| Rivista Italiana di Paleontologia e Stratigrafia | volume 110 | no. 1 | 3 pls. | pp. 357-372 | April 2004 |
| --- | --- | --- | --- | --- | --- |

# MIDDLE JURASSIC - EARLY CRETACEOUS INTEGRATED BIOSTRATIGRAPHY (AMMONITES, CALCAREOUS NANNOFOSSILS AND CALPIONELLIDS) OF THE CONTRADA DIESI SECTION (SOUTH-WESTERN SICILY, ITALY)

MARIA CONCETTA MARINO[1], GLORIA ANDREINI[2], ANGELA BALDANZA[2], CAROLINA D'ARPA[3], NINO MARIOTTI[4], GIOVANNI PALLINI[5], GUIDO PARISI[2] & FABIO MASSIMO PETTI[4]

*Received December 7, 2002; accepted October 1st, 2003*

*Keywords*: ammonites, calcareous nannofossils, calpionellids, biochronology, Middle-Late Jurassic-Early Cretaceous, Sicily, Italy.

*Abstract*. Facies and biostratigraphic analyses of the Contrada Diesi succession, cropping out along the northern slope of Mt. Magaggiaro (Sciacca, SW Sicily), provided new data on the Middle Jurassic-Early Cretaceous pelagic sedimentation in the Saccense domain. The richness in ammonites allowed the identification of Bathonian-Kimmeridgian Biozones and Subzones, while the Tithonian-Valanginian interval was defined mainly by calpionellids and calcareous nannofossils. Facies and microbiofacies analyses of the Jurassic-Cretaceous pelagic sediments of the area, together with ammonite, calpionellid and calcareous nannofossil integrated biostratigraphy, were very effective tools for comparison of biostratigraphic events. Many gaps in sedimentation were recognized, the most important spanning the middle and late Berriasian and part of the early Berriasian. The Contrada Diesi succession provides new litho-biostratigraphic data on the Saccense Domain. It suggests a high degree of internal variability tied to the irregular paleotopography of the carbonate platform substrate (Inici Fm.), derived from Early Jurassic tectonics. Gaps in sedimentation in the Contrada Diesi sections indicate that the environment of the Saccense Domain was characterized by a variable rate of sedimentation and energy changes.

*Riassunto*. L'analisi biostratigrafica e delle litofacies della successione Contrada Diesi, affiorante sul versante settentrionale di Monte Magaggiaro (Sciacca, Sicilia sud-occidentale), ha fornito nuovi dati riguardanti l'evoluzione sedimentaria "pelagica" nel Dominio Saccense dal Giurassico medio al Cretaceo inferiore. La ricchezza di ammoniti ha permesso di riconoscere biozone e subzone dell'intervallo Bathoniano-Kimmeridgiano, mentre l'intervallo Titonico-Valanginiano è stato ben definito principalmente mediante nannofossili calcarei e calpionellidi. La biostratigrafia integrata ad ammoniti, calpionellidi e nannofossili calcarei ha fornito una buona opportunità di comparazione tra differenti eventi sia litostratigrafici che biostratigrafici. Sono state individuate numerose lacune di sedimentazione, fra cui la più imponente è quella comprendente il Berriasiano medio e superiore e parte dell'inferiore. All'interno del Dominio Saccense si delinea così un elevato grado di variabilità interna legato, con ogni probabilità, alla paleotopografia irregolare del substrato carbonatico (Fm. Inici) ereditata dalle fasi distensive del Giurassico inferiore. La ripetuta presenza di lacune consente inoltre di avanzare l'ipotesi che l'ambiente deposizionale sia stato caratterizzato da tassi di sedimentazione variabili e da improvvisi cambi energetici.

## Introduction

The results of stratigraphic analyses carried out on a Jurassic-Cretaceous succession of the Saccense Domain are here presented. The succession is well exposed in the quarry at Contrada Diesi, near Sciacca (South-Western Sicily), on the northern slope of Mt. Magaggiaro (Fig. 1). Lithostratigraphic, biostratigraphic and facies-microbiofacies analyses highlighted several aspects of the sedimentary evolution of the Saccense pelagic succession during the Jurassic-Early Cretaceous interval. The sediments examined consist of different lithologies belonging to the Inici Fm., Buccheri Fm. and Lattimusa Fm. (Di Stefano et al. 2002). The time interval ranges from the Bathonian to the late Valanginian. The richness of different fossil groups (ammonites, calcareous nannofossils and calpionellids) offered the opportunity to compare and calibrate different biozonations, improving the knowledge of Jurassic and Cretaceous biochronology.

1 Dipartimento di Scienze Geologiche - Università di Catania, Corso Italia 55, 95129 Catania, Italy. E-mail: marinom@unict.it
2 Dipartimento di Scienze della Terra - Università degli Studi di Perugia, Piazza Università, 06100 Perugia, Italy. E-mail: abaldanz@unipg.it - gparisi@unipg.it
3 Dipartimento di Geologia e Geodesia, Università di Palermo - Corso Tukory 131, 90134 Palermo, Italy. E-mail: mgup@unipa.it
4 Dipartimento di Scienze della Terra, Università degli Studi di Roma "La Sapienza" - Piazzale Aldo Moro 5, 00165 Roma, Italy. E-mail: nino.mariotti@uniroma1.it; fabio.petti@uniroma1.it
5 Dipartimento di Scienze della Terra - Università "G. D'Annunzio" di Chieti, Via dei Vestini 30, 66013 Chieti Scalo (CH), Italy.

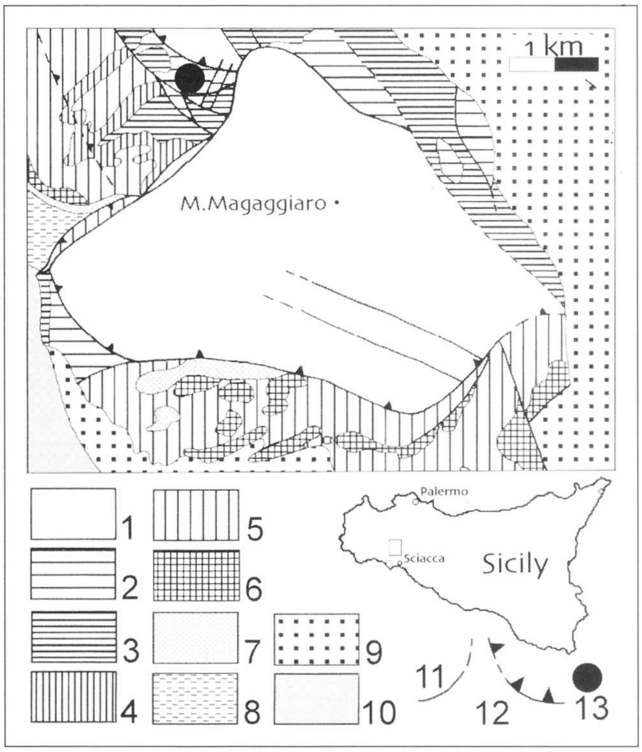



Fig. 1 - Geological map of the Monte Magaggiaro area and location of the studied sections. 1) Limestone and dolostone of peritidal platform environment (Late Triassic/lower part of Early Jurassic); 2) Condensed pelagic deposits (Pliensbachian-Tithonian); 3) Calpionellid limestone (Lattimusa Fm. Auctt., Tithonian-Albian); 4) Scaglia Fm. (Cenomanian-Eocene); 5) Marly limestone with intercalated nummulitic biocalcarenites (middle-Late Oligocene); 6) Grey and pink limestone and dolostone with *Lepidocyclina* (Aquitanian); 7) Glauconitic sandstones (Burdigalian-Langhian); 8) Deltaic and turbiditic deposits (late Tortonian-Messinian); 9) *Amphistegina* calcarenites (Pliocene); 10) Calcarenites and marls (Early Pleistocene); 11) fault; 12) thrust; 13) location of the studied sections

## Geological setting

The area investigated is at Mt. Magaggiaro (Sciacca, SW Sicily) and it is part of the external portion of the south-verging side of the Apennine-Maghrebian mountain chain, a thrust system derived from slight deformation of Meso-Cenozoic units covered by syntectonic terrigenous deposits (Catalano et al. 1995a, 1995b, 2000). Structural and stratigraphic analyses in the Sciacca area were carried out by Mascle (1970, 1974, 1979), Di Stefano & Vitale (1994), and Vitale (1990, 1995). Di Stefano & Vitale (1993) mapped the Western Sicanian Mts., compiling a detailed lithostratigraphic scheme which shows high degree of variability among different successions throughout the area.

The area studied belongs to the Saccense Domain (Catalano & D'Argenio 1978, 1982; Mascle 1970), which represents the outer and less deformed domain and is interpreted as a Triassic carbonate platform evolving to a pelagic carbonate platform (PCP of Santantonio 1993, 1994). In recent papers (Catalano et al. 1995a, 1995b), due to new structural data (more internal position of the basinal units – Imerese and Sicanian – with respect to the carbonate platform units – Panormide, Trapanese and Saccense) this paleogeographic reconstruction was changed. In this new scheme the Saccense Domain, together with the Panormide and Trapanese Domains, represents the remains of an extended carbonate platform, with irregular morphology, passing to a basinal area (Imerese and Sicanian Domain). According to this palinspastic restoration, the area of Mt. Magaggiaro belongs to the Hyblean-Pelagian Domain, a morphostructural high with complex morphology and neritic-pelagic, locally condensed, sedimentation that took place above continental crust of "normal" thickness.

The Jurassic-Lower Cretaceous litostratigraphic succession of the Saccense Domain has been the object of accurate studies (Catalano & D'Argenio 1990; Catalano et al. 1995a, 1995b; Catalano et al. 2000; Di Stefano et al. 1996; Vitale 1990; Di Stefano & Vitale 1993). The lowermost part of the succession consists of several thousand metres of platform limestone and dolostone of Late Triassic age, formally named Sciacca Fm. and synonymous with the Gela Fm. of the Hyblean Plateau. It is overlain by 200-300 m of shallow water carbonates of Early Jurassic age (Inici Fm.) (Schmidt di Frieberg 1965; Ronchi et al. 2000). This unit is followed upwards by the Buccheri Fm. (or "Rosso Ammonitico"), consisting of different condensed pelagites with abundant ammonites, which spans the Early Jurassic-early Tithonian interval. The Buccheri Fm. is replaced by the "Calcari a Calpionelle", better known as Lattimusa Fm. or Chiaramonte Fm., equivalent to the Apenninic Maiolica Fm. The Lattimusa Fm. is referred to the latest Jurassic to Early Cretaceous time interval.

## Lithostratigraphy and microfacies analysis

### Section I

Section I crops out along an artificial exposure of an active quarry (Fig. 2). It may be subdivided into six informal lithostratigraphic units: (bottom to top) Bioclastic platform limestone (Inici Fm.), *Bositra* limestone, Calcisiltitic limestone, Stromatolitic calcarenitic limestone, Pebbly calcarenite, Grey-reddish nodular marly limestone/Calcari a Calpionelle (Fig. 3).

**Bioclastic platform limestone (Sinemurian p.p.)** - This unit is made of thick-bedded bioclastic limestone showing fenestral lamination, with peloids, intraformational lithoclasts, oncolites and algae. The microfossil assemblage is represented by *Siphovalvulina* sp., *Textularia* sp., *Lituosepta* sp., *Ammobaculites* sp., *Trocholina* sp., *Glomospira* sp., associated with *Cayeuxia* sp., gastropods, bivalves, and echinoderm fragments. The end of the carbonate platform sedimentation is regionally known to be

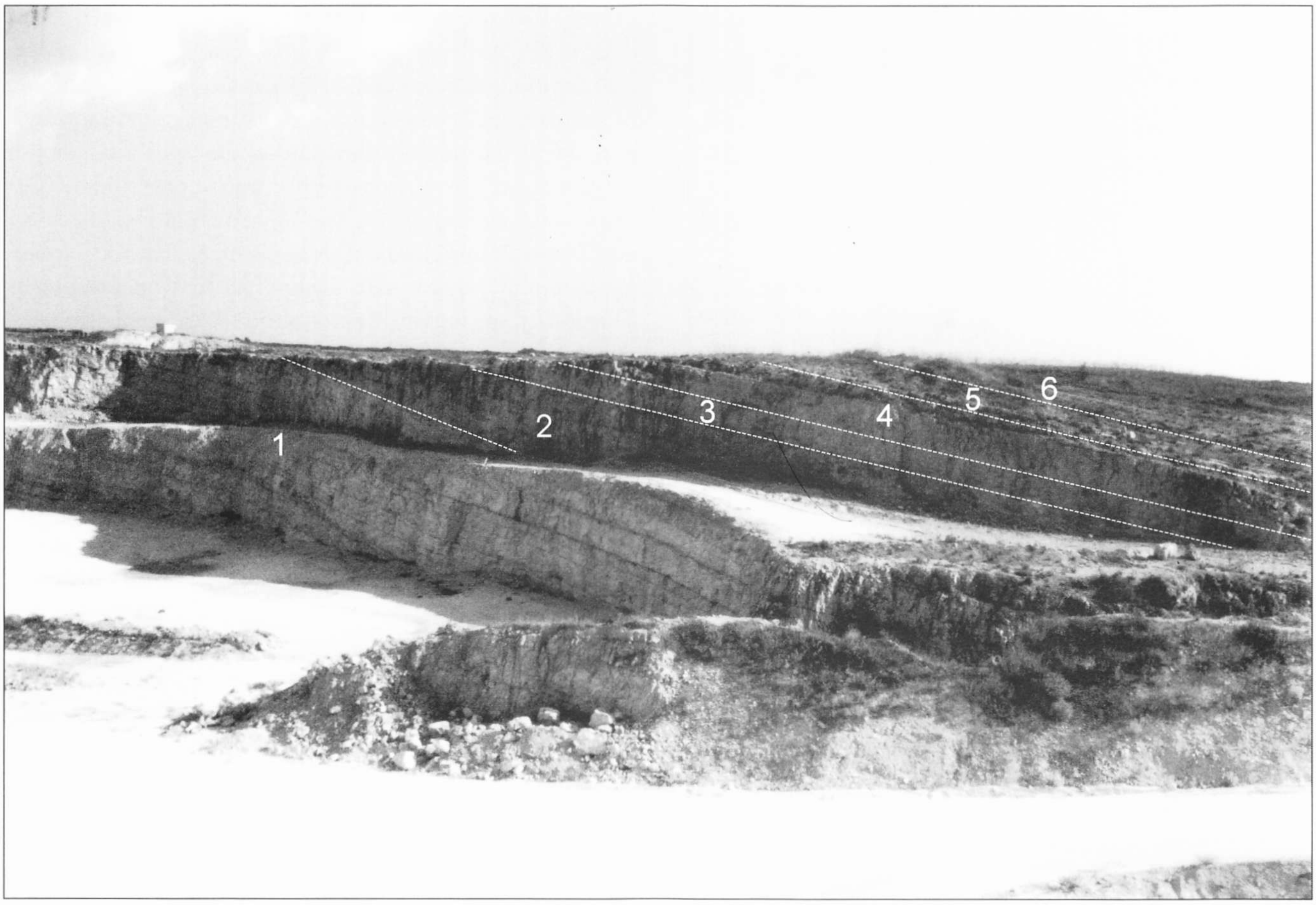



Fig. 2 - Panoramic view and schematic drawing of the lithostratigraphic units. Contrada Diesi Quarry, Section I. For the lithostratigraphic units see Fig. 3.

Sinemurian in age (Di Stefano et al. 2002). The uppermost portion of the unit is cut across by mono- and polyphase neptunian dykes of different age ranging from latest Early Jurassic to Late Jurassic. Carbonate platform sediments are overlain paraconformably with a sharp contact by pelagites corresponding to a stratigraphic hiatus ranging from the Sinemurian p.p. to the late Bajocian.

***Bositra* limestone (lower Bathonian–middle Oxfordian p.p.)** - The pelagic succession starts with a massive, ochre to reddish biogenic calcisiltite to calcarenite; sheet-cracks sub-parallel to bedding occur locally. The unit consists of packstone, more rarely wackestone, with abundant thin-shelled bivalves (sensu Conti & Monari 1992), often chaotically arranged. Peloids and intraformational lithoclasts are also present. The representative microfossils in this portion are foraminifers (rare small Protoglobigerinids, Textulariids, Valvulinids, Spirillinids), *Stomiosphaera* sp., ostracods and rare radiolarians, while echinoderm fragments are common throughout. *Globochaete* sp. is ubiquitous. Upward, the occurrence of ellipsoidal wackestone intraclasts, several centimetres across, indicates a facies change. Thin-shelled bivalves are rarer than in underlying levels, while the frequency of echinoderm fragments increases; *Globochaete* sp. and large Protoglobigerinids are common in finer-grained portions.

A discontinuity surface at 6.75 m is marked locally by a black LLH (after Logan et al. 1964) stromatolite. This discontinuity is a distinctive horizon that can be followed along the entire front of the quarry.

**Calcisiltitic limestone (middle Oxfordian p.p.-upper Oxfordian p.p.)** - Above the discontinuity, a level rich in ammonites lying parallel to the bedding is present. It can be followed laterally, across the entire section and it makes a useful marker level. The calcisiltitic limestone, 2.5 m thick, consists mainly of wackestone with Protoglobigerinids and radiolarians. Many ammonites bear stromatolitic caps and some have domes on both sides. This unit records the disappearance of thin-shelled bivalves, coincident with a bloom of Protoglobigerinids. The uppermost 2 m of the interval are made of reddish calcisiltitic limestone, impregnated with ferruginous minerals. Upward, the colour shades into light brown.

**Stromatolitic calcarenitic limestone (Kimmeridgian-lower Tithonian p.p.)** - This unit is about 3 m thick, massive, with stromatolites occurring both as isolated domes and as LLH continuous structures. Weathering enhances cryptalgal lamination, as well as randomly oriented skeletal remains such as belemnites and echinoids. Ammonites, as well as small clasts and brachiopods, are frequently capped by stromatolitic

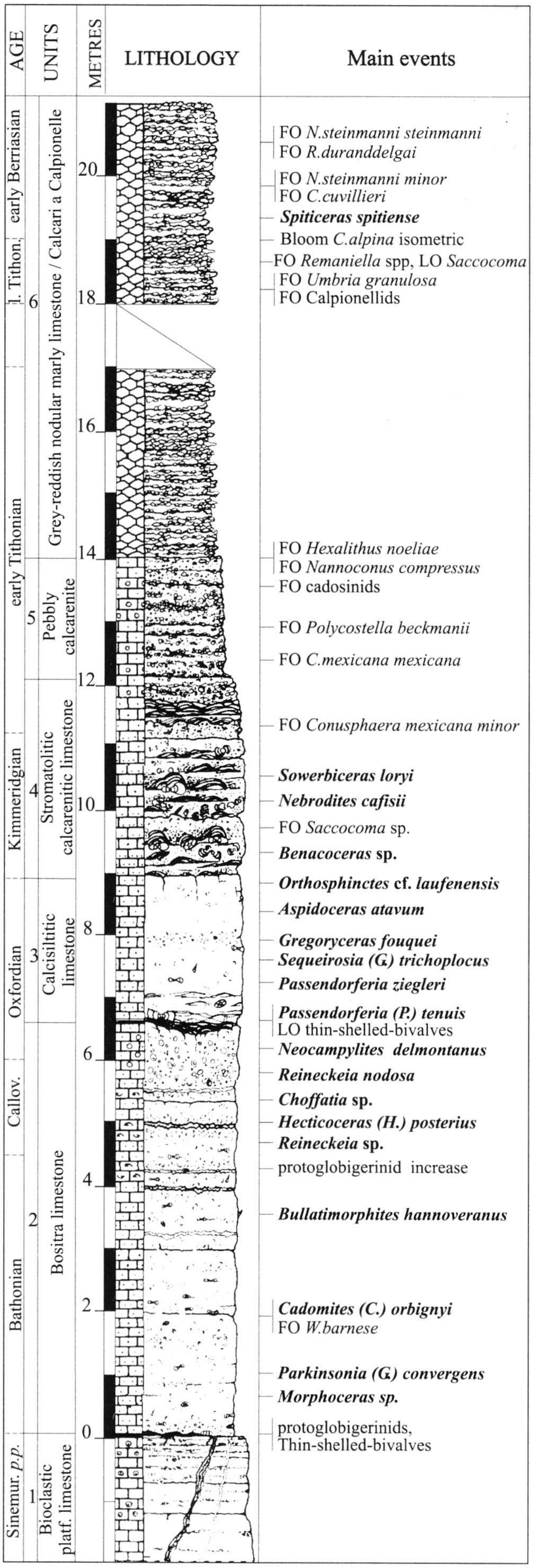



Fig. 3 - Chrono-lithostratigraphy and main bioevents of the Contrada Diesi Quarry, Section I.

domes. The texture is a laminated packstone with abundant echinoderm fragments. Protoglobigerinids are less frequent in levels dominated by echinoderms. At the top of this unit, coarse calcarenites (often grainstone) contain rounded intraclasts. Microfossils include *Globochaete* sp., *Spirillina* sp., *Stomiosphaera* sp., *Involutina* sp., *Lenticulina* sp., *Turrispirillina* sp., Ophthalmidiids, Lagenids, and Protoglobigerinids. Echinoderm debris and *Lamellapthychus* fragments also occur. The first occurrence of *Saccocoma* sp. is recorded at about 9.75 m of the total thickness of the section.

**Pebbly calcarenite (lower Tithonian p.p.)** – Upward, the section continues for a thickness of nearly 2 m with alternating conglomeratic and sand-sized crinoidal levels (also with belemnites, echinoid spines, bivalves and *Saccocoma* sp.). Discontinuous stromatolitic levels are present as well. The first occurrence of Cadosinids is recorded at the top of this unit.

**Grey-reddish nodular marly limestone/Calcari a Calpionelle (lower Tithonian p.p.-lower Berriasian)** - This unit consists of grey-reddish nodular and marly limestone in thin beds. The nodular limestone is a packstone with crinoidal debris, internal moulds of ammonites and apthychi. Nodules are made of mudstone/wackestone, often with stylolithic contact. Microfossils include foraminifers, mainly *Lenticulina* sp. and *Spirillina* sp., radiolarians, Cadosinids and *Saccocoma* sp. Unfortunately, ammonites are represented only by stratigraphically not diagnostic Phylloceratids and Lytoceratids. Because of a little tectonic disturbance, the upper part of this unit was analysed some metres further, along the road outside the quarry. The last occurrence of *Saccocoma,* together with the first occurrence of Calpionellids, is recorded at this site. The interval is named conventionally Calcari a Calpionelle for the inception of calpionellids.

## Section II

Section II is exposed in a small natural trench just outside the quarry (Fig. 4). In the small natural trench, near Section I, a small outcrop, about 26 m thick, of Upper Jurassic p.p./Lower Cretaceous p.p. sediments, corresponding to the top of Section I, is visible. Section II differs slightly from Section I because the Stromatolitic interval is here replaced by a calcarenitic/calcisiltitic level.

This section could be subdivided into three informal lithostratigraphic units (bottom to top): Calcarenitic/calcisiltitic limestone, Nodular marly limestone, Calcari a Calpionelle (Fig. 5, 6).

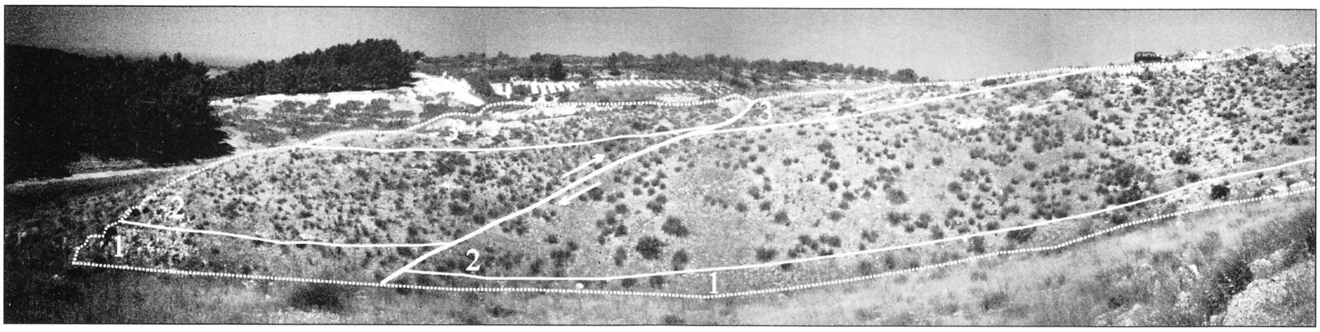



Fig. 4 - Panoramic view and schematic drawing of the lithostratigraphic units. Contrada Diesi, Section II. For the lithostratigraphic units see Fig. 5.

**Calcarenitic/calcisiltitic limestone (upper Kimmeridgian-lower Tithonian p.p.)** - This unit is represented by a light brown calcarenitic/calcisiltitic limestone rich in thin-shelled bivalves, and by wackestone and packstone with abundant *Saccocoma* and echinoid fragments. From 3.5 m, *Saccocoma* increases and Protoglobigerinids decrease. Protoglobigerinids disappear at the top of the unit.

**Nodular marly limestone (lower Tithonian p.p.-upper Tithonian p.p.)** - Grey-yellowish nodular marly limestone with thin cherty levels are ascribed to this unit. The texture is a wackestone and subordinate packstone with *Saccocoma,* radiolarians and echinoid fragments. In this unit *Saccocoma* decreases, while Cadosinids increase.

**Calcari a Calpionelle (upper Tithonian p.p.- upper Valanginian)** - This unit is characterized at the base by a white nodular limestone of limited thickness, which is replaced by a thin, white well-bedded limestone. As a whole, this interval includes wackestone and mudstone with abundant Calpionellids, foraminifers (Textulariids and Valvulinids), rare radiolarians, echinoid fragments and some ammonites. *Saccocoma* disappears at the base of this unit in the uppermost Tithonian; the last (rare) *Saccocoma* occur together with the first Calpionellids.

## Biostratigraphy

### Ammonites

**Section I** - Ammonite-rich deposits in this section provided new biostratigraphic data on the Bathonian-Kimmeridgian interval. Bed by bed sampling yielded more than 300 specimens. Selected ammonite species are illustrated in Pl. 1, and the range of species observed is reported in Fig. 3 and 7. Biostratigraphic data are referred to the zonal schemes proposed by Meléndez & Fontana (1993), Cariou & Hantzpergue (1997) and Meléndez et al. (1997), including some more recent modifications by Matyja & Wierzbowski (1997).

The first metre of the pelagic succession displays an ammonite assemblage composed of *Morphoceras* sp. ind., *Morphoceras* cf. *macrescens* (Buckman), comparable to the specimens illustrated by Mangold (1970b) (pl. 5, figs. 11, 12, 13), *Parkinsonia* sp., *Parkinsonia* (*Gonolkites*) *convergens* (Buckman), *Cadomites* (*C.*) sp., *Cadomites* (*Cadomites*) *daubenyi* (Gemmellaro), *Cadomites* (*Polyplectites*) sp., *Strigoceras* sp., *Procerites* sp. and *Oppelia undatiruga* Gemmellaro; the latter is similar to the form illustrated by Wendt 1964 (pl. XVIII, fig. 2) under the name *Oppelia* (*Oxycerites*) *aspidoides* and is synonymous with the specimen described by Gemmellaro, 1877 and 1882 (p. 137, pl. XVIII, fig. 8). All the forms mentioned above may be related to the lower Bathonian *Z. zig-zag* Zone. From 1.00 to 1.30 m the disappearance of Parkinsoniidae and of the genus *Morphoceras* is noteworthy; *Procerites* sp. ind., *Cadomites* sp. ind., *Cadomites* (*Cadomites*) *daubenyi* (Gemmellaro) (Pl. 1, figs.10-13) are still present, together with *Procerites* (*Procerites*) cf. *tmetolobus* Buckman, *Procerites* (*Procerites*) *postpollubrum* Buckman and a specimen of *Bullatimorphites* sp.. However, the absence of other diagnostic taxa precludes the referral of this interval to the lower Bathonian *P. aurigerus* Zone. The interval between 1.30 and 1.80 m is poorly fossiliferous, yielding only two specimens of *Cadomites* (*Cadomites*) *orbignyi* (de Grossouvre) (Pl. 1, fig. 12) and a single specimen of *Hecticoceras* (*Prohecticoceras*) cf. *ochraceum* Elmi which mark the beginning of the middle Bathonian *P. progracilis* Zone (*C. orbignyi* Subzone). Oppeliidae are also present. From 2.20 to 3.20 m no significant ammonite was found. The upper Bathonian *H. retrocostatum* Zone was recognized in the interval between 3.20 and 4.00 m, based on an ammonite assemblage characterized by some diagnostic taxa, i.e. *Homoeplanulites* (*Homoeplanulites*) *bugesiacus* (Dominjon) (close to the specimens illustrated by Mangold 1970a, pl. II, figs. 2-9, *H. blanazense* Subzone), *Bullatimorphites hannoveranus* (Roemer) (Pl. 1, fig. 11) (similar to the specimen illustrated by Géczy & Galácz (1998), pl. III, figs.1-2, *B. hannoveranus* Subzone) and *Choffatia* (*Choffatia*) *densidecorata* Galàcz (Galàcz, 1980, pl. XXXV). No ammonites related to the *T. subcontractus, M. morrisi* and *C. bremeri* Zones (middle Bathonian) and *C. discus* Zone (uppermost Bathonian) were found. From 4.65 to 5.30 m, a rich assemblage of *Hecticoceras* (*Hecticoceras*) *posterius*

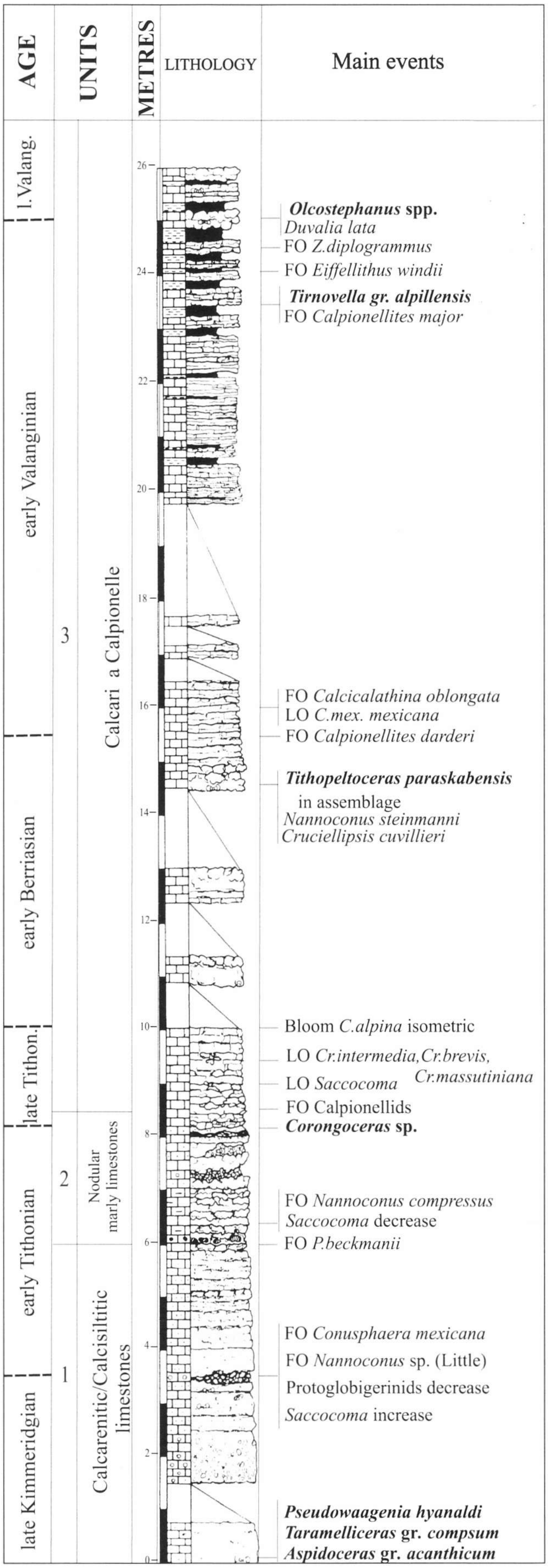



Fig. 5 - Chrono-lithostratigraphy and main bioevents of the Contrada Diesi, Section II.

Zeiss (Pl. 1, fig. 8), resembling the specimens illustrated by Elmi (1967) (pl. 12, figs. 4, 6, 7, 8, 9), *Holcophylloceras zignodianum* (d'Orbigny), *Calliphylloceras disputabile* (Zittel), *Reineckeia* sp. ind., *Choffatia* sp. ind., indicate the lower Callovian *M. gracilis* Zone. There are no ammonite records indicating the *B. bullatus* Zone (lowermost Callovian). Between 5.30 and 5.86 m, the occurrence of *Choffatia* sp., *Reineckeia nodosa* Till (Pl. 1, fig. 9) and *Reineckeia* cf. *nodosa* Till (Pl. 1, fig. 14) was detected; the latter, described and illustrated by Jeannet (1951), are related to the *R. anceps* Zone. At about 6.20 m, the occurrence of a truncated specimen of *Passendorferia* (Macroconch), close to the group *czenstochowiensis* (Siemiradzki), suggests the upper part of the *P. claromontanus* Zone. Two specimens of *Prososphinctes*, close to the form described *Prososphinctes* sp. nov. *A* by Bourseau (1977) were found between 6.25 and 6.30 m. Two specimens, of *Neocampylites delmontanus* (Oppel) and of *Taramelliceras obumbrans* Hölder respectively, come from the same level. According to Bourseau (1977), these species may represent the lower *P. plicatilis* Zone, i.e. *C. vertebrale* Subzone. Upwards, at 6.50 m, a specimen of *Perisphinctes* sp. was recovered. This specimen could represent the macroconch of *Perisphinctes montfalconensis* de Loriol, also typical of the *C. vertebrale* Subzone. *Passendorferia* (Macroconch *Passendorferia*) aff. *tenuis* (Enay) (Pl. 1, fig. 5) also occurs in this level. At 6.75 m, the succession is marked by a sharp discontinuity surface, where a truncate specimen of *Tornquistes* sp., showing intermediate features between *Pachytornquistes* (*Tornquistes*) *kobyi* de Loriol and *Pachytornquistes* (*Tornquistes*) *oxfordiense* (Tornquist), was found. This surface probably represents the *P. plicatilis-G. transversarium* Zone boundary. The ammonite record indicates the existence of a biostratigraphic gap comprising at least the *P. antecedens* and *P. parandieri* Subzones.

The *G. transversarium* Zone is well represented in the overlying interval, between 6.75 and 7.25 m. The *P. luciaeformis* Subzone is characterized, between 6.75 m and 7.10 m, by an ammonite assemblage comprising *Passendorferia* (Macroconch *Passendorferia*) *ziegleri* (Brochwicz-Lewinski), found just five centimetres above the discontinuity surface, *Sequeirosia* (microconch *Gemmellarites*) *trichoplocus* (Gemmellaro), a specimen of *Gregoryceras transversarium* (Quenstedt), and several *Euaspidoceras* species. The *L. schilli* and *P. rotoides* Subzones could be recognized between 7.17 and 7.25 m, in a mixed fossil assemblage. The specimens recorded, representative of this stratigraphic interval, are: a juvenile specimen of *Passendorferia* (Macroconch) *erycensis* Melendez (Pl. 1, fig. 7),

Fig. 6 - Contrada Diesi Section II: distribution chart of the studied fossils.

| AGE | Kim. | | | early Tithonian | | | | | | | | | | | | l.Tithon. | | | | early Berri. | | | | | | early Valanginian | | | | | | | | | | | | | | | l.Valang. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lithostratigraphic units** | Calcar./Calcisiltitic limestone | | | | | | | Nodular marly limestone | | | | | | | | Calcari a Calpionelle | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Metres** | 0.00 | 1.50 | 2.50 | 3.50 | 3.80 | 4.50 | 5.50 | 6.00 | 6.15 | 6.30 | 6.60 | 7.00 | 7.20 | 7.70 | 8.10 | 8.15 | 8.50 | 8.90 | 9.50 | 10.00 | 11.30 | 11.70 | 12.50 | 14.50 | 14.70 | 15.50 | 16.00 | 16.50 | 17.00 | 17.50 | 20.50 | 21.00 | 21.50 | 22.00 | 22.50 | 23.00 | 23.50 | 24.00 | 24.20 | 24.50 | 25.00 | 25.20 | 25.50 | 25.70 | 26.00 | |
| **Samples** | A 0.00 | A 1.50 | A 2.50 | A 3.50 | A 3.80 | A 4.50 | A 5.50 | A 6.00 | A 6.15 | A 6.30 | A 6.60 | A 7.00 | A 7.20 | A 7.70 | A 8.10 | A 8.15 | A 8.50 | A 8.90 | A 9.50 | A 10.00 | A 11.30 | A 11.70 | A 12.50 | L9 | L9A | L9C | L9B | L8 | L8A | L7 | L6 | L6A | L5 | L5A | L4 | L4A | L3 | L3B | L3C | L3A | L2 | L2A | L1 | L1A | L0 | |
| *Pseudowaagenia hyanaldi* | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | AMMONITES |
| *Taramelliceras* gr. *compsum* | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aspidoceras* gr.*acanthicum* | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Corongoceras* sp. | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Tithopeltoceras paraskabensis* | | | | | | | | | | | | | | | | | | | | | | | | • | | | | | | | | | | | | | | | | | | | | | | |
| *Tirnovella* gr.*alpillensis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | | | | | | | |
| *Olcostephanus* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | | • | |
| *Cyclagelosphaera margerelii* | | | | | | • | | | | | • | | • | • | | | | | • | | | | | • | | • | • | | • | | | | | | | | | | | | | | | | | CALCAREOUS NANNOFOSSILS |
| *Watznaueria manivitae* >15µ | | | • | • | | | • | | • | | • | | • | • | | | | | • | | | | | • | | • | • | | • | | | | | | | | | | | | | | | | | |
| *Watznaueria barnesae* | | | • | • | | • | • | • | • | | • | | • | • | | | • | • | • | | | | | • | | • | • | | • | | | • | • | | | | | • | | • | | | | | | |
| *Cyclagelosphaera wiedmannii* | | | | • | | • | • | • | • | | • | | • | • | | | | • | • | | | | | • | | • | • | | • | | | • | • | | | | | • | | • | | | | | | |
| *Cyclagelosphaera deflandrei* | | | | • | | • | • | • | • | | • | | • | | | | | | • | | | | | | | • | • | | • | | | • | | | | | | | | | | | | | | |
| *Conusphaera mexicana minor* | | | | • | | | • | • | | | | | • | | | | | | • | | | | | • | | • | | | | | | | | | | | | | | | | | | | | |
| *Conusphaera mexicana mexicana* | | | | • | | • | • | • | • | | • | | • | • | | | • | | • | | | | | • | | • | | | | | | | | | | | | | | | | | | | | |
| *Zeugrhabdotus embergerii* | | | | | | | | | | | • | | • | | | | | | | | | | | • | | • | • | | • | | | • | | | | | | | | | | | | | | |
| *Nannoconus* sp. | | | | • | | • | | • | • | | | | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Polycostella beckmanii* | | | | | | | | • | • | | • | | • | | | | | | | | | | | | | • | • | | • | | | • | • | | | | | • | | | | | | | | |
| *Nannoconus compressus* | | | | | | | | | • | | • | | • | | | | | | | | | | | • | | | | | | | | | | | | | | | | | | | | | | |
| *Cruciellipsis cuvillieri* | | | | | | | | | | | | | | | | | | | | | | | | • | | • | • | | • | | | • | • | | | | | | | | | | | | | |
| *Zeugrhabdotus cooperi* | | | | | | | | | | | | | | | | | | | | | | | | • | | | • | | • | | | • | • | | | | | | | | | | | | | |
| *Nannoconus steinmanni steinmanni* | | | | | | | | | | | | | | | | | | | | | | | | • | | • | • | | • | | | • | • | | | | | • | | • | | | | | | |
| *Retecapsa surirella* | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | • | | | | • | | | | | | | | | | | | | |
| *Retecapsa angustiforata* | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | | | | • | • | | | | | | | | | | | | | |
| *Calcicalathina oblongata* | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | • | | | • | • | | | | | • | | • | | | | | | |
| *Assipetra infracretacea* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | | • | | | | | • | | | | | | | | |
| *Diazomatholitus lehmani* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | • | | | | | | | | • | | | | | | |
| *Eiffelithus windii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | • | | | | | | |
| *Zeugrhabdotus diplogrammus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | | | | |
| *Tintinnopsella remanei* | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | CALPIONELLIDS |
| *Calpionella alpina* (large variety) | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | |
| *Calpionella alpina* isometric | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | |
| *Tintinnopsella carpathica* | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | |
| *Crassicollaria intermedia* | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crassicollaria massutiniana* | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crassicollaria brevis* | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crassicollaria parvula* | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | |
| *C.alpina trans C.elliptica* | | | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | | | | | | | | | | | | | | | | | | | | | |
| *Remaniella catalanoi* | | | | | | | | | | | | | | | | | | | | • | | | • | • | | | | | | | | | | | | | | | | | | | | | | |
| *Remaniella duranddelgai* | | | | | | | | | | | | | | | | | | | | cf. | • | | • | | | | | | | | | | | | | | | | | | | | | | | |
| *Lorenziella dacica* | | | | | | | | | | | | | | | | | | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | |
| *Remaniella ferasini* | | | | | | | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | | |
| *Calpionellopsis oblonga* | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | |
| *Praecalpionellites dadayi* | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | | | | | | | | | • | | | |
| *Praecalpionellites murgeanui* | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | | | | | | | • | | | | | | | | | | | |
| *Praecalpionellites filipescui* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | |
| *Calpionellites darderi* | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | |
| *Calpionellites major* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | • | • | • | • | • | | |
| *Tintinnopsella longa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | • | | | | | |
| **Texture** | W/P | W/P | W/P | W | W | W | W | W | W | W | W | W | W | P | P | W | W/P | W | W | W | W | W | W | W | W | W | M | M | M | M | M | M | M | M/W | M | M/W | M | M | M | M | M | M | M | M | M | |
| *Globochaeta* sp. | • | • | • | | • | • | • | | • | ● | • | | • | | • | • | ● | • | | • | • | | | • | • | | | • | • | • | • | | • | | • | | • | | | | | | | | | OTHER ORGANISMS |
| Radiolarians | | • | • | ● | • | ● | • | • | • | • | ● | • | • | • | | • | • | • | • | • | • | • | ● | | • | • | • | • | • | | • | • | | • | • | | | | | • | • | • | • | • | • | |
| Cadosinids | | | | | • | • | | • | • | • | | ● | ● | • | | ● | | | • | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | |
| Protoglobigerinids | • | • | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Benthic foraminifera | • | • | • | | | | • | • | | • | • | • | | • | • | • | • | | • | • | • | • | • | • | • | | | • | • | • | | • | | | | • | | • | | | • | | | • | • | |
| *Saccocoma* sp. | | | • | ● | ● | ● | ● | ● | • | • | • | • | • | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Thin-shelled bivalves | ● | ● | | • | | • | • | • | | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Echinoid fragments | | • | • | | • | • | • | | • | | • | • | • | ● | ● | • | • | | • | • | • | • | • | • | • | • | | | • | • | • | | • | • | • | | | | | | • | • | • | • | • | |
| Gastropods | | | • | • | • | | | • | | | | • | | | | | | | | | • | | | | | | | | | | | • | • | | | | | | | | | | | | | |
| Apthycus | | | | | • | | • | • | • | | | | | | | | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

• occurrence
● abundant

M: mudstone
W: wackestone
P: packstone

*Gregoryceras* aff. *G. fouquei* (Kilian) and *Sequeirosia* (Macroconch *Sequeirosia*) aff. *trichoplocus* (Gemmellaro). The *P. bifurcatus* Zone can be recognized at 7.30 m. It is characterized by the occurrence of *Sequeirosia* (Macroconch *Sequeirosia*) sp. (Pl. 1, figs. 2,3), in some way comparable to the specimen illustrated as *P. (Arisphinctes)* ex gr. *tenuis* Enay by Brochwicz-Lewinski (1973) and several specimens of *Gregoryceras fouquei* (Kilian) (Pl. 1, fig. 6).

The interval between 8.10 and 8.60 m yielded a few specimens of *Aspidoceras atavum* (Oppel) (Pl. 1, fig. 4) and *Clambites schwabi* (Oppel). This association may be typical of the *E. bimammatum* Zone, even though no typical representative of the genus *Epipeltoceras* was found. The *I. planula* Zone was recognized between 8.80 and 9.0 m. The lower part of this Zone is characterized by a specimen of *Orthosphinctes* cf. *laufenensis* (Siemiradzki) in association with several specimens of *Aspidoceras* sp. and *Physodoceras* sp.. We have defined the Oxfordian-Kimmeridgian boundary at the base of the *I. planula* Zone according to Matyja & Wierzbowski (1997). The base of the *S. platynota* Zone can be identified at about 9 m, where a specimen of *Benacoceras* sp. (Pl. 1, fig.1) was recovered. The interval between 10 to 11.00 m yielded *Nebrodites cafisii* (Gemmellaro) (*P. herbichi* Zone) and several specimens of *Taramelliceras* sp. and *Sowerbyceras loryi* (Munier-Chalmas).

In the upper part of this section ammonites are very rare. Some specimens of early Berriasian ammonites, i.e. *Spiticeras spitiense* (Blanford) were found in the nodular facies at about 19.30 m.

**Section II** - In this section the ammonites are scanty, represented by common Phylloceratids and rare diagnostic specimens (Fig. 6, Pl. 2). At the base of the section the presence of *Pseudowaagenia haynaldi* (Herbich, in Neumayr), *Taramelliceras* gr. *compsum* (Oppel) and *Aspidoceras* gr. *acanthicum* (Oppel) indicates a late Kimmeridgian age. At 8.15 and 8.50 m, *Corongoceras* spp. are present, defining the base of the upper Tithonian. At 14.50 m *Tithopeltoceras paraskabensis* (Fallot & Termier) (Pl. 2, fig. 6) indicates the *F. boissieri* Subzone, of the lowermost Berriasian. Toward the top of the section, at 25 and 25.25 m, common specimens of *Olcostephanus* spp. (Pl. 2, fig. 2) suggest a late Valanginian age. Lower Cretaceous belemnites like *Duvalia lata* de Blainville occur in the same level.

### Calcareous nannofossils

**Section I** - Seventy samples were examined for calcareous nannofossils using standard techniques for smear slides preparation. Smear slides were observed under a light polarizing microscope, at 1000x magnification. The nannofossil zonation schemes utilized are those of Mattioli & Erba (1999) for the Aalenian-Bathonian interval, and Bralower et al. (1989) and Bown (1998) for the Oxfordian-Valanginian time span. The first eleven metres of Section I are very poor in nannofossils, because the lithology is unfavourable to their preservation. Along the section, ammonites are very frequent while the calcareous nannofossil assemblages are poor, because of the large amount of biodetritical supply, scarcity of micritic sediments and additional impoverishment by diagenesis. *Watznaueria barnesae* (Black) first appears at 2.00 m. The FO of *W. barnesae* is reported by Mattioli & Erba (1999) as typical for the early Bathonian. The ammonite fauna found below this event is indeed Bathonian in age (Fig. 3). The upper portion of the section represents the opposite situation: the calcareous nannofossils content is very high and the assemblages show high species diversity, while the ammonite fauna is rare. Several calcareous nannofossil events were identified during the Kimmeridgian, Tithonian and Berriasian. The FO of *Conusphaera mexicana minor* Bown & Cooper is found at 11.30 m in the upper part of the Kimmeridgian, followed by *C. mexicana mexicana* Trejo and *Polycostella beckmannii* Thierstein first appearances at the base of the Tithonian. The first small specimens of the genus *Nannoconus* are found just below the simultaneous occurrences of *Nannoconus compressus* Bralower & Thierstein and *Hexalithus noeliae* Loeblich & Tappan at 14.00 m. The FO of *Umbria granulosa* Bralower & Thierstein, marker for the upper Tithonian, is found at 18.00 m. The lower Berriasian is identified by the FO events of *Nannoconus steinmannii* Kamptner subsp. *minor* Deres & Achéritéguy and *Cruciellipsis cuvillierii* (Manivit) at 19.00 m. The last event is the FO of *N. steinmannii* Kamptner subsp. *steinmannii* Kamptner found at 20.20 m. These events identify the NJ20 Zone, with both Subzone NJ20a and NJ20b, equivalent to Zone NJK and NK1 of Bralower et al. (1989).

**Section II** (Fig. 5, 6) - Forty-five samples were examined, but only 30 samples were productive, with medium to poor calcareous nannofossil assemblages. The sterile samples are enriched by very fine quartz sand.

The first representative sample, at 3.50 m, contains *Watznaueria manivitae* Buckry, *Cyclagelosphaera deflandrei* (Manivit), *Conusphaera mexicana mexicana* Trejo and the first small specimens of *Nannoconus* sp. The presence of *Conusphaera mexicana mexicana* and of *Nannoconus* sp. characterizes the lower Tithonian.

*Conusphaera mexicana mexicana* increases rapidly until 6.0 m, where *P. beckmannii* Thierstein is found, followed by the first occurrence of *Nannoconus compressus* which indicates the upper part of the lower Tithonian. Up to 10 m, the assemblages are always dominated by species of the genus *Watznaueria*; this is a typical consequence of dissolution processes resulting in assemblages impoverished by diagenesis. The presence of more massive and dissolution resistant taxa such as *Conusphaera*, *Polycostella* and *Nannoconus* in the assemblage confirms this interpretation.

Starting at 14.50 m, the calcareous nannofossil assemblage is characterized by abundant *Nannoconus steinmannii steinmannii*, *Cruciellipsis cuvillieri*, *Watznaueria*

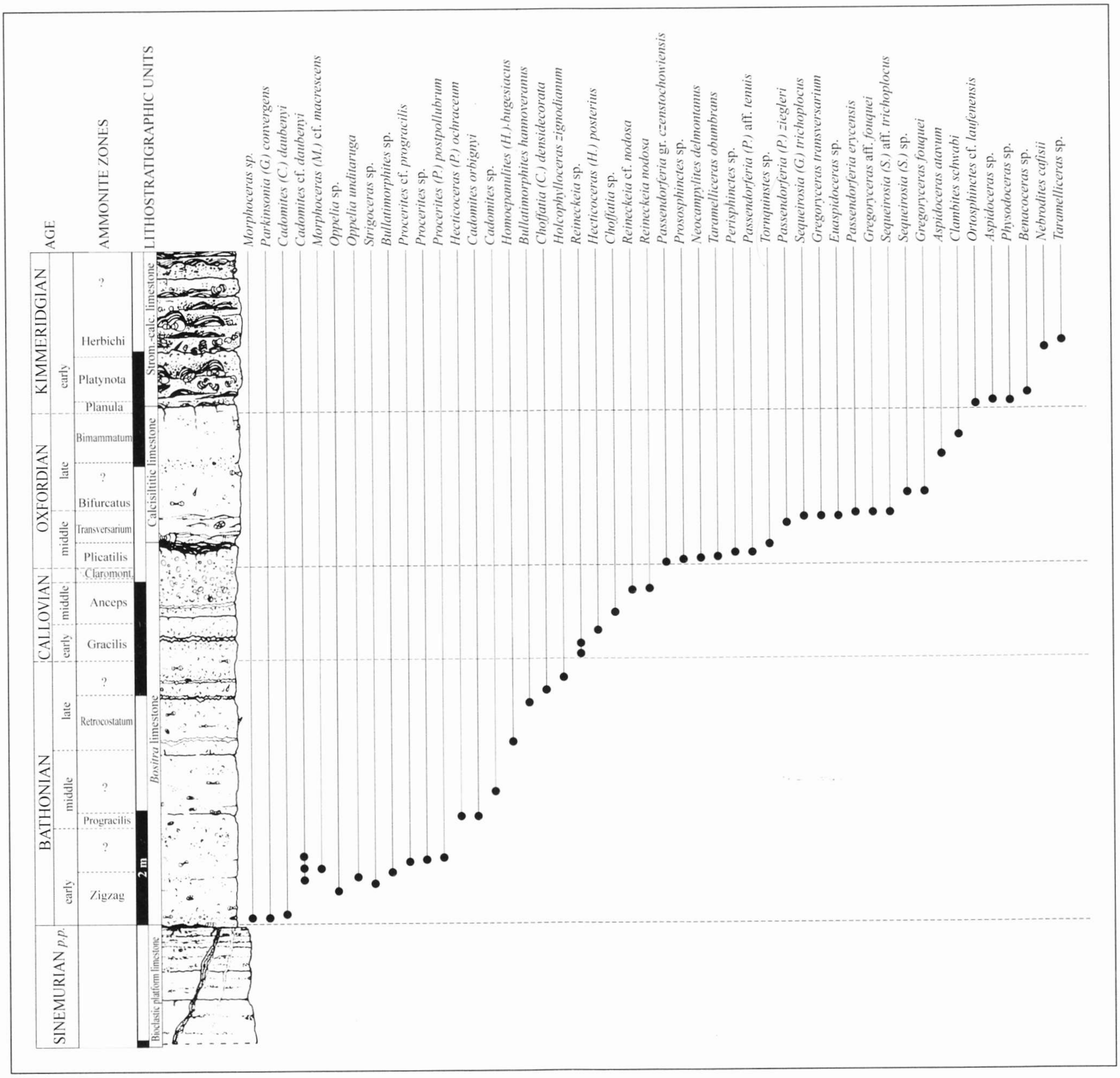



Fig. 7 - Contrada Diesi Quarry, Section I: Ammonite distribution chart.

*barnesae*, *C. margerelii*, *C. wiedmannii*, *Zeugrabdothus cooperii* Bown and very rare *Conusphaera mexicana mexicana*. This assemblage is typical of the lower Berriasian. At 15.50 m from the base of the section, the assemblage is characterized by the presence of common *Retecapsa surirella* (Deflandre & Fert), *Retecapsa angustiforata* Black, *Nannoconus steinmannii steinmannii*, *Cruciellipsis cuvillieri*, *Watznaueria barnesae*, *W. manivitae*, *C. margerelii* Nöel, *C. wiedmannii* Reale & Monechi and *Zeugrabdothus cooperii*. The *Calcicalathina oblongata* (Worsley), marker of the lower Valanginian, first occurs at 16.00 m, while *Conusphaera mexicana mexicana* disappears. The lower Valanginian assemblages are very rich. *C. oblongata* becomes common and *Assipetra infracretacea* (Thierstein) and *Diazomatholitus lehmanii* Noël are also present. At 24.00 m, *Eiffellithus windii* Applegate & Bergen, important marker for the lower Valanginian, first occurs, while *Zeugrabdothus diplogrammus* (Deflandre), indicating the uppermost lower Valanginian, first occurs at 24.50 m.

### Calpionellids

Some studies on the region of Sicily were taken into consideration mainly to correlate the sequence of events (De Wever et al. 1986; Catalano & Liguori 1971; Cecca et al. 2001; Caracuel et al. 2002). Different biostratigraphic zonations (Remane 1985; Grün & Blau 1997; Remane 1998) were utilized for the identification of the calpionellid zones and subzones.

**Section I** (Fig. 3) - The calpionellid assemblages are very poor and the state of preservation is moderate. The first occurrence of calpionellids is at 18.00 m and is represented by common and diversified species of *Crassicollaria*. Just above, *Remaniella* sp. occurs in concomitance with the last occurrence of *Saccocoma*. At 19.00 m the bloom of *Calpionella alpina* Lorenz, isometric specimens, is found. This event is used to identify the Tithonian/Berriasian boundary (Remane 1998; Oloriz et al. 1995; Caracuel et al. 2002). Just above, the FO of *Remaniella duranddelgai* (Pop), confirms the early Berriasian age (Grün & Blau 1997).

**Section II** - Section II of Contrada Diesi shows well preserved, diversified and abundant calpionellid assemblages that allow the identification of several zones and subzones (Figs. 5, 6 and Pl. 3).

The first occurrence of calpionellids is found at 8.50 m from the base of the section and it is represented by small *Tintinnopsella remanei* (Colom), *Calpionella alpina* Lorenz and *Crassicollaria* spp.. This assemblage identifies the *Crassicollaria* Zone (A Zone of Remane 1998 and *Remanei* Subzone of Grün & Blau 1997), which mark the base of the upper Tithonian. From 8.90 m, the assemblage becomes more abundant and diversified with the appearance of *Crassicollaria brevis* Remane (Pl. 3, fig. 3), *Crassicollaria massutiniana* (Colom) (Pl. 3, fig. 4), *Crassicollaria intermedia* (Durand-Delga) (Pl. 3, fig. 1), *Crassicollaria parvula* Remane (Pl. 3, fig. 2); in this assemblage also *C. alpina*, *Tintinnopsella carpathica* (Murgeanu & Filipescu) (Pl. 3, fig. 15) and transitional forms of *C. alpina*/*Calpionella elliptica* (Pl. 3, fig. 8) (*Calpionella* sp. in Catalano & Liguori 1971, Pl. 2, figs. 11, 12 and *C. alpina* homeomorph of *C. elliptica* in Remane 1985, fig. 6 and in Cecca et al. 2001) are present. This assemblage is referable to the *Crassicollaria* Zone (*Intermedia* Subzone). At 9.50 m, the genus *Remaniella*, that marks the *Catalanoi* Subzone (Grün & Blau 1997), first occurs. The finding of all three subzones of the *Crassicollaria* Zone records the presence of the entire upper Tithonian.

The Tithonian/Berriasian boundary was recognized on the basis of the *C. alpina* isometric bloom (Pl. 3, fig. 9) (explosive extention of a smaller and spherical variety of *C. alpina* in Remane 1986). This event shows clearly the decrease of the *Crassicollaria* genus, which is represented only by *Cr. parvula* (Cecca et al. 2001). The first occurrence of *Remaniella* cf. *duranddelgai* (Pop) (Pl. 3, fig. 7) is coeval with this bloom. On the whole, this change inside the assemblage identifies the base of the B Zone (Remane 1998), that corresponds to the base of the *Calpionella* Zone (Grün & Blau 1997). Just above, *Lorenziella dacica* (Filipescu & Dragastan) occurs. The assemblage does not change until 15.50 m, where the FO of *Calpionellites darderi* (Colom) (Pl. 3, figs. 16) marks the base of the Valanginian (*Calpionellites* Zone). *Ct. darderi* is recorded together with *Praecalpionellites dadayi* (Knauer) (Pl. 3, fig. 13), *Calpionellopsis oblonga* (Cadisch) (Pl. 3, fig. 10) and *Praecalpionellites murgeanui* (Pop). At 23.50 m, *Calpionellites major* (Trejo), marker of the *Major* Subzone, first occurs, indicating the upper part of the early Valanginian. Calpionellid assemblages referable to the middle and upper Berriasian age were not found.

## Discussion and conclusion

An interpretation of the Saccense Domain sedimentary evolution during the early Bathonian- late Valanginian time interval was made possible by the new litho- and biostratigraphic data collected at Mt. Magaggiaro. In addition, the comparison of bioevents related to different fossil groups was useful to critically assess the calibrated biostratigraphic schemes already existing.

One of the most striking features of this succession is the paraconformity between the bioclastic platform limestone (Inici Fm., Sinemurian p.p.) and the overlying pelagic deposits, i.e. the *Bositra* limestone (lower Bathonian-middle Oxfordian). This pelagic unit is followed by a calcisiltitic limestone (middle-upper Oxfordian), through a sharp discontinuity surface marked by a thin, black stromatolitic crust. The sedimentation then evolves, through a stromatolitic level and a pebbly calcarenite (Kimmeridgian-Tithonian), into a nodular marly limestone (Tithonian). The nodular marly limestone is gradually replaced by a whitish, thinly-bedded limestone, the Calcari a Calpionelle of late Tithonian to late Valanginian age.

In the lower part of the succession the biostratigraphic analysis was facilitated by the presence of rich ammonite assemblages. Ammonite distribution produced new biostratigraphic elements indicating several biozones of the Bathonian-late Valanginian time interval. Callovian ammonites (*M. gracilis* Zone, *R. anceps* Zone) are relatively rare, while Bathonian (*Z. zigzag* Zone, *P. progracilis* Zone, *H. retrocostatum* Zone), Oxfordian (*P. claromontanus* Zone, *P. plicatilis* Zone, *G. transversarium* Zone, *P. bifurcatus* Zone, *E. bimammatum* Zone), and early Kimmeridgian (*I. planula* Zone, *S. platynota* Zone, *P. herbichi* Zone) ammonites are well represented. The occurrence of *Corongoceras* spp. indicates the base of the upper Tithonian, while *Tithopeltoceras paraskabensis* (Fallot & Termier) and *Spiticeras spitiense* (Blanford) indicate the lower Berriasian. Furthermore, common specimens of *Olcostephanus* spp. at the top of the succession suggest a late Valanginian age.

Biofacies analysis pointed out the occurrence of the following significant events:

- the abundance of thin-shelled bivalves characterizes the Bathonian-Callovian interval and their disappearance at the base of the middle Oxfordian is coincident with a sharp discontinuity surface;

- Protoglobigerinids from the Bathonian to the lower Kimmeridgian are replaced by *Saccocoma* sp.; the first occurrence of *Saccocoma* is recorded in the *S. platynota* Zone (lower Kimmeridgian), and its last appearance is recorded in the latest Tithonian;

- the bloom of isometric *C. alpina* marks the Tithonian/Berriasian boundary, which is here included between the FO of *U. granulosa* of the uppermost upper Tithonian and the occurrence of *S. spitiense*, which indicates the base of the lower Berriasian;

- the base of the Valanginian is marked by the first occurrence of *Ct. darderi*. It was found just above the occurrence of *Tithopeltoceras paraskabensis*, early Berriasian in age;

- just above the FO of *Ct. darderi* (base of the Valanginian), the FO of *C. oblongata* and LO of *C. mexicana mexicana* occur;

- upper Valanginian ammonites and belemnites (*Olcostephanus* spp. and *Duvalia lata*) are found together with *Tirnovella* gr. *alpillensis* and FO of *Ct. major*, *E. windii* and *Z. diplogrammus*.

These data show that the middle-upper part of the lower Berriasian and the middle-upper Berriasian are not recorded, indicating the presence of sedimentary gaps. It is confirmed that the nodular marly limestone facies persists until the lower Berriasian, as it often happens in other high structural areas in Sicily and in other Tethyan areas.

The different and sudden facies changes, with ammonites capped by stromatolitic domes, found at different stratigraphic levels, the occurrences of many discontinuity surfaces and the reduced thickness of the sequence, suggest an environment characterized by reduced but still active sedimentary supply, low sedimentation rate and abrupt and quite important energy changes.

All these sedimentary features suggest a very complex scenario for the depositional environment of the pelagic sediments cropping out in the Mt. Magaggiaro succession. Nevertheless, the existence of gaps could be related to submarine non-deposition or erosion. The presence of pelagic sediments, together with rich biogenic and bioclastic supply, suggest that the environment of the Mt. Magaggiaro area was a pelagic carbonate platform that followed the drowning of the carbonate platform. The major deepening happened during the Valanginian. The sediments recorded in the Saccense domain display a high degree of facies variability, probably due to the irregular pre-existing, perhaps tectonically controlled, palaeomorphology.

*Acknowledgments*. We thank J. Cope (Cardiff), P. Di Stefano (Palermo) and U. Nicosia (Roma) for assistance in the field. We are grateful to A. Galácz (Budapest) and J. Remane (Neuchâtel) for their comments and suggestions. This work was supported by the Italian Ministry of University and Research and by the University of Perugia and Rome (grants to G. Parisi and U. Nicosia, COFIN1999 and 2001).

During the printing of this paper unfortunately Giovanni Pallini, coauthor besides remarkable scientist and darling friend, died. All the Authors should like to mention him and dedicate this paper to his memory.

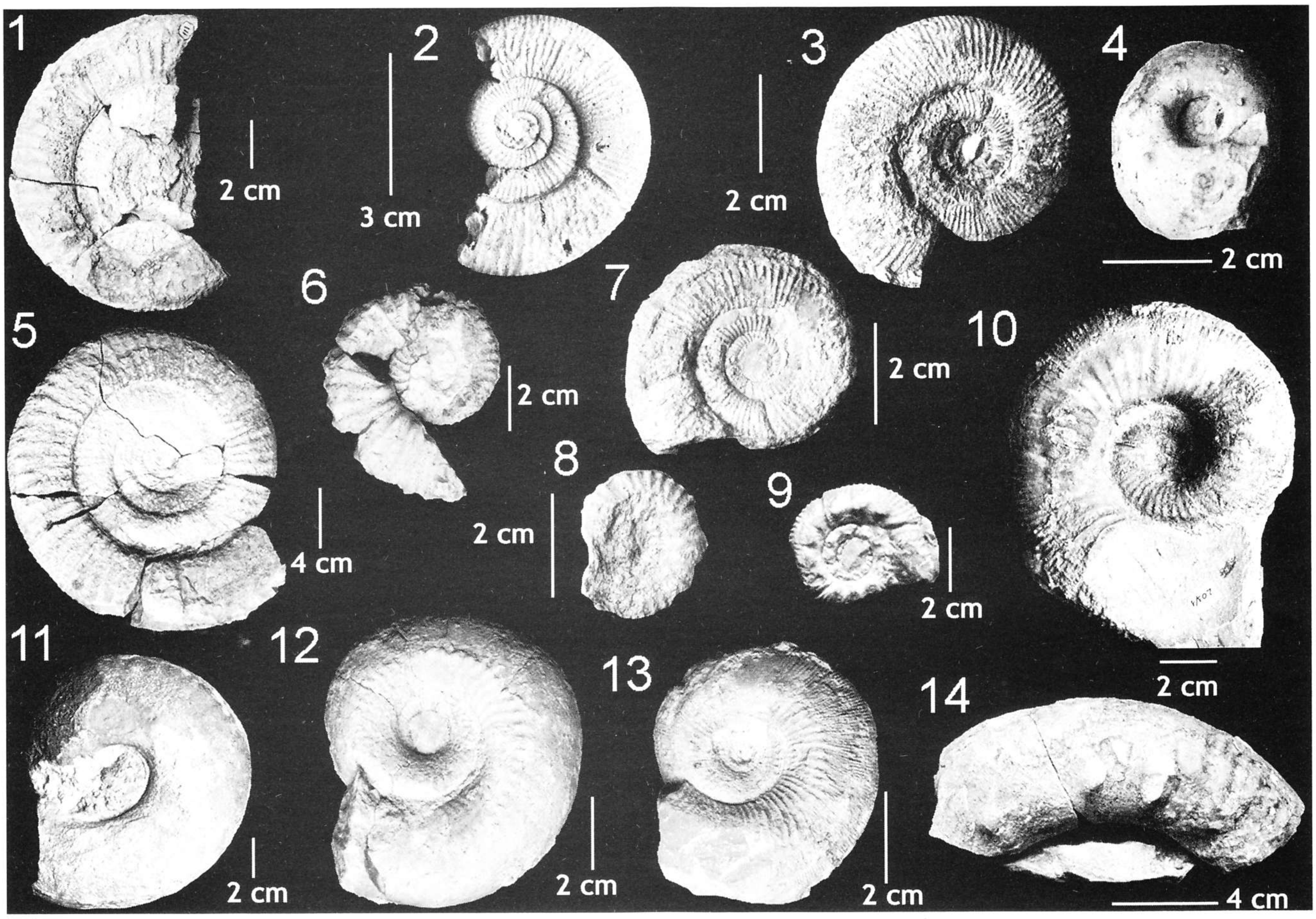
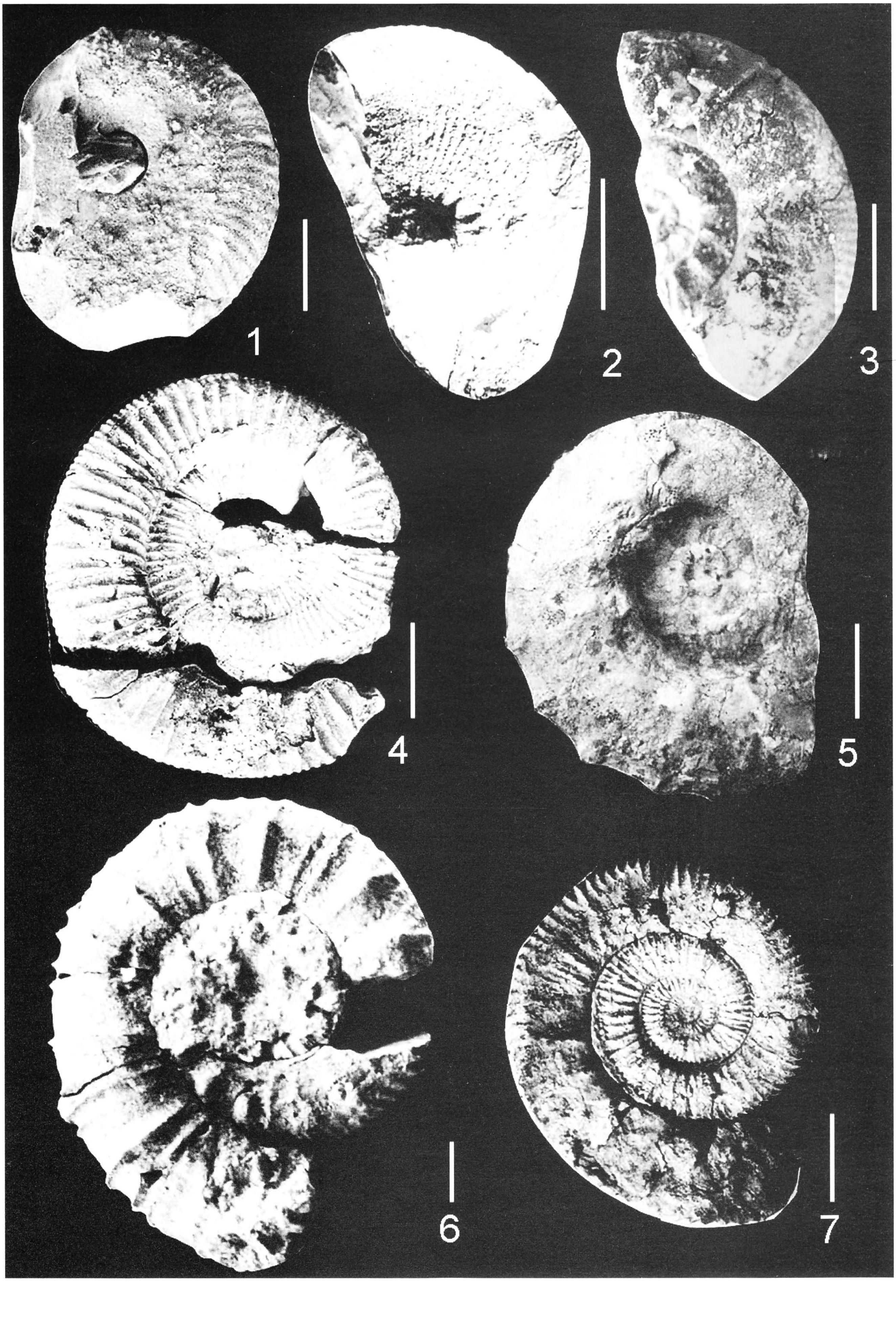



PLATE 1

Ammonites of Contrada Diesi Quarry, Section I: Fig.1) *Benacoceras* sp.; Figs 2 and 3) *Sequeirosia* sp.; Fig. 4) *Aspidoceras atavum* (Oppel); Fig. 5) *Passendorferia* aff. *tenuis* (Eany); Fig. 6) *Gregoryceras fouquei* (Kilian); Fig. 7) *Passendorferia erycensis* (Melendez); Fig. 8) *Hecticoceras posterius* Zeiss; Fig. 9) *Reineckeia nodosa* Till; Figg. 10 and 13) *Cadomites (Cadomites) daubenyi* (Gemmellaro); Fig. 11) *Bullatimorphites (Bullatimorphites) hannoveranus* (Roemer); Fig. 12) *Cadomites (Cadomites) orbignyi* (De Grossouvre); Fig. 14) *Reineckeia* cf. *nodosa* Till.

PLATE 2

Ammonites of Contrada Diesi, Section I and II: Fig. 1) *Taramelliceras* sp.; Fig. 2) *Olcostephanus* sp.; Fig. 3) *Spiticeras spitiense* (Blanford); Fig. 4) *Torquatisphinctes* gr. *laxus* Oloriz; Fig. 5) *Taramelliceras pugile pugiloides* (Canavari); Fig. 6) *Tithopeltoceras paraskabensis* (Fallot & Termier); Fig. 7) *Micracathoceras micracanthum* (Oppel). Scale bar = 2 cm.


1
2
3
4
5
6
7

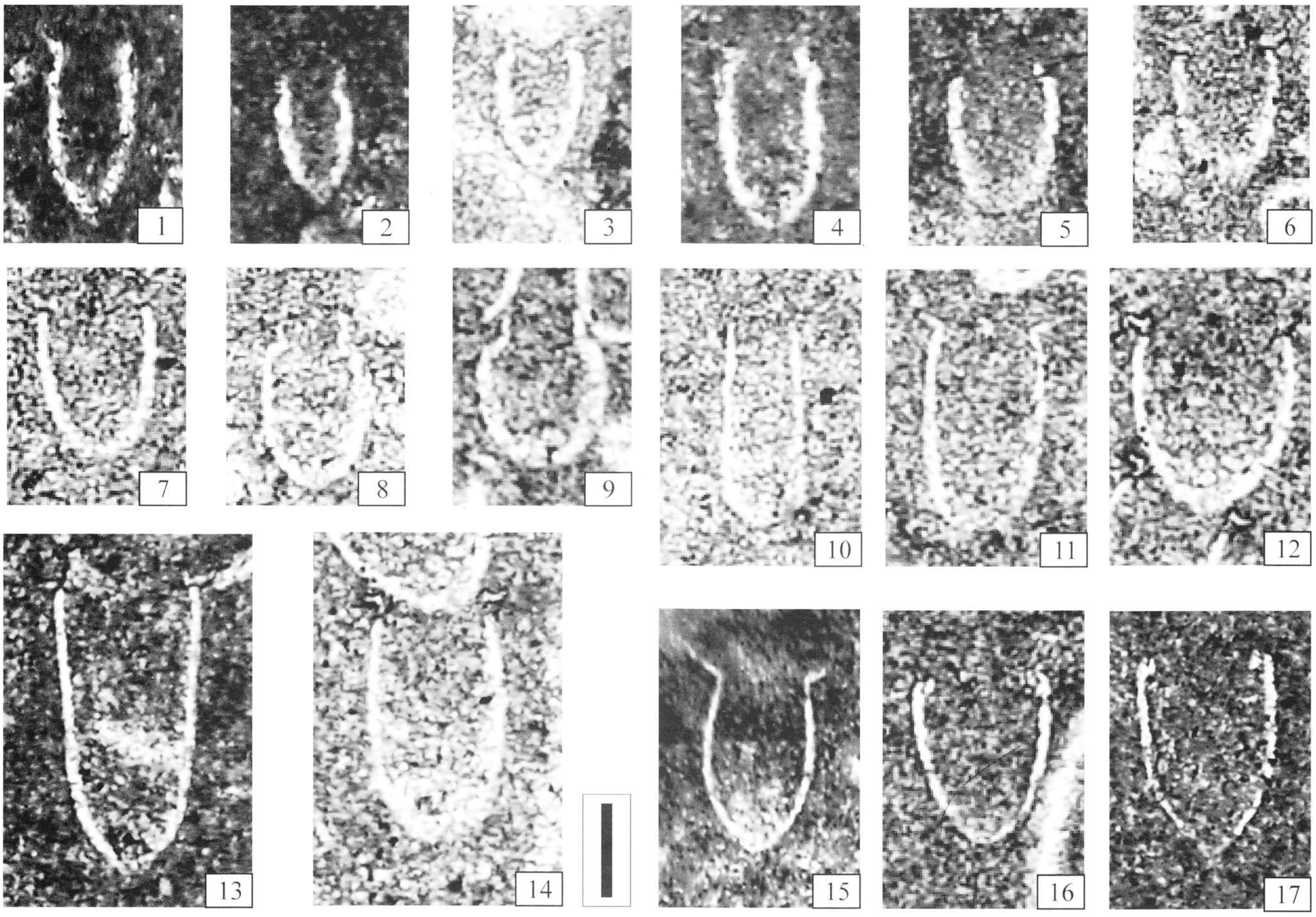



PLATE 3

Calpionellids of Contrada Diesi, Section II: Fig. 1) *Crassicollaria intermedia* (Durand-Delga), sample A9.50; Fig. 2) *Crassicollaria parvula* Remane, sample A9.50; Fig. 3) *Crassicollaria brevis* Remane, sample A9.50; Fig. 4) *Crassicollaria massutiniana* (Colom), sample A8.90; Fig. 5) *Remaniella ferasini* (Catalano), sample A8.90; Fig. 6) *Remaniella catalanoi* Pop, sample L9; Fig. 7) *Remaniella* cf. *duranddelgai* Pop, sample A11.30; Fig. 8) *Calpionella alpina* transitional form to *Calpionella elliptica*, sample A11.30; Fig. 9) *Calpionella alpina* Lorenz isometric form, sample L9; Fig. 10) *Calpionellopsis oblonga* (Cadish), sample L6; Fig. 11) *Tintinnopsella longa* (Colom), oblique section, sample A12.50; Fig. 12) *Praecalpionellites filipescui* (Pop), sample L6A; Fig. 13) *Praecalpionellites dadayi* (Knauer), L5A; Fig. 14) *Tintinnopsella longa* (Colom), sample L2; Fig. 15) *Tintinnopsella carpathica* (Murgeanu & Filipescu), sample L9; Fig. 16) *Calpionellites darderi* (Colom), sample L5; Fig.17) *Calpionellites* cf. *major* (Trejo), sample L3A. Scale bar= 50 $\mu$m.

# REFERENCES


Bourseau J. P. (1977) - L'Oxfordien moyen a nodules des «terres noires» de Beauvoisin (Drome). *Nouv. Arch. Mus. Hist. Nat. Lyon*, 15: 116, Lyon.

Bown P.R. (1998) - Calcareous Nannofossils Biostratigraphy, V. of 314 pp. Chapman & Hall, Cambridge.

Bralower T.J., Monechi S. & Thierstein H.R. (1989) - Calcareous nannofossils Zonation of the Jurassic-Cretaceous boundary interval and correlation with geomagnetic polarity timescale. *Marine Micropal.*, 14: 153-235, Amsterdam.

Brochwicz-Lewinski W. (1973) - Some remarks on the origin of the subfamily Idoceratinae Spath, 1924 (Perisphinctidae, Ammonoidea). *Acta Paleont. Polonica*, 18 (3): 299-320, Warszawa.

Caracuel J.E., Parisi G., Bartolini A. & Mattioli E. (2002) - Baia di Guidaloca (Scopello): integrated biostratigraphy in the Rosso Ammonitico facies of the Guidaloca section (Upper Jurassic - Jurassic/Cretaceous boundary). In: Santantonio M. (ed.) General Field Trip Guidebook, 6th Int. Symp. on the Jurassic System, GEDA, Torino.

Cariou E. & Hantzpergue P. (1997) - Biostratigraphie du Jurassique ouest-européen et méditerranéen. *Bull. Centes Rech. Explor. Prod. Elf Aquitaine, Mém.*, 17: 155, Pau.

Catalano R. & D'Argenio B. (1978) – An essay of palinspastic restoration across the Western Sicily. *Geologica Romana*, 17: 145-159, Roma.

Catalano R. & D'Argenio B. (1982) – Schema geologico della Sicilia. In: R. Catalano & B. D'Argenio, Guida alla Geologia della Sicilia occidentale, Guide Geologiche Regionali. *Mem. Soc. Geol. It.*, 24 (A): 9-42, Roma.

Catalano R. & D'Argenio B. (1990) – Hammering a seismic section. In: Catalano R. & D'Argenio B. (eds)., Field Trip in Western Sicily. Guide Book. Dipartimento di Geologia e Geodesia, Università di Palermo, Palermo.

Catalano R., Di Stefano P. & Vitale P. (1995a) – Structural trends and paleogeography of the central and western Sicily belt: new insights. *Terra Nova*, 7: 189-199, Oxford.

Catalano R., Di Stefano P., Sulli A. & Vitale F.P. (1995b) – Evoluzione paleogeografica e strutturale della Sicilia e dei mari adiacenti. *Naturalista Siciliano*, 14 (3-4): 143-187, Palermo.

Catalano R., Franchino A., Merlini S. & Sulli A. (2000) – Central western Sicily structural setting interpreted from seismic reflections profiles. *Mem. Soc. Geol. It.*, 55: 5-16, Roma.

Catalano R. & Liguori V. (1971) - Facies a Calpionelle della Sicilia Occidentale. In: A. Farinacci (ed), Proceedings of the II Planktonic Conference Roma: 167-209, Tecnoscienza Roma.

Cecca F., Savary B., Bartolini A., Remane J. & Cordey F. (2001) – The Middle Jurassic-Lower Cretaceous Rosso Ammonitico succession of Monte Inici (Trapanese Domain, western Sicily): sedimentology, biostratigraphy and isotope stratigraphy. *Bull. Soc. géol. France,* 172 (5): 647-660, Paris.

Conti M.A. & Monari S. (1992) – Thin-shelled bivalves from the Jurassic Rosso Ammonitico and Calcari a Posidonia Formations of the Umbrian-Marchean Apennine (Central Italy). *Paleopelagos*, 2: 193-213, Roma.

De Wever P., Geyssant J.R., Azema J., Devos J., Duée G., Manivit G. & Vrielynck B. (1986) - La coupe de Santa Anna (zone de Sciacca, Sicilie): Une synthèse biostratigraphique des apports des macro-micro et nannofossiles du Jurassique supérieur et Crétacée inférieur. *Revue Micropal.*, 29 (5): 141-186, Paris.

Di Stefano P., Alessi P. & Gullo M. (1996) – Mesozoic and Paleogene Megabreccias in Southern Sicily: New data on the Triassic Paleomargin of the Siculo-Tunisian Platform. *Facies*, 34: 101-122, Erlangen.

Di Stefano P., Mallarino G., Marino M., Mariotti N., Muraro C., Nicosia U., Pallini G. & Santantonio M. (2002) – New stratigraphic data from the Jurassic of Contrada Monzealese (Saccense domain, SW Sicily). *Boll. Soc. Geol. It.*,121: 121-137, Roma.

Di Stefano P. & Vitale F.P. (1993) – Carta Geologica dei Monti Sicani occidentali. Scala 1:50.000. *Dipartimento di Geologia e Geodesia,* Palermo.

Di Stefano P. & Vitale F.P. (1994) – Propagazione dei thrust e dinamica dei bacini sintettonici: esempi dai Monti Sicani. Sicilia. *77 Congr. Soc. Geol. Ital., Bari (Italy), 26-28 september 1994,* Abstract Vol., pp. 75-79.

Elmi S. (1967) - Le Lias supérieur et le Jurassique moyen de l'Ardéche. *Doc. Lab. Géol. Fac. Sci. Lyon*, 19 (3): 509-845, Lyon.

Galácz A. (1980) - Bajocian and Bathonian ammonites of Gyenespuszta Bakony Mts., Hungary. *Geol. Hungarica, s. Palaeontologica*, 39: 1-227, Budapest.

Géczy B. & Galácz A. (1998) - Bathonian ammonites from the classic Middle Jurassic locality of Villány, South Hungary. *Revue Paléobiol.*,17 (2): 479-511, Genève.

Gemmellaro G.G. (1877) – Sopra alcuni fossili della zona con *Posidonomya alpina* Gras di Sicilia. *Giorn. Sc. Nat. Econ. di Palermo*,12: 51-81, Palermo.

Gemmellaro G. G. (1882) - Sopra alcune faune giuresi e liasiche della Sicilia. Stabilimento Tipografico Lao, Palermo: 1-434, A volume dated 1872-1882 and comprensive of numerouses monographies, Palermo.

Grün B. & Blau J. (1997) – New aspects of the calpionellid biochronology: proposal for a revised calpionellid zonal and subzonal division. *Revue Paléobiol.*,16 (1): 197-214, Genève.

Jeannet A. (1951) - Stratigraphie und paläontologie des oolithischen Eisenerzlagers von Herznach und seiner Umgebung. *Beitr. Geol. Schweiz, Geotechnische Serie*, 13: 1-545, Basel.

Logan B.W., Rezak R. & Ginsburg R.N. (1964) – Classification and environmental significance of algal stromatolites. *J. Geol.*, 72: 68-83, Chicago.

Mangold C. (1970a) - Les Perisphinctidae (Ammonitina) du Jura Meridional au Bathonien et au Callovien. *Doc. Lab. de Géol. Fac. Sci.*, 41 (2): 1-246, Lyon.

Mangold C. (1970b) - Morphoceratidae (Ammonitina-Perisphinctaceae) bathoniens du Jura méridional, de la Nièvre et du Portugal. *Geobios*, 3 (1): 43-130, Lyon.

Mascle G.H. (1970) – Geological Sketch of Western Sicily. In: W Alvarez & K. Gohbrandt (eds.): Geology and History of Sicily. *PESL:* 231-243, Tripoli.

Mascle G.H. (1974) – Réflexion sur le Jurassique condensée de Sicile Centro-occidentale. *Riv. It. Paleont.*, 80 (3): 389-408, Milano.

Mascle G.H. (1979) – Étude géologique des Monts Sicani. *Mem. Riv. Ital. Paleont. Strat.*,16: 1-431, Milano.

Mattioli E. & Erba E. (1999) - Synthesis of calcareous nannofossil events in Tethyan Lower and Middle Jurassic succession. *Riv. Ital. Paleont. Strat.*, 105 (3): 343-376, Milano.

Matyja B.A. & Wierzbowski A. (1997) - The quest for a unified Oxfordian/Kimmeridgian boundary: implications of the ammonite succession at the turn of the Bimammatum and Planula Zones in the Wielun Upland, Central Poland. *Acta Geol. Polonica*, 47 (1-2): 77-105, Warszawa.

Meléndez G. & Fontana B. (1993) - Biostratigraphic correlation of the Middle Oxfordian sediments in Iberian Chain, eastern Spain. *Acta Geol. Polonica*, 43 (3-4): 193-211, Warszawa.

Meléndez G., Bello G., Delvene G. & Perez-Urresti I. (1997) - Middle to Upper Jurassic (Callovian-Kimmeridgian) in the "Arcos Plateau" (Ariño-Oliete area, eastern Iberian chain, Spain): taphonomic analysis and biostratigraphy. *Cuad. Geologia Iberica*, 23: 269-300, Madrid.

Olòriz F., Caracuel J.E., Marques B. & Rodrìguez-Tovar F. (1995) – Asociaciones de tintinnoides en facies Ammonitico Rosso de la Sierra Norte (Mallorca). *Rev. Esp. Paleont.*, N° Homenaje al Dr. G. Colom: 77-93, Madrid.

Remane J. (1985) – Calpionellids. In: Bolli H.M., Saunders J.B. & Perch-Nielsen K. (eds.) – Plankton stratigraphy, *Cambridge University Press*: 555-572, Cambridge.

Remane J. (1986) - Calpionellids and the Jurassic-Cretaceous boundary. *Acta Geol. Hung.*, 29 (1-2): 15-26, Budapest.

Remane J. (1998) – Les calpionelles: possibilités biostratigraphique et limitations paléobiogéographiques. *Bull. Soc. géol. France*, 169: 829-839, Paris.

Ronchi P., Lottaroli F. & Ricchiuto T. (2000) – Sedimentary and Diagenetic Aspects of the Liassic Inici Fm. and its Stratigraphic Context (Sicily Channel, Italy). *Mem. Soc. Geol. It.*, 55: 261-269, Roma.

Santantonio M. (1993) – Facies associations and evolution of pelagic carbonate platform/basin systems: examples from the Italian Jurassic. *Sedimentology*, 40: 1039-1067, Oxford.

Santantonio M. (1994) – Pelagic carbonate platforms in the geologic record: their classification, and sedimentary and paleotectonic evolution. *AAPG Bull.*, 78: 122-141, Tulsa.

Schmidt Di Frieberg P.(1965) – Litostratigrafia petrolifera della Sicilia. *Riv. Min. Siciliana*, 88-90: 198-217; 91-92; 50-71, Palermo.

Vitale F.P. (1990) – Studi sulla Valle del Medio Belice (Sicilia centro occidentale). L'avanfossa plio-pleistocenica nel quadro dell'evoluzione paleotettonica dell'area. PhD Thesis (unpablished), Università degli Studi di Palermo – Dipartimento di Geologia e Geodesia: 1-200, Palermo.

Vitale F.P. (1995) – Il segmento sicano della catena sud-tirrenica: bacini neogenici e deformazione attiva. *Studi Geologici Camerti*, Spec. vol.: 491-507, Camerino.

Wendt J. (1964) - Stratigraphisch-Paläontologische Untersuchungen im Dogger Westsiziliens. *Boll. Soc. Paleont. It.*,2 (1): 57-145, Modena.