTS TO THE NOMINATION

During the candidature process, several endorsements were collected in favour of the specific recognition of this area as a World Heritage Site by dozens of exponents of the international scientific community. Among them many specialists recognized for their expertise in the areas mentioned in the comparative analysis are included, strengthening its value. The endorsement body consists of more than 55 researchers and university professors (mineralogists, karst geomorphologists, geologists, archaeologists), 22 high-profile representatives of the International Speleological Union and of national and international caving associations from all over the world, 10 members of commissions for biodiversity, for protection, for the research of karst in evaporites.
Included are numerous authors of comparative studies on a global scale or scientists in roles that have allowed them to compare numerous evaporitic karst sites around the world:

Paul Williams

In the recent revision of the framework for the application of criterion (viii) of the World Heritage Convention it was pointed out that "there has been no progress regarding nominations in relation to gypsum karst" (Mc Keever and Narbonne 2021).

This new nomination of the Evaporite Karst and Caves of Emilia Romagna is therefore timely and justifies serious consideration. I also commend another important and unusual feature about the site and that is the extraordinarily long (since 1612) and detailed record of scientific publications associated with the gypsum area. The Emilia Romagna district has clearly been recognised as an area of special scientific interest for centuries.

Stephan Kempe

The gypsum outcrops of the Northern Apennine (Emilia Romagna) in Italy cover a much smaller area (50 km in total) but feature a much larger number of caves, i.e., ca. 700, apparently all epigenic. This alone is an outstanding attribute not matched by cave densities in other gypsum areas of the world. Furthermore, the Emilia Romagna karst is not a coherent area, but represents six separate parcels composed of two different stratigraphic units (Triassic anhydrite, ca. 20 km, and Messinian gypsum, ca. 30 km). The total added cave length approaches 100 km, a large sum for a small area, only topped by the hypogenic maze-caves of Podolia (Ukraine and Moldavia). Furthermore, the deepest yet discovered sulfate cave is also located here (265 m-deep anhydrite cave Caldina Abyss).

Apart from the caves as such, the area is also known for its diverse mineralogy, more diverse than in any other area yet described. This is due to the effort of the eminent mineralogist Prof. P. Forti, who has discovered and described a series of minerals previously not documented in caves. This leads to another outstanding attribute of the Emilia Romagna: its importance in science. Due to the proximity of the University of Bologna, one of the oldest in Europe, to the areas in question, research has a remarkably long history for the area. Some of very important geological and speleological discoveries were made here and the publication record for the area is impressive,

even though other areas may have similar records, published in local languages.

Alexander Klimchouk

To date there are no representative sites of karst phenomena in evaporites in the UNESCO World Heritage List, compared to more than 37 sites in limestones. These phenomena must certainly be represented in the World Heritage List, – at least by one site for each of two fundamental genetic categories of karst, epigenic and hypogenic, which differ drastically in their basic characteristics.

The Evaporite Karst and Caves of Emilia Romagna is the foremost example of epigenic karst in these lithologies, due to its outstanding landscape characteristics, high value as the repository of scientific information about evolution of environmental conditions, its great historical interest and high level of protection by national and regional regulations. This karst region is one of the best studied in the world and has the very detailed geological, archaeological and environmental documentation.

George Veni

In 1997, I visited the Northern Apennine area and was surprised to find this well-developed evaporite karst. Gypsum, the evaporite rock predominantly exposed, dissolves rapidly and is degraded in temperate climates and yet there it was, preserved beautifully with large caves, diverse and rare geological features, and a rich cave-adapted ecosystem. I knew immediately this was a special place and worthy of protection. As I studied the region further, I found over 300 scientific papers have documented the area since my visit, demonstrating its international value and importance.

I have travelled around the world to dozens of countries to study their karst and can report that the Northern Apennine Evaporite Karst is the best example of temperate climate evaporite karst I have seen or have read about.

International speleological associations/commissions that provided an endorsement to this candidature:

Country	Institution name
	European Speleological Federation
	International Union of Speleology - UIS
	Karst and Cave Protection Commission UIS
	European Environmental Bureau European Cave Protection Commission

International associations/commissions that provided an endorsement to this candidature:

Country	Institution name
Albania	International Music Council (UNESCO)
Slovenia	UNESCO Chair on Karst Education

Universities and research centres that provided an endorsement to this candidature:

Country	Institution name
Albania	Academy of Fine Arts, Tirana
Albania	University of Tirana
Austria	Naturhistorisches Museum Wien
Georgia	Tbilisi State University
Germany	Technische Universität Darmstadt
Israel	The Hebrew University of Jerusalem, Institute of Earth Sciences, Israel Cave Research Center
Italy	Istituto italiano di Speleologia, Università di Bologna
Italy	Istituto Italiano Di Preistoria E Protostoria
Italy	Polytechnic University of Turin
Italy	Union Internationale de Radioécologie
Italy	University of Bari, Earth and Geo-Environment Sciences dept.
Italy	University of Florence
Italy	University of Trento, Department of Humanities
Italy	University of Trieste, Geosciences and Mathematics dept.
Italy	University of Palermo, Head of Earth and Sea Sciences department
New Zealand	The University of Auckland
Poland	University of Warsaw, Faculty of Geography and Regional Studies
Portugal	Azores University
Portugal	Centro de Arqueologia da Universidade de Lisboa. Faculdade de Letras de Lisboa.
Portugal	Centro Ciência Viva do Alviela - Carsoscópio
Portugal	Ciência Viva
Portugal	Department of Geography and Tourism, University of Coimbra
Portugal	Façultade de Ciências da Universidade de Lisboa
Portugal	Instituto Português do Mar e da Atmosfera
Portugal	Instituto Superior Técnico, University of Lisbon
Portugal	Portuguese Institute for the Conservation of Nature and Forests
Portugal	University of Algarve / CCMAR, Centre of Marine Sciences
Portugal	University of Évora
Russia	Department of Physical Geography and landscape ecology PSNIU
Slovenia	ZRC SAZU Karst Research Institute
Spain	Universidad de Almería
Swiss	Swiss Institute for Speleology and Karst Studies
Ukraine	Institute of Geological Sciences of NAS of Ukraine
Venezuela	Universidad Central de Venezuela
USA	University of South Florida
USA	US National Cave and Karst Research Institute

• *(facing page) Vertical conduit in the Tre Anelli cave (2012) . Vena del Gesso Romagnolo © P.Lucci*

National scientific commissions/foundations that provided an endorsement to this candidature:

Country	Institution name
Albania	Academy of Sciences of Albania
Albania	Commission of Art and Heritage at the Academy of Sciences of Albania
Albania	Art & Heritage Academy ODEA
Brazil	Ministério do meio ambiente - Instituto Chico Mendes de conservação da biodiversidade - centro nacional de pesquisa e conservação de cavernas
Brazil	Fundação cultural "Pascoal Andreta"
Portugal	Scientific Council of the SPE – Portuguese Speleological Society
Portugal	Sociedade Geológica de Portugal
Russia	State Institute of the Ural Branch of the Russian Academy of Sciences
Ukraine	National Academy of Sciences of Ukraine;

National speleological associations that provided an endorsement to this candidature:

Country	Institution name
Albania	Albanian Speleological Didactic Scientific Association
Argentina	Federación Unión Argentina de Espeleología
Belgium	Fédération Nationale Belge de Spéléologie
Belgium	Nationaal Speleologisch Verbond van België
Brazil	Brazilian Speleological Society - International Relations Section
Brazil	Sociedade Brasileira de Espeleologia
Cyprus	Mağara Meraklıları Derneği
Italy	Società Speleologica Italiana
Mexico	Unión Mexicana de Agrupaciones Espeleológicas A.C.
Portorico	Federación Espeleológica de América Latina y del Caribe, Departamento de estado de Puerto Rico
Portugal	Portuguese Speleological Society
Spain	Sociedad Española de Espeleología y Ciencias del Karst

The complete list and all the endorsements are attached in the Annexes.

Conclusions

For the above-mentioned reasons, despite the Northern Apennines is not the widest evaporitic karst area in the world, the density of geological processes, the uniqueness of geologic-climatic factors, the physical and cultural accessibility and the role that consequently it had in the development of speleology, mineralogy, hydrogeology allow to state that **there are no other systems in the world that compare to the Northern Apennines**.

3.3 PROPOSED STATEMENT OF OUTSTANDING UNIVERSAL VALUE

A. Brief synthesis

The **Evaporite Karst and Caves of Northern Apennines** serial property constitute the most complete, outstanding and accessible examples of the karst phenomena in gypsum and anhydrite at sub-tropical wet climate conditions. Located in northern Italy, this serial site unites together the most internationally studied areas with regard to hydrogeology, mineralogy and speleology in evaporitic karstic systems since 16th century: the explorations and discoveries that took place in this area are considered as milestones in the development of the respective disciplines. As highlighted by the comparative analysis, many speleothems and minerals are unique to this area, due to a complex relationship between rocks, geological evolution and climate. The serial property includes all the deposits that host different type of mineralogical evolution of gypsum, including its transformation into anhydrite and alabaster, as well as all the historical study areas described in the pioneer speleological publications.

In fact, despite evaporite karst is generally considered unspectacular compared to limestone, in this area it constitutes a prominent feature of the landscape and crystals over one meter across can be observed in some localities. In a very narrow belt made of vertical cliffs emerging from the surrounding clays it is possible to study the evolution of Mesozoic and Cenozoic evaporitic deposits, with the same access easiness that led to their exploration since the pre-scientific era. Actually, caves have been explored since prehistoric times, and they became one of the first excavation areas of lapis specularis, the stunning transparent crystals, which replaced glass during Roman times.

Excavation in the area is strictly regulated in order to preserve the caves and the landscape. The standards of protection, management (including specific hypogean protection measures) and monitoring ensure that the Evaporite Karst and Caves of Northern Apennines phenomena and the ecosystems that are linked to them will be preserved and continue to evolve naturally.

For these reasons this area can be considered an unicum on the entire planet, that collects, protects, documents and makes available to scientists from all over the world the set of karst forms and phenomena that develop in evaporites in subtropical-humid climates.

B. Justification for criteria

Criterion VIII.

The nominated serial property comprises one of the most complete evaporitic karst systems in the world. By an exceptional combination of humid sub-tropical climatic conditions and a peculiar geological setting, the candidate area is a one of his kind in the world. It constitutes one of the best places where karst in gypsum and anhydrite deposits can be observed and studied. In a relatively small area over 900 caves (amongst the largest, deepest and most complex of this type in the world) allow an easy access to most of the phenomena observable in evaporitic karst, a geological setting not yet represented in the World Heritage List (Williams P.*, 2008; Gunn J., 2021**).

An uncommon richness of rare speleothems and minerals, sometimes unique to these caves, have attracted naturalists and scientists since the 16th century. In these places the discipline of speleology in evaporites was born, and tens of phenomena have been described here for the first time.

Nowadays the rocks and caves of the Northern Apennines represent the best scientifically documented sulfate-halite karst in the world from the geological, speleological and hydrological points of view. These features can be easily accessed and explored, making this area a leading evaporitic karst research location.

* *Paul Williams (2008). World Heritage Caves and Karst. Gland, Switzerland: IUCN. 57pp.*

** *Gunn J. 2021. Karst groundwater in UNESCO protected areas: a global overview. Hydrogeology Journal, 29(1), 297-314.*

C. Statement of integrity

The seven component sites of the nominated serial property involve approximately 90% of the entire evaporitic rocks of the northern Apennine chain. They represent the entire karst phenomena in gypsum and anhydrite, including all the outcropping and underground karst areas, all the main karst aquifers, and all their recharge areas. They also include a complete collection of epigean and hypogean karst morphologies from the dissolution surfaces in vertically exposed gypsum cliffs to the speleothems in the abysses of the caves.

From the environmental integrity point of view, the quality of the karst systems is excellent. The continuity of the karst hydrological system, above and below ground, is well preserved in all the component sites. The fruition of the few caves open to the public takes place with speleological modalities, without alterations of the natural cavities and their habitats.

From the development pressures point of view, settlement pressures are absent, although some component sites fall within the range of influence of intensely settled areas, agriculture – if present - is very limited and extensive, and the management of the existing woods is conservative, aimed at increasing their wilderness. The mining exploitation of gypsum for local use, which has affected these areas since Roman times, is now prohibited in the nominated property.

As a whole, the natural property is essentially perceived also as a site of scientific and cultural interest and therefore the human use and intervention are very limited.

D. Statement of authenticity for properties nominated under criteria (i) to (vi)

Not relevant as this nomination is submitted under criterion (viii).

E. Requirements for protection and management

All evaporitic karst areas of the nominated property are specifically identified and strictly protected by a specific geological and speleological heritage protection act, in accordance with European, national and regional regulations.

The great majority (96%) of the nominated property is protected by European Community directives and is part of the Natura 2000 Network. Most of the candidate property (71%) is protected by a national park and by two regional parks. The remaining areas are nature reserves and protected landscapes, preserved by law. The land adjacent to the nominated property is subject to the territorial and landscape planning of the Emilia-Romagna Region that establishes the rules for the management of the territory and is one of the most effective tools to implement the protection measures.

The management system consists of two bodies. The component site 1 is managed by the Appennino Tosco-Emiliano National Park. The component sites from 2 to 7 are under the control of the the Emilia-Romagna Region which directly supervise the management bodies of the regional protected areas. These management bodies have a management plan, a specific budget and a dedicated staff (technical and administrative) to manage and control the respective areas.

Key management issues include the protection of the attributes and values of the geological heritage, conservation measures for habitats and species of Community interest, knowledge and communication of the natural environments. The karst hydrological system is also a very relevant management topic in these highly dynamic environments. Other management themes include education, enhancement, the quality of visitor experience, and finally the environmental restoration and conversion of abandoned and disused quarries for educational purposes.

A long-term monitoring system has been set up, using ground- and underground-based observations, for improved evaluation of the chemical and ecological state of karst aquifers, seismo-tectonic movements, and climate cave conditions. Key aspects of the property's flora and fauna are also monitored.

STATE OF CONSERVATION
AND FACTORS AFFECTING THE PROPERTY

4

4.A PRESENT STATE OF CONSERVATION

It is widely believed that rocks and landforms are essentially immutable and therefore not subject to change or damage by human activities or natural events. For this reason, it is assumed that they do not need special measures for their conservation. In reality this is not the case, as rocks and landforms are sensitive to both natural threats and human intervention, particularly evaporitic rocks as they are easily soluble.

Taking into account the peculiar, somewhat unique characteristics of the candidate property within the current WHL sites, conservation measures must be identified taking into account the general principles for geo-conservation (IUCN – Crofts et al., 2020) applied to the elements that constitute the Outstanding Universal Value. The attributes that determine the criterion for inclusion include: the presence of a significant on-going geological process (evaporitic karst in sub-tropical humid climate), some significant geomorphic or physiographic features (including more than 900 caves, among the deepest and more complex of their kind in the world), a key role in the early development of evaporite karst scientific disciplines and a significative representation of major stages of Earth's history.

These multiple values of geodiversity and geoheritage have been recognised and identified in the territory and they are now part of a large inventory. Their vulnerabilities were known and subject to an assessment since the late 1980s that locally drove to a specific protection, like in c.s.5. In the last 30 years a combination of specific protection measures has thus been developed and now almost the entire karst systems are protected by law, both above and below the surface. The site is thus adequately protected by various laws and regulations, and benefits already from effective and mature integrated regional governance and land-management policies, with a notably high level of local input to decision making. As a consequence of the development of the regional mining plan and of the environmental and land-use plans, a comprehensive monitoring campaign took place in the whole area since the late 1990s – as described in detail on chapter 6. The regional and national management strategy for the area includes several protection measures that can guarantee for a maintenance or improvement of the actual conservation of both abiotic and biotic values of the candidate property for a long term, virtually indefinitely.

The Cadastre of natural cavities

The "Cadastre of natural cavities" originates from a first nucleus of 112 caves included as early as 1934 in the first National Cadastre, then kept at the Italian Institute of Speleology in Postojna (present-day Slovenia).

In 1959 the Regional Commission for the Land Registry of the natural cavities of Emilia-Romagna was set up and began the systematic work of retrieving data from the newly discovered caves.

This work led to the publication, in 1980, of the first regional cadastre of natural cavities, by the Emilia-Romagna Regional Speleological Federation (FSRER) and the Region authority, including a list of 564 caves. Currently the caves included in the Land Registry of the natural cavities of Emilia-Romagna are more than 900, for a total development of about 90 km in lenght.

The results of the comprehensive land and nature management strategy, which is subject to regular review and updating, as well as an effective long-term monitoring system already in place, allow to say that the candidate property is in a good state of conservation and the state is likely to be maintained, or increased, for the foreseeable future.

A detailed overview of the **state of conservation** of both **abiotic and biotic systems** is provided in the next paragraph.

- *(in front) The Triassic gypsum cropping out along the Secchia Valley with the Miocene calcarenite slab of the Pietra di Bismantova in the background © G. Bianchini*

The left-hand columns list the key issues of active conservation and the cultural components and physical characteristics at which conservation actions are directed; the right-hand columns describe how conservation actions are implemented and who is responsible for implementing them.
The last columns indicate whether the single component site is the subject of that specific activity
All the component sites share the same level of knowledge, analysis, approach to mitigate vulnerabilities and monitoring strategy.

KEY ISSUES	PHISICAL AND CULTURAL FEATURES	
identification of the intrinsic geologic value	significant on-going geological processes	karst morphologies
		caves
		springs
	significant geomorphic or physiographic features.	speleothems
		minerals
	importance for the development of evaporite karst scientific disciplines	original book and articles
		original localities identification
	representation of major stages of earth's history	evaporitic rocks
vulnerability assessment	significant on-going geological processes	climate change sensitivity
		vulnerability to natural phenomena
		active human exploitation
protection	significant on-going geological processes	landscape
		lithic resources
		water resources
	significant geomorphic or physiographic features.	landscape
	importance for the development of evaporite karst scientific disciplines	accessibility assurance
		original studies and materials accessibility
	biodiversity controlled by geologic features	habitats
monitoring	significant on-going geological processes	karst morphologies
		cave minerals and speleothems
		springs
	importance for the development of evaporite karst scientific disciplines (and geological awareness)	cultural facilities
		caves access

IMPLEMENTING MEANS	IMPLEMENTING AUTHORITY	c.s.1 - Alta Valle del Secchia	c.s.2 - Bassa Collina Reggiana	c.s.3 - Gessi di Zola Predosa	c.s.4 - Gessi Bolognesi	c.s.5 - Vena del Gesso Romagnola	c.s.6 - Evaporiti di San Leo	c.s.7 - Gessi di Onferno
geological maps	Regional Geologic Survey	✔	✔	✔	✔	✔	✔	✔
caves inventory	Regional Speleological Association	✔	✔	✔	✔	✔	✔	✔
hydrogeologic maps	Regional Geologic Survey	✔	✔	✔	✔	✔	✔	✔
scientific publications	Universities, Regional Speleological Association	✔	✔	✔	✔	✔	✔	✔
scientific publications	Universities, Regional Speleological Association	✔	✔	✔	✔	✔	✔	✔
scientific research	Public Libraries; Universities	✔	✔	✔	✔	✔	✔	✔
field studies; scientific research	Universities; Regional Speleological Association; Regional Geologic Survey	✔	✔	✔	✔	✔	✔	✔
scientific publications	Universities, Regional Speleological Association	✔	✔	✔	✔	✔	✔	✔
vulnerability assessment of water resources	Regional Agency; Regional Geologic Survey	✔	✔	✔	✔	✔	✔	✔
geological and geomorphological vulnerability assessment of geologic sites to earthquakes, floods in regional plans	Regional Geologic Survey	✔	✔	✔	✔	✔	✔	✔
demand prevision of raw materials, ornamental stones, rocks for chemical industry in the regional extractive plans	Regional Geologic Survey; Regional Land-Use Planning Office	✔	✔	✔	✔	✔	✔	✔
national and regional laws; land-use planning;	Regional Offices;	✔	✔	✔	✔	✔	✔	✔
regional laws and planning	Mining Police;	✔	✔	✔	✔	✔	✔	✔
regional laws and planning	Regional Laws And Planning Office;	✔	✔	✔	✔	✔	✔	✔
national and regional laws; land-use planning;	National And Regional Laws; Land-Use Planning;	✔	✔	✔	✔	✔	✔	✔
regulation of caves access; security;	Park Forestal Police; Regional Speleological Association	✔	✔	✔	✔	✔	✔	✔
original works preservation	Public Libraries; University Book Collections	✔	✔	✔	✔	✔	✔	✔
regional laws; park regulation; land-use planning;	Regional Laws; Park Regulation; Land-Use Planning;	✔	✔	✔	✔	✔	✔	✔
monitoring of mining exploitation (regulated, illegal)	Mining Police; Regional Land-Use Planning Office	✔	✔	✔	✔	✔	✔	✔
monitoring of caves integrity	Regional Speleological Association; Parks Staff	✔	✔	✔	✔	✔	✔	✔
water resources monitoring	Regional Environmental Agency	✔	✔	✔	✔	✔	✔	✔
monitoring of museum/cultural facilities access	Regional Speleological Association; Parks Staff; Cultural Associations	✔	✔	✔	✔	✔	✔	✔
monitoring of authorised caves access	Regional Speleological Association; Parks Staff; Cultural Associations	✔	✔	✔	✔	✔	✔	✔

Ridge area - Component Site 1

- *The Monte Rosso cliff along the Secchia river valley (2010). Alta Valle del Secchia © Piero Lucci*

The Triassic gypsum is subject to an extremely rapid geomorphological evolution due to the strong deformation of the rocks and the presence of covering deposits formed by the continuous dissolution of halite in the subsoil. The direct erosion-dissolution of the Secchia river along the main evaporite body for a few kilometres directly at the foot of the vertical gypsum scarps creates the condition for countless rockfalls and the vertical wall is continuously changing.

The river is also eroding the toes of landslide deposits originated in the argillaceous rocks laying at the back of the evaporite masses, a condition which would possibly trigger further back-stepping of the landslide crowns in the future. In this extremely dynamic scenario, characterised by scarce vegetation due to the chemical characteristics of the soil, human activities play a negligible role: new collapse features by karst dissolution are expected to form because halite and gypsum in the subsurface are continuously removed by karst water flow and landforms change continuously being modelled by erosion, rockfalls and mudslides.

Lower hills area and Eastern area - Component Sites 2-7

Erosion and collapses phenomena in the Messinian gypsum areas are much slower than in the Triassic evaporites, as highly-soluble halite is not present in the subsurface. The most common phenomena are rockfalls from the gypsum cliffs and limited mudslides from the argillaceous formations lying both above and below the gypsum strata.

Natural phenomena in Messinian deposits cannot be influenced by human activity as the integrity of the evaporite protected areas is guaranteed by a series of restrictions provided by the park management plans, regional landscape plan, and Natura 2000 regulations.

The measures include: preventing the access to motor vehicles (unless authorized for scientific research or civil defence activities), forbidding the modification of water regimes, prohibiting mining and quarrying exploitation, as well as collection and removal of soil, minerals, rocks and any other material (also regulated by national or regional laws).

Cave Minerals and Speleothems

The mineralogical and speleothems heritage is mainly concentrated in a few caves, all located in the zones of maximum preservation of the regional protected areas. The collection of minerals and speleothems is strictly forbidden. The indirect damaged eventually caused by speleological exploration is minimised by careful behaviours, education and by definition of precise paths to follow inside the caves.

Lapis specularis

The karst cavities of the Messinian gypsum offer the possibility of observing mega-crystals of secondary gypsum. **These crystals have been excavated in ancient times** due to their aesthetic value as well as to use them as substitutes for glass. The particular characteristics of the crystals are the consequence of a specific process, visible only in a few caves in the World.

The fractures present in the Messinian evaporites are commonly filled with mud sediments in which transparent lenticular, "arrow head" or "swallow-tail" twin crystals formed, rarely exceeding one meter in length. The mechanism, completely original, which has allowed these gypsum crystals to develop, is closely linked to the presence of clay-silty fillings. The low permeability of the filling in the fractures allows a very slow water circulation characterized by poor exchange (evaporation and/or oxygenation) with the possibly aerated areas of the karst cavities. As a consequence, the

4.A.2 BIODIVERSITY: STATE OF CONSERVATION

Habitats

The conservation status of habitats in the nominated property can generally be considered good. There are six habitats that best characterize the property:

- *Sparse thermo-xerophilous vegetation of south-facing cliffs* (habitat 6110* of Directive 92/43/EEC "Rupicolous calcareous or basophilic grasslands of the Alysso-Sedion albi");
- *Marsh vegetation in the Poiano spring* (habitat 7210* of Directive 92/43/EEC "Calcareous fens with Cladium mariscus and species of the Caricion davallianae");
- *Chasmophytic vegetation of rocks exposed to the north and near the entrances of the caves* (habitat 8210 of Directive 92/43/EEC "Calcareous rocky slopes with chasmophytic vegetation");
- Caves (habitat 8310 of Directive 92/43/EEC "Caves not open to the public");
- *Woods of Tilia sp. and Acer pseudoplatanus of the cooler parts of the northern slopes* (habitat 9180* of directive 92/43/CEE "Tilio-Acerion forests of slopes, screes and ravines");
- *Forests dominated by Quercus pubescens of the southern slopes* (habitat 91AA* "Eastern white oak woods").

Four of these habitats have been the subject of the **LIFE Gypsum project** (see chapter 6), carried out by the three Parks (2010-2016). Thanks also to the plentiful interventions foreseen by this project, the habitats 6110 *, 7210*, 8210 and 8310 in the property can be considered the optimal and best-preserved example of such typologies on gypsum rock at European level. The LIFE project allowed:

- **Habitat 6110 *:** the restoration of sunny conditions in critical situations, by cutting exotic trees artificially planted in the 1950s; the protection of rocky substrates from the illegal car park by positioning cyclopic boulders; in-depth monitoring of the vegetation structure for better habitat characterization.
- **Habitat 7210*:** a complete restoration of the typical marsh vegetation, damaged by previous hydraulic adjustment operations.
- **Habitat 8210**: the physical protection of the accesses of some sinkholes and caves has allowed to avoid the accidental trampling of the fragile

supersaturation with gypsum remains extremely low, allowing the growth of a few crystals only. In this way, with a process that may have lasted over several millennia, not only very large crystals could form, but also, thanks to the slowness of the formation process, their crystal lattice is almost devoid of impurities, such as mud or iron oxides particles, thus being perfectly clear and transparent. This is the reason why the crystals were particularly sought after as lapis specularis by the Romans, with the opening of many mines in the Vena del Gesso Romagnola.

Because the particular "swallow-tail" and/or "arrow head" gypsum crystallizations were present inside fractures intercepted by the underground quarries, starting since the end of the mining activities it was no longer possible to find these crystals directly on site. However, they are exhibited in the specialized museum collections of the Natural Science Museum in Faenza, Bombicci Mineralogy Museum of the University of Bologna, Luigi Fantini Museum of the Gruppo Speleologico Bolognese-Unione Speleologica Bolognese, in Bologna, where it is possible to observe and study them.

chasmophytic vegetation; tons of waste, accumulated in the first 60 years of the 20th century, have been removed, increasing the space available for habitat development.

- **Habitat 8310:** the regulation and protection (by special gates designed to facilitate the bats flight paths) of caves accesses, allowed to decrease the disturbance of bats colony and other fauna; tons of waste, accumulated in the first 60 years of the 20th century, have been removed, recreating useful passages for the movement of bats.

The 91AA* habitat is currently the subject of another **LIFE 4 Oakforests project**, launched in 2017 and aimed at improving the forest and floristic structure and composition of these woods and to remove the artificial reforestations with exotic pines in the Vena del Gesso Romagnola area.

Microbiological aspects (water quality)

The karst systems waters of the property are mostly microbiologically pure, also thanks to the protection of waterways upstream and water catchment areas, included in natural parks and Natura 2000 network sites. All the species and microbial groups present in the underground waters are natural and are not consequence of human activities.

Flora

The conservation status of the plants in the candidate property is on average good. The spontaneous flora is everywhere safeguarded in the protected areas: territorial park plans, park regulations, reserve regulations, conservation measures for Natura 2000 and management plans as well include specific protection rules.

The number of new species discovered in recent years is high and only very few species, recorded in the past, have not been confirmed in the last decade. Extinction has been verified only for very few species and, for the most interesting ones (e.g. *Asplenium sagittatum*), a reintroduction project is planned in the Vena del Gesso Romagnola area. Among the species present and in some way threatened, they must be highlighted:

• *Allosorus (Cheilanthes) persicus*

- *Allosorus (Cheilanthes) persicus,* is threatened by loss of habitat due to spontaneous reforestation and the development of the old artificial reforestation with exotic pines;
- *Galanthus nivalis* (NT in the IUCN Red List) is threatened by the climate change (warmer temperature, less rainfall), but in the sinkholes it has an extremely favourable habitat, where the effects of these changes are mitigated by the phenomenon of thermal inversion
- *Bellevalia webbiana* (EN in the IUCN Red List) is threatened by loss of habitat due to land use changes (cultivation abandonment, spontaneous reforestation, building and infrastructure development), use of chemical herbicides and mowing of prairies in unsuitable periods. Moreover, the bulbs of *Bellevalia webbiana* are eaten by *Sus scrofa*;
- *Himantoglossum adriaticum* is threatened by changes cultivation in the grassland areas, use of chemical herbicides and mowing of prairies or road margins in unsuitable periods; along the roads it is also often damaged or destroyed during the extraordinary maintenance work on the road quay;
- *Delphinium fissum*: very localized species, threatened by the forest cover increase;
- *Anacamptis morio, A. pyramidalis, Ophrys apifera, O. bertolonii, O. fuciflora, O. fusca, O. insectifera, Orchis coriophora, O. provincialis, O. purpurea, O. papilionacea, Serapias vomeracea*: species threatened by forest cover increase, use of chemical herbicides and mowing of prairies or road margins in unsuitable periods;
- *Typha minima*: species threatened by the reclamation of small wetlands.

Micro-thermal species are also threatened, due to global warming: they are present only in

the sinkholes bottoms in the gorges exposed to the north, thanks to the phenomenon of thermal inversion, which stratifies the cold air coming out from the caves bottom. Some have almost disappeared in recent years (*Polystichum lonchitis)*, for the higher summer temperatures, but the cooler sites of the property are playing the very important role of "fresh islands" for the global conservation of these species.

Fauna

As for the flora, the rules and management activities of the protected areas ensure an adequate state of conservation of the fauna safeguarded in the protected areas: territorial park plans, park regulations, reserve regulations, conservation measures for Natura 2000 and management plans as well include specific protection rules.

As a result of the strict access regulation to the caves and to the protection of the catchment basins, the underground streams and caves invertebrate fauna is in a good state of conservation. The other species of cave invertebrates and *Speleomantes italicus* (NT in the IUCN Red List) are also in a good state of conservation, as the cavities are strictly protected. In the Croara cave only, occasionally there is a lack of water during part of the year.

Bats are strictly protected. All the most important species, regularly monitored, are stable or increasing, also thanks to the **LIFE Gypsum project** (2010 to 2016), that allowed the regulation, the protection of the cave accesses, the cleaning of the cavities, the significant disturbance decrease inside the caves and the improving of the bats living conditions. Furthermore, within the Monte Tondo gypsum quarry, the inert materials are used for partially closing the dismissed tunnels entrances, ensuring a more stable microclimate inside and allowing a rapid numerical development of bats colonies.

- *Plecotus auritus*
- *Rhinolophus ferrumequinum*

The conservation status of other wildlife groups is, in general, good, with some negative exceptions: *Bubo bubo* appears in general decline (the causes of this contraction of the local population are unknown). *Antus campestris, Riparia riparia, Lanius collurio, Emberiza hortulana* are in strong contraction, but this is a general condition for most of the European territory and the causes are, probably, to be found in the wintering districts in Africa. *Bombina pachypus* (EN in the IUCN Red List) has been strongly reduced in recent years, most likely due to chytridiomycosis. Osmoderma eremita (EN in the IUCN Red List) is extremely localized, but a LIFE Eremita project is underway, involving all three Parks that manage the sites of the candidate property, for the active conservation of this rare beetle. Even *Coenagrion castellani* (EN in the IUCN Red List), present only in the Vena del Gesso, is a species in contraction and also for it the same LIFE Eremita project has allowed important interventions to restore the fragile habitat of this rare damselfly.

4.B FACTORS AFFECTING THE PROPERTY

4.B.(i) DEVELOPMENT PRESSURES (E.G., ENCROACHMENT, ADAPTATION, AGRICULTURE, MINING)

Agriculture

Traditional agriculture in the area is mainly abandoned: the cultivation of the bottom of dolines for wheat or pasture is no more convenient. Only vineyards and olive groves are still present locally (in the Vena del Gesso Romagnola, most of all at the base of the southern slopes, together with some orchards, cereals and pastures). There are still some chestnut orchards on the northern, cool, slopes of Vena del Gesso: some are abandoned (near Rio Basino, Monte del Casino and Passo della Prè), some are still cultivated (like in Carnè, Sasso Letroso); in Sasso Letroso there is the most important and still well-cultivated chestnut orchard. In the Gessi Bolognesi area there is a higher variety, because the hills are lower and less rocky: olive groves have been recently introduced, there are vineyards, orchards and also cereals and pastures. In the Triassic Gypsum (c.s.1), in the Gessi di Zola Predosa (c.s.3) and in San Leo (c.s.6) areas agriculture is essentially absent.

• *Monte Mauro and the site of Grotta della Lucerna cave. Gypsum microclimate makes possible a Mediterranean cultivation in a Continental biome (2011). Vena del Gesso Romagnola © Piero Lucci*

Ridge area - Component Site 1

In the core area and in the buffer zone there is no agricultural activity except in a very residual one, as subsistence agriculture. The nominated property is mostly a rocky or covered in woods outcrop, and few factors can influence or threaten the property. The quality of the groundwater (monitored with the LIFE Gypsum project) and the surface water is very good. The forest management of the wooded areas is carried out according to the rules of the National Park Authority.

Possible threats are represented by the frequentation inside or outside the caves (waste abandonment and disturbance to the fauna), the excessive tourism in the Poiano Springs area, the hydraulic-morphological modifications of the Secchia river, made for security reasons (road erosion).

Lower hills area and Eastern area - Component Sites 2-7

In Component Sites 2, 3, 6 there is no agricultural activity except in a very residual one, as subsistence agriculture. The properties are mostly a rocky or covered in woods outcrop, and few factors can influence or threaten the nominated property. In Component Site 4 and 7 agriculture is very limited and extensive. The management of the woods is conservative, aimed at increasing the wilderness of the forest and protecting the numerous sporadic or rare species present there.

In over 30 years of activity, the Park Authorities has exercised strong control over all possible forms of water pollution that could negatively interfere with karst aquifers, whether of agricultural origin (pesticides, fertilizers, spreading) or of domestic origin. In the Vena del Gesso area (Component Site 5) practically no sector is subject to agricultural activities, apart from a large organic farm. The agriculture of the buffer zone is practiced with the integrated control method and presents mainly non-intensive crops, such as pastures (mainly extensive goat breeding), meadows, olive groves and vineyards. Throughout the core area the woods are managed for the purpose of a high-trunk conversion, according to the standards of the Park.

The underground waters (monitored during the **LIFE Gypsum project**) have excellent quality. Settlement pressures are almost absent.

Mining

The karst phenomena are largely intact. In particular, the large systems of the Caldina abyss in the Gessi Triassici, of the Spipola-Acquafredda and of the Croara in the Gessi Bolognesi, of the stream Gambellaro, of the streams Stella-Basino, of the dolines of Monte Mauro, of the stream Cavinale in the Vena del Gesso Romagnola are absolutely intact from every point of view. The sole exception is the system of Re Tiberio cave in the Vena del Gesso Romagnola Component Site, locally altered by the quarry of Monte Tondo.

In a not too distant past, however, the Messinian Gypsum areas, and only those ones, have been partially altered by the mining of the gypsum quarries both for lapis specularis (in Roman times) and for later plaster production. These quarries, in limited but sometimes very interesting areas, have damaged a part of the existing karst phenomena. To preserve the geological, ecological and landscape values of the gypsum outcrops, however, from the 1980s the Emilia-Romagna Region has progressively closed all these quarries - limiting the extractive activities as of today to Monte Tondo and Valmarecchia sites only.

Ridge area - Component Site 1

No quarrying activities are present in the area.

Lower hills area and Eastern area - Component Sites 2-7

In the protected area of Gessi Bolognesi the industrial gypsum exploitation stopped before the establishment of the Natural Park, since more than 35 years ago. The Park Authority is now owning of three of the five quarry areas active until the 1980s. No extractive activities are present nowadays in the core areas. In the buffer of c.s.5 the only active quarry is Monte Tondo. A few quarries are present outside the candidate property near c.s.6 and 7.

4.B.(ii) ENVIRONMENTAL PRESSURES (E.G., POLLUTION, CLIMATE CHANGE, DESERTIFICATION)

Ridge area - Component Site 1

The air pollution persistent in the Po valley does not affect the Triassic Gypsum area, because of the distance, the high

Monte Tondo Quarry

The Monte Tondo area (in the municipalities of Riolo Terme and Casola Valsenio), which is still involved in mining activities, is an exception to the overall comforting picture of the state of the main karst area in Romagna. Mining at Monte Tondo by the gypsum quarry began in **1958** (photo above) : it is the largest gypsum mining site in the European Union. The quarry near Borgo Rivola is indicated in the 1989 Regional Territorial Plan as the single centre in Emilia-Romagna for gypsum quarrying. While this choice has interrupted mining activity in the other Emilia-Romagna gypsum areas, it has led to concentrated exploitation in this area and the more than 20 km of tunnels excavated by the quarry, as well as the impressive external mining activity and the landfills located above the karst systems, have visibly altered the area. Some natural cavities have been intercepted and damaged in several places, the external and underground waters have been channelled and do not follow, to a large extent, their natural path.

From the early 1990s onwards, the Regional Speleological Federation of Emilia-Romagna and numerous local associations have intervened to monitor and safeguard the karst area of Monte Tondo from quarrying activities. Following the study commissioned to ARPA (Regional Agency for Prevention and Environment of Emilia-Romagna) by the Emilia-Romagna Region and completed in December 2001, an insurmountable limit to the extraction activity was assigned. The limit was accepted by the Intra-regional quarry plan (PIAE "Piano infraregionale delle attività estrattive") and so the karst systems near the quarry are mostly safeguarded. A subsequent study, promoted by Emilia-Romagna Region in order to assess the environmental and socio-economic impacts, and alternative solutions for the final settlement

and environmental recovery completed at the end of 2021 as the expiry of the current mining concession approaches, also recommends limiting the excavation to the area and volumes already defined in 2001 and decommissioning the quarry, after restoration, in no more than 10 years.

Although **the Monte Tondo Quarry area is not included in the Property,** it is located in the buffer zone of the c.s.5. Despite the fact that the area is characterized by an evident visual and hydrological impact, it was considered appropriate to include it in the buffer zone because the competent Administrative Bodies are currently working to find an optimal environmental, landscape and economic-social solution, to cease the exploitation in a time span allowing a complete restoration and reorganization of the employment. Similar positive experiences can be identified in the former Brisighella quarry, now managed by the Regional Park of the Vena del Gesso. From this perspective, the inclusion of the quarry area in the buffer zone may also be an additional tool to protect the integrity of of the Re Tiberio Cave system, a site of extreme scientific and speleological importance located next to the quarry area.

elevation and the presence of a constant ventilation due to the proximity to the Northern Apennine watershed, factors that guarantee excellent air quality. No agricultural activity is present in the area and therefore no chemical products are used. The small villages located upstream, outside the park area, are equipped with purification systems and no industrial settlements are present, therefore the superficial and ground waters are generally of excellent quality. The effect of climate change however may affect the conditions of the cool, shady southern sides of the evaporite outcrops and of the lower part of the dolines.

Lower hills area and Eastern area - Component Sites 2-7

The diffuse atmospheric pollution from the Po Valley is not a problem for these areas as the hill barrier laying in between does divert the winds blowing from the north and guarantee excellent air quality. Locally, the use of chemicals in agriculture can be a threat to bats. The waters are generally of good quality. Climate change is affecting the habitats and species linked to the wet and fresh conditions of the northern slopes and of the bottom of the sinkholes (e.g. rare ferns and mountain herbs). Extreme weather events may drastically change the hydraulics of underground waterways and cause disruption in the fragile ecosystem of cave invertebrates.

4.B.(iii) NATURAL DISASTERS AND RISK PREPAREDNESS. (EARTHQUAKES, FLOODS, FIRES, LANDSLIDES, ETC.)

The nominated property has been subjected to natural phenomena, including landslides and rock collapses, induced by rainfall (rarely by seismic shocks), and important floods of the main streams. All these so-called "natural disasters", which actually contributed to shape the morphological and landscape evolution of the nominated property, are addressed in the Civil Protection emergency plan of the local communities and are periodically updated. Specific measures, for the Triassic Gypsum area, include an automatic system to close the visitor centres access road in case of flood by the nearby Secchia river. In the Messinian gypsum areas, some dolines have been protected by a gate to prevent the debris transported from blocking the water flow during floods.

The caves accesses are regulated according to guidelines and assistance support from the local speleological groups. Selected members of the groups are specifically trained for rescue operations within caves and for any emergency situation produced by natural disasters, such as an earthquakes and floods. The training of the members is based on nationwide and international technical standards at different levels of instruction, periodic tests and a constant re-certification process.

4.B.(iv) RESPONSIBLE VISITATION AT WORLD HERITAGE SITES

Ridge area - Component Site 1

Due to its location and morphology, there are no direct data available on the number of people accessing the area to the area. It is possible to estimate the visitation on the basis of the

• *Excursion in memory of F. Malavolti (1913 – 1954) one of the early explorers of the Secchia valley. The entrance of the Tanone piccolo della Gaggiolina (2018). Alta valle del Secchia*
© S.Lugli

frequentation of the busiest area (near the Poiano Springs) of a snack bar, equipped with a didactic area and illustrative panels about the characteristics of karst phenomena.

Whoever enters the nominated property area for recreation, study, contact with the natural environment and the karst landscape or to reach the restaurant, usually visits the refreshment bar and the Gessi Triassici info point. Therefore, an annual presence of about 15-20,000 people can be estimated among tourists, hikers, students of all levels and their professors.

A consolidated approach that mixes sportive practice with education activities is proposed: from hiking with local naturalistic guides to (infrequent) cave visits with speleologists, to "bat-nights" for bats observation, up to training courses for local operators and guides and to educational for schools.

• *Visiting the Tana della Mussina cave with primary school kids (2004). Bassa Collina Reggiana*
© GSPGC

• *Guided speleotour inside the Grotte di Onferno cave - Quarina Room (2016). Gessi di Onferno*
© Piero Gualandi

Lower hills area and Eastern area - Component Sites 2-7

Component sites 2, 3 and 6 are not tourist destinations. Component site 4 "Gessi Bolognesi", being close to a metropolitan area with over 500,000 inhabitants, is visited annually by many thousands citizens, students and tourists. A conservative estimate of at least 2,500 visitors / week leads to an assessment of over 130,000-150,000 presences in the c.s. area. Two of the more than 100 caves present in the Component Site (Spipola and Farneto Caves), are destined to a controlled tourist fruition – always with specialized guides: annually about 2,000 visitors are accompanied inside these two caves, about 80% of these are school-age children, often on an educational visit.

The main visitor centre of the Vena del Gesso Romagnola Component Site (c.s.5), equipped with restaurant, bar, hostel, info-point, museum, classroom, conference room, picnic areas, summer camp, is attended by 50,000 people every year. There are two caves that can be visited, out of a total of 220 caves (Tanaccia and Re Tiberio caves), visited by about 2,000 people a year. Two quarry galleries that can be also visited in the context of the Vena del Gesso area, the ancient **Roman lapis specularis quarry of Ca' Toresina** and the **20th century quarry of cava Marana**, equipped with didactic panels about karst and caves. Soon a museum about karst and caves will be open in Vena del Gesso, close to Re Tiberio cave, financed by ERDF founds. The estimated number of visitors throughout the area is around 85,000, mainly for hiking and museum visits. Also, the Onferno caves in c.s.7 are visited by about 10,000 people a year. So far, the tourist turnout has not been a threat. An *Interreg Adrion "Adriaticaves" project* assessed the touristic carrying capacity of the two caves that are currently open to the public, to evaluate the possibility to redirect part of the tourist flow toward the mentioned quarry galleries in order to eventually reduce the pressure on the other two caves, if needed.

4.B.(v) NUMBER OF INHABITANTS WITHIN THE PROPERTY AND THE BUFFER ZONE

Basing on density of population data provided by the National Institute for Statistics (ISTAT) with a resolution of 1 km^2, and proportionating the value to the number of buildings located within the nominated property, a homogeneous estimation of the population living within the candidate area on a permanent, year-round basis is provided. The numbers have been validated by exact, direct counting where possible.

component site	Population	
	Core Zone	Buffer Zone
c.s.1 - Alta Valle del Secchia	6	18
c.s.2 - Bassa Collina Reggiana	9	37
c.s.3 - Gessi di Zola Predosa	4	9
c.s.4 - Gessi Bolognesi	12	34
c.s.5 - Vena del Gesso Romagnola	47	503
c.s.6 - Evaporiti di San Leo	1	3
c.s.7 - Gessi di Onferno	1	2
TOTAL	**80**	**606**

• *The 20th century quarry cava Marana converted into a performance space (2018)*
© PRDVGR

PROTECTION
AND MANAGEMENT OF THE PROPERTY

5

5.A OWNERSHIP

Permanent protection of the above- and below-ground geological heritage is guaranteed through legislative designations of protection. Thus, long-term conservation is independent from the ownership structure, since the Italian Civil Code states that waters, minerals and crystals, fossils, archaeological findings and antiquities belong to the State.

On the basis of cadastral data, which are checked and legally validated at regional level, a detailed survey was carried out on the ownership regime of nominated property (core areas only), distinguishing between public and private property. Public property means the property of municipalities and Region or State, all state property and the property of public law bodies, such as Parks.

The presence of public ownership is very varied and depends on different factors (possibility of agricultural use of the area, morphological characteristics, etc.). For this reason it should be mentioned that some Parks are acquiring private areas to extend public ownership.

- *(facing page) Guided speleo-tour at the Canyon One, Onferno Caves (2018). Gessi di Onferno*
© P. Gualandi

ID	Component Site name	Core Area of nominated property	public ownership	% public	% privat
c.s.1	Alta Valle Secchia	1596 ha	656 ha	41,13 %	58,87 %
c.s.2	Bassa Collina Reggiana	274 ha	3 ha	1,02 %	98,98 %
c.s.3	Gessi di Zola Predosa	57 ha	1 ha	1,32 %	98,68 %
c.s.4	Gessi Bolognesi	237 ha	95 ha	39,86 %	60,14 %
c.s.5	Vena del Gesso Romagnola	1313 ha	127 ha	9,72 %	90,28 %
c.s.6	Evaporiti di San Leo	119 ha	2 ha	1,39 %	98,61 %
c.s.7	Gessi di Onferno	84 ha	24 ha	28,10 %	71,90 %
		3 680 ha	**908 ha**	**24,65 %**	**66,35 %**

5.B PROTECTIVE DESIGNATION

All the component sites of the nominated serial property possess a strong legal protection framework.

It consists of a coherent system of measures that link different levels of legislation (European, national, and local) protecting epigean and hypogeal geological attributes of the candidate property and their natural habitats.

The overlapping levels of protection, which affect all the component sites of the nominated property, is a characteristic of the Italian - and European Union – context, where protected areas no longer generally coincide with wild, remote or virtually uninhabited areas of the Earth as elsewhere.

It stems from the will to increasingly strengthen the protection of natural ecosystems, commonly adjacent to

History of the establishment of Protected Areas in the nominated property

The first step towards the creation of the protected areas of Emilia-Romagna was taken in the late Seventies, with regional law n. 2/1977, that considered for the first time the possibility to establish parks and reserves for the protection of the most preserved natural assets and the restoration of the most interesting ones from the naturalistic point of view. After this first result, the Region rapidly established its system of parks and natural reserves though the framework law 11/1988 (only in Italian).

Regarding the candidate Property, two regional parks were established: the "Alto Appennino Reggiano" Park (which would later become national

park and corresponds to component site 1) and the "Gessi Bolognesi e Calanchi dell'Abbadessa" Park (component site 4).

In 1989 the Regional Plan of Territory and Landscape defined the framework of the regional protected areas; in whose context the list of existing parks and reserves was integrated by a programme for the creation of several new protected areas, implemented partially the subsequent year.

In 1991 the "Onferno Natural Reserves" was established (component site 7). In 2001 the Appennino Tosco-Emiliano National Park absorbed the former regional park, i.e. the Alto Appennino Reggiano. In 2005 the Region established the "Vena del Gesso Romagnola Park" (component site 5).

In 2005 the regional law No.6/2005 replaced the law No. 11/1988 with the aim of updating its natural heritage protection and valorisation policies, moving from limited and sectorial protection to systematic logics throughout integrated planning and institutional cooperation.

The goal was to harmonically intertwine the sectorial policies of parks and reserves, with policies supporting the environmental and social sustainability of the regional development.

In July 2009 the Regional Council approved the "Programme for the Regional System of Protected Areas and Natura 2000 Network Sites", as required by art. 12 of the regional law 6/2005, including the provisions to establish new parks and natural reserves and other protection forms such as the "Natural and Semi-natural Protected Landscapes" and the "Ecological Rebalancing Areas".

In accordance with the Programme, in 2011 the "Collina Reggiana Protected Landscape" (component site 2) was established, and each component site of the nominated Property became a Natura 2000 site.

The regional law 24/2011 "Reorganization of the regional system of protected areas and natura 2000 network sites" reorganized governance model grouping the protected areas present on the regional territory into five management macro-areas and instituting as many Park and Biodiversity Management Authorities for the related governance.

areas where human presence is historicised and represents an integral part of the natural landscape.

In the case of the nominated property, the history of natural heritage protection began in the 1970s, with the establishment of the first parks and nature reserves, and continued with the constant refinement of protection up to the present day.

In particular, based on a law reforming the protected areas system, the protection structure has been further strengthened thanks to the transformation of some regional parks into national parks and the establishment of Natura 2000 sites on – but also outside - existing regional protected areas.

Protective status – core zone (entire serial property)

The great majority of the nominated Property core areas, 3,548 hectares (96.4%), is protected by European Community directives and corresponds to karst and gypsum habitats belonging to the European Natura 2000 network (IUCN Protection Category IV). The remaining part, 131 hectares (3.4%), is protected by law as Protected Landscape (IUCN Protection Category V) or are registered as Geosite of regional importance (IUCN Protection Category III).

The update of the General Measures of Conservation of Natura 2000 sites in 2018 (Resolution of the Regional Council of Emilia-Romagna No. 1147 of July 16, 2018) is the most recent protective measure which concerns the nominated property and overlaps with - but does not replace - earlier protective legislation, national and regional. In particular, the zones protected by the European directives include five areas - all previously established - which protect epigean and hypogean evaporitic karst environments both for environmental and landscape-cultural aspects. These five protected areas cover 2,597 hectares (71% of the nominated property). They are the Appennino Tosco-Emiliano National Park, established in 2001 (IUCN Cat. II), the Gessi Bolognesi and Calanchi dell'Abbadessa Regional Park, established in 1988, the Vena del Gesso Romagnola Regional Park, established in 2005, the Onferno Regional Reserve established in 1991 (all of them are IUCN Cat. IV), and the Collina Reggiana Protected Landscape, established in 2011 (IUCN Cat. V).

The entire subsurface area of the nominated property is registered thank to the law L.R. no. 9/2006 "Regulations for the conservation and enhancement of the geodiversity of Emilia-Romagna" as geological sites of regional importance (IUCN Protection Category III) and protected accordingly to the Parks Management Plans. Under this law, an inventory of geological sites, which includes caves, artificial cavities, and karst areas, has been established. Each geological

site is mapped and illustrated by a descriptive sheet, which provides information on the protection measures.

Altogether, these protection measures form a consolidated system of environmental protection that has proven its effectiveness over time.

Protective status - buffer zone (entire serial property)

The buffer areas of each component site, being included entirely within the perimeters of the protected areas, also present the characteristic coexistence of several levels of protection, although in different proportions compared to the core areas.

The great majority of the buffer zone of the nominated property, 6,207 hectares (74.7% of the entire buffer zone), is protected by European Community directives and belongs to the European Natura 2000 network (IUCN Protection Category IV). The remaining part, 42 hectares (0.5%), is protected by law as national park (IUCN Protection Category II) or as regional protected area, 2,065 hectares (24.8%) (IUCN Protection Category IV and V).

PROTECTIVE STATUS AT THE EUROPEAN LEVEL

The protective designations at international level are based on the European protocols of the Natura 2000 network. These protocols protect the area of the nominated property both in terms of natural and semi-natural habitats typical of gypsum environments - such as cliffs, garrigue, dry grasslands alternating with cool environments - and specific and representative habitats of these areas, including calcareous marshes, large karst springs, caves and gully environments, as well as a very diverse flora with Mediterranean and Central European elements, and an interesting epigean and hypogeal fauna.

This level of legal protection covers the 96.4% of the core area and the 74.7% of the buffer area of the candidate property.

c.s. #	Natura 2000 code	Name	designation year(s)	Legislative act(s)
1	SAC - IT4030009	Gessi Triassici	2008	Deliberazione Giunta Regionale 167 13/02/2008
2	SAC - IT4030017	Ca' del Vento, Ca' del Lupo, Gessi di Borzano	2009 2019	Deliberazione Giunta Regionale 512/2009 e Ministero dell'Ambiente e della Tutela del Territorio e del Mare D.M. 13 marzo 2019
3	SAC - IT4050027	Gessi di Monte Rocca, Monte Capra e Tizzano	2006	Deliberazione Giunta Regionale 167 13/02/2006
4	SAC-SPA - IT4050001	Gessi Bolognesi, Calanchi dell'Abbadessa	2009	Deliberazione Giunta Regionale 512/2009
5	SAC-SPA - IT4070011	Vena del Gesso Romagnola	2009	Deliberazione Giunta Regionale 512/2009
6	SAC-SPA - IT4090003	Rupi e Gessi della Valmarecchia	2010	Deliberazione Giunta Regionale 145/2010
7	SAC - IT4090001	Onferno	2006	Deliberazione Giunta Regionale 167 13/02/2006

In addition, at international level, the National Park is the coordinator of the Appennino Tosco-Emiliano Biosphere Reserve UNESCO, which entirely includes c.s.1 and part of c.s.2 of the nominated property.

MAP OF EUROPEAN PROTECTION OF THE NOMINATED SERIAL PROPERTY

Projected Coordinate System: WGS 84 Fuse 32N

Data sources: EU-DEM v.1.1 (GMES / Copernicus), CTR50K (Emilia-Romagna Region)

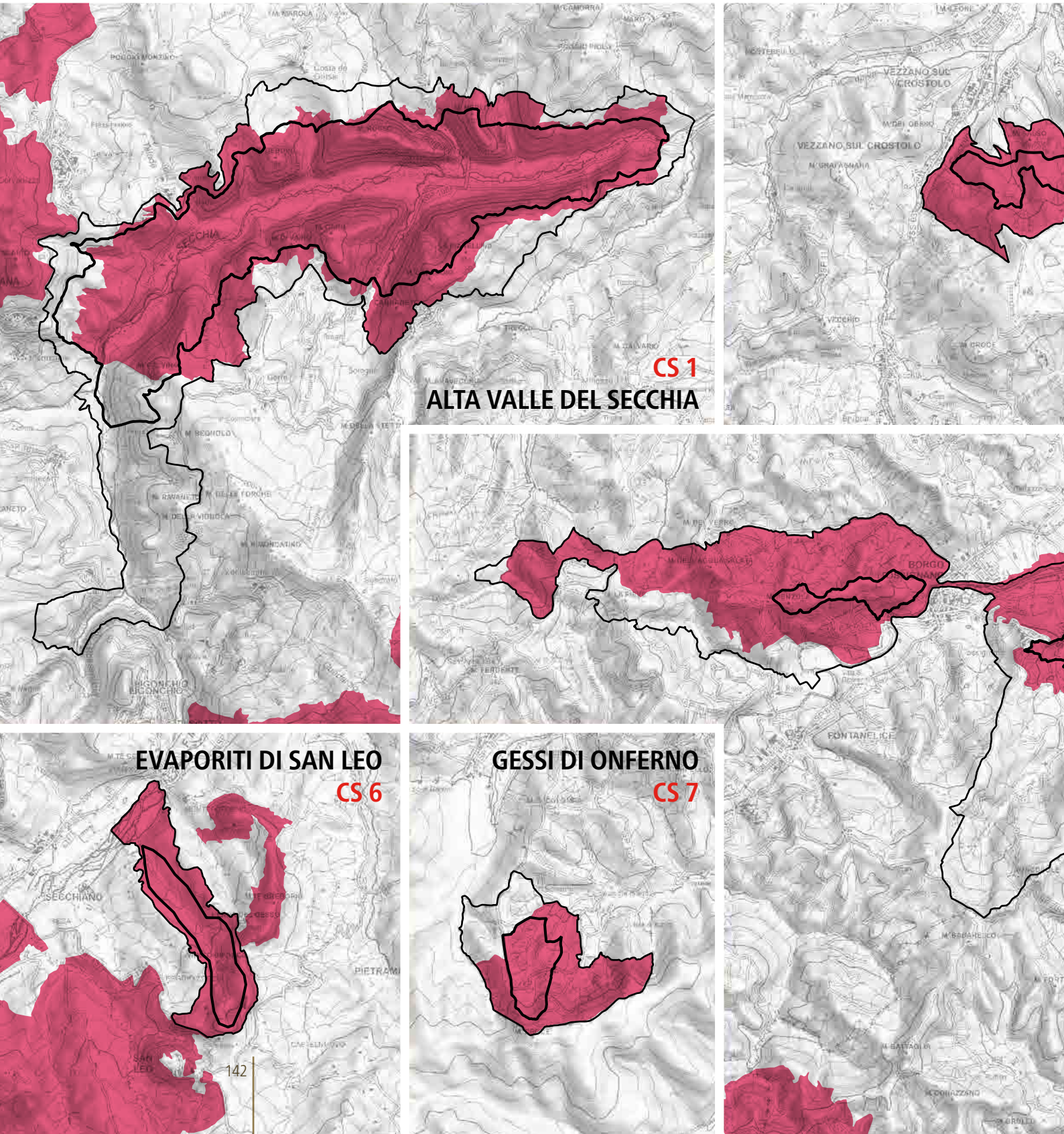
SCALE 1:75,000

buffer zone

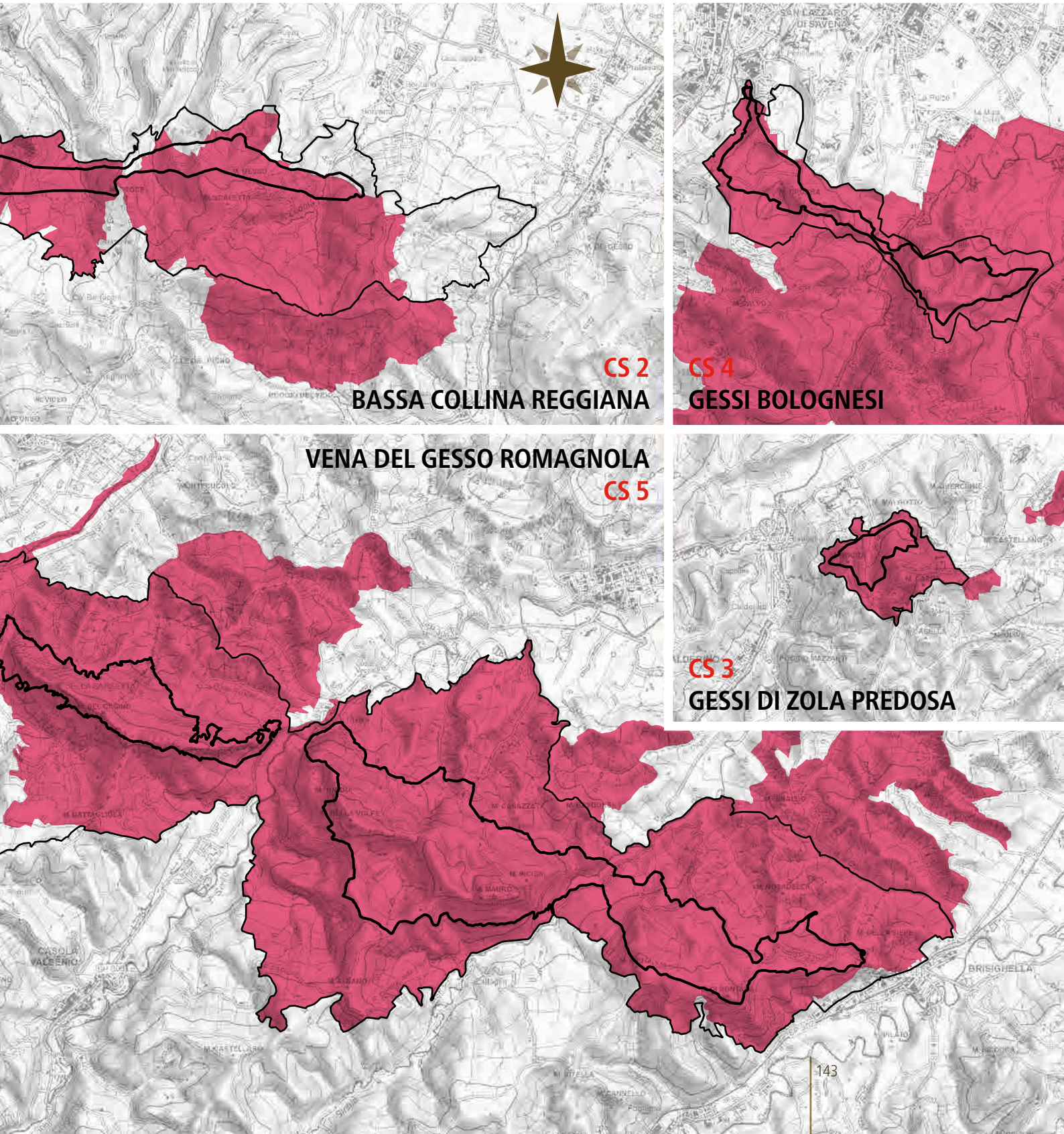
core zone

0 1 2 km

0 1 2 mi



European protection



PROTECTIVE STATUS AT THE NATIONAL LEVEL

At this level the nominated property is preserved by two legislative acts:

- The Decree of the President of the Republic 21/05/2001 which established the Appennino Tosco-Emiliano National Park (IUCN Cat. II);
- the Legislative Decree n. 42/2004, Code of the Cultural and Landscape Heritage (Code) - the protection Code of laws which identifies and subjects sites of high public interest to environmentally and landscape protective restrictions (IUCN Cat. V).

The **Appennino Tosco-Emiliano National Park** (limited to c.s.1 only) protects the area from anthropogenic pressures by regulating compatible activities and prohibiting activities that are incompatible with the protection of the natural environment. Forbidden activities are for example the collection of materials of significant geological and paleontological interest, the opening and operation of quarries, mines and landfills, as well as the removal of minerals, or the introduction by private individuals, of weapons, of explosives, or any destructive or catching tools. More information about compatible and incompatible activities are listed in paragraph 5d.

The **Code** affects much of the surface and underground areas of five of the seven component sites of the nominated property (see table below). It identifies and maps much of the karst phenomena to be subject to protection restrictions. The features to be protected are both natural and cultural. They are, for example, watercourses feeding the karst systems to be protected from abstraction and exploitation, external outcrops and contiguous areas covered by forests and woods to be protected from fires and deforestation, and caves of archaeological interest to be protected from human activities.

The regional spatial planning assumes the Code restrictions and specifies the protective regulation of each restriction. The evaluation of the interventions, which are compatible with the protective restrictions, is exercised by the Regional Secretariat for the Emilia-Romagna region of the Ministry of Cultural Heritage.

The following table shows the protection restrictions established by the Code in the nominated property.

- *the Secchia Valley in the Appennino Tosco-Emiliano Nationa Park . Alta valle del Secchia (2017)*
© G.Bianchini

c.s. #	Name	protective restriction code	Legislative act(s)
1	Declaration of notable public interest of Pietra di Bismantova and Gessi Triassici, located in Castelnovo ne' Monti Municipality (RE)	CODVR = 200385 environmentally protective restriction of the Triassic gypsum area	Law1437/1939 art. 136 del D.Lgs. 42/2004 Deliberazione Giunta Regionale n. 258 29/02/2016
2	Declaration of notable public interest of area of Borzano - Le Croci located in the Albinea and Viano Municipalities	CODVR = 80146 environmentally protective restriction of the *Gessoso-Solfifera Fm* including karst phenomena and rich of forests and historical-architectural treasures	Deliberazione Giunta Regionale n. 512/2009 e Ministero dell'Ambiente e della Tutela del Territorio e del Mare D.M. 13 marzo 2019
3	Declaration of notable public interest of an area in Zola Predosa Municipality	CODVR = 80061 environmentally protective restriction of the karst area characterised by gypsum outcrops with hillside slopes, perfect fusion between cultivated areas and high-tree forests	Law 1437/1939 art. 136 del D.Lgs. 42/2004 DM 3 marzo 1976
4	Declaration of notable public interest of "Croara" place in San Lazzaro di Savena Municipality	CODVR = 80059 environmentally protective restriction of the area characterised by karstic terrain that forms caves such as the Spipola cave in the centre of a sinkhole.	Law 1437/1939 art. 136 del D.Lgs. 42/2004 DM 25 ottobre 1965
	Declaration of notable public interest of Castel de Britti area in San Lazzaro di Savena Municipality	CODVR = 80060 environmentally protective restriction of the area characterised by the presence of deep natural cavities and external features manifesting themselves in movements of hilly masses	Law 1437/1939 art. 136 del D.Lgs. 42/2004 DM 3 marzo 1976
5	Declaration of notable public interest of "Vena del Gesso" area located in Borgo Tossignano Municipality	CODVR = 80029 environmentally protective restriction of the gypsum line area, which forms a detachment between the mountain and the badlands area and is characterized by anthropological, and palaeontological-archaeological findings	Law 1437/1939 art. 136 del D.Lgs. 42/2004 DM 1 agosto 1985
	Declaration of notable public interest of "Vena del Gesso" area located in Riolo Terme, Casola Valsenio, and Brisighella Municipalities	CODVR = 80238 environmentally protective restriction of the area of Monte Mauro, Monte Tondo, Monte della Volpe (Vena del Gesso) of naturalistic and speleological interest with remnants of Mediterranean vegetation and dominated by a relief of gypsum	L.1437/1939 art. 136 del D.Lgs. 42/2004 DM 30 luglio 1974DM 12 dicembre 1975
6	No declaration	-	-
7	No declaration	-	-

MAP OF NATIONAL PROTECTION OF THE NOMINATED SERIAL PROPERTY

Projected Coordinate System: WGS 84 Fuse 32N

Data sources: EU-DEM v.1.1 (GMES / Copernicus), CTR50K (Emilia-Romagna Region)

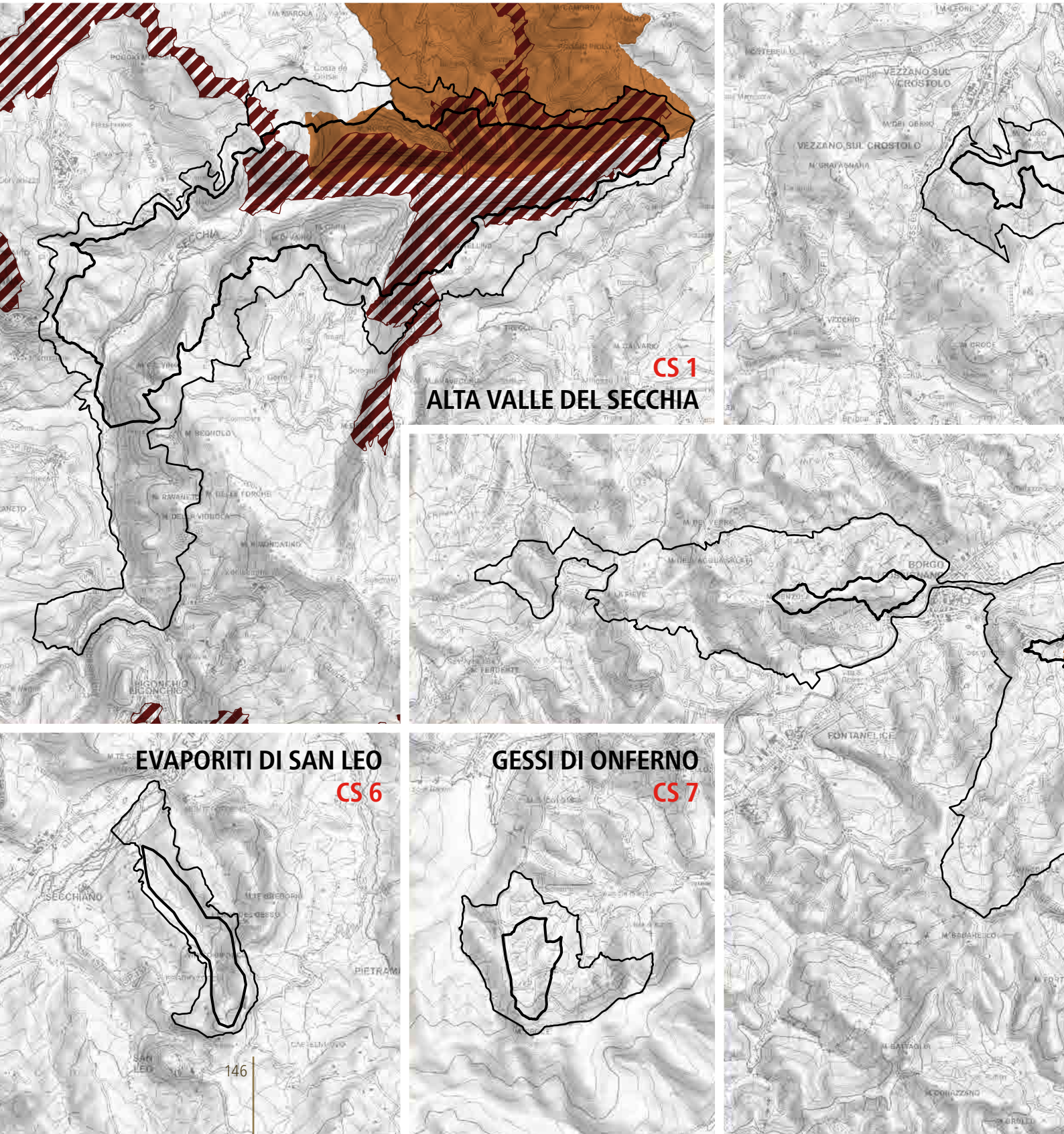
SCALE 1:75,000

buffer zone

core zone

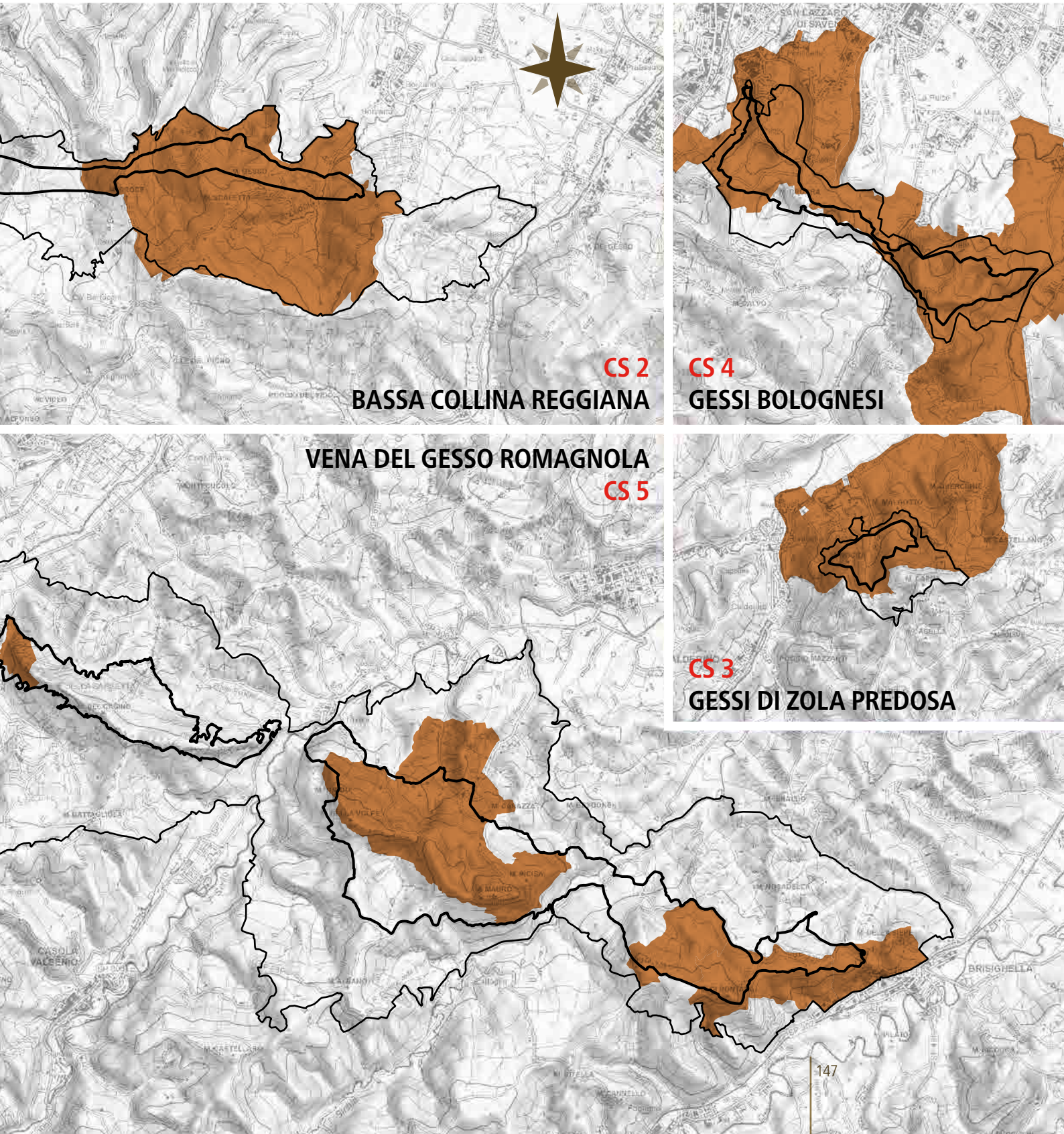
0 1 2 km

0 1 2 mi



National Park

Art. 136 comma c, D.Lgs 42/2004



• *Entrance of the Grotta della Lucerna cave. Vena del Gesso Romagnola (2012) © P. Lucci*

PROTECTIVE STATUS AT THE LOCAL LEVEL (EMILIA-ROMAGNA REGION)

At the local level, two Regional Parks, a Nature Reserve (all IUCN Cat. IV), and a Protected Landscape (IUCN Cat. V) protect the nominated property (see table below).

These protected areas specifically protect the geological and archaeological heritage by strictly regulating human activities.

c.s. #	Status	Name	designation year(s)	Legislative act(s)
2	Protected Landscape	Paesaggio naturale e seminaturale protetto della Collina Reggiana	2011	Deliberazione del Consiglio Provinciale di Reggio Emilia n. 111 del 23/06/2011
4	Regional Park	Parco regionale Gessi Bolognesi e Calanchi dell'Abbadessa	1988	Legge regionale 2 aprile 1988, n. 11
5	Regional Park	Parco regionale Vena del Gesso Romagnola	2005	Legge regionale 21 febbraio 2005, n.10
7	Regional reserve	Riserva regionale Onferno	1991	Deliberazione del Consiglio Regionale n. 421 del 23/4/1991 - modificata da Deliberazione del Consiglio Regionale n. 631 del 3/10/1991

Moreover, all the evaporitic karst and caves phenomena are identified and catalogued by a specific regional law, adopted in 2006 following Recommendation Rec(2004)3 of the Committee of Ministers of the Council of Europe on the conservation of the geological heritage and areas of particular geological interest, as well as in the implementation of the national Code (Legislative Decree n. 42/2004, art. 136 and 142).

This regional law (L.R. n. 9/2006, "Regulations for the conservation and valorisation of the geodiversity of Emilia-Romagna and related activities") promotes the valorisation of the geological and speleological heritage and supports studies, research, and protection of caves and karst areas.

c.s. #	Status	Name	designation year(s)	Legislative act(s)
1-7	Geological site (epigean and hypogean)	caves, artificial cavities, karst areas and systems	2006	L.R. n. 9/2006 Regulations for the conservation and valorisation of the geodiversity of Emilia-Romagna and related activities

In addition to the protection measures mentioned above, there are also the protections established by the **Regional Landscape Territorial Plan** (PTPR), which is one of the most effective tools for the implementation of protection measures.

In particular, the PTPR adopts the legal protection measures and establishes the rules for their management and conservation (see par. 5.d).

MAP OF REGIONAL PROTECTION OF THE NOMINATED SERIAL PROPERTY

Projected Coordinate System: WGS 84 Fuse 32N

Data sources: EU-DEM v.1.1 (GMES / Copernicus), CTR50K (Emilia-Romagna Region)

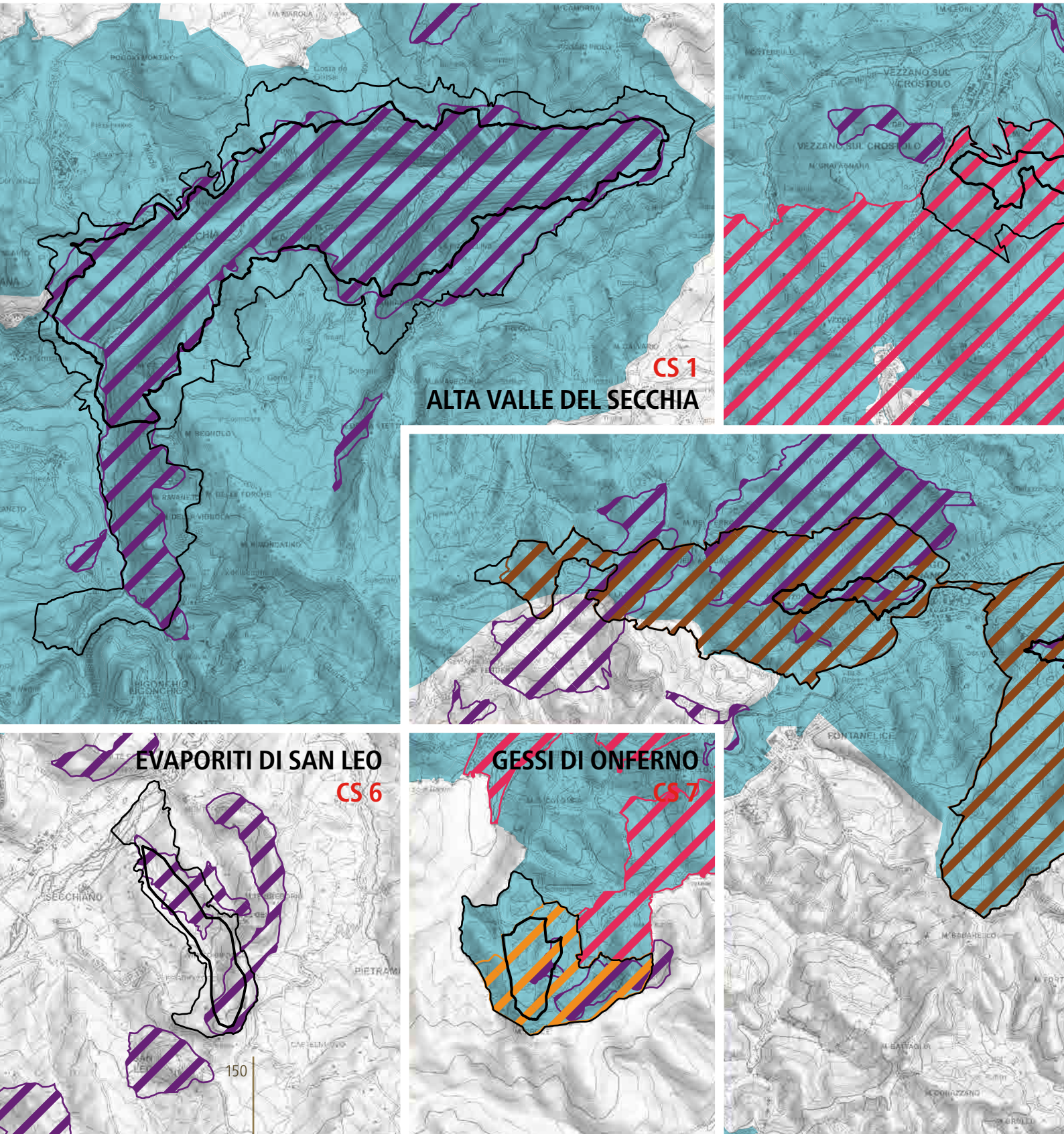
SCALE 1:75,000

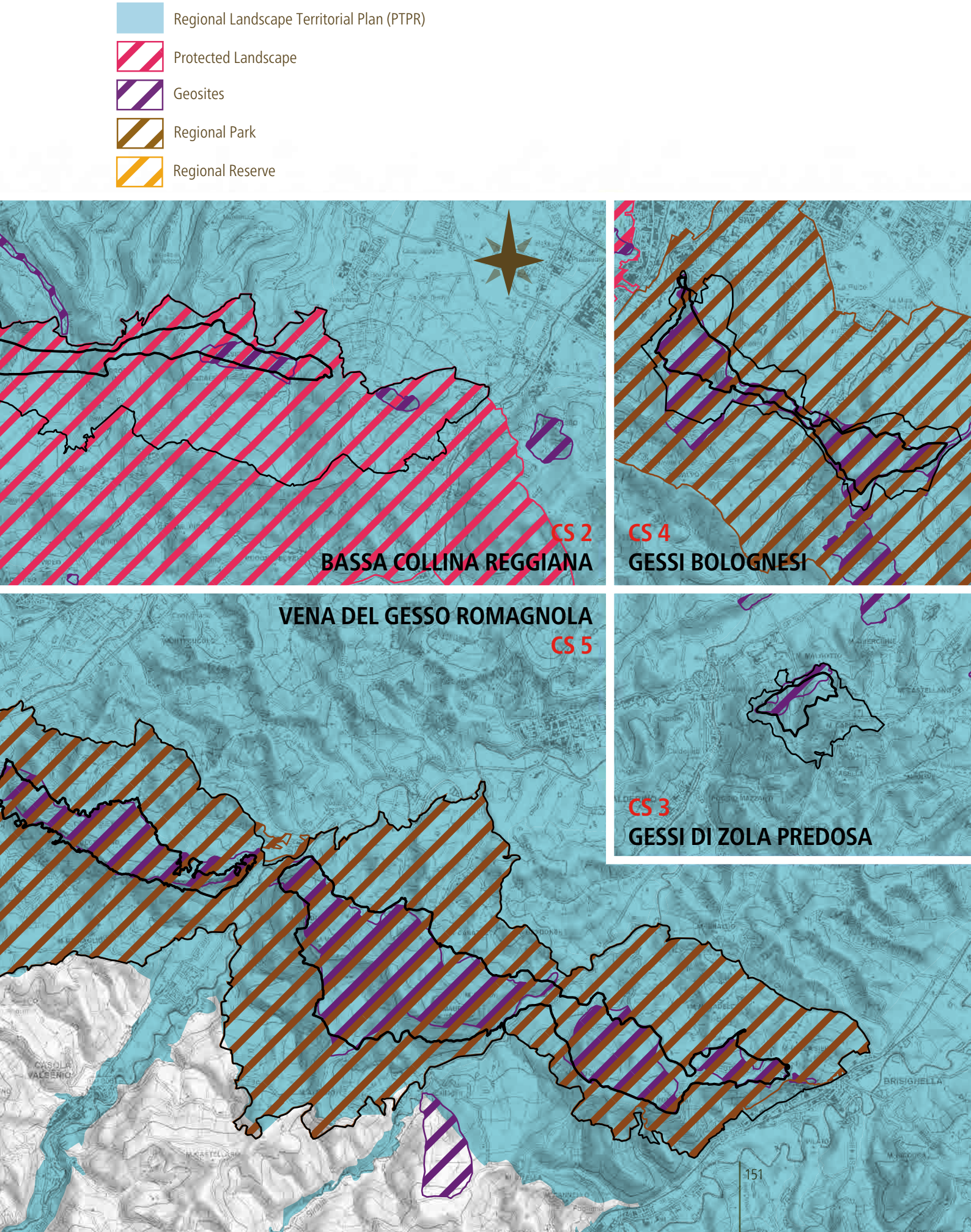
buffer zone

core zone

0 1 2 km

0 1 2 mi




Regional Landscape Territorial Plan (PTPR)
Protected Landscape
Geosites
Regional Park
Regional Reserve
CS 2
BASSA COLLINA REGGIANA
CS 4
GESSI BOLOGNESI
VENA DEL GESSO ROMAGNOLA
CS 5
CS 3
GESSI DI ZOLA PREDOSA

SUMMARY OF PROTECTION DESIGNATIONS FOR EACH COMPONENT SITE

In conclusion, each component site of the nominated property has more than one protection designation, added to and overlaid on top of each other over a course of many years. Each measure does not obliterate the previous one but completes and reinforces the protection status, increasing the improvement and coordination based on the current and future protection and valorisation requirements.

The following table is a synopsis of the protective designations of each component site, distinguished by the level of protection and year of establishment.

OVERVIEW OF PROTECTIVE DESIGNATIONS PER COMPONENT SITES

c.s. #	name	management authority
1	Alta Valle del Secchia	Management Authority of Appennino Tosco-Emiliano National Park
2	Bassa Collina Reggiana	Management Authority for Parks and Biodiversity - Emilia Centrale
3	Gessi di Zola Predosa	Protected Areas, Forests and Mountain Development Service of Emilia-Romagna Region
4	Gessi Bolognesi	Management Authority for Parks and Biodiversity - Emilia Orientale
5	Vena del Gesso Romagnola	Management Authority for Parks and Biodiversity - Romagna
6	Evaporiti San Leo	Protected Areas, Forests and Mountain Development Service of Emilia-Romagna Region
7	Gessi di Onferno	Management Authority for Parks and Biodiversity - Romagna

• *The Triassic gypsum cropping out along the Secchia Valley with the Miocene calcarenite slab of the Pietra di Bismantova in the background (2014) © G.Bianchini*

protective designation	IUCN category.	protection level	YEAR
SAC - IT4030009 Gessi Triassici	IV	European	2008
Appennino Tosco-Emiliano National Park	II	national	2001
Declaration of notable public interest of Pietra di Bismantova and Gessi Triassici, located in Castelnovo ne' Monti Municipality (RE)	not reported	national	2016
SAC - IT4030017 Ca' del Vento, Ca' del Lupo, Gessi di Borzano	IV	European	2009
Declaration of notable public interest of area of Borzano - Le Croci located in the Albinea and Viano Municipalities	not reported	national	2009
Collina Reggiana Protected Landscape	V	regional	2011
SAC - IT4050027 Gessi di Monte Rocca, Monte Capra e Tizzano	IV	European	2006
Declaration of notable public interest of an area in Zola Predosa Municipality	not reported	national	2004
SAC-SPA - IT4050001 Gessi Bolognesi, Calanchi dell'Abbadessa	IV	European	2009
Declaration of notable public interest of "Croara" place in San Lazzaro di Savena Municipality Declaration of notable public interest of Castel De Britti area in San Lazzaro di Savena Municipality	not reported	national	2004
Gessi Bolognesi, Calanchi dell'Abbadessa Regional Park	IV	regional	1988
SAC-SPA - IT4070011 Vena del Gesso Romagnola	IV	European	2009
Declaration of motable public interest of "Vena del Gesso" area located in Borgo Tossignano Municipality Declaration of notable public interest of "Vena del Gesso" area located in Riolo Terme, Casola Valsenio, and Brisighella Municipalities	not reported	national	2004
Vena del Gesso Romagnola Regional Park	IV	regional	2005
SAC-SPA - IT4090003 Rupi e Gessi della Valmarecchia	IV	European	2010
SAC - IT4090001 Onferno	IV	European	2006
Onferno regional nature reserve	IV	regional	1991

MAP OF IUCN PROTECTION CATEGORIES OF THE NOMINATED SERIAL PROPERTY

Projected Coordinate System: WGS 84 Fuse 32N

Data sources: EU-DEM v.1.1 (GMES / Copernicus), CTR50K (Emilia-Romagna Region)

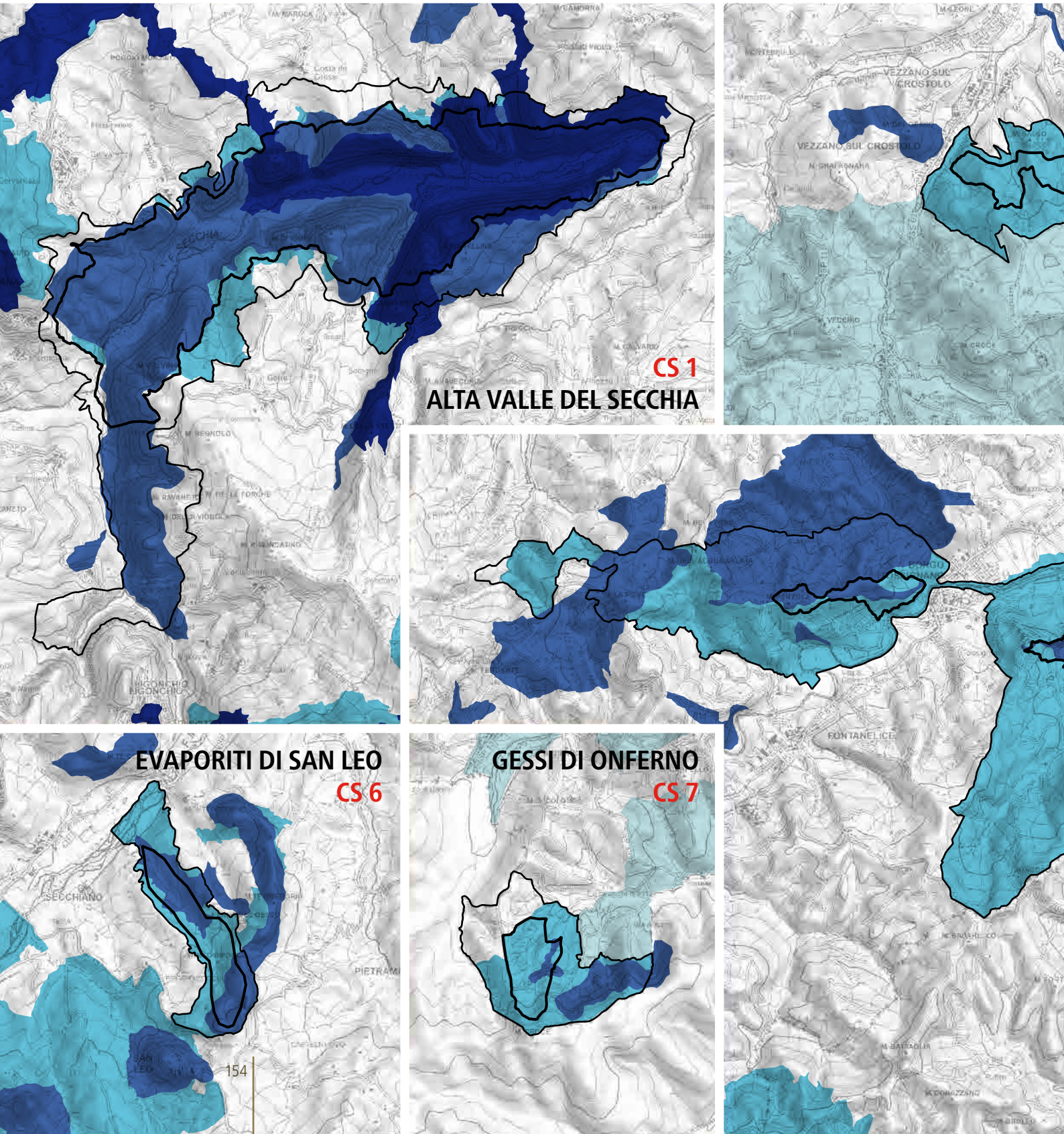
SCALE 1:75,000

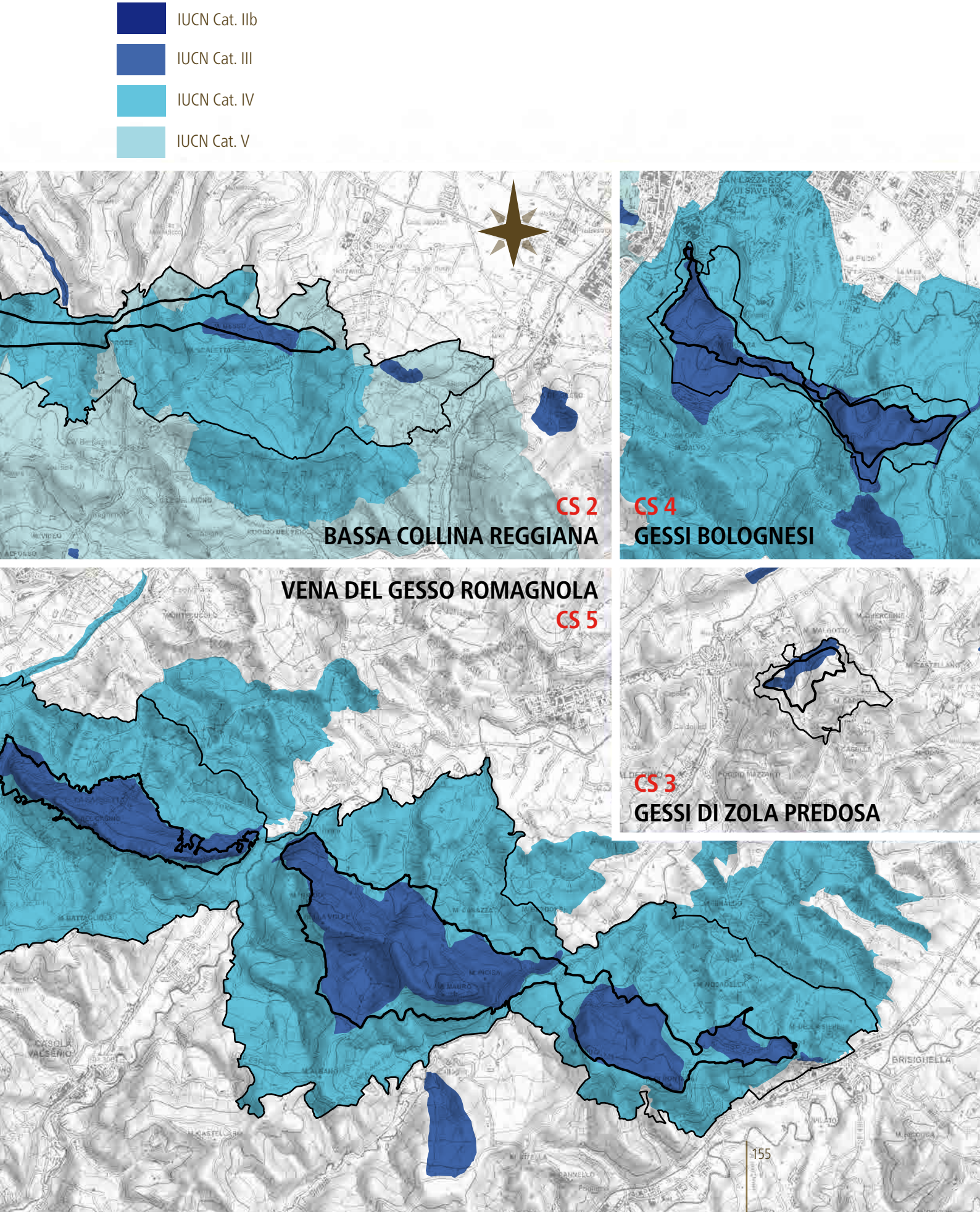
buffer zone

core zone

0 1 2 km

0 1 2 mi




IUCN Cat. IIb
IUCN Cat. III
IUCN Cat. IV
IUCN Cat. V
CS 2
BASSA COLLINA REGGIANA
CS 4
GESSI BOLOGNESI
VENA DEL GESSO ROMAGNOLA
CS 5
CS 3
GESSI DI ZOLA PREDOSA

5.C MEANS OF IMPLEMENTING PROTECTIVE MEASURES

Two leading administrative authorities implement the protective measures of the nominated property: the Appennino Tosco-Emiliano National Park (which depends directly on the Ministry of Ecological Transition) and the Emilia-Romagna Region.

The National Park manages the protected area of the park, and applies the conservation measures of the Natura 2000 site, limited to c.s.1 "Alta Valle del Secchia". The Region manages the regional protected areas, corresponding to the component sites 2-7, through its Parks and Biodiversity Management Authorities ("Enti di gestione per i Parchi e la Biodiversità").

These management Authorities operate on large territorial areas (also called "Macro-areas" - 5 throughout the Region) and have the objective of managing regional protected areas and Natura 2000 sites in a coordinated and systemic logic.

The macro-areas manage the regional parks, regional nature reserves, Natura 2000 sites within the protected areas, and protected natural landscapes.

A specific regional office manages the Natura 2000 sites outside the protected areas.

Administrative Authorities	Management Authorities	c.s.#	protected areas
Management Authority of Appennino Tosco-Emiliano National Park	Management Authority of Appennino Tosco-Emiliano National Park	**1**	Appennino Tosco-Emiliano National Park
			SAC - Gessi Triassici
Emilia-Romagna Region	Management Authority for Parks and Biodiversity -Emilia Centrale	**2**	Collina Reggiana Protected Landscape
			SAC - Ca' del Vento, Ca' del Lupo, Gessi di Borzano
	Management Authority for Parks and Biodiversity - - Emilia Orientale	**4**	Gessi Bolognesi and Calanchi dell'Abbadessa regional Park
			SAC - Gessi Bolognesi, Calanchi dell'Abbadessa
	Management Authority for Parks and Biodiversity - Romagna	**5**	Vena del Gesso Romagnola regional Park
			SAC - Vena del Gesso Romagnola
		7	Riserva regionale Onferno
			SAC - Onferno
	Natura 2000 Regional Office	**3**	SAC - Gessi di Monte Rocca, Monte Capra e Tizzano
		6	SAC - Rupi e Gessi della Valmarecchia

What these authorities do concerning protected areas and conservation measures implementation?

The **Appennino Tosco-Emiliano National Park** guarantees:

- the conservation of animal or plant species, geological formations, paleontological singularities, biological communities, biotopes, natural processes, hydraulic, hydrogeological, and ecological balances;
- the protection of the landscape and the application of appropriate management methods;
- the promotion of education, training and scientific research activities as well as compatible recreational activities;

- the defence and reconstitution of hydraulic and hydrogeological balance;
- the experimentation and enhancement of eco-sustainable activities;
- the protection and enhancement of the uses and customs and of the traditional activities of the populations residing in the territory, as well as the cultural expressions and identity characteristics of the local communities;
- the rights and the traditional civic uses of local communities that are put in practice according to local customs.

The **Emilia-Romagna Region**:

- establishes Parks and Natural reserves;
- coordinates the activities of management, planning and programming of the Protected Areas through a dedicated Regional Programme;
- coordinates the activities of the Parks and Biodiversity Management Authorities ;
- dispenses the grants to support the regional system of Protected Areas and Natura 2000 Sites;
- provides guidelines for the Plans, Programmes and Regulations;
- participates to the approval of Plans and approves Regulations;
- approves General and Specific Conservation Measures and Management Plan of Natura 2000 sites;
- promotes integrated conservation projects;
- coordinates biodiversity monitoring;
- promotes activities of information, dissemination and education concerning the biodiversity, the environmental sustainability and the technical and scientific knowledge exchange;
- promotes networks of sustainable tourism (see Alta Via dei Parchi, Ciclovie dei Parchi and European cooperation projects like CEETO, Made In Land, etc.).

Geological and speleological heritage

Under the regional law n. 9/2006 "*Regulations for the conservation and valorisation of the geodiversity of Emilia-Romagna and related activities*", a geological sites inventory, which includes caves, artificial cavities, and karst areas (IUCN Cat. III), has been developed. Each geological site has been mapped and defined by a descriptive sheet, which provides information on its specific features, values, protection status, and accessibility conditions.

The law promotes knowledge, public visit of geological sites, and their educational use. It also establishes that local authorities, research institutes, and associations active in the environmental field can propose new geological sites. The decision on which elements of the geological heritage have the characteristics to become geological sites is under the responsibility of a technical-scientific council. Lastly, the law states that the geological sites register, approved by the regional council, must be included in the territorial and urban planning instruments.

All this information is available on the website Geoportal of the Emilia-Romagna Region.
The Geoportal allows the cartographic consultation of the datasheets related to:

- Inventoried Geosites on the territory of the Emilia-Romagna Region (https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=geositi). The reports of each geological site contain the geological map with the perimeter, a geographical description, the geoscientific interest, the geology, the values, the protections, the accessibility.

- Cadastre of Natural Caves of Emilia-Romagna Region (https://geo.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=grotte). For each cave, a sheet report contains a brief description, the identification data, the geometric survey, and some pictures.

The WebGIS also provides the following cartographic levels Regional Geological Map in scale 1:10,000 and 1:25,000; Geological Landscape Map in scale 1: 250,000, perimeters of Regional Parks and Reserves.

Programme for the Regional System of Protected Areas and Natura 2000 Network sites

The harmonization of the various protected areas regulations takes place on the basis of the "Programme for the Regional System of Protected Areas and Natura 2000 Network sites" (Programme), provided for by art. 12 of the L.R. n. 6/2005. The Programme is the strategic tool that determines the regional policy on nature conservation and protected areas. The main objective is to establish the conditions to promote coordinated actions among the different categories of protected areas. The relationships concern both biological and ecosystemic aspects and opportunities for use, economic complementarities, etc.

The strategic and specific objectives, the actions, and the instruments of the Programme are the result of the consultation with the main cultural, social and institutional actors in the regional society and are inspired by the main treaties, agreements, programs, and directives defined at international, community and national level regarding the conservation of biodiversity.

The **Programme** establishes:

- the definition of the state of conservation of the natural heritage included in the system;
- the priorities for the management of the regional system of protected areas and Natura 2000 Network sites;
- the financial framework as a three-year regional program of investments in favour of the protected of the system of protected areas and Natura 2000 Network sites;
- the criteria for the distribution of regional contributions for the operation of the individual protected areas;
- the identification of the areas to be allocated to regional parks, nature reserves, protected natural and semi-natural landscapes, and ecological rebalancing areas;
- the identification of ecological connection areas at the regional level;
- any territorial modifications to existing protected areas;
- the definition of the purpose objectives of the existing protected areas.

Regulations governing the activities in the seven component sites.

In all component sites of the nominated property, there are very similar, if not the same, regulations. This substantial homogeneity is the effect of the application of the Programme for the Regional System of Protected Areas and Natura 2000 Network sites (see the previous paragraph) and of the Regional Landscape Territorial Plan prescriptions (see par. 5d).

The only authorized activities are exploration, scientific research, and educational dissemination.

The transformations related to human activities present in some areas (traditional agriculture, forest management, and land security) are subject to specific authorizations of the competent Authorities (parks authorities and local authorities). In the Natura 2000 network sites, any human activity that may have an environmental impact is subject to a preventive environmental impact assessment (the "Valutazione d'Incidenza Ambientale" - VINCA) that determines whether the transformation is acceptable and - if so - what measures should be taken to mitigate the impact. The opening and operation of quarries, mines and landfills, as well as the removal of minerals is forbidden in the entire property by park regulations and spatial landscape planning (see par. 5d).

Below is a summary of the main rules governing the activities in the seven component sites taken from the primary tools for implementing conservation measures, such as the management plans of the three natural Parks, the specific regulations of the Natural Reserve and Protected Landscape, the protection measures of the Natura 2000 sites. Full versions of the management plans and regulations are attached (see chap. 7).

SUMMARY OF THE REGULATIONS PER COMPONENT SITES

c.s.	management document	activities subject to specific authorizations	forbidden activities
1 Alta Valle del Secchia	Protection Discipline of the Appennino Tosco-Emiliano National Park (2001) General and Specific Conservation Measures of the "Gessi Triassici" Natura 2000 site (2016)	-• the forest plans, the opening and widening of forest tracks, cuts in the use of the woods; • the interventions of functional technological adaptation; • the works for transport routes; • the technological works; • the aquaculture and breeding facilities and the storage facilities; • the construction of new buildings and the change of use of existing ones.	• the capture, killing, damaging and disturbance of animal species; • the collection and damage of spontaneous flora and forest products; • the introduction into the natural environment (if non-enclosed in fences) of plant or animal species unrelated to the native flora and fauna; • the extraction of materials of significant geological and paleontological interest; • the opening and operation of quarries, mines and landfills, as well as the removal of minerals; • the introduction of weapons, of explosives, of any destructive or catching tools; • the camping outside the designed and equipped areas; • the overflight; • the transit of motorized vehicles off the roads; • the use of motorboats in lakes; • the modification of the water regime. • the construction of new buildings and works for new transport routes (except those already provided for in the intra-regional planning); • the realization of technological works; • the transformation of the forest into other crops or vegetation formations (except for traditional forest cultivation activities); • the affixing of advertising signs and artefacts (excluding the road signs and the informative signs of the Park); • to access the caves in groups of more than 20 people; • to light fires; • to illuminate cavities and caves used as a refuge for bats.
2 Bassa Collina Reggiana	Three-year Programme for the protection and enhancement of the protected landscape of the Collina Reggiana (2020) General and Specific Conservation Measures of the "Ca' del Vento, Ca' del Lupo, Gessi di Borzano" Natura 2000 site (2018)	• research activities; • monitoring activities; • educational and training activities; • introduction of protection measures for the gypsum outcrops and the related karst aquifer; • predisposition of panels and informative material; • maintenance of traditional management practices.	• to access the caves in groups of more than 20 people; • to light fires; • to remove minerals; • to illuminate cavities and caves used as a refuge for bats.

c.s.	management document	activities subject to specific authorizations	forbidden activities
3 Gessi di Zola Predosa	General and Specific Conservation Measures of "Gessi di Monte Rocca, Monte Capra e Tizzano" Natura 2000 site (2016)	• research activities; • monitoring activities; • educational and training activities; • predisposition of panels and informative material; • maintenance of traditional management practices	• to access the caves in groups of more than 20 people; • to light fires; • to remove minerals; • to illuminate cavities and caves used as a refuge for bats.
4 Gessi Bolognesi	Park Territorial Plan of the Gessi Bolognesi e Calanchi dell'Abbadessa Park (2005) General and Specific Conservation Measures of "Gessi Bolognesi, Calanchi dell'Abbadessa" Natura 2000 site (2018)	• access to and use of the caves are permitted with particular limitations and methods in order to avoid significantly changing to the ecosystem and to the hypogean microclimate and solely in the context of activities organized or authorized by the Managing Authority (dissemination, research, etc.) or of speleological activities in the strict sense (reserved only for speleological groups belonging to FSRER, SSI, and UIS); • speleological activity is carried out taking into account the particular vulnerability of some caves on certain periods of the year. Furthermore, to prevent irregular access or damage to the karst habitat, there are as many as 19 caves protected by special gates compatible with fauna and other ecological requirements (e.g. microclimatic); • access for didactic and excursional reasons is allowed only in the Grotta della Spipola and in the Grotta del Farneto. Accesses are controlled by closing the entrances to the caves; • maintenance interventions are carried out exclusively by the park in such a way as to ensure the conservation of the cave cenosis and the natural morphology. • (note) the protection of the Regional Park and Natura 2000 site is specifically aimed at the gypsum outcrops and cavities and karst elements in their complexity. Particular attention is paid to the issue of water and soil pollution or to the disturbance of troglophile ecosystems and vulnerable fauna.	• to access the caves in groups of more than 20 people; • to light fires; • to remove minerals; • to illuminate cavities and caves used as a refuge for bats; • any activity of collection and removal of fossils, minerals and concretions, as well as paleontological and archaeological finds.
5 Vena del Gesso Romagnola	General and Specific Conservation Measures of "Vena del Gesso Romagnola" Natura 2000 site (2018)	A specific regulation of the Park, signed in agreement with the Speleological Federation, also specifies the cavities subject to full protection and the authorization procedures for access to the other caves only for research purposes.	modification or alteration of the underground hydraulic system; • modification or alteration of caves, dolines, sinkholes, karst springs or other superficial or underground karst phenomena; • unregulated access to caves and natural cavities in general;

c.s.	management document	activities subject to specific authorizations	forbidden activities
		In particular, the park regulations ensure absolute respect of gypsum outcrops (isolated cliffs, cave entrances, gorges, collapse dolines). The Park has a list of "speleological guides", which are the only ones authorized to guide visitors in the caves that can be visited and are constantly formed to guarantee the maximum respect for the conservation of the caves and karst phenomena; The Park Authority has also approved its own regulation for the protection of the geological and archaeological heritage in January 2018.	• access to the caves limited to 20 people per group; • ban on lighting fires in caves; • prohibition of cutting shrub or arboreal vegetation within 10 metres around the entrances to caves, sinkholes or other natural cavities; • ban on lighting bat shelters, such as caves or other natural cavities; • ban on removing mineralogical and paleontological material with particular reference to crystallization in caves; • the opening of new quarries or the enlargement of the existing ones is forbidden, providing, moreover, that the final recovery of mining areas is persued for naturalistic purposes, according to the regulation (for example, modelling with natural morphologies of the detritus accumulations, closing quarry galleries, forestation with autochthonous species, creation of humid areas for amphibians, etc.).
6 Evaporiti San Leo	Management Plan of the "Rupi e Gessi della Valmarecchia" Natura 2000 site (2018)	• research activities; • monitoring activities; • educational and training activities; • predisposition of panels and informative material; • maintenance of traditional management practices; • regulations of the access to the hypogeal sites; • interventions, where necessary, to keep the entrance to the various cavities usable by bats, preventing collapses and removing excess vegetation.	• to access the caves in groups of more than 20 people; • to light fires; • to remove minerals; • to illuminate cavities and caves used as a refuge for bats.
7 Gessi di Onferno	Regulations of the Onferno Natural Reserve (2010)	• research activities; • monitoring activities; • educational and training activities; • predisposition of panels and informative material; • maintenance of traditional management practices.	• to access the caves in groups of more than 20 people; • to light fires; • to remove minerals; • to illuminate cavities and caves used as a refuge for bats; • to work the soil at a depth greater than 30 cm in an area of respect of the karst sinkhole/point for a radius of at least 10 m, in order to limit the solid transport and the occlusion/alteration of speleogenetic phenomena.

5.D EXISTING PLANS RELATED TO MUNICIPALITIES, PROVINCES AND REGION IN WHICH THE PROPOSED PROPERTY IS LOCATED

For the areas involved in the nominated property, the **Regional Landscape Territorial Plan (PTPR**), represents the reference planning tool for the verification of the current landscape-environmental protections.

The PTPR (approved by Regional Council Resolution n.. 1388 dated January 28th 1993 and n. 1551 dated July 14th, 1993) of the Emilia -Romagna Region is a territorial plan focused on the landscape and the environmental values.

This plan identifies the large subdivisions of physiographic types (mountain, hill, plain, coast), the thematic systems (agricultural, forest, water, settlement), and the biological, geomorphological, or settlement components that for their persistence and resistance to change, were placed as ordering elements of the growth and transformation of the regional territorial structure. It imposes constraints, directives and prescriptions that are directly effective with regard to the Provinces, Municipalities and individuals and establishes provisions aimed at protecting the entire regional territory in order to pursue the following objectives:

- *to preserve the recognizable connotations of the historical event of the territory in its complex relationships with the settled populations and with human activities;*
- *to guarantee the quality of the environment, natural and man-made, and its collective usage;*
- *to ensure the protection of the territory and its primary physical, morphological and cultural resources;*
- *to identify the actions necessary for the maintenance, restoration and integration of landscape and environmental values, including through the implementation of specific plans and projects.*

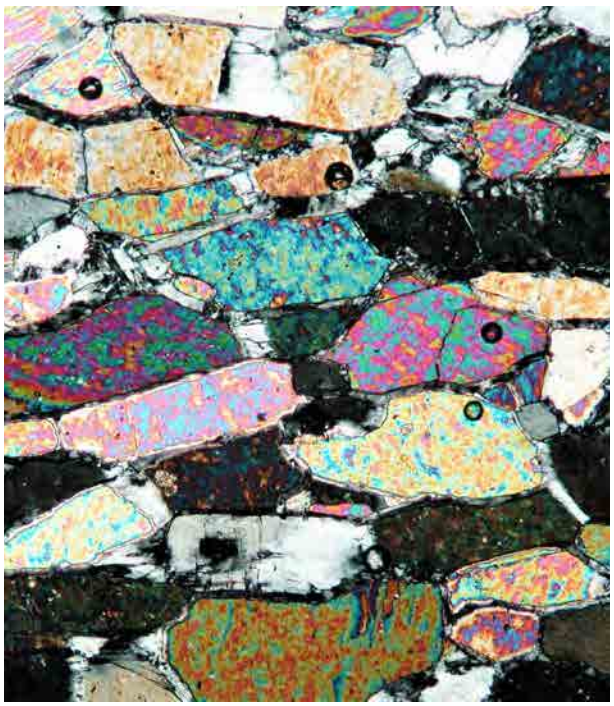
The regulations of the PTPR prevail over the regulations of subordinate plans (provincial, municipal and inter-municipal ones).

The following table summarises the main permitted and prohibited activities which also apply in the absence of subordinate plans (extract from the technical implementation rules - articles 17, 20, 25, 28).

art. #	permitted activities	forbidden activities
art. 17 **Areas for the protection of environmental features of lakes, reservoirs and watercourses** (perimeters indicated in the plan cartography)	(only if planned in the municipal or inter-municipal plans) • parks whose facilities are removable and/or precarious, with the exclusion of any works involving soil sealing; • footpaths and rest areas for non-motorised transport; • ecological corridors and green spaces for leisure activities; • kiosks and removable and/or precarious constructions for bathing as well as storage of materials and tools necessary for the maintenance of such equipment;	The areas subject to flooding (and in any case for a strip of 10 linear metres from the limit of the reservoirs and ordinary floodplains of lakes, basins and natural watercourses) must be kept free from any construction in order to encourage the reformation of spontaneous vegetation and the creation of ecological corridors, as well as to allow technical access for surveillance, maintenance and operation of reclamation, irrigation and soil protection works.

art. #	permitted activities	forbidden activities
	• the construction of technical infrastructures for mountain drainage and soil conservation, canalisations, hydraulic defence works, as well as their operation and maintenance. Infrastructures of supra-local significance (roads, water supply and telecommunications facilities, sewage disposal networks, technological systems for hydroelectric power generation and energy transport) are only permitted if they are provided for in supra-local planning instruments. These projects, if compatible with environmental and landscape features, must be submitted for environmental impact assessment	In these areas it is forbidden: • new construction of buildings; • agricultural land use; • reforestation for productive purposes; • planting of trees for wood production.
art. 20 **Special protection measures of specific elements**	• only works and activities aimed at improving the hydrogeological structure of the badlands, are allowed, where not in contrast with possible naturalistic and landscape aspects, and those aimed at preserving such aspects.	• all activities that may negatively alter the existing morphological and environmental characteristics of the lowland rises, indicated in the plan cartography.
art. 25 **Nature conservation areas** (perimeters indicated in the plan cartography)	• surveillance, scientific research, study and observation aimed at the formation of planning instruments; • interventions and activities aimed at preserving or restoring the natural components and their balances; • infrastructures and equipment for the surveillance and collective use of natural components, such as paths and rest areas, shelters and refreshment places, as well as the limits and conditions of such use; • the installation of the above-mentioned equipment, whether fixed, removable or mobile, may be envisaged only where compatible with the conservation purposes and strictly necessary for the performance of the functions of surveillance and protection of users; • works strictly necessary to meet drinking water requirements; • ordinary maintenance and avoidance of imminent collapse hazards on existing buildings;	• all activities that may damage geological or mineralogical features; • the opening and operation of quarries, mines and landfills, as well as the removal of minerals; • the introduction in any form of non-native wild animal and plant species; • changes of cultivation entailing the conversion of forests, pastures and permanent grassland; • harvesting and removal of wild flora species; • hunting activities other than sanitary or selective culling; • the transit of motorised vehicles on paths, mule tracks, farm and inter-farm roads, forestry tracks and forestry service roads; transit is only permitted for vehicles necessary for agricultural, zootechnical and forestry activities or for surveillance, fire-fighting, and in general civil protection, rescue and health and veterinary assistance activities.

art. #	permitted activities	forbidden activities
	• reuse of existing buildings for surveillance, scientific research, study and observation purposes; • maintenance and rehabilitation of drainage, irrigation and soil conservation infrastructures; • conservation management of forests and woodlands and agricultural and livestock activities limited to areas where such activities already exist; • hiking activities.	
art. 28 **Protection zones for surface and underground water bodies**		• unrestricted discharges of liquids and other substances of any kind or origin into the soil and subsoil; • the slurry lagoons from livestock farms; • the search for groundwater and the digging of wells, on one's own land or that of others, where not authorised; • the construction and operation of new landfills for the disposal of waste of any kind and origin; • the burying, interruption or deviation of underground aquifers, with particular regard to those supplying aqueducts for drinking water use.



• *Anhydrite rock seen under to optical microscope (crossed polars). © Stefano Lugli*

The regional plan is implemented through regional, intra-regional and sub-regional planning tools, which have specified and deepened the contents and provisions of the PTPR.

Specifically, these implementation tools are provincial (Provincial Coordinating Territorial Plan, known as PTCP), metropolitan (Metropolitan Territorial Plan) and municipal (General Town Plan, known as PRG; Municipal Structural Plan, known as PSC, etc.).

The regional, provincial and municipal planning tools, according to their level of competence, represent the single protection reference on the regional policies for the territorial development programs.

The control and supervision of the application of compliance with landscape protection regulations is under the responsibility of the Region, the Province and the Municipalities (Municipality, Association of Municipalities, Union of Municipalities, etc.) according to the planning level concerned in the territory.

5.E PROPERTY MANAGEMENT PLAN OR OTHER MANAGEMENT SYSTEMS

The management system of the nominated property is hinged on the main territorial Authority - the Emilia-Romagna Region - since all the 7 components sites fall within its administrative boundary. As already pointed out in paragraphs 5.c and 5.d, all the component sites are managed by park authorities that are under the authority of the Emilia-Romagna Region, except for one (Alta Valle del Secchia) which is under the direct authority of the Appennino Tosco-Emiliano National Park.

In order to ensure a unitary and homogeneous management of the nominated property, various possible alternatives have been considered, taking inspiration from the governance models available in UNESCO and/or international contexts. In particular, various management examples of other complex territories with physical and administrative characteristics similar to those of the candidate property were analysed:

1. properties with geological value of global importance (World Heritage List sites according to criterion viii; UNESCO Global Geoparks geosites);
2. serial properties (Italian and European serial sites inscribed in the World Heritage List; sites inscribed in the MaB programme);

On the basis of these criteria some case studies have been identified among the World Heritage serial properties which appear significant for geological aspects such as Caves of Aggtelek Karst and Slovak Karst, HUN-SVK or The Dolomites, ITA.

GOVERNANCE OF THE SERIAL PROPERTY

The proposed governance system brings together the existing forms of management, without overlapping them, but creating a new coordination structure that can effectively converge the various park management Authorities on shared objectives.

This coordination is based on the establishment of an office exclusively dedicated to the World Heritage Site (if inscribed) within the lead administrative structure. In the Italian context, there are several examples of a similar scheme (although related to historical urban centres and cultural heritage), which allow us to observe the effectiveness of this solution.

The establishment of a management coordination office represents a "light" solution that does not require the formation of a Director Board, new management bodies or external support roles. Moreover, it can be quickly set up using human and financial resources which are available within the lead administration.

The involvement of stakeholders (non-institutional or NGOs) in conservation, management and promotion guidelines for the nominated property is guaranteed through the establishment of specific supporting bodies that involve universities and research centres (UNI GeoLab), or that engage individuals and associations (EKCNA WH club) in research, promotion and monitoring activities of the geological heritage.

However, the administrative-managerial characteristics of the components of the EKCNA serial site, which consists of the following areas, should also be considered in the evaluation:

1. **Alta Valle del Secchia** belonging to the Appennino Tosco-Emiliano National Park (PNATE), therefore subordinate to Ministry of Ecological Transition (MITE);
2. **Bassa Collina Reggiana** belonging to the Management Authority for Parks and Biodiversity - Emilia Centrale, and therefore subordinate to the Emilia-Romagna Region (RER);
3. **Gessi di Zola Predosa** belonging to Natura 2000, and therefore directly referred to

the Protected Areas Service of RER;

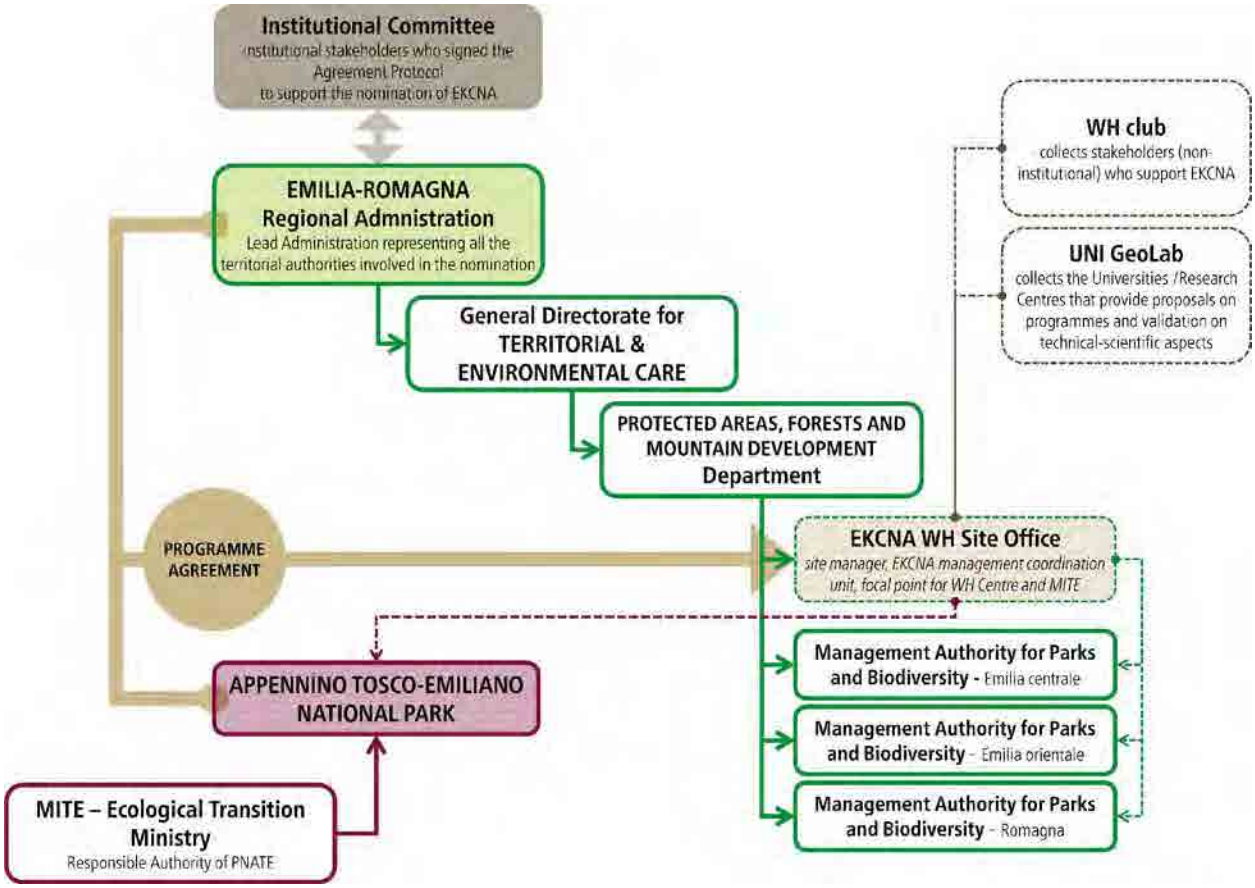
4. **Gessi Bolognesi** belonging to the Management Authority for Parks and Biodiversity - Emilia Orientale, and therefore subordinate to the RER;
5. **Vena del Gesso Romagnola** belonging to the Management Authority for Parks and Biodiversity - Romagna, and therefore subordinate to the RER;
6. **Evaporiti di San Leo** belonging to Natura 2000 and therefore directly referred to the Protected Areas Service of RER;
7. **Gessi di Onferno** belonging to the Management Authority for Parks and Biodiversity - Romagna, and therefore subordinate to the RER.

Therefore, since only one of the components does not depend on the RER the degrees of difficulty at the organisational-management level are limited.

The involvement of PNATE can be resolved through a Programme Agreement between the RER and the MITE/PNATE with which to establish the methods, times, and forms of coordination of the management and actions for the protection/enhancement/promotion of the property, including other very important management elements such as the administration/seeking of funding, the financing of activities, the provision of a current management fund, etc.

The Office in charge of coordinating/managing the nominated WH Site must exercise coordination activities between the various implementing subjects (the Park and Biodiversity Management Bodies), which in turn are subject to the control of the RER through the Service for Protected Areas, Forests, and Mountain Development, which also directly manages the Natura 2000 Network sites.

- *governance scheme of serial site EKCNA: the continuous line/ perimeter indicates that the office/ structure already exists; the dashed line/perimeter indicates that the structure/office is to be established*



Therefore, in order to be able to effectively exercise the role of guidance and management co-ordination among different implementers, the EKCNA WH Site Office will be provided with the best available coordination.

COORDINATED MANAGEMENT STRATEGY

The central aim of management, i.e. the maintenance of the integrity of the nominated property, is articulated following some concepts widely shared at international level: conservation and protection / valorisation / communication.

The presence of stratified competences and forms of management on the candidate property also requires a coordinated and inclusive management strategy.

The management project is based on three principles:

I. *to develop existing collaboration (cf. the collaboration experience of the LIFE Gypsum project)*

II. *networking knowledge and experience between Regional Park and National Park Management Authorities;*

III. *enhancing geological scientific value by focusing on seriality and connecting factors between the component sites.*

IV. *sustainable developping of the territory through promotion and compatible economic activities.*

The project has identified a number of central themes on which to converge the experience and expertise already present locally through mutual collaboration. The aim is to build widespread knowledge and awareness of the outstanding universal values, both among the resident population and among visitors.

The key themes identified are:

GeoHeritage:

1. promoting in-depth and coherent knowledge of the geological values spread over the territory as an exceptional testimony of the Earth's history;
2. identifying a unique geoprotection concept to be included in planning;
3. to strengthen common geoprotection measures to be applied locally;
4. to activate exchange and collaboration with other World Heritage sites that are comparable in scientific or organisational terms.

GeoTourism:

1. increasing the quality of tourism (both domestic, i.e. surrounding the nominated property, and incoming tourism) by managing present-day flows and improving attractiveness (e.g. by creating visitor itineraries that combine and summarize elements of both epigean and hypogean geological values);
2. defining a coordinated communication strategy (for different component sites), the dissemination of which promotes the understanding of geologic values to the broader public;
3. reinforcing the attractiveness by creating routes (geo-trails) that cover all the geological values;
4. introduction of the practice of "geocaching" and design of applications/software for the understanding of the geological value of each component of the serial property;

5. promotion of the network of interpretation centres;
6. promoting the network of tourist facilities (restaurants, museums, refuges, B&Bs, etc.) for the dissemination of the geological value of the nominated property.

Knowledge and Training:

1. to promote the knowledge of geological values through school education and the professional training of operators, promoting the creation of the network of museums in the territory;
2. to promote the creation of a computerised repertoire (bibliographic, photographic, iconographic) specific to the EKCNA site, according to the OUV;

Sustainable development and cooperation between the single components:

1. pursue the mitigation of anthropogenic pressure factors and the conservation of the natural heritage basde on the exemplary experiences of parks and protected areas;
2. orientate conservation activities and the promotion of the territory's values towards a progressive integration of the actions promoted by the individual management Authorities

5.F SOURCES AND LEVELS OF FINANCE

The financing sources of the nominated areas are public, namely national, regional and municipal. The Emilia-Romagna Region is the main source of financing as it directly manages most of the candidate territory.

FINANCE SOURCES PER COMPONENT SITE – AVERAGE ANNUAL BUDGET IN €

no.#	component site	institution	funding source	current expenditure	capital expenditure
1	**Alta Valle del Secchia**	Park Authority	national	20,000	60,000
			European		50,000
			regional		50,000
2	**Bassa Collina Reggiana**	Park Authority	regional and local	5,000	50,000
3	**Gessi di Zola Predosa**	Regional Authority	regional	5,000	30,000
4	**Gessi Bolognesi**	Park Authority	regional	90,000	200,000
5	**Vena del Gesso Romagnola**	Park Authority	regional	300,000	75,000
		Municipality	local	50,000	25,000
6	**Evaporiti San Leo**	Regional Authority	data not available		
7	**Gessi di Onferno**	Park Authority	regional	50,000	
			local		5,000
			TOTAL	**535,000**	**545,000**
			Main source (RER)	450,000	55,000
				84%	*65%*

At present, the Region contributes 84% of the current expenditure and 65% of the capital expenditure. The average annual budget (calculated over the period of the last 5 years) is about 1,100,000 € (about 300 €/ha), nearly exactly balanced in half between current and capital expenditure.

In addition to this ordinary funding, must be mentioned the Region's special investment programs for regional protected areas and, in perspective, national funds for the conservation and enhancement of World Heritage List sites, established by Law n. 77/2006.

In particular, for the three years 2021-2023, the Region has approved an "Investment Programme for Parks and Protected Areas" intended for projects of environmental requalification and enhancement and biodiversity conservation. This three-years investment programme is planned by the Programme for the Regional System of Protected Areas and Natura 2000 Network sites (see par. 5c).

Furthermore, the Region has recently approved the PAF - Prioritised Action Frameworks - a strategic document that is an integral part of the new programming cycle of the European Funds for 2021-2027. Based on the PAF, for the next seven years, the Natura 2000 sites belonging to the nominated property will count on specific investments for carrying out concrete actions of protection, regulation, monitoring, training, and dissemination.

Finally, National Law n.77/2006 supports specific interventions for the protection, promotion and enhancement of the Italian UNESCO sites. In particular the Law supports the elaboration of management plans for listed sites, which entail special measures for the OUV conservation.

Thanks to these programmes and this national law, the additional funding earmarked for nominated areas could reach around one million euros per year.

5.G SOURCES OF EXPERTISE AND TRAINING IN CONSERVATION AND MANAGEMENT TECHNIQUES

The main source of expertise is represented by the universities of the neighbouring cities, considered among the oldest in the world: Alma Mater Studiorum University of Bologna (founded in 1088), University of Modena and Reggio-Emilia (founded in 1175), University of Parma (founded in the Middle Ages, too), University of Ferrara (founded in 1391). These universities offer bachelor's and

Special measures for the protection and use of Italian Sites inscribed on the 'World Heritage List', placed under the protection of UNESCO

The National Law of 20 February 2006 no. 77 "*Special measures for the protection and use of Italian sites and elements of cultural, landscape and environmental interest, inscribed on the 'World Heritage List', placed under the protection of UNESCO*", reiterates that, due to their uniqueness, the Sites and Elements inscribed on the Lists provided for by the respective UNESCO Conventions, are points of excellence and fundamental elements of the representation of Italy, including at an international level. It involves financial measures to support the enhancement, communication and use of the Sites and Elements (art.4), intended for interventions aimed at:

- the study of specific cultural, artistic, historical, environmental, scientific and technical problems relating to Italian UNESCO sites and elements, including the development of management plans;
- the provision of cultural assistance and hospitality services for the public, as well as cleaning, waste collection, control and security services;
- the creation, including in areas adjacent to the sites, of parking areas and mobility systems, provided they are functional to the sites themselves;
- the promotion, protection and enhancement of the Italian UNESCO sites and elements, the dissemination of their knowledge and their requalification;
- in the context of educational institutions, enhancement is also implemented through support for educational trips and cultural activities by schools;
- the enhancement and dissemination of the wine heritage characterising the site, in the context of the promotion of the overall traditional food and wine and agricultural-pastoral heritage.

The Law also formally recognises the Management Plans and the Safeguarding Measures Plans as indispensable tools to "ensure the conservation and enhancement of Italian UNESCO Sites and Elements" (art. 3 paragraph 1).

master's degree courses in all scientific, cultural and management disciplines required for the conservation and management of protected areas.

Staff are generally recruited through public competitions based on qualifications, exams, skills, and experience acquired. The local and parks authorities also regularly organise training and refresh courses in nature conservation, laws and regulations, nature interpretation and communication, aimed at current staff and staff to be recruited.

In order to improve the preparation of employees, administrative Authorities and parks periodically organise internal competitions to advance staff in terms of salary and role.

5.H VISITOR FACILITIES AND INFRASTRUCTURE

The overall average number of visitors to the nominated property is approximately 290,000 per year, with different concentrations in different areas of the property. This number derives from a count of annual visitors to geological and nature museums and visitor centres in parks and nature reserves. The figures are supplemented by an estimate of hikers on geological trails, by calculating the vehicles in the parking lots at the entrances to the protected areas and the number of visitors who walk or travel by public transport or bicycle.

Of over 900 catalogued caves, only 6 can be visited, with guided tours in small groups: the Spipola Cave and the Farneto Cave (both in c.s.4), the Re Tiberio Cave, the Tanaccia Cave, and the Roman lapis specularis quarry of Cà Toresina (all in c.s.5), and the Onferno Cave (in c.s.7). The visit of these few caves open to the public takes place with speleological modalities, without alterations of the natural cavities and their habitats.

• *The entrance of the Re Tiberio cave (2016). Vena del Gesso Romagnola © P.Lucci*

The organization to support the informed visit is very valuable in all the seven component sites of the nominated property. There are five visitors' centres and five geological museums, one of which is an open-air museum obtained from the environmental restoration of an abandoned quarry. In addition, the galleries of a Roman lapis specularis quarry have been transformed into an underground educational area. Finally, all the geological trails are equipped with panels and signs for self-information.

The mobility system is well regulated, while rest and refreshment points are well organized and delimited to specially equipped areas (park gates with rest areas, picnic areas, and refreshment points).

Information and descriptive panels and tourist signage are positioned at all crossroads nearby the protected areas as well as at most of the attractive hotspots. More extensive signages are placed at the protected areas entrances, where it is essential to inform visitors of the protected area (or OUV) itself. Warning signs, information, and interpretive posts are located along geological trails and picnic areas on less-used routes.

c.s.#	Component site	management Authority	visitors per year	visitor facilities	opening period
1	**Alta Valle del Secchia**	Appennino Tosco-Emiliano National Park	20,000	Infopoint Gessi Triassici	Apr - Oct
2	**Bassa Collina Reggiana**	Management Authority for Parks and Biodiversity Emilia Centrale	not available	Cà del Vento trail geo-oriented signage Information and interpretive boards	always
3	**Gessi di Zola Predosa**	Protected Areas, Forests and Mountain Development Service of Emilia-Romagna region	5,000	Sentiero dei Gessaroli geo-oriented signage picnic area for day visitors	always
4	**Gessi Bolognesi**			Spipola geological trails geo-oriented signage picnic area for day visitors	always
				Spipola Cave (guided speleological tours only) geo-oriented signage (outside)	for the protection of bats, excursions do not take place in winter
			50,000	Visitor Centre "Casa Fantini"	always
			1,000	Farneto Cave (guided speleological tours only) geo-oriented signage (outside)	for the protection of bats, excursions do not take place in winter
5	**Vena del Gesso Romagnola**	Management Authority for Parks and Biodiversity Romagna	11,000	Open-air Geological Museum former quarry of Monticino (RA)	always
			1,500	Karst Museum "Casa Cantoniera" (RA)	soon to be inaugurated
			3,000	Geological Museum "Palazzo Baronale" (BO)	soon to be inaugurated
			1,500	Re Tiberio Cave (RA) (guided speleological tours only)	always
			1,000	Educational Area of former quarry Marana (RA) (guided tours only)	always
			900	Tanaccia Cave (RA) (guided speleological tours only)	Apr-Oct
			50,000	Visitor Centre "Cà Carnè" (RA)	always
			5,000	Visitor Centre "La Casa del Fiume" (BO)	always
			19,000	"Man and Gypsum" Museum (RA)	always
			500	Ca' Toresina Roman lapis specularis quarry (RA) (guided tours only)	always
6	**Evaporiti di San Leo**	Management Authority for Parks and Biodiversity Romagna	not available		
7	**Gessi di Onferno**	Management Authority for Parks and Biodiversity Romagna Municipality of Gemmano (RM)	10,000	Naturalistic Museum of the Oriented Natural Reserve of Onferno	Dec-Mar week end / Mar-Oct all the year
			10,000	Visitor Centre "Grotte di Onferno"	Oct-Mar week end / Mar-Nov all the year
		TOTAL	**290,400**		

5.I POLICIES AND PROGRAMMES RELATED TO THE PRESENTATION AND PROMOTION OF THE PROPERTY

Environmental and sustainability education is managed in a coordinated way by the Emilia-Romagna Region through the Regional Agency for the Environment, Prevention, and Energy (ARPAE). The Agency draws up the "Regional Programmes of Information and Education for Sustainability", based on the objectives of the 2030 Agenda for Sustainable Development.

The Emilia-Romagna Sustainability Education Network (RES) connects all organizations (public and private) responsible for promoting sustainability education in the region. It includes local authorities, educational and training institutions, scientific agencies, park authorities, business, and voluntary associations. In particular, the Centres for Education for Sustainability (CEAS) of Emilia-Romagna have been established. They are specialised structures distributed throughout the region. The CEAS "Protected Areas" have been set up by the Management Authority for Parks and Biodiversity (Macro-areas), and are responsible for sustainability education, with particular reference to biodiversity and natural heritage.

• *Excursion in the Secchia valley at Sologno (2018). Alta Valle del Secchia © S.Lugli*

In the territory of the nominated property, there are three of them: the "Protected Areas Emilia Orientale" CEAS, the "Protected Areas Emilia Centrale" CEAS, the "Parks School Romagna" CEAS.

These CEAS-Protected Areas coordinate the educational activities of the "Gessi Bolognesi e Calanchi dell'Abbadessa" Regional Park, the "Vena del Gesso Romagnola" Regional Park, the "Onferno Reserve", and the "Collina Reggiana Protected Landscape".

In these protected areas, educational and informative activities are carried out for schools, citizens, and visitors. In the first hill area, educational programmes are mainly developed for schools, while in the mountain area initiatives aimed at tourists prevail.

The main activities developed are:

- planning and implementation of educational routes and programmes for schools (educational routes, guided tours, activities in visitor centres and museums, etc.);
- realisation of information projects for citizens, seminars, conferences, and public events;
- organisation of educational stays, summer centres, and initiatives related to ecological tourism;
- support and didactic assistance on environmental themes for teachers and educators, also through training and refresh courses.

• *Lower entrance to the Grotte di Onferno. (2016) Gessi di Onferno © P. Gualandi*

The proposals make it possible to address and explore natural, environmental, and historical-cultural issues in-depth, with paths integrated with school training plans.

The organisation is in constant contact with schools, public administrations, and associations

in various areas. The management of the educational and dissemination activities is entrusted to several external subjects, which guarantee the service with the help of qualified operators (educators, disseminators, environmental excursion guides, etc.).

The Appennino Tosco-Emiliano National Park is engaged in an intensive environmental education activity, which contain a wide range of educational and training proposals. Equally substantial is the promotion activity of the natural values that include the importance of the UNESCO Biosphere Reserve recognition.

Many activities are managed in collaboration with neighbouring regional park authorities (Management Authority for Parks and Biodiversity Emilia Centrale and Management Authority for Parks and Biodiversity Emilia Orientale), linked by partnership agreements.

The National Park and the Emilia-Romagna Region supported various studies, research, teaching, and dissemination of the value of the areas of the nominated property.

Recent examples of this collaboration are the European projects such as the LIFE Gypsum project, the Interreg Central Europe Eco-TOurism (CEETO), the Hiking Europe and Made in Land projects.

The LIFE Gypsum project allowed an environmental restoration intervention in the karstic resurgences Poiano Springs area, compromised in the 1970s and now restored from the natural point of view and with significant signs of natural recovery.

The CEETO project, of which the Region is the leader, promotes an innovative model of sustainable tourism inspired by the criteria contained in the European Charter for Sustainable Tourism in Protected Areas (ECST). Of the eight pilot actions, one concerns the national park, where the diversified tourist flow is not always aware of the value and fragility of the protected areas themselves.

The Hiking Europe cooperation project (in which the Region is a partner), has led to the development of 6 tourist proposals, thanks to the cooperation with the Appennino Tosco-Emiliano National Park, the Casentino Forests, Monte Falterona, Campigna, and the Vena del Gesso Romagnola Regional Park. The project represented an opportunity to promote the Alta Via dei Parchi at an international level and offer visitors a wide choice of trails allowing them to combine physical activity with the discovery of the natural and cultural features of the nominated territory. The creation of sustainable tourism proposals saw the active involvement of businesses and host communities.

The Made in Land Project goal is to promote the protection and enhancement of natural and cultural capital of inland areas, far from the usual tourist circuits, improving accessibility and tourist fruition.

Finally, all protected areas have established solid

The travelling exhibition of the nomination project

One of the most significant initiatives to support the nomination was the traveling exhibition organized by the Regional Speleological Federation of Emilia-Romagna and the Speleo GAM of Mezzano. The exhibition - also supported by the Emilia-Romagna Region, by the Appennino Tosco-Emiliano National Park, by the Vena del Gesso Romagnola Park, and by the Gessi Bolognesi e Calanche dell'Abbadessa Park - is composed of 13 panels.

Each panel illustrates a specific aspect of the candidate property: the phenomenon of evaporitic karst, the geo heritage values of each component site, the safeguarding, the facilities for visits and interpretation, the scientific research, the survey and monitoring activities.

The exhibition has been set up in the various villages of the territory of the candidate property on the occasion of festivals and folk festivals organized by the local *pro loco* (=associations promoting local culture and tourism). Together with the exhibition, side events such as visits, meetings, and conferences were organized. Set-ups calendar:

- September 29, 2018 - Casalfiumanese (Bologna)
- November 1-4, 2018 - Casola Valsenio (Ravenna)
- November 27 - December 21, 2018 - Faenza (Ravenna)
- March 1-5, 2019 - Borgo Tossignano (Bologna)
- April 6-7, 2019 - Borgo Rivola (Ravenna)
- April 22, 2019 - Fontanelice (Bologna)
- May 3, 2019 - Brisighella (Ravenna)

The continuation of the activity in the territory was interrupted by the Covid-19 pandemic.

• *Visit to the Farneto cave (2019) . Gessi Bolognesi*
© R. Simonetti

partnerships with other actors and stakeholders active on the territory of the nominated property, especially concerning field research, monitoring, and visitor guidance activities.

The main stakeholders or user groups involved and networked among themselves through various training/updating/dissemination projects on the value of the property are:

- Italian Speleological Society;
- Regional Speleological Federation of Emilia-Romagna (FSRER);
- Regional Speleological Groups;
- Environmental Hiking Guides;
- Universities (Bologna, Modena and Reggio Emilia).

SUPPORT ACTIVITIES FOR THE NOMINATION

In January 2018, after the inclusion of the nominated property in the Italian Tentative List, the activities in support of the proposition were intensified with the realization of numerous events on the territory such as informative meetings, symposia, and conferences of a dissemination character, articles, and reports in the press and local TV, public forums, exhibitions, and documentaries. The promotion activities organized by the parks, by the Regional Speleological Federation of Emilia-Romagna, by the local speleological groups, and by the local environmental associations were particularly important.

Among these activities, we mention the realization of an informative website on karst phenomena in evaporites with pages dedicated to the nomination (http://www.venadelgesso.it/wh.html) and a Facebook profile in support of the candidature where all the events organized from March 2018 to today are reported (https://www.facebook.com/Grottecarsismo/?ref=page_internal).

MEANS OF SUPPORTING THE INFORMED AND AWARE FIELD VISIT

Visitor centres

The five visitor centres are the primaries of environmental education and interpretation spaces of the nominated areas. They all provide exhibitions on different aspects of geological and natural values and deliver excellent visitor services and facilities.

Museums

The five geological museums are specifically dedicated to the divulgation of karst and gypsum values of the nominated property. One of these is a remarkable open-air museum, created by the environmental restoration of a disused quarry. It represents a clear demonstration of how disused mining areas can be renaturalised and reused for sustainable activities.

Two new museums created from the reuse of two historic buildings will be opened soon and will be dedicated to karst and gypsum. The following is a brief description of the interpretation centres, museums and guide services to support an informed and aware field visit of the nominated property.

c.s.	component site	INTERPRETATION CENTRES
1	**Alta Valle del Secchia**	**Information Point "Gessi Triassici"** Dedicated to the Triassic Gypsum, it is located inside a building owned by the Villa Minozzo Municipality. The building is directly adjacent to the area of the salty karst springs, the Poiano Springs. The Centre is equipped for reception of school and tourist groups, for teacher training courses, Excursion Environmental Guides, Italian Alpine Club (CAI), Speleological groups in addition, as mentioned, for other kind of recreational activities. The Centre, parking and bar and restaurant service are all accessible to people with disabilities. Also, around the info point the disabled visitor, may closely observe the area of the Poiano salt springs of using a dedicated trail and information signs. Also, at the entrance to the Poiano Springs and in the core area, there are parking areas with special information signs dedicated to the Gessi Triassici area.
4	**Gessi Bolognesi**	**Visitor Centre "Casa Fantini"** It is located in Val di Zena, near Farneto, in the house which belonged to Luigi Fantini, a pioneer in the exploration of the Bolognese gypsum caves and founder of the Bolognese Speleological Group. In the offices it is possible to find leaflets, brochures, posters, books and audio-visual material on the various aspects of the protected area and to get information on the activities of the park and the naturalistic and speleological guided tours organized for schools and groups of visitors. A few steps from the recently opened Farneto Cave is the meeting point for guided tours of the cave.
5	**Vena del Gesso Romagnola**	**Ca' Carné Visitor Centre** The Centre offers several facilities for the visitors. The building houses the info point of Vena del Gesso Romagnola Park and the naturalistic museum dedicated to the wildlife of Vena del Gesso Romagnola, preserving finds of almost all the most interesting animal species living in the Park, including the wolf, the crested porcupine, the Eurasian eagle owl, the peregrine falcon, and the blue rock thrush, a conference room, and a classroom. At Ca' Carné, characteristic rural house built in the framework of Apennine reclamation projects during the 1920s-1930s, after which the Visitor Centre has been named, there is the mountain hut, with restaurant and café, as well as two dormitories and two smaller rooms for families. The centre has also a summer camp. **Casa del Fiume Visitor Centre** The Visitor Centre is dedicated to water and it provides information about the Park of Vena del Gesso Romagnola and Santerno Valley. The Visitor Centre includes a multifunctional and didactic room (with a complete laboratory for the study of water), able to host courses, conventions, seminars, and events for up to 50 people. The Centre is accessible to people with disabilities through a staircase servo. In addition, the Centre has a restaurant, a cafè, and a hostel..
7	**Gessi di Onferno**	**Onferno Nature Reserve Visitor Centre** The Visitor Centre, housed in the ancient Pieve di Santa Colomba which was in large part destroyed by the bombings during the last war, is the reference point for the guided visits to the cave, the hikes and the other opportunities for schools or groups. Here visitors will receive all the information related to the reserve and the surrounding territory, and they will have the opportunity to take part in the daily guided visits to the caves equipped with helmet and lamp.

c.s.	component site	TOUR GUIDE SERVICES - CAVES
4	Gessi Bolognesi	**Farneto Cave** The visit route is about one kilometre long and is the final part of a complex karst system originating in the Ronzana steephead valley. The cave is an important prehistoric site in the Gessi Bolognesi and Calanchi dell'Abbadessa regional nature park, an interesting and stimulating place for geologists, speleologists, biologists and historians.
		Spipola Cave The cave path about is 700 m long with a minimum difference in height and therefore suitable for everyone, but moving in a particular environment, rich in humidity. Along the route there is a hypogeal fauna of great scientific interest consisting, in particular, of various species of bats and invertebrates that have evolved and specialised for life in the absence of light.
5	Vena del Gesso Romagnola	**Re Tiberio Cave** The visit unfolds along a 60 meters "archaeological" route equipped and illuminated and a 350 meters "historic" route not illuminated and not equipped. The visit is a real speleological experience, for which the Park provides speleological suit and lighting helmets. The cave, with a total length of over four kilometres, can be easily explored with normal clothing for a stretch of about sixty metres as far as the Sala Gotica. Beyond this point it can only be visited with speleological equipment. The lower branches of the cave are very difficult due to the presence of shafts and bottlenecks and can only be visited by speleologists with appropriate equipment. **Tanaccia Cave** The visit route is about 400 meters long, not illuminated and not equipped. The visit is a real speleological experience, for which the Park provides speleological suit and lighting helmets. The path runs along the Tanaccia underground stream, passing three big cave rooms, with many interesting speleothemes. **Marana quarry gallery** The quarry gallery of Marana is a big artificial galley reused for educational purposes after the closure of exploitation activities. It represents a preparatory space for the speleological excursion. Since it is large, it can also be visited by people who would have problems accessing a real natural cave, who can still experience a visit underground. The gallery is also easily accessible for wheelchairs and visually impaired people. Didactic panels complete the visit route. Inside the quarry, there is also a hall equipped with a temporary platform for acoustic concerts of classical music. This space attracts every year hundreds of people, making them discover the importance of the underground habitats and karst phenomena of the Vena del Gesso. **Ca' Toresina Roman lapis specularis quarry** The Cà Toresina quarry is one of the Roman quarries discovered in the Vena del Gesso. It has been equipped for the visit and can be visited during guided tours along the "Crystal Path", a special walk created to visit the most important Roman quarries of *lapis specularis* in the area of Monte Mauro, in the core area of the property.
7	Gessi di Onferno	**Onferno Cave** The cave is 700 metres long, with a difference in height of about 64 metres and a depth of 70 metres, but not all of it can be visited. In fact, the tourist trail is only 350 metres long, while the side rooms and the second and third levels of the cave are off-limits to tourists.

c.s.	component site	MUSEUMS
5	Vena del Gesso Romagnola	**"Man and Gypsum" Museum** The Museum is located at the Rocca di Brisighella. The Rocca, built in 1310, stands on one of the three gypsum pinnacles that dominate the village. The Museum has been set up inside the Rocca: an itinerary that crosses the long history of man's relationship with this territory and with the mineral that characterises it, from the Copper Age (Tanaccia caves, Re Tiberio cave, Banditi cave), to Roman times (Roman building of Carné, Lapis specularis quarries), to the Middle Ages (Rontana castle). **Monticino Geological Open-air Museum** It is an extraordinary museum in a former quarry, in which interesting geological, speleological and paleontological aspects were brought to light, with paths, didactic panels, spectacular dioramas about the Messinian tropical fauna. In particular, fossils of crocodiles, antelopes, rhinos, hyenas and monkeys, dating back to about 5 and a half million years ago, have been discovered inside the karst conduits brought to light by the excavations. **Casa Cantoniera Karst Museum** The Museum is located in Borgo Rivola (just outside the core and buffer areas), overlooking a long-distance road, equipped with a classroom, conference room, information point, library, a very interesting and complete documentation centre on karst and caving, bar, hostel. The Museum is specifically dedicated to the dissemination of karst values of the Emilia-Romagna gypsum and it could be the head base of the nominated property; it will be also the starting point for visits to the Re Tiberio cave. *Opening soon.* **Baronial Palace Geological Museum** The Museum is situated in the middle of the village called Tossignano, built on the Vena del Gesso. It is located in the Baronial Palace, a building dating back to the 16th century with a garden, where it is possible to find a direct connection with the Park trail network. The Museum is dedicated to the particular geological features of the Vena del Gesso, and it deals with the Gessoso-solfifera Formation and with the other surrounding geological formations of the protected area, as well as with the relationship between man and gypsum. *Opening soon*.
7	Gessi di Onferno	**Onferno Reserve Nature Museum** In the Nature Museum guests will have the opportunity to experience a journey to discover the Reserve's geological, speleological, plant and wildlife features. During the itinerary within the museum visitors will not only observe the exhibited objects, but they will also interact with them through equipment allowing an interactive use.

- *The Monticino Geological Open-air Museum, obtained from former quarry. Vena del Gesso Romagnola © Parco Museo Geologico Cava di Monticino*

5.J STAFFING LEVELS AND EXPERTISE

The management of the candidate property can count on a dedicated staff of approximately 40 people, 25 of whom are full-time and 15 part-time.

In addition, the Carabinieri Forestali and about 80 Voluntary Ecological Guards (GEV) (voluntary agents) provide a surveillance service in the field as rangers, regulated by special agreements. There are also environmental excursion guides and speleological guides from the parks who accompany small groups of visitors to the caves.

All the permanent employees have a degree in different fields of natural or social sciences - biology, geology, forestry, natural sciences, history or education as well as in business management and bookkeeping. All staff members working in the field are required to take courses in first aid and rescue.

Lower educational requirements are demanded of other part-time staff, such as general workers.

The Voluntary Ecological Guards (rangers)

The Voluntary Ecological Guards (GEV) are Voluntary Particular Guards who, in the exercise of their functions, can proceed with the ascertainment of administrative offences within the framework of environmental protection legislation. Appointment as a Voluntary Ecological Guards is ordered by the Emilia-Romagna Region for those who have attended special training courses and passed examinations. The effectiveness of the appointment is subject to the approval of the Prefect (art. 138 of the Consolidated Law on Public Security n. 773/1931) and the taking of an oath.

The act of appointment defines the specific tasks that each Voluntary Ecological Guardsman is called upon to carry out in relation to the various environmental regulations. In particular, the act of appointment defines in detail, on the basis of binding directives issued by the Region, the rules for the violation of which administrative fines are envisaged. Each Voluntary Ecological Guardsman has a personal identification card in accordance with the model approved by the Regional Council. In carrying out their duties, the Ecological Guards are required to qualify by showing their badge.

The GEVs are organised in one or more provincial groups with their own statutes and service regulations, the latter approved by the Public Security Authority. They act in agreement with public bodies and organisations responsible for environmental protection.

c.s.	component site	management authority	full-time staff	part-time staff	rang-ers(-GEV)
1	Alta Valle del Secchia	Appennino Tosco-Emiliano National Park	**9**	**6**	**5**
2	Bassa Collina Reggiana	Management Authority for Parks and Biodiversity Emilia Centrale	**3**	**2**	**10**
3	Gessi di Zola Predosa	Protected Areas, Forests and Mountain Development Service of Emilia-Romagna region	**1**	**2**	**5**
4	Gessi Bolognesi	Management Authority for Parks and Biodiversity Emilia Orientale	**5**	**1**	**30**
5	Vena del Gesso Romagnola	Management Authority for Parks and Biodiversity Romagna	**7**	**4**	**30**
6	Evaporiti di San Leo				
7	Gessi di Onferno				
		TOTAL	**25**	**15**	**80**

- *The Medieval castle and tower of Brisighella, built, for defensive reasons, on the impervious cliffs of the Vena del Gesso Romagnola. Now the fortress houses the **"Man and Gypsum"** museum (2014). Vena del Gesso Romagnola © Pietro Fabbri, .*

MONITORING

6

6.A KEY INDICATORS FOR MEASURING STATE OF CONSERVATION

• *(facing page) In situ laboratory at the Novella cave. Gessi Bolognesi © A. Pumo*

The nominated property is constituted by 7 component sites extending in a W-E strip, between the Po Plain to the north and the Apennine ridge, which represents the watershed between the Adriatic and the Tyrrhenian basins. This portion of the northern Apennines is characterised by a very high level of socio-economic development and by a complex hydro-geo-morphological system.

The inevitable interaction between the anthropic and natural systems influences the state of conservation of both epigeal and hypogeal karst phenomena (see chapter 4) . For this reason, monitoring activities concern not only the geological and hydro-geological aspects but also the climatic ones and those related to socio-economic activities, environmental education, and training. The major part of the factors influencing the geo-heritage state of conservation concern not only the nominated phenomenon, but also the wide area that contains the nominated property and the various elements that contribute to the natural evolution of the karst features (e.g. climatic aspects). For this reason, monitoring activities are carried out both at regional and national level by land management and protected areas agencies; some factors are also monitored at European level.

At the moment, the main aspects that directly and indirectly influence the conservation of the entire geo-heritage in the nominated area are investigated by monitoring:

- **caves**
- **streams and rivers**
- **gravitational mass movement and erosion phenomena**
- **earthquakes**
- **weather and climate**
- **forest cover and land use**
- **tourism pressure**
- **access roads and trails.**

Details of the agencies and institutions responsible for monitoring, and the frequency of the surveys, are given in the following paragraphs.

6.A.1. GEOLOGY AND HYDROGEOLOGICAL VULNERABILITY

The factors determining geological and hydrogeological vulnerability were considered on the basis of the scientific literature on geomorphological and karst phenomena monitoring (EPA - Quinlan J.F. 1989; IGRACT 2008; RER

Biological monitoring of the groundwater fauna of upper Secchia Valley (c.s.1) performed by the Italian Speleological Society (SSI) within the "Trias Project"

Project carried out on the initiative of the Appennino Tosco-Emiliano National Park with the involvement of the Italian Speleological Society, students and researchers of the University of Bologna, University of Modena and Reggio Emilia, the Regional Geological Service, the Province of Reggio Emilia, the Municipalities of Castelnovo ne' Monti, and Villa Minozzo, the association "Vivere Sologno", and individuals.

A. In the cold saline springs of Poiano the collected species (all stygobiont) belong to the following taxa: *Copepoda Harpacticoida (Nitocrella psammophila)*, Ostracoda (*Pseudolimnocythere sp.*), Amphipoda (*Niphargus poianoi*) and Oligochaeta; two species are new to Science. The faunistic assemblages sampled at the Poiano Springs is characterized by very low species richness, all species being stygobionts. The low species richness is likely related to the high chlorinity of the spring waters (Stoch F. et al. 2009-a).

• *The Poiano salt karst springs. Alta Valle del Secchia. © P. Lucci*

B. The groundwater fauna of the upper Secchia valley shows in gypsum aquifers the large presence of stygobiotic species (30%), some of which are new to Science and exclusive to the Triassic evaporites areas. The discovery of some stygobionts of ancient marine origin poses some interesting questions dealing with historical biogeography. Two new species belonging to the oligochaete genera *Abyssidrilus* (a marine genus distributed in deep oceanic waters) and *Coralliodrilus* (comprising species linked to shallow waters in warm seas), and a new species of the ostracod genus *Pseudolimnocythere* are noteworthy. These Apenninic species probably represent phylogenetic relicts, members of groups that have existed in the marine interstitial habitat; they survived in an area where gypsum karstic aquifers may be characterized by high sodium chloride content (Stoch F. et al. 2009-b).

2005; Renard K. G. et al. 1997). These factors can affect the candidate phenomenon both negatively and positively.

On the one hand, they may record or determine the physical disappearance and fragmentation of key attributes; or they may affect the physical accessibility of caves. On the other hand, the same factors may also create the conditions for the discovery of new caves or exposing new attributes.

- *Water tracing dye of the Sologno stream (mai 1984). Alta Valle del Secchia*
  © GSPGC

value / feature	key indicators	frequency	mon.lev	data h.
erosion / solids transport	loss of land through overbuilding and infrastructure	P	N	ISPRA SNPA
	Soil loss for Hydrologic Erosion	P+C	R+N+E	ISPRA ESDAC RER-SGS
slope instability	number of landslides	P	R+N	RER-SGS ARSTPC ISPRA
	number of deep gravitational slope deformations	P+C	R+N	RER-SGS ARSTPC ISPRA
hydrographic and hydrogeological conditions	chemical and physical source water parameters	P+C	R	ARPAE RER-SGS RER-STR
	morphological quality index	P+C	R	ARPAE RER-STR
	No. of nodes hydrometric monitoring networks	C	R	ARSTPC
	groundwater table level	P+C	R	ARPAE RER-SGS RER-STR
seismology	number of earthquakes	C	N	INGV
	extent of damage to infrastructure	O	R+N	RER-SGS ARRSIS ARSTPC DPD-DCC NVR
	number of municipalities with seismic zoning	O	N	INGV RER-SGS
floods	number of floods	O+P	R+N	ADBPo ARSTPC ARPAE-S RER-SDS

LEGEND

frequency	O = occasional, P = periodic, C = continuous
monitoring level	R = regional; N = national; E = European
database holder	for acronyms see Tab - Institutions, agencies responsible for the monitoring

6.A.2. HABITATS AND CLIMATE

The ecological conditions of habitats are very useful indicators for monitoring the conservation status of underground karst systems. Monitoring is carried out at the regional level with the support of universities and speleological associations. Climate factors paly also have an important role on the state of conservation of the underground cave system, in relation to two elements that characterise the karst phenomenon:

a. at ***the hypogeal level***, the interaction between precipitation and the underground water circulation system;

b. at ***the epigean level***, in relation to the geographical-climatic location of the phenomena. In fact, this second factor distinguishes the nominated property from many other sites with similar karst phenomena (see par. 3.2).

The monitoring of these global factors, which are not influenced by anthropogenic activities of local origin, is continuously carried out both at the regional and the national level, so that their effects are known. It should also be emphasized that constant monitorin of cave climate indicators (temperature and humidity) provides information on the response of underground karst systems to global climate change.

• *Ice stalactites in the Tanone grande della Gaggiolina cave (2012, feb.). Alta Valle del Secchia*
© GSPGC

value / feature	key indicators	frequency	mon.lev	data h.
ecological conditions	ecological state of karst aquifers	P	R	PNATE RER-SAP ARPAE RER-EEC RER-EEO RER-ER FSRER
	number of faunal communities	O+P	R	PNATE
	number of floral communities	O	R	RER-SAP RER-EEC RER-EEO RER-ER
surface climate	surface temperature	C	R+N	PNATE
	precipitation	C	R+N	ARPAE-S
cave climate	cave temperature	O+P	R	PNATE RER-EEC RER-EEO RER-ER FSRER
	humidity	O+P	R	RER-EEC RER-EEO RER-ER FSRER

LEGEND

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6.A.3. HUMAN ACTIVITIES

Human activities affecting the state of conservation of the nominated area can be grouped into two macro-categories. The first one is directly related to **the exploitation of subsoil resources** (quarrying activity). These activities, which can potentially alter or destroy the geo-heritage, are very localised and are strictly regulated by the regional legislation (see par. 5.d); the few existing activities outside the core areas are permanently monitored at the regional level.

value / feature	key indicators	frequency	mon.lev	data h.
quarrying activity	number of concessions by type of extracted material	C	R	RER-SDS
	number of interventions of environmental restoration and rehabilitation	C	R	RER-SDS
	area extensions	C	R	RER-SDS
inhabitants	number of inhabitants	P	R+N	ISTAT
	mobility data	P	R	RER-STM
	data on schooling	P	R+N	RER-DGE
	waste management data	P	R	RER-SGA
flow of visitors/ tourists	number of overnight stays	P	R	UC-RER RER-STC ONTENIT DT
	number of accesses to the sites of interest;	P	R	
	distribution of attendance;	P	R+N	
	types of visitors;	P	R	
	index of satisfaction and evaluation of services (number of sample surveys).	P	R	
sampling of rocks and fossils	number and outcome of controls by the competent bodies	O	R	PNATE RER-EEC RER-EEO RER-ER CCF
pressures from abandonment (development of vegetation and loss of physical accessibility and perceptibility)	advancement of the forest	P	R	RER-SAP RER-SSS
	number of abandoned settlements	O	R	PNATE RER-EEC RER-EEO RER-ER
	number of disused roads and tracks	O+P	R	
development pressures	water pollution (surface and groundwater)	P	R	ARPAE-S RER-STR PNATE RER-EEC RER-EEO RER-ER
	soil pollution	P	R	ARPAE-S RER-STR RER-SGS PNATE RER-EEC RER-EEO RER-ER
	atmospheric pollution	P+C	R	ARPAE-S PNATE RER-EEC RER-EEO RER-ER
	acidification of precipitation	P	R	

LEGEND

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- *Agricultural activity on feet of the Vena del Gesso near Tossignano village. Vena del Gesso Romagnola © Piero Lucci*
- *View of the Monte Tondo quarry (2019). Vena del Gesso Romagnola © Piero Lucci.jpg*

Agricultural activity, which is much less invasive but a little more widespread, is however regulated and monitored at the regional level and at the level of the single Park or protected area (see par. 5.b. and 5.c). The second macro-category includes the effects deriving from proximity to intensely anthropized areas (settlements, tourist attractions, pollution, depression from abandonment).

These factors produce differentiated forms of pressure on individual component sites and do not occur in a diffuse form but a few well-localized places. In these locations, the combination of pressure factors could lead locally to the alteration or loss of legibility of the processes or attributes that contribute to the exceptional geological value. However, these situations are known, and continuous monitoring ensures that pressure factors are kept under control.

Monitoring of the human activity (c.s.5) Assessment of the environmental, landscape and socio-economic factors of Monte Tondo Quarry

Project coordinated by a working group, formally established at the General Directorate for Territorial and Environmental Care of the Emilia-Romagna Region and including officials of the Region, the Province of Ravenna, the Union of Municipalities of Romagna Faentina, ARPAE - Technical Directorate, the Territorial Safety and Civil Protection Agency of Ravenna and the Parks and Biodiversity Management Authorities of Romagna.

During the 20th century, the exploitation of gypsum as a valuable material for fertilizers, building and construction led to the opening of numerous quarries along the outcrops of the Vena del Gesso Romagnola. Fortunately, after the economic boom of the 1950s and 1960s, quarrying activity gradually declined and, as early as 1989, the Emilia Romagna region decided to concentrate gypsum excavation at the Monte Tondo quarry, proceeding to the gradual closure and environmental recovery of the countless quarries located along the Gessoso-Solfifera Fm. In the meantime, a constant monitoring was carried out by the Regional Speleological Federation of Emilia-Romagna, to evaluate the state of conservation of the karst systems surrounding the quarry area.

In anticipation of the possible conclusion of the mining activity and the final settlement of the area, a study promoted by Emilia-Romagna Region was carried out in order to define the environmental and socio-economic indicators, and alternative solutions for the final settlement and environmental recovery. Together with the option of ceasing activity in 2023, a number of scenarios of controlled cultivation and remediation of the area were also evaluated. The effort is trying to combine the protection and enhancement of the landscape, naturalistic, geological and hydrogeological components, including hypogean and epigean karst phenomena, as well as possible tourist-scientific development scenarios, with the socio-economic factors connected to the quarrying exploitation and the induced activities (Servin scrl et al. 2021).

• *Entering the Gortani cave (2012) © F.Grazioli*

6.A.4. OTHER FACTORS

Communication of the speleological and geological values of the nominated property is strategic to its conservation. Monitoring the communication of values and attributes, which constitute the basis of the outstanding scientific value, ensures sufficient information - about the site as a whole and its individual components - to meet the requirements of all stakeholders, from the specialist to the generalist groups.

value / feature	key indicators	frequency	mon.lev	data h.
education	number of interventions in schools and among stakeholders;	O	R+E	PNATE RER-EEC RER-EEO RER-ER ARPAE-R
	number of extracurricular educational projects;	O	R	
	number of training courses.	O	R	
cataloguing and production of scientific material	number of geological/geomorphological publications	O+P	R+E	UNIMORE UNIBO FSRER
communication	number of articles in academic journals	O+P	R+N+E	UNIMORE UNIBO FSRER
	number of film productions	O	R+N	PNATE RER-EEC RER-EEO RER-ER
	number of television reports	O	R+N	

LEGEND

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database holder	for acronyms see Tab - Institutions, agencies responsible for the monitoring

6.B ADMINISTRATIVE ARRANGEMENTS FOR MONITORING PROPERTY

Generally, the current administrative arrangements for monitoring the state of conservation within the nominated property can be considered adequate for the evaporitic karst values and attributes. As noted, all the 7 component sites are located within Parks (national and regional) or Natura 2000 Network protected areas, whose management plans clearly establish the monitoring framework for biotic aspects (habitats and climate) and those related to educational and training activities (education and communication).

Regarding the geological and hydrogeological aspects, the monitoring of karst systems is regulated at regional and national level, including aspects related to human activities pressure.

The National Institutes, Regional Agencies, management Authorities, and Associations guarantee a constant survey frequency and the indicators used are fully relevant to the objectives of protection and conservation of the geo-heritage. The public administrations and structures from which the data populating the indicators are collected are listed below.

- *Bats census in karst systems of Spipola-Acquafredda e Rio Stella-Basino, within the framework of the Life+ Project 08NAT/IT/000369 "Gypsum" (2010-2016). Gessi Bolognesi © F. Grazioli*

6.C RESULTS OF PREVIOUS REPORTING EXERCISES

Considering the characteristics of the nominated serial property, which brings together the evaporitic karst areas of the northern Apennines in an unprecedented entity, and considering the particular nature of the hypogeal phenomena, there are no previous reporting exercises that cover all the candidate areas.

Nevertheless, there are many reports of environmental monitoring related to protected areas and Natura 2000 habitats, carried out by parks and protected areas management bodies as part of their institutional activities. These activities are, for example, the monitoring of flora and fauna characteristic of cave environments (such as bat populations), the biological monitoring of the groundwater fauna ("Trias project") but also of water quality and anthropic activities (such as agricultural or mining exploitation). Several monitoring reports were produced as part of European projects by one or more parks in collaboration with the Emilia-Romagna Region or research institutes.

For example, the monitoring of vegetation and temperature within the project GLobal Observation Research Initiative in Alpine Environments - GLORIA Europe (Appennino Tosco-Emiliano National

Chemical and microbiological monitoring on groundwaters in gypsum areas of Northern Apennines (c.s.4) Project Life + 08NAT/IT/000369 "Gypsum"

Project undertaken by Gessi Bolognesi e Calanchi dell'Abbadessa Regional Park (project leader), the Appennino Tosco-Emiliano National Park, the Vena del Gesso Romagnola Park, and the Onferno Nature Reserve.Water circulation and water quality are some of the determining factors in gypsum karst systems, but because of their intrinsic characteristics, they are not always easy to study and classify.

Since the end of the last century, a series of studies have been carried out, but they did not homogeneously cover the whole Apennine karst area: some areas had been well investigated from a hydrogeological point of view (for example the Poiano springs), others less in detail (such as the karst systems of Spipola, Bologna, the Farneto, Rio Stella/Rio Basino and the karst area of Borzano).

For other areas, such as the Gypsum area of Rontana and Castelnuovo, Brisighella, just limited data were available. In general, for most karst systems, there was a limited knowledge of both the quantity and the quality of the water flowing in the gypsum areas.

In order to fill this gap, within the framework of the Life+ Project 08NAT/IT/000369 "Gypsum", a multi-year monitoring (2010-2014) of the main karst aquifers was carried out for the chemical and microbiological aspects, in order to characterise the groundwater ex-ante and ex-post the project. This monitoring made possible to investigate the environmental quality of numerous sites and, if necessary, to plan reclamation and protection measures (Bergianti S. 2011).

Park and the University of Parma), or the monitoring of the tourist pressure at the entrances of the protected areas carried out within the project Interreg Central Europe Eco-Tourism - CEETO (Emilia-Romagna Region and Appennino Tosco-Emiliano National Park).

The LIFE+GYPSUM project (2010-2016) is particularly significant. It has involved several of the component sites: the Gessi Bolognesi e Calanchi dell'Abbadessa Regional Park as project leader, the Appennino Tosco-Emiliano National Park, the Vena del Gesso Romagnola Park, and the Onferno Nature Reserve. For this reason, it represents a considerable coordination experience among the protected areas of the nominated property. As part of the project, several monitoring activities have been carried on the habitats associated with gypsum outcrops characterized by karst phenomena.

Generally, considering that 6 out of 7 sites are under the direct responsibility of the Emilia Romagna Regional Administration, which ensures the entire administrative chain and manages most of the Agencies and Monitoring Institutes, the integrated coordination represented an added value for the previous reporting exercises. Furthermore, the activities of the Regional Parks and the National Park are already geo-heritage-oriented and therefore the experience acquired in the definition of the geo-tourism potential and the responsible and sustainable tourism, will be particularly useful to steer the monitoring actions of the nominated property.In addition, it should not be forgotten that the high level of scientific knowledge, linked to the particular accessibility of the sites and the proximity to international university and research centres, leads to the publication of countless scientific articles every year. Most of these articles are related to research and monitoring of the main geological, biological, hydrological, floristic and faunistic factors. The monitoring reports are attached and an example of this extensive scientific production is available in the Annexes.

• *The* Tana della Mussina *cave of Borzano (2012). Bassa Collina Reggiana*
© H. Artioli

INSTITUTIONS, AGENCIES RESPONSIBLE FOR THE MONITORING

acronym	name	address	website
	NATIONAL LEVEL		
ESDAC	European Soil Data Centre - Joint Research Centre	ec-esdac@ec.europa.eu	https://esdac.jrc.ec.europa.eu/
CCF	Corpo dei Carabinieri Forestali - Comando Regione Emilia Romagna Bologna	Viale Antonio Silvani, 6, 40122 Bologna BO	
DPC-DCC	Dipartimento di Protezione Civile - Direzione di Comando e Controllo	Via Ulpiano, 11 - 00193 Roma Tel. (+39) 06 68201	https://www.protezionecivile.gov.it/it/
ISTAT	Istituto nazionale di statistica	Via Cesare Balbo, 16 – 00184 Roma Tel. +39 06 46731	https://www.istat.it/it/censimenti/popolazione-e-abitazioni
INGV	Istituto Nazionale Geofisica e Vulcanologia	Via di Vigna Murata 605, 00143 Roma Tel. +39 06 518 601 "	https://www.ingv.it/
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale	Via Vitaliano Brancati, 48 - 00144 Roma (I)	https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/il-consumo-di-suolo/il-consumo-di-suolo
SNPA	Sistema Nazionale per la Protezione dell'Ambiente	Via Vitaliano Brancati, 48 – 00144 Roma	https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio?-set_language=en
ONTENIT	Osservatorio Nazionale del Turismo Istituito Ente Nazionale del Turismo	Via Marghera, 2, 00185 Roma Tel: +39(0)649711	http://www.ontit.it/opencms/opencms/ont/it/index.html
ADBPo	Autorità di bacino distrettuale del fiume Po		
PNATE	Parco Nazionale Appennino Tosco Emiliano	Via Comunale, 23 54013 Sassalbo di Fivizzano (MS) Tel. +39(0)585 947 200	http://www.parcoappennino.it/
UNIMORE	Università di Modena e Reggio Emilia - Dipartimento di Scienze Chimiche e Geologiche	Via Università 4, 41121 Modena, Tel. +39(0)59 205 6511"	https://www.unimore.it/ateneo/DCG.html
UNIBO	Università di Bologna - Dipartimento di Scienze Biologiche, Geologiche ed Ambientali BiGeA; Dipartimento di Scienze dell'Educazione "Giovanni Maria Bertin"	Via Zamboni, 67 - 48121 Bologna Tel: +39(0)51 209 4520	https://bigea.unibo.it/it/index.html
MiC-SABAP	Soprintendenza Archeologia Belle Arti e Paesaggio per la Città Metropolitana di Bologna e le province di Modena, Reggio-Emilia e Ferrara	via IV novembre, 5 - 40123 Bologna - Tel. 0516451311	https://sabapbo.beniculturali.it/
MiC-SABAP	Soprintendenza Archeologia Belle Arti e Paesaggio) per le province di Ravenna, Forlì-Cesena e Rimini	Via S. Vitale, 17 - 48121 Ravenna - tel. +39 0544 543711	https://www.soprintendenzaravenna.beniculturali.it/
	REGIONAL LEVEL		
FSRER	Federazione Speleologica Regionale dell'Emilia-Romagna	Casa Fantini, Via C. Jussi, 171 Farneto 40068 S. Lazzaro di Savena (BO)	http://fsrer.it/site/
DT	DestinazioniTuristiche (LR 4/2016) (DT Emilia; DT Bologna-Modena - Bologna Welcome; DT Romagna)	Viale Martiri della Libertà, 15 - Parma	https://it.readkong.com/page/destinazione-turistica-emilia-parma-piacenza-reggio-emilia-7630263
RER-DGE	Direzione Generale Economia della conoscenza, del lavoro e dell'impresa	Viale A. Moro, 38 - 40127 Bologna	https://scuola.regione.emilia-romagna.it/

acronym	name	address	website
RER-SGA	Servizio Giuridico dell'Ambiente, rifiuti, bonifica siti contaminati e servizi pubblici ambientali	"Viale della Fiera, 8 40127 Bologna tel. 051.527.6078 / 6003 / 6061"	https://ambiente.regione.emilia-romagna.it/it/rifiuti
ARRSIS	Agenzia regionale per la ricostruzione – Sisma 2012	Viale d. Fiera, 8 - 40127 Bologna Tel: +39 (0)51 5276078	https://www.sisma2012.it/
ARPAE	Agenzia Regionale Prevenzione, Ambiente ed Energia Emilia-Romagna	Via Po, 5 –40139, Bologna Tel: +39 (0)51 6223811	https://www.arpae.it/it
ARPAE-R	ARPAE - Rete Regionale Educazione alla Sostenibilità (CEAS) Centro Tematico Regionale - Educazione alla sostenibilità Agenzia Regionale Prevenzione Ambiente Energia (Arpae)	Largo Caduti del Lavoro, 6 - 40122 Bologna. Tel. +39(0)51 528 1200"	https://www.arpae.it/it/temi-ambientali/educazione_alla_sostenibilita
ARPAE-S	Agenzia Regionale per la Prevenzione, l'Ambiente ed Energia - Servizio Idro-Meteo	Via Po, 5 – 40139 Bologna Tel. +39(0)51 6223811	https://www.arpae.it/it/temi-ambientali/meteo
ARSTPC	Agenzia Regionale per la Sicurezza Territoriale e la Protezione Civile	Viale Silvani, 6 - 40122, Bologna Tel. +39(0)51 5274404"	https://protezionecivile.regione.emilia-romagna.it/
RER-SAP	Regione Emilia-Romagna - Servizio Aree Protette, Foreste e Sviluppo della Montagna	Viale Aldo Moro 30, 40127 Bologna tel. +39 (0)51 527 6080	https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/aree-protette/aree-protette-in-er/aree-protette-1
RER-EEC	Ente di Gestione Parco e Biodiversità - Macroarea Emilia Centrale	Viale Martiri della Libertà 34 – 41121 Modena. Tel. +39(0)59 209 311	http://www.parchiemiliacentrale.it/
RER-EEO	Ente di Gestione Parco e Biodiversità - Macroarea Emilia Orientale	Piazza XX Settembre, 1 - 40043 Marzabotto (BO) Tel. +39(0)51 670 2811 - 625 4811	https://enteparchi.bo.it/
RER-ER	Ente di Gestione Parco e Biodiversità - Macroarea Romagna	Via Aldo Moro 2 - 48025 Riolo Terme (RA) Tel. +39(0)546 77404	http://www.parchiromagna.it/
RER-SDS	Regione Emilia-Romagna - Servizio Difesa del Suolo, della Costa e Bonifica	Viale della Fiera, 8 - 40127, Bologna Tel: +39(0)515276811	https://ambiente.regione.emilia-romagna.it/it/suolo-bacino/argomenti/attivita-estrattive-e-minerarie
RER-SGS	Regione Emilia-Romagna - Servizio Geologico, Sismico e dei Suoli	Viale d.Fiera, 8 - 40127, Bologna Tel: +39(0)51 5274792	https://ambiente.regione.emilia-romagna.it/it/geologia
RER-STR	Regione Emilia-Romagna - Servizio Tutela e Risanamento Acqua, Aria e Agenti Fisici	viale della Fiera, 8 - 40127 Bologna tel. 051 527 6980-6041	https://ambiente.regione.emilia-romagna.it/it/acque/servizio-tutela-risanamento-acqua
RER-SSS	Regione Emilia-Romagna - Servizio Statistica e Sistemi informativi geografici	Viale A. Moro, 52 - 40127 Bologna Tel: +39 (0)51 5273247	https://partecipazione.regione.emilia-romagna.it/chi-siamo/servizio-statistica
RER-STC	Regione Emilia-Romagna - Servizio Turismo e Commercio e Sport	viale A. Moro, 38 - Torre - 40127 Bologna tel. +39 (0)51 527 6433	https://imprese.regione.emilia-romagna.it/turismo/temi/osservatorio-regionale-sul-turismo
RER-STM	Regione Emilia-Romagna - Servizio Trasporti e Mobilità	Viale A. Moro, 52 - 40127 Bologna Tel: +39 (0)51 5271	https://mobilita.regione.emilia-romagna.it/
NVR	Nucleo di Valutazione Regionale composto dai tecnici della Regione e degli enti locali	Viale Aldo Moro, 52 - 40127 Bologna Tel: +39 (0)51 5271	https://trasparenza.regione.emilia-romagna.it/opere-pubbliche/nucleo-di-valutazione
UC - RER	UNIONCAMERE Emilia-Romagna - Osservatorio del Turismo dell'Emilia-Romagna	viale A. Moro, 62 - 40127 Bologna Tel +39 051 6377011	https://www.ucer.camcom.it/osservatori-regionali/os-turistico

DOCUMENTATION

7

7.A PHOTOGRAPHS AND AUDIOVISUAL IMAGE INVENTORY AND AUTHORIZATION FORM

All digital photographs related to section 7.a included the table of contents and the appropriate records, are available in the Annexes on the attached DVD.

- *(facing page) Gypsum crystals in the Grotta I nei gradoni Cave. Vena del Gesso Romagnola © P. Lucci*

7.B TEXTS RELATING TO PROTECTIVE DESIGNATION, COPIES OF PROPERTY MANAGEMENT PLANS OR DOCUMENTED MANAGEMENT SYSTEMS AND EXTRACTS OF OTHER PLANS RELEVANT TO THE PROPERTY

See digital texts and documents related to section 7.b, available in the Annexes on the attached DVD. In the table below are listed the documents and the main online data sources, referring to the whole nominated property and divided by component site.

c.s.#	**name of textes, plans or documents** *Each filename recorded in the table shows the title of the document (protective act, management plan or protective regulations), the year of approval and the language in which it is written.*
entire nominated property	EU-CommissionDecision-2015-69-eighth update of Natura 2000_EN.pdf General Conservation Measures Natura2000_2018_IT.pdf Leg.Decree 42-2004-Code of the Cultural and Landscape Heritage_2004_EN.pdf LR 6-2005-Protected Areas and Natura 2000 Regional Discipline_2005_IT.pdf LR 24-2011-Protected Areas and Natura 2000 Regional System_2011_IT.pdf National Law on Protected Areas_1991_abstract_EN.pdf National Law on Protected Areas_1991_IT.pdf National Official List of Protected Areas_2010_IT.pdf Piano Tutela_Acque Regione Emilia-Romagna_2005_IT.pdf Regional Landscape Territorial Plan-Technical Rules_1993_IT.pdf Regional Law-9-2006_Geodiversity conservation and valorisation_IT.pdf Regional Program Protected areas and Natura 2000 sites_2005_IT.pdf Regional Water Protection Plan_2006_EN.pdf
1 Alta Valle del Secchia	Appennino Tosco-Emiliano National Park-Founding Act_1991_IT.pdf DPR 251-2010-New perimeter of PNATE-2010_IT.pdf Gessi Triassici-Declaration of notable public interest_2016_IT.pdf Leg.Decree 42-2004-Gessi Triassici-area perimeter_2016_IT.pdf Leg.Decree 42-2004-Gessi Triassici-classification report_2016_IT.pdf Ministerial Decree-29-11-2019-SAC designation_2019_IT.pdf PNATE_National Park Territorial Plan-Technical Regulations_2011.pdf SCI_IT4030009-Gessi Triassici-Management Plan_2018_IT.pdf SCI_IT4030009-Gessi Triassici-Special Measures_2018_IT.pdf
2 Bassa Collina Reggiana	Borzano-Le Croci-Declaration of notable public interest_1985_IT.pdf Founding Act of Collina Reggiana Protected Landscape_2011_IT.pdf Leg.Decree 42-2004 Borzano-Le Croci area perimeter_2019_IT.pdf Leg.Decree 42-2004 Borzano-Le Croci classification report_2019_IT.pdf SCI_IT4030017-Management Plan_2018_IT.pdf SCI_IT4030017-Specific Conservation Measures_2018_IT.pdf Three-year Protection-Enhancement Programme_2020_IT.pdf Three-year Protection-Enhancement Programme_Approval act_2020_IT.pdf
3 Gessi di Zola Predosa	Leg.Decree 42-2004-Zola Predosa-area perimeter_2019_IT.pdf Leg.Decree 42-2004-Zola Predosa-classification report_2019_IT.pdf SCI_IT4050027-ZolaPredosa-Specific Conservation Measues_2018_IT.pdf Zola Predosa-Declaration of notable public interest_1976_IT.pdf

c.s.#	**name of textes, plans or documents** *Each filename recorded in the table shows the title of the document (protective act, management plan or protective regulations), the year of approval and the language in which it is written.*
4 **Gessi Bolognesi**	Castel de Britti-Declaration of notable public interest_1976_IT.pdf Croara-Declaration of notable public interest_1965_IT.pdf Gessi Bolognesi-Calanchi Abbadessa Park-Founding Act_1988_IT.pdf Gessi Bolognesi-Calanchi Abbadessa Park-Management Plan_2005.pdf Gessi Bolognesi-Calanchi Abbadessa Park-Trails and rest areas_2005.pdf Gessi Bolognesi-Calanchi Abbadessa Park-Zoning_2005.pdf Leg.Decree 42-2004-Castel de Britti-area perimeter_2020_IT.pdf Leg.Decree 42-2004-Castel de Britti-classification report_2020_IT.pdf Leg.Decree 42-2004-Croara-area perimeter-2020_IT.pdf Leg.Decree 42-2004-Croara-classification report_2018_IT.pdf SCI-SAC-IT4050001-Gessi Bolognesi-Management Plan_2018.pdf SCI-SAC-IT4050001-Gessi Bolognesi-Specific Measures_2018.pdf
5 **Vena del Gesso Romagnola**	Brisighella (RA)-Declaration of notable public interest_1968_IT.pdf Fouding Act of Vena del Gesso Romagnola Park_2005.pdf Leg.Decree 42-2004-Brisighella-RA-area perimeter_2018_IT.pdf Leg.Decree 42-2004-Brisighella-RA-classification report_2018_IT.pdf Leg.Decree 42-2004-Parco Carnè-RA-area perimeter_2018_IT.pdf Leg.Decree 42-2004-Parco Carnè-RA-classification report_2018_IT.pdf Leg.Decree 42-2004-Vena Gesso-BO-area perimeter_2018_IT.pdf Leg.Decree 42-2004-Vena Gesso-BO-classification report_2018_IT.pdf Leg.Decree 42-2004-Vena Gesso-RA-area perimeter_2018_IT.pdf Leg.Decree 42-2004-Vena Gesso-RA-classification report_2018_IT.pdf Leg.Decree 42-2004-Zona Rontana-RA-area perimeter_2018_IT.pdf Leg.Decree 42-2004-Zona Rontana-RA-classification_2018_IT.pdf Parco Carnè-RA-Declaration of notable public interest_1975_IT.pdf PRVGR-Park Territorial Plan-Geoheritage Conservation Rules_2014.pdf PRVGR-Park Territorial Plan-Report_2014_IT.pdf PRVGR-Park Territorial Plan-zoning_2014_IT.pdf Regulation for visiting the Park_2020_IT.pdf SCI-SAC-IT4070011-Management Plan_2018_IT.pdf SCI-SAC-IT4070011-Specific Conservation Measures_2018_IT.pdf Vena-Gesso (BO)-Declaration of notable public interest_1985_IT.pdf Vena-Gesso (RA)-Declaration of notable public interest_1974_IT.pdf Zona Rontana (RA)-Decl. of notable public interest_1974_IT.pdf
6 **Evaporiti di San Leo**	SCI-SAC-IT4090003 -Management Plan_2018_IT.pdf SCI-SAC-IT4090003-Specific Measures_2018_IT.pdf
7 **Gessi di Onferno**	Founding Act of Onferno Nature Reserve_1991_IT.pdf Regional Council Decree-Onferno Nature Reserve-Perimeter_2003_IT.pdf Regional Law 6-2005-Onferno Nature Reserve-Regulations_2005_IT.pdf SCI-IT4090001-Onferno-Specific Measures Implementation_2018.pdf SCI-IT4090001-Onferno-Specific Measures_2018.pdf

c.s.#	**Online data sources** (dedicated web-pages)
entire nominated property	*Emilia-Romagna Regional Landscape Territorial Plan.* *(It provides all the plan documents, approval acts, maps, reports and regulations)* https://territorio.regione.emilia-romagna.it/paesaggio/PTPR/strumenti-di-gestione-del-piano/documenti-di-piano-1/documenti-di-piano
1 **Alta Valle del Secchia**	*Management Plan of the Appennino Tosco-Emiliano Nationa Park* *(It provides all the plan documents, approval acts, maps, reports and regulations.)* http://www.parcoappennino.it/pagina.php?id=5

c.s.#	**Online data sources** (dedicated web-pages)
2 Bassa Collina Reggiana	*Three-year Protection and Enhancement Program (PTTV) of the Collina Reggiana Protected Landscape (It provides all the plan documents, approval acts, maps, reports and regulations.)* http://www.parchiemiliacentrale.it/pagina.php?id=214
4 Gessi Bolognesi	*Management Plan of the Gessi Bolognesi e Calanchi dell'Abbadessa Park (It provides all the plan documents, approval acts, maps, reports and regulations.)* https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/consultazione/Programmi-Piani-e-Regolamenti/piani-programmi-e-regolamenti-del-settore-aree-protette/ptp/ptp-gessi-bolognesi/piano-territoriale-parco-gessi-bolognesi
5 Vena del Gesso Romagnola	*Management System of the Vena del Gesso Romagnola Park* https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/aree-protette/parchi/vege/carta-zone

7.C FORM AND DATE OF MOST RECENT RECORDS OR INVENTORY OF PROPERTY

See digital texts and documents related to section 7.c, available in the Annex 2 on the attached DVD. In the table below are listed the documents and the main online data sources, referring to the whole nominated property and divided by component site.

c.s.#	**textes or documents** *Each filename recorded in the table shows the title of the document (protected area status report, monitoring report, informative framework), the year of approval and the language in which it is written.*
entire nominated property	Environmental report (Regional Protected Areas Program)_2009_IT.pdf Geosites of Emilia-Romagna_2012_IT.pdf Life-Gypsum-abstract_2016_EN.pdf Life-Gypsum-abstract_2016_IT.pdf Life-Gypsum-extended report_2016_IT.pdf
1 Alta Valle del Secchia	Appennino Tosco-Emiliano Nationa Park-monitoring report_2019_EN.pdf Appennino Tosco-Emiliano Nationa Park-status report_2009_IT.pdf EU-COSME-HikingEurope Project-Route Guide Apennines_2017_EN.pdf Leg.Decree 42-2004-Gessi Triassici-status report_2013_IT.pdf SCI-IT4030009-Gessi Triassici-status report_2018_IT.pdf
2 Bassa Collina Reggiana	Collina Reggiana Protected Landscape status report_2011_IT.pdf Collina Reggiana Protected Landscape status report_2009_IT.pdf Leg.Decree 42-2004-Borzano-Le Croci-status report_2013_IT.pdf SCI-IT4030017-SCI status report_2014_IT.pdf
3 Gessi di Zola Predosa	Leg.Decree 42-2004-Zola Predosa-status report_2013_IT.pdf SCI-IT4050027-Gessi ZolaPredosa-status report_2018_IT.pdf
4 Gessi Bolognesi	Gessi Bolognesi-park report_2009_IT.pdf Leg.Decree 42-2004-Castel de Britti-status report_2012_IT.pdf Leg.Decree 42-2004-Croara-status report_2012_IT.pdf SCI-SAC-IT4050001-Gessi Bolognesi-status report_2018.pdf
5 Vena del Gesso Romagnola	EU-COSME-HikingEurope Project-Route Guide Vena-Gesso_2017_EN.pdf Leg.Decree 42-2004-Brisighella (RA)-status report_2012_IT.pdf Leg.Decree 42-2004-Vena del Gesso (BO)-status report_2012_IT.pdf Leg.Decree 42-2004-Vena del Gesso (RA)-status report_2012_IT.pdf SCI-SAC-IT4070011-status report_2018_IT.pdf Vena del Gesso park status report_2009_it.pdf

c.s.#	**textes or documents** *Each filename recorded in the table shows the title of the document (protected area status report, monitoring report, informative framework), the year of approval and the language in which it is written.*
6 Evaporiti di San Leo	SCI-SAC-IT4090003-Gessi Valmarecchia_status report.pd
7 Gessi di Onferno	Onferno Nature Reserve-status report_2009_IT.pdf SCI-IT4090001-Onferno-status report_2018_IT.pdf»

c.s.#	**Online data sources** (dedicated web-pages)
entire nominated property	*Geological sites (Web pages, edited by the Geological, Seismic and Soil Survey of Emilia-Romagna Region, providing information about the geological sites, organized in sheets containing data, maps, descriptions and scientific contents, bibliography, useful links, etc.)* https://geo.regione.emilia-romagna.it/schede/geositi/ *WebGIS of geological sites (The WebGIS site allows the cartographic consultation of the data and of the sheets related to the geological sites surveyed.)* https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=-geositi *WebGIS of the Natural Caves Register (Cartographic WebGIS to consult the Register of Natural Caves. For each cave is available a brief description, the identification data, the geometric survey and some pictures.)* https://geo.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=grotte *Geo-environmental itineraries and geo-paleontological trails (Web pages containing simplified geologic maps of an informative character, descriptions of a variety of hiking trails with geologic and naturalistic themes, brochures, and photo galleries.)* https://ambiente.regione.emilia-romagna.it/it/geologia/geologia/geositi-paesaggio-geologico/itinerari-geo-ambientali#autotoc-item-autotoc-0

7.D ADDRESS WHERE INVENTORY, RECORDS AND ARCHIVES ARE HELD

acronym	name	address	website
	NATIONAL LEVEL		
ESDAC	European Soil Data Centre - Joint Research Centre	ec-esdac@ec.europa.eu	https://esdac.jrc.ec.europa.eu/
CCF	Corpo dei Carabinieri Forestali - Comando Regione Emilia Romagna Bologna	Viale Antonio Silvani, 6, 40122 Bologna BO	
DPC-DCC	Dipartimento di Protezione Civile - Direzione di Comando e Controllo	Via Ulpiano, 11 - 00193 Roma Tel. (+39) 06 68201	https://www.protezionecivile.gov.it/it/
ISTAT	Istituto nazionale di statistica	Via Cesare Balbo, 16 – 00184 Roma Tel. +39 06 46731	https://www.istat.it/it/censimenti/popolazione-e-abitazioni
INGV	Istituto Nazionale Geofisica e Vulcanologia	Via di Vigna Murata 605, 00143 Roma Tel. +39 06 518 601 "	https://www.ingv.it/
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale	Via Vitaliano Brancati, 48 - 00144 Roma (I)	https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/il-consumo-di-suolo/il-consumo-di-suolo

acronym	name	address	website
SNPA	Sistema Nazionale per la Protezione dell'Ambiente	Via Vitaliano Brancati, 48 – 00144 Roma	https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio?-set_language=en
ONTENIT	Osservatorio Nazionale del Turismo Istituito Ente Nazionale del Turismo	Via Marghera, 2, 00185 Roma Tel: +39(0)649711	http://www.ontit.it/opencms/opencms/ont/it/index.html
ADBPo	Autorità di bacino distrettuale del fiume Po		
PNATE	Parco Nazionale Appennino Tosco Emiliano	Via Comunale, 23 54013 Sassalbo di Fivizzano (MS) Tel. +39(0)585 947 200	http://www.parcoappennino.it/
UNIMORE	Università di Modena e Reggio Emilia - Dipartimento di Scienze Chimiche e Geologiche	Via Università 4, 41121 Modena, Tel. +39(0)59 205 6511"	https://www.unimore.it/ateneo/DCG.html
UNIBO	Università di Bologna - Dipartimento di Scienze Biologiche, Geologiche ed Ambientali BiGeA; Dipartimento di Scienze dell'Educazione "Giovanni Maria Bertin"	Via Zamboni, 67 - 48121 Bologna Tel: +39(0)51 209 4520	https://bigea.unibo.it/it/index.html
MiC-SABAP	Soprintendenza Archeologia Belle Arti e Paesaggio per la Città Metropolitana di Bologna e le province di Modena, Reggio-Emilia e Ferrara	via IV novembre, 5 - 40123 Bologna - Tel. 0516451311	https://sabapbo.beniculturali.it/
MiC-SABAP	Soprintendenza Archeologia Belle Arti e Paesaggio) per le province di Ravenna, Forlì-Cesena e Rimini	Via S. Vitale, 17 - 48121 Ravenna - tel. +39 0544 543711	https://www.soprintendenzaravenna.beniculturali.it/

	REGIONAL LEVEL		
FSRER	Federazione Speleologica Regionale dell'Emilia-Romagna	Casa Fantini, Via C. Jussi, 171 Farneto 40068 S. Lazzaro di Savena (BO)	http://fsrer.it/site/
DT	DestinazioniTuristiche (LR 4/2016) (DT Emilia; DT Bologna-Modena - Bologna Welcome; DT Romagna)	Viale Martiri della Libertà, 15 - Parma	https://it.readkong.com/page/destinazione-turistica-emilia-parma-piacenza-reggio-emilia-7630263
RER-DGE	Direzione Generale Economia della conoscenza, del lavoro e dell'impresa	Viale A. Moro, 38 - 40127 Bologna	https://scuola.regione.emilia-romagna.it/
RER-SGA	Servizio Giuridico dell'Ambiente, rifiuti, bonifica siti contaminati e servizi pubblici ambientali	"Viale della Fiera, 8 40127 Bologna tel. 051.527.6078 / 6003 / 6061"	https://ambiente.regione.emilia-romagna.it/it/rifiuti
ARRSIS	Agenzia regionale per la ricostruzione – Sisma 2012	Viale d. Fiera, 8 - 40127 Bologna Tel: +39 (0)51 5276078	https://www.sisma2012.it/
ARPAE	Agenzia Regionale Prevenzione, Ambiente ed Energia Emilia-Romagna	Via Po, 5 –40139, Bologna Tel: +39 (0)51 6223811	https://www.arpae.it/it
ARPAE-R	ARPAE - Rete Regionale Educazione alla Sostenibilità (CEAS) Centro Tematico Regionale - Educazione alla sostenibilità Agenzia Regionale Prevenzione Ambiente Energia (Arpae)	Largo Caduti del Lavoro, 6 - 40122 Bologna. Tel. +39(0)51 528 1200"	https://www.arpae.it/it/temi-ambientali/educazione_alla_sostenibilita
ARPAE-S	Agenzia Regionale per la Prevenzione, l'Ambiente ed Energia - Servizio Idro-Meteo	Via Po, 5 – 40139 Bologna Tel. +39(0)51 6223811	https://www.arpae.it/it/temi-ambientali/meteo
ARSTPC	Agenzia Regionale per la Sicurezza Territoriale e la Protezione Civile	Viale Silvani, 6 - 40122, Bologna Tel. +39(0)51 5274404"	https://protezionecivile.regione.emilia-romagna.it/
RER-SAP	Regione Emilia-Romagna - Servizio Aree Protette, Foreste e Sviluppo della Montagna	Viale Aldo Moro 30, 40127 Bologna tel. +39 (0)51 527 6080	https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/aree-protette/aree-protette-in-er/aree-protette-1

acronym	name	address	website
RER-EEC	Ente di Gestione Parco e Biodiversità - Macroarea Emilia Centrale	Viale Martiri della Libertà 34 – 41121 Modena. Tel. +39(0)59 209 311	http://www.parchiemiliacentrale.it/
RER-EEO	Ente di Gestione Parco e Biodiversità - Macroarea Emilia Orientale	Piazza XX Settembre, 1 - 40043 Marzabotto (BO) Tel. +39(0)51 670 2811 - 625 4811	https://enteparchi.bo.it/
RER-ER	Ente di Gestione Parco e Biodiversità - Macroarea Romagna	Via Aldo Moro 2 - 48025 Riolo Terme (RA) Tel. +39(0)546 77404	http://www.parchiromagna.it/
RER-SDS	Regione Emilia-Romagna - Servizio Difesa del Suolo, della Costa e Bonifica	Viale della Fiera, 8 - 40127, Bologna Tel: +39(0)515276811	https://ambiente.regione.emilia-romagna.it/it/suolo-bacino/argomenti/attivita-estrattive-e-minerarie
RER-SGS	Regione Emilia-Romagna - Servizio Geologico, Sismico e dei Suoli	Viale d.Fiera, 8 - 40127, Bologna Tel: +39(0)51 5274792	https://ambiente.regione.emilia-romagna.it/it/geologia
RER-STR	Regione Emilia-Romagna - Servizio Tutela e Risanamento Acqua, Aria e Agenti Fisici	viale della Fiera, 8 - 40127 Bologna tel. 051 527 6980-6041	https://ambiente.regione.emilia-romagna.it/it/acque/servizio-tutela-risanamento-acqua
RER-SSS	Regione Emilia-Romagna - Servizio Statistica e Sistemi informativi geografici	Viale A. Moro, 52 - 40127 Bologna Tel: +39 (0)51 5273247	https://partecipazione.regione.emilia-romagna.it/chi-siamo/servizio-statistica
RER-STC	Regione Emilia-Romagna - Servizio Turismo e Commercio e Sport	viale A. Moro, 38 - Torre - 40127 Bologna tel. +39 (0)51 527 6433	https://imprese.regione.emilia-romagna.it/turismo/temi/osservatorio-regionale-sul-turismo
RER-STM	Regione Emilia-Romagna - Servizio Trasporti e Mobilità	Viale A. Moro, 52 - 40127 Bologna Tel: +39 (0)51 5271	https://mobilita.regione.emilia-romagna.it/
NVR	Nucleo di Valutazione Regionale composto dai tecnici della Regione e degli enti locali	Viale Aldo Moro, 52 - 40127 Bologna Tel: +39 (0)51 5271	https://trasparenza.regione.emilia-romagna.it/opere-pubbliche/nucleo-di-valutazione
UC - RER	UNIONCAMERE Emilia-Romagna - Osservatorio del Turismo dell'Emilia-Romagna	viale A. Moro, 62 - 40127 Bologna Tel +39 051 6377011	https://www.ucer.camcom.it/osservatori-regionali/os-turistico

7.E BIBLIOGRAPHY

A comprehensive bibliography on the evaporites of Northern Apennines related to section 7.e, is available in the Annexes on the attached DVD. This biblioghaphy, edited by Paolo Forti and organized in chronological order, contains all texts written on karst and caves of the nominated area from **1648** to **2021**, including early studies of pioneering speleology in karst systems.

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CONTACT INFORMATION
OF RESPONSIBLE AUTHORITIES

8

8.A PREPARER

RER **Emilia-Romagna Region**

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Secretariat of nomination process
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city 40127 Bologna (BO) - ITALY
tel. +39 051 527 3711
e-mail dgcta@regione.emilia-romagna.it
website https://ambiente.regione.emilia-romagna.it/en

- *(in front) Descent into the 1st well of* Grotta delle Pisoliti *© G. Agolini*

8.B OFFICIAL LOCAL INSTITUTION/AGENCY

component site	*Institution/Agency*	*Name*	*address*	*City, Province/ State, Country*	*Tel.*	*email*	*website*
serial site	Emilia-Romagna Region	Gianni Gregorio	Via della Fiera 8, Bologna	40127 - I Bologna (BO)	+39 051 527 6080	segrprn@regione.emilia-romagna.it	https://ambiente.regione.emilia-romagna.it/en/parchi-natura2000?set_language=en
c.s. 1 Alta Valle del Secchia	Parco Nazionale Appennino Tosco-Emiliano	Fausto Giovanelli (president)	Via Comunale 23 Sassalbo	54013 - I Fivizzano (MS)	+39(0)585 947 200	info@parcoappennino.it - gypsum@parcoappennino.it	www.parcoappennino.it www.mabappennino.it
		Giuseppe Vignali (director)	Via Comunale 23 Sassalbo	54014 - I Fivizzano (MS)	+39(0)585 947 201	info@parcoappennino.it gypsum@parcoappennino.it giuseppe.vignali@parcoappennino.it	www.parcoappennino.it www.mabappennino.it
		Alessandra Curotti (technical referent)			+39 335 848 5160	info@parcoappennino.it gypsum@parcoappennino.it	www.parcoappennino.it www.mabappennino.it
c.s.2 Bassa Collina Reggiana	Ente di gestione per i Parchi e la Biodiversità – Emilia Centrale	Giovanni Battista Pasini (president)	Viale Martiri della Libertà, 34	41124 - I Modena (MO)	+39(0)59 209 311 Pres.: +39 335 8326190	info@parchiemiliacentrale.it giovanni.pasini@parchiemiliacentrale.it	www.parchiemiliacentrale.it
		Valerio Fioravanti (director)	Viale Martiri della Libertà, 34	41125 - I Modena (MO)	+39(0)59 209 311 Dir.: +39 366 7835301	info@parchiemiliacentrale.it valerio.fioravanti@parchiemiliacentrale.it	www.parchiemiliacentrale.it
c.s.3 Gessi di Zola Predosa c.s.4 Gessi Bolognesi	Ente di gestione per i Parchi e la Biodiversità – Emilia Orientale	Sandro Ceccoli (president)	Piazza XX Settembre, 1	40043 - I Marzabotto (BO)	+39(0)51 670 2811 625 4811	protocollo@enteparchi.bo.it presidente@enteparchi.bo.it	www.enteparchi.bo.it
		Massimo Rossi (director)	Piazza XX Settembre, 1	40043 - I Marzabotto (BO)	+39(0)51 670 2811 - 625 4811	protocollo@enteparchi.bo.it massimo.rossi@enteparchi.bo.it	www.enteparchi.bo.it
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c.s.5 Vena Gesso Romagnola c.s.6 Evaporiti di San Leo c.s.7 Gessi di Onferno	Ente di gestione per i Parchi e la Biodiversità – Romagna	Antonio Venturi (president)	Via Aldo Moro 2	48025 - I Riolo Terme (RA)	+39(0)546 77404	promozione@parchiromagna.it	www.parchiromagna.it
		Nevio Agostini (director)	Via Aldo Moro 3	48026 - I Riolo Terme (RA)	+39(0)546 77429	nevio.agostini@parchiromagna.eu	www.parchiromagna.it
		Oscar Zani (technical referent)	Via Aldo Moro 3	48027 - I Riolo Terme (RA)	+39(0)546 77433	oscar.zani@regione.emilia-romagna.it	www.parchiromagna.it

- *Visitor centre and Environmental Education Centre - Onferno Reserve, Gemmano. Gessi di Onferno*
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8.C OTHER LOCAL INSTITUTIONS

component site	*Institution/Agency*	*Name*	*address*	*City, Province/ State, Country*	*Tel.*	*email*	*website*
museum	Museo di Ecologia e Centro Visitatori Mirco Bravaccini		Via della Rocca, 21	47014 -I Meldola (FC)	+39(0)543 499 405	scardavilla@comune.meldola.fc.it	www.museodiecologia.it
university	UNIBO - BiGeA	Stefano Piastra	Via Filippo Re 6	40100 -I Bologna (BO)	+39 051 209 1610	stefano.piastra@unibo.it	https://www.unibo.it/sitoweb/stefano.piastra
		Federico Fanti	Piazza di Porta S.Donato 1	40100 -I Bologna (BO)	+39 051 209 4565	federico.fanti@unibo.it	https://www.unibo.it/sitoweb/federico.fanti
	UNIMORE	Stefano Lugli	Via Università 4	41121 -I Modena (MO)	+39 059 205 8475	stefano.lugli@unimore.it	https://personale.unimore.it/Rubrica/dettaglio/luglis
research center	SSI - Società Speleologica Italiana	Paolo Forti					
	FSRER Federazione Speleologica Regione Emilia Romagna	Massimo Ercolani	Parco Regionale dei Gessi Bolognesi e Calanchi dell'Abbadessa via Carlo Jussi, 171 Farneto	40068 -I San Lazzaro di Savena (BO		info@fsrer.org	http://www.fsrer.it/
visitor centre/ interpretative centre	Centro Visite Rifugio Cà Carnè	Ivano Fabbri	Via Rontana, 42	48013 -I Brisighella (RA)	+39(0)546 80628; +39 339 240 7028"	ivanofabbri@alice.it	
	Centro Visite Rifugio Casa del Fiume	Stefano Schiassi	Via Rineggio, 22	40021 -I Borgo Tossignano (BO)	+39 328 741 4401	stefanoschiassi@gmail.com	
	Centro Visite e Centro di Educazione Ambientale Onferno		Via Prov.le Onferno, 50	47855 -I Gemmano (RN)	+39 389 199 1683	onferno@nottola.org	www.onferno.it
	Centro Visite Casa Fantini		Via Jussi, 171 – Loc. Farneto	40068 -I San Lazzaro di Savena (BO)	+39(0)51 625 4821	infea@enteparchi.bo.it	https://enteparchi.bo.it/parco-dei-gessi-bolognesi-e-calanchi-dellabbadessa/centro-visita/
	Centro Visite Villa Torre		Via Tolara di Sopra, 99 – Settefonti	40064 -I Ozzano Emilia (BO)	+39(0)51 625 4821	infea@enteparchi.bo.it	https://enteparchi.bo.it/parco-dei-gessi-bolognesi-e-calanchi-dellabbadessa/centro-visita/
	Centro Visite delle Fonti di Poiano	c/o Ristoro Le Fonti	Poiano di Villa Minozzo	42030 -I Villa Minozzo (RE)	+39(0)522 802 031		
Centro di Educazione Ambientale Romagna - C.E.A.S. Scuola Parchi Romagna "P. Zangheri"	Ente di gestione per i Parchi e la Biodiversità – Romagna	Fiorenzo Rossetti	Piazza Morgagni, 9	47121 -I Forlì (FC)	+39(0)543 714313 +39 338 2151442	fiorenzo.rossetti@regione.emilia-romagna.it	
Progetto Europeo "Made In Land"	Ente di gestione per i Parchi e la Biodiversità – Romagna	Beatrice Giorgi			+39(0)546 77402	beatrice.giorgi2@gmail.com	
Progetto europeo LIFE 4 Oak forests	Ente di gestione per i Parchi e la Biodiversità – Romagna	Serena Petroncini			+39(0)546 77402	serenaparco@gmail.com	

8.D OFFICIAL WEBSITE

No official website, at the moment [jan 2022].

SIGNATURE
ON BEHALF OF THE STATE PARTY

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• *(in front) Surveying the Triassic gypsum caves . Alta Valle del Secchia © M. Malvini*

Italian Ministry for the Ecological Transition

Emilia-Romagna Regional Government

Regione Emilia-Romagna

MINISTERO DELLA
TRANSIZIONE ECOLOGICA