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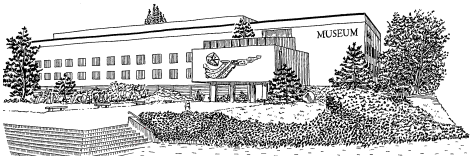

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Early Toarcian (post-OAE) Hildoceratinae (Ammonitina) fauna from the Marchean Apennines (Italy)

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Abstract
The Apennines (Italy) outcrop of the Marconessa quarry yielded a very interesting ammonite fauna of early Toarcian. Here the ammonite *Hildaites* (early Hildoceratinae) radiation is recorded after the black shales of the OAE. The earliest forms of this genus, which are useful as indexes for West Tethyan zonation, were found in assemblage with very rare *Dactylioceras* (*Orthodactylites*), which in NW Europe are suitable as indexes of the Tenuicostaum zone. The early Toarcian West Tethyan standard zonation is however questioned because the accepted indexes *H. serpentinus* and *H. levisoni* are unsuitable for the Apennines zonation and correlations. Elsewhere the authors proposed for the local Apennines zonation *H. striatus* and *H. undicosta* as indexes, being chiefly the former widespread in the West Tethyan Province. Furthermore, Hildoceratids were affected by a some degree of provincialism, which makes hard detailed correlations. On the other side, Dactylioceratids were cosmopolitan, so that they are more useful to correlate the West Tethyan and NW European Provinces. These Apennines biostratigraphical data seem to suggest that the maximun of extinction and recovery of the ammonite fauna across the OAE must be placed in the Tenuicostatum zone. New *Hildaites* taxa are here proposed, such as *H. evolutus*, *H. planiventris*, *H. bisulcatus* and *H. calamantis*.

Keywords
Apennines, Tethys, Jurassic Biostratigraphy, Early Toarcian OAE, Hildoceratinae, New species.

Résumé
Hildoceratinae (Ammonitina) fauna du Toarcien inférieur (post-OAE) de l'Apennin des Marches (Italie).- La coupe de la carrière Marconessa (Apennins, Italie) offre une grande variété et une grande richesse en ammonites du Toarcien inférieur. Ici, la radiation évolutive des ammonites du genre *Hildaites* (les plus anciennes ammonites Hildoceratinae) est enregistrée d'après le dépôt des argilites noires de l'événement anoxique du Toarcien inférieur (OAE). Les anciennes ammonites du genre *Hildaites*, qui sont ici employées comme indice zonal par la Téthys méditérranéenne, ont été recueillies en assemblage avec de très rares *Dactylioceras* (*Orthodactylites*), qui sont employées comme indices par la zone à Tenuicostatum de l'Europe du NW. La zonation standard du Toarcien inférieur est ici mise en discussion à cause de la difficulté d'employer les indices traditionnels *H. serpentinus* et *H. levisoni* pour la zonation locale des Apennins et leur corrélation. Les auteurs ont proposé ailleurs *H. striatus* et *H. undicosta* comme indices locaux des Apennins. De toute façon les corrélations sont très difficiles, car les Hildoceratidae sont atteintes d'un certain dégré de provincialisme. Au contraire les Dactylioceratidae sont ubiquistes, elles sont donc les plus utiles pour les corrélations entre la Téthys méditérranéenne et l'Europe du NW. Les nouvelles données biostratigraphiques sur les coupes des Apennins semblent suggérer que le maximum d'extinction et de survivance des ammonites pendant l'événement anoxique devrait être placé dans la zone à Tenuicostatum. L'abondance et la diversité des ammonites de la carrière Marconessa ont permis de créer plusieurs espèces nouvelles du genre *Hildaites*: *H. evolutus*, *H. planiventris*, *H. bisulcatus* et *H. calamantis*.

Mots-clés
Apennins, Tethys, Jurassique, biostratigraphie, Anoxique du Toarcien inférieur, Hildoceratinae, nouvelles espèces.

I. INTRODUCTION

This work deals with some ammonite zonal indexes, chiefly the forms of the genus *Hildaites* (Hildoceratinae, Ammonitina), which occurs during the early Toarcian in the West Tethyan (Mediterranean) Province. The lower portion of this stage is usually subdivided in two ammonite chronozones. The Tenuicostatum zone and the Serpentinum (or Falciferum) zone are commonly accepted for NW European Zonation (ARKELL, 1956; DEAN *et al.*, 1961; ELMI *et al.*, 1994; PAGE, 2004) besides for the West Tethyan Province are commonly accepted an earliest Polymorphum zone (ELMI *et al.*, 1994), index *Dactylioceras* (*Eodactylites*) *polymorphum* FUCINI, 1935, followed by a *Hildaites serpentinus* zone (*sensu* MOUTERDE, 1967; PELOSIO, 1968; ELMI *et al.*, 1974; GABILLY, 1976) or the *Hildaites levisoni* zone (*sensu* GUEX, 1973; ELMI *et al.*, 1994, 1997). This

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zonation is also adopted for the Apennines (Italy, West Tethyan Paleoprovince). The ammonite samples here studied were collected from the Marchean Apennines, where in the outcrop of Marconessa quarry (Cingoli, Macerata) was carried out a bed-by-bed biostratigraphic sampling, which yielded a very rich and well-preserved Toarcian ammonite fauna. This outcrop is located on the left side of the valley cut by Rudielle Creek in the Jurassic rock sequences, between Carcatora Mount and S. Angelo Mount (see the location map Fig. 1). Here a typical Apennines succession called Bugarone Formation occurs (CECCA *et al.*, 1990) (see the general stratigraphic column Fig. 2). Further informations on Marconessa quarry outcrop can be found in SASSAROLI & VENTURI (2005, 2010) and PASSERI (1994).

From the remarkable ammonoid collection of the Marconessa quarry outcrop were found many samples of the genus *Hildaites*, which are suitable index fossils for the early Toarcian of the West Tethyan Province. This genus prevail in number samples and biodiversity over the specimens of the subfamily Harpoceratinae, whose species are usually chosen as index fossils for the Subboreal, and Submediterranean Provinces or NW European Province (see DEAN *et al.*, 1961; HOWARTH, 1992; PAGE 1996, 2003, 2004, 2008). The current early Toarcian ammonoid standard zonation for the West Tethyan (Mediterranean) Province, instead, will be here questioned being possible another and better zonation. In the Apennines outcrops the early forms of *Hildaites* first occur after the record of the early Toarcian Oceanic

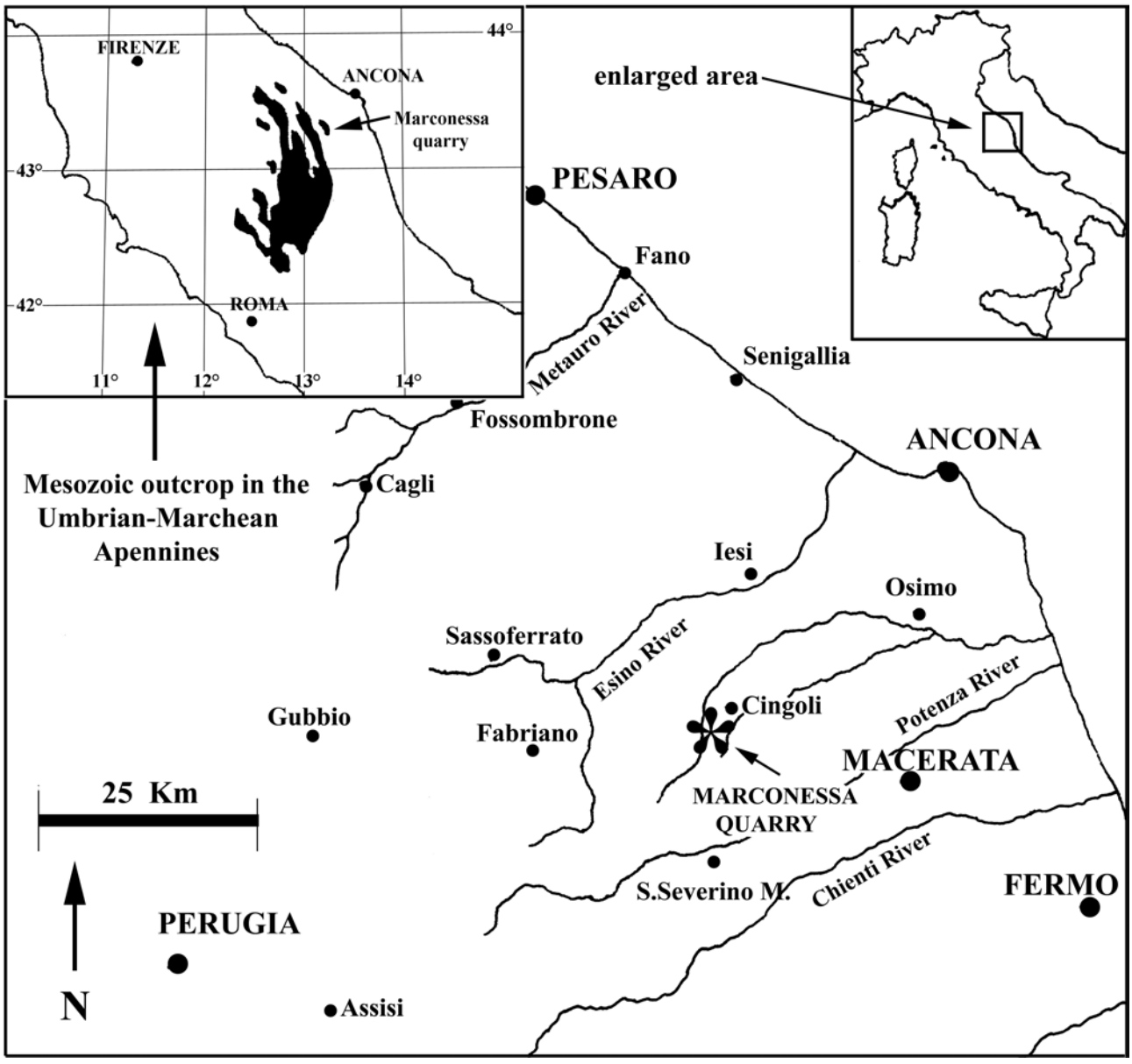

Fig. 1: Location map of the Marconessa quarry, near Cingoli (Macerata), Italy.

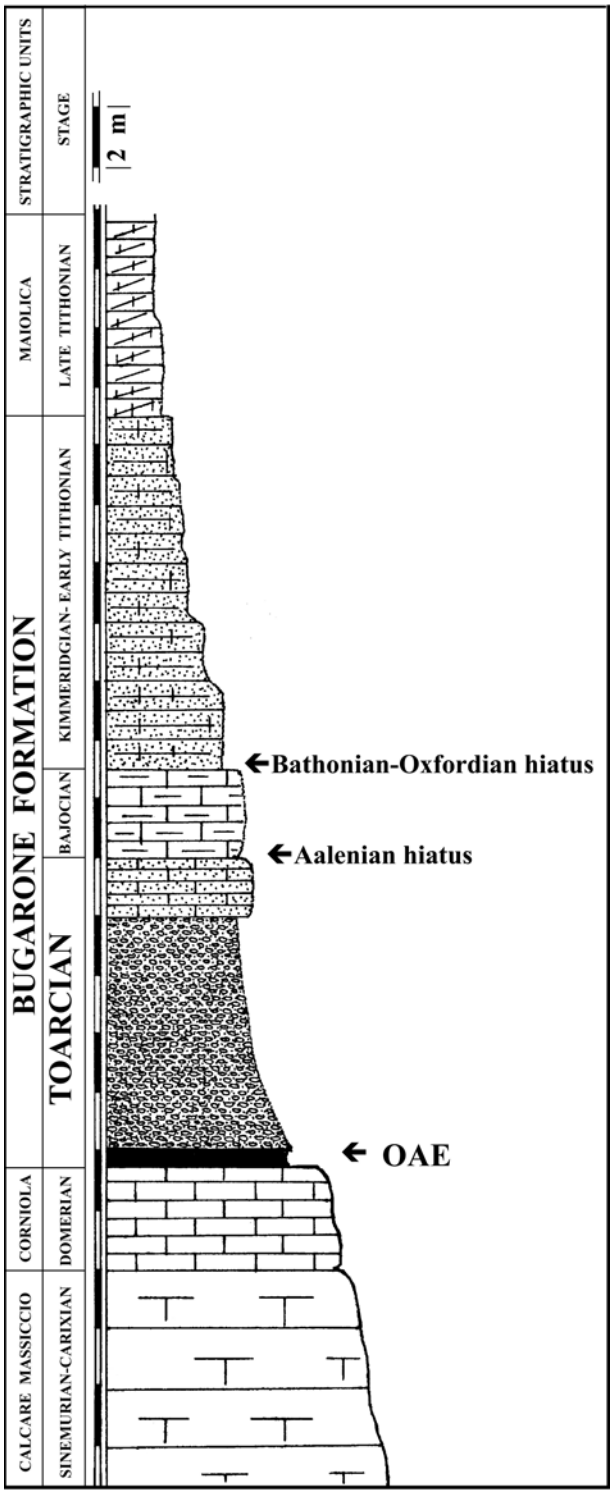

Fig. 2: Stratigraphic column of the Bugarone Formation in the Marconessa quarry outcrop.

Anoxic Event (OAE) (Jenkins, 1988; McArthur *et al.*, 2000; Bailey *et al.*, 2003; Sabatino *et al.*, 2009), when a sudden event of extinction, recovery and origination of several ammonite lineages can be observed in the fossil record (Sassaroli & Venturi, 2010; Bilotta *et al.*, 2010; Dera *et al.*, 2010; Faraoni *et al.*, 1994; Macchioni, 2002a; Macchioni & Cecca, 2002; Cecca & Macchioni, 2004). The current Mediterranean standard zonation is unsuitable to report the ammonites faunal turnover across the OAE observed in the Apennines outcrops, as well as to correlate the West Mediterranean Province to the Subboreal and Submediterranean Provinces. For instance, there is not evidences of the recording of *Hildaites levisoni* (Simpson, 1843) and *Hildaites serpentinus* (Reinecke, 1818) in the Apennines. Besides, other species such as *Hildaites striatus* Guex, 1973 and *Hildaites undicosta* (Merla, 1932) were found copiously in the Apennines sections and in other Mediterranean sections, and they are also better morphologically and chronologically defined. Thus, they are more suitable as indexes (Sassaroli & Venturi, 2010; Bilotta *et al.*, 2010).

Nevertheless, during the late Pleinsbachian-early Toarcian the Hildoceratids taxa were affected by provincialism (Howarth, 1973; Page, 2008; Bilotta *et al.*, 2010) whereas Dactylioceratids, which are commonly useful indexes in the NW Europe zonation, seem to have a worldwide dispersal from Pliensbachian-Toarcian boundary (Howarth, 1973; Mouterde & Elmi, 1991; Page, 2008). In the Marconessa quarry outcrop very rare Dactylioceratids of the NW European Tenuicostatum zone were found in the local Apennines Striatus zone. This finding can help to get a new insight on the questions of the dating the OAE and the Pliensbachian-Toarcian boundary. Furthermore, there is evidence of an ammonite radiation immediately after the OAE biological crisis, which was recorded in the local Apennines Striatus zone, whereas the ammonite fauna pre-OAE has clearly a late Pliensbachian (uppermost Domerian) affinity (Faraoni *et al.*, 1994; Bilotta *et al.*, 2010).

II. EARLY TOARCIAN AMMONITE ZONATION

During the late Pliensbachian (upper Domerian) and the early Toarcian, according to Page (1996, 2003, 2004, 2008), European and Mediterranean palaeobiogeography seems to be subdivided in three Provinces: a Suboreal Province (England, northern Germany, northern France, Russian Platform); a Submediterranean Province (northern Spain, southern and central France, southern Germany, Portugal, etc.) and a Mediterranean or West Tethyan Province (Italy, Greece, Austria, Hungary, southern Spain, North Africa). Whereas, in the late Toarcian both Subboreal and Submediterranean Provinces were included into a Northwest (NW) European Province, which retains its difference with the West Tethyan Province. However, during the late Pliensbachian-early Toarcian, when connections between the Boreal and the Tethys seem to be first established, a partial ammonite faunas interchange between these Provinces occurred.

The British sections studied by Howarth (1955, 1956, 1957, 1962a, b, 1973a, b, 1978, 1980, 1992) record a

typical Subboreal ammonite faunas in the Yorkshire coast and the Hebrides or a transitional ammonite fauna between the Subboreal and Submediterranean Provinces (reference sections located in Leicestershire, Northamptonshire, Somerset and Dorset coast). In the late Pliensbachian the British ammonite faunas are characterized by late Liparoceratidae as *Pleuroceras*, whereas in the early Toarcian by Dactylioceratidae (*Orthodactylites*), which are dominating, and Hildoceratidae (early Harpoceratinae, mainly *Elegantuliceras*, *Ovaticeras* and *Pseudolioceras*; early Hildoceratinae (some *Hildaites*, *Orthildaites* and mainly later *Hildoceras*). On the contrary, the French Submediterranean sections studied by GABILLY, 1976 (Thouars reference section, Western France); ELMI & RULLEAU, 1991, RULLEAU *et al.*, 2001 (Carrières Lafarge references sections, near Lyon, Eastern France) and BÉCAUD, 2006 (Deux-Sèvres and Vendée reference sections, Western France) have instead recorded a typical Submediterranean ammonite fauna, which show Hildoceratidae (Harpoceratinae and Hildoceratinae) usually dominating whereas, the Dactylioceratidae (*Eodactylites*, *Orthodactylites*) dominates only the underlying levels of the Toarcian beginning. This framework seems to be confirmed by the ammonite faunas found in the proposed Toarcian GSSP section of Peniche (Portugal), where in the Pliensbachian-Toarcian boundary a Tethyan fauna characterized by Dactylioceratidae (i.e. early *Dactylioceras* such as *Eodactylites* and *Orthodactylites*, which traditionally marks the beginning of the Toarcian) and Hildoceratidae (*Emaciaticeras*, *Canavaria*, *Tauromeniceras*, *Lioceratoides*, *Neolioceratoides*, *Tiltoniceras*, *Protogrammoceras*, *Paltarpites*) occurs (ELMI, 2006, 2007; ELMI *et al.*, 2007; MOUTERDE *et al.*, 2007). Finally, the West Tethyan sections (ELMI *et al.*, 1974, Algeria reference sections; GUEX 1973, Morocco reference sections; KOTTEK, 1966, Greece reference sections; JIMÉNEZ JIMÉNEZ & RIVAS CARRERA, 1991, 1992, Betic Cordillera reference section; FARAONI *et al.*, 1994 and SASSAROLI & VENTURI, 2010, Apennines reference sections) are characterized by Phylloceratidae and Lytoceratidae, which are widely dominating at several levels, and by Hildoceratidae (Protogrammoceratinae, typical endemic West Mediterranean Harpoceratinae such as *Taffertia*, *Martanites*, early Hildoceratinae such as *Hildaites*). Dactylioceratids, with the only exception at some levels of early *Dactylioceras* (*Eodactylites*, *sensu* SCHMIDT-EFFING, 1972), are rare (as *Orthodactylites*, *sensu* BUCKMAN) or absent in the most levels, as well as the late Liparoceratidae (*Pleuroceras*).

Despite of the three Provinces were neighbouring and probably connected between the late Pliensbachian and the early Toarcian, difficult to correlate them arisen. Firstly, because the taxa occurrence shows sometimes a different dispersal in space and time through the Subboreal, Submediterranean and West Tethyan Provinces, where they can be locally rich, but also rare or absent in the sections sampled. Secondly, because to characterize and to correlate the three Provinces, the taxa used as indexes for the zones and subzones are different and sometimes misinterpreted by workers or also really absent. ELMI *et al.* (1994, 1997) have provided an updated Toarcian ammonite standard zonation and related correlations between the NW European and West Tethyan Provinces. PAGE (2003, 2004) more recently carried out an updated correlation framework between the Subboreal and Submediterranean Provinces, generally based on the classical British Toarcian ammonite zonation provided by DEAN *et al.* (1961) and HOWARTH (1992).

Harpoceratinae and Dactylioceratinae were used as indexes for the early Toarcian zonation mainly by British workers. DEAN *et al.* (1961) confirmed the *Spinatum* zone and *Spinatum hemerae* [index: *Pleuroceras spinatum* (BRUGUIÈRE, 1789)] introduced respectively by OPPEL (1856) and BUCKMAN (1930) to mark the late Pliensbachian (upper Domerian) in the NW European Province. The following Toarcian stage (OPPEL, 1856) includes three zones: a Tenuicostatum zone [index: *Dactylioceras* (*Orthodactylites*) *tenuicostatum* (YOUNG & BIRD, 1822)]; a Falcifer (=Falciferum) zone [index: *Harpoceras falcifer = H. falciferum* (SOWERBY, 1820)] and a Bifrons zone [index: *Hildoceras bifrons* (BRUGUIÈRE, 1789)]. The Falciferum zone *sensu* DEAN *et al.* (1961) should be characterized by the occurrence of *Eleganticeras* (*Elegantuliceras*) and *Harpoceras* in assemblage with *Dactylioceras* (*Orthodactylites*) and *Hildaites* and it has two subzones: an Exaratum subzone [index: *Harpoceras* (*Cleviceras*) *exaratum* (YOUNG & BIRD, 1822)] and a Falcifer (=Falciferum) subzone. The overlying Bifons zone, which covers the whole range of *Hildoceras* (excluding *Hildaites*), was subdivided in three subzones characterized by Dactylioceratidae: Commune subzone [index: *Dactylioceras* (*Dactylioceras*) *commune* (SOWERBY, 1815)]; Fibulatum Subzone [index: *Peronoceras fibulatum* (SOWERBY, 1923)] and Braunianus subzone [index: *Zugodactylites braunianus* (D'ORBIGNY, 1845)]. This zonation was basically confirmed by HOWARTH (1992) with a few exceptions, because the four horizons of the Tenuicostatum zone *sensu* DEAN *et al.* (1961) were replaced by four subzones: a Paltum subzone [index: *Protogrammoceras paltum* (BUCKMAN, 1922)] where no *Dactylioceras* (*Orthodactylites*) occurs; a Clevelandicum subzone [index: *Dactylioceras* (*Orthodactylites*) *clevelandicum* HOWARTH, 1973; a Tenuicostatum subzone and a Semicelatum subzone (index: *Dactylioceras* (*Orthodactylites*) *semicelatum* (SIMPSON, 1843)]. Furthermore, HOWARTH (1992) replaces the Braunianus subzone (uppermost Bifrons zone) with the Crassum subzone [index: *Catacoeloceras crassum* (YOUNG & BIRD, 1828)]. More recently this zonation was accepted by PAGE (2003, 2004), who nevertheless contrary to DEAN *et al.* (1961) and HOWARTH (1992) replaces the Falciferum zone with the Serpentinum zone (OPPEL, 1856) [index: *Harpoceras*

serpentinum (SCHLOTHEIM, 1813)] for reason of priority over *Harpoceras falciferum*, so that the comparison between the zonation of the British sections and the standard zonation of the Submediterranean Province (ELMI *et al.*, 1994, 1997) becomes easier at zone level. In fact, the standard zonation proposed by ELMI *et al.* (1994, 1997) includes the same zones: Tenuicostatum zone, Serpentinum zone and Bifrons zone. However, some differences remain at subzone level, because the Tenuicostatum zone is subdivided in only two subzones: Paltum subzone and Semicelatum subzone. The Serpentinum zone is subdivided in an Elegantulum subzone [index: *Eleganticeras elegantulum* (YOUNG & BIRD, 1822)] and a Falciferum subzone. Finally, the Bifrons zone is subdivided in a Sublevisoni zone (index: *Hildoceras sublevisoni* FUCINI, 1922), being the early *Hildoceras* rare or absent in the British section, and a Bifrons subzone. Nevertheless, at biohorizon/zonule level many differences noticeably remain (see PAGE, 2004; DE GRACIANSKY *et al.*, 1998). The Submediterranean standard zonation was recently accepted without changes by BÉCAUD (2006).

The NW European Harpoceratinae and Dactylioceratinae, wich were used as indexes to partially successful correlate the Subboreal and Submediterranean Provinces, are scarcely useful for the early Toarcian zonation of the West Tethyan Province (DONOVAN, 1958; KOTTEK, 1966; PELOSIO, 1968; GALLITELLI WENDT, 1969; ELMI *et al.*, 1974; GUEX, 1973). *Harpoceras serpentinum,* which seems to be a very common and well substantiated form in the NW European and Sub-Mediterranean Provinces, is uncommon and not well recorded in the West Tethyan Province, as well as in the Apennines section. The typical NW European forms *Eleganticeras elegantulum* and *Cleviceras exaratum* were never found in the Apennines and the most West Tethyan sections, where were collected other typical early Harpoceratinae genera, such as *Martanites* (VENTURI, 1996) and *Taffertia* (GUEX, 1973), despite of MACCHIONI's (2001 and 2002a) taxa misinterpretation. According to DONOVAN (1958), PINNA (1968), GALLITELLI WENDT (1969) and ELMI *et al.* (1974) *Harpoceras falciferum* is not useful for West Tethyan zonation. The PINNA's subspecies *H. falciferum mediterraneum,* not formally established at the species level by GUEX, 1973, is also unsuitable, because not well morphologically and stratigraphically defined. Indeed, in some section of the Apennines (unpublished data), we found many forms comparable to *H. falciferum*, but they occur only in the Bifrons zone. The early *Dactylioceras* (*Eodactylites*) species such as *mirabile*, *polymorphum*, *pseudocommune*, *simplex*, *tauromense*, firstly collected by FUCINI (1935) in Taormina (Sicily), seems to be common and well substantiated in some West Tethyan sections (GUEX, 1973; FARAONI *et al.*, 1994), but it is still controversial the question whether their first occurrence was the early Toarcian or the late Pliensbachian (upper Domerian) (FISCHER, 1966; FERRETTI, 1967, 1970, 1972, 1990; CANTALUPPI, 1968, 1970; CANTALUPPI & SAVI, 1968; CANTALUPPI & MONTANARI, 1969; CANTALUPPI & CASSINIS, 1984; PINNA & LEVI SETTI, 1971; SCHMIDT-EFFING, 1972; GUEX, 1973; SCHLATTER, 1982, 1985; GAKOVIC, 1986; FARAONI *et al.*, 1994; RAKUS, 1995; NINI *et al.*, 1996; PARISI *et al.*, 1998; ELMI, 2006 and 2007; ELMI *et al.*, 2007; BILOTTA *et al.*, 2010). Other Dactylioceratids (*Dactylioceras* and *Orthodactylites*) common in the NW European Province and used as indexes for the Falciferum/Serpentinum and Bifrons zones are rare or also absent, and usually not well substantiated in the West Tethyan Province (PINNA & LEVI SETTI, 1971). For a synthetic correlations chart among the ammonite zonation of the European and the Mediterranean Provinces see Fig. 10.

Several authors have more properly used some Hildoceratinae as index fossils for the early Toarcian West Tethyan zonation (KOTTEK, 1966; MOUTERDE, 1967; PELOSIO, 1968; GUEX, 1973; ELMI *et al.*, 1974). This choice is preferable being this taxon better substantiated than other taxa and it widely characterizes also, excluding Phylloceratidae and Lytoceratidae, the early Toarcian ammonite fauna in all West Mediterranean sections, as well as in the Apennines sections. Contrary to DONOVAN (1958) opinion, based on data collected mainly in the classical Valdorbia outcrop, which unfortunately has recorded an early Toarcian low stratigraphical resolution with a few levels and some also reworked (MONACO, 1992; CARACUEL *et al.*, 2000), the well known species of the genus *Hildoceras* are the best indexes for the Bifrons zone. They can be useful to easily correlate the West Tethyan and Submediterranean Provinces at subzone and biohorizon/zonule levels. Besides, the genus *Hildaites* may be used for the earliest Toarcian zonation in the West Tethyan as substitute for *Harpoceras* and *Dactylioceras*. Nevertheless, the *Hildaites* species used as indexes by the above quoted authors, such as *H. propeserpentinus*, *H. levisoni* and *H. serpentinus* are not suitable as indexes, at least for the local Apennines sections zonation. In fact, the forms assigned by KOTTEK (1966) to *Hildaites propeserpentinus* BUCKMAN, 1921, which is believed by HOWARTH (1992) to be a synonym of *Hildaites murleyi* (MOXON, 1841), are instead samples of *Hildaites undicosta* (MERLA, 1932). On the other side, *Hildaites levisoni* (SIMPSON, 1843) is clearly an unreliable taxon, because usually affected by workers misinterpretation. In fact *H. levisoni* is believed by HOWARTH (1992) to be another synonym of *H. murleyi*. However, the small sized *H. levisoni* holotype figured by BUCKMAN (1921, pl. 12, figs. 1a-1b) and refigured by HOWARTH (1992, pl. 31, figs. 2a-2b) remarkably differs from the small sized *H. murleyi* holotype, which was figured by BUCKMAN (1921, pl. 216, figs. 1-2-3) and refigured by HOWARTH (1992, pl 30, figs. 10a-10b), for the venter size, which is wider and tabulate in *H. murleyi*, and the ribs appearance, which are coarser and falcoid-sinuous from the inner whorls in *H. murleyi*. On the contrary, the *H. levisoni*

holotype shows a narrower weakly bisulcate venter and finer and biconcave ribs in the inner whorls. Therefore, it is not surprising that under the name *H. levisoni* were figured very different each other morphologies characterized by uncertain or various stratigraphical occurrence, as made for example by ZANZUCCHI (1963, Tav. 18, figs. 5-5a), GALLITELLI WENDT (1969, pl. 3, figs. 1a-1b), GUEX (1973, pl. 11, fig. 2; pl. 7, fig. 1 and pl. 14, fig. 14), WIEDENMAYER (1980: 99); MAUBEUGE (1984: 92-93), JIMÉNEZ JIMÉNEZ & RIVAS CARRERA (1992, pl. 5), FARAONI *et al.* (1994, pl. 13, fig. 22) and BÉCAUD (2006, pl. 36, figs. 1a-b).

Finally, *Hildaites serpentinus* is also an unreliable taxon for the West Tethyan (see ARKELL, 1956: 35) and mainly for the local Apennines zonation. In fact, *Argonauta serpentinus* REINECKE, 1818, is probably a sample of *Harpoceras*. The *Hildoceras serpentinus* (REINECKE) THOMPSON, 1909, is believed by HOWARTH (1992) to be a synonym of *Hildaites subserpentinus*. GUEX (1973) never found *H. serpentinus* in the Moroccan section and this taxon was never found in the Apennines and in the South Alps. The not figured specimen by RAMACCIONI is unreliable (1939) and the not bedded specimens figured by ZANZUCCHI (1963, Tav. XVIII, figs. 1-3-6-7-8; the sample of fig.1 was also refigured by PINNA, 1969, Tav.1, fig. 16), seem to be synonyms of *H. subserpentinus* (figs. 1-7-8) or *H. striatus* (figs. 3-6). The Greek specimen figured by KOTTEK (1966, pl. VI, fig. 2) is also synonym of *H. subserpentinus*. Therefore, the occurrence of *H. serpentinus* in all West Mediterranean sections is uncertain. For a synthetic correlation chart of the Apennines outcrops see Fig. 9.

The above reasons lead us already to choose *Hildaites striatus* GUEX, 1973, and *Hildaites undicosta* (MERLA, 1932) as indexes for early Toarcian local Apenninic sections and to proceed then in correlating and calibrating the West Tethyan, Submediterranean and Subboreal Provinces zonations (SASSAROLI & VENTURI, 2010, see also BILOTTA *et al.*, 2010).

III. EARLY TOARCIAN BIOSTRATIGRAPHY OF THE MARCONESSA QUARRY OUTCROP

In the sloping outcrop of the Marconessa quarry we carried out a bed-by-bed sampling across three section placed at different altitude. In section one (1) we have sampled in the bottom of early Toarcian post-OAE a first bed only, because the quarrying promptly covers again the strata. In section two (2) we have sampled a thickness of more than two meters of the nodular limestone and grey marls, which includes the early Toarcian until the bottom of the *Bifrons* zone (see log Fig. 3). In section three (3) we have sampled a thickness of more than five meters, which includes the early and middle Toarcian and over (see log Fig. 4). In this outcrop at the top of Corniola limestone a hardground surface rich in pyrite nodule and probably late Pliensbachian in age occurs, which records the marine regression phase and probably a gap in sedimentation according to GABILLY *et al.*, 1985; GUEX *et al.*, 2001 and MORARD *et al.*, 2003. This gap probably affects the Mirabile subzone, which was here unrecorded but it is well recorded in other Apennines outcrops (FARAONI *et al.*, 1994; BILOTTA *et al.*, 2010). Immediately over the black shale of the well-known early Toarcian Oceanic Anoxic Event (T-OAE) rich in organic matter occur, which records the beginning of a marine transgression phase. The thickness of the OAE level, which is barren, varies about from 10 cm to 50 cm along the outcrop. These paleoevents are also recorded in other studied Apennines sections (FARAONI *et al.*, 1994; NINI *et al.*; 1996, PARISI *et al.*, 1998; BILOTTA *et al.*, 2010). Near the top of underlying Corniola limestone were collected ammonoid specimens difficult to recognise, because badly preserved. However, some of them were recognized as *Juraphyllites libertus*, *Neolioceratoides hoffmanni*, *Neolioceratoides schopeni*, *Protogrammoceras* sp. indet. This fauna can be dated to the late Pliensbachian (upper Domerian) according to CANTALUPPI (1970) and CANTALUPPI & SAVI (1968), (see also WILMSEN *et al.*, 2002 and MEISTER *et al.*, 2011). The overlying Toarcian nodular limestone and grey marl levels yielded a rich and well preserved ammonite fauna with several sample of large size and sometime encrusted of pyrite, which is a phenomenon clearly related to an anoxic environment, which still continued in the seamounts of the Bugarone Formation.

In section 1 the genera *Hildaites*, *Dactylioceras* (*Orthodactylites*), *Rakusites*, *Taffertia*, which are all meaningful taxa for a biostratigraphical account, firstly occur. Unfortunately, in this section we have collected ammonites from the basal level immediately over the OAE black shale, because this outcrop was suddenly covered by quarring. In sections 2 and 3 a limestone layer of different thickness occurs above the OAE black shales, where we have observed the first occurrence of the genus *Hildaites*. Above this layer the nodular limestone and grey marls occur, with several beds yielded ammonites of the genera *Hildaites*, *Cingolites*, *Orthildaites*, *Leukadiella*, *Renziceras*, *Harpoceras*, *Martanites*, *Rarenodia*, early "*Phymatoceras*", *Dactylioceras* (*Orthodactylites*), *Rakusites*, *Taffertia*, *Nodicoeloceras*, *Phylloceras*, *Calliphylloceras*, *Lytoceras*. This ammonite assemblage marks the beginning of the Toarcian as recorded in the Apennines outcrop of the Marconessa quarry, which we subdivided in the earliest Striatus zone, followed by the Undicosta zone and finally overhanging by a Bifrons zone, which traditionally begins with the first occurrence of the genus *Hildoceras* (see range chart Fig. 3 and Fig. 4; a more exhaustive bed-by-bed ammonite biostratigraphical framework of the Marconessa quarry outcrop, although still provisional, can be read in SASSAROLI & VENTURI, 2010).

The Striatus zone is characterized by massive occurrence

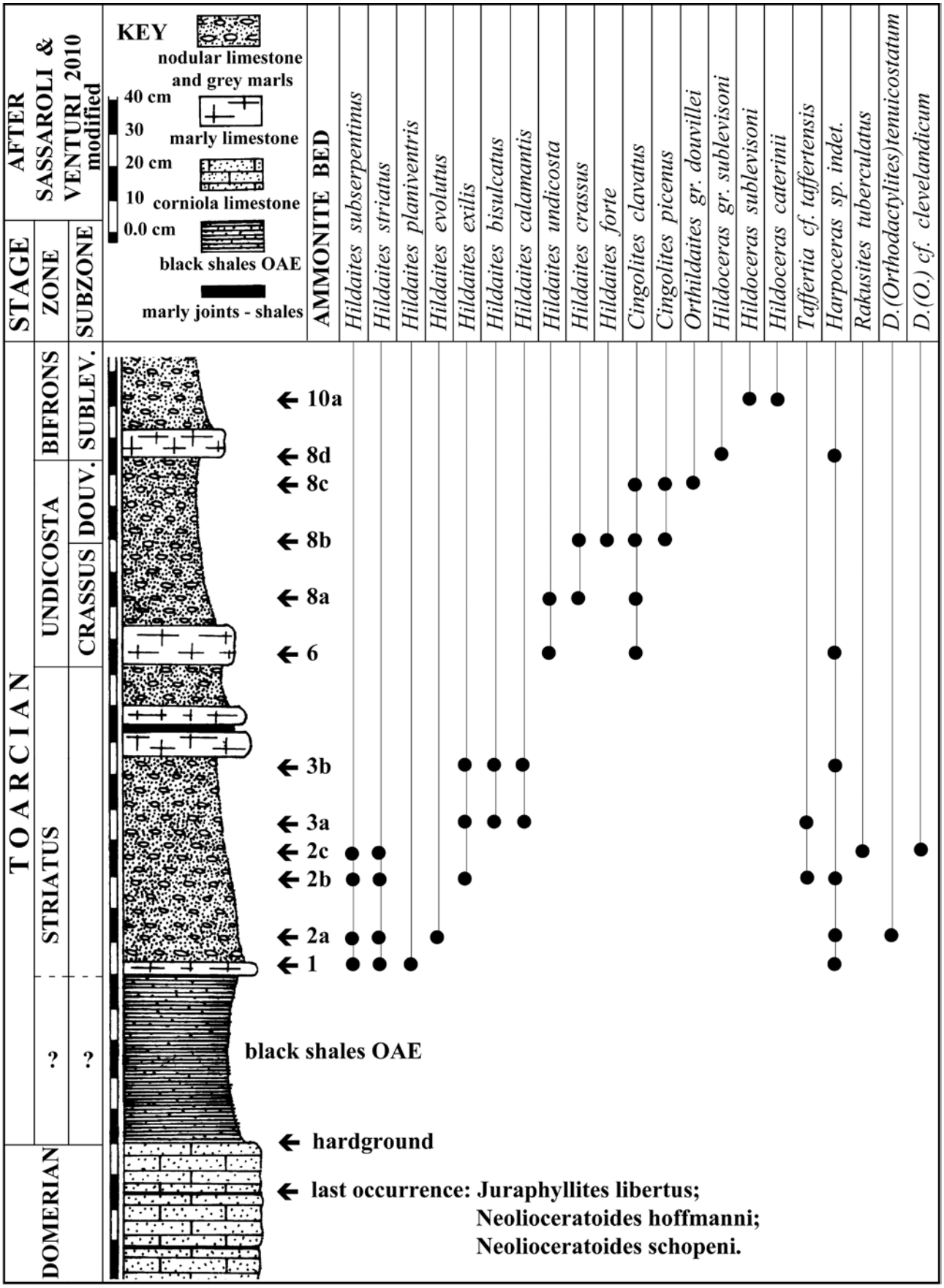

Fig. 3: Log of the Marconessa quarry section 2 and range chart of Hildoceratinae and other major ammonite taxa.

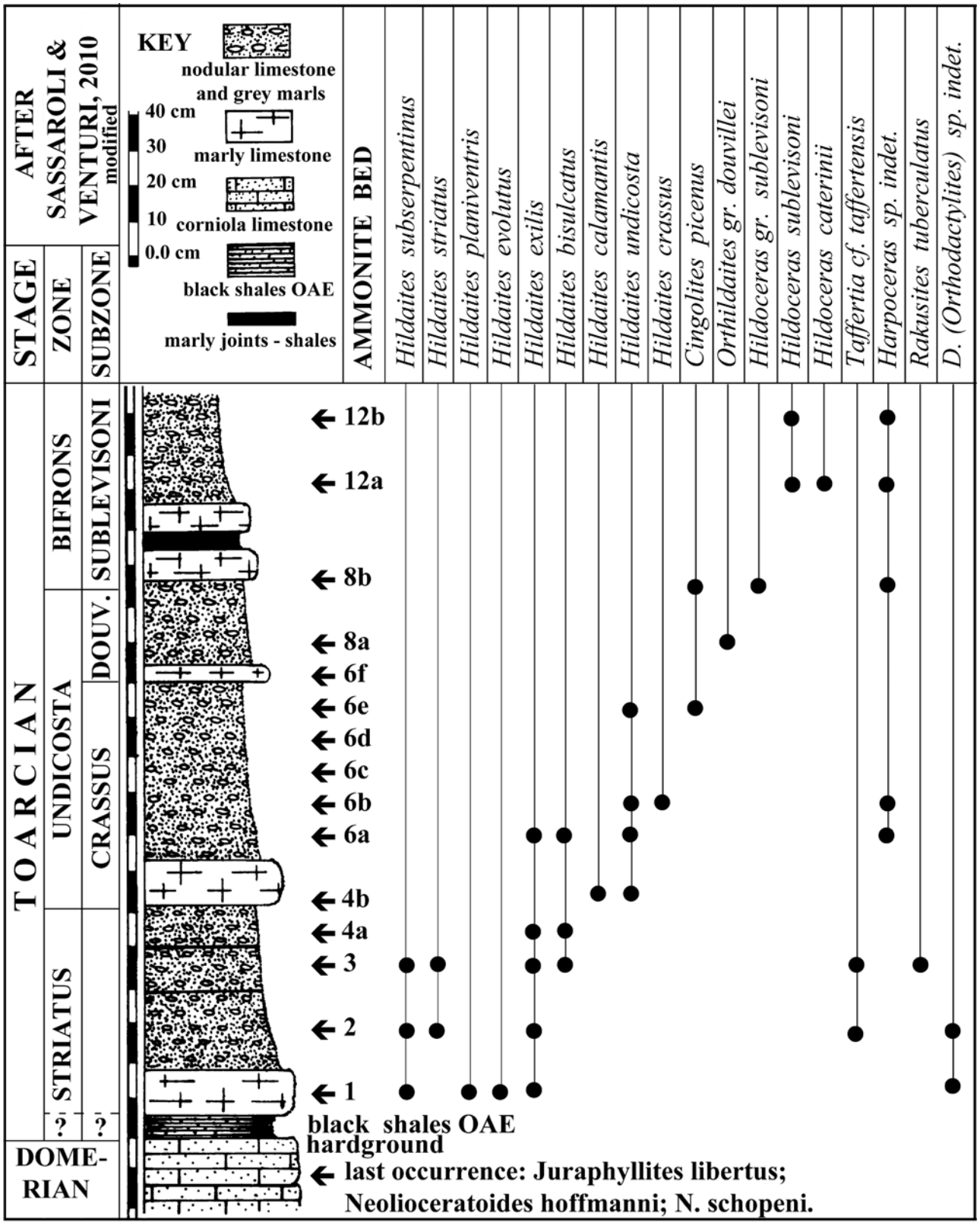

Fig. 4: Log of the Marconessa quarry section 3 and range chart of Hildoceratinae and other major ammonite taxa.

and radiation of *Hildaites* showing fine ornament and narrow venter, such as *H. striatus* and *H. subserpentinus*, which disappear at the end of the same zone. Here no subdivision in subzone is attempted. The Undicosta zone begins with the massive occurrence and radiation of *Hildaites* showing coarser ornanemt and wider and tricarinate-bisulcate venter, such as *H. undicosta* and *H. crassus*. This zone is subdivided in a Crassus subzone, characterized by the first occurrene of *H. undicosta* and by the whole range of *H. crassus*, and in a Douvillei subzone, characterized by the occurrence of the gr. *Orthildaites* forms (see range chart Fig. 3 and Fig. 4; the subdivision is achieved by a biostratigraphical data comparison of the logs of sections 2 and 3; in section 3 the bed 6f records the occurrence of *Orthildaites* sp. indet. and in section 2 no ammonite beds are recorded between the bed 3b and the bed 6).

Protogrammoceratinae, Harpoceratinae and Hildoceratinae, which usually provided taxa as indexes, seem to be affected by a partial provincialism at genus and species level during the Pliensbachian/Toarcian boundary and the early Toarcian. Therefore, several problems in correlation and calibration of the Subboreal, Submediterranean and West Tethyan Provinces zonation arisen (for an updated review see MACCHIONI, 2002a). On the other side, Dactylioceratids have a worldwide dispersal, although they have not the same abundance and probably synchronic occurrence in the three Provinces. May be useful, however, to correlate the occurrence of Dactylioceratidae with Protogrammoceratinae, Harpoceratinae and Hildoceratinae from the three Province to local Apennines sections.

From the badly preserved material collected at Marconessa quarry near the top of the Corniola limestone, below the hardground which recorded the marine regression, no Dactylioceratids were detected. So that, we are at present day unable to point out the first occurrence of *Dactylioceras* (*Eodactylites*), which is commonly believed to mark the beginning of the Toarcian. Nevertheless, very rare Dactylioceratids occurs into levels immediately overlying the OAE and they are all relevant taxa for stratigraphical correlations. In fact we found *Rakusites tuberculatus* GUEX, 1973, *Dactylioceras* (*Orthodactylites*) *tenuicostatum* (YOUNG & BIRD, 1822), *Dactylioceras* (*Orthodactylites*) *semicelatum* (SIMPSON, 1843), *Dactylioceras* (*Orthodactylites*) cf. *clevelandicum* HOWARTH, 1973 and *Dactylioceras* (*Orthodactylites*) cf. *aequistriatum* (MUENSTER *in* ZIETEN, 1830) *sensu* GUEX, 1973 (see Fig. 5). These Dactylioceratids characterize, excluding *R. tuberculatus*, the Tenuicostatum zone of the Subboreal and Submediterranean Provinces. They were found in assemblage with early *Hildaites* of the Striatus zone and this evidence allows to correlate therefore the Apennines local sections zonation and the NW European Province zonation. There is evidence that the Striatus zone is equivalent or almost equivalent to the whole Tenuicostatum zone or at least to the Semicelatun subzone (Tenuicostatum zone) only. Remarkably, the first occurrence in the West Tethyan Province of early *Hildaites* and the first occurrence in West Tethyan Province of the typical Dactylioceratids commonly widespread in Subboreal and Submediterranean Provinces seem to be a synchronous event, and it happened immediately above the OAE records.

This evidence, if confirmed by further studies (see however GUEX, 1973 and ELMI *et al.*, 1994), implies a diachronic occurrence of *Hildaites*, i.e. that this genus occurs earlier in West Tethyan Province (during the late Tenuicostatum zone) and later in the Subboreal and NW European Provinces (during the Falciferum/Serpentinum zone). However, the related question about whether or when the NW European ammonite fauna of the earliest Tenuicostatum zone (Paltus subzone) occurs in the Apennines sections is still unclear. Does it occur before or after the OAE recording? Can the NW European Paltus subzone be compared to the Tethyan (Apennines) Mirabile subzone? We note that in some high resolution Apennines sections, such as I Lecceti (Bosso River Valley) and Maranghi quarry (Burano River Valley) the Mirabile zone has recorded an ammonite fauna with late Domerian (Uppermost Pliensbachian) affinity (see FARAONI *et al.*, 1994 and BILOTTA *et al.*, 2010). Therefore, the question of the Pliensbachian/Toarcian boundary in the Apennines outcrops is still open and to solve it further data are required.

IV. SYSTEMATICS

Order Ammonoidea ZITTEL, 1884
Suborder Ammonitina HYATT, 1889
Superfamily Hildocerataceae HYATT, 1867
Family Hildoceratidae HYATT, 1867
Subfamily Hildoceratinae HYATT, 1867

Diagnosis: From evolute to moderately involute planulates, more or less compressed shell. The whorl section varies from elliptical to sub-trapezoidal or from sub-rectangular to sub-quadrate. The keeled venter varies from elliptical to ogival, from tabulate to bisulcate or else to tricarinate-bisulcate. The ornament varies also showing ribs from fine to coarse; they can be single, bifurcating, rarely trifurcating and sometimes bundled with sinuous, sigmo-falcoid or strongly angled falcate and rarely almost rectiradiate appearance. The ammonitic suture is simple.

Discussion: This subfamily includes to the present-day the following genera: *Hildaites* BUCKMAN, 1921; *Orthildaites* BUCKMAN, 1923; *Cingolites* SASSAROLI & VENTURI, 2010; *Hildoceras* HYATT, 1867; *Urkutites* GÉCZY, 1967. All these genera occur in the Apennines outcrops (SASSAROLI & VENTURI, 2010).

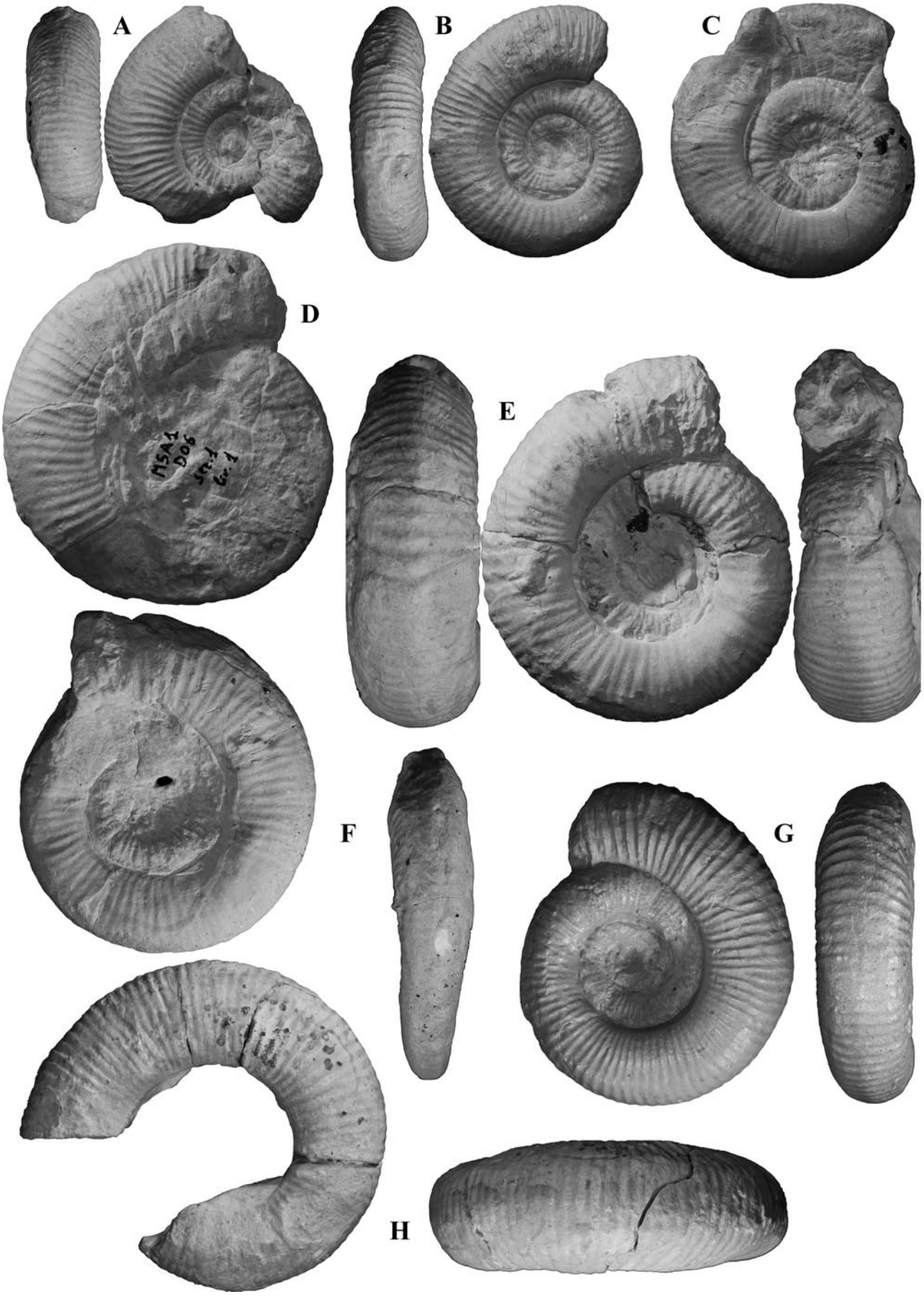
A
B
C
D
MSA1
D06
str.1
fr.1
E
F
G
H

Fig. 5: Early Toarcian representative Dactylioceratids occurring after the OAE black shales geological record in the Apennines, Marconessa quarry outcrop. **A**: *Dactylioceras* (*Orthodactylites*) *tenuicostatum* (YOUNG & BIRD, 1822), specimen MSA1D03, section 2, bed 2a. **B**: *Rakusites tuberculatus* GUEX, 1973, specimen MSA1D01, section 1, bed 1. **C**: *Rakusites tuberculatus* GUEX, 1973, specimen MSA1D02, section 1, bed 1. **D**: *Dactylioceras* (*Orthodactylites*) *tenuicostatum* (YOUNG & BIRD, 1822), specimen MSA1D08, section 1, bed 1. **E**: *Dactylioceras* (*Orthodactylites*) cf. *clevelandicum* HOWARTH, 1973, specimen MSA1D07, section 2, bed 2c. **F**: *Dactylioceras* (*Orthodactylites*) *semicelatum* (SIMPSON, 1843), specimen MSA1D04, section 1, bed 1. **G**: *Dactylioceras* (*Orthodactylites*) cf. *aequistriatum* (MUENSTER *in* ZIETEN, 1830) *sensu* GUEX, 1973, specimen MSA1D05, section 1, bed 1. **H**: *Dactylioceras* (*Orthodactylites*) cf. *clevelandicum* HOWARTH, 1973, specimen MSA1D08, section 2, bed 2c. All specimens coll. SASSAROLI. All photographs are natural size.
⬅

Genus *Hildaites* BUCKMAN, 1921

Type species: *Hildaites subserpentinus* BUCKMAN, 1921.
Synonyms: *Murleyiceras* BUCKMAN, 1921; *Hildoceratoides* BUCKMAN, 1921; *Harpohildoceras* REPIN, 1970, according to HOWARTH (1992) and BÉCAUD (2006).
Amended diagnosis: From evolute to moderately involute shells of various size, which usually show more or less overlap of the whorls. The whorl section may be elliptical, ovaloid, sub-trapezoidal, sub-quadrate or sub-rectangular. The umbilical edge is rounded; the high or low umbilical wall may be sloping, variably rounded or vertical. The wide or narrow venter may be acute-keeled, tabulate, either bisulcate or tricarinate-bisulcate with raised keel characterized by a sub-triangular section. The ornament shows from fine to strong ribs, which usually are single and sometimes bifurcating, more rarely trifurcating or bundled (fasciculate) forming some reliefs and dimples (sometime with little tubercles or bullae) placed near the umbilical edge. The ribs are more or less fading and also backwards angled (retroverted) near the umbilical edge, but sometimes they start sharply from the umbilical wall; then, they became more or less sinuous and variously projected toward the ventro-lateral edge, taking the typical sinuous, sigmoidal, falcate-falcoid appearance. The suture lines are usually slightly jagged or frilled with spaced lobes; they usually do not intersect each other. The E lobe is sometimes as long as the L lobe, otherwise it is shorter than L lobe. The two umbilical U_2 and U_3 lobes are not much developed, but U_2 is always larger than U_3. The ES saddle commonly is as wide as the double width of saddle LS_1, which on the other hand is wider than the saddle LS_2; they are rarely equal. The hidden internal suture line shows a U_1 lobe, which is shorter and narrower than U_2, or equal. The I lobe is simple, long and narrow.
Remarks: We have improved the HOWARTH (1992) and BÉCAUD's (2006) diagnosis, because the finding of until unpublished samples from the Marconessa quarry have enlarged the genus variability.
Occurrence: This genus characterizes the early Toarcian. It shows a considerable biodiversity over the time-span and a wide geographical dispersal, chiefly in the West Tethyan, Submediterranean and Suboreal Provinces.

Hildaites wrighti SPATH, 1913
Pl. I, fig. 1a-b; Fig. 6, A-B

?1870. *Ammonites radians* REINECKE. - MENEGHINI, pl. 11, fig. 7.
1884. *Harpoceras normaniaum* (D'ORBIGNY). - WRIGHT, pl. 83, figs. 1-2 (holotype).
1913. *Protogrammoceras wrighti* SPATH, p. 553 (*nom. nov.* holotype).
?1969. *Protogrammoceras* sp., PINNA, pl. 4, fig.6.
?1980. *Hildaites striatus* GUEX. - WIEDENMAYER, pl. 32, figs. 1-5.
1992. *Hildaites wrighti* SPATH. - HOWARTH, pl.30, figs. 7a-b (holotype).
?2001. *Hildaites wrighti* SPATH. - MACCHIONI, pl. 6, fig. 14.
?2002a. *Hildaites wrighti* SPATH. - MACCHIONI, fig. 4.9.
?2006. *Hildaites wrighti* SPATH. - BÉCAUD, pl. 32, fig. 1.

Material: Only one medium sized specimen MSA60 with the body chamber partly preserved and the shell strongly encrusted by pyrite, coming from Marconessa quarry.
Diagnosis: Moderately evolute and compressed shell, almost elliptical whorl section, narrow and gently bisulcate or tabulate keeled venter, high almost vertical umbilical wall in the outer whorls and rounded umbilical edge. The venter is gently bisulcate with a strong and raised keel. The fine, dense and gently sigmoidal ribs start gently backward from the umbilical wall and they end moderately projected on the ventro-lateral edge.
Description: Compared to the holotype refigured by HOWARTH (1992, pl. 30, figs. 7a-7b) our specimen seems to have a more compressed whorl section and lesser falcate ribs. HOWARTH (1992) states that the holotype has «*a narrow tricarinate-bisulcate venter*», but we think that this statement overemphasizes the same HOWARTH's figure (7b), which like our specimen really shows the weak sulci jointed with a strong and raised keel, which also shows a narrow and gently bisulcate venter in the fragmocone and a narrow and flattened venter in the body chamber. HOWARTH has not provided a draw or description of the suture line of SPATH's holotype. Our specimen has a simple not jagged suture, with a wide L lobe and moderately developed umbilical lobes.
Discussion and comparative diagnosis: HOWARTH (1992) inferred that WRIGHT's holotype, which is the only sample collected in Britain, comes from Somerset

(Ilmister, Barrington) and probably it was found in the Fish and Insect Bed, which is Exaratum subzone, Falciferum zone in age. Contrary to HOWARTH's (1992) opinion we think that *H. wrighti* is not a synonym of *Hildaites striatus* GUEX, 1973, because the latter shows lesser sigmoidal, finer and denser ribs, bundled or bifurcating near the umbilical wall with typical streaking appearance as well as a narrower and not sulcated venter with a thin keel. On the other side, *H. wrighti* shows a bisulcate venter with strong keel and usually single ribs. Besides, *H. striatus* has a more compressed and evolute shell than *H. wrighti*, whose umbilical wall is high and rounded, not sloped and flattened as that of *striatus*. Consequently, we cannot share HOWARTH's opinion. The Italian specimens figured by MENEGHINI (1870, pl. 11, fig. 7), ZANZUCCHI (1963, pl. 18, figs. 1-6) and PINNA (1969, pl. 1, fig. 16) have an uncertain taxonomy, as well as the little and badly preserved small sized fragment of the GEMELLARO's collection, recently revisioned by MACCHIONI (2002b, p. 147). However, they have not stratigraphical recording. We also doubt whether to ascribe the specimens figured by WIEDENMAYER (1980, pl. 32, figs. 3-5) to *H. wrighti*.

Occurrence: HOWARTH (1992) believes that the holotype occurs in the *Exaratum* subzone (lower *Falciferum* zone), thus it should be the earliest occurrence of *Hildaites* in Britain. However, the Apennines specimen occurs in the early *Striatus* zone.

Hildaites subserpentinus BUCKMAN, 1921
Pl. I, figs. 2a-b, 3, 4a-b, 5a-c, 6a-b, 7; Fig. 6, C-D

1919. *Hildoceras serpentinum* (REINECKE). - BUCKMAN, pl. 138B.
1921. *Hildaites subserpentinum* BUCKMAN, pl. 217, figs. 1-2 (holotype).
1963. *Hildaites serpentinus* BUCKMAN. - ZANZUCCHI, pl. 18, figs. 7- 8.
?1973. *Hildaites* aff. *striatus* GUEX. - GUEX, pl. 9, fig. 2.
1973. *Hildaites subserpentinus* BUCKMAN. - GUEX, pl. 7, fig. 5 and pl. 8, fig.1.
1975. *Hildaites subserpentinus* BUCKMAN. - VENTURI, pl. 30, fig. 7.
1992. *Hildaites subserpentinus* BUCKMAN. - HOWARTH, pl. 33, figs. 1a-b.
2002a. *Hildaites serpentinus* (REINECKE). - MACCHIONI, fig. 4.8

Material: Twenty-one specimens of small and medium size and three specimens of large size, all collected in the beds of the *Hildaites striatus* zone, from Marconessa quarry.

Remarks: We consider here the BUCKMAN's (1921, pl. 217) holotype only, refigured by HOWARTH (1992, pl. 33, figs. 1a-b), not the examples provided by HOWARTH (1992, pl. 32, figs. 5a-b; pl. 33, figs. 2a-b, 3a-b, 4a-b; pl. 34, fig.1) and BÉCAUD (2006, pl. 37, fig. 1a-c). In fact, these samples are very different from each other and mainly from the holotype for some morphological traits and also for stratigraphical occurrence. Therefore in the following description, we compare our specimens from Marconessa quarry with BUCKMAN's holotype only, which has not an exact stratigraphical occurrence (Upper Lias at Ilminster, Somerset), but was also stated that it occur from the Whitbian zone (Falciferum subzone ?).

Amended diagnosis: Evolute, compressed shell, characterized by an elliptical whorl section and a narrow acute-keeled venter in the inner whorls of the microconch, more flattened in the outer ones of the macroconch. The low umbilical wall is characterized by a rounded umbilical edge. Sigmoidal, fine and dense ribs, which are usually single in the inner whorls, sometimes bifurcating in the outer ones, more or less projected on the ventro-lateral edge. Rib-density decrease in outer whorls of large sized samples. The ammonitic suture is simple, moderately frilled, showing a long L lobe, a shorter E lobe, and well developed umbilical lobes.

Description and comparative diagnosis: We set the Apennines specimens in the morphological range of the *H. subserpentinus*, because they have the same whorl section, the same whorls coiling and the same ribs appearance of BUCKMAN's holotype. The Apennines samples show the shell little more evolute than holotype, a compressed elliptical whorls section with little overlap. The narrow not sulcated venter shows a thin keel; in the microconch it has an almost acute-keeled appearance, whereas the larger sized samples show a moderately trend to flattening. The ornament has sigmoidal, moderately sinuous, little projected on the ventro-lateral edge, fine and dense ribs, which shows a trend to increase in number and to fade and to bifurcate in the body chamber of the small-medium sized specimens, chiefly the ones that early occur in the stratigraphical range. On the contrary, the outer whorls of the larger sized specimens show a decrease in rib-density and more sinuous and projected ribs, mainly the samples which occur later. The suture line is close to the holotype for the ratio of the lobes. The Apennines samples of *H. subserpentinus* are at a glance close to *Hildaites striatus*. Besides, they have the same stratigraphic occurrence. Nevertheless, *H. subserpentinus* differs from *H. striatus* for larger sized sample, the greater shell evolution, for the slower increase of the coiling and for the ornament showing in the inner whorls single ribs starting from the umbilical edge. On the contrary *H. striatus* shows bifurcating or gentle bundled ribs from the inner whorls, which start from the umbilical wall; they are also finer and denser than those of *H. subserpentinus*.

Discussion: The BUCKMAN's holotype (1921, pl. 217) of *H. subserpentinus* is very important from a historical point of view, because it is the type species of the genus *Hildaites*. It was collected by MOORE and it was recently refigured by HOWARTH (1992, pl. 33, figs. 1a-1b), who nevertheless has included in the range of the species several examples that, in our opinion, are

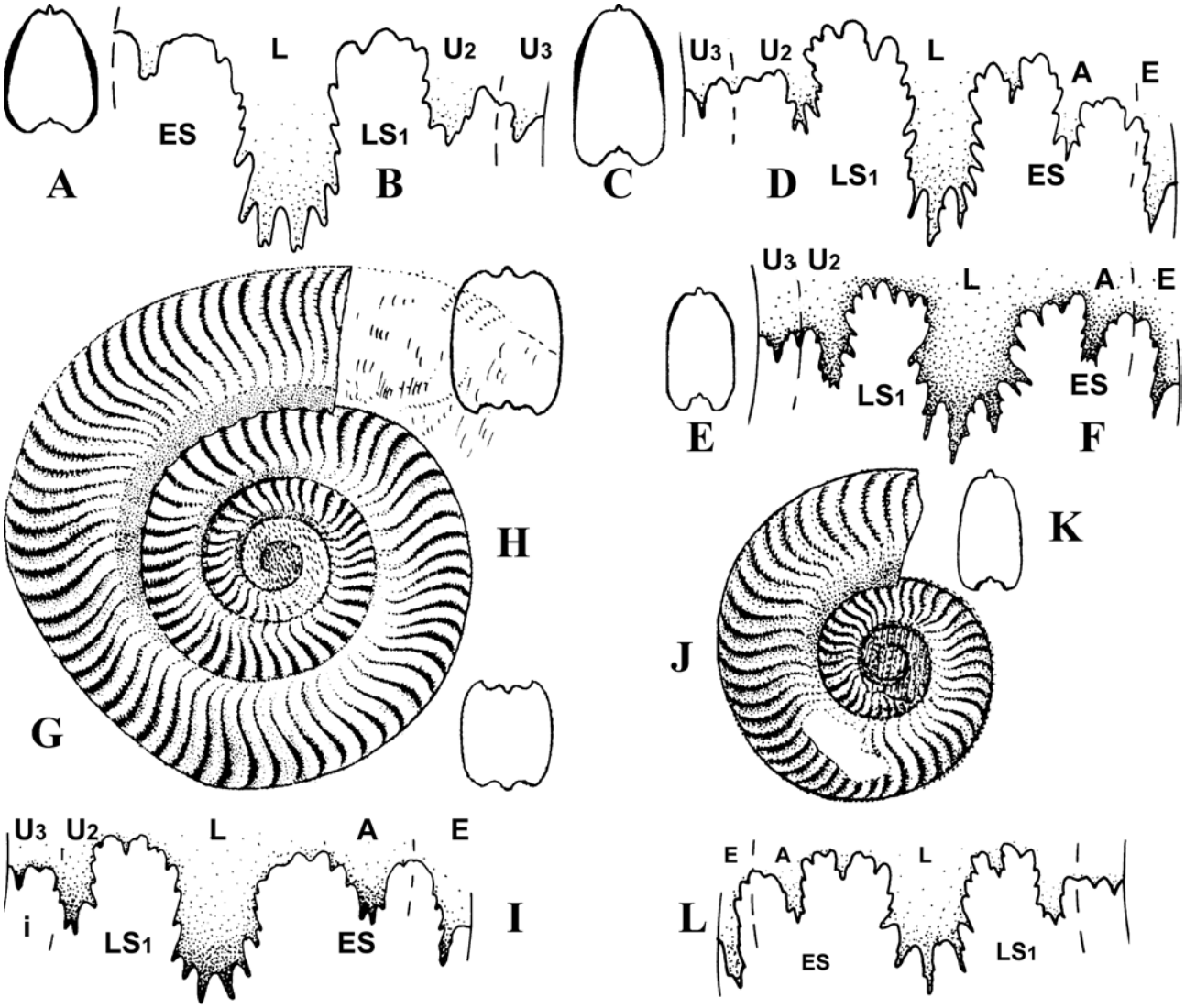

Fig. 6: **A-B**: *Hildaites wrighti*, specimen MSA60, whorl section (x1) and suture (x5). **C-D**: *Hildaites subserpentinus*, specimen MSA254, whorl section (x1) and suture (x3). **E-F**: *Hildaites striatus*, specimen MSA30, whorl section (x1) and suture (x3). **G-I**: *Hildaites evolutus* n. sp., holotype MSA426, shell draw (x1), whorl section (x1) and suture (x3). **J-L**: *Hildaites exilis*, specimen MSA102, shell draw (x1), whorl section (x1) and suture (x3).

too different from the holotype for morphology and probably for stratigraphic occurrence. A synonymy was also established by HOWARTH (1992) between *H. subserpentinus* and the ammonites figured by REINECKE, THOMPSON and BUCKMAN: the holotype of *Argonauta serpentinus* REINECKE, 1818, refigured by THOMPSON (1909, fig. 13) and by BUCKMAN (1919, fig. 138A) such as *Hildoceras serpentinum*; *Hildoceras serpentinum* BUCKMAN, 1889, refigured by BUCKMAN (1923, fig. 267B) as holotype of *Hildaites serpentiniformis* and the plesiotype of *Hildoceras serpentinum* REINECKE, 1818, refigured by BUCKMAN (1919, fig. 138B). Nevertheless, this account is very questionable. KOTTEK has figured two samples as *H. subserpentinus* (1966, pl. 5, figs. 1-2) which are close to the Apennines examples. We note that these Greek examples were found in assemblage with two specimens which were assigned by KOTTEK (1966, pl. 5, fig. 3 and pl. 6, fig. 1) to *Hildaites acutus* TATE, 1895, but they are probably *Hildaites striatus*.

Occurrence: The Apennines specimens of *H. subserpentinus* occur in the *Striatus* zone, from the beds immediately overlying the OAE recording. On the contrary, HOWARTH (1992) states that the British examples of *H. subserpentinus* occur in the mid-Falciferum subzone. He also states that the holotype occurred in the mid-Falciferum subzone, following MOORE, THOMPSON and BUCKMAN's poor informations. But we suspect that the holotype has a different occurrence in respect of several examples figured by HOWARTH, which are morphologically very different.

Noticeably, HOWARTH (1992) found at Barrington (Ilminster, Somerset) *H. subserpentinus* in assemblage with *Hildoceras lusitanicum*. The Apennines examples of *H. subserpentinus* are clearly older; they were found in assemblage with *H. striatus*.

Hildaites striatus GUEX , 1973
Pl. II, figs. 1a-b, 2, 3a-c, 4, 5, 6; Fig. 6, E-F

?1913. *Hildoceras (Fuciniceras) pectinatum* MENEGHINI. - MEISTER, pl. 13, fig. 1
?1963. *Hildaites serpentinum* BUCKMAN. - ZANZUCCHI, pl. 18, fig. 6.
?1966. *Hildaites acutus* TATE. – KOTTEK, pl. 5, fig. 3 and pl. 6, fig.1.
1973. *Hildaites striatus* GUEX, pl. 7, fig. 3 (holotype); pl. 3, fig. 10 and pl. 10, fig. 2.
1973. *Hildaites* sp. ind. GUEX, pl. 6, fig. 3.
1980. *Hildaites striatus* GUEX. - WIEDENMAYER, pl. 32, figs. 1-4.
1992. *Hildaites striatus* GUEX. - JIMÉNEZ JIMÉNEZ & RIVAS CARRERA, pl. 4, figs. 11-15.
2002a. *Hildaites wrighti* SPATH. - MACCHIONI, fig. 4.6.
2010. *Hildaites striatus* GUEX. - BILOTTA *et al.*, fig. 17 A-B.

Material: Eighteen specimens of small and medium size, five of which with the body chamber, from Marconessa quarry.
Amended diagnosis: Evolute compressed shell, elliptical whorl section with little overlap of the whorls. The coiling rapidly increase in height whorl. The venter is moderately narrow, tabulate with raised and coarse keel. The umbilical edge is rounded and the low umbilical wall is gently sloped. The moderately sinuous ribs are finest and dense, usually bifurcating or sometimes bundled mainly in the outer whorls and in the body chamber. The ribs start little retroverted from the umbilical wall, ending projected on the ventro-lateral edge. They become more sinuous and projected in the body chamber. The ammonitic suture is simple, little frilled and it shows a slanting ES saddle, which is wider twice as wide as LS_1.
Description: Evolute small sized shell. The elliptical very compressed shell shows a little overlap of the whorls and a rapid coiling increase. The low umbilical wall shows a gently sloped or rounded umbilical edge. The moderately sinuous, finest and dense ribs are sometime single or usually bifurcating; in the outer whorls and in the body chamber they become densest and sometime bundled forming the typical striatures. The venter is narrow and flattened with coarse keel, similar to *H. subserpentinus*, which instead has a more narrow and more acute venter. The ribs are sinuous in the fragmocone, but not much backward near the umbilical and moderately projected on the ventro-lateral edge, becoming more sinuous in the body chamber. The suture shows little jagged lobes, a lengthened L lobe, a E lobe shorter than L. The umbilical lobes are moderately developed, and the A lobe is slanting. The LS_1 saddle is narrow, and the ES saddle is about twice as wide as the former. The Apennines specimens are very close to GUEX's holotype for the ornament and the whorl section and coiling; they are less evolute than those figured by JIMÉNEZ JIMÉNEZ & RIVAS CARRERA (1992).
Remarks and comparative diagnosis: HOWARTH (1992) believes that *H. striatus* is a synonym of *Hildaites wrighti*. In our opinion these are two well separate species. The ribs of *H. striatus* are finer and denser, bifurcating or bundled with the typical striatures. On the contrary the ribs of *H. wrighti* are usually single, more falcoid and more projected on the ventro-lateral edge. Besides, *H. wrighti* shows a greater shell involution, a more overlap of the whorls, a lesser rapid coiling increase, while *H. striatus* has a more compressed and evolute shell. The venter of *H. wrighti* is bisulcate, narrower and more acute-keeled than of *H. striatus*, which is flat without sulci. The umbilical wall of *H. striatus* is lower and more sloped than of *H. wrighti*, which is higher and more rounded. Despite of the remarkable likeness between *H. striatus* and *H. subserpentinus*, which also have the same stratigraphic occurrence, the former differs from the later by having finer and denser ribs, which are from bifurcating to bundled, more sinuous and projected on the ventro-lateral edge chiefly in the outer whorls and in the body chamber. The two Grecian specimens assigned by KOTTEK (1966, pl. 5, fig. 3 and pl. 6, fig. 1) to *Hildaites acutus* (TATE, 1895) probably must be assigned to *H. striatus*.
Occurrence: *Striatus* zone. We choose *Hildaites striatus* as zonal index of early Toarcian (post-OAE) of the Apennines outcrops.

Hildaites exilis VENTURI, 1973
Pl. II, figs. 7, 8a-c, 9, 10a-b, 11a-c, 12, 13; Fig. 6, J-L

? 1966. *Protogrammoceras isseli* FUCINI. - KOTTEK, pl. 12, fig. 6.
1973. *Hildaites exilis* VENTURI, p. 595, fig. 11 (holotype) and p. 600; figs. 14h-14i (holotype).
1981. *Hildaites* gr. *exilis* VENTURI. - VENTURI, p. 596, fig 4.
1985. *Hildaites* (?) cf. *exilis* VENTURI. - VENTURI, p. 72, fig. 104
2001. *Hildaites exilis* VENTURI. - VENTURI & FERRI, pl. 25, fig. e.

Material: Twenty specimens of medium and small size, some with the body chamber, all coming from Marconessa quarry.
Amended diagnosis: The several specimens collected allow us to improve the diagnosis. Moderate involute shell with elliptical and compressed whorl section and moderately overlap of the whorls. The low umbilical wall is almost vertical, the umbilical edge is rounded. It has an usually narrow and tabulate, sometimes gently sulcated venter, with raised and fine keel. The moderately fine, sparse and gently falcoid ribs arise from the umbilical wall with a gentle flexion and they end projected on the ventro-lateral edge. The ornament also shows weak

bundles, and sometimes the ribs are joined by gentle *bullae*. The simple ammonitic suture shows the E lobe usually only just shorter than L; the U_2 and U_3 lobes are small.

Description: Moderately involute and more or less compressed shell, characterized by elliptical whorl section with a remarkable overlap of the whorls compared to other *Hildaites* such as *H. striatus* and *H. subserpentinus*. The narrow keeled venter varies from tabulate or little rounded (mainly in the later examples) to gently bisulcate. The low and almost vertical umbilical wall shows a rounded umbilical edge. The moderately fine, sparse and sigmo-falcoid ribs vary from single, mainly in the inner whorls and in the former samples, to bifurcating or bundled in the outer whorls and in the later samples. The ribs can be more or less projected on the ventro-lateral edge; they start ever little retroverted from the umbilical wall. Sometimes, mainly in the later samples, the ribs are joined by gentle *bullae*. The suture shows a wide and low L lobe, the E lobe only just shorter than L or as long as L, the A lobe and the umbilical lobes little developed.

Remarks and comparative diagnosis: We observe from the former to latter examples the remarkable evolutionary trend to develop a swelling whorl section, to lose the sulci on the venter, which is more flattened among the older specimens, and to increase the ribs bundles. This species clearly differs from gr. *H. subserpentinus* and *H. striatus*, mainly for the sparser and sigmo-falcoid ribs. The badly preserved Greek specimen figured by KOTTEK (1996, pl. 12, fig. 6) as *Protogrammoceras isseli* FUCINI, 1929, is probably an example of *H. exilis*.

Occurrence: From lower to upper *Striatus* zone.

Hildaites planiventris n. sp.
Pl. IV, figs. 3a-c, 4, 5; Fig. 7, A-C

Material: Six specimens of large, medium and small size, all coming from Marconessa quarry.

Derivatio nominis: By reason of its typical wide and perfectly flattened venter.

Holotype: A well preserved shell MSA 61 of large size with the body chamber, coming from Marconessa quarry, section 3, bed 1 (Pl. IV, figs. 3a-b-c; Fig. 7, A-C).

Stratus typicus: Nodular limestone and grey marls of early Toarcian (Bugarone Formation).

Diagnosis: Evolute very compressed shell with little coiling overlap, high sub-rectangular whorl section by flattened sides. The wide and flattened not sulcated venter show a strong and raised keel. The falcoid, sparse, moderately strong usually single ribs start from a low and gently sloped umbilical wall. The umbilical edge is rounded. The ammonitic suture is simple, little frilled, characterized by a wide and little developed in height L lobe.

Holotype measurements. D (diameter): 87 mm - U (umbilical width): 44 mm - ratio U/D: 0.51 - Wb (whorl breadth): 15 mm - Wh (whorl height): 24 mm - ratio Wh/Wb: 1.6 - ratio Wb/Wh: 0.62.

Description: Evolute very compressed shell with little coiling overlap and a high sub-rectangular whorl section by flattened sides. The venter is wide and perfectly flat, not sulcated with a raised, sharp and strong keel. The low umbilical wall is sloped and the umbilical edge is rounded. The shell shows a spiral groove in the body chamber, placed at 1/3 of height of the whorl side from the umbilical edge, which, contrary to some *Hildoceras*, is not smooth. The falcoid ribs are moderately strong and spaced with low rib-density (we count 45 ribs in the last whorl of the phragmocone) and they are usually single, rarely bifurcating, in the phragmocone, and not much projected on the ventro-lateral edge showing a relatively short proximal segment. In the body chamber ribs increase in number becoming finer, denser and usually bifurcating-trifurcating. The suture line is simple and little frilled; it shows a L lobe wide and short, and a E lobe shorter than L. The ES saddle is much wider than the LS_1 saddle.

Paratypes: The paratypes are very similar to the holotype, showing an evolute shell, a flat venter and a rounded umbilical edge. The ribs are more or less falcoid than the holotype. The suture line shows more or less short L and E lobes. Both small sized paratypes MSA64 and MSA78 show a flat venter, never bisulcate. The species is characterized in all growth stages by a tabulate venter (see Table 1 for measurements of all figured samples).

Remarks and comparative diagnosis: The dorsal sight of holotype seems to be close to a specimen figured by HOWARTH (1992, pl. 30, figs. 9a-b) as *Hildaites murleyi*. Nevertheless, HOWARTH's specimen compared to *H. planiventris*'s holotype has a narrower venter, a sub-quadrate whorls section and a stronger keel and its ribs are finer and denser. Furthermore, its unbilical wall is higher than *planiventris*. On the other hand, BUCKMAN's (1921, pl. 216, figs. 2-3) holotype of *H. murleyi* differs from our holotype and from HOWARTH's specimen, because it has an almost swollen sub-quadrate whorl section, a wider flat venter and coarse, sinuous not falcoid ribs from the inner whorls too, which end near the keel. On the contrary the wide venter of *H. planiventris* is smooth because the ribs end on the ventro-lateral edge. For these reasons we think that *planiventris* is not a synonym of *H. murleyi*. We believe also that HOWARTH has enlarged the morphological range of the British species *H. murleyi* too much in having figured specimens sometime very different from each other.

Occurrence: Lowermost *Striatus* zone.

Hildaites evolutus n. sp.
Pl. III, figs. 1a-b, 2a-c, 3, 4a-b, 5, 6; Fig. 6, G-I

2010. *Hildaites evolutus*, SASSAROLI & VENTURI (in VENTURI *et al.*), p. 279, 355.

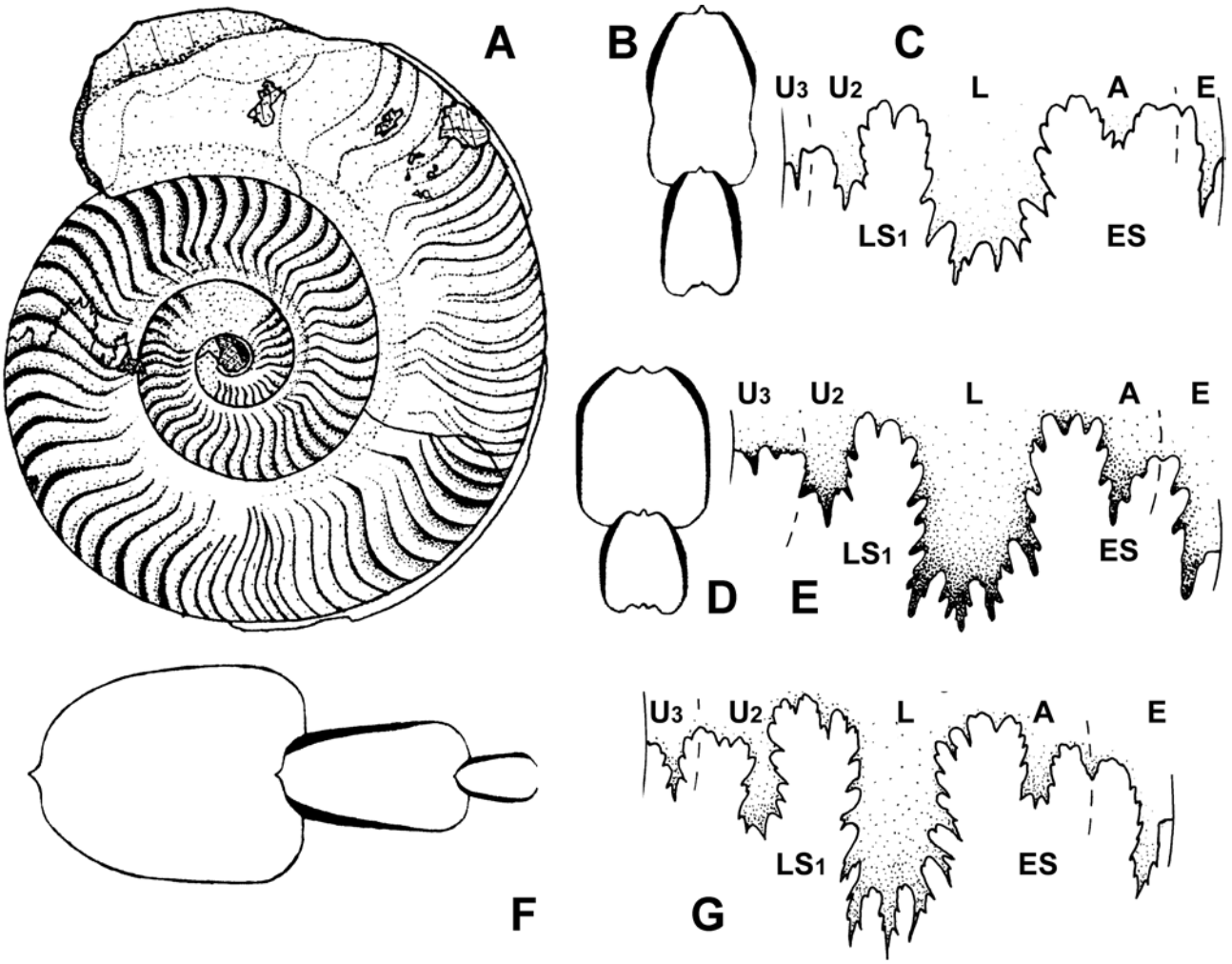

Fig. 7: **A-C**: *Hildaites planiventris* n. sp., holotype MSA61, shell draw (x1), whorl section (x1) and suture (x3). **D-E**: *Hildaites bisulcatus* n. sp., holotype MSA351, whorl section (x1) and suture (x3). **F-G**: *Hildaites calamantis* n. sp., holotype MSA85, whorl section (x1) and suture (x2).

Material: Eleven specimens of various size from small to large, all coming from Marconessa quarry.

Derivatio nominis: For the reason of its very evolute shell without overlap of the whorls coiling.

Holotype: A large sized and well preserved specimen MSA426 with the body chamber, coming from Marconessa quarry, section 3, bed 1a (Pl. III, figs. 1a-b; Fig. 6, G-I).

Stratus typicus: Nodular limestone and grey marls of the lowermost *Striatus* zone (Bugarone Formation).

Diagnosis: Very evolute compressed shell by flattened sides; from sub-quadrate to sub-rectangular whorl section. No whorls overlap occurs. The shell shows also a slow-growth coiling. Tricarinate-bisulcate and moderately wide venter with a thin keel. The sulci are little deep. The low umbilical wall is gently sloped and the umbilical edge is rounded. The sparse, fine, single, falcoid and rursiradiate ribs are projected on the ventro-lateral edge and they show a short proximal segment moderately angled backward. The ammonitic suture is very simple and little frilled.

Holotype measurements. D: 83 mm - U: 43 mm - U/D: 0.52 - Wb: 17,5 mm - Wh: 23 mm - Wh/Wb: 1.31 - Wb/Wh: 0.76.

Description: Very evolute compressed shell showing from sub-quadrate to sub-rectangular whorl section without overlap of the whorls and flattened sides. The moderately wide venter is tricarinate-bisulcate with little deep sulci and a thin keel. The umbilical wall is low and sloped in the phragmocone, higher and angled in the body chamber. The umbilical edge is gently rounded. The ribs are spaced with a moderately rib-density (we count 54 ribs in the last phragmocone whorl), fine, single and rursiradiate with falcoid appearance. They show a short proximal segment gently angled backward and they are moderately projected on the ventro-lateral edge. The suture is simple, little frilled, with a developed L lobe and a wide E lobe shorter than L. The U_2 lobe is long about the half length of L. U_3 is dentiform and the A lobe is little developed.

Paratypes: The paratypes are very close to the holotype description. They vary mainly in having a more or less

wide venter and ribs projection. The paratype MSA831 shows the sides gently convex. The small sized specimens show a sub-quadrate whorl section and ever a tricarinate-bisulcate venter.

Remarks and comparative diagnosis: This species is characterized by having the most evolute shell among the earliest *Hildaites* of the Striatus zone. It differs from *H. planiventris* chiefly in having a tricarinate-bisulcate venter, finer ribs and a more evolute whorl section.

A specimen of *H. evolutus*, coming from Valdorbia outcrop, was firstly figured and not formally described in Venturi *et al.* (2010: 279, 255). It was wrongly pointed-out as holotype, but really it is a sample only, because the holotype MSA426 was already described and figured in a previous unpublished paper.

Occurrence: Lowermost *Striatus* zone.

Hildaites bisulcatus n. sp.
Pl. III, figs. 7, 8, 9a-b, 10a-c; Pl. IV, figs. 1, 2; Fig. 7, D-E

2010. *Hildaites* n. sp. - Bilotta *et al.*, fig. 17C

Material: Fourteen specimens of small and medium size, all coming from Marconessa quarry.

Derivatio nominis: From the bisulcate venter shown in all stages.

Holotype: A medium size and wholly septate specimen MSA351, coming from Marconessa quarry, section 2, bed 3a (Pl. III, figs. 10a-b-c; Fig.7, D-E).

Stratus typicus: Nodular limestone and grey marls of the early Toarcian (Bugarone Formation).

Diagnosis: Moderately evolute compressed shell showing a little overlap of the whorls, from fastigate to sub-trapezoidal whorl section by flattened or little convex sides, wide and bisulcate venter with gentle keel. The shell shows a fast-growth coiling, mainly in the outer whorls. High and sloped umbilical wall and rounded umbilical edge. Falcoid, sparse and single ribs, strongly projected on the ventro-lateral edge. The moderately frilled suture is simple.

Holotype measurements. D: 74,5 mm - U: 33,5 mm - U/D: 0.45 - Wb: 18 cm - Wh: 23 mm - Wh/ Wb: 1.27 - Wb/Wh: 0.78.

Description: Moderately evolute shell by little convex sides and a sub-trapezoidal whorl section. The bisulcate venter is wide, showing narrow and little deep sulci and a gentle keel. The sloped umbilical wall is high and the umbilical edge is rounded. The falcoid ribs are sparse (moderately rib-density, we counted 46 ribs in the last whorl of the phragmocone), ever single, little coarse and strongly projected on the ventro-lateral edge. The ammonitic suture is slightly jagged, with the E lobe shorter than L lobe, which is wide and little developed in high.

Paratypes: The paratypes features coincide almost perfectly to the holotype's description. They vary chiefly in having a more or less rib projection on the ventro-lateral edge. All samples in all growth stages show a bisulcate venter, which is the typical character of the species.

Remarks and comparative diagnosis: This species clearly differs from Buckman's holotype of *Hildaites subserpentinus* for whorl section, rib-sculpture and rib-density. At a glance it has a resemblance with some specimens figured by Howarth (1992) as *Hildaites subserpentinus* (pl. 32, figs. 5a-5b; pl. 33, figs. 4a-4b and Pl. 34, figs. 1a-1b), mainly for the ornament. Nevertheless, *H. bisulcatus* differs for the wider and bisulcate venter. This species differs from *H. evolutus* chiefly in having a lesser evolute shell from a sub-trapezoidal whorl section, a narrower bisulcate venter and strongly projected and coarser ribs.

Occurrence: Upper *Striatus* zone.

Hildaites calamantis n. sp.
Pl. IV, fig. 6; Pl. V, figs. 1a-c; Fig. 7, F-G; Fig. 8

Material: Six specimens of large and medium size, all coming from Marconessa quarry.

Derivatio nominis: From the surname of the owner of the SIELPA Company, which mine at Marconessa quarry and well known for his rudeness and discourtesy towards all fossil collectors and deep indifference for the advancement of science.

Fig. 8: *Hildaites calamantis*, n. sp., paratype MSA113, section 2, bed 3b (natural size x 1.17). Coll. Sassaroli.

Holotype: A well preserved specimen of large size with the body chamber MSA85 from Marconessa quarry section 3, bed 4b (Pl. V, figs. 1a-b-c; Fig.7, F-G).
Stratus typicus: Nodular limestone and grey marls of the early Toarcian (Bugarone Formation).
Diagnosis: Evolute compressed shell with moderately overlap of the whorls, flattened sides, from sub-rectangular to swollen almost sub-quadrate whorl section mainly in the body chamber. The wide venter varies from tabulate in the inner whorls to rounded in the outer whorls with a strong and low keel. The umbilical wall is high and almost vertical and the umbilical edge is rounded. Sparse, fine not raised and bifurcating ribs, which have a sinuous retroverted appearance, showing a short not angled proximal segment and a moderate projection on the ventro-lateral edge. The ammonitic suture is more or less frilled, with well developed L and U_2 lobes.
Holotype measurements. D: 149 mm - U: 78 mm - U/D: 0.52 - Wb: 30 mm - Wh: 37 mm - Wh/Wb: 1.23 - Wb/Wh: 0.81.
Description: Evolute compressed shell characterized by flattened sides, a whorl section which is from sub-rectangular in the inner whorls to almost sub-quadrate in the outer whorls. The wide keeled venter varies from tabulate not sulcated in the inner whorls to rounded without a sharply delimited ventral area in the outermost whorl. The umbilical edge is rounded and the umbilical wall is high and almost vertical. The sinuous ribs are fine, spaced, retroverted, usually bifurcating, rarely trifurcating, and almost faded in the proximal segment, where occasionally some gentle reliefs and dips occurs. The ribs are characterized by an almost straight (not angled backward) short proximal segment and by a moderate projection on the ventro-lateral edge. We count 60 ribs in the last whorl of the phragmocone. The little frilled suture show the E lobe shorter than L lobe, which is long with lanceolate accessory lobes. The U_2 lobe is narrow and about the half length of L. The U_3 lobe is shorter and placed on the umbilical wall. The ES saddle is gently slanting, twice as wide as the LS_1 saddle and it shows two additional lobes.
Paratypes: The paratypes have an essential uniformity with the species features for the shell coiling, venter, ornament and suture. Nevertheless, some differences can be observed in the whorl section for a more or less flattened appearance, for a more o less high and vertical umbilical wall. The not bedded paratype MSA193 shows single ribs in the innermost whorls and the paratypes MSA113 has finer and denser ribs, mainly in the inner whorls.
Remarks and comparative diagnosis: The ornament of *H. calamantis* remind that *Hildaites subserpentinus* (with reference to BUCKMAN's holotype only), but it differs chiefly for the wider tabulate and rounded venter, for rib-density and usually bifurcating ribs. The shell size and the occurrence are very unlike too. It is possible, however, a descent of *H. calamantis* from the forms of the gr. *H. subserpentinus*.

Occurrence: Uppermost *Striatus* zone and lower *Undicosta* zone.

Table 1: Measurements in mm of the figured specimens (measurements of holotypes are in the text). D = diameter; U = umbilical width; Wb = whorl breadth; Wh = whorl height.

sample	D	U	Wb	Wh
Hildaites wrighti				
MSA60	61	28	14	19,5
Hildaites subserpentinus				
MSA89	68,5	31	13	22
MSA74	63,5	28,5	11	18,5
MSA133	57	25,5	10	17
MSA219	64	30,5	12	19,5
MSA245	113,5	56	18	30
MSA254	83	41	13	22,5
Hildaites striatus				
MSA30	54	22	10,5	18
MSA108	43	17,5	9	15
MSA214	55,5	25	10	17,5
MSA216	42,5	17,5	9	15,5
MSA218	55,5	25,5	10,5	18
MSA262	19	6,5	7	12
Hildaites exilis				
MSA10	45	18,5	8	16
MSA29	54,5	24	10	18
MSA71	48	20	10	17
MSA97	78,5	33	16	27
MSA102	54	22,5	12	19
MSA148	57,5	25	9	14
MSA277	44	18,5	8	13
Hildaites evolutus				
MSA6	54	30	13	13
MSA28	67,5	38	12	16
MSA58	56	31	11	12
MSA63	28,5	15,5	--	9
MSA831	59,5	28	12,5	17,5
Hildaites bisulcatus				
MSA15	58	29	13	18
MSA146	50	25	12	15
MSA385	39	16	10	14
MSA397	58	26	12,5	19
MSA423	40,5	16	10	14,5
Hildaites planiventris				
MSA64	44	21,5	9	13,5
MSA120	86	42	15	25,5
Hildaites calamantis				
MSA113	106,5	51,5	21	27,2
MSA283	164	70	28	42

V. DISCUSSION AND CONCLUSIONS

In this paper we described some *Hildaites* taxa found in assemblage with very rare Dactylioceratids comparable with *Dactylioceras* (*Orthodactylites*) of the Subboreal and Submediterranean Provinces occurring in the Tenuicostatum zone. Besides, early Toarcian *Hildaites* were abundant in the West Tethyan Province, as proved by the Apennines fossil record. A few *Hildaites* taxa seem to have both a NW European Province and a West Tethyan Province occurrence. Other *Hildaites* taxa seem to have only a West Tethyan Province occurrence, chiefly earliest *Hildaites* as *H. striatus*. We described also four still unpublished taxa *H. bisulcatus*, *H. calamantis*, *H. evolutus* and *H. planiventris*, which seem to characterize the Apennines early Toarcian ammonite assemblage. Dactylioceratids have a worldwide dispersal, so that they are useful to compare the NW European zonation with the Apennines local zonation, where the best indexes are taxa of the genus *Hildaites*.

The Apennines outcrop of the Marconessa quarry yielded some typical early Toarcian Dactylioceratids, i.e. very rare *Dactylioceras* (*Orthodactylites*), such as *D.*(*O.*) *tenuicostatum*, *D.* (*O.*) *semicelatum*, *D.* (*O.*) cf. *clevelandicum* and *D.* (*O.*) cf. *aequistriatum*. These Dactylioceratids characterize the Tenuicostatum zone of the Subboreal and Submediterranean Provinces and they were found in assemblage with early *Hildaites* of the Striatus zone. Therefore, the Apennines Striatus zone is equivalent or almost equivalent to the whole Tenuicostatum zone or at least to the Semicelatum subzone (Tenuicostatum zone) only (see correlation charts, Figs. 9 and 10). Remarkably, in the Marconessa quarry sections (West Tethyan Province) the first occurrence of early *Hildaites* and the first occurrence of some typical Dactylioceratids, which are commonly widespread in the Subboreal and Submediterranean (NW European) Provinces, seem to be a synchronous event and it happened immediately above the OAE black shales recording.

Nevertheless, the question about whether or when the ammonite fauna of the early Tenuicostatum zone (Paltum subzone) of the NW European Province or Polymorphum zone (Mirabile subzone) of the West Tethyan Province occurs in the Apennines sections is still uncertain. In the Marconesssa quarry sections the Dactylioceratids of the FUCINI's Taormina fauna, which are typical markers of the West Tethyan Standard Polymorphum zone (Mirabile subzone), were not found. Probably this FUCINI's fauna is here lacking, because the marine regression of the Pliensbachian-Toarcian boundary, which is marked by the hardground underlying the OAE black shales, produces a gap in the fossil record. This missing record seem to be a common event in several European and Mediterranean sections (GABILLY *et al.*, 1985; GUEX *et al.*, 2001; MORARD *et al.*, 2003; see discussion in ELMI, 2006, 2007). The Moroccan sections studied by GUEX (1973) show an early Toarcian ammonite fauna closer to that of the Apennines. Here, the FUCINI's Dactylioceratids fauna, i.e. *Dactilioceras* (*Eodactylites*) *polymorphum*, *D.* (*E.*) *mirabile*, *D.* (*E.*) *pseudocommune*, *D.* (*E.*) *simplex*, was found by GUEX in assemblage with a Domerian affinity fauna such as *Fontanelliceras fontanellense*, *Juraphyllites libertus*, *Protogrammoceras* (*Paltarpites*), *Lioceratoides* and *Partschiceras*. This fauna occurs below the barren levels called by GUEX "schistes feuilletés bruns", which probably record the OAE. *Hildaites striatus* and *Hildaites subserpentinus* occur above these levels. This author marks the Toarcian beginning with the FO of FUCINI's Dactylioceratids fauna, but this dominant opinion is not universally supported by the fossil record evidence. Some workers believed or still believe that the FUCINI's Dactylioceratids fauna whether associated with a Domerian affinity fauna marks the latest Pliensbachian (FUCINI, 1935; MOUTERDE, 1955; SCHLATTER, 1982; MOUTERDE & RUGET, 1984; CANTALUPPI, 1968;

AGE	MERLA 1932	DONOVAN 1958		GALLITELLI WENDT 1969		FERRETTI 1990		FARAONI et al. 1994		THIS STUDY
	ZONE	ZONE	SUBZONE	ZONE	SUBZONE	ZONE	HORIZON	ZONE	SUBZONE	ZONE
LOWER TOARCIAN	Bifrons (Mercati)	Mercati	Semipolitum	Bifrons	Semipolitum			Bifrons		Bifrons
			Sublevisoni		Sublevisoni				Sublevisoni	
	Serpentinum	Unnamed		Falcifer				Serpentinus	Pseudolevisoni	Undicosta
				Tenuicostatum		Tenuicostatum	Dactylioceras		Striatus	Striatus
									OAE	
UP. DOMERIAN						Spinatum	Emaciaticeras	Mirabilis	Bassani	?
									Simplex	
								Emaciatum		
							Lioceratoides			

Fig. 9: Apennines ammonite zonation correlation between previous studies (MERLA, 1932; DONOVAN, 1958; GALLITELLI WENDT, 1969; FERRETTI, 1990; FARAONI *et al.*, 1994) and this study.

AGE	NW EUROPE Howarth 1992 Page 2003		SUBMEDITERRANEAN Elmi et al. 1994, 1997 Bécaud 2006		MEDITERRANEAN TETHYS "STANDARD" Elmi et al. 1994, 1997; Page 2004			APENNINES Bilotta et al. 2010		THIS STUDY
	ZONE	SUBZONE	ZONE	SUBZONE	ZONE	SUBZONE	HORIZON	ZONE	SUBZONE	ZONE
LOWER TOARCIAN	Bifrons	Crassum	Bifrons	Bifrons	Bifrons	Bifrons		Bifrons		Bifrons
		Fibulatum								
		Commune		Sublevisoni		Sublevisoni			Sublevisoni	
	Falciferum / Serpentinum	Falciferum	Serpentinum	Falciferum	Levisoni	Falciferum		Serpentinus	Douvillei	Undicosta
									Undicosta	
		Exaratum		Elegantolum		Levisoni			Striatus	Striatus
	Tenuicostatum	Semicelatum	Tenuicostatum	Semicelatum	Polymorphum	Semicelatum	Striatus			
		Tenuicostatum		Tenuicostatum				OAE		OAE
		Clevelandicum		Crosbeyi		Mirabile	Paltarpites	Mirabilis	Bassani	?
		Paltum		Paltum					Mirabilis	
PLIENS.	Spinatum	Hawskerense	Spinatun	Hawskerense						
		Apyrenum		Apyrenum						

Fig. 10: Correlation hypotheses among the ammonite zonation based on NW Europe, Submediterranean, Mediterranean Tethys Standard, Apennines (BILOTTA *et al.*, 2010) and this study.

CANTALUPPI & SAVI, 1968; CANTALUPPI & MONTANARI, 1969; PINNA & LEVI SETTI, 1971; GAKOVIC, 1986; RAKUS, 1995). So that, the question of the Pliensbachian-Toarcian boundary occurrence and dating of the West Tethyan Mirabile subzone is still controversial. This question is furthermore intricate by the finding in two Marchean Apennines sections, I Lecceti (Bosso River Valley, Pesaro) (FARAONI *et al.*, 1994) and Maranghi quarry (Burano River Valley, Pesaro) (paleontological data partially published in BILOTTA *et al.*, 2010) of a very interesting ammonite fauna assemblage pre-OAE. These outcrops show the contact between the Corniola limestone Formation (Pliensbachian in age) and the Rosso Ammonitico Umbro-Marchigiano Formation (RAUM, Toarcian in age), which are indeed separated by the OAE black shales. Here, in the Pliensbachian-Toarcian boundary the gap in the fossil record seems to be absent or lesser appreciable than elsewhere. In fact, the top of calcareous layers of Corniola Formation has recorded a rich FUCINI's Dactylioceratids fauna in assemblage

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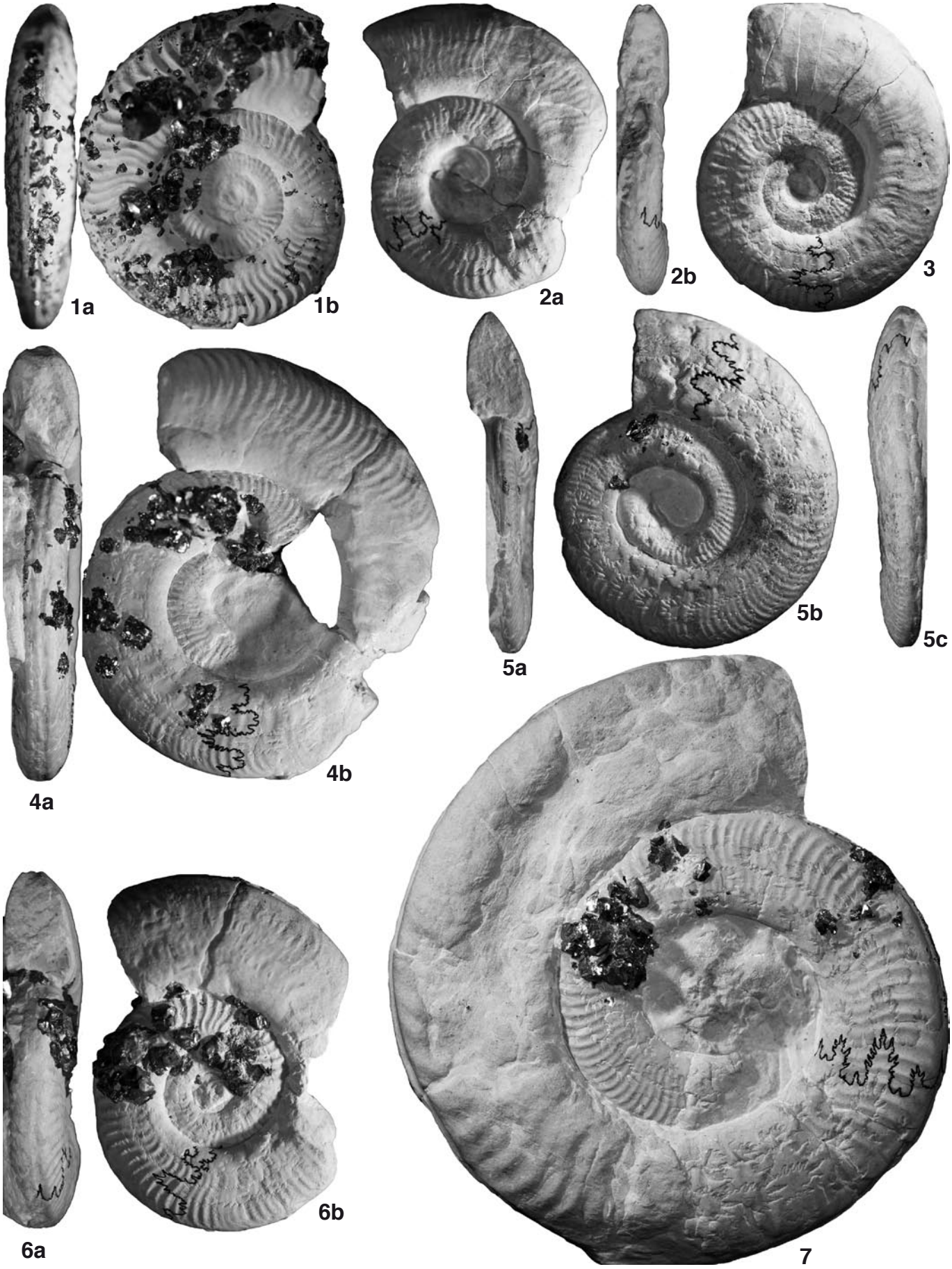
Plate I

Fig. 1a-b: *Hildaites wrighti* (SPATH, 1913). Marconessa quarry, specimen MSA60, section 1, bed 1.
Fig. 2a-b: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA133, section 3, bed 2.
Fig. 3: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA74, section 3, bed 2.
Fig. 4a-b: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA254,section 2, bed 2c.
Fig. 5a-b-c: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA219, section 2, bed 2b.
Fig. 6a-b: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA89, section 3, bed 2.
Fig. 7: *Hildaites subserpentinus* BUCKMAN, 1921. Marconessa quarry, specimen MSA245, section 2, bed 2b.
All specimens coll. SASSAROLI. All figures of this and following plates are natural size.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with a Domerian affinity fauna such as *Partschiceras*, *Meneghiniceras*, *Juraphyllites*, *Tauromeniceras*, *Fontanelliceras*, *Distefaniceras*, *Canavaria*, *Emaciaticeras*, *Protogrammoceras*, *Lioceratoides*, *Neolioceratoides*. Immediately above the nodular limestone, marls and grey-wine coloured calcareous layers occur containing a very rich and very well preserved ammonite fauna still Domerian in affinity, which seems to be a typical assemblage never found elsewhere. This fauna counts at least 15 ammonite genera including Phylloceratidae, Lytoceratidae, rare Dactylioceratidae and aboundant Hildoceratidae (*Fontanelliceras*, *Canavaria*, *Trinacrioceras*, *Distefaniceras*, *Protogrammoceras*, *Petranoceras* and other still unpublished genera). Note that in these sections the faunal mixing assemblage must be excluded. The OAE black shales and then early *Hildaites* of the Apennines Striatus zone occur in the overlying levels.

So that, some questions must be discussed. Is it enough to mark the beginning of the Toarcian with the first occurrence of FUCINI's Dactylioceratids fauna only? Is it really the Mirabile subzone Toarcian in age? Was the occurrence of FUCINI's Dactylioceratids fauna a synchronous event in the Subboreal, Submediterranean and West Tethyan Provinces? Beyond these still open questions, some stand-points nevertheless can be stated on the base of Apennines fossil record evidences:

1) until the OAE occurrence the ammonite fauna shows a Domerian affinity at genus and subfamily levels, probably excluding *Dactylioceras* (*Eodactylites*);

2) a real faunal renewal occurs from the Striatus zone, after the OAE occurrence, when Domerian affinity fauna disappear and the typical Toarcian fauna appears (new Dactylioceratids and Hildoceratids), as *Hildaites* and *Dactylioceras* (*Orthodactylites*);

3) the maximum of anoxia as well as a real and remarkable drop of ammonite fauna extinction seem to be occurred between the Mirabile subzone and the Tenuicostatum subzone (Tenuicostatum zone), i.e. immediately before of the Apennines Striatus zone recording.

4) this result seems to confirm that the acme of the OAE shales recording was not reached in the Serpentinum zone, as commonly believed, but it was reached in the Tenuicostatum zone, as previously substantiated by WIGNALL *et al.* (2005), WIGNALL & BOND (2008) and LITTLER *et al.* (2010) for the Yorkshire coast geological record.

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Plate II

Fig. 1a-b: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA214, section 2, bed 2b.
Fig. 2: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA218, section 2, bed 2b.
Fig. 3a-c: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA30, section 1, bed 1.
Fig. 4: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA216, section 2, bed 2b.
Fig. 5: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA108, section 2, bed 1.
Fig. 6: *Hildaites striatus* GUEX, 1973. Marconessa quarry, specimen MSA262, section 2, bed 2c.
Fig.7: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA97, section 2, bed 3a.
Fig. 8a-c: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA102, section 2, bed 3a.
Fig. 9: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA10, section 1, bed 1.
Fig. 10a-b: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA148, section 3, bed 4a.
Fig. 11a-c: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA29, section 1, bed 1.
Fig. 12: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA71, section 3, bed 1.
Fig. 13: *Hildaites exilis* VENTURI, 1973. Marconessa quarry, specimen MSA277, section 2, bed 3b.
All specimens coll. SASSAROLI.

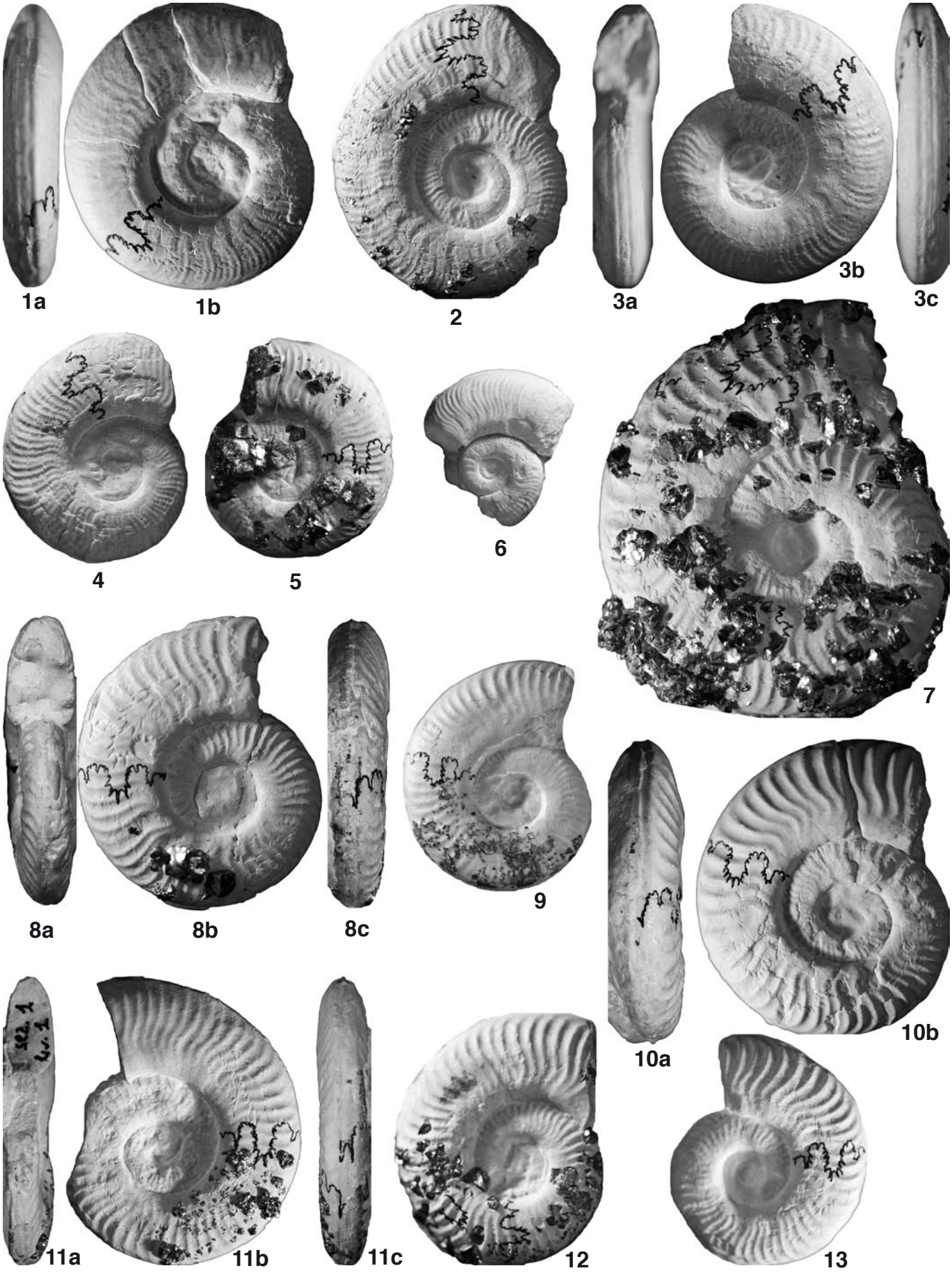
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Plate III

Fig. 1a-b: *Hildaites evolutus* n. sp., Marconessa quarry, holotype MSA426, section 3, bed 1.
Fig. 2a-c: *Hildaites evolutus* n. sp., Marconessa quarry, paratype MSA28, section 1, bed 1.
Fig. 3: *Hildaites evolutus* n. sp., Marconessa quarry, paratype MSA63, section 3, bed 1.
Fig. 4a-b: *Hildaites evolutus* n. sp., Marconessa quarry, paratype MSA6, collected *ex-situ* from detritus of the Striatus zone.
Fig. 5: *Hildaites evolutus* n. sp., Marconessa quarry, paratype MSA831, section 2, bed 2a.
Fig. 6: *Hildaites evolutus* n. sp., Marconessa quarry, paratype MSA58, section 3, bed 1.
Fig. 7: *Hildaites bisulcatus* n. sp., Marconessa quarry, paratype MSA423, section 3, bed 4a.
Fig. 8: *Hildaites bisulcatus* n. sp., Marconessa quarry, paratype MSA385, section 3, bed 4a.
Fig. 9a-b: *Hildaites bisulcatus* n. sp., Marconessa quarry, paratype MSA15, collected *ex situ* from detritus of the Striatus zone.
Fig. 10a-c: *Hildaites bisulcatus* n. sp., Marconessa quarry, holotype MSA351, section 2, bed 3a.
All specimens coll. SASSAROLI.

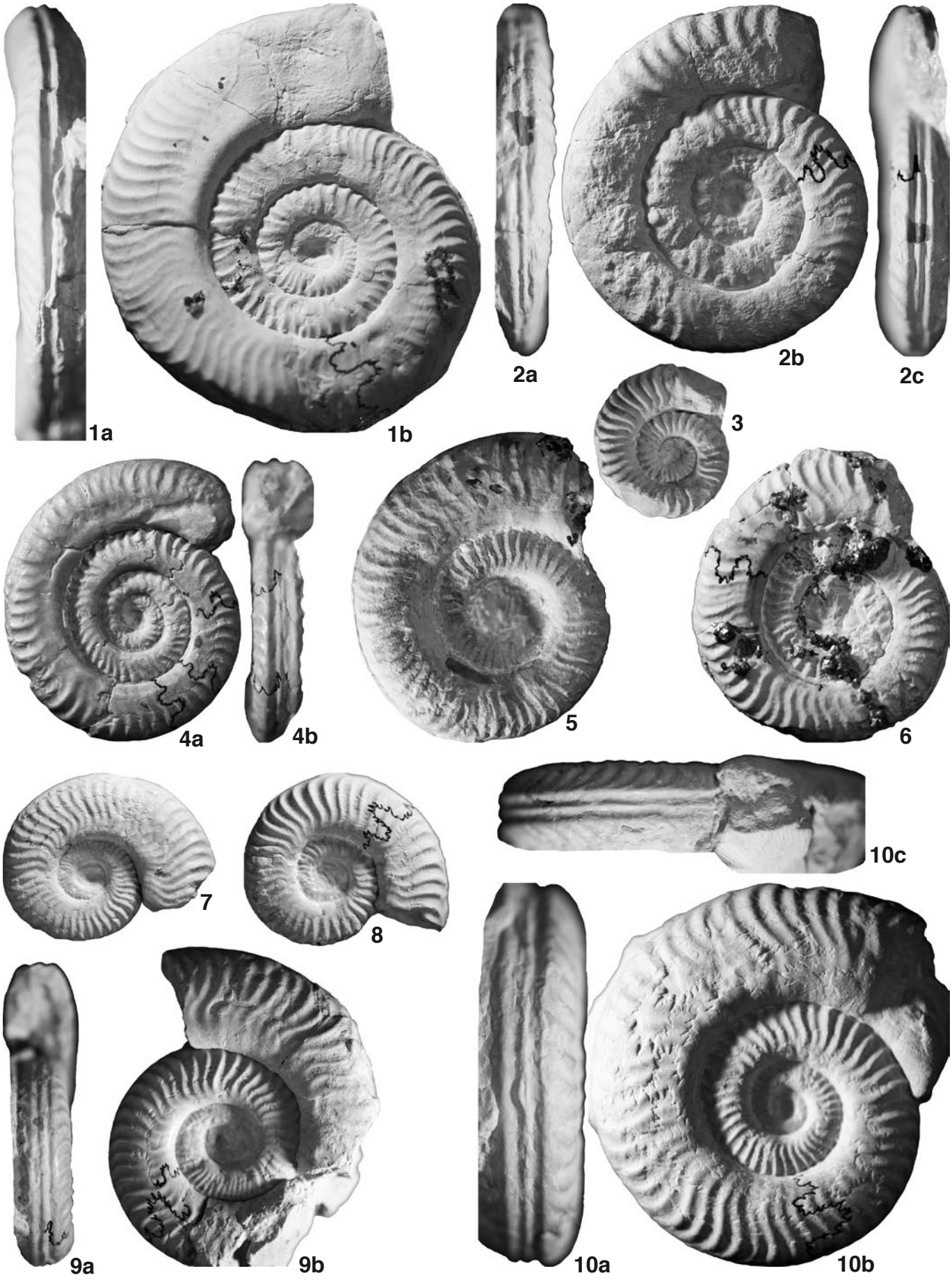
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Plate IV

Fig. 1: *Hildaites bisulcatus* n. sp., Marconessa quarry, paratype MSA146, section 3, bed 3.
Fig. 2: *Hildaites bisulcatus* n. sp., Marconessa quarry, paratype MSA397, section 3, bed 3.
Fig. 3a-c: *Hildaites planiventris* n. sp., Marconessa quarry, holotype MSA61, section 3, bed 1.
Fig. 4: *Hildaites planiventris* n. sp., Marconessa quarry, paratype MSA64, section 3, bed 1.
Fig. 5: *Hildaites planiventris* n. sp., Marconessa quarry, paratype MSA120, section 3, bed 1.
Fig. 6: *Hildaites calamantis* n. sp., Marconessa quarry, paratype MSA283, section 2, bed 6.
All specimens coll. SASSAROLI.

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Plate V

Fig. 1a-c: *Hildaites calamantis* n. sp., Marconessa quarry, holotype MSA85, section 3, bed 4b. Coll. SASSAROLI.

1a

1b

1c

ratidae, Nannolytoceratidae, Hammatoceratidae, Hildoceratidae. *Memorie della Società Italiana di Scienze Naturali e del Museo Civico Storia di Naturale Milano*, 17(1): 1-69.

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