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HETTANGIAN AMMONITES AND RADIOLARIANS IN THE MT. CAMICIA (GRAN SASSO, CENTRAL APENNINES)

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Abstract. The Vallone di Vradda stratigraphic section is situated in the eastern part of the Gran Sasso range and shows the transition from Late Triassic euxinic facies to Early Liassic open pelagic facies. This paper describes Middle and Late Hettangian ammonite and radiolarian assemblages found in the upper part of the succession. The existence of an anoxic event below the Middle Hettangian beds is noted. Assemblages of small-sized Middle Hettangian ammonites suggest some taxonomic innovation within the early Lytoceratina: gen. n. (Pleuroacanthitidae) and *Analytoceras* n. sp. indet. Radiolarians found together with ammonites improve the knowledge of Hettangian radiolarian assemblages of the western Tethys.

Riassunto. È brevemente descritta la successione del Vallone di Vradda (parte orientale della catena del Gran Sasso) che contiene facies da euxiniche a bacinali aperte, riferibili all'intervallo Trias superiore - Lias inferiore. La parte principale del lavoro è dedicata alla descrizione delle ricche associazioni ad ammoniti e radiolari dell'Hettangiano medio e superiore, trovate nella parte alta di questa successione. Un evento anossico è segnalato sotto gli strati dell'Hettangiano medio. Le associazioni a piccole ammoniti dell'Hettangiano medio suggeriscono alcune novità tassonomiche nel campo delle Lytoceratina primitive: gen. n. (Pleuroacanthitidae) e *Analytoceras* n. sp. indet. I radiolari trovati insieme agli ammoniti permettono di migliorare le conoscenze sulle associazioni a radiolari hettangiani della Tetide occidentale.

Introduction

The Gran Sasso thrust belt is made up of an imbricate stack of tectonic elements, the number and boundaries of which change according to the interpretation of different authors (Adamoli et al. 1981b, 1990; Ghisetti & Vezzani, 1986). This thrust belt shows facies variations from South to North since the Middle Liassic and from East to West during the Late Triassic - Early Liassic. The first trend defines the transition between the Latium-Abruzzi Carbonate Platform (to the south) and the Tuscany-Umbria-Marche Basin (to the north) which was connected during the Jurassic with the Liguria-Piedmont Ocean. The second trend records the existence of early euxinic basins and sea-ways probably loosely connected, but genetically related, with the Late Triassic - Jurassic Lagonegro Basin of the Southern Apennines (Ciarapica & Passeri 1998, 2002). The Late Triassic - Early Liassic facies of the Gran Sasso range are referable to a carbonate platform environment in the western part (Corno Grande area) and to an euxinic-to-open pelagic basin in the eastern part (Mt. Camicia area).

The Corno Grande area is characterized by the Dolomia Principale Formation in the Late Triassic and by the Calcare Massiccio Fm. in the Early Liassic. Both formations show sedimentary cycles with repeated emersion surfaces. The Dolomia Principale contains massive beds, often with megalodontids, and stromatolitic layers with fenestrae; the Calcare Massiccio is mainly composed of massive beds often separated by layers with vadose pisoids (Alessandri et al. 1968; Adamoli et al. 1978; Bigozzi 1990). The transition between Dolomia Principale and Calcare Massiccio, visible along the SE wall of the Corno Grande below the Bafile hut, is affected by late diagenetic coarse-crystalline dolomitization. The Calcare Massiccio is overlain by Middle and Late Liassic open marine facies (Corniola and Verde Ammonitico) formations of the Tuscany-Umbria-Marche Basin.

Late Triassic - Early Liassic facies in the Mt. Camicia area are represented by bituminous layers, dolos-

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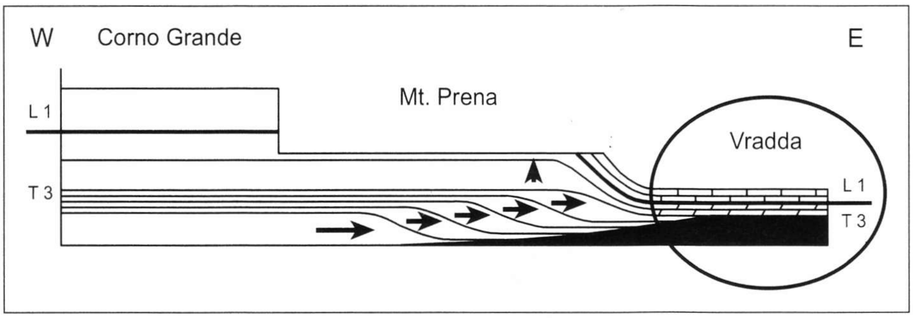


Fig. 1 - Relationships between the Corno Grande carbonate platform and the Vradda basin (western and eastern part of the Gran Sasso range) during the Late Triassic and Early Liassic; the upper part of Mt. Prena succession is missing for erosion (after Bigozzi et al. 1991, modified). T_3 = Late Triassic, L_1 =Early Liassic.

tones, nodular limestones and cherty limestones; these lithofacies are referred to a basinal environment evolving from euxinic to open marine conditions (Adamoli et al., 1981a, 1984, 1990; Ciarapica 1990; Bigozzi et al. 1991; Damiani et al. 1991).

The lateral transition from the Late Triassic Dolomia Principale platform facies of the Corno Grande toward the Mt. Camicia euxinic basinal facies occurs by means of massive coarse-crystalline dolostones prograding on the bituminous dolostones; the massive dolostones contain rare forams, algae and ghosts of encrusting organisms; the presence of storm-layers in the bituminous dolostones suggest the existence of a carbonate ramp. The Early Liassic part of this transition is not visible (Fig. 1).

The Vradda section (Mt. Camicia area)

This stratigraphic section was sampled along the Vallone di Vradda and on the western side of Mt. Tremoggia (Figs. 2, 3). It is characterized by the following lithological intervals (Fig. 4): 1) bituminous dolostones and bituminous layers (Bituminous dolostones fm.); 2) thin bedded dolostones (Vradda dolostones fm.); 3) nodular and spotted limestones (Spotted limestones fm.); 4) micrite

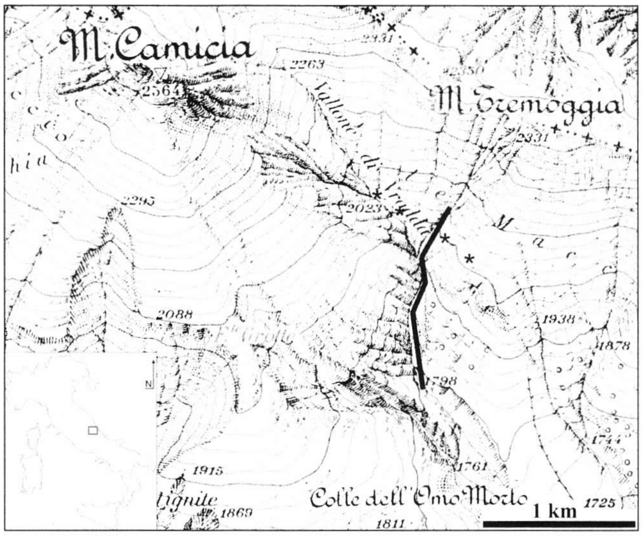


Fig. 2 - Topographic map of the Mt. Camicia area: the Vradda section is marked by a black line; the Ammonitic beds are indicated by small asterisks (Istituto Geografico Militare - Aut.ne n. 5733 of the 17.04.03).

and calcarenites with ammonites (Ammonitic beds fm.); 5) cherty limestones (Corniola Fm.).

1) Bituminous dolostones (Scisti bituminosi, Dolomie bituminose) - The most typical lithofacies are black and white rhythmites in very thin laminas of carbonate and organic matter; this lithofacies irregularly alternates with massive dolostones. The Bituminous dolostones show synsedimentary microfaults, convolute laminations, slumping and various kinds of synsedimentary angular bituminous breccias; these structures are related to compaction, fluids escape and gravity movements. Asymmetrical ripples, with a short wave length, were observed at one level (in the lower part) and cross laminations are uncommon. Some small parts of the Bituminous dolostones are silicified and the silicification occurred before the last generation of coarse-crystalline dolomite.

The entire section is strongly tectonized making it difficult to distinguish the primary sedimentary structures from the tectonic ones; the thickest dolostone beds (many dm) have a brittle behaviour and are often cataclastic, while the thin-bedded bituminous rhythmites were plastically deformed and sometimes stretched in boudins.

The paleontological content is very poor, only some ostracods, thin-shelled pelecypods and few forams (*Glomospirella* sp.) were found. This lithofacies is referred to the Late Triassic mainly on the basis of palynomorphs reported in Adamoli et al. (1990) and Damiani et al. (1991) (*Corollina classoides* Pflug, *C. meyeriana* Klaus, *Corollina* sp., *Duplicisporites granulatus* Leschik, *Duplicisporites* sp., *Praecirculina granifer* Leschik, *Praecirculina* sp.).

The Bituminous dolostones are visible for a thickness of 180 m, true thickness is unknown because they overthrusted the younger formations of the Corniola and Verde Ammonitico.

2) Vradda dolostones - Thin-bedded, fine-grained dolostones, lacking bituminous layers and with cherty nodules. The upper part is cataclastic. Thickness is around 110 m.

3) Spotted limestones (Calcari maculati) - They are characterized by the presence of mottled and nodular pink limestones and show some thickening upward cycles (30-50 m thick). These strata are

Fig. 3 - Panoramic view of the southern side of Mt. Camicia and Mt. Tremoggia: the Vradda section is marked by a white line.

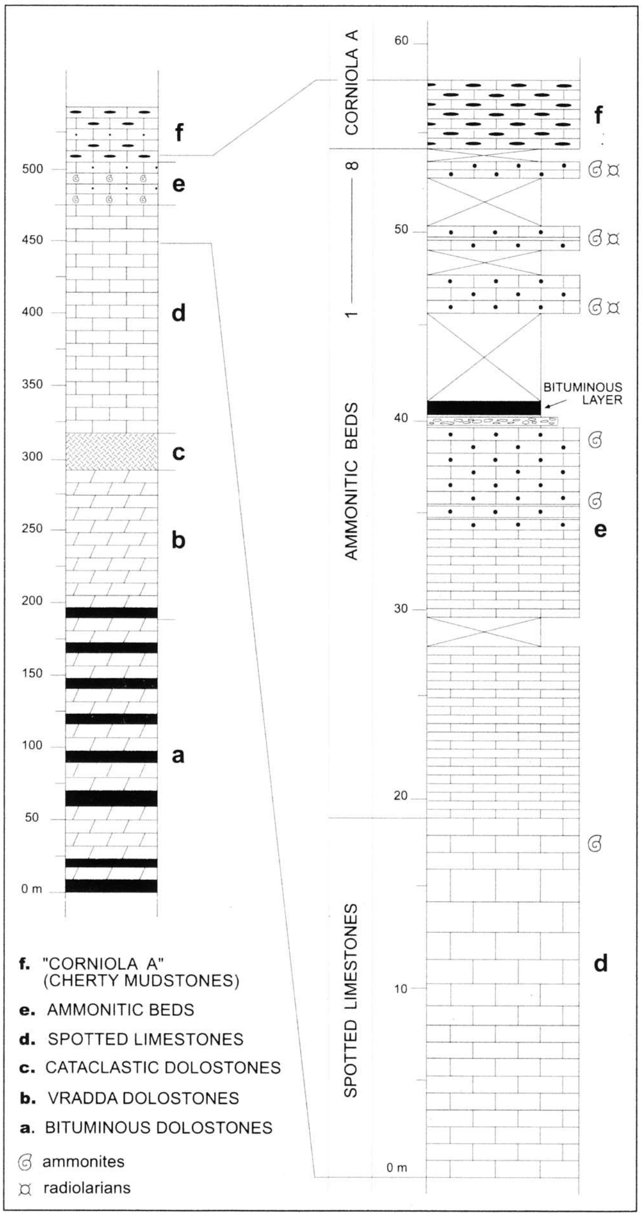


Fig. 4 - The Vradda stratigraphic section and detail of the transition from the Spotted Limestone to the Corniola fm.; 1-8: ammonitic horizons illustrated in Fig. 5.

wackestone and packstone with pellets, coated grains, echinoid plates and rare forams; the upper part contains radiolarians, sponge spicules, algae such as *Thaumatoporella parvovesiculifera* (Raineri) and forams (*Siphonovalvulina* sp. and Nodosariidae). The thickness of the Spotted limestones reaches 160 m.

4) **Ammonitic beds** - They are typically represented by thin-bedded micrites and calcarenites with even lamina, thin beds of chert and ammonites of Middle and Late Hettangian age. Ammonitic beds crop out along the western side of Mt. Tremoggia and are marked by a characteristic grassy ledge between the cliffs of Spotted limestones and cherty limestones of the Corniola fm.

Along the sampled section the Spotted limestones are overlain by: a) thin bedded limestones (17 m) made up of packstone, wackestone and mudstone containing pellets, thin-shelled pelecypods, echinoid plates, sponge spicules, radiolarians and some forams (Textulariidae); b) thin bedded calcarenites (6 m) with yellow and grey beds; c) a thin level (10 cm) of pebbly mudstone with encrusting forams (*Tolypammina*); d) a black bed of felted organic matter ("bituminous layer", 40 cm); e) thin-bedded calcarenites and micrites (14 m) with many levels containing small-sized, silicified ammonites (Ammonitic beds s.s.).

Intervals c, d, e are somewhat weathered and often covered by detritus. The detailed stratigraphic log of the ammonitic levels (Fig. 5) was achieved by combination of several short sections cropping out in different gullies along the western side of Mt. Tremoggia.

5) **Corniola** – The lower part of this formation (Corniola A) is a well-bedded cherty mudstones, similar to the typical Corniola Fm., but devoid of calcirudites and calcarenites. Corniola A overlies the Ammonitic beds; a double system of faults, marked by cataclastic dolostones, separates these cherty limestones from the typical Corniola Fm. cropping out up to the Mt. Tremoggia ridge.

Ammonites of the Vradda section

Several levels with small, silicified ammonites were found in the Ammonitic beds; the specimens lie on the bedding plane, do not show sutures and probably preserve part of their original shell. Four lithologic discontinuous ammonite-bearing intervals were identified in different gullies, separated by detritic and grassy areas (Fig. 5).

The first interval (1 m) lacks ammonites, but contains a characteristic black bed of felted organic matter.

The second interval contains six horizons with ammonites (Fig. 5):

- horizon 1 contains very small specimens (few mm diameter) of gen. indet. cf. *Protocymbites*; Middle Hettangian;

- horizon 2 (2 m above) contains many specimens, almost 1 cm large, of two species: gen. n. (Pleuroacanthitidae) and *Discamphiceras* sp. indet.; the first one is dominant; Middle Hettangian;

- horizon 3 (40 cm above) contains small specimens of gen. indet. (Pleuroacanthitidae), *Kammerkarites* sp. indet. and an indeterminate genus of Schlotheimiidae; *Kammerkarites* is the most common; Middle Hettangian;

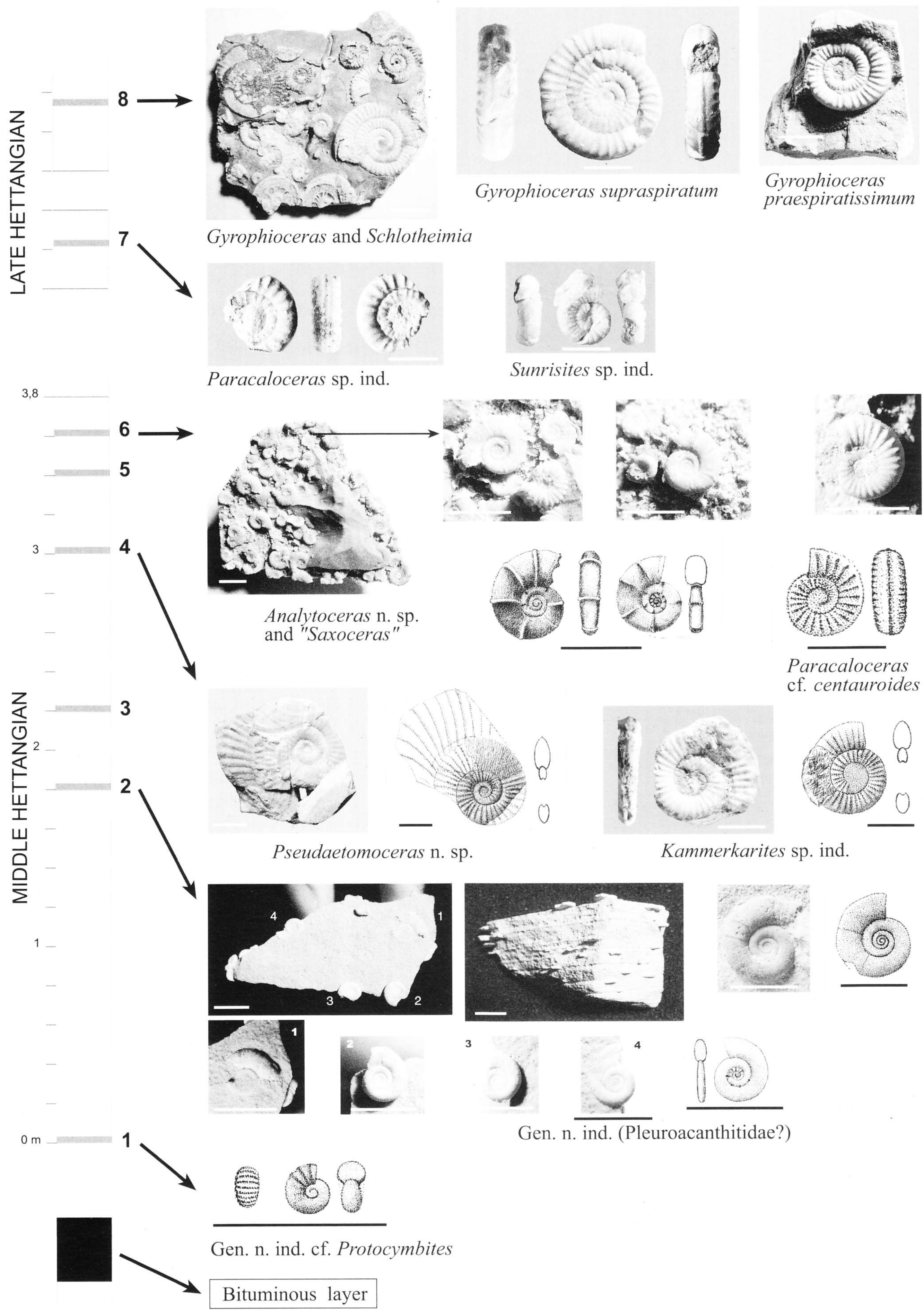
- horizon 4 contains many larger specimens, mostly *Kammerkarites* sp. indet. and *Pseudoaetomoceras* sp. indet. and a gen. indet. of Schlotheimiidae; this assemblage can be assigned to both the Middle and Late Hettangian;

- horizon 5 contains small and medium-sized specimens of *Schlotheimia* sp. indet.; Middle or Late Hettangian;

- horizon 6 shows dominant *Analytoceras* n. sp., fewer *Discamphiceras* sp. indet. and rare *Paracaloceras* cf. *centauroides* (Savi & Meneghini, 1851). Specimens of *Analytoceras* n. sp. are very different from the species of this genus described by Wähner (1894); Middle or Late Hettangian.

The third interval (horizon 7) contains two species: *Sunrisites* sp. indet. and *Paracaloceras* sp. indet.; it is probably referable to the Late Hettangian.

The fourth interval (horizon 8) contains dominant *Gyrophioceras*, some *Schlotheimia* sp. indet. and rare *Kammerkaroceras*? sp. indet.; it is assigned to the Late Hettangian.


LATE HETTANGIAN
MIDDLE HETTANGIAN
8
7
3,8
6
5
3
4
3
2
2
1
0 m
1
Gyrophioceras and Schlotheimia
Gyrophioceras supraspiratum
Gyrophioceras praespiratissimum
Paracaloceras sp. ind.
Sunrisites sp. ind.
Analytoceras n. sp. and "Saxoceras"
Paracaloceras cf. centauroides
Pseudaetomoceras n. sp.
Kammerkarites sp. ind.
Gen. n. ind. (Pleuroacanthitidae?)
Gen. n. ind. cf. Protocymbites
Bituminous layer

Features of the Vradda ammonites (in stratigraphic order)

Gen. n. cf. *Protocymbites* sp. indet. (horizon 1) - It has been identified for the typical subglobular conch, but is different from *Protocymbites* because of the large ribs that cross the venter without interruption (in *Protocymbites* the venter is smooth).

Gen. n. indet. (Pleuroacanthitidae) (horizon 2, 3) - This genus has been referred to the Pleuroacanthitidae for the presence of ventrolateral parabolic nodes in the inner whorl at the end of the ribs; coiling is similar to the one of the Pleuroacanthitidae, but the conch is more compressed.

Kammerkarites sp. indet. (horizon 3) - The specimens are characterized by evolute coiling, a compressed whorl, rectiradiate ribs and by a subrounded venter without keel.

Gen. indet. (Schlotheimiidae) sp. indet. (horizons 3, 4, 5, 6) - They are strongly ribbed with ventral groove or smooth band. The specimens have varying compressed conches and varied strong ribs; some can be referred to the genus *Schlotheimia*.

Pseudoaetomoceras sp. indet. (horizon 4) - Only one specimen was found; ribs are similar to those of *Kammerkarites*, but the conch is very involute (mainly on the inner whorl) and the venter is sharp. The inner whorls of this specimen are smooth up to a diameter of 9 mm.
Analytoceras sp. n. indet. (horizon 6) - The attribution to this genus is due to the presence of conspicuous parabolic nodes on the inner whorls.

Discamphiceras spp. indet. (horizons 4, 6) - Specimens are very small but recognizable for the subglobular conch with involute coiling in the inner whorls. Some specimens have ribs on the whorl sides with large and smooth venter, others are completely smooth.

Schlotheimia sp. indet. (horizons 6, 8) - It is recognized by compressed conch and ribs interrupted by ventral groove; ribs are less strong than in other genera of Schlotheimiidae.

Sunrisites sp. indet. (horizon 7) - Some specimens have been referred to this genus for the intermediate involute conch, the round section of the whorl, ribs developed only on the sides and the large and smooth venter. One strongly ribbed specimen can be referred to *Sunrisites sunrisensis* Guex (type species of the genus; Guex, 1995).

Paracaloceras spp. indet. (horizons 6, 7) - Specimens small; recognized by the intermediate evolute conch, depressed whorl, ribs only on the sides, smooth venter and blunt keel.

Fig. 5 - Four lithologic intervals corresponding to a part of the Ammonitic beds of Fig. 4. Only the most abundant species are illustrated. Length of scale bars = 1 cm.

Gyrophioceras supraspiratum Wähner 1885 and *G. praespiratissimus* Wähner 1887 (horizon 8) - This genus was distinguished from *Vermiceras* by Bloos (1994, 1996); it was recognized by the very evolute conch, subrounded section of the whorl, absence of ventral grooves and blunt keel; rectiradiate and strong ribs terminate or become very feeble on the venter. Inner whorls of the Vradda specimens are smooth, while Wähner's specimens are ribbed.

Kammerkaroceras? sp. indet. (horizon 8) - The identification of these specimens is uncertain because the ribs are numerous, dense and cross the venter.

Hettangian ammonites in Italy and in the Austrian Alps

Important contributions to the knowledge of the Hettangian ammonites of the Tethys are due to Wähner (1882 - 1898) who documented Middle and Late Hettangian and Early Sinemurian in the condensed cephalopod limestones of the basal Lias (Northern Calcareous Alps, Austria). Later the same succession was studied by Dommergues et al. (1995) who documented the presence of hiatuses in the Hettangian *Schlotheimia marmorea* Zone.

Hettangian ammonites coming from the La Spezia area (Northern Apennines) were first described by Canavari (1882, 1888) who ascribed them to Early Liassic in general. Later other ammonites coming from the same succession and preserved in the Palaeontological Museum of Bologna University (Capellini collection), were revised by Venturi (1985) who suggested the presence of the Late Hettangian and Early Sinemurian.

Cantaluppi & Lualdi (1983) studied the Early Liassic in the Ligurian Alps finding a large hiatus between the Early Hettangian and the Early Sinemurian.

Gaetani (1970) contributed to the knowledge of Hettangian ammonites with a study on Sedrina Limestone (Bergamo area, Lombardian Basin, Italy) where the described ammonites are considered Late Hettangian in age (gen. *Schlotheimia*).

Adamoli et al. (1990) described the succession of Vradda where, at that time, only a few ammonitic levels had been found (belonging exclusively to the *Gyrophioceras* horizon). During this new research more levels were documented and at present the Vradda section appears to be the most complete Italian stratigraphic succession of Hettangian ammonites.

Radiolarian fauna

The most important papers on Hettangian radiolarians are by Pessagno et al. (1987) who made a preliminary radiolarian zonation for the Jurassic of North America; Carter, Whalen & Guex (1998) who proposed a more detailed zonation of Hettangian and Sinemurian radiolarians of Queen Charlotte Island, British Columbia, defined by Unitary Associations (UA; Guex, 1977); Hori (1990) who proposed a radiolarian zonation for the Lower Jurassic of SW Japan. Other authors, as Dumitrica (1970, 1985, 1995), De Wever (1982), Matsuoka & Yao (1986), Takemura (1986), Kozur & Mostler (1990), Gorican (1994), Sugiyama (1997), Yeh & Cheng (1998) and Tekin (2002) have given valuable contributions to the systematics of the Early Jurassic (mainly Hettangian and Sinemurian) radiolarians.

The Ammonitic beds of the Vradda section are rich in ammonites and radiolarians. Many radiolarians are calcified. However, well-preserved faunas with siliceous tests have been found in two out of the eight horizons sampled. This is the first time that well preserved radiolarians and ammonites have been found together in the Hettangian of the western Tethys. Preservation of the radiolarians is generally excellent. The specimens are very fragile, with well defined meshwork: most are entire, others have fragile spines, sometimes broken. These assemblages are rich in spherical and irregularly spinose forms, often with tubercles.

The lowest level containing siliceous radiolarians occurs in the second ammonitic horizon (with Pleuroacanthitidae and *Discamphiceras* – Middle Hettangian): these radiolarians are less well preserved then those in the higher level. The second level rich in radiolarians is horizon 7, which contains *Sunrisites* and *Paracaloceras* and could be referred to the Late Hettangian.

Spumellarians dominate in both Middle and Late Hettangian assemblages. Diversity is low, but increases in the Late Hettangian. Spherical Spumellarians with strongly raised nodes (similar to the genus *Praeconocaryomma* Pessagno) are the most abundant in both levels.

The first level with siliceous radiolarians (horizon 2 – Middle Hettangian) presents an assemblage (Fig. 6, 22-25) with many specimens of Spumellaria gen. et sp. indet. (most are similar to *Praeconocaryomma* genus and others to Spum. gen. et sp. indet A) and with the genera *Charlottea* Whalen & Carter; *Archaeocenosphaera* Pessagno & Yang, *Thurstonia* Whalen & Carter, and a few indeterminate Nassellaria.

The second level (horizon 7 – Late Hettangian) presents a very rich assemblage (Fig. 6, 1-21) with several genera (in decreasing order of abundance): dominant Spumellaria gen. et sp. indet. (as in the first level); *Thurstonia* Whalen & Carter, *Amuria* Whalen & Carter, *Kungalaria* Whalen & Carter, *Charlottea* Whalen & Carter; rare *Pantanellium* Pessagno & Blome, *Paronaella* Pessagno, *Crucella* Pessagno, *Udalia* Whalen & Carter; very rare *Anaticapitula* Dumitrica & Zügel, *Bipedis* De Wever and *Farcus* Pessagno, Whalen & Yeh. Their study is still in progress.

Conclusions

The Vradda section shows the transition from euxinic to open-marine facies. Hettangian ammonites in the upper part of this section confirm the existence of a marine trough running to the east of the Calcare Massiccio carbonate platform older than the post-Hettangian Tuscany-Umbria-Marche pelagic basin. Drill cores in the Adriatic off-shore indicate this trough was probably connected with the Emma basin.

The presence of two oligotypic assemblages of small-sized Ammonites (horizons 2 and 6) suggests the existence of a partially isolated basin during the transition from the Late Triassic euxinic environment to open-marine conditions in the Middle Liassic.

The Vradda section contains several levels of Hettangian ammonites in stratigraphic succession and, at present, it is the most important section in the Apennines for studies on the Hettangian ammonites.

Some ammonites in the Vradda section suggest taxonomic innovations within the early Lytoceratina during the Middle Hettangian: gen. n. (Pleuroacanthitidae) and *Analytoceras* n. sp. indet.; their phyletic relations with the larger specimens described by Canavari (1882, 1888) and Wähner (1882-1888) have still to be studied.

The recovery of siliceous radiolarians in the ammonitic levels of the Vradda section is important, because this is the first time that well-preserved Hettangian radiolarians and ammonites were found together in the western Tethys. Further studies are necessary to evaluate the importance of the anoxic level inside the ammonitic succession.

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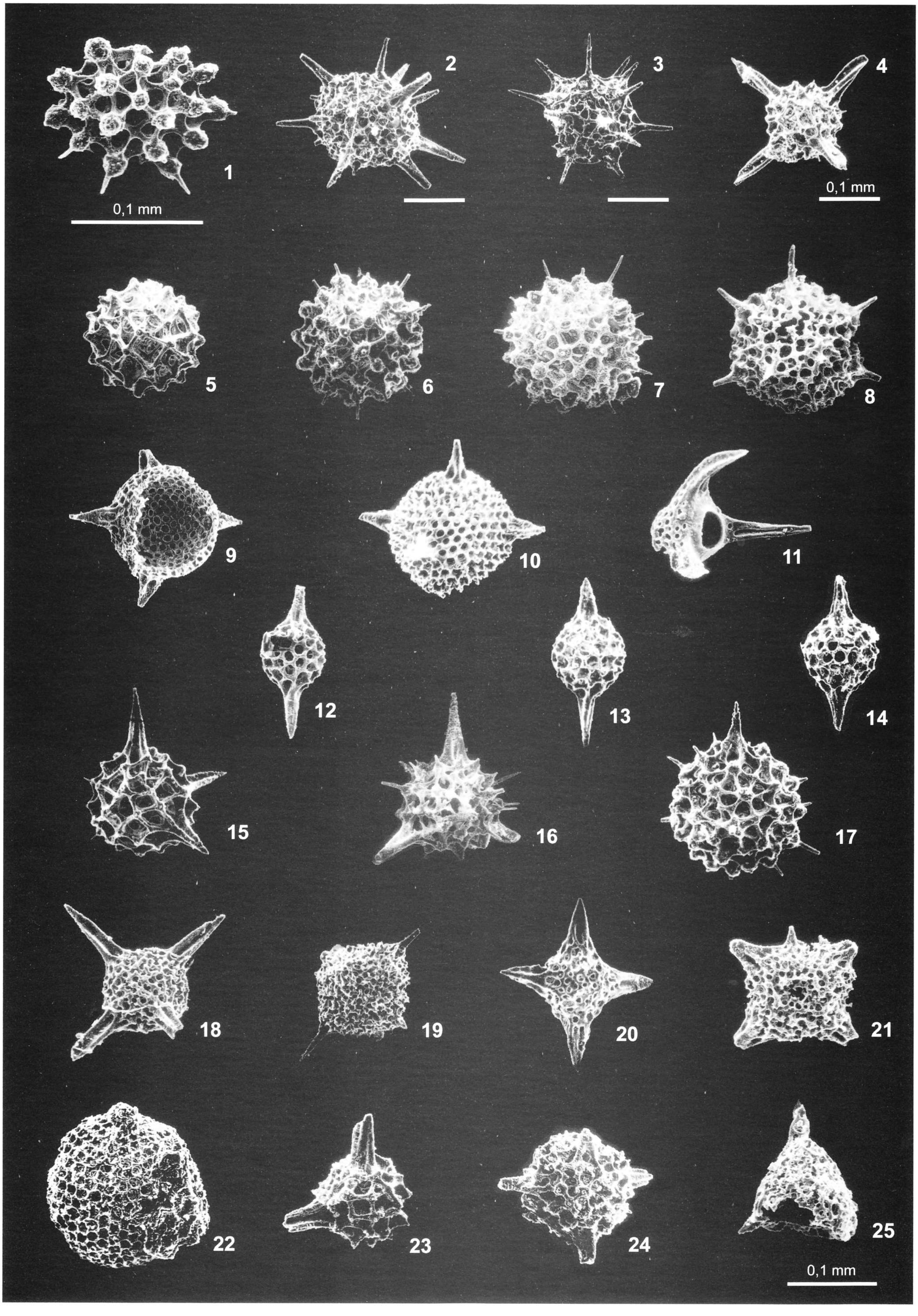
Fig. 6 - Scanning electron micrographs of radiolarians found in the horizons 2 and 7: 1-21 belong to horizon 7 (Late Hettangian) and 22-25 to horizon 2 (Middle Hettangian). Length of scale bar = 0,1 mm.
1-8: Spumellaria indet.; 9-10: *Amuria* sp.; 11: Nassellaria indet.; 12-14: *Pantanellium* spp.; 16: *Charlottea* ? sp.; 15, 17-18: Spumellaria indet.; 19: *Udalia* sp.; 20-21: Spumellaria indet.; 22: *Archaeocenosphaera* sp.; 23: *Charlottea* sp.; 24: *Thurstonia* sp.; 25: Nassellaria indet.


1
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17
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20
21
22
23
24
25
0,1 mm

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