RegioneEmilia-Romagna
Direzione Generale Cura del Territorio e dell'Ambiente

Evaporite karst & caves of Emilia Romagna Region

Tentative List – supplementary description

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United Nations Educational, Scientific and Cultural Organization · World Heritage Convention

TENTATIVE LIST SUBMISSION FORMAT

STATE PARTY

Italy

Name: **Italy; REGIONE EMILIA-ROMAGNA;**
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NAME OF THE PROPERTY

Evaporite karst & caves of Emilia Romagna Region

State, Province or Region: **Italy, Emilia Romagna Region**

GEOGRAPHICAL COORDINATES

Latitude and Longitude, or UTM coordinates:

Triassic anhydrites of the Upper SecchiaValley:
from 10°26'49,284"E to 10°22'04,29"E; from 44°23'56,005"N to 44°21'30,81"N

Messinian Gypsum of Zola Predosa:
from 11°13'30,016"E to 11°12'57,749"E; from 44°28'05,666"N to 44°27'47,035"N

Messinian Gypsum of Bologna:
from 11°25'48,668"E to 11°22'19,339"E; from 44°27'19,226"N to 44°25'11,108"N

Gypsum Vein of Romagna:
from 11°46'37,985"E to 11°33'25,681"E; from 44°16'47,945"N to 11°33'25,681"E

TEXTUAL DESCRIPTION

The Emilia-Romagna evaporite karst outcrops (Fig. 1) are particularly exiguous (less than 0,5% of the whole territory) and consist of two different lithologies: Triassic anhydrites (with a total area of ~ 20 km2) and Messinian gypsum (~ 30 km2).

Despite their reduced dimensions, these areas host well developed and varied surface forms (blind valleys, dolines, roofless caves, tumulus, candles etc.) (Lucci & Rossi 2011). Over 700 caves (https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer. jsp?service=grotte) have been explored and mapped so far.

With over 50 sites spread over 5 continents, karst and caves are well represented in the UNESCO World Heritage. Recently the IUCN (International Union for Conservation of Nature), as advisory body of the UNESCO World Heritage Convention on natural heritage, printed a global review on World Heritage karst properties (Williams, 2008).

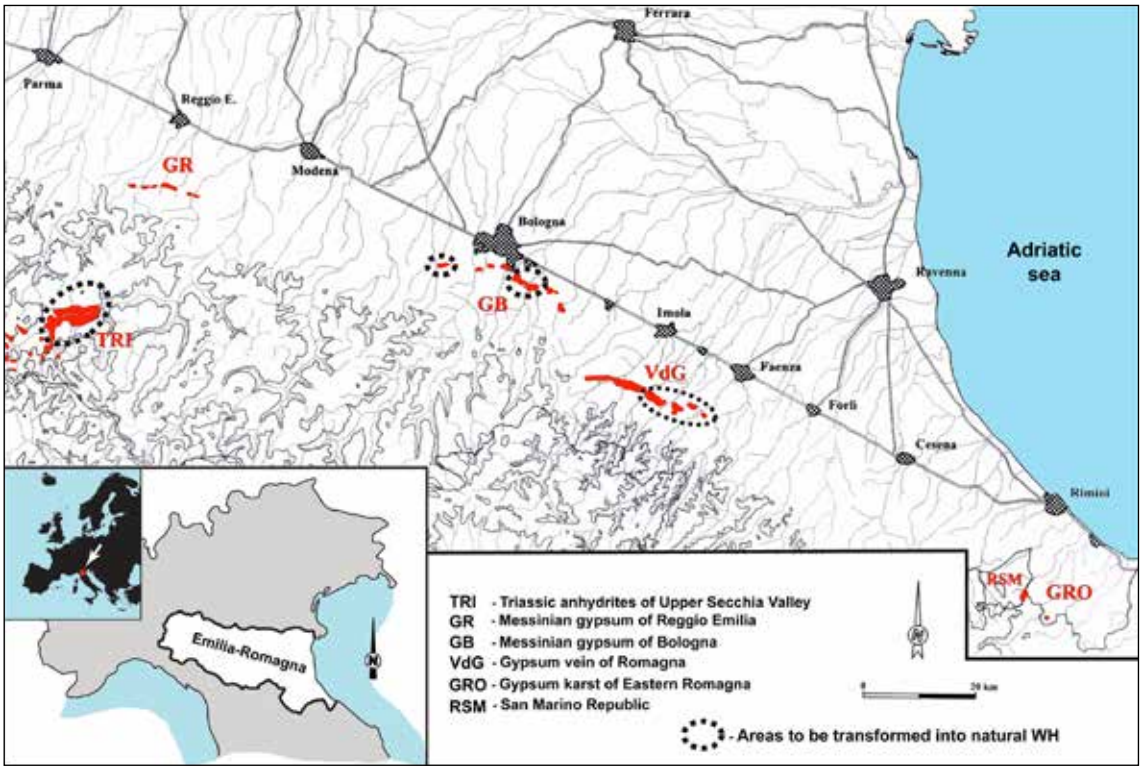


Fig. 1 – Evaporite karst outcrops (red areas) of the Emilia-Romagna Region: areas within the dotted lines are those to be submitted to UNESCO for becoming a new natural World Heritage (after Forti 2017b).

In this book the present situation, the future prospects and the management of the Karst World Heritage was shortly presented and it was clearly stated that in the near future only a few more karst sites are expected to attain the status of World Heritage, even if theoretically some of them meet one or more of the needed criteria for inclusion in WH list.

In the IUCN book, it is clearly written:

> *Possibilities exist only for those karst types that are still totally unrepresented in the WH list. That is the case of karsts on evaporite rocks... In cases where karst features on evaporite rocks are demonstrably of outstanding universal value in relation to geoscience, and are not just of a specialized scientific importance, but are accessible and comprehensible by civil society, then such cases could merit consideration for World Heritage inscription...*

And few pages later the Recommendation 4 says:

*That States Parties whose territories include **karst terrains situated on evaporite rocks** consider the potential of their sites for natural World Heritage recognition….*

Consequently, … the highest priorities for completion of a comprehensive range of karst World Heritage sites are:

- *to cover more adequately the karst type region of Europe,*
- *to fill gaps in coverage in cold regions, arid/semi-arid regions and tropical oceanic regions,*
- ***to identify evaporite karst sites of outstanding universal value.***

No anhydrite and/or gypsum kart area has been submitted to attain the rank of WH since then.

Evaporite karsts, developed within halite, gypsum, and anhydrite formations, are relatively widespread all around the world, but they are still scarcely explored, studied, and even less protected. This is not the case of the evaporite (gypsum & anhydrite) karst of the Emilia-Romagna Region (Italy).

Therefore, in order to obtain the rank of natural World Heritage, the Emilia-Romagna Regional Government decided to submit the candidature of the most relevant portion of the regional evaporite karst to UNESCO.

Nevertheless, there are many other important reasons to support their nomination to the natural World Heritage.

CRITERIA UNDER WHICH PROPERTY IS NOMINATED

(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.

CRITERIA SUPPORTING THE NOMINATION

(iii) bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared.

(vii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

(ix) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.

(x) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

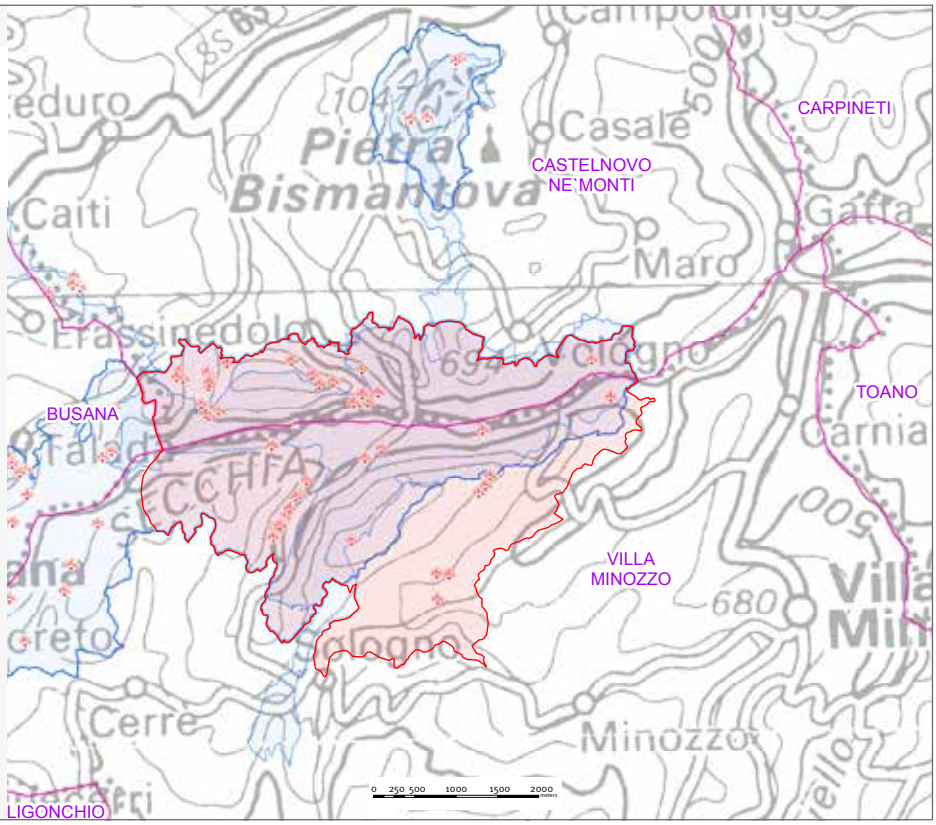
KARST AREA
Alta Val Secchia
TRI

Caves

Candidate areas

Borders Municipality

Protected Areas



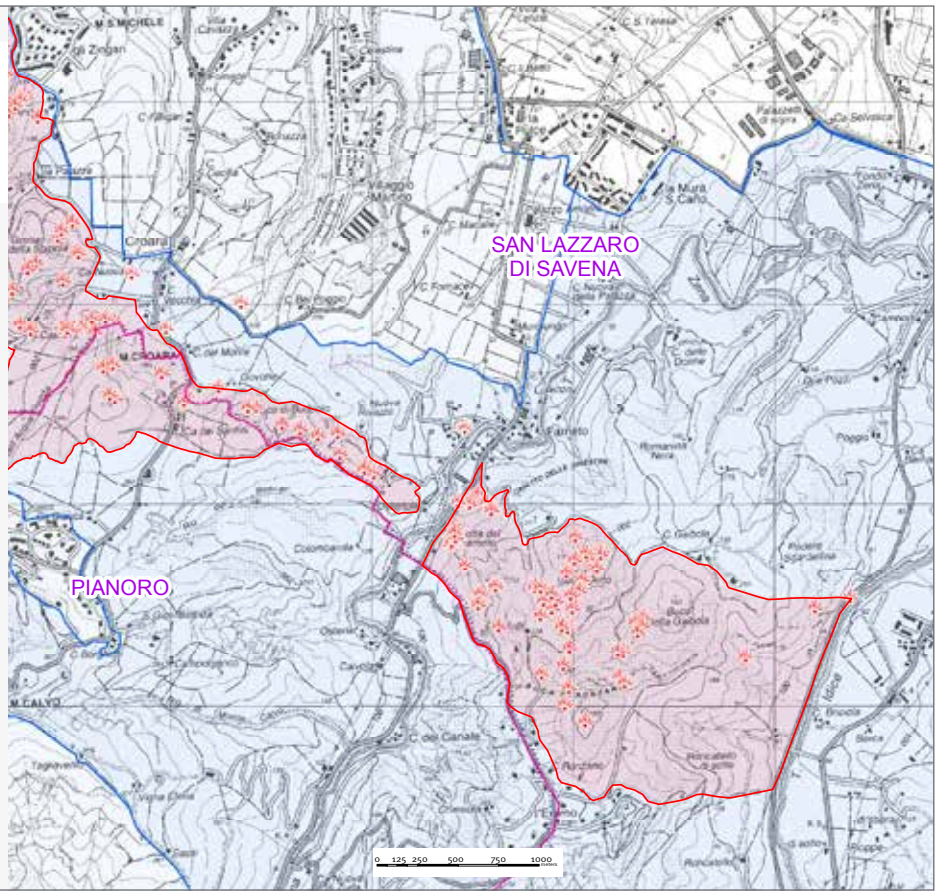
KARST AREA
Gessi Bolognesi
GB

Caves

Candidate areas

Borders Municipality

Protected Areas



KARST AREA
Gessi Bolognesi:
Gortani

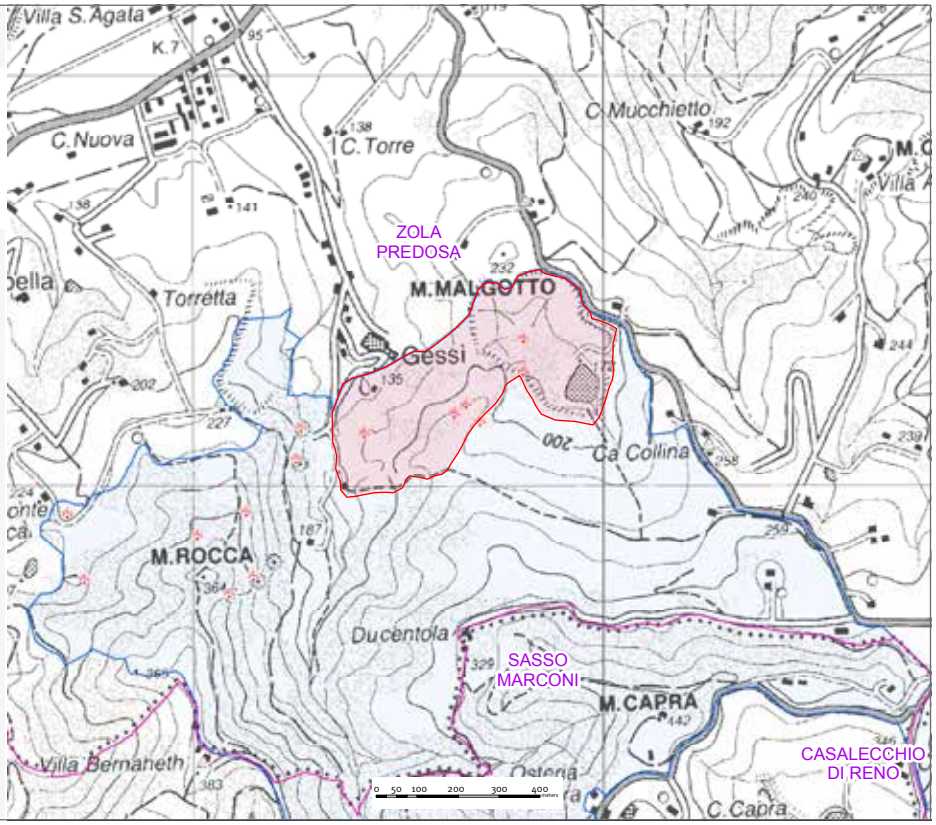
GB

Caves

Candidate areas

Borders Municipality

Protected Areas



KARST AREA
Vena del Gesso
Romagnola

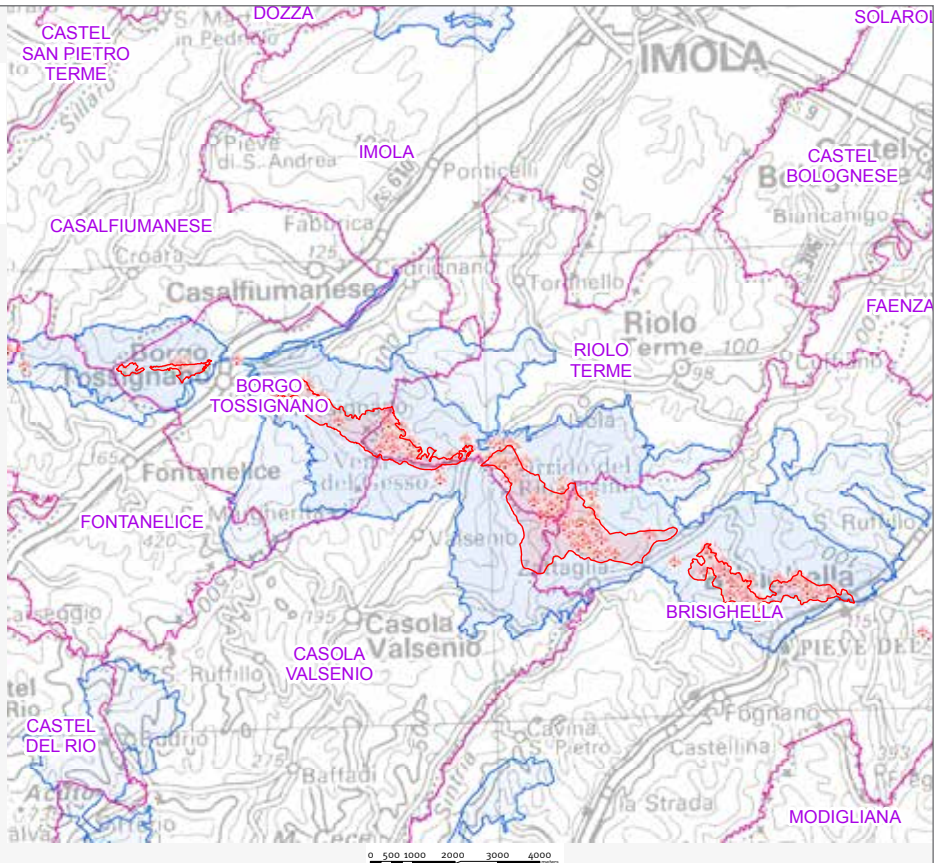
VdG

Caves

Candidate areas

Borders Municipality

Protected Areas



- The Emilia-Romagna anhydrite caves are the single epigenic ones in the world; they host the world deepest anhydrite cave and the largest salt karst spring of Italy.
- Some of the gypsum caves are among the deepest and longest world epigenetic caves in these lithologies.
- The lithological variability (anhydrite and gypsum), the presence of two different (intra-Messinian and actual) speleogenetic cycles, the richness of epigean and hypogean karst forms, the huge dimensions of both anhydrite and gypsum caves, together with their peculiar ecosystem, which gives shelter to endangered or peculiar species, ecological and biological processes, mineralogy and paleontology are significant factors supporting their candidature.
- The evaporite areas of Emilia Romagna are by far the best explored, documented and studied evaporite karst in the world.

Justification for Criteria

Evaporite karst and caves of Emilia Romagna meet the following naturalistic criteria:

(viii)

And, supporting the nomination, the following naturalistic and cultural criteria:

(vii) (ix) (x) (iii)

In detail:

(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.

Fig. 2 - Sinkhole near Monte Mauro, ~~Tanone della Gacciolina entrance~~ - Vena del Gesso Romagnola (epigean karst form).

In the previous page

Fig. 3 - Hypogean karst forms: Buco dei Buoi (Gessi Bolognesi); Cave under Ca' castellina, Monte Mauro (Vena del Gesso romagnola); Risorgente del Rio Basino Cave (Vena del Gesso romagnola);

The lithological variability (anhydrite and gypsum), the presence of two different (intra-Messinian and actual) speleogenetic cycles, the richness of epigean and hypogean karst forms (Fig. 2 - 3), the rare/new speleothems and/or cave minerals (some of them unique), and the huge dimension of both anhydrite and gypsum caves are certainly important requirements for this candidature.

Many speleogenetic studies on gypsum and anhydrite caves were carried out in the Emilia-Romagna region and, just to mention a few, they involve the investigation of: 1) underground bends in anhydrite caves (Malavolti, 1949), 2) antigravitative evolution (Pasini 1975, 2009), 3) the role of CO_2 in the dissolution of gypsum and the deposition of carbonate speleothems (Forti & Rabbi, 1981), 4) the role of condensation in gypsum speleogenesis (Cigna & Forti, 1986), 5) the possibility to use stalagmites and the deviations in their growth axes as indicators of past earthquakes (Forti & Postpischl, 1979), and last but not least 6) the possibility to use calcite speleothems in gypsum caves as paleoclimate proxies (Fig. 4) (Calaforra & Forti, 1999, Dalmonte et al., 2004; Calaforra et al. 2008).

Fig. 4 - Speleothems and paleoclimates.

Fig. 5 – Skull of Plioviverrops faventinus from the intra-Messinian gypsum cave found inside a gypsum quarry of Brisighella, which is now transformed into an Open Air Geological Museum.

Geomorphological and mineralogical features, however, are not the only outstanding aspects of the Emilia-Romagna gypsum karst and caves. Indeed, in these areas were found some rare and well preserved paleontological remains (Fig. 5) of intra-Messinian (Costa et al., 1985) and upper Pleistocene fauna (Pasini, 1969, 1970).

(vii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

The Evaporite karst and Caves of Emilia-Romagna hosts rare geologic and karst landscapes both in the Anhydrites and Gypsum outcrops, which, beside their geologic importance, are also very important from the aesthetic point of view (see Fig. 9 - 10 - 11).

(ix) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.

Some of the properties host peculiar on-going ecological and biological processes. In particular, it is worth mentioning the Poiano Spring in the Upper Secchia Valley and its related brackish aquifer.

The karst groundwater feeding this spring hosts several rare and/or new to science organisms like the endemic amphipod *Niphargus poianoi* (Fig. 6).

Fig. *6 - Niphargus n.s.* and *Acanthocyclops n.s.*

Moreover, the discovery of some stygobionts of ancient marine origin poses some interesting questions about 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* (up to now represented in Italy by a single species living in anchihaline ground waters of Apulia) are noteworthy. They probably represent phylogenetic relicts, members of groups that have existed in the marine interstitial habitat; they survived in an area where anhydrite karst aquifers are characterized by high sodium chloride content (Stoch et al. 2009).

Fig. 7 - a) Ferro di Cavallo maggiore - b) Collembolo Deuteraphorura sp., discovered in the Gessi di Rontana and Brisighella gypsum quarries, represents a new species, endemic to the Vena del Gesso Romagnola.

(x) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

Emilia-Romagna gypsum and anhydrite caves are extremely important biological shelters, hosting some of the largest and varied bat colonies of Europe, and several peculiar endemic troblobitic species, restricted to these environments (Fig. 7).

Moreover, the gypsum and anhydrite outcrops influence the local microclimate allowing the presence of rare botanic associations.

Over 500 different botanic species have been detected (Alessandrini 1988) in the Triassic Anhydrites of the Upper Secchia Valley; making this area one of the richest, in terms of floristic biodiversity, of the whole Emilia Romagna region. Among them there are some extremely rare species that in Italy are restricted to this area *(Artemisia lanata, Daphne alpina, Helianthemum oelandicum, Ononis rotundifolia, Rhamnus saxatilis)*. In addition, the Triassic anhydrites are still characterized by a very high naturality with an extremely low number of exotic species.

Fig. *8 - Cheilanthes (Notholaena) persica.*

Over 1000 different botanic species have been detected in the Messinian gypsum, including *Mediterranean Tortula revolvens*, distributed only over gypsum areas but extremely rare in Europe. In particular, the Vena del Gesso Romagnola hosts 31 species of Orchids, including the Himantoglossum adriaticum (protected by the directive 92/43/EEC), and 22 species of Ferns, including the *Cheilanthes (Notholaena)* persica (Fig. 8), that in Italy can be found only on the Vena del Gesso, the only growing area in Western Europe, being the species distributed from the Eastern Balkans to the Himalaya.

Last but not least, the same area hosts 247 species of Vertebrates (including some 19 species of Bats) and at least 13 species of endemic Invertebrates (many of those which are troglobian), four of whom can be can be found only in the Vena del Gesso Romagnola *(Medioppis melisi, Ramusella caporiacci, Lathrobium maginii subsp. mingazzinii, Choleva convexipennis*).

Moreover:

Anhydrite karst

The outcrop of Triassic Anhydrites in the Upper Secchia Valley are a rare, perfectly preserved, example of a evaporite, still partially active, diapir, with dome shaped hills which were cut along a main fault by the Secchia river. The subvertical cliffs along this river exhibit an extremely convoluted structure which is the direct consequence of the volume expansion induced by the anhydrite hydration to gypsum (Fig. 9).

Fig. 9 - Aerial view of the Upper Secchia Valley Triassic anhydrite outcrop.

Moreover, at present, the Emilia-Romagna anhydrite caves are the only epigenic ones in the world: since the other known cavities in this lithology are hypogenic (Kempe, 2014). Among them there is also a completely new kind of cavity: the "hypogean bend" (Malavolti, 1949), the development of which is strictly controlled by the hydration of anhydrite and by the tensional release along the external surface of the anhydrite-gypsum-halite diapir (Chiesi & Forti, 2009). In addition, the Emilia-Romagna anhydrite caves (Fig. 10) host the world deepest anhydrite cave (Caldina Abyss with a total depth of 265 m) (Franchi & Casadei, 1999) and the largest salt karst spring in Italy and one of the largest in Europe (Chiesi et al., 2010).

Fig. 10 - Tanone piccolo della Gacciolina (Triassic Anhydrites in the Upper Secchia Valley).

Gypsum Karst

In the Vena del Gesso Romagnola (Fig. 11) the Messinan gypsum outcrops exhibit a spectacular monoclinal structure which has been exposed by the differential erosion of the overlying impervious deposits.

The Messinian sequence is therefore exposed and it is easy to "read" all the details in its structure, consisting of huge gypsum strata with sometime 1 m thick clay marl interbeds, over which peculiar sinsedimentary forms ("memelons") developed.

The gypsum outcrops of Emilia Romagna underwent two different speleogenetic cycles (Fig. 12): the first was intra- Messinian (De Waele & Pasini, 2013) while the second started over 500.000 years BP and is still going on today (Colunbu et al., 2015).

Fig. 11 - An aerial view of the Messinian outrops in the Vena del Gesso romagnola.

Fig. 12 - Zola Predosa, Bologna, Italy: a large Messinian karst developed along a gypsum interbed. After the evolution of the cave, gypsum strata were displaced becoming quite vertical (red line), while the cave (white dot line) were filled of marine sediments.

Some of these caves are among the world's deepest and longest epigenetic caves in these lithologies: the Spipola Acquafredda karst system near Bologna is the longest (over 12 km of mapped galleries, De Maria et al., 2012), while some others exceed 5 km in length (Ercolani et al., 2013, Forti & Lucci, 2010). Moreover, they host peculiar solution-corrosion forms, speleothems and cave minerals (Forti, 1997; 2017), important paleontological and archeological remains, while some endemic organisms can be found only there.

To date, with over 2,000 printed papers (more that the cumulative bibliography of all the other gypsum and anhydrite caves in the world), the evaporite areas of Emilia Romagna are by far the best explored, documented, and studied evaporite karst in the world (Bentini & Lucci, 1999; Chiesi & Forti, 2009; De Maria et al., 2012; Forti & Lucci, 2010; Lucci & Rossi, 2011; Ercolani et al., 2013; Lucci & Piastra 2015; and the references therein).

The "gypsum karst" of our Region was the first to be studied in the world; investigations started in the late XVI century thanks to Ulisse Aldrovandi (1648), in the XVII-XVIII centuries they were later

carried on by Luigi Ferdinando Marsili and Antonio Vallisneri, and they are still going on today (Altara et al., 1995). Indeed, some of the most peculiar forms (e.g. the "candle like erosion", Capellini, 1876) and deposits (Laghi, 1806; Santagata, 1835) of the gypsum caves were firstly described in these territories. Last, but not least, Gypsum caves in Emilia-Romagna were some of the very first sites in Italy where stratigraphic approach was applied in Prehistoric archaeology in the XIX century (Tassinari, 1865; Scarabelli, 1866).

(iii) bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared.

In addition to what already said, some of the caves within the property (Calindri and Farneto caves in the Messinian gypsum of Bologna and Banditi, Tanaccia and Re Tiberio Caves in the Vena del Gesso Romagnola) are important archaeological sites for the copper, bronze, and iron ages, during which they were used as places of settlement, burial or cultic sites (De Maria et al. 2012, Ercolani et al.2013), as well as for some perfectly preserved roman aged mine-caves of "Lapis Specularis" that were recently found and studied (Guarnieri, 2015) (Fig. 13).

Furthermore, many of the caves are important for their recent history since, during World War II, they were used as shelters by the local population. Even now, local community uses small caves as warehouses or cellars.

Fig. 13 - a) Grotta di Ca' Toresina; fully chiselled walls and subsequently mineralized - b) Lapis specularis slab partially shaped - c) Globular cap with comb decoration, Bronze Age.

Statements of authenticity and/or integrity

Most of the property (over 95%), identified as significant to this nomination, fall within the boundaries of the Alto Appennino Tosco-Emiliano National Park (Triassic anhydrites of the Upper Secchia Valley of Fig. 1), and of two Regional Parks: the Gessi Bolognesi Park (Messinian gypsum of Bologna of Fig. 1) and the Vena del Gesso Romagnola Park (Gypsum vein of Romagna of Fig. 1). Only the small area of Zola Predosa (NW of Bologna in Fig. 1) is not included into a park, although it is already a Natura 2000 site.

The Natura 2000 network stems from the Habitats Directive (Dir. 92/43/CEE). Natura 2000 is a network of sites selected to ensure the long-term survival of Europe's most valuable and threatened species and habitats.

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, thanks to its archaeological importance, Re Tiberio cave is also protected by a specific law, issued on 9th July 1951 on the basis of the national law 1089/1939 and confirmed by decree 42/2004, as archaeological site.

Consequently, all the proposed properties are protected by law. Moreover, these three Parks are still expanding their territories by acquiring new private areas and these acquisitions will be further enhanced if these properties will be nominated WH.

Last but not least, 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 (Forti, 2004, 2017).

Moreover all the proposed properties, from 2010 to 2016, were interested by 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)", 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.

For all these reasons, we think that the Evaporite karst & caves of the Emilia Romagna region perfectly fit the needed prerequisite to be in "...the conditions of integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding."

Comparison with other similar properties

Presently no other gypsum and/or anhydrite karst area is present in the Tentative List. Gypsum, and to a lesser extent, anhydrite, outcrop in many places around the world (Chabert & Courbon, 1997) and often lie buried at a shallow depth. Occurrences are particularly extensive in the Russian Federation, Ukraine and North America (Klimchouk, et al. 1996). In particular, huge Messinian evaporitic (gypsum, and halite), often well karstified, deposits are present all around the Mediterranean sea.

Anyway, only few of them have been explored and studied yet (Fig. 14) and even less have a protection suitable to be considered for a WH application.

A few gypsum and/or anhydrite outcrops of the world are perhaps known worldwide as those of the Emilia Romagna Region. Among them surely the gigantic gypsum caves of Ukraine (Klimchouk, 2009) and the big and widespread anhydrite cavities of Germany (Kempe, 2014) are worth of mention. Anyway, actually, these areas lack of protection and therefore cannot be taken into consideration by UNESCO.

Fig. 14 – Location of the main evaporite karst areas which have been at least partially explored. *Halite*: 1) Mt. Sedom, Israel; 2) Central Iran; 3) New Mexico, USA; 4) Atacama, Chile, 5) Cardona, Spain, 6) Mînzălești, Romania, 7) Wieliczka, Poland, and 8) Quinghai China. *Anhydrite:* 1) Upper Secchia Valley, Italy; 2) Central Germany. *Gypsum*: 1) Emilia Romagna, Italy; 2) Verzino, Calabria, Italy; 3) Santa Ninfa Sicily, Italy; 4) Pinega (Russia); 5) Kungur, Russia; 6) Podolia, Ukraine; 7) Almeria, Spain; 8) Darhedi, Algeria; 9) New Mexico, USA; 10) Punta Alegre, Cuba; and 11) Neuquén, Argentina (After Forti 2017a).

Anhydrite karst

Presently the single Country in which caves in this lithotype are known and explored is *Germany*. Their genesis is hypogenic (Kempe 2014, Knolle et al. 2017), while that of Emilia Romagna is epigenic (De Waele J. et al. 2017) and therefore the two karsts are hardly comparable.

Anyway, concerning **criterium viii** a single speleogenetic mechanism is responsible for their development and therefore the resulted forms are few (only phreastic tubes) while those in Emilia Romagna are much more and complex. Moreover the cave size, the hosted speleothems and cave minerals, their hydrogeology (with the presence of a huge salt spring) make the Emilia Romagna Anidrite karst much more interesting.

Moreover taking into account the "supporting criteria":

Concerning criterium ix the German anhydrites were dried by mining activities only a couple of century ago, therefore they had not the possibility to develop **outstanding examples representing significant on-going ecological and biological processes which in tourn are present in the Emilia Romagna ones.**

The same can be said for **criterium x**

While they have no interest at all with respect to **criterum iii**

In conclusion the Emilia Romagna anhydrite karst is by far more interesting than that of Germany.

Gypsum karsts

Many gypsum karst areas exists in the world and some of them have been at least partially explored and studied. Anyway most of them are very small and host only few peculiar forms, deposits and/or living organisms.

Here the most important of them (see Fig. 2) are shortly described and compared with the Gypsum Karsts of the Emilia Romagna in order of their importance.

All of them, beside that in Algeria have been visited in the past by us and therefore the comparison with the Gypsum karst of the Emilia Romagna is based not only on papers existing in the literature but mainly on a direct knowledge of these areas.

1] Gigantic caves of Podolia, Ukraine

These maze cave reaching over 300 km in length (Klimchouk, 2009) are by far the longest gypsum caves of the world.

Their genesis and evolution (hypogenic) have been studied and their infilling described.

Anyway these caves are hardly comparable with those of Emilia Romagna because the latter, as already said, are epigenic.

Anyway regarding **criterium viii** it must be stressed that morphological varieties, 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 while in Emilia Romagna at least two (intramessiniana and actual).

Regarding **critera ix and x** it must be said that nothing is actually known on the hosted ecosystems and their in time evolution and no paleontological remains at all are hosted in those caves.

While they have no interest at all with respect to criterum iii.

Finally Podolia gypsum karst still lacks of a suitable protection.

It is therefore evident that the Emilia Romagna gypsum karst is by far more interesting and worth to be nominated in the WH list.

2] 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 Gypsum formations (Calaforra et al. 1992). The karst and caves are well explored documented and studied.

Regarding the **criterium viii** it must be said that they are less interesting of those of Emilia Romagna because their dimension are smaller and only the actual karst cycle is represented.Moreover they lack of several forms and speleothems (those of calcite are practically absent) as well as cave minerals.

Regarding **criteria ix and x** their ecosystems, at least on the basis of the actual knowledges, are by far poorer than that of Emilia Romagna Region. No paleontological remains at all are hosted in those caves.

While they have no interest at all with respect to **criterum iii**.

In conclusion the interests of the Almeria is restricted to abiotic phenomena of a Messinian Gypsum where only a single karst cycle is represented, moreover only a partial protection is actually imposed to that area.

For all these reasons the Evaporite Karst of Emilia Romagna should be considered much more valid to obtaining the WH rank.

3] Santa Ninfa, Sicily, Italy

The Messinian gypsum of Santa Ninfa hosts several surface and deep karst forms, resulting the most interesting among the gypsum karst areas of Sicily (Agnesi & Macaluso, 1989).

Regarding the **criterium viii** it must be said that the variability of forms and deposits is far

less than in the Emilia Romagna gypsum karst.

Most of the karst forms and of the speleothems of the Santa Ninfa area are very similar to those present in the Emilia Romagna area (the few differences are controlled by the different climate, which is hotter and dyer than that of the Emilia Romagna).

Regarding **criteria ix and x** extremely few is known on cave ecosystems and its evolution in time.

No paleontological remains are present in that area and only scarce evidence of a roman mine of lapis pecularis.

Finally only the Santa Ninfa cave is a Regional Natural Preserve, while the other parts of the gypsum outcrop has no protection at all.

For all this reasons the interests present in the Emilia Romagna region are by far much more and varied, and will prevail.

4] Pinega, Russia

Permian gypsum is covered by thick fluvio-glacial deposits and occupies a large portion of territory several km NE of Arkangelsk (Forti P. 1990). The Pinega gypsum karst is inserted in a Natural Park characterized by a huge taiga forest with practically no inhabitants, therefore its safeguard is optimal.

Regarding the **criterium viii** surface karst forms are rare and are represented only by a few vertical sinkhole where water sinks during the short thaw period and by seasonal springs along the main river cutting the area. Caves are very recent (most of them developed after the last glaciation) and are partially frozen all the year. The single hosted morphologies are related to the early summer floods related to thawing.

Only a very few speleothems and practically no cave minerals beside ice have been reported from the caves of this region.

Regarding **criteria ix and x** nothing is known on cave ecosystems and its evolution in time.

Finally no paleontological or arhcaeologicla remains are present in that area

It is therefore evident that Emilia Romagna properties are much more valuable.

5] Kungur, Russia

The huge Permian gypsum outcrop around the Kungur village host lot of well developed sinkholes, several different small karst forms (karren etc..) and a few caves, the most renown of which is the Kungur Ice Cave.

Regarding the **criterium viii** the main characteristic of Kungur Ice Cave is given by the hosted huge ice deposits giving rise to l speleothems 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. In any case its morphological and mineralogical interest are by far less and less interesting than those of the Emilia Romagna ones.

Regarding **criteria ix and x** It must be said that probably the underground lakes host peculiar ecosystems but, at least at our knowledge, they are still totally unknown.

Finally the cave has scarce paleontological and/or archaeological interest and its protection is scarce because the Kungur cave is long since a show cave with not high standard of of attwention to the environment.

In any case, our opinion is that even if in the near future more detailed information on this karst area will be available, we think that the importance and interest of the Gypsum caves of Emilia Romagna will remain by far higher.

6]New Mexico, USA

In the desert of New Mexico there is a large peneplanar area of outcropping gypsum characterized by flat extremely large dolines at the bottom of which sometimes sinkholes allow the access to even large caves (Chiesi & Forti, 1996). This karst area has been only partially explored and mapped but no specific analyses and studies have been performed over it. Probably the cave ecosystem will be of noticeable importance because the cavities represent a shelter against the extremely dry weather conditions of that area. Anyway, at least in the near future, the quite total lack of knowledge on their characteristics avoid the possibility to consider them for a possible WH candidature

7] Darhedi, Algeria

This area is the single one among the gypsum karsts of this section which was not visited by us.

Therefore all what written here comes from the scarce available bibliography (Kosa 1980). The area hosts a rather large cavity (Bir al Ganham) hosting some speleothems and cave minerals.

Unfortunately nothing else is presently known on this area. At the moment no kind of safeguard exists for the whole karst area. In any case, actually, it is hard to believe that Darhedi may become even in a future a WH.

8] Neuquén, Mendoza Argentina

In this area of Argentina there are several relatively small gypsum outcrops which host time by time dolines, karren-fields and some peculiar forms like small chimneys. Some gypsum caves are also known but their size is generally small (Forti et al. 1993). Only a minor part of these areas have been at least partially explored. Very important would be the high mountain gypsum karst (over 3000 m a.s.l.) but these areas have been only observed in distance and no surface recognition at all has been done until present. Nothing is known about their ecosystems. Therefore it is evident that the actual knowledge is too scarce to apply to be inserted in the WH list.

9] Punta Alegre, Cuba

The gypsum karst area of Punta Alegre (Chiesi et al., 1992) is very small, consisting of a diapir in which few very small gypsum caves (never exceeding 20-30 m in length) are present (Fagundo et al., 1993). All the karst form are controlled by the peculiar tropical climate, which allow 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.

At our knowledge this area has no specific safeguard rules and at least when we visited it, the karst aquifer was hardly polluted by a factory of a traditional liquor from sugar can.

It is therefore evident that the actual knowledge is too scarce to apply to be inserted in the WH list

10] Verzino, Calabria, Italy

The small Messinian gypsum outcrop host a single important and relatively long (a couple of km) karst system which a rather complex hydrogeology. Along the underground river small sulphide springs allowed the development of peculiar speleothems and a few cave minerals (Forti & Lombardo 1998).

Presently this area has no specific safeguard rules.

At the end of this short, and maybe not exhaustive, recognition on the main actually known gypsum and anhydrite karsts of the world, it is evident that the Evaporite karst and caves of Emilia Romagna, thanks to its characteristics, is by far the best, among these properties and therefore it should be considered for attaining the rank of WH.

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