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The Italian Cenozoic siliceous sponges: a review, with a revision of the Catullo (1856) collection

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ABSTRACT - Siliceous sponges are known from Eocene, Miocene and Pliocene levels in Italy, but they are poorly investigated. The taxa recognized or erected by authors of the second half of the nineteenth century (T.A. Catullo, A. Manzoni, P. Malfatti) are listed and discussed. The geographical, geological and paleoenvironmental knowledge about the marine levels bearing their rigid skeletal bodies are reviewed. For most of these deposits, the presence of a volcanoclastic input has been evidenced. All the examined original specimens of Catullo's (1856) siliceous sponge collection, stored at the Geological and Paleontological Museum of University of Padua, are recognized as non referable to siliceous sponges.

KEY WORDS: siliceous sponges, Cenozoic, Italy

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INTRODUCTION

The world-wide record of Cenozoic siliceous sponges with rigid skeleton is relatively scarce, in particular for the Oligocene and the Pliocene (Wiedenmayer, 1994; Pisera, 1999, 2006), whereas relatively rich Eocene and Miocene assemblages are known from Australia (de Laubenfels, 1953; Gammon et al., 2000), New Zealand (Kelly and Buckeridge, 2005), Spain (Pisera and Busquets, 2002; Ott D'Estevou et al., 1981; Brimaud and Vachard, 1986a, b) and Algeria (Pomel, 1872; Moret, 1924); however, according Pisera (1999, 2006), the diversity of the known faunas has been only partially investigated. In Italy, Eocene, Miocene and Pliocene assemblages have been firstly described by Menin (1972), Mazzetti and Manzoni (1879) and Malfatti (1895) respectivly, but most of them are unsufficiently studied. Otherwise, thick deposits rich in siliceous spicules are well known in the Central Apennines (Parotto and Praturlon, 1975).

As a contribution towards the study of the Italian Cenozoic siliceous sponges through the revision of historical collections and new field material, this paper aims to review the available knowledge up to now and to discuss their geological settings.

Here, we present the results of the study of the original specimens on which Catullo (1856) recognized and erected some species of siliceous sponges, stored at the Geological and Paleontological Museum of the University of Padua.

GEOLOGICAL SETTING OF THE SILICEOUS SPONGES BEARING LEVELS

In Italy, Cenozoic marine levels with spicules and skeletal bodies of siliceous sponges are known from different geographic, stratigraphic and geodynamic settings (Fig. 1).

Eocene

The oldest Cenozoic occurrence is that of the Middle Eocene of Lessini Mountains (Fig. 2), firstly erroneously recognized (see appendix) by Catullo (1856), later by Menin (1972) and more recently by Matteucci and Russo (2005). The siliceous sponge-rich levels crop out mainly in the caves open in the Chiampo Valley, from where the studied fauna originates. These beds belong to the Lessini shelf (Fig. 2), a

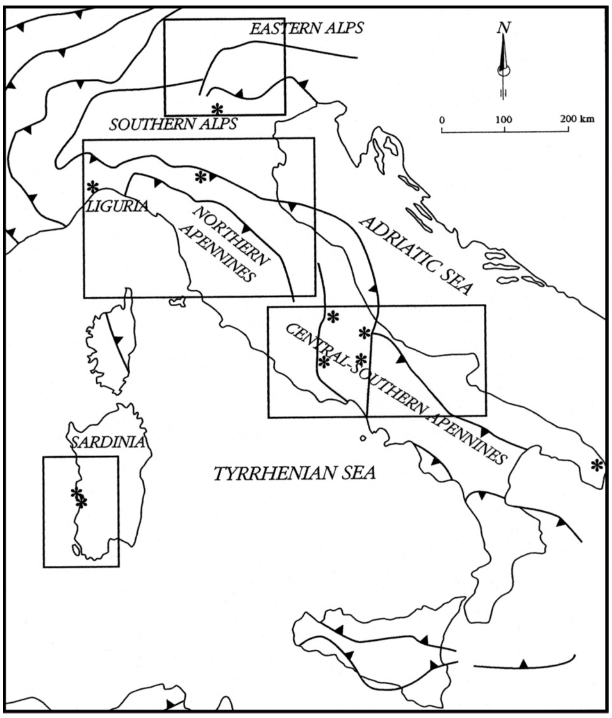

Fig. 1 - Geographic location of the Cenozoic levels bearing siliceous sponges in Italy. Redrawn, simplified and modified from Cerrina Ferroni et al. (2004).

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shallow-water carbonate platform which developed around paleo-highs, formed by various uplifted blocks of the submerged Mesozoic Trento platform and volcanic piles (Bosellini, 1988; Bosellini and Russo, 1988; Bosellini, 2004). In Paleogene times, the Veneto region has been affected by an intraplate volcanic activity ("Veneto Volcanic Province"; De Vecchi and Sedea, 1995; Lustrino and Wilson, 2007). Siliceous sponges are included in marly-tuffaceous and hyaloclastic horizons, intercalated between calcareous beds rich in larger foraminifers, molluscs and corals. The sponge assemblages developed in a shallow-water paleoenvironments, characterized by volcanoclastic influx.

Miocene

The Miocene biosiliceous deposits yielding siliceous sponge spicules and rigid skeletons are located in four different areas: Ligurian Piedmont basin, northern Apennines, central-southern Apennines and south-western Sardinia.

Ligurian Piedmont basin

Miocene biogenic marine deposits with siliceous sponge spicules are known in the Ligurian Piedmont Basin and in Monferrato region (Bonci et al., 1990; 1994); these deposits are mainly dominated by diatoms and only rarely, as in the Cappella Montei section near Serravalle Scrivia (Alessandria), sponge spicules are abundant; the spiculitic event is assigned to the late Miocene and its depositional environment is related to an open marine inner platform lacking terrigenous input (Bonci et al., 1991, 1997).

Northern Apennines

The siliceous sponges, recognized for the first time by Mazzetti and Manzoni (1879) and more accurately described by Manzoni (1881, 1882) and Malfatti (1901), come from various outcrops (Montese and Santa Maria Vigliana, Modena hills; Jola, Maserna and Serra de' Guidoni, between the Panaro and Reno rivers, Bologna hills; Rosino, Bottazzo valley, Parma hills) of the Emilia region (Fig. 3).

The siliceous sponge-bearing levels belong to the episutural successions filling the Epiligurian thrust top basin during the post Mesoalpine Phase (Cerrina Ferroni et al., 2004).

The sponges come from two different sedimentary levels: a) marls and arenaceous rocks ("Molassa miocenica" according to Manzoni, 1882), mainly cropping out in the hills south of the towns of Modena and Parma; in these deposits the siliceous bodies are totally or partially replaced by $CaCO_3$; b) incoherent siliceous marly sediments, mainly cropping out in the Apennines near Bologna, where the sponges preserve their siliceous skeletons (Manzoni, 1882; Malfatti, 1901); according to Manzoni (1882), the latter levels overlie the "Mergel-Molasse" deposits of the Schlier Fm.

The first level, bearing siliceous skeletons mainly replaced by $CaCO_3$ and rich in other invertebrates (irregular echinoids, molluscs and bryozoans), is referable to the Bismantova Fm., and may belong to its basal portion, where Bettelli et al. (1987) recorded abundant macrofossils, mainly echinoids; the second one, bearing well-preserved siliceous skeletons and rare other macrofossils (some encrusting bryozoans and serpulids, pectinid shell fragments), probably belongs to the topmost part of the underlying Antognola Fm., whose siliceous composition is well known (Amorosi et al., 1995). The topmost part of the Antognola Fm., clearly distinguishable for its high silica content, previously called "Tripoli di Contignaco" (Pieri, 1961) or "Marne di S. Michele" (Fornaciari, 1982) has been distinguished as Contignaco Fm. (Amorosi et al., 1995; Mancin et al., 2006). The depositional environment of the two sedimentary complexes is quite different: slope-basin as concerns the Contignaco Fm. (upper bathyal, with a paleobathymetric range of 200-600 m, according Mancin et al., 2006); shelf-slope for the basal part of the Bismantova Fm; ranking the former Bismantova Fm. as

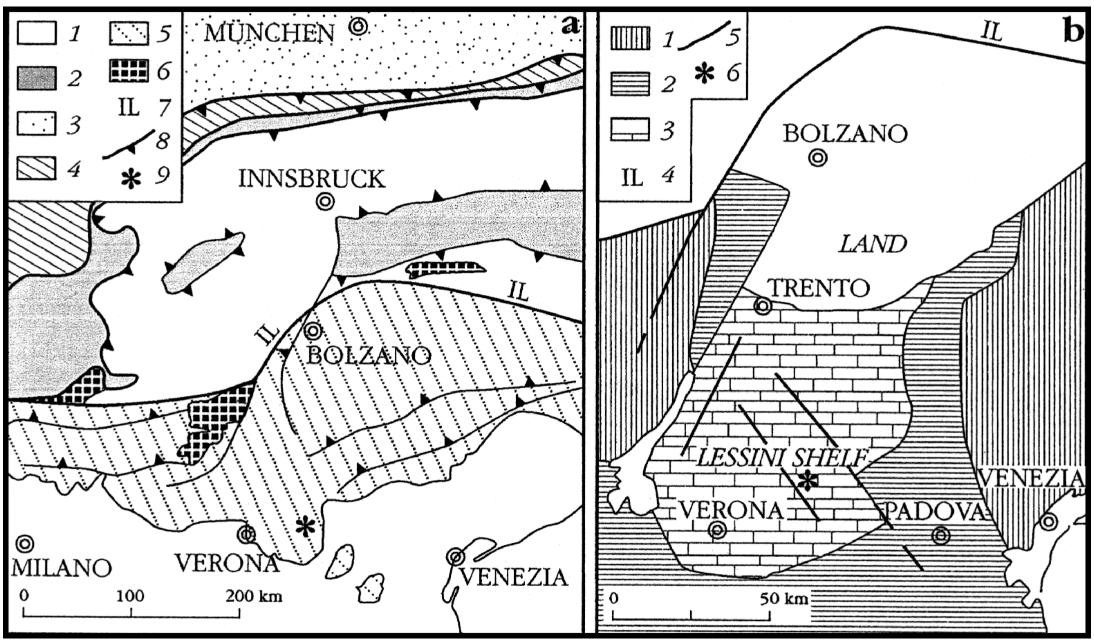

Fig. 2 - a) Geological sketch of Southern Alps, redrawn, simplified and modified from Castellarin et al. (2004): 1) Austroalpine; 2) Penninic; 3) Molasse; 4) Helvetic; 5) Southern Alps; 6) Periadriatic intrusions; 7) Insubric lineament; 8) Thrusts; 9) Location of the outcrops of Chiampo valley; b) Eocene Lessini shelf, redrawn, simplified and modified from Bosellini (2004): 1) Deep-water sediments of Jurassic basins; 2) Paleogene pelagic claystones; 3) Paleogene lagoon and reef limestones; 4) Insubric lineament; 5) Faults; 6) Location of the Chiampo valley.

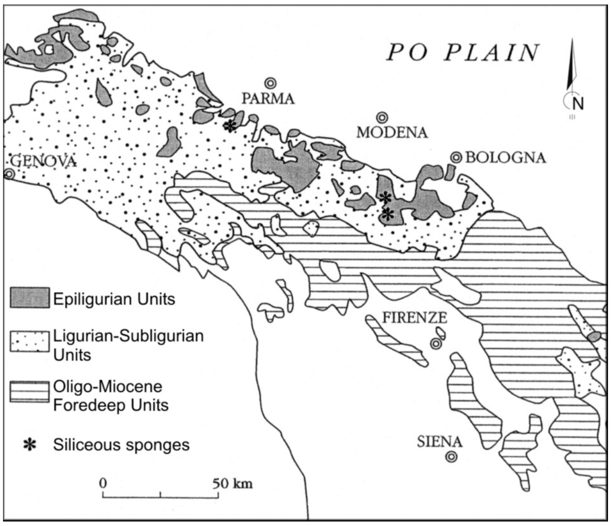

Fig. 3 - Geological sketch of the Northern Apennines, redrawn, simplified and modified from Conti and Fontana (1999), and location of the siliceous sponges outcrops (Parma, Modena and Bologna hills).

a Group, its basal unit, made up of shallow-water limestones and calcarenites and marked at its base by a regional unconformity, was distinguished as Pantano Fm. by Amorosi et al. (1996). The ages are also different: late Burdigalian-early Langhian for the Pantano Fm., late Aquitanian-middle Burdigalian for the Contignaco Fm. (Mancin et al., 2006).

According to Amorosi et al. (1995), the Upper Aquitanian-Upper Burdigalian sedimentary complex including piggy-back basin ("Siliceous marls", "Tripoli di Contignaco"), foredeep (Lower Vicchio Fm.) and ramp (Bisciaro Fm.) deposits (Fig. 7), because of their high siliceous content, volcanic and biogenous in origin, constitute a lithostratigraphic marker, the "Lower Miocene siliceous Zone", widespread in the northern Apennines. Except for evidences by nineteenth century authors (Mazzetti, Manzoni and Malfatti), the siliceous sponge content of this sedimentary complex, mainly spicules, is only rarely mentioned in the literature, as for the Bisciaro Fm. (Guerrera, 1977, 1978; Balogh et al., 1993; Sheet n. 87 Bologna, Geological Map of Italy, 1:100.000).

The emission area of the volcanic input evidenced in early Miocene siliceous deposits of the northern Apennines domain was probably located in Sardinia (Mezzetti et al., 1991; Amorosi et al., 1995), where the eruptive activity, mainly basaltic-andesitic and rhyodacitic, started about 32 Ma ago and continued until 13 Ma ago (Beccaluva et al., 2004); nevertheless, the presence of a closer source area, already hypothesized by various authors (Amorosi et al., 1995; Campos Venuti et al., 1997), cannot be excluded.

Central and Southern Apennines

The siliciclastic succession known as Guadagnolo Formation or "Sabina Flysch" (Parotto and Praturlon, 1975) is characterized by its abundant content in siliceous sponges spicules. Thickness varies from few meters (Rocca di Cave, Opi) to several hundreds of meters (Tornimparte, Guadagnolo) and its age is Aquitanian-Serravallian (Carboni et al., 1982). The Guadagnolo Fm. deposits crop out in various localities around the Latium-Abruzzi carbonate platform (Fig. 4).

Spicules and small reticular fragments have been firstly described by Panseri (1952) from Langhian marls outcropping near Rocca di Cave, in the Prenestini Mountains. Matteucci (1979) and Carboni et al. (1982, 1992a, b) firstly described preserved rigid skeletons, coming from the thick sequence cropping out near Torninparte (L'Aquila). According to Civitelli et al. (1988), the Guadagnolo succession represents a ramp-deposit bordering the emerged, partly dismantled Latium-Abruzzi carbonate platform; these deposits connected the emerged area and its shallow water fringe with the surrounding basins. According Pomar et. al. (2004), the marls with planktonic foraminifera and siliceous sponge spicules sedimented in the distal outer part of a low-angle carbonate ramp occupied by the "Calcari a Briozoi e Litotamni" Fm. Taking into account the palinspastic reconstruction of the Central-Southern Apennine domain in Langhian times by Patacca and Scandone (2007), the location of the up to now known spiculitic deposits encircles the Simbruini-Matese and the Western Marsica platforms (Fig. 5).

The heavy mineral content found in the Guadagnolo deposits in the Tornimparte succession evidences a volcanoclastic contribution during the biosiliceous sedimentation and its similarity with the volcanoclastic content of the Bisciaro Fm. (Carboni et al., 1982).

Furthermore, Giattini (1909) pointed out the presence of siliceous sponges in the hemipelagic limestones cropping out in the S. Valentino basin, along the northeastern flank of the Maiella Mountain. The sponge-bearing level, Langhian-Serravallian in age according to Brimaud and Vachard (1986a, b), could correspond to one of the two drowning phases recognized in the Bolognano Fm., probably to the topmost one, characterized by abundant biogenic silica (Mutti et al., 1997). Finally, Carboni et al. (1992a, b) recorded the occurrence of siliceous spicules in the Upper Miocene transgressive deposits cropping out in the Aventino river valley (Abruzzo).

In the Southern Apennines (Fig. 4), spiculitic levels are known from the Lower Miocene Longano Formation (Accordi et al., 1967; Matteucci, pers. observations). Volcanoclastic levels are present in Lower Miocene sedimentary units in several localities (Beccaluva et al., 2004), often associated to siliceous spicules (Sgrosso, pers. com.).

Sardinia

Spiculitic rich levels are known at Funtanazza (southwestern Sardinia), where deep infralittoral deposits filling the lateral depressions related to the distensive tectonics generating the graben of Campidano crop out (Casula et al., 2001; Murru, pers. comm.) (Fig. 6). These Upper Aquitanian-Lower Burdigalian deposits, characterized by a very abundant volcanoclastic and terrigenous content, can be referred to the Arenarie di Gesturi Fm. (Cherchi, pers. comm.). In the Funtanazza outcrop only one specimen of *Laocoetis crassipes* Pomel has been found up to now (Comaschi Caria, 1962).

Pliocene

Only a few Lower Pliocene outcrops characterized by abundant spicules and rigid skeletons are known up to now. Malfatti (1885) recognized the outcrop near the village of Borzoli, a locality now completely included in the metropolitan area of Genoa; more recently, Bonci et al. (1993) found spicules in the Pliocene sediments (Argille di Ortovero Fm.) cropping out in the surroundings of the town.

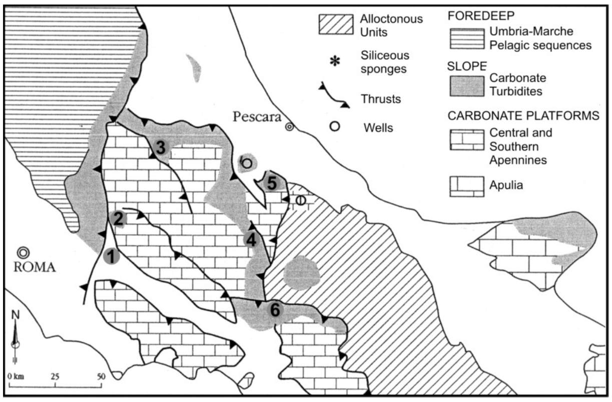

Fig. 4 - Geological sketch of central and southern Apennines, redrawn, simplified and modified from Bosellini (2004), and location of some siliceous sponges outcrops (1- Rocca di Cave; 2- Guadagnolo; 3- Tornimparte; 4- Opi; 5- S. Valentino; 6- Longano).

Mariani and Parona (1887) firstly recognized the siliceous sponge spicules in the Capo San Marco outcrop (Sinis peninsula), considered as Tortonian. Both outcrops, which contain spicules and rigid skeletons, are connected to the post-Messinian marine Atlantic transgression, referred to the lowermost Pliocene *Globorotalia margaritae* zone (Giammarino and Tedeschi, 1980 and Cherchi and Martini, 1981, for the Borzoli and the Capo San Marco outcrops respectively); both are characterized by a clayey sedimentation of circalittoral or deep infralittoral coastal environment. Furthermore, in Sardinia, a strong volcanic activity during the Pliocene is documented (Lustrino et al., 2000).

Finally, Lower Pliocene circalittoral marly sediments cropping out near Otranto (Salento Peninsola), are rich in siliceous spicules (Bossio et al., 1985) and reticular fragments (Matteucci, pers. observ.).

Pleistocene

Neviani (1905) recorded the occurrence of abundant tetractinellid spicules and rare reticular fragments in the Pleistocene sediments cropping out near the village of Carrubare in Calabria.

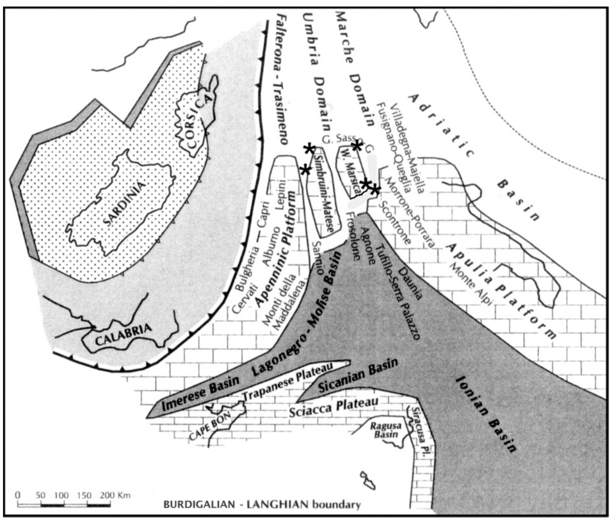

Fig. 5 - Palinspastic restoration of the Central-Southern Apennine domain at the Burdigalian-Langhian boundary, from Patacca and Scandone (2007), modified, with location of some siliceous sponges outcrops.

THE CENOZOIC TAXA

The recognized and erected genera and species, most of which have been neglected in the recent literature and considered as uncertain or unrecognizable in the different editions of the sponges volume of the Treatise on Invertebrate Paleontology (de Laubenfels, 1955; Finks et al., 2004), are here listed and discussed without a systematic revision. The Italian historical collections are being revised by the authors; here, the results of the study of the Catullo's collection are presented in the Appendix.

Eocene

Catullo (1856) erected five new species (*Scyphia compressa*, *Ierea lobata*, *Manon porosa, Cnemidium fungiforme, Siphonia quadrangula*). The first species has been ascribed by Catullo to the genus *Scyphia* Oken, which, according de Laubenfels (1955) and Rigby (2004) includes over 200 fossil inadequately documented or unrecognizable species. The second species has been included in the genus *Ierea* (= *Jerea* Lamoroux), a Jurassic-Cretaceous genus. The third and the fourth species have been assigned respectively to the genera *Manon* Oken and *Cnemidium* Goldfuss, two of the most commonly cited genus names in the nineteenth century, mainly for Cretaceous forms, which are now considered as unrecognizable (de Laubenfels, 1955; Rigby, 2004). The last species has been ascribed to the genus *Siphonia* Goldfuss, a Cretaceous (Aptian-Maastrichtian) genus; its extension to the Neogene of Italy is dubitatively recorded by Reid (2004a), probably on the basis of Manzoni's described and figured specimen (1882). The present authors consider that all the species recognized and erected by Catullo do not belong to the siliceous sponges (see Appendix).

Menin (1972) first found true siliceous sponge bodies in the Eocene deposits cropping out in the Chiampo valley (Vicenza), recognizing *Craticularia* Zittel (= *Laocoetis* Pomel), *Guettardia* Michelin (= *Guettardiscyphia* From.), *Siphonia* Goldfuss and *Jereica* Zittel. Matteucci and Russo (2005) reported a preliminary list of 13 genera (see Table I) and 23 species, 12 of which are in open nomenclature, collected in the same area studied by Menin (1972).

Miocene

Catullo (1856) erected the new species *quadricostata of* the genus *Halliroha* (*Hallirhoa* Lamoroux,1821*)* on a specimen reported as coming from Miocene levels cropping out near the town of Belluno. *Hallirhoa* is also a genus known from the Cretaceous (Reid, 2004a).

Mazzetti and Manzoni (1878) ascribed some cup fragments collected in the sediments from the hills near Montese (Modena) to the genus *Craticularia* Zittel, pointing out also its correspondence with *Laocoetis* Pomel, which Moret (1924) recognized to be its senior synonym; they also erroneously identified some skeletal basal fragments as belonging to *Chenendopora* Lamoroux.

In his paper on the skeletal framework of the siliceous sponges collected from the northern Apennines, Manzoni (1882) corrected the previous attribution of Mazzetti and Manzoni (1878) of some fragments to *Chenendopora* as root parts of *Craticularia*. Further, he recognized some other genera: *Tretostamnia* Pomel, synonym of *Stamnia* Pomel, an

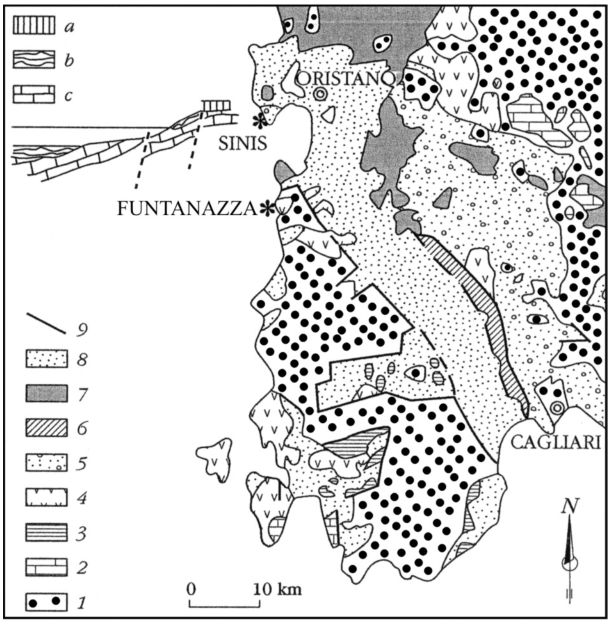

Fig. 6 - Location map of the Miocene and Pliocene rigid skeleton siliceous sponges in Sardinia. Geological sketch of southwestern Sardinia, redrawn, simplified and modified from Casula et al. (2001): 1) Paleozoic basement; 2) Permian to Mesozoic; 3) Paleocene-Eocene; 4) Oligo-Miocene volcanics; 5) Oligocene to Neogene deposits; 6) Pliocene continental deposits; 7) Plio-Quaternary volcanics; 8) Quaternary; 9) faults.
E-W section from the Sinis Peninsula, redrawn, simplified and modified from Lecca et al. (1986): a) basalts; b) Pliocene sediments; c) substrate.

unrecognizable genus in de Laubenfels, 1955, reported as a Cretaceous Lychnischosid in Reid (2004d); *Astrocladia* Zittel, *Siphonia* Parkinson, *Jerea* Lamoroux, *Meta* Pomel (objective synonym of *Stichophyma* Pomel, in Reid (2004d), and *Chenendopora* Lamoroux.

Malfatti (1901) described in detail the siliceous sponges from the northern Apennines. Among the Hexactinellida, he ascribed 5 species to *Craticularia* Zittel, three of which he considered as new species (*C. manzoni, C. emiliana, C. globularis*), whereas the other two have been identified as *C. radicosa* Pôcta and *C. patula* Pomel. Furthermore, he described *Verrucocoelia* Étallon and *Tremadyction* Zittel, which is considered as an objective synonym of *Cribrospongia* in Reid (2004c), and created the new genus and new species *Zittelospongia meandriformis.* Reid (2004c) records *Zittellospongia*, as in the first occurrence of the name (Malfatti, 1901), whereas de Laubenfels (1955) reported the locution *Zittelospongia*, as in all the other occurrences in the same Malfatti's paper (description and figures captions). The present authors consider the first spelling of the name as an imperfect name. The proposal by De Gregorio (1908) of a change of the name *Zittellospongia* in *Malfattispongia* is inappropriate. Among the Lithistida, Malfatti (1901) recognized *Hyalotragos* Zittel and *Cnemidiastrum* Zittel, two genera known only from pre-Cretaceous levels (Reid, 2004b).

Giattini (1909) first found siliceous sponges in the Central Apennines, with *Manzonia aprutina* n. gen., n. sp.

From the sediments cropping out near Torninparte (Aquila), Matteucci (1979) recognized *Laocaetes crassipes* Pomel, *Aphrocallistes* sp. and, doubtfully, *Discodermia* sp. and *Paschastrella* sp. Following Moret (1924), de Laubenfeld (1955) adopted the transcription *Laocaetes* instead of *Laocoetis*, the correct form.

Bonci et al. (1995, 1997) recognized *Geodia* by its typical sterrasters, from diatomaceous deposits of the Ligurian Piedmont basin.

Pliocene

Mariani and Parona (1887) and Canaveri (1910) described the spicules of siliceous sponges from the Capo S. Marco outcrop. Malfatti (1895) erected (and figured later, in 1901), *Craticularia razorei* n. sp., *Craticularia* sp. and *Donatispongia patellaris* n. gen., n. sp., from the Pliocene clayey sediments near Borzoli (Genoa). Matteucci (1989) found *Laocoetis crassipes* Pomel in the Pliocene outcrop of Capo S. Marco (Sardinia) and figured two thin sections of the skeleton of *Craticularia razorei*, stored in the Palaeontological Museum of Florence University; following Moret (1924), Malfatti's species is considered as a junior synonym of *Laocoetis crassipes* Pomel.

DISCUSSION

Up to now, in the Western Mediterranean area, siliceous sponges assemblages have been recognized in Eocene and Miocene of Spain and Algeria.

For the Eocene, Pisera and Busquets (2002) described from Spain (Ebro Valley, Catalonia) a rich assemblage, constituted of 16 genera of which 2 new (Tab. 1), and 16 species, of which 11 new.

As regards the Miocene, a rich Tortonian sponge fauna from southeastern Spain (Andalusia) has been studied by Ott d'Estevou and Termier (1978), Ott d'Estevou et al. (1981), and Brimaud and Vachard (1986a, b); the latter authors described numerous genera, 4 of which are new (Tab. 1) and 52 species, 18 of which are new. Van Kempen (1977) erected the new genus *Roepella.*

From Algeria, a very rich assemblage has been recognized by Pomel (1872) in the Miocene (Burdigalian?) of Oran area (Dj. Djambeida and Beni Bou Mileuk localities). Pomel (1872) described 33 genera, and 125 species, almost all considered as new taxa. The spongiofauna from Algeria has been studied again later by Zeise (1906), Moret (1924) and Moissette et al. (1984); Moret (1924) revised the taxa erected by Pomel (1872), retaining as valid only 19 genera (Tab. 1).

Whereas the Eocene fauna from Veneto recorded by Matteucci and Russo (2005) in their preliminary study is rich and diversified, and comparable to that almost coeval from Catalonia, the number of taxa up to now known from the Miocene of Italy is extremely scarce, if compared with the diversity and richness of the assemblages from Spain and Algeria. Besides, small Pliocene sponge faunas are known only from Sardinia and Liguria regions.

The Miocene siliceous sponges with rigid skeletons from the Apennines are mainly represented by *Laocoetis* and *Aphrocallistes*, the other up to now cited taxa being very rare and some of them doubtful. This contrasts with the high diversity of the Miocene rigid skeleton sponge assemblages from Algeria and, above all, Spain (Tab. 1); the Spanish assemblages include also *Laocoetis* and *Aphrocallistes* and originate from similar terrigenous slope deposits (Brimaud and Vachard, 1985). Moreover, abundant loose spicules from outcrops of the Central Apennines, most of which of tetractinellid type (Carboni et al. 1982, 1992a, b), indicate rich siliceous sponge assemblages with loose skeletons.

Even if the available inventory on the Miocene deposits of Apennines is still very incomplete, we observe that the Miocene of the Apennines spiculitic sequences contain abundant nodules and layers of chert. In the northern Apennines - whereas Malfatti (1901), who mentions nodules of chert together with rigid skeletons from Bologna deposits, remarks that none of the nodules preserve skeletal traces - siliceous sponges from the Modena hills, which are preserved in calcite, often contain inner parts completely made up of chert. In the Central Apennines sometimes a relationship between partially dissolved skeletons and surrounding chert nodules can be observed. Dissolution and precipitation in situ of skeletal silica could, at least in part, explain the low diversity observed up to now. Contemporaneous *in situ* dissolution and precipitation processes have been evidenced by Brachert (1987) in Pleistocene deposits of the Thyrrenian Sea. Moreover, the Miocene biosiliceous slope deposits of the Apennines are characterized by a strong terrigenous input, either coarse or very fine, perhaps promoting the extraordinary development of the two dominant taxa. As evidenced by Brimaud and Vachard (1986a, b) and Carboni et al. (1992a, b), *Laocoetis* has a robust structure and a developed radical apparatus for living on high-energy substrates, whereas recent *Aphrocallistes,* an ubiquitous sponge (Reiswig, 2002), thrives in calm waters (Krautter et al., 2001; Conway et al., 2004). Living *Laocoetis* up to now has been found only in the western Indian Ocean, from a depth of 250-750 m (Lévi, 1986).

CONCLUSIONS

Data on Cenozoic siliceous sponges with rigid skeleton from Italy are still largely insufficient to support reliableconclusions on their assemblage composition, distribution and ecology; new findings and accurate systematic revisions are necessary. The up to now scarce knowledge of Cenozoic siliceous sponges will highly benefit from new findings, as evidenced by the stratigraphic record of *Laocoetis* genus, considered extinct at the end of the Messinian (Ott D'Estevou et al., 1981), but found in the Lower Pliocene in Italy (Malfatti, 1901; Matteucci, 1989) and living in the Indian Ocean (Lévi, 1986).

Nevertheless, the available data on the Cenozoic siliceous sponges with rigid skeleton from Italy, allow us to draw some conclusions, as follows:

a) in the Cenozoic of Italy, the development of communities of siliceous sponges with rigid skeleton occurred in different paleoenvironmental settings: 1) shallow-water carbonate platform in the Veneto shelf, in the Eocene; 2) slope or ramp of piggy-back and foredeep basins, with a strong terrigenous input in the Apennine domain, in the Miocene; 3) infra-circalittoral environment with terrigenous sedimentation, in the Miocene of Sardinia and in other Pliocene localities;

b) all siliceous sponges deposits (except in the Pliocene of the Salento Peninsula) are characterized by a volcanoclastic content, due to a contemporaneous volcanic activity; according to Lustrino and Wilson (2007), a widespread magmatism developed within the circum-Mediterranean province during the whole Cenozoic timespan.

c) the siliceous sponge-bearing deposits extensively developed in the whole Apennines belt in Lower Miocene times (Upper Aquitanian-Lower Burdigalian). The "siliceous zone" of Amorosi et al. (1995) can be extended to the Central Apennines (Fig. 7).

d) the Miocene low-diversity assemblages of rigid skeletal sponges from Italy, as results from the available knowledge,

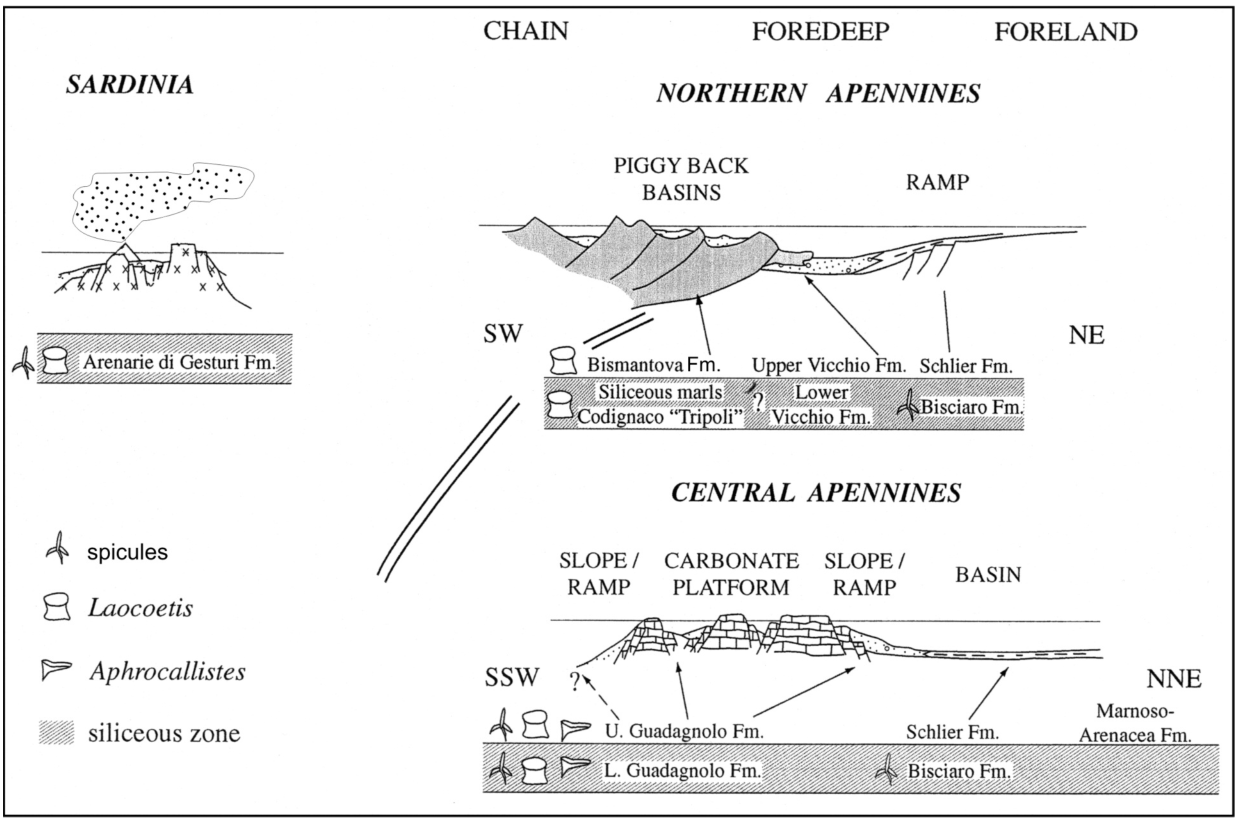

Fig. 7 - Cross-sections of the northern Apennines (after Campos Venuti et al., 1997, redrawn, simplified and modified), the central Apennines and Sardinia, showing the extension of the biosiliceous deposits during the Lower-Middle Miocene ("Siliceous zone" of Amorosi et al., 1995).

can be ascribed, at least in part, to particular environmental conditions (coarse substrates for assemblages rich in *Laocoetis*; calm environments with strong turbidity for assemblages rich in *Aphrocallistes*).
e) the Pliocene siliceous sponge assemblages from Italy are, up to now, the only ones known in the fossil record.

APPENDIX

The Catullo Collection

The fossil collection of invertebrates from Mesozoic and Cenozoic levels of northeastern Italy described by Catullo (1856) is deposited in the Geological and Paleontological Museum of the University of Padua. We have examined some of the specimens of the collection which are referred by Catullo to Cretaceous, Eocene and Miocene siliceous sponges; most of them are figured in the original paper, others are referred to sponges in the original labels of the specimens.

The examined material consists of 15 isolated specimens, of which:
- one specimen (Pl. 1, Fig. 7; Pl. 2, Fig. 1a, b) - collection number: 8185C; cited provenience: S. Trintità on the label; Montecchio Maggiore in the text; figured in Catullo (1856) in tav. XVIII, Fig. 7A, B, attributed to *Sciphia compressa* n. sp.
- one specimen (Pl. 1, Fig. 8; Pl. 2, Fig. 3a, b) - collection number: 8186C; cited provenience: M. Luzziano in the label; Monte Lupiaro (Castelgomberto) in the text; figured in Catullo (1856), Tav. XVIII, Fig. 8, attributed to *Jerea lobata* n. sp.
- one specimen (Pl. 1, Fig. 16; Pl. 2, Fig. 8) - collection number: 8220C; provenience: M. Berici; figured in Catullo (1856), Tav. XIX, Fig. 16, attributed to *Cnemidium fungiformis* n. sp.
- one specimen (Pl. 1, Fig. 9; Pl. 2, Fig. 7a,b) - collection number: 8188C: provenience: Monteviale in the label; Sette Comuni? in the text; figured in Catullo (1856), Tav. XVIII, Fig. 9, A, B, attributed to *Halliroha infundibuliformis* n. sp.
- four specimens - collection numbers: 7319, 7324, 7318, 7323; provenience: Sette Comuni; specimen n. 7318 (Pl. 1, Fig. 14; Pl. 2, Fig. 5) is figured in Catullo (1856), Tav. XIX, Fig. 14 and attributed to *Siphonia tetragona* n. sp.; on the specimen label, the reported name is *Siphonia triangula*; one specimen (collection number 7319) is figured in Pl. 2, Fig. 6.
- one specimen (Pl. 1, Fig. 12; Pl. 2, Fig. 4a, b) - collection number n. 8218; provenience: Novale, near Valdagno; figured in Catullo (1856), Tav. XIX, Fig. 12 A, B, attributed to *Siphonia pyriformis* Goldfuss.
- six specimens - collection numbers: 7314-15, 7316, 7322; cited provenience: Crosara; Sette Comuni) attributed on the label to *Alcyionium*. One specimen (collection number 7314 or 7315) is figured in Pl. 2, Fig. 2.

The examination of the skeletal structure of the specimens revealed, for some of them (those attributed to *Scyphia*, *Jerea*, *Halliroha*, *Cnemidium* and *Siphonia pyriforms* Goldfuss) the presence of a coralline colonial architecture, with recognizable radially septate corallites, for the others, referred to *Siphonia quadrangula* and *Siphonia triangula* and *Alcyonium* (on the labels), the complete lack of a skeletal structure and a microcrystalline siliceous texture. Some of latter specimens (*Alcyonum*) exhibit a more or less elongated cylindrical feature, with a thick wall around a more or less ramiform axial medullary part, others (*Siphonia triangula*) a subtriangular outline. The inner channels seem mainly due to incomplete silicization. The morphology of the specimens reminds that of a thalassinoid ichnofossil.

All the determinations as siliceous sponges of the specimens of the Catullo collection have to be considered erroneous; in detail:
- the specimen attributed to *Scyphia compressa* is a scleractinian colony referable to the genus *Placosmiliopsis* Beauvais (Pl. 2, Fig. 1a, b);
- the specimen attributed to *Jerea lobata* is a scleractinian colony referable to the genus *Actinacis* d'Orbigny (Pl. 2, Fig. 3a, b);
- the specimen attributed to *Cnemidium fungiformis* is a scleractinian colony referable to the genus "*Cyathoseris*" Milne Edwards (Pl. 2, Fig. 8);
- the specimen attributed to *Halliroha infundibuliformis* is a scleractinian colony referable to the genus *Astrocoenia* Milne Edwards and Haime (Pl. 2, Fig. 7a, b).
- the specimen attributed to *Siphonia tetragona* and the other named *Siphonia triangula* on the label are referable to silicized nodules, probably derived from thalassinoidal traces (Pl. 2, Figs. 5, 6);
- the specimen attributed to *Siphonia pyriformis* Goldfuss is a scleractinian colony referable to the genus *Actinacis* d'Orbigny (Pl. 2, Fig. 4a, b);
- the other specimens, attributed to *Alcyonium* (on the labels) are referable to silicized nodules, probably derived from thalassinoid traces (Pl. 2, Fig. 2).

In conclusion, these species recognized and erected as siliceous sponges are not sponges.

We have been unable to examine the specimens referred by Catullo to his new species *Halliroha quadricostata* (Pl. 1, Fig. 10) - provenience: vicinity of Belluno; age: Miocene; figured in Catullo, (1856, tav. XVIII, fig. 10); *Manon porosa* (Pl. 1, Fig. 14 A, B - provenience: Montecchio Maggiore; age: Cretaceous; figured in Catullo (1856, Tav. XVIII, Fig. 11); *Siphonia subfusiformis* (Pl. 1, Fig. 13 - provenience: Conco, Vicentino; age: Cretaceous; figured in Catullo (1856, Tav. XIX, Fig. 13); *Ventriculites biosculata* (Pl. 1, Fig. 15) - provenience: Pinè dell'Alpago, Belluno; age: Cretaceous; figured in Catullo (1856, Tav. XIX, Fig. 15). Figures and descriptions of these specimens allow us to consider their attribution to sponges by Catullo as erroneous, as for the other specimens preserved in the collection.

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		Cretaceous	Eocene		Miocene			Pliocene	Recent
			Spain	Italy	Spain	Italy	Algeria	Italy	
Halicondrida	*Roepella* Van Kempem				X				
Lyssacinosa	*Regadrella* Schmidt	X	X		X				X
	Reguantella Pisera & Busq.		X						
Hexactinosa	*Tremadictyon* Zittel	X				?X			
	Pleuroguettardia Reid	X	X	X					
	Guettardiscyphia From.	X	X	X					
	Verrucocoelia E'tallon	X				X			
	Pleurostoma	X					X		
	Laocoetis Pomel	X	X	X	X	X	X	X	X
	Eurete Semper	X	X	X	X				X
	Aphrocallistes Gray	X	X		X	X	X		X
	Hexactinella Carter	X	X		X				X
	Lefroyella Thomson	X			X		X		X
	Myliusia Gray	X			X				X
	Paracraticularia Schramm.			X					
	Dactylocalyx Stutchb.				X				X
	Sclerothamnopsis Wilson				X				
	Ramalmerina Brim. & Vach.				X				
	Zittelospongia Malfatti					X			
	Placochlaenia Pomel						X		
Lychniscosa	*Ventriculites* Mantell	X	X						
	Rhizocheton Lachasse	X	X	X					
	Callicylix Schramm.	X	X	X					
	Centrosia Schramm.	X	X	X					
	Brachiolites Smith	X	X	X					
	Becksia Schl ter	X		X					
	Manzonia Giattini				X	X			
	Tretostamnia Pomel					X	X		
Ancorinida	*Geodia* Schmidt				X	X			
Protomonaxonida	*Opetionella* Zittel		X						
Pachastrellida	*Pachastrella* Schmidt	X				X	X		X
Haplosclerida	*Propetrosia* Pisera & Busq.		X						
Tetralithistida	*Discodermia* Bocage	X		X	X				
	Phyllodermia Schramm.	X			X				
	Chenendopora Lamx.	X			X	X			
	Siphonia Park.	X				X			
	Astrocladia Zittel	X				X			
	Jerea Lamx.	X				X			
	Pliegatella Brim. & Vach.				X				
	Corallistes Schmidts						X		X
Megalithistida	*Pleroma* Sollas				X				
	Doryderma Zittel				X				X
Monalithistida	*Chonella* Zittel	X		X					
	Jereopsis Pomel	X			X				
	Cnemaulax Pomel	X			X				
	Pliobolia Pomel	X	X	X			X		
	Cucumaltina Brim. & Vach.	X			X		X		
	Trachydictya Pomel	X			X		X		
	Stichophyma Pomel	X				X	X		
	Seliscothon Zittel	X					X		
	Jereica Zittel	X					X		
	Coscinostoma Zittel	X					X		
	Phlyctia Pomel	X			X		X	?X	
	Plioboliopsis Brim. & Vach.	X			X	X	X		X
	Cnemidiastrum Zittel				X				
	Astrobolia Zittel					?X	X		
	Verruculina Pomel						X		X
unrecogn. genera	*Donatispongia* Malfatti							X	

Tab. 1 - Cenozoic siliceous sponge genera recognized in the Western Mediterranean area (from various sources, unrevised). For the Algerian sponges, the genera revised by Moret (1924) are listed; from Italy, the genera cited in Catullo (1856) are excluded. Cretaceous and Recent records after Finks et al. (2004).

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