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Ammonites, taphonomical analysis and biostratigraphy of the Aalenian (Middle Jurassic) from Capo San Vigilio (Lake Garda, N Italy)

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Abstract:

The Aalenian succession of Capo San Vigilio shows high historical value by the studies of palaeontologists of the Nineteen Century, which instituted many species of molluscs, mainly ammonites that are still used as reference for the Aalenian biochronostratigraphy. The absence of a definitive biostratigraphical succession due to intense stratigraphical condensation, and the opportunity to recognize the type-horizons of the new ammonite taxa lead to resume the study of the area north of Capo San Vigilio. Two sections have been sampled: Monte Pomo and Capitello Quarry, the latter a bit more expanded. In both sections, the lithostratigraphical succession is made up of three units: the Oolite di San Vigilio Fm (Toarcian-Aalenian), Calcari a *Skirroceras* del Capitello Fm (latest Aalenian-Bajocian) and Rosso Ammonitico Veronese Fm (late Bajocian-Tithonian). The researches were concentrated on the uppermost part of the “San Vigilio Oolite” that shows a characteristic lithofacies of pinkish to yellow grainstones with mineralized ooids, and on the lower part of the “*Skirroceras* Limestone” with pink, bioclastic, fine-grained grainstones. The palaeontological study deals with the Aalenian ammonites that are common along the studied interval. Due to the evidence of stratigraphical condensation within the succession, a taphonomical analysis has been carried out in view to distinguish between resedimented fossils, coeval to the encasing bed, and reworked fossils firstly taphonomically produced and buried in a older sediment. The criteria of their distinction are discussed. The fossil assemblages are affected by recurrent taphonomical reworking, except for the scattered resedimented fossils present at the topmost Monte Pomo section, namely *Haplopleuroceras subspinatum* referred to as the latest Aalenian Concavum Chron, Formosum Subchron. The use of “indirect biostratigraphy” made possible to build up and correlate the biostratigraphical successions of the two sections in which each fossil-assemblage has been referred to the

biochronostratigraphical scale of the Aalenian Stage. Thus, the basal “*Skirroceras* Limestone” at the Capitello Quarry results to be affected by a degree of stratigraphical condensation higher than the Monte Pomo section. In the taxonomical part some selected ammonite taxa are analyzed in detail: four species of *Spinammatocheras* SCHINDEWOLF, 1964, five species of *Malladaites* LINARES & SANDOVAL, 1996, among which the new *M. sandovali* n. sp., one species of *Haplopleuroceras* BUCKMAN, 1892, one species of *Zurcheria* (*Parazurcheria*) FERNÁNDEZ-LÓPEZ, 1988, three species of *Abbasitoides* GÉCZY, 1966, one species of *Riccardiceras* WESTERMANN, 1995, one species of *Westermannites* DIETZE et al., 2001. The resedimented specimens of *Haplopleroceras subspinatium* represent the first finding of the species in the Mediterranean Province, and allow dating the upper beds of the Monte Pomo section to the latest Aalenian Concavum Chron, Formosum Subchron. *Malladaites sandovali* n. sp. resembles in its general morphology *Spinammatocheras tenax* and connects these both genera. The publication of DE GREGORIO (1886a), “forgotten” in nearly all later publications, was published in January 1886, so prior to VACEK (1886), which was published in July 1886. However, regarding the taxa here under investigation, the taxa described by DE GREGORIO (1886a) are either nomina oblita or nomina dubia. DE GREGORIO (1886b) was published post VACEK (1886) so that VACEK’s species claim priority.

Key words: Aalenian Stage, taphonomy, taphorecords, biostratigraphy, ammonite taxonomy.

Abbreviations: HT: holotype

LT: lectotype

MGPU-PU: collection code of the Museo di Geologia e Paleontologia of the Torino University

GBA: Geologische Bundesanstalt, Wien

RS: resedimented fossil

RL: reelaborated fossil

1 - Introduction

The area around Capo San Vigilio is one of the classical sites for the Mediterranean Middle Jurassic. The type specimens of many Aalenian ammonites described by BENECKE (1865), VACEK (1886) and DE GREGORIO (1886a, 1886b) come from localities on the eastern shore of Lake Garda in N Italy, all of them close to Capo San Vigilio, lying between Garda and Torri

del Benaco (Fig. 1). The beds under investigation occur and disappear repeatedly between Capo San Vigilio and Capitello Quarry (see e.g. BENECKE 1865: 4; DE GREGORIO 1886b: 4). Some of the places, where the ammonites described by these authors came from, were no longer available, so that further reinvestigations became difficult. Nevertheless, in the middle of the 20th century STURANI (1964) produced a large and modern revision of the Middle Jurassic stratigraphy of the Venetian Alps. The author described two sections of the “*Calcari a Skirroceras del Capitello*” Fm that were regarded as to equivalent of those studied by the ancient authors: the Capitello Quarry and the slopes of Monte Pomo, just aside of Capo San Vigilio. STURANI’s work demonstrated that it would be possible to distinguish different fossiliferous layers in those sections. Such evidence opened the possibility to locate stratigraphically the ammonite taxa formally instituted by DE GREGORIO (1886a, 1886b) and VACEK (1886) in appropriate stratigraphical position and to make detailed fossil samplings, bed by bed, and thus either to find important topotypes of most species useful for increasing taxonomic definition.

Following STURANI’s conclusion, in the years 1990-1995 a team of Italian scientists of the University of Torino, in collaboration with the former Italian Geological Survey, investigated in detail the sections of Monte Pomo and the Capitello Quarry, and made stratigraphical survey and large collections of fossils that were used to draw up the papers of AMBROSI et al. (1991), CALLOMON et al. (1994), POCHETTINO (1995) and MARTIRE & PAVIA (1996). The in situ ammonite finds of those field-works serve for this paper that deals with (1) the detailed description of the two studied sections, (2) the biostratigraphical arrangement of the stratigraphical units on the basis of the taphonomical studies of fossil-assemblages and the biochronologic signal of taxa, (3) the detailed description of some selected ammonite groups that constitute typical taxonomic elements of the Aalenian of San Vigilio.

2 - Geological setting (Fig. 1)

The studied succession pertains to the Trento Platform, a paleogeographic unit developed during the Early Jurassic rifting on the southern passive margin of the western Tethys now preserved in the Southern Alps (WINTERER & BOSELLINI 1981; SARTI et al. 1992; BERTOTTI et al. 1993; ZEMPOLICH 1993). The Trento Platform was a fault-bounded structural high surrounded by deeper basins, the Lombardy and Belluno Basins, and was characterized from the Late Triassic to the early Aalenian by deposition of shallow platform carbonate sediments, from the peritidal Dolomia Principale (Upper Triassic) and peritidal-lagoonal Calcari Grigi

Fm (Hettangian-Pliensbachian: MASETTI et al. 2016) to platform margin oolite shoals of the Oolite di San Vigilio Fm (Toarcian-Aalenian: BARBUJANI et al. 1986). Over most part of the Trento Platform the top of the platform limestones is unconformably overlain by the typical condensed pelagic facies of Rosso Ammonitico Veronese Fm, which range in age from late Bajocian to latest Tithonian and record the drowning of the platform to a submerged plateau (MARTIRE et al. 2006). On the western edge of the Trento Platform this Aalenian-Bajocian hiatus is recorded by a few meters-thick succession of pink, ammonite-bearing, fine-grained grainstones with thin-shelled bivalves, echinoderm debris and peloids (Calcari a *Skirroceras* del Capitello Fm). These sediments may be interpreted as a drowning sequence (SCHLAGER 1989) i.e. a succession of condensed sediments deposited when the carbonate production slowed down because the accelerated subsidence rates caused the demise of the platform

3 - The sections of Capo San Vigilio (Fig. 2)

Many workers of the nineteenth century who studied the Jurassic palaeontology and stratigraphy of the Southern Alps celebrated the Capo San Vigilio on the eastern coast of the Garda Lake. BENECKE (1865), DE GREGORIO (1886a, 1886b), VACEK (1886), WAAGEN (1867), MENEGHINI (1879), NICOLIS (1882), NICOLIS & PARONA (1885), FUCINI (1892), GIOLI (1889), PARONA (1894) discussed the fossil-assemblages from the limestone succession at the passage from the Toarcian to the basal Bajocian. We have to wait for many decades before getting modern studies on this subject: DAL PIAZ (1956) tried to organize the different lithostratigraphic units present in that area in a natural succession according to the fossil-assemblages described by literature; STURANI (1964) sampled and described in detail three sections located northwards of Capo San Vigilio (Monte Pomo, Capitello Quarry, Acque Fredde) and arranged the fossil-assemblages collected bed by bed in the correct succession. In the following pages the textural and lithological characteristics of the Monte Pomo and Capitello sections are described in detail, based of the survey made by the authors at the end of the last century.

a. Monte Pomo section

The stratigraphy was first detailed by STURANI (1964) on a section by the side of the Gardesana road, at the base of the relief named Monte Pomo; the outcrop disappeared in short time. Later on, a new section was sampled nearly one hundred meters above the Gardesana on the slope of Monte Pomo (45°34'46,70"N – 10°40'28,32"E). POCHETTINO (1995) described the stratigraphy, which proved to be quite different from STURANI's data, and made a preliminary taphonomical study of the Aalenian fossil-assemblages. Basing on Pochettino's

work, MARTIRE & PAVIA (1996) summarized innovative conclusions on the depositional environment and the biostratigraphic arrangement of the fossiliferous beds. It is noteworthy that the outcrop of Monte Pomo may be assumed as corresponding to the sampling place of ancient authors (e.g. VACEK 1886) the dig marks of which are still visible on the slope and in the detritus piled in the area.

The section (Fig. 2) starts with some meters of whitish ooidal grainstones. Bedding is massive and cross lamination locally occurs. The uppermost 120 cm (beds 2-4) differ for some aspects: bedding is more regular and thinner, grain size is smaller, peloids and bioclasts are more abundant, some micrite matrix is locally present, and the colour ranges from pinkish to yellow and red. This is due to a variable degree of coating and staining of grains by Fe oxides that commonly fill microborings at the edge of ooids (Fig. 3a). Discontinuity surfaces are common which are characterized by an irregular surface, due to burrowing and erosion, and by intense coating by Fe oxides (Fig. 3b). Locally a lag of Fe-coated intraclasts and reelaborated ammonite moulds overlies the discontinuity surface. An analogous discontinuity bounds these ooid-bearing limestones, referred to the Oolite di San Vigilio Fm (OSV) from the reddish, evenly bedded limestones of the Calcari a *Skirroceras* del Capitello Fm (CSC).

The first bed of CSC (Bed 5) is very irregular and changes from 10 cm to 0 over short distances. It consists of a lag made of intraclasts and reelaborated ammonite moulds, up to 10 cm large, coated by crusts of Fe-Mn oxides, several millimeter thick, of stromatolitic aspect (Fig. 3c). The overlying beds (6 to 12) consist of quite coarse grainstones with bioclasts (thin shelled bivalves, echinoderm debris) and peloids (Fig. 3d). Intraclasts made of ooidal grainstones to packstones are locally recognizable. Fossils are quite common in all beds and are mainly represented by ammonite moulds and brachiopod shells. Small, cm-wide, neptunian dykes, mainly bed-parallel, are present in bed 9 and are filled with fine-grained and thinly laminated red sediments.

b. Capitello Quarry section

The outcrop of Capitello corresponded to the walls of an ancient limestone quarry (45°35'0,65"N - 10°41'28,25"E) that was already inactive at STURANI's time. At present the site is totally inaccessible because it has been transformed inside a gas station area. The field researches made in 1990-91 on the outcrop were used by CALLOMON et al. (1994) to produce a detailed investigation with on the ammonite assemblages, partly based on the material we use also for this work. However, on the basis of further finds from the San Vigilio area, their

conclusions on the biostratigraphical arrangement of the fossiliferous beds need some corrections.

In the Capitello section (Fig. 2) the whitish ooidal grainstones of the OSV were exposed for a thickness of about 3 meters with the same features described in the Monte Pomo section. The lithofacies characterized by a pinkish colour, Fe-stained grains, and discontinuity surfaces cropped out for a thickness of 80 cm (beds 2 a-d). Over another discontinuity, about 6 meters of the bioclastic-peloidal grainstones of the CSC follow. They show a pink to light brown colour and an even bedding with decimeter-thick beds separated by plane parallel surfaces. A sharp, erosional discontinuity surface, locally coated with Fe-Mn oxides, bounds the CSC from the overlying wackestone with thin-shelled bivalves and planktonic foraminifera (*Protoglobigerina*) of the lower member of the Rosso Ammonitico Veronese Fm. Small neptunian dykes, both parallel and perpendicular to bedding, occur in the upper half of the CSC. They are filled with fine-grained, laminated, reddish to grey sediments, which locally contain *Saccocoma* debris of Late Jurassic age and may be ascribed to the upper member of the Rosso Ammonitico Veronese Fm.

4 - Material and methods for palaeontological studies

As already shown by POCHETTINO (1995) and MARTIRE & PAVIA (1996), the succession of Aalenian ammonite assemblages occurring in the strata of Capo San Vigilio can only be understood by a very careful taphonomical analysis. Additionally must be considered that - at least in some parts - the strata and their ammonite content at each locality are slightly different, so that not at each locality each ammonite group can be found at all or in the same abundance as elsewhere.

The fossil-assemblages sampled from both San Vigilio localities are composed of mainly brachiopod and mollusc remains. A general picture of the fossil content of San Vigilio beds may be obtained from the works of DE GREGORIO (1886a, 1886b), VACEK (1886), GIOLI (1889) and FUCINI (1892). The Aalenian fossils of Capo San Vigilio show different kinds of preservation. The original shells, where present, are usually affected by a high degree of recrystallization that produced neomorphic shells. Locally septa are encrusted by different generations of cement rims, usually turbid to limpid prismatic spar (Fig. 3f). Very frequently, shells and internal moulds are stained or coated by Fe-oxide or glauconite films (Fig. 4e), locally covered by crusts of Fe and Mn oxides with stromatolitic texture Fig. 4f). In a few cases the concretionary internal moulds have the same lithological, mineralogical and textural

composition of the encasing matrix, but usually peculiar stainings of Fe-oxides or sedimentological features allow to distinguish them from the matrix (Fig. 4d).

Our taphonomical study deals with the ammonite fossils, among molluscs. Macroscopic and microscopic analyses have been carried out on the collected material based on the recognition of a variety of mechanisms of taphonomic alteration of fossils (FERNÁNDEZ-LÓPEZ 1991, 1995, 2007, 2011).

Most ammonites from the Capitello and Monte Pomo sites, and in general from the San Vigilio area, are taphonomically reworked. The term reworking in taphonomy refers to the particular processes which taphonomic elements were subjected to during their permanence on the substrate prior to final burial (cf. PAVIA et al. 2013; PAVIA & FERNÁNDEZ-LÓPEZ 2016; and references therein). Two cases:

RESEDIMENTED FOSSILS: elements displaced on the sea floor, after accumulation by taphogenic production and prior to first burial, and coeval with the encasing sediment in which they are buried. The resedimented ammonites from San Vigilio are preserved as entire or fragmented shells with concretionary internal moulds that show the same textural composition of the encasing matrix (see *Haplopleuroceras subspinatum*, Plate 1, Figs. 31-32)..

REELABORATED FOSSILS: elements derived by exhumation from previous sediments, exposed on the sea-bottom or the neighbouring areas, and finally incorporated in new, younger sediment. Distinctive features may identify the reelaborated ammonites of San Vigilio:

- lithological and/or textural differences between the internal mould and the encasing matrix and consequently evidence of a discontinuity surface between the sedimentary filling of the mould and the matrix (Fig. 4d);
- different phases of sedimentary infilling (Figs. 3g-1);
- Fe-oxide or glauconite crusts on the shells (Fig. 4f);
- Fe-oxide or glauconite stainings of the shell and/or the internal mould (Figs. 4b, e, g);
- facets of mould disarticulation at septal surfaces (Fig. 4d);
- abrasion surfaces on the internal mould (Fig. 4g), frequently corresponding to erosional surfaces along the symmetry plan of the fossils;
- geopetal filling of the mould inconsistent with the position of the fossil in the bed (Fig. 3 g-i).

The distinction of taphorecords has also been taken into consideration according to literature (FERNÁNDEZ-LÓPEZ 1987, 1991, 1995, 1997; PAVIA & MARTIRE 1997; ZUNINO et al.

2012; PAVIA et al. 2013, 2015). Taphorecords are palaeontological units composed of fossils showing distinctive taphonomic features related to a peculiar set of biostratigraphic or fossil-diagenetic processes. They have any stratigraphical, taxonomical or chronological meaning, and thus each taphorecord may occur in different overlying beds. The fossil-assemblage of a bed may be composed of elements belonging to one or more taphorecords. This reflects taphonomical condensation (GÓMEZ & FERNÁNDEZ-LÓPEZ 1994) and the study of a condensed fossil-assemblage allows heterochronies to be detected among fossils.

We must note that the biostratigraphy of the “*Calcarei a Skirroceras*” of San Vigilio is difficult to be precised due to the frequent reelaboration of fossils; this means that the time covered by the component of a condensed fossil-assemblage is wider than the sedimentation time of the bed. Therefore, whenever the resedimented fossils are missing, so that no biostratigraphic position can be directly stated, and the fossil-assemblage is formed only by reelaborated fossils, we apply the practice of “indirect biostratigraphy” as generically presented by FERNÁNDEZ-LÓPEZ (1997, fig. 3) and applied by PAVIA & MARTIRE (2010) and PAVIA et al. (2013, 2015): the biostratigraphical position of one bed could be inferred (or at least approximately indicated) by the biochronological datum of the youngest taxon present in the fossil-assemblage (maximum age) and is further supported by the absence of any older taxon in the overlying bed.

As to the scheme of biochronostratigraphic classifications and units that proposed by CALLOMON et al. (1994) is referred with slight modifications as accepted in principle by most workers (see CONTINI et al. 1997, and references therein). The ammonite Standard Zones, into which the Aalenian Stage of the NW Tethyan area is divided, are as follows from bottom up: OPALINUM ZONE (Opalinum and Comptum subzones), MURCHISONAE ZONE (Haugi and Murchisonare subzones), BRADFORDENSIS ZONE (Bradfordensis and Gigantea subzones), CONCAVUM ZONE (Concavum and Formosum subzones) (see Fig. 5 in the following chapter 5).

The studied specimens collected during the 1990-95 field-works are housed in the palaeontological collections of the Museo di Geologia e Paleontologia of the Torino University, with code MGPT-PU and progressive cataloguing numbers from PU41199 to PU41718. The taxonomic composition of the whole ammonite collection from the Aalenian of Capo San Vigilio is detailed in Appendix 1 (for Monte Pomo) and Appendix 2 (for Capitello), in which fossils are listed bed by bed in alphabetical order.

5 - Biostratigraphical arrangement of the Aalenian succession of Capo San Vigilio

The Aalenian ammonites from Capo San Vigilio are grouped into five taphorecords (resedimented RS and reelaborated RL) that integrate those proposed by MARTIRE & PAVIA (1996). Taphorecord [RS-1] refers to resedimented fossils showing the same textural composition as the encasing matrix without any Fe-oxide or glauconite stainings.

Taphorecords [RL-2] to [RL-5] refer to reelaborated fossils; they show features of reelaboration with different degree and evidence; the most evident distinction deals with the intensity of oxide staining/coating both on the recrystallized shell and the internal mould:

- RS-1: (= TR1 of MARTIRE & PAVIA 1996) (Plate 1, Figs. 29, 31, 32).
- RL-2: internal moulds and shells without any Fe-oxide film, occasionally with glauconite staining (Fig. 4a).
- RL-3: Fe-oxide film staining on the shell and possibly the internal mould (= TR2 of MARTIRE & PAVIA 1996) (Fig. 4b).
- RL-4: internal moulds and/or shells coated by thick Fe-oxide films (= TR3 of MARTIRE & PAVIA 1996) (Fig. 4e).
- RL-5: internal moulds coated by thick crusts of Fe and Mn oxides with stromatolitic aspect (= TR4 of MARTIRE & PAVIA 1996) (Figs 4f).

Each ammonite specimen is taphonomically classified according to these five taphorecords. In Tables 1 and 2 and in Appendix 1 and 2 the taphorecord of specimens are specified in a separate column.

On the whole, we identified 76 taxa, most of which are determined at specific level, and just a reduced part is limited to open nomenclature at species or genus level. A significant part of taxa (11%) and specimens (18%) belongs to the families Phylloceratidae and Lytoceratidae, assigning a Mediterranean pattern to the ammonite assemblages of Capo San Vigilio (cf. PAGE 1996; WESTERMANN 1996; SANDOVAL et al. 2001; and references therein).

The following paragraphs are dealing with the biostratigraphical arrangement of the two studied sections at Capo San Vigilio. In detail, we analyse the ammonite content of Monte Pomo and Capitello in order to state the relative biostratigraphic position of each bed basing on the taphonomical analysis with taphorecord definition of the respective fossil-assemblages. For this purpose, only the taxa with short biochronologic distribution are taken into account; thus Phylloceratidae and the Lytoceratidae and as a rule the taxa in open nomenclature are omitted.

5a – Monte Pomo section

Ammonites determined at Monte Pomo total 337 specimens representing 73 taxa. Tab. 1 lists the most significant species with their taphorecord characters and biochronological meaning. The biostratigraphical analysis of the section is summarized in Fig. 5.

- BED 3 –The fossil-assemblage comprehends 92 specimens representing 29 taxa. The resedimented ammonites (*Abbasitoides modestus*, *Spinammatoceras pugnax*, *Tmetoceras scissum*) do not give any precise biostratigraphical information as their biochronological distribution extends from the Opalinum Zone to the Bradfordensis Zone and even to the Concavum Zone. Nevertheless the reelaborated ammonites help to refer Bed 3 to the middle/upper part of the Murchisonae Zone, because *Ancolloceras opalinoide*s and *Erycites gonionotus* limit the maximum age of the bed to the Haugi Subzone and *Abbasites punctus* dates the overlying Bed 4 to at least the Bradfordensis Subzone.
- BED 4 – The fossil-assemblage comprehends 24 specimens representing 13 taxa. The biostratigraphical position of Bed 4 is constraint in the upper Bradfordensis Zone because the reelaborated ammonite *Abbasites punctus* limits the maximum age of the bed to the Bradfordensis Subzone, whereas *Praeoppelia platyomphala* and *P. subplicatella* date the overlying Bed 5 to the Concavum Zone.
- BED 5 - The fossil-assemblage comprehends 129 specimens representing 41 taxa. Even though no resedimented fossil is present, the biostratigraphical position of Bed 5 has to be referred at least to the base of the Concavum Subzone due to the biochronological distributions of the already mentioned *Praeoppelia platyomphala* and *P. subplicatella* and of *Zurcheria* (*Parazurcheria*) nov. sp. 1 from the Concavum Zone.
- BED 6 - The fossil-assemblage comprehends 15 specimens representing 9 taxa. None of the fossil gives particular information. In any case, the biostratigraphical position of Bed 6 has to be fixed in the lower part of the Concavum Subzone.
- BED 8 - The fossil-assemblage comprehends 5 specimens representing 4 taxa. The presence of the *Riccardiceras longalvum* states that Bed 8 cannot be older than the Concavum Subzone.
- BED 9 - The fossil-assemblage comprehends 23 specimens representing 14 taxa. *Graphoceras* sp. ind. and *Riccardiceras longalvum* point to the Concavum Zone. More precisely, the resedimented specimens of *Bradfordia* (*Iokastelia*) *praeradiata* and *Haplopleuroceras spinatum* fix the biostratigraphical position of Bed 11 to the Formosum Subzone.

- BED 10 - The fossil-assemblage comprehends 24 specimens representing 16 taxa. The resedimented *Haplopleuroceras spinatum* indicates the Formosum Subzone.
- BEDS 11-13 - The fossil-assemblages comprehend 26 specimens representing 11 taxa. The reelaborated ammonites do not give precise information, except to a general assignment to the Formosum Subzone. The possibility to indicate the lowermost Bajocian, Discites Zone, though suggested by STURANI (1964) for the topmost fossiliferous layer of the Monte Pomo outcrop, is not supported by any taxon referable to the lowermost Bajocian among the fossils recorded in Bed 13.

The fossil assemblages described by STURANI (1964, fig. 2) at Monte Pomo do not correspond to the present one because his section was sampled in a different outcrop. In particular STURANI distinguished two layers with Aalenian ammonites: the first fossiliferous horizon lies in the OSV, particularly at the top of his lithological interval 3b with scattered *Erycites fallifax*; the second one lies at the very base of CSC and contains a rich fossil-assemblage that results to be highly condensed with taxa biochronologically referable to all the zones of the Aalenian and possibly of the earliest Bajocian (*Hyperlioceras* sp.). It is possible to trace a correlation between Sturani's log and the ones here described: Bed 3 and Bed 4 (?) may be regarded as equivalent to Sturani's layer 3b, whereas his fossiliferous layer 4 at the base of CSC condenses fossils of our beds 5 to 13.

In conclusion, the stratigraphic succession at the passage between the topmost OSV (beds 3-4) and the basal CSC (beds 5-13) in the Monte Pomo area shows reduction of thickness and high degree of taphonomical condensation, whose intensity clearly increases upwards from bed 3 to bed 6. The Monte Pomo section described in the present paper is the only available to define a reasonable biostratigraphical arrangement of the Aalenian succession, with two layers located by resedimented fossils respectively at the middle and the uppermost Aalenian.

5b – Capitello Quarry

In a detailed investigation, partly based on the material we use also for this work, CALLOMON et al. (1994) described the succession at Capitello and compared the type material of VACEK (1886) with the new in situ finds from Capitello Quarry. However, on the basis of an up-to-date revision of the collection and of our further researches from the San Vigilio area, their conclusions regarding the biostratigraphic sequence of beds need corrections.

Ammonites determined at Capitello total 149 specimens representing 45 taxa. Tab. 2 lists the most significant species, bed-by-bed, with their taphorecord characters and the

biochronological meaning. All the ammonites are reelaborated, so that the biostratigraphy for the Capitello succession cannot be precised and beds may be only tentatively referred within the Aalenian biochronostratigraphic scheme (Fig. 5).

- BED 2b – The fossil-assemblage comprehends 16 specimens of 8 taxa. The biochronologically significant species *Accardia proceroinsigne* and *Leioceras comptum* do not help because of reelaboration. In general the time of deposition of Bed 2b covers the Comptum Subchron and the Bradfordensis Chron, but the analogy with Bed 3 of the Monte Pomo section suggests a biostratigraphical assignement to the Murchisonae Subzone.
- BED 2d – The fossil-assemblage comprehends 92 specimens of 28 taxa. The absence of resedimented fossils hinders from giving any indisputable biostratigraphy. *Abbasites punctus*, *Malladaites sandovali* nov. sp. and *Spinammatocheras sagax* fix the Bradfordensis Chron as the maximum age, whereas *Praeoppelia platyomphala* states that the age of sedimentation of Bed 2d cannot be older than the Concavum Chron.
- BED 3 – The fossil-assemblage comprehends 41 specimens of 24 taxa. *Praeoppelia platyomphala* and *P. subplicatella* state that the age of sedimentation of Bed 3 cannot be older than the Concavum Chron. On the other hand, the absence of any ammonite typical of the Concavum Zone, such as Ghaphoceratidae and *Riccardiceras longalvum*, seems to limit the position of Bed 3 at Capitello at the passage between the Bradfordensis and the Concavum zones.
- CALCARI A *SKIRROCERAS* DEL CAPITELLO – The only fossil referable to the CSC succession of the “Calcari a *Skirroceras* del Capitello” above Bed 3 is a resedimented specimen collected from an undefined bed cropping out at the beach of the Garda Lake, just below the Capitello Quarry. It has been identified as *Euhoploceras* sp. that is a taxon biochronologically referred as to the lowermost Bajocian.

Our conclusions for the Capitello section differ from those presented by CALLOMON et al. (1994). First of all, the abundance of fossils and the specific list cited by these authors do not correspond to the present material kept in the MGPU collection; it is difficult to explain such discrepancies unless the collected material from Bed 2b to Bed 2d was mixed during its study or Callomon’s hypothetical assumption increased the list of fossils of Bed 2b on the basis of Vacek’s original material he saw in the collection of the Geological Survey of Vienna (CALLOMON et al. 1994: 106). A second point deals with the taphonomical analyses that were repeatedly declared to be necessary but never done. The consequence of that concerns the biostratigraphic arrangement of beds; in particular the assignment of Bed 2b by CALLOMON et al. (1994) to the top Comptum Subzone or to the passage between the Opalinum and the

Murchisonae zones must be transferred to the Bradfordensis Zone. Similarly, Bed 2d was referred as to lower Murchisonae Zone, but our taphonomical analyses indicate an age only a bit older than the Concavum Chron.

5c – Correlation of Monte Pomo to Capitello Quarry sections

The biostratigraphical arrangement of the two sections helps to correlate their lithostratigraphic logs according to the biochronological meaning of the respective fossil-assemblages (Figs. 2, 5). The correlation is necessarily approximate because ammonites are prevalently reelaborated and the Monte Pomo (“MP-”) and Capitello (“C-”) sections show a high degree of taphonomical and stratigraphical condensation. In detail it is possible to trace the following equivalences:

- Bed C-2b roughly corresponds to Bed MP-3 in the Murchisonae Zone.
- Bed C-2d cannot be correlated to Bed MP-4 in spite of their lithological analogies; the former is dated to the early Concavum Chron and Bed MP-4 is located within the Gigantea Subzone.
- Bed C-3 covers the biostratigraphical meaning of MP-5 and MP-6 at the base of the Concavum Zone.

No records are present in the Capitello section to be equivalent to beds MP-8 to MP-13. The Capitello section thus registers only a part of the Concavum Zone and the Formosum Subzone is totally missing; such hiatus is reflected by the discontinuity surface upon the lenticular Bed C-3.

As to the upper body of the Calcari a *Skirroceras* del Capitello Fm their biostratigraphical assignment to the lower Bajocian is testified by the specimen of *Euhoplloceras* sp. ind. coming from an undefined layer above Bed 3 of the Capitello section. This age is confirmed by STURANI’s work (1964) that reports specimens of *Skirroceras* from different outcrops of the area just northwards of Capo San Vigilio. WAAGEN (1867) also described Lower Bajocian ammonites (*Skirroceras*, *Emileia*) from about 10 m above the level with *Leioceras* sp., *Erycites fallifax* and *Tmetoceras scissum* from Capo San Vigilio.

6. The Aalenian ammonites from Capo San Vigilio

a. Introduction

BENECKE (1865) was the first author who made known the outcrops and who described Aalenian ammonites from Capo San Vigilio, including such important species as *Ammonites scissus* BENECKE, *A. fallifax* BENECKE and *A. gonionotus* BENECKE. Unfortunately his type material seems to be lost in Strasbourg; only a cast of the type-specimen of “*Ammonites fallax*” [= *Erycites fallifax* ARKELL] was found in the Geological Survey of Vienna (CALLOMON et al. 1994: 109).

WAAGEN (1867) published a list of ammonites from two different levels at Capo San Vigilio; he was the first who recognised that the strata on Capo San Vigilio yield beneath Aalenian ammonites in their higher parts also Lower Bajocian ammonites. After some years of exhaustive collecting, three monographs on the fossils of Capo San Vigilio were published in 1886 by two authors:

The classical monograph by VACEK (1886), who had - beneath some single ammonites from the Upper Toarcian - collected hundreds of specimens of Aalenian age. He erected about two dozens new species from the type-locality Capo San Vigilio. Some of these were already photographically refigured:

- *Riccardiceras longalvum* (VACEK) (in WESTERMANN 1964, pl. 6, fig. 1 [LT], pl. 6, Fig. 1; DIETZE et al. 2001, fig. 6 [LT])
- ?*Abbasites punctus* (VACEK) (in WESTERMANN 1964, pl. 6, fig. 7 [LT])
- *Abbasitoides modestus* (VACEK) (in WESTERMANN 1964, pl. 6, fig. 8 [LT])
- *Euaptetoceras amaltheiforme* (VACEK) (in WESTERMANN & RICCARDI, 1982, text-fig. 4 A –B [LT])
- *Planammatoceras planinsigne* (VACEK) (in WESTERMANN & RICCARDI, 1982, text-fig. 3 [LT])
- *P. klimakomphalum* (VACEK) (in WESTERMANN & RICCARDI 1982, text-fig. 4 C–E [LT])
- *Csernyeiceras subaspidoides* (VACEK) (in SCHWEIGERT et al. 2000, fig. 1a [LT], in SCHWEIGERT et al. 2007, Fig. 4 [ST])
- *Onychoceras vacekii* SCHWEIGERT et al. ([= *Sphaeroceras* cf. *globosus* SCHÜBLER in VACEK, 1886] in SCHWEIGERT et al. 2000, fig. 3a [HT])

Furthermore, DE GREGORIO (1886a, 1886b) published two monographs and described many Aalenian ammonites from Capo San Vigilio. The first one in January 1886 (DE GREGORIO 1886a), and so earlier than VACEK (1886), whose monograph was published in July 1886. The second one is dated on December 1886 (DE GREGORIO 1886b), thus later than VACEK (1886). In principle, the taxa already erected by DE GREGORIO (1886a) have priority on the (synonymous) taxa erected by VACEK (1886). However, the taxa introduced by DE GREGORIO (1886a, b) were mostly ignored since their publication, so most of these must be regarded as nomina oblita. Some of these, lacking a sufficient diagnostic description, must be regarded as nomina dubia, because DE GREGORIO’s collection has been declared lost by the

curator of the Museo G. GEMMELLARO in Palermo (Sicily). Only few specimens, which are of no interest for this publication, are housed in the Museo Regionale of Terrasini (Sicily). We analyze each taxon we describe further down in detail separately under respect of the rules of the ICZN.

ARKELL (1956) compiled a list of many ammonites figured by VACEK (1886) with modern names.

Subsequently AMBROSI et al. (1991), CALLOMON et al. (1994), POCHETTINO (1995) and MARTIRE & PAVIA (1996) investigated the sections and ammonites of Capitello Quarry and Monte Pomo primarily under stratigraphical and taphonomical aspects. RULLEAU (2010) published a reprint of VACEK (1886) with a very short taxonomical revision of the ammonites figured by VACEK (1886).

b. Description of selected ammonite taxa

ba. Taxonomical remarks

- **Family Hammatoceratidae BUCKMAN, 1887**

- **Subfamily Zurcheriinae HYATT, 1900:** In the “Treatise” HOWARTH (2013) included the genera *Spinammatoceras* SCHINDEWOLF, 1964, *Malladaites* LINARES & SANDOVAL, 1986, *Zurcheria* DOUVILLÉ, 1885 and *Haplopleuroceras* BUCKMAN, 1892 into the subfamily Zurcheriinae within the family Hammatoceratidae. We follow this proposal because this taxonomy on the one hand reflects excellently the natural connections between these closely related genera (LINARES & SANDOVAL 1986a, 1996; FERNÁNDEZ-LÓPEZ et al. 1988) and on the other hand emphasizes their separate position with respect to the subfamilies Erycitinae SPATH, 1928 and Hammatoceratinae BUCKMAN, 1887. However, it may be mentioned that LINARES & SANDOVAL (1986, 1996) included the genera *Spinammatoceras* and *Malladaites* in the subfamily Hammatoceratinae within the family Hammatoceratidae, whereas FERNÁNDEZ-LÓPEZ (1988) included the genus *Zurcheria* DOUVILLÉ, 1885 into the subfamily Zurcheriinae within the family Erycitidae SPATH, 1928. However, at the present stage of knowledge there exists one inconsistency in each of these suggested taxonomies: the oldest specimens of the species *Spinammatoceras pugnax* (from the Lower Aalenian Comptum Subzone) are the dimorphic partner of *Erycites fallifax* (LINARES & SANDOVAL 1986, 1996), but they are included in different genera (*Spinammatoceras* resp. *Erycites*) and partly also in different subfamilies (Zurcheriinae resp. Erycitinae). HOWARTH (2013: 114) hid

the problem in postulating that *S. pugnax* is the microconch and *S. tenax* the macroconch within the genus *Spinammatocheras*.

Due to the complex taphonomy of the ammonite assemblages of Capo San Vigilio, the finds of ammonites of the subfamily Zurcheriinae from Capo San Vigilio are not particularly suitable for a direct evidence of the variability within the different species of the genera *Spinammatocheras*, *Malladaites*, *Zurcheria* and *Haplopleuroceras* and their phylogeny. But we can present some morphological intermediate morphs between some of these genera, which well may be also biological links between succeeding taxa, e.g. *Malladaites sandovali* n. sp. as intermediate link between *Spinammatocheras tenax* and *Malladaites pertinax*; *M. parvispinatus* and *Zurcheria (Parazurcheria)* sp. nov. 1 sensu FERNÁNDEZ-LÓPEZ et al. as possible links between the genera *Malladaites* and *Zurcheria*.

- **Subfamily Erycitinae SPATH, 1928:** For the reasons just mentioned we follow the proposals of HOWARTH (2013), DIETZE et al. (2013) and GALÁCZ & KOVÁCS (2013), who included the genus *Abbasitoides* GÉCZY, 1966 in the subfamily Erycitinae Spath, 1928 of the family Hammatoceratidae BUCKMAN, 1887. Earlier KOVÁCS & GÉCZY (2008) and later SANDOVAL et al. (2015) included the subfamily Erycitinae into the family Erycitidae SPATH, 1928. The genus *Abbasitoides* is, through the species *Mollistephanus westermanni* (SANDOVAL) from the Discites Zone (CHANDLER & DIETZE 2004), a well fitting candidate as ancestor of the genus *Mollistephanus* (SANDOVAL 2000, 2001).

- **Family Stephanoceratidae NEUMAYR, 1875**

The systematic position of the genus *Riccardiceras* WESTERMANN, 1995 has been discussed controversially. The author of the genus *Riccardiceras* WESTERMANN, 1995, interpreted *Riccardiceras* as an ancestral genus of the family Stephanoceratidae NEUMAYR, 1875. He was followed e.g. by DIETZE et al. (2001, 2007), CALLOMON & CHANDLER (2004), CHANDLER et al. (2013), and GALÁCZ (2015). In contrast e.g. SANDOVAL et al. (2000) and FERNÁNDEZ-LÓPEZ (2014) regarded *Riccardiceras* as a member of the Otoitidae MASCKE, 1907. We prefer to follow the original interpretation and accept *Riccardiceras* as a genus of the family Stephanoceratidae NEUMAYR, 1875. This is supported by the evolute-platyconic to serpenticonic coiling, rounded whorl-section and ribbing style shared by all genera of this family (cf. WESTERMANN 1995). A stephanoceratid chronocline can be easily followed from the Bradfodensis/Concavum zonal boundary up to the Laeviuscula Zone (DIETZE et al. 2001) and, via the genera *Skirroceras* and *Stephanoceras*, which exhibit the same morphological

characters, up to the Humphriesianum Zone. Otoitidae MASCKE, 1907 are well-characterized by a (sub-)cadiconic to sphaeronic coiling. They appear in the latest Discites Zone with the dimorphic couple *Docidoceras* – *Trilobiticeras*, evolving to *Emileia* – *Otoites* in the Ovale Zone. Arguments in favour of an inclusion of *Riccardiceras* in Otoitidae are less convincing. The septal suture of *Riccardiceras* was said to resemble that of typical Otoitidae (see WESTERMANN 1995, SANDOVAL et al. 2000 for details). However, both families have an erycitid rootstock (WESTERMANN 1995, CALLOMON & CHANDLER 2004), so that a similar suture line in early representatives is not surprising. Moreover, the interpretation of SANDOVAL et al. (2000) that the “otoitid” microconchs described by these authors (their pl. 3, figs. 3a–6b and pl. 4, figs. 1a, 2b) correspond to macroconchiate *Riccardiceras* is not supported by a similarity of the juveniles resp. inner whorls as one would expect in a dimorphic couple. For these reasons the proposition by FERNÁNDEZ-LÓPEZ (2014), who suggested an evolution of *Albarracinites* in the Discites/Ovale zones from the otoitid genus *Riccardiceras* by proterogenesis [= the appearance of features in the early stages in an organism’s life characteristic of adult forms of its evolutionar descendants], does not appear the most favourable.

bb. Family Hammatoceratidae, BUCKMAN, 1887

Subfamily Zurcheriinae DOUVILLÉ, 1885

Genus *Spinammatoceras* SCHINDEWOLF, 1964

Type-species: *Hammatoceras pugnax* VACEK, 1886. The type-locality of the lectotype of the type-species is Capo San Vigilio.

Diagnosis: For extensive diagnosis see LINARES & SANDOVAL (1986) and HOWARTH (2013). Diagnostic for the genus - in contrast to the closely related genera *Erycites* and *Malladaites* - are two rows of well developed spines resp. nodes on the umbilical and the ventrolateral edge. The microconchs (*S. pugnax* (VACEK) and *S. schindewolfi* LINARES & SANDOVAL) exhibit this feature regularly up to the end of the body chamber. In the macroconchs (*S. tenax* (VACEK) and *S. sagax* (VACEK)) the ventrolateral spines are strongest at a diameter of about 2,5 cm and disappear then rapidly. The inner row of spines continues in the macroconchs up to a diameter of about 5 cm (VACEK 1886: 95). The ribs never cross the hardly developed keel/venter.

Spinammatoceras pugnax (VACEK, 1886)

Pl. 1, Figs. 1–6

- 1886 *Aspidoceras anasis* DE GREG. – DE GREGORIO, 1886a, p. 13; pl. 24, fig. 14–15 [nomen oblitum].
- 1886 *Aspidoceras anasis* DE GREG. F.^a *aculecostatus* DE GREG. – DE GREGORIO, 1886a, p. 13; pl. 24, fig. 16–18 [nomen oblitum].
- 1886 *Hammatoceras pugnax* n. sp. – VACEK, p. 96, pl. 16, fig. 1 [LT] –4.
- 1886 *Aspidoceras anasis* DE GREG. – DE GREGORIO, 1886b, p. 16; pl. 10, fig. 14–15 [nomen oblitum].
- 1886 *Aspidoceras anasis* DE GREG. mut. *aculecostatus*. – DE GREGORIO, 1886b, p. 16; pl. 10, fig. 16–18 [nomen oblitum].
- 1964 *Zurcheria pugnax* (VACEK). – STURANI, p. 10.
- 1965 *Spinammatoceras pugnax* (VACEK). – WENDT, p. 300.
- 1975 *Spinammatoceras pugnax* (VACEK). – HINKELBEIN, fig. 14.
- 1984 *Hammatoceras pugnax* (VACEK). – PALLINI, p. 212, pl. 7, fig. 8.
- 1986 *Spinammatoceras* (m) *pugnax* (VACEK, 1886). – LINARES & SANDOVAL, 1986a, p. 209, fig. 1 a, b; pl. 1, figs. 16–18 [cum syn.].
- 1988 *Spinammatoceras pugnax* (VAC.). – CRESTA, p. 215.
- 1988 *Spinammatoceras pugnax* (VAC.). – LINARES, URETA & SANDOVAL, p. 198, fig. 3.
- 1991 *Spinammatoceras pugnax*. – AMBROSI et al., p. 79, 80.
- 1993 *Spinammatoceras pugnax*. – LINARES & SANDOVAL, p. 193, 194, 197, fig. 10.
- 1994 *Spinammatoceras pugnax* (VACEK), 1886. – CRESTA, p. 115.
- 1994 *Spinammatoceras pugnax* (VACEK) (m). – CALLOMON et al., p. 106, 107.
- 1996 *Spinammatoceras pugnax*. – HENRIQUES et al., p. 145, fig. 3.
- 1996 *Spinammatoceras pugnax*. – SADKI, p. 132, figs. 23, 46.
- 2001 *Spinammatoceras pugnax*. – SANDOVAL et al., p. 393.
- 2004 *Erycites pugnax* (VACEK 1886). – PALLINI† et al., p. 27.
- 2009 *Spinammatoceras pugnax* (VACEK). – RULLEAU, p. 83; pl. 85, figs. 6 [LT]–7.
- 2010 *Spinammatoceras pugnax* (VACEK). – RULLEAU, Pl. 16, Figs 1–4.
- 2011 *Spinammatoceras pugnax*. – SANDOVAL et al., p. 246, figs. 5–8.
- 2013 *S. pugnax* (VACEK). – HOWARTH, p. 114, fig. 1a [LT].

Material: 7 specimens from Monte Pomo: (Bed 3) MGPU-PU 41628, 41630, 41632, 41633; (Bed 4) MGPU-PU 41631, 41634; (loose) MGPU-PU 41629, 41631. 4 specimens from Capitello Quarry: (Bed 2d) MGPU-PU 41635, 41636, 41637, 41638.

Nomenclatural Status: The nominal taxon “*Aspidoceras*” *anasis* DE GREGORIO, 1886a is a nomen oblitum (Art. 23.9 ICZN). We state explicitly that the younger name *pugnax* is valid. This action is taken in accordance with Article 23.9 ICZN (Art. 23.9.2. ICZN).

The senior synonym “*anasis*” was to our knowledge never used as a valid name after 1899 (Art. 23.9.1.1 ICZN) and the junior synonym “*pugnax*” has been used for a particular taxon, as its presumed valid name, in at least 25 works, published by at least 10 authors in the immediately preceding 50 years and encompassing a span of not less than 10 years (Art. 23.9.1.2 ICZN). Additionally to the list in the references the taxon “*pugnax*” was used also by: DUBAR et al. (1971), FERNÁNDEZ-LÓPEZ (1979), FERNÁNDEZ-LÓPEZ & MOUTERDE (1985), FERNÁNDEZ-LÓPEZ et al (1985), GOY et al. (1991), GUTIERREZ (1992), GARCIA-GOMEZ et al. (1994), SANDOVAL & CHANDLER (2000), SANDOVAL et al. (2001), CRESTA & URETA (2002), SANDOVAL et al. (2007), DIETZE et al. (2010).

The taxon “*aculecostatus*” was used by DE GREGORIO (1886a) as F.^a (= forma) and has to be regarded as subspecific according to Art. 45.6.4. ICZN. It is also a nomen oblitum (Art. 23.9. ICZN); we refer to our comments on the name “*anasis*”. DE GREGORIO (1886b) used the name “*aculecostatus*” later as “mut.” (= mutation). If DE GREGORIO (1886b) would erect a new taxon (what is not plausible), this taxon should become infrasubspecific (Art. 45.5. ICZN), so not available and in any case a junior subjective synonym to the taxon “*pugnax*”. The specimens figured by DE GREGORIO (1886a, 1886b) on pl. 24, figs. 14–18 resp. pl. 10, figs. 14–18 are housed in the Museo Regionale of Terrasini (Sicily) – however this is of no relevance for their nomenclatural status described above.

Remarks: The species is largely described in previous works, so that a new description is useless.

Pl. 1, Figs. 1–2 show for the first time the lectotype of the species (VACEK 1886, pl. 16, fig. 1) photographically. None of the new in situ finds shows an apophysis, although the ammonite Pl. 1, Figs. 5–6 is nearly complete. Both specimens (Pl. 1, Figs. 3–6) show the two rows of small spines/nodules near the umbilicus and at the ventrolateral edge as well as the relatively small size of the species.

According to LINARES & SANDOVAL (1986) *S. pugnax* is probably the dimorphic counterpart of *Erycites* gr. *fallifax*; both co-occur in the same stratigraphical level, this can be observed also at Capo San Vigilio.

Stratigraphical provenance: Italy: Apennins: Fallifax Biozone [pars, ~ Murchisonae Zone] (CRESTA 1988, 1994); Spain: Betic Cordillera: Bifidatum Subzone – Obtusifomis Subzone (LINARES & SANDOVAL 1986); Comptum Subzone – Haugi Subzone (LINARES et al. 1988), Fallix Biozone [= Comptum Subzone – Haugi Subzone] (LINARES & SANDOVAL 1993); Comptum – lower Bradfordensis Subzone (HENRIQUES et al. 1996); Comptum Subzone (SANDOVAL et al. 2001); Fallifax Biozone [= Comptum Subzone] (SANDOVAL et al. 2011); Morocco: Comptum Subzone (SADKI 1996).

Biochronology at Capo San Vigilio: Most specimens are reelaborated. The resedimented specimens come from Bed 3 of Monte Pomo section and are restricted to the Murchisonae Subchron.

***Spinammatocheras* cf. *pugnax* (VACEK, 1886)**

Pl. 1, Figs. 7–9

Material: 2 specimens from Monte Pomo: (Bed 3) MGPU-PU 41627, (Bed 5) MGPU-PU 41626.

Description: The figured specimen (Pl. 1, Figs. 7–9) shares characters of both, *S. pugnax* and *S. schindewolfi* and is obviously an intermediate morph between both stratigraphically succeeding [Opalinum resp. Murchisonae Zone (LINARES & SANDOVAL 1986)] species; however closer to *S. pugnax*. The ribbing of the phragmocone shows the typical morphology of *S. pugnax*, whereas the body-chamber shows the dense ribbing of *S. schindewolfi*, partly bifurcating.

Remarks: Close to our finds are the figurations of *Aspidoceras anasis* F.^a *aculecostatus* in DE GREGORIO (1886a, pl. 24, fig. 16) [= *Aspidoceras anasis* mut. *aculecostatus* (DE GREGORIO 1886b, pl. 16, fig. 10)].

Biochronology at Capo San Vigilio: Both specimens are reelaborated from Bed 3 and Bed 5 of Monte Pomo section that are referred respectively to as Murchisonae and basal Concavum subzones.

***Spinammatoceras* nov. sp. 1 [sensu LINARES & SANDOVAL, 1986a]**

Pl. 1, Figs. 14–17, 20–21

1986 *Spinammatoceras* nov. sp. 1. – LINARES & SANDOVAL, 1986a, p. 213; pl. 1, fig. 12.

Material: 4 specimens from Monte Pomo: (Bed 5) MGPU-PU 41281, 41282, 41639, 41640.

Remarks: The figured specimens are all incomplete phragmocones, which fit well with the inner whorls of the macroconch specimen figured by LINARES & SANDOVAL (1986) on pl. 1, fig. 10 from the Bradfordensis Subzone, though *S. schindewolfi* [m] differs by a denser and more irregular ribbing; additionally the phragmocone of the specimens figured by LINARES & SANDOVAL (1986, pl. 1, figs. 6–11) shows a smaller diameter.

Stratigraphical provenance: Spain: Betic Cordillera: Bradfordensis Subzone (Murchisonae Zone) (LINARES & SANDOVAL 1986).

Biochronology at Capo San Vigilio: All specimens are reelaborated. They come from a fossil-assemblage that is referred to the basal Concavum subzone.

***Spinammatoceras tenax* (VACEK, 1886)**

Pl. 1, Figs. 18–19, 22–23

1886 *Hammatoceras tenax* n. sp. – VACEK, p. 94, pl. 15, figs. 10 [LT]–14.

1975 *Zurcheria tenax* (VACEK). – HINKELBEIN, fig. 14.

1986 *Spinammatoceras* (M) *tenax* (VACEK). – LINARES & SANDOVAL, 1986a, p. 210 [pars], pl. 1, figs. 2,4 [only].

1988 *Sp. tenax*. – LINARES et al., p. 199, fig. 3.

? 1991 *Spinammatoceras tenax*. – AMBROSI et al., p. 80.

- 1992 *S. tenax*. – LINARES & SANDOVAL, p. 89, fig. 3.
- 1993 *Spinammatoceras tenax*. – LINARES & SANDOVAL, p. 194, 196, 197, figs. 10–12.
- 1994 *Spinammatoceras tenax* (VACEK). – CALLOMON et al., p. 106, 107.
- ? 1995 *Spinammatoceras tenax* (VACEK). – POCHETTINO, p. 59.
- 1995 “*S.*” *tenax*. – HENRIQUES, p. 231, fig. 3.
- 1996 *S. tenax*. – HENRIQUES et al., p. 145, fig. 3.
- 2001 *Spinammatoceras tenax*. – SANDOVAL et al., fig. 3.
- ? 2001 *Spinammatoceras* aff. *tenax* (VACEK). – RULLEAU et al., pl. 30, figs. 5–6.
- 2004 *Erycites tenax* (VACEK 1886). – PALLINI† et al., p. 27.
- ? 2006 *Spinammatoceras* aff. *tenax* (VACEK). – RULLEAU, p. 111, pl. 8, figs. 7a, b.
- 2009 *Spinammatoceras tenax* (VACEK). – RULLEAU, p. 84; pl. 85, fig. 9 [LT].
- 2010 *Spinammatoceras tenax* (VACEK). – RULLEAU, révision planche 15, figs. 10–14.
- 2011 *Spinammatoceras tenax*. – SANDOVAL et al., p. 248, 250, figs. 6–7, 11.3.
- 2013 *Spinammatoceras* [*Hammatoceras tenax* VACEK]. – HOWARTH, p. 114, fig. 1b [LT].
- 2016 *Spinammatoceras tenax*. – HENRIQUES et al., p. 485.

Material: 2 specimens from Capitello Quarry: (Bed 2d) MGPU-PU 41623, 41624.

Description: The figured specimen (Pl. 1, Fig. 18–19) is a small nucleus comparable to the ammonite figured by VACEK (1886) on pl. 15, fig. 12.

Remarks: We figure here for the first time the lectotype of the species (VACEK, 1886, pl. 15, fig. 10) photographically (Pl. 1, Figs. 22–23). Although VACEK (1886) mentions ten syntypes in his hands, surprisingly no complete, large specimens of this species were found by us. This is again a hint, that at different places at Capo San Vigilio slightly different old strata and ammonites are preserved.

Stratigraphical provenance: Spain: Betic Cordillera: Bradfordensis Subzone (LINARES & SANDOVAL 1986, 1988); upper Haugi Subzone – lower Bradfordensis Subzone (LINARES et al. 1988); Schindewolfi Zone [= Murchisonae Subzone – lower part Bradfordensis Subzone] (LINARES & SANDOVAL 1988, 1993); Murchisonae Subzone – Bradfordensis Subzone (LINARES & SANDOVAL 1992); Murchisonae Subzone – Bradfordensis Subzone (HENRIQUES et al. 1996); Comptum - Murchisonae Zone (SANDOVAL et al. 2001); Tenax Zone [= Haugi – Bradfordensis Subzone] (SANDOVAL et al. 2011); Iberian Cordillera:

upper Bradfordensis – lower Concavum Zone (HENRIQUES et al. 1996); Portugal: Bradfordensis Zone (HENRIQUES 1995, HENRIQUES et al. 2016); France: Bradfordensis Zone (RULLEAU 2006).

Biochronology at Capo San Vigilio: Both specimens are reelaborated. They come from a fossil-assemblage that is referred to the topmost Bradfordensis Subzone. The LT comes by its preservation from the Oolite di San Vigilio Fm (OSV).

***Spinammatoceras sagax* (VACEK, 1886)**

Pl. 1, Figs. 10–13

- 1886 *Hammatoceras sagax* n. sp. – VACEK, p. 95, pl. 15, figs. 15–18.
 1996 *Spinammatoceras sagax*. – SADKI, p. 133, figs. 23, 46.
 2004 *Erycites sagax* (VACEK 1886). – PALLINI† et al., p. 27.
 2010 *Spinammatoceras tenax* (VACEK). – RULLEAU, révision planche 15, Figs 15–18.

Material: 2 specimens from Capitello Quarry: (Bed 2d) MGPU-PU 41618, 41619. 1 specimen from Monte Pomo: (Bed 6) MGPU-PU 41620.

Description: The figured ammonite from Monte Pomo (Pl. 1, Figs. 12–13) is a small nucleus showing the coronate whorl section, which is typical for the species.

Remarks: As VACEK (1886: 95), we keep *S. sagax* for the moment separated from *S. tenax*, because their whorl-sections differ significantly. On the other hand, LINARES & SANDOVAL (1986) were of the opinion that *S. sagax* is probably synonymous to *S. tenax*. We show for the first time a photograph of the largest specimen of the species figured by VACEK (1886, pl. 15, fig. 15; Pl. 1, Figs. 10–11), which comes by its preservation from the Oolite di San Vigilio Fm (OSV).

Stratigraphical provenance: Morocco: Bradfordensis Subzone (SADKI 1996).

Biochronology at Capo San Vigilio: Both specimens are reelaborated and come from Bed 6 of Monte Pomo and Bed 2d of Capitello sections. They are referred respectively to the Concavum Subzone and to topmost Bradfordensis Subzone.

Genus *Malladaites* LINARES & SANDOVAL, 1986

Type-species: *Hammatoceras pertinax* VACEK, 1886. The type-locality of the lectotype of the type-species is Capo San Vigilio.

Diagnosis: For an extensive diagnosis see LINARES & SANDOVAL (1986) and HOWARTH (2013). Diagnostic for the genus is that the minute keel disappears at the end of the phragmocone and that the ribs cross the venter strongly projected forward on the body-chamber. There exist small tubercles at the umbilical and in some species on the ventrolateral edge, disappearing normally at the end of the phragmocone.

***Malladaites pertinax* (VACEK, 1886)**

Pl. 2, Figs. 1–8

- 1886 *Perisphinctes lepis* DE GREG. – DE GREGORIO, 1886a, p. 12; pl. 19, fig. 10, 11 [nomen oblitum].
- 1886 *Perisphinctes lepis* DE GREG. F^a. *emias*. DE GREG. – DE GREGORIO, 1886a, p. 12; pl. 19, figs. 12–14 [nomen oblitum].
- 1886 *Hammatoceras pertinax* n. sp. – VACEK, p. 96, pl. 16, fig. 5 [LT] –7.
- 1886 *Perisphinctes lepis* DE GREG. – DE GREGORIO, 1886b, p. 13; pl. 9, fig. 10, 11 [nomen oblitum].
- 1886 *Perisphinctes lepis* DE GREG. mut. *emias* DE GREG. – DE GREGORIO, 1886b, p. 13; pl. 5, figs. 12–14 [nomen oblitum].
- 1964 *Z. pertinax*. – STURANI, p. 10.
- 1975 *Zurcheria pertinax* (VACEK). – HINKELBEIN, Abb. 13.
- 1986 *Malladaites* (M) *pertinax* (VACEK, 1886). – LINARES & SANDOVAL, p. 215, fig. 6 a, b; fig. 7 a, b; pl. 2, figs. 1–4 [cum syn.].
- 1988 *Malladaites pertinax*. – LINARES et al., fig. 3, pl. 2, fig. 6.
- 1991 *Malladaites pertinax*. – AMBROSI et al., p. 81.
- 1993 *Malladaites pertinax*. – LINARES & SANDOVAL, p. 196, figs. 4, 5.

- ? 1994 *Malladaites pertinax* (VACEK). – SADKI, 1994a, fig. 2.
- ? 1994 *Malladaites pertinax* (VACEK). – SADKI, 1994b, p. 315, Fig. 3.
- 1994 *Malladaites pertinax* (VACEK). – CALLOMON et al., p. 106.
- 1995 *Malladaites pertinax* (VACEK). – POCHETTINO, p. 59.
- 1996 *Malladaites pertinax* (VAC.). – SADKI, p. 133, fig. 46.
- 1996 *Malladaites pertinax*. – HENRIQUES et al., p. 145.
- 2001 *Malladaites pertinax* (VACEK). – RULLEAU et al., p. pl. 29, fig. 9.
- 2004 *Erycites pertinax* (VACEK 1886). – PALLINI† et al., p. 27.
- 2006 *Malladaites pertinax* (VACEK). – RULLEAU, p. 111, figs. 4–5.
- 2009 *Malladaites pertinax* (VACEK). – RULLEAU, p. 83; pl. 85, figs. 4–5 [LT].
- 2010 *Malladaites pertinax* (VACEK). – RULLEAU, révision planche 16, Figs 5–7.
- 2011 *Malladaites pertinax*. – SANDOVAL et al., p. 250, figs. 2, 7, 11.4.
- 2013 *M. pertinax* (VACEK). – HOWARTH, p. 115, p. 114, fig. 3 [LT].
- 2015 *Malladaites pertinax*. – SADKI, Fig. 3.

Material: 7 specimens from Monte Pomo: (Bed 5) MGPU-PU 41245, 41246, 41247, 41248, 41249, 41250, 41251. 5 further specimens are determined as *M. cf. pertinax*: 4 specimens from Monte Pomo: (Bed 5) MGPU-PU 41253, 41254, 41255, 41256); 1 specimen from Capitello Quarry: (Bed 3) MGPU-PU 41252).

Nomenclatural Status: The specific taxon “*Perisphinctes*” *lepis* DE GREGORIO, 1886a is a nomen oblitum (Art. 23.9 ICZN). We state explicitly that the younger name *pertinax* is valid. This action is taken in accordance with Article 23.9 ICZN (Art. 23.9.2. ICZN). The senior synonym “*lepis*” was to our knowledge never used as a valid name after 1899 (Art. 23.9.1.1 ICZN) and the junior synonym “*pertinax*” has been used for a particular taxon, as its presumed valid name, in at least 25 works, published by at least 10 authors in the immediately preceding 50 years and encompassing a span of not less than 10 years (Art. 23.9.1.2 ICZN). Additionally to the list in the references the taxon “*pertinax*” was used also by: FERNÁNDEZ-LÓPEZ & GOMEZ (1990), GOY et al. (1991), HERNÁNDEZ-MOLINA et al. (1991), GUTIERREZ (1992), KULLBERG et al. (1997), NIETO et al. (1996), SANDOVAL et al. (2001), SANDOVAL et al. (2007), KOZAI et al. (2011), HIRSCH (2011).

The taxon “*emias*” was used by DE GREGORIO (1886a) as F.^a (= forma) and has to be regarded as subspecific according to Art. 45.6.4. ICZN. It is also a nomen oblitum (Art. 23.9. ICZN); we refer to our comments on the name “*lepis*”. DE GREGORIO (1886b) used the name “*emias*” later as “mut.” (= mutation). If DE GREGORIO (1886b) would erect a new taxon (what

is not plausible), this taxon should become infrasubspecific (Art. 45.5. ICZN), so not available so not available and in any case a junior subjective synonym to the taxon “*pertinax*”.

Remarks: Specimen Pl. 1, Figs. 5–6 is a complete phragmocone with a small part of the body-chamber preserved. At about $\frac{3}{4}$ whorl before the end of the phragmocone, the ribbing crosses the venter sinuous over a delicate keel. At about $\frac{1}{2}$ whorl before the end of the phragmocone, the specimen develops an unusual pronounced keel, which soon fades out and which seems to be pathogenic. Pl. 1, Figs. 3–4, 7–8 are, although less complete preserved, very close to the lectotype, which is figured photographically for the first time (Pl. 1, Figs. 1–2).

Stratigraphical provenance: Spain: Betic Cordillera: Gigantea-Subzone – basal Concavum Zone (LINARES & SANDOVAL 1988); upper Bradfordensis – lower Concavum Zone (LINARES et al. 1988); Pertinax Zone [= upper Bradfordensis Zone – lower Concavum Zone] (LINARES & SANDOVAL 1988, 1993, SANDOVAL et al. 2011), Bradfordensis Subzone (HENRIQUES et al. 1996); France: Bradfordensis Zone (RULLEAU 2006, 2009); Morocco: basal Concavum Zone (SADKI 1996).

Biochronology at Capo San Vigilio: All specimens are reelaborated and come from Bed 5 of Monte Pomo and Bed 3 of Capitello sections. Both beds are aged to the early Concavum Subchron. The LT and the paralectotypes figured by VACEK (1886) come by their preservation from the lower parts of the Calcarei a *Skirroceras* del Capitello Fm (CSC).

***Malladaites sandovali* n. sp.**

Pl. 2, Figs. 10–13, 16–17

- ? 1886 *Ammonites fallax* BENECKE. – DE GREGORIO, 1886a, p. 13; pl. 23, fig. 2 (only).
 ? 1886 *Ammonites fallax* BEN. mut. *leghinus* DE GREG., DE GREGORIO, 1886b, p. 13, pl. 9, fig. 2.
 ? 1986 *Spinammatoceras* (M) *tenax* (VACEK). – LINARES & SANDOVAL, 1986a, p. 210, pl. 1, figs. 1, 3, 5.
 ? 1992 “*Spinammatoceras*” *tenax* (VACEK, 1886). – HENRIQUES, p. 148, pl. 5, fig. 12.

Material: 3 specimens from Capitello Quarry: (Bed 2d) MGPU-PU 41621, 41622, 41625.

Holotype: MGPU-PU 41622: Pl. 2, Figs. 10–11.

Locus typicus: Capitello Quarry (Capo San Vigilio).

Stratum typicum: San Vigilio Oolite, bed 2d, that is referred to the topmost Gigantea Subzone.

Derivatio nominis: in honour of our friend JOSÉ SANDOVAL GABARRÓN (Granada, Spain), who worked together with ASUNCION LINARES on the monograph of the genera *Spinammatoceras*, *Malladaites* and *Haplopleuroceras*.

Measurements (mm):

| | D | U | H | W |
|------------------|------|----|------|----|
| PU 41622 (HT) | ~ 80 | 32 | ~ 26 | - |
| PU 41621 (PT I) | 53 | 16 | ~ 23 | - |
| PU 41635 (PT II) | 46 | 14 | 19 | 15 |

Nomenclatural Status: The taxon “*leghinus*” is a nomen dubium, because the figuration is hardly detectable, and DE GREGORIO’s specimen is neither present in the Museo Regionale of Terrasini (Sicily) (personal verification by S. Cresta and G. Pavia in 1995) nor in the Museo G. GEMMELLARO of Palermo (Sicily), where the curator declared the DE GREGORIO collection as lost. So it is impossible to use the taxon “*leghinus*” because, we don’t know what it is. So we can also not decide, if the taxon “*leghinus*” is a senior subjective synonym of our newly erected species *M. sandovali* n. sp. Additionally, “*mut. leghinus*” should also regarded as infrasubspecific (Art. 45.5; 45.6.4. ICZN) and so not as an available name.

Description: The holotype (Pl. 2, Figs. 10–11) is ventrally cut obliquely, so that only the figured side is preserved, mostly with its test. The flanks of the whorls are more or less flat; the ventral area becomes broad-rounded. The whorl section of the body-chamber is high oval. The umbilical wall is steep. The primary ribs on the phragmocone begin directly at the rectangular umbilical edge. The prorsiradiate primaries are somewhat thickened, sometimes exhibiting small, protracted tubercles. At about half of the whorl the primaries split into two or three fine secondaries, sometimes with intercalated ribs. At the end of the phragmocone,

where parts of the ammonite are missing, small ventrolateral tubercles can be seen which are normally covered by the next whorl. On the body-chamber mainly the long, thickened primaries can be seen. Where the test is missing, the fine secondaries never cross the venter. At the end of the phragmocone, where the test is preserved, the prorsiradiate secondaries of both sides of the ammonite nearly touch each other ventrally. The steep umbilical wall disappears on the body-chamber and the umbilical edge becomes rounded and disappears near the end of the ammonite. The suture line cannot be observed.

Paratype I (Pl. 2, Figs. 12–13) is also half cut and only the figured side, mainly with the test, is preserved. The inner whorls were destroyed while the specimen was discovered. At the end of the phragmocone, the ribs are bundled near the umbilical edge and run somewhat falcid.

Paratype II (Pl. 2, Figs. 16–17) is a completely preserved phragmocone, mostly preserved with the test. On the flanks broad depressions can be observed, starting between the primary ribs. Whereas the straight, prorsiradiate secondaries at the end of the phragmocone are separated by a marked band, they reach each other at an earlier stage on the venter, running into a very low, sharp keel. The primaries exhibit at the umbilical edge long and small nodes that remain until the end of the phragmocone. On the ventrolateral edge small, round nodes can be observed, very close to the seam of the umbilical wall.

Remarks and differential diagnosis: At first glance these ammonites (Pl. 1, Figs. 10–13, 16–17) resemble *Spinammatoceras tenax*. However, a more deep investigation shows that an important diagnostic feature of the genus *Spinammatoceras* is missing: the two rows of prominent nodes/spines, especially the clearly visible spines on the umbilical edge on the phragmocone (see VACEK 1886, pl. 15, figs. 10–12). On the other hand, the two rows of delicate tubercles and the flat sides are typical for the genus *Malladaites*. *M. pertinax* is different from *M. sandovali* n. sp. by its smaller size, the even more parallel flanks and especially the ventral aspect of the body chamber, where the fine ribs cross the venter strongly projected forward (e. g. Pl. 2, Figs. 1–4). Confusion with other species is not possible. *M. sandovali* n. sp. seems to be an intermediate taxon between *S. tenax* and *M. pertinax*.

Stratigraphical provenance: *M. sandovali* n. sp. occurs also in the Bradfordensis-Zone of the Betic Cordillera (Spain; personal information and pictures of some specimens were sent from S. FERNÁNDEZ-LÓPEZ to V. DIETZE; coll. V. DIETZE from Tuejar, S Spain).

Biochronology at Capo San Vigilio: The holotype and the paratypes I and II of *M. sandovali* n. sp. are reelaborated within the fossil-assemblage of Capitello-Bed 2d. The bed is referred to the topmost Gigantea Subzone.

***Malladaites* nov. sp. 1 [sensu LINARES & SANDOVAL, 1986a]**

Pl. 2, Fig. 9

1986 *Malladaites* nov. gen (M) nov. sp. 1 – LINARES & SANDOVAL 1986a, p. 218, pl. 1, figs. 13–15.

1992 *Malladaites* nov. sp. 1 (LINARES et SANDOVAL, 1986). – HENRIQUES, p. 5, figs. 10–11.

1994 *Malladaites* nov. sp. 1 LINARES et SANDOVAL – SADKI et al., Fig. 10.

1995 *Malladaites* n. sp. 1 (LINARES & SANDOVAL). – HENRIQUES, p. 231, pl. 1, fig. 8.

Material: 1 specimen from Monte Pomo: (Bed 5) MGPU-PU 41263. 1 further specimen is determined as *Malladaites* cf. nov. sp. 1 from Monte Pomo: (Bed 10) MGPU-PU 41262.

Remarks: Although incomplete, the specimen on Pl. 1, Fig. 9 fits very well to the ammonites figured by LINARES & SANDOVAL (1986, pl. 1, figs. 13–15). Specimen on Pl. 1, Figs. 18–19 matches with *Malladaites* nov. sp. 1, except for its slightly less high and more rounded whorl-section and is therefore determined as *Malladaites* cf. nov. sp. 1.

Stratigraphical provenance: Spain: Betic Cordillera: basal Concavum Zone (LINARES & SANDOVAL 1988); Portugal: Bradfordensis-Subzone (HENRIQUES 1992, 1995).

Biochronology at Capo San Vigilio: Both specimens from Monte Pomo are reelaborated. MGPU-PU 41263 comes from Bed 5 that is aged to the early Concavum Subchron, whereas MGPU-PU 41262 from Bed 10 that is referred to the Formosum Subchron.

***Malladaites parvispinatus* (BUCKMAN), 1892**

Pl. 2, Figs. 26–28

1892 *Zurcheria parvispinata*, S. BUCKMAN. – BUCKMAN, p. 296, pl. 49, figs. 18–20, pl. 50, figs. 1–3.

Material: 1 specimen from Monte Pomo: (Bed ?5): MGPU-PU 41583.

Description: The minute keel, which can be seen at the beginning of the last whorl, is at its end crossed by the ventral sinuous ribbing. Whereas the tubercles at the umbilical edge end at about the beginning of the last preserved whorl, the tubercles/swollen inner ends of the primary ribs continue until the end of the preserved last whorl.

Remarks: The high-oval whorls-section of our find fits with the specimen figured by BUCKMAN (1892) on pl. 49, figs. 18–20 (the keel on fig. 19 is drawn too prominent). A comparable ammonite, with slightly denser ribbing, was figured by LELIÈVRE (1960, pl. 6, fig. 14) as *Zurcheria* cf. *pertinax* VACEK from the Aalenian of Morocco. Our specimen is morphologically intermediate to *Zurcheria* (*Parazurcheria*), however the diagnostic features of *Malladaites* are still present. The umbilical row of tubercles - which has disappeared in *Zurcheria* (*Parazurcheria*) - is in our specimen only sporadically developed: only the inner ends of the ribs are slightly swollen. The persistent row of ventrolateral tubercles, which disappears or is very reduced in *Zurcheria* (*Parazurcheria*) (cf. Pl. 2, Figs. 24–25), is still well developed in our specimen. A comparable ammonite, with slightly denser ribbing, was figured by LELIÈVRE (1960, pl. 6, fig. 14) as *Zurcheria* cf. *pertinax* (VACEK) from the Aalenian of Morocco

Stratigraphical provenance: England: probably Concavum Zone (BUCKMAN, 1892).

Biochronology at Capo San Vigilio: Specimen MGPU-PU 41583 was doubtfully collected from Bed 5, or from a bed a bit higher. In any case it comes from a layer referred to the Concavum Subzone.

***Malladaites* cf. *striatus* LINARES & SANDOVAL, 1986**

Pl. 2, Figs. 14–15, 20–23

cf. 1986 *Malladaites* (M) *striatum* nov. sp. – LINARES & SANDOVAL, 1986a, p. 216, fig. 8 a, b; fig. 9 a, c; pl. 2, figs. 9–12, 13 [HT], 14.

cf. 1986 *Malladaites* (M) *striatum* nov. sp. – LINARES & SANDOVAL, 1986b, p. 871.

cf. 1990 *Malladaites* (M.) *striatum* LINARES et alii. - BENSILI, p. 75.

Material: 5 specimens from Monte Pomo: (Bed 5) MGPU-PU 41258, 41259, 41260, 41261; (Bed 6) MGPU-PU 41257.

Description: The specimens from Capo San Vigilio show the very fine ribbing of the species *M. striatum*, which crosses, when the test is preserved, projecting forward the venter without interruption. However, they differ in exhibiting a more rounded whorl section compared to the rectangular whorl section of the material of *M. striatum* described by LINARES & SANDOVAL (1986) from the Subbetic Zone of Southern Spain. Specimen Pl. 2, Figs. 14–15 is an incomplete phragmocone, where the ribs cross the venter over a low keel, resembling already the ventral character of the genus *Haplopleuroceras*. Specimen Pl. 2, Figs. 20–21 shows just the beginning of the body-chamber: it is an internal cast so that the ventral sculpture cannot be observed.

Remarks: According to LINARES & SANDOVAL (1986a), the species *M. striatus* occurs in the uppermost Concavum Zone of the Aalenian. The finds from Monte Pomo show some more ancient characters, especially regarding the whorl-section. Probably they come from the slightly older Bradfordensis Zone (Gigantea Subzone). Such specimens as Pl. 2, Figs. 14–15 seem to be part of the ancestral stock of the genus *Haplopleuroceras* (LINARES & SANDOVAL 1986; 1996).

Stratigraphical provenance: *M. striatus* occurs in Spain in the Betic Cordillera: lower Concavum Zone (LINARES & SANDOVAL 1986); Pertinax Zone resp. upper Bradfordensis – lower Concavum Zone (SANDOVAL et al. 2011).

Biochronology at Capo San Vigilio: All specimens of *Malladaites* cf. *striatus* are reelaborated in Bed 5 and in Bed 6 that are referred to the lower part of the Concavum Zone. Such biostratigraphic evidence does not contrast with the hypothesis that these fossils were reelaborated from beds aged to the Gigantea Subzone in the uppermost Bradfordensis Zone.

Genus *Haplopleuroceras* BUCKMAN, 1892

Type-species: *Amaltheus subspinatum* BUCKMAN, 1881.

Remarks: For an extensive diagnosis of the genus we refer to LINARES & SANDOVAL (1986), HOWARTH (2013) and YIN & CHANDLER (2016). Ammonites of the genus *Haplopleuroceras* were until now not described from Capo San Vigilio.

***Haplopleuroceras subspinatum* (BUCKMAN, 1881)**

Pl. 1, Figs. 26–32

- 1881 *Amaltheus subspinatus* BUCKMAN. – BUCKMAN, p. 606.
- 1883 *Amaltheus subspinatus* BUCKMAN. – BUCKMAN, pl. 1, fig. 1.
- 1892 *Haplopleuroceras subspinatum* BUCKMAN. – BUCKMAN, p. 300; pl. 51, figs. 1–3, 6–10.
- 1988 *Haplopleuroceras subspinatum* BUCK. – CRESTA, p. 218.
- 1990 *Haplopleuroceras subspinatum*. – ROCHA et al., Fig. 2.
- 1991 *Haplopleuroceras subspinatum* (BUCKMAN, 1881). – HENRIQUES, p. 156, pl. 5, fig. 16.
- 1995 *Haplopleuroceras subspinatum* (BUCKMAN). – POCHETTINO, p. 59, 60.
- 1996 *Haplopleuroceras subspinatum* (BUCKMAN, 1881). – LINARES & SANDOVAL, p. 290, figs. 3a–d; pl. 35, figs. 1–5 [cum syn.].
- 1996 *Haplopleuroceras subspinatum*. – HENRIQUES, LINARES, SANDOVAL & URETA, fig. 3.
- 2006 *Haplopleuroceras subspinatum* BUCKMAN. – RULLEAU, p. 110, pl. 86, figs. 6a, b.
- 2009 *Haplopleuroceras subspinatum* BUCKMAN. – RULLEAU, p. 84, pl. 85, fig. 11.
- 2013 *H. subspinatum*. – HOWARTH, p. 115, fig. 78.4 [LT].
- 2016 *Haplopleuroceras subspinatum* (BUCKMAN). – YIN & CHANDLER, p. 178, 180, 184, fig. 5c [LT], 6a–b, figs. 8a, c–d.

Material: 7 mostly fragmentary specimens from Monte Pomo: (Bed 9) MGPU-PU 41484, 41488; (Bed 10) MGPU-PU 41485, 41486, 41487; (Bed 12) MGPU-PU 41482, 41483.

Remarks: All specimens are either fragmentary and/or badly preserved. For a general description of the species *H. subspinatum* we refer to LINARES & SANDOVAL (1996) and YIN & CHANDLER (2016), who described the species in detail. One fragment, too small to be

figured, is relatively broad and is determined as *H. cf. subspinatum* (MGPUT-PU 41489). The ribbing of the specimen on Pl. 1, Figs. 31–32 is relatively dense for the species, but following LINARES & SANDOVAL (1996, pl. 35, fig. 5) it lies within the variability of the morphospecies. Remarks: All *Haplopleuroceras* come from Monte Pomo.

Stratigraphical provenance: According to LINARES & SANDOVAL (1996) the morphospecies *H. subspinatum* occurs from the Concavum Zone (Upper Aalenian) to the Discites Zone (Lower Bajocian); the type-horizon of its lectotype lies in the Concavum Zone (YIN & CHANDLER 2016).

Biochronology at Capo San Vigilio: The ammonites from beds 9 and 10 are re-sedimented (taphorecord RS-1) and are dated to the late Formosum Subchron. One specimen from bed 10 and the specimens from bed 12 are re-elaborated (taphorecord RL-3) within fossil-assemblages that are referred to the Formosum Subzone. Although all nominal species of *Haplopleuroceras* seem to be just morphological segments of one (palaeo)biospecies (LINARES & SANDOVAL, 1996; YIN & CHANDLER, 2016), we assume that all our specimens originate from the Concavum Chron, because no diagnostic ammonites for the Discites Chron, especially no *Hyperlioceras*, were found until now in our sampled sections of Monte Pomo and Capitello at Capo San Vigilio (CALLOMON et al. 1994: 108). The possibility to indicate the lowermost Bajocian, Discites Zone, in Bed 13 founds on STURANI's (1964) paper for specimens of *Hyperlioceras* sp. at the base of the *Skirroceras*-limestone; most likely STURANI's finds refer to a layer higher than Bed 13. However, the genus *Hyperlioceras* occurs already in the Formosum Subzone, so that one find of this genus is not convincing for beds of the Discites Zone.

Genus *Zurcheria* DOUVILLÉ, 1885

Type-species: *Zurcheria ubaldi* DOUVILLÉ, 1885.

Subgenus *Parazurcheria* FERNÁNDEZ-LÓPEZ, 1988

Type-species: *Zurcheria (Parazurcheria) costulata* FERNÁNDEZ-LÓPEZ, MOUTERDE & ROCHA, 1988.

Remarks: We refer to FERNÁNDEZ-LÓPEZ et al. (1988) and HOWARTH (2013), who described the macroconchs as subgenus *Parazurcheria* of the genus *Zurcheria*, the microconchs being the nominal subgenus *Zurcheria*.

Zurcheria (Parazurcheria) sp. nov. 1 [sensu FERNÁNDEZ-LÓPEZ, MOUTERDE & ROCHA, 1988]

Pl. 2, Figs. 24–25

1988 *Z. (Parazurcheria) sp. nov. 1* – FERNÁNDEZ-LÓPEZ et al., p. 293, fig. 10A, B.

Material: 1 specimen from Monte Pomo from Bed 5 or from a slightly higher bed: MGPUPU 41582.

Description: The specimen is preserved with the recrystallized shell, so that an investigation of the suture-line is impossible. The ribbing consists of prominent, nearly radiate primaries, which end on the phragmocone with a delicate tubercle at the ventral edge. On the body-chamber the primaries project forward at the umbilical edge and become weaker and cross the venter as a sinus. On the body-chamber weak secondaries occur. The whorl-section is high-oval, without any keel.

Remarks: The best match in the literature is the ammonite figured as *Z. (Parazurcheria) sp. nov. 1* by FERNÁNDEZ-LÓPEZ et al. (1988, pl. 2, fig. 10). Our find is similarly evolute and shows the same ribbing style. In contrast, *Z. (Parazurcheria) inconstans* (BUCKMAN) is more involute and the ribbing weakens on the body-chamber of this species; furthermore, the whorl-section of *Z. (P.) inconstans* is more compressed compared to *Z. (P.) nov. sp. 1* sensu FERNÁNDEZ-LÓPEZ et al. Morphologically our find connects the genera *Malladaites* and *Zurcheria*: it resembles the specimen of *Malladaites parvispinatus* (BUCKMAN) figured on Pl. 2, Figs. 26–28, however showing the diagnostic features of the genus *Zurcheria*.

Stratigraphical provenance: Portugal: Concavum – Discites Zone (FERNÁNDEZ-LÓPEZ et al. 1988).

Biochronology at Capo San Vigilio: Specimen MGPUPU 41583 was doubtfully collected from Bed 5, or from a bed a bit higher. In any case it comes from a layer referred to the Concavum Zone.

Subfamily Erycitinae SPATH, 1928

Genus *Abbasitoides* GÉCZY, 1966

Type-species: *Coeloceras modestum* VACEK, 1886. The type-locality of the lectotype of the type-species is Capo San Vigilio.

Remarks: For extensive diagnoses see KOVÁCS & GÉCZY (2008), GALÁ CZ & KOVÁCS (2013) and SANDOVAL et al. (2015).

As SANDOVAL et al. (2015) we regard *Abbasitoides* in respect of its size, ornament, coiling, mouth-border and septal sutures as different from the genus *Erycites* GEMMELLARO, 1886. In contrast, *Abbasitoides* has been regarded as synonymous of the genus *Erycites* by HOWARTH (2013), whereas KOVÁCS & GÉCZY (2008) and GALÁ CZ & KOVÁCS (2013) considered *Abbasitoides* as a subgenus of *Erycites*.

Abbasitoides modestus (VACEK, 1886)

Pl. 7, Fig. 2–3, 4–5 [LT], 7–8

- 1886 *Coeloceras modestum* n. sp. – VACEK, p. 100, pl. 17, fig. 4 [LT] –6.
 1964 *Erycites* (n. subg. ?) *modestus* (VACEK). – WESTERMANN, p. 57, pl. 6, fig. 8 [LT].
 2002 *Abbasitoides modestus* (VACEK). – CRESTA & URETA, p. 235, 237, fig. 13f–h.
 2008 *Abbasitoides modestus* (VACEK). – KOVÁCS & GÉCZY, p. 83, pl. 9, figs. 2–3, pl. 13, fig. 2 [cum syn.].
 2013 *Erycites* (*Abbasitoides*) *modestus* (VACEK, 1886). – GALÁ CZ & KOVÁCS, p. 10, text-figs. 2 a–g.
 2015 *Abbasitoides modestus* (VACEK, 1886) [M] & [m?]. – SANDOVAL et al., p. 95, pl. 6, figs. 1–5 [cum syn.].

Material: 8 specimens from Monte Pomo: (Bed 3) MGPU T-PU 41502, 41503; (Bed 4) MGPU T-PU 41509; (Bed 5) MGPU T-PU 41510, 41511; (Bed 6) MGPU T-PU 41506, 41512; (bed ind.) MGPU T-PU 41515. 8 specimens from Capitello Quarry: (Bed 2d) MGPU T-PU 41505, 41513, 41514, 41516, 41517, 41518, 41519, 41520.

Description: The specimen on Pl. 7, Figs. 2–3 is perfectly preserved and complete to the peristome. The ribbing is slightly coarser and less dense as in the LT (Pl. 7, Figs. 4–5). Both specimens differ in the ventral aspect: while the ribs of the LT do not meet each other exactly on the venter, the specimen on Pl. 7, Figs. 2–3 shows a relatively broad, ventral band. The ammonite Pl. 7, Figs. 7–8 is a phragmocone matching the LT exactly.

Remarks: According to GALÁ CZ & KOVÁ CS (2013) a phylogenetic trend can be observed in *A. modestus*: the “erycitid” interruption of the ribbing at the venter seems to subside in the specimens found in younger strata, leading to a “stephanoceratid” character. *Abbasitoides modestus* may thus well be the ancestor of the equally small sized stephanoceratid genus *Mollistephanus* (SANDOVAL et al. 2000, 2015).

Stratigraphical provenance: Extensive overviews were given by KOVÁ CS & GÉ CZY (2008) and GALÁ CZ & KOVÁ CS (2013): the taxon occurs throughout the Aalenian, from the Opalinum zone to the Concavum zone, however most of the finds come from the stratigraphical interval Comptum subzone – Murchisonae zone.

Biochronology at Capo San Vigilio: Most specimens are reelaborated. The only specimen with features of resedimentation comes from Bed 3 of Monte Pomo section whose fossil-assemblage is restricted to the Murchisone Subchron. All the other specimens, from Monte Pomo and Capitello Quarry, are reelaborated fossils that pertain to the Gigantea and Concavum subzones. The LT comes by its preservation from the Oolite di San Vigilio Fm (OSV).

***Abbasitoides compressus* (PRINZ, 1904)**

Pl. 7, Figs. 16–17, 19–20

- 1904 *Coeloceras modestum* VACEK mut. nov. *compressa*. – PRINZ, p. 100, pl. 35, fig. 3 [HT].
- 1966 *Erycites (Abbasitoides) modestus crassornatus* n. subsp. – GÉ CZY, p. 118, text-fig. 103, pl. 33, figs. 2, 4 [HT] –5, pl. 43, fig. 8, pl. 44, figs. 6–7.

- 1966 *Erycites (Abbasitoides) modestus compressus*. – GÉCZY, p. 119, text-fig. 108, pl. 33, fig. 3 [HT], pl. 43, fig. 7.
- 2015 *Abbasitoides compressus* (PRINZ, 1904). – SANDOVAL, MARTÍNEZ & URETA, p. 93, pl. 5, figs. 5–8 [cum syn.].

Material: 3 specimens from Monte Pomo: (Bed 4) MGPU-PU 41496, 41497, 41498. A further specimen (bed ind., MGPU-PU 41501) has been determined as *A. cf. compressus*.

Description: The ammonite on Pl. 7, Figs. 16–17 is complete to the peristome, whereas the specimen figured at Pl. 7, Figs. 19–20 shows only the inner whorls of an incomplete phragmocone. The complete specimens exhibit the typical, dense ribbing of the species; the ribs are on the venter interrupted by a smooth band.

Remarks: As SANDOVAL et al. (2015) we regard *A. crassornatus* (GÉCZY) as synonymous of *A. compressus*.

Stratigraphical provenance: SANDOVAL et al. (2015) showed that the material from Csernye (Hungary: PRINZ, 1904; GÉCZY, 1966) comes from the Comptum/Haugi subzones. In the Subbetic Cordillera (S Spain: SANDOVAL et al., 2015) *A. compressus* occurs in the Comptum Subzone; only one specimen comes from the Haugi Subzone.

Biochronology at Capo San Vigilio: Due to the occurrence of this species in Hungary and S Spain the specimens of Capo San Vigilio come originally most likely also from the Comptum – Haugi Subchrons, though the three specimens are reelaborated fossils from Bed 4 at Monte Pomo whose fossil-assembly is taphonomically assigned to the uppermost Bradfordensis Zone, upper Gigantea Subzone.

***Abbasitoides placidus* (VACEK, 1886)**

Pl. 7, Figs. 6, 9–15

- ? 1886a *Ammonites (Hildoceras?) blampis* DE GREG. (*Lillia dilatatum* MENEGH. aff.). – DE GREGORIO, p. 13, Pl. 25, Figs. 5 a–c.
- 1886 *Coeloceras placidum* n. sp. – VACEK, p. 100, pl. 17, figs. 7–8.
- 1886 *Coeloceras pumilum* n. sp. – VACEK, p. 101, pl. 17, figs. 10–11.

- ? 1886b *Ammonites (Hildoceras) blampis* DE GREG. – DE GREGORIO, p. 11, pl. 11, figs. 5 a–c.
- 2015 *Abbasitoides modestus* (VACEK, 1886) [M] & [m?]. – SANDOVAL et al., p. 95, pl. 6, figs. 6–7.

Material: 2 specimens from Monte Pomo: (Bed 5) MGPU-PU 41504, 41507.

Nomenclatural Status: The DE GREGORIO taxon “*blampis*” is a nomen dubium. The figuration is badly drawn without showing enough characteristic features, and the specimen is neither present in the Museo Regionale of Terrasini (Sicily) (personal verification by S. Cresta and G. Pavia in 1995) nor in the Museo G. GEMMELLARO in Palermo (Sicily), where the curator declared the DE GREGORIO collection as lost. GALÁ CZ & KOVÁ CS (2008) – obviously without knowledge of the existence of DE GREGORIO (1886a) - supposed that “*Ammonites blampis*” is synonymous with *Abbasitoides placidus*. In contrast we think, that “*A. blampis*” is closer to *Abbasitoides modestum*, but there is no striking evidence for one of these opinions. The figurations of DE GREGORIO (1886a, 1886b) are doubtful, so the taxon “*blampis*” can’t be used: (1) it is not clear, what it is at all; (2) it is also impossible to decide if the taxon “*blampis*” is a senior subjective synonym with priority to either *A. placidum* or *A. modestus* – so we have to put it aside.

Remarks: The specimen figured on Pl. 7, Figs. 9–10 is a phragmocone, which fits excellently with the specimens figured by VACEK as *Coeloceras placidus*. The specimen on Pl. 7, Figs. 11–12 has got slightly less broad and high whorls, and the ventral band is not so broad. However, this specimen lies within the variability of *A. placidus*.

Two of the specimens from Capo San Vigilio we assign to the genus *Abbasitoides* are obviously microconchs. Both, *A. pumilus* (VACEK) and *A. placidus* (VACEK) are microconchs and synonyms of each other (WESTERMANN 1995, SANDOVAL et al. 2015). *A. placidus* was described earlier in VACEK’S (1886) monograph than *A. placidum*, so the former has got priority.

Stratigraphical provenance: S Spain: Bradfordensis – Concavum zones (SANDOVAL et al. 2015).

Biochronology at Capo San Vigilio: The specimens MGPU-PU 41504 and 41507 are reelaborated within the fossil-assemblages that can be aged to the earliest Concavum Zone.

bc. Family Stephanoceratidae, NEUMAYR, 1875

Genus *Riccardiceras* WESTERMANN, 1995

Type-species: *Coeloceras longalvum* VACEK, 1886. The type-locality of the lectotype of the type-species is Capo San Vigilio.

Diagnosis: For an emended diagnosis we refer to DIETZE et al. (2001), who restricted the genus to large serpenticonic stephanoceratids of the uppermost Aalenian and the lowermost Bajocian with circular whorl section and a body-chamber of about 1 1/3 whorls. Beneath the type-species *Coeloceras longalvum* VACEK they included *Coeloceras longalvum* var. *trapanica* RENZ, *Riccardiceras richardsoni* DIETZE, CHANDLER, SCHWEIGERT & AUER, *Docidoceras perfectum* BUCKMAN and *Stephanoceras telegdirothi* GÉCZY into the genus. *Riccardiceras* is an almost pandemic genus (see for details SANDOVAL et al. 2000: 32).

***Riccardiceras longalvum* (VACEK, 1886)**

Pl. 3, Figs. 1–3, Pl. 4, Figs. 1–2; Pl. 5, Figs. 1–4; Pl. 6, Figs. 1–4

- 1886 *Ammonites asgus* DE. GREG. – DE GREGORIO 1886a, p. 12, pl. 20, fig. 2 [nomen oblitum].
- 1886 *Perisphinctes inglos* DE GREG. – DE GREGORIO 1886a, p. 13, pl. 25, figs. 1–4 [nomen oblitum].
- v 1886 *Coeloceras longalvum* n. sp. – VACEK, p. 97, pl. 17, figs. 1–2 [LT].
- 1886 *Coeloceras* nov. sp. indet. – VACEK, p. 98, pl. 17, figs. 3, 3a.
- 1886 *Ammonites asgus* DE. GREG. – DE GREGORIO 1886b, p. 13, pl. 6, fig. 2 [nomen oblitum].
- 1886 *Perisphinctes inglos* DE GREG. – DE GREGORIO 1886b, p. 13, pl. 11, figs. 1–4 [nomen oblitum].
- 1925 *Docidoceras longalvum* (VACEK) var. *trapanica* (nov. var.). – RENZ, p. 30, pl. 1, fig. 6.
- v 1964 *Docidoceras longalvum* (VACEK). – WESTERMANN, p. 48, pl. 6, figs. 1–2 [LT].
- v 1994 *Stephanoceras longalvum* (VACEK). – CALLOMON et al., pp. 107, 108.
- 2000 *Riccardiceras longalvum* (VACEK, 1886) [M]. – SANDOVAL et al., p. 2, pl. 1, figs.

1–2; Pl. 2, fig. 1 [with extensive synonymy until then].

v 2001 *Riccardiceras longalvum* (VACEK). – DIETZE et al., p. 8 Fig. 6 [LT].

Material: 15 specimens from Monte Pomo: (Bed 8) MGPU-PU 41556, 41558; (Bed 9) MGPU-PU 41548, 41559; (Bed 10) MGPU-PU 41560, 41561, 41555, 41553; (Bed 12) MGPU-PU 41542, 41543, 41545, 41546, 41554; (bed ind.) MGPU-PU 41544. A further specimen (Bed 13, MGPU-PU 41557) has been determined as *R. cf. longalvum*.

Nomenclatural Status: The specific taxa *Perisphinctes inglos* DE GREGORIO, 1886a and *Ammonites asgus* DE GREGORIO, 1886a are both nomina oblita (Art. 23.9 ICZN). We state explicitly that the younger name *longalvum* is valid. This action is taken in accordance with Article 23.9 ICZN (Art. 23.9.2. ICZN).

The senior synonyms “*inglos*” and “*asgus*” were to our knowledge never used as valid names after 1899 (Art. 23.9.1.1 ICZN) and the junior synonym “*longalvum*” has been used for a particular taxon, as its presumed valid name, in at least 25 works, published by at least 10 authors in the immediately preceding 50 years and encompassing a span of not less than 10 years (Art. 23.9.1.2 ICZN). Additionally to the list in the references the taxon “*longalvum*” was used also by [the list is by far not complete]: RENZ (1925); STURANI (1964); BRAUN & JORDAN (1976); FERNÁNDEZ-LÓPEZ (1979); SANDOVAL (1983); URETA (1985); LINARES et al. (1988); CRESTA (1988); CRESTA & GALÁ CZ (1990); ROCHA et al. (1990); LINARES & SANDOVAL (1990); CECCA et al. (1990); GALÁ CZ (1991); CRESTA (1991), MOUTERDE (1991), HENRIQUES (1992); LINARES & SANDOVAL (1993); HENRIQUES (1995); WESTERMANN (1995); SADKI (1996); HENRIQUES et al. (1996); CLAPHAM et al. (2002), PALLINI † et al. (2004); RULLEAU (2009); RULLEAU (2010); GALÁ CZ (2015), YIN & CHANDLER (2016).

Description: The ammonite on Pl. 5, Figs. 3–4 matches the LT of *R. longalvum* perfectly, with the exception of its slightly larger size. On Pl. 3, Fig. 3 a small, incomplete phragmocone and on Pl. 3, Fig. 4 a phragmocone with parts of the body-chamber are also nearly identical to the LT. However, the relatively smooth body-chamber of the specimen on Pl. 3, Figs. 4 shows some resemblance to the one figured by CRESTA & GALÁ CZ (1990) from Hungary as *Docidoceras telegdirothi* (GÉ CZY). The phragmocone of the ammonite Pl. 5, Figs. 1–2 shows no differences to the LT, however the whorl-section of the body-chamber is slightly more high oval and the primaries on the body chamber are somewhat coarser compared to the LT. The specimen on Pl. 6, Figs. 3–4 shows at the umbilical edge of the phragmocone slightly more pronounced and more distant ribs compared to the LT. This feature is still more

emphasized in the specimen Pl. 4, Figs. 1–2, however on the body-chamber this feature is reduced and the distance between the primary ribs is only slightly higher as in the LT; its whorl-section and the serpenticonic character are identical to the LT. So this specimen lies still in the variability of *R. longalvum*.

The specimens on Pl. 6, Fig. 5 (MGPOT-PU 41557) shows on the phragmocone the ribbing style of the type-specimen of *Riccardiceras perfectum* (BUCKMAN) (Pl. 7, Figs. 1, 18); its prominent primaries are sharper and stand more distant compared to the LT of *R. longalvum*. In respect of the ribbing on the body-chamber, where the primaries are reduced again similar as in the LT of *R. longalvum*, we determine this specimen as *R. cf. longalvum* and consider that PU 41557 is a morphological transient to *R. perfectum*.

Comparisons: For the first time the variability of *R. longalvum* can be observed with abundant material from the type-locality. *R. perfectum* (BUCKMAN) differs from *R. longalvum* mainly by its more pronounced primaries, especially on the body chamber, and its less serpenticonic coiling. *R. telegdirothi* (GÉCZY) occurs in the Discites Zone (GALÁ CZ 2015) and represents an intermediate taxon between *R. longalvum* resp. *R. perfectum* of the uppermost Aalenian and *R. richardsoni* DIETZE, CHANDLER, SCHWEIGERT & AUER, which occurs in the Ovale and Laeviuscula Zones. The type-specimen of *R. telegdirothi* is very poorly preserved and shows nearly nothing of its sculpture, so that morphological features are very difficult to recognise. A better preserved topotype was figured by GALÁ CZ (2015, textfig. 3.4), however as *Westermannites telegdirothi* (GÉCZY, 1967).

Remarks: The origin of the genus *Riccardiceras* is discussed controversially: WESTERMANN (1995) supposes as its origin the “*Erycites*” *gonionotus* – *Abbasitoides* group. SANDOVAL et al. (2000) considered *Riccardiceras* as a direct descendant of the Erycitidae, probably from the *A. modestus* “group”, or less possibly from *Erycites gonionotus*. Although we agree that there are at present no other candidates likely, we want to point out that – in contrast to the extremely long body chamber (about 1/1/3 of a whorl) of *Riccardiceras* – the body chamber of *Abbasitoides* is very short, between ½ and ¾ of a whorl. The ribbing styles and the peristomes of both taxa are different. The biochronologically oldest *Riccardiceras* (CALLOMON & CHANDLER 2000) of the Bradfordensis/Concavum Zones are large specimens compared to the small *Abbasitoides modestus* of these levels. The large-sized *A. compressus* are known only until the Haugi Subzone, so there is a large gap between the youngest large-sized *Abbasitoides* and the oldest *Riccardiceras*. The taxonomical status of *Erycites*

gonionotus (BENECKE) is not clear without any doubts, because the BENECKE collection and thus the type-specimen are lost (CALLOMON et al. 1994). Nevertheless the figuration of BENECKE (1865, pl. 7, figs. 3a–b) and the new collected topotypes allow leaving *E. gonionotus* within the genus *Erycites*. *E. gonionotus* is for us at the moment the most probable candidate, from which the family Stephanoceratidae with *Riccardiceras* as its ancestral genus evolves.

Stratigraphical provenance: According to SANDOVAL et al. (2000): Concavum and Discites Zones (uppermost Aalenian to lowermost Bajocian). However, their interpretation of the species *R. longalvum* differs from ours.

Biochronology at Capo San Vigilio: All specimens from Monte Pomo are reelaborated. The presence of a specimen in Bed 8, referred to the passage Concavum-Formosum subzones, means that origin of *R. longalvum* ages to the Concavum Subchron together with *Graphoceras formosum*, *Eudmetoceras eudmetum* and *Haplopleuroceras subspinatum*. The other specimens come from beds 9, 10 and 12 that, on the whole, represent sedimentary episodes of the Formosum Subzone. The LT comes from the Calcari a *Skirroceras* del Capitello Fm (CSC), however not from its deepest parts.

Genus *Westermannites* DIETZE, CHANDLER, SCHWEIGERT & AUER, 2001

Type-species: *Coeloceras limatum* POMPECKJ, 1897.

Diagnosis: The genus is characterized by its coronate-cadiconic inner whorls, the bullate cross-section and the slightly eccentric coiling at the end of the phragmocone (DIETZE et al. 2001, GALÁCZ 2015).

***Westermannites* aff. *parvus* (GÉCZY, 1967) [n. sp.]**

Pl. 4, Figs. 3–5.

Material: 2 specimens from Monte Pomo: (Bed 10) MGPU-PU 41550, 41551.

Description: The specimen figured on Pl. 4, Figs. 3–5 is an incomplete phragmocone with remains of the neomorphic shell. The inner whorls are coronate-cadiconic, becoming more rounded at the end of the phragmocone (Pl. 4, Fig. 5). The whorl-section is rounded depressed. The prorsiradiate and sharp primaries start directly at the beginning of the steep umbilical wall and thicken at the sharp, coronate umbilical edge, sometimes exhibiting a small spine. Just at the beginning of the ventral area the primaries split mostly in two, sometimes in three fine secondaries, occasionally there are secondaries intercalated. The ribs are somewhat irregular at the venter, similar as in the *Riccardiceras* sp. figured by CALLOMON & CHANDLER (1990, pl. 3, figs. 1a–c as *Stephanoceras* aff. *perfectum*). Specimen MGPU-PU 41551 is ventrally half cut, smaller than the figured MGPU-PU 41550 and shows the same features.

Remarks: The greatest resemblance we could find in the literature is with the specimen of “*Docidoceras*” n. sp. (GÉCZY 1967, pl. 60, fig. 2, textfig. 2, refigured by GALÁ CZ 2015, pl. 8, figs. 7–8), however this specimen exhibits radiate primaries. With the exception of the much denser ribbing of our specimens they also fit very well to the holotype and topotypes of *Westermannites parvus* (GÉCZY 1967, pl. 59, figs. 1, 3; GALÁ CZ 2015, pl. 8, figs. 3–5), which also show prorsiradiate primaries and a coronate-cadiconic phragmocone. The irregularity of the ventral ribbing can be interpreted as a reminiscence of their “erycid” origin. GALÁ CZ (2015, pl. 7, figs. 2–3) figured a *Westermannites chocsinskyi* (HANTKEN in PRINZ, 1904) from the Concavum Zone of Csernye (Hungary).

In conclusion, the specimens represent a new species. Nevertheless, because we have only one well preserved incomplete phragmocone and a fragment in hands, we prefer to keep this taxon in open nomenclature as *Westermannites* aff. *parvus*. *Westermannites* aff. *parvus* [n. sp.] and *W. chocsinskyi* figured by GALÁ CZ (2015) show that also the origin of the genus *Westermannites* lies in the uppermost Aalenian.

Biochronology at Capo San Vigilio: Both specimens are ree laborated in the fossil-assemblage of Bed 10 that, according to the taphonomical analysis, has to be referred to the Formosum Subzone. For the same reason as stated for *Riccardiceras* we assume that *Westermannites* aff. *parvus* originates from the Concavum Subchron or the early Formosum Subchron and represents the oldest members of the genus *Westermannites*.

7. Conclusions

The Aalenian succession of Capo San Vigilio assumed high historical value by the studies of many palaeontologists of the Nineteenth Century, among which BENECKE (1865), DE GREGORIO (1886a, 1886b) and VACEK (1886) described the ammonite record with institution of many new species that are still used as reference for the Aalenian biostratigraphy. However the consistency of the diverse fossil-assemblages of that classical Aalenian remained far to be defined. On the other hand the subsequent studies by STURANI (1964) and CALLOMON et al. (1994) were not sufficient to clarify the biostratigraphical succession due to the high degree of stratigraphical and taphonomical condensation present in the Capitello Quarry section, the only available at that time. The discovery of the Monte Pomo section, thanks to the collaboration with L. AMBROSI and B. GASPARI, gave the opportunity to describe a bit more expanded succession that results to be equivalent of the site sampled by the ancient Authors, and crucial to assign appropriate biochronostratigraphical tag to ammonite assemblages. As all ammonites present in the Aalenian succession of Capo San Vigilio are affected by reworking, our study has been necessarily developed according to the the most recent practices of taphonomical analysis (FERNÁNDEZ-LÓPEZ 2011; PAVIA et al. 2013; and references therein) that distinguish in each fossil-assemblage between resedimented fossils, coeval to the encasing bed, and reelaborated fossils produced in a sediment older than the encasing sediment.

On the basis of the taphonomical analysis of both Capitello Quarry and Monte Pomo sections and the biochronological character of the sampled ammonites, each fossil-assemblage has been correlated to the biochronostratigraphical scale of the Aalenian Stage. The result (Fig. 5) makes evident the presence of recurrent hiatuses that reduce the Aalenian succession of the San Vigilio area. In particular the basal “*Skirroceras* Limestone” at the Capitello Quarry is affected by a degree of stratigraphical condensation higher than the Monte Pomo section. More in general, the studied lithostratigraphical succession that spans the top of the Oolite di San Vigilio Fm and the Calcari a *Skirroceras* Fm shows the typical sedimentological and taphonomical features of a drowning sequence. Sedimentation rates are very low, discontinuity surfaces frequent, authigenic mineral precipitation common as well as erosion, reworking, and taphonomical reelaboration. All these phenomena are due to the demise of a Bahamian-type carbonate platform which, due to increased subsidence rates, drowns and gradually changes into a submarine plateau exposed to the action of bottom currents (e.g. ZEMPOLICH, 1993). Sediments were continuously winnowed and fossils buried and exhumed repeatedly. This lasted from Middle Aalenian to the Late Bajocian when the pelagic

sediments of the Rosso Ammonitico Veronese Fm draped uniformly the whole Trento Platform (MARTIRE et al. 2006).

The ammonite sampling produced 512 specimens, of which 486 fossils were determined at specific level: 338 specimens from the Monte Pomo section and 150 specimens from the Capitello section (Appendix 1 and 2).

Due to the complex sedimentary processes in the area and the slightly different places, from where VACEK's (1886) type-material partly comes from, it is impossible to reconstruct the exact type-horizons of the type-specimens and to diagnose more as we did already in the text. However we can ascertain, that the here figured original specimens from VACEK (1886) are all resedimented.

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CAPTIONS OF FIGURES

Fig. 1 – Geographical and palaeogeographical setting of the study area. (Redrawn after BOSELLINI et al. 1981).

Fig. 2 – Stratigraphic logs of the two studied sections (Monte Pomo and Capitello).

Fig. 3

a) Photomicrograph of ooidal grainstone from the Oolite di SanVigilio Fm (Monte Pomo section, Bed 3). Note the microborings at the edge of ooids filled with dark brown Fe oxides.

b) Monte Pomo section. Discontinuity surface at beds 3-4 boundary. The top of Bed 3 is irregular and coated by Fe oxides. In the depressions, remnants of Bed 4, including reelaborated fragmentary ammonite moulds, are recognizable.

c) Monte Pomo section. The succession from top of Bed 4 to Bed 6 is exposed. Note the large intraclasts coated by thick Fe-Mn oxides in Bed 5.

d) Photomicrograph of a bioclastic grainstone of the Calcari a *Skirroceras* del Capitello Fm (Monte Pomo section, Bed 10). Thin-shelled bivalves, echinoderm debris and peloids are recognizable in addition to an intraclast made of ooidal packstone.

e) John H. Callomon standing on the top of the Oolite di SanVigilio Fm in the Capitello section in 1991.

f) Photomicrograph of the internal mould of a *Praeoppelia gracililobata*, RL3 (Monte Pomo section, Bed 8). Note: the neomorphic septa, the two generations of cement rimming the septa, and the fragment of cement-encrusted septum surrounded by sediment. The latter documents reelaboration, shell fracturing, and sediment infill.

g) Polished slab of the internal mould of a *Erycites fallifax*, RL4 (Monte Pomo section, Bed 5). Note the polyphase filling with two sediments clearly distinguishable for the colour.

h) Line drawing of g).

i) Photomicrograph of the squared area in Fig. 3h). Note the geopetal infill of chamber on the right. It shows that after the first sediment infill (S1) was laid down into the phragmocone, the shell was turned by about 25° and filled again by a second sediment generation (S2).

Fig. 4 – Reelaborated ammonites from the Aalenian of Capo San Vigilio.

a) *Ancolioceras opalinooides* (MAYER), MGPUT-PU 41375. Monte Pomo section, Bed 3.

Taphorecord RL-2. Note the absence of oxide stainings on the internal mould and the frontal fracture at the body-chamber.

- b)** *Alocolytoceras ophioneum* (BENECKE), MGPU-PU 41264 Monte Pomo section, Bed 3, Taphorecord RL-3. Thin films of Fe-oxide and glauconite stain both the neomorphic shell and the internal mould.
- c)** *Erycites fallifax* ARKELL, MGPU-PU 41426. Monte Pomo section, Bed 5. Taphorecord RL-5. Thick crusts of Fe and Mn oxides with stromatolitic aspect coat the internal mould.
- d)** *Leioceras* sp. ind., MGPU-PU 41375. Monte Pomo section, Taphorecord RL-4. The internal mould rich in Fe-oxides end with a frontal facet of disarticulation.
- e)** *Leioceras striatum* (BUCKMAN), MGPU-PU 41209. Monte Pomo section, Bed 4. Taphorecord RL-3. Thick Fe-oxide films coat both the neomorphic shell and the internal mould.
- f)** *Planammatoceras planinsigne* (VACEK), MGPU-PU 41360. Monte Pomo section, Bed 5. Taphorecord RL-5. The Fe-Oxide crust with stromatolitic aspect was partially removed during collecting work; the internal mould is rich in Fe-oxides.
- g)** *Erycites fallifax* ARKELL, MGPU-PU 41445. Monte Pomo section, Bed 3, Taphorecord RL-3. The reelaboration processes are marked by the thin Fe-oxide and glauconite film staining the neomorphic shell erosional facet cutting the distal part of the preserved body-chamber.

Fig. 5 – The biostratigraphical successions of Monte Pomo beds 3-13 and Capitello beds 2b-3 result from the taphonomical analysis of their fossil assemblages. Except for Monte Pomo beds 9 to 11, the correlation to the biochronostratigraphical scale has been done through the practice of “indirect biostratigraphy” described in the text. The displacement of the Monte Pomo figures 10–13 is a graphical convenience for an easier lecture of the scheme.

Fig. 6 – Figs. **1–6**: *Spinammatoceras pugnax* (VACEK). **1–2**: Original of VACEK (1886, pl. 16, fig. 1 [LT]), GBA 1886/5/43/1; **3–4**: CQ, Bed 3/RL 2, MGPU-PU 41632; **5–6**: MP, Bed 3/RS-1, MGPU-PU 41630.

Figs. **7–9**: *S. cf. pugnax* (VACEK), MP bed 3/RS-1, MGPU-PU 41627.

Figs. **10–13**: *S. sagax* (VACEK). **10–11**: Original of VACEK (1886, pl. 15, figs. 15, 15a, GBA 1886/5/41/2; **12–13**: MP Bed 6/RL-5, MGPU-PU 41620.

Figs. **14–17, 20–21**: *S. nov. sp.* [sensu LINARES & SANDOVAL, 1986a]. **14–15**: MP Bed 5/RL-5, MGPU-PU 41640; **16–17**: MP Bed 5/RL-4, MGPU-PU 41639; **20–21**: MP Bed 5/RL-5, MGPU-PU 41281.

Figs. **18–19, 22–25**: *S. tenax* (VACEK). **18–19**: CQ Bed 2d/RL-2, MGPUT-PU 41623; **22–23**: Original of VACEK (1886, pl. 16, figs. 10, 10a [LT]), GBA 1886/5/40/1; **24–25**: Original of VACEK (1886, pl. 16, fig. 11), GBA 1886/5/40/2.

Figs. **26–32**: *Haplopleuroceras subspinatum* (BUCKMAN). **26–27**: MP Bed 12/RL-2, MGPUT-PU 41483; **28**: MP Bed 10/RL-2, MGPUT-PU 41486; **29**: MP Bed 9/RS-1, MGPUT-PU 41484; **30**: MP Bed 12/RL-2, MGPUT-PU 41482; **31–32**: MP Bed 10/RS-1, MGPUT-PU 41487 .

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 7 – Figs. **1–8**: *Malladiates pertinax* (VACEK). **1–2**: Original of VACEK (1886, pl. 16, fig. 5 [LT]), GBA 1886/5/42/1; **3–4**: MP Bed 5/RL-5, MGPUT-PU 41249; **5–6**: MP Bed 5/RL-4, MGPUT-PU 41245; **7–8**: MP Bed 5/RL-5, MGPUT-PU 41246.

Fig. **9**: *Malladaites* nov. sp. 1 [sensu LINARES & SANDOVAL, 1886a], MP Bed 5/RL-5, MGPUT-PU 41263.

Figs. **10–13, 16–17**: *M. sandovali* n. sp. **10–11**: HT, CQ Bed 2d/RL-2, MGPUT-PU 41622; **12–13**: CQ Bed 2d/ RL-2, MGPUT-PU 41621; **16–17**: CQ Bed 2d / RL-2, MGPUT-PU 41625.

Figs. **14–15, 20–23**: *M. cf. striatus* (LINARES & SANDOVAL). **14–15**: MP Bed 6A/RL-5, MGPUT-PU 41257; **20–21**: MP Bed 5/ RL-5, MGPUT-PU 41259; **22–23**: MP Bed 5/ RL-5, MGPUT-PU 41261.

Figs. **24–25**: *Zurcheria (Parazurcheria)* sp. nov. 1 [sensu FERNÁNDEZ-LÓPEZ, MOUTERDE & ROCHA, 1988], MP Bed 5 or higher/RL-5; MGPUT-PU 41582.

Figs. **26–28**: *Malladaites parvispinatus* (BUCKMAN); MP Bed 5 or higher/ RL-5; MGPUT-PU 41583.

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 8 – Figs. **1–4**: *Riccardiceras longalvum* (VACEK). **1–2**: Original of VACEK (1886, pl. 17, fig. 1, 1a [LT]), GBA 1886/5/46/1; **3**: MP Bed 10/RL-2, MGPUT-PU 41555; **5**: MP Bed?12 [by matrix probably bed 11 or bed 12, ex coll. L. AMBROSI] / RL-2, MGPUT-PU 41544.

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 9 – Figs. **1–2**: *Riccardiceras longalvum* (VACEK); MP Bed 12/ RL-2, MGPUT-PU 41554.

Figs. **3–5**: *Westermannites* aff. *parvus* (GÉCZY) [n. sp.]; MP Bed 10/ RL-2, MGPUT-PU 41550.

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 10 – All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Figs. **1–4**: *Riccardiceras longalvum* (VACEK). **1–2**: MP Bed 9/ RL-2, MGPUT-PU 41559; **3–4**: MP Bed 8/ RL-2, MGPUT-PU 41558.

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 11 – Figs. **1–4**: *Riccardiceras longalvum* (VACEK). **1–2**: MP Bed 12/ RL-2, MGPUT-PU 41545; **3–4**: MP Bed 10/ RL-2, MGPUT-PU 41553.

Fig. **5**: *Riccardiceras* cf. *longalvum* (VACEK) [with a fragment of *Haplopleuroceras subspinatum* (BUCKMAN), indicated by an arrow]; MP Bed 13/RL-4, MGPUT-PU 41557.

All figures from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

Fig. 12 – Figs. **1, 18**: *Riccardiceras perfectum* (BUCKMAN) [HT]; Louse Hill (S England), Concavum Zone (Aalenian).

Figs. **2–5, 7–8**: *Abbasitoides modestus* (VACEK). **2, 3**: MP Bed ?5 / RL-4, MGPUT-PU 41512; **4–5**: Original of VACEK (1886, pl. 17, figs. 4–4b [LT]), GBA 1886/5/48/1; **7–8**: CQ, Bed 2d/ RL-4, PU 41505.

Figs. **6, 9–15**: *A. placidus* (VACEK): **6, 15**: Original of VACEK (1886, pl. 17, figs. 7, 7a, GBA 1886/5/49/1. **9–10**: MP Bed 5/ RL-5, MGPUT-PU 41504; **11–12**: MP Bed 5 / RL-4, MGPUT-PU 41507; **13–14**: Original of “*Coeloceras pumilum*” VACEK (1886, pl. 17, figs. 10, 10a), GBA 1886/5/50/1.

Figs. **16–17, 19–20**: *A. compressus* (GÉCZY). **16–17**: MP Bed 4/ RL-4, MGPUT-PU 41496; **19–20**: MP Bed 4/ RL-4, MGPUT-PU 41497.

All figures with the exception of Figs. 1, 18, from the Aalenian of Capo San Vigilio (Lake Garda, N Italy). All figures x1.

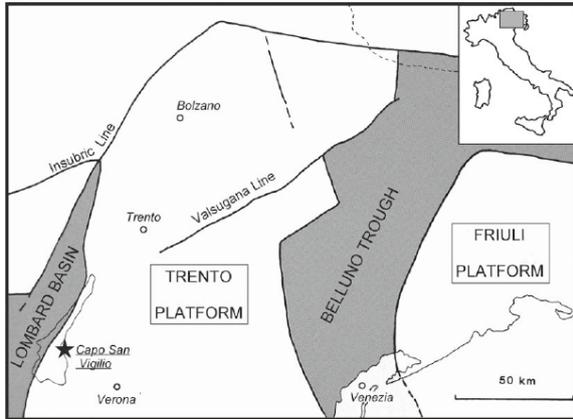


Fig. 1

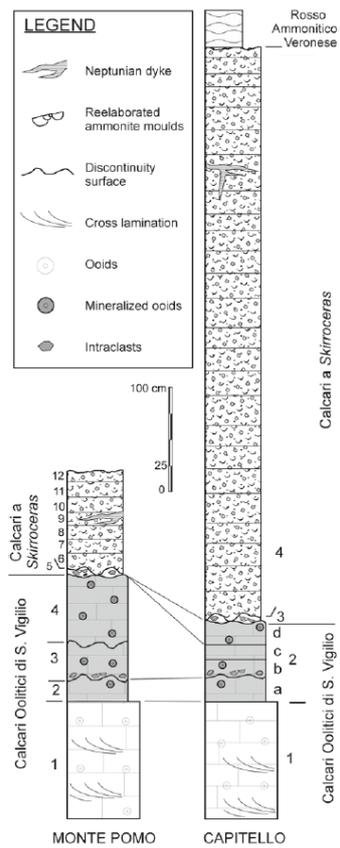


Fig. 2

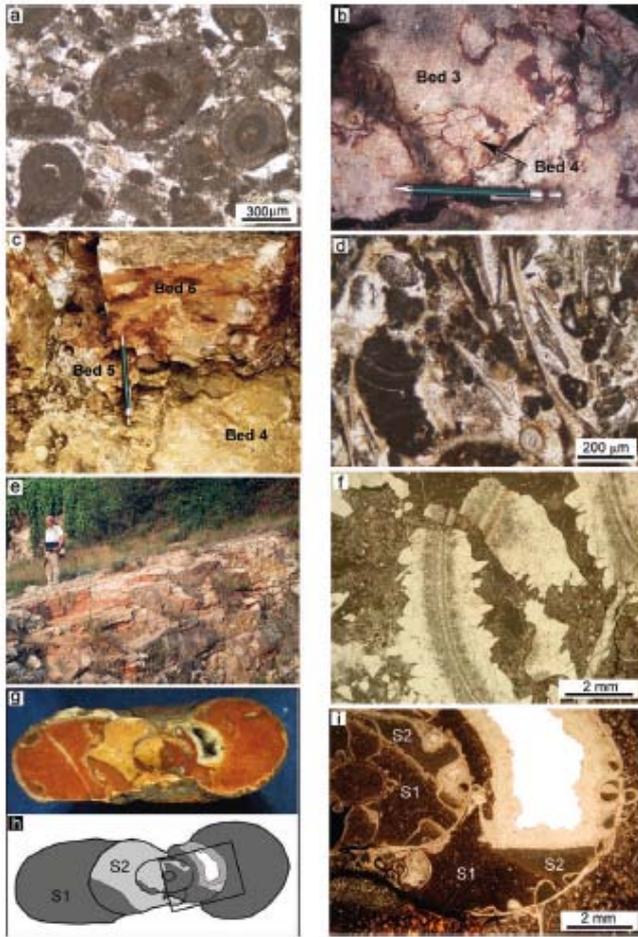


Fig. 3

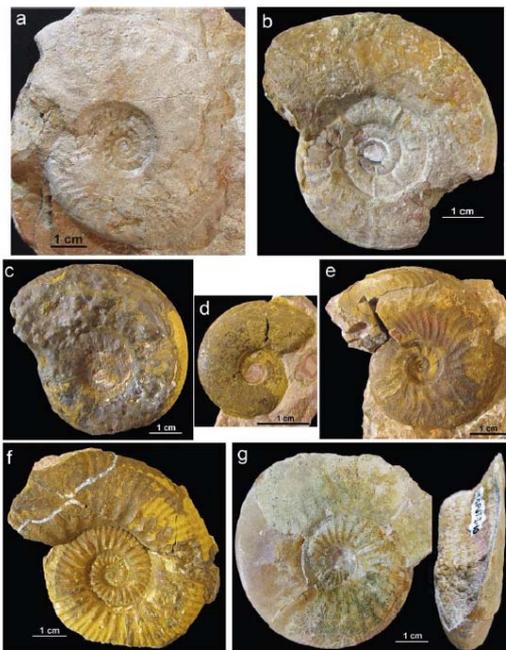


Fig. 4

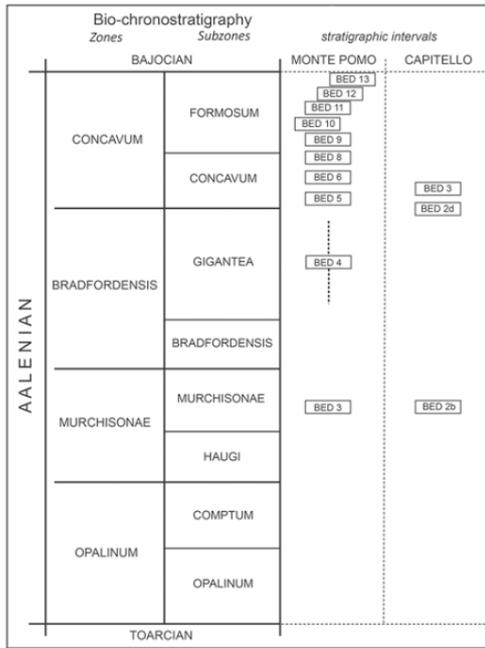


Fig. 5

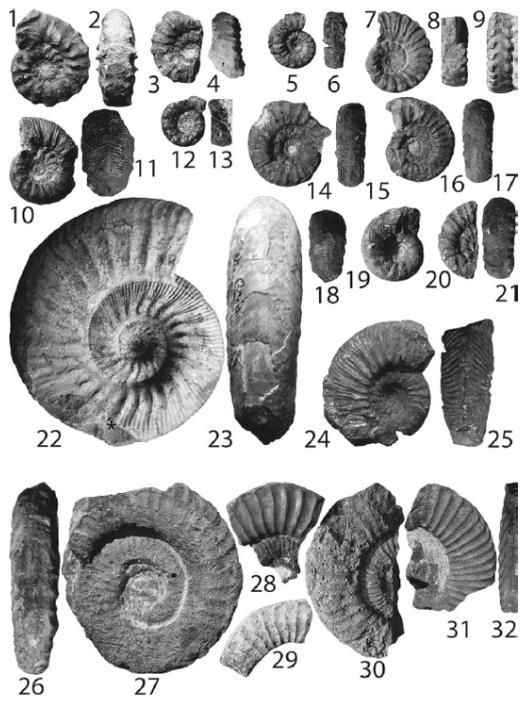


Fig. 6

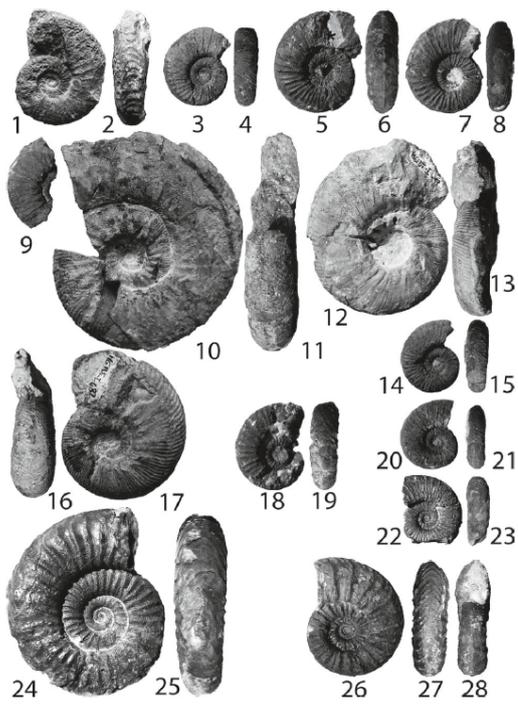


Fig. 7

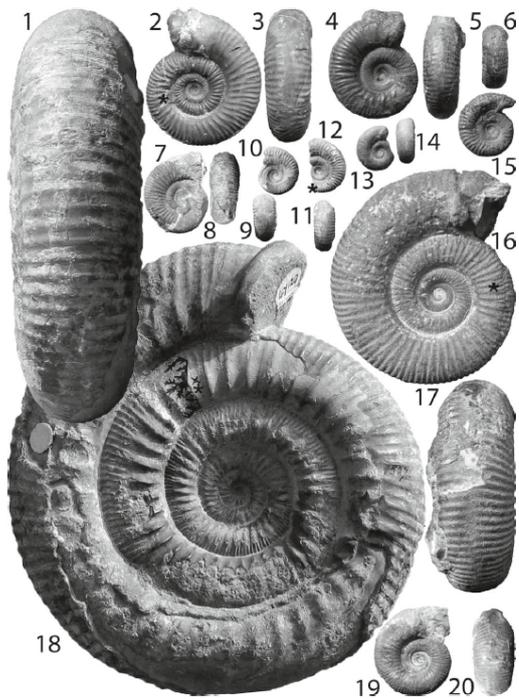


Fig. 8

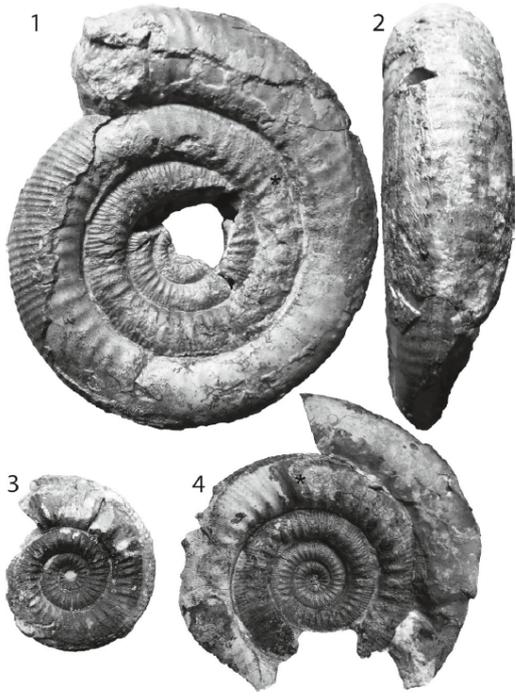


Fig. 9

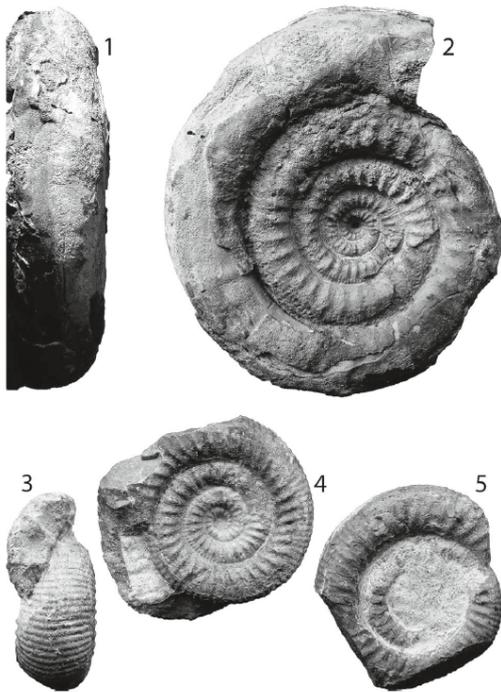


Fig. 10



Fig. 11



Fig. 12

