Biostratigraphic remarks on the Caltavuturo Formation (Eocene-Oligocene) cropping out at Portella Colla (Madonie Mts., Sicily)

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Abstract
An outcrop of the Caltavuturo Formation (Eocene-Oligocene) in the Madonie Mts. (Northern Sicily) has been micropaleontologically investigated. Two stratigraphic sections were sampled and studied in rock thin sections. The formation consists of marly clays and several 2-30 cm thick breccia layers, rich in larger foraminifera, and is affected by prominent silicification and bioturbation. The clayey layers are dominated by deep-water agglutinated foraminifera (DWAF) in isolated forms, with rare epibathyal and bathyal hyaline taxa, which disappears at the top of the succession. The collected samples are barren of planktonic foraminifera and calcareous nanoplankton.

Selected larger benthic foraminifera species in the displaced layers register a vertical variation and were analysed to have a biostratigraphical control according to shallow benthic zones (SBZ). Heterostegina reticulata italica, Borelis vonderschmitti, Halkyardia minima, Dyscocyclina dispansa dispansa, Orbitocyclus varians and Nummulites ex. gr. incrassatus mark the upper Eocene assemblages. Nummulites vascus dominates the Early Rupelian assemblages in association with N. fichteli, Halkyardia maxima, Operculina complanata and Heterostegina sp., whereas the FO of Nephrolepidina praemarginata marks the Late Rupelian. Imbrication of resedimented larger foraminiferal tests indicates a N-S paleodirection of the flows.

Keywords
Larger foraminifera, systematics, biostratigraphy, SBZ, Eocene, Oligocene, Sicily.

I. INTRODUCTION

Micropaleontological investigations on the Caltavuturo Formation, belonging to Imerese domain and cropping out at Portella Colla (Madonie Mts., Northern Sicily), provide new evidence on Late Eocene-Oligocene foraminiferal assemblages (BENEDETTI & PIGNATTI, 2008). The autochthonous assemblages are dominated by deep water agglutinated foraminifera (DWAF) studied in isolated forms, whereas allochtonous and coeval larger foraminifera assemblages occur in resedimented breccias layers.

The investigated sections belong to the Caltavuturo Formation (SCHMIDT DI FRIEDBERG et al., 1960), cropping out 20 km south of Cefalù, between Monte dei Cervi and Monte Mufara (37° 52' 02"N-14° 00' 19"E) (Fig. 1). At Portella Colla the Caltavuturo Fm. does not exceed 30 m thick (GRASSO et al., 1978) and dip 25° S-E, it is conformably overlain by the Portella Colla Clay (WEZEL, 1966), considered the lower member of the Numidian Flysch. Micropaleontological data on the Caltavuturo Fm. are scarce and fragmentary (WEZEL, 1966).

The aim of this work is to present the results of biostratigraphic studies on thin sections and dry residue samples of displaced larger foraminifera assemblages of two investigated stratigraphic sections cropping out in the above mentioned places; this formation in fact was never sufficiently investigated in the past and it is one of the richest in Eocene to Oligocene larger foraminifera in the north-western Sicily containing some undescribed forms.

II. THE PORTELLA COLLA OUTCROP AND THE INVESTIGATED SECTIONS

Two sections were sampled to investigate the Portella Colla outcrop (Figs. 1, 2). The first one was identified by the abbreviation PC and is about 24 m thick including the top of the Crisanti Fm. The second section, abbreviated MM, was sampled along a gully erosion and measures about 10 m.

At the base of the investigated succession a detritic limestone crops out, assigned to the Crisanti Formation (SCHMIDT DI FRIEDBERG et al., 1960). The contact between the Crisanti Fm. and the Caltavuturo Fm., not directly visible in the analysed sections, is described as transgressive in the literature (SCHMIDT DI FRIEDBERG et al., 1960; OGNIBEN, 1960, 1963; GRASSO et al., 1978).

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Fig. 1: Outcrop location and schematic geological map of the investigated area.

Fig. 2: The investigated outcrop; 1. location of the two sampled stratigraphic sections; 2. *Nummulites vascus* dominated layer PC8; 3. *Nephrolepida* bearing layer.
The Caltavuturo Fm. consists of marly clays and several 2-30 cm thick breccia layers rich in larger foraminifers and is affected by prominent silification and bioturbation. Clay colour changes upsection: it is wine red at the bottom and becomes gray from the middle towards the upper part of the outcropping sections.

The clay layers contain poor foraminiferal assemblages studied in isolated forms, essentially composed by DWAF, hyaline benthic or planktonic foraminifera are being rare and badly preserved (BENEDETTI & PIGNATTI, 2008). Some samples are completely barren of hyaline taxa, rare epibathyal and bathyal hyaline taxa such as Cibicidoides occurs in the uppermost Eocene and lower Rupelian samples and disappears in upper Rupelian sediments (BENEDETTI & PIGNATTI, 2008). This suggests a deposition of the clay layers close or below the CCD.

### III. BIOSTRATIGRAPHICAL DATA

The top of the Crisanti Fm. can be referred to the Aptian according to the presence of assemblages essentially composed by Palorbitolina sp. and Trocholina aff. alpina (LEUPOLD) sensu ARNAUD-VANNEAU, BOISSEAU & DARSAC, 1988.

As previously described, the clayey layers of the Caltavuturo Fm. are devoid of planktonic foraminifera with the exception of some badly preserved specimens of “Globobaculina” ex. gr. tapuriensis-tripartita isolated from the gray clays. The DWAF assemblages and the rare benthic hyaline taxa are composed of cosmopolitan taxa with a prolonged stratigraphical range. For example Cibicidoides grimsdalei (NUTTALL, 1930) and C. havanensis (CUSHMAN & BERMUDEZ, 1937) occurring in the red clay of the PC section and in the early gray clay of both sections, range from early Eocene to Miocene.

In the resedimented layers several displaced larger foraminiferal taxa occur: the assemblages are allochthonous and reworking seems to be extremely limited, except for rare Cretaceous forms such as orbitoidiforms. Therefore it was attempted to use larger foraminifera for dating the succession using the standard biozones of SERRA-KIEL et al. (1998) for the Eocene and CAHUZAC & POIGNANT (1997) for the Oligocene.

In the lowermost part of the Caltavuturo Fm. the displaced larger foraminifera dominated layers are absent, and the first occurrence of these taxa is in the sample PC2 for the section PC (Fig. 3). Heterostegina reticulata italica HERB, 1978, Borelis vanderschmitti (SCHWEIGHAUSEN, 1951), Discocyclina dispansa dispansa (OWERBY, 1840), Orbitoclypeus varians (KAUFMANN, 1867) and Halkyardia minima (LIEBUS, 1911) indicate SBZ 19 (SERRA-KIEL et al., 1998); no markers strictly referred to SBZ 20 (Late Priabonian) were found.

In the section MM (Fig. 4) this stratigraphic interval is absent, no Late Eocene markers was found. The first occurrence of Nummulites vascus JOLY & LEYMERIE, 1848 marks the Early Rupelian in both the investigated sections. This species was found associated with other nummulitids such as N. fichteli MICHELOTTI, 1841, Operculina complanata (DEFRANCE, 1822), Heterostegina sp. (maybe a new species), borelids such as Borelis pygmaea HANZAWA, 1930 and B. inflata ADAMS, 1965 and others foraminifers: Victoriella conoidea (RUTTEN, 1914), Halkyardia maxima CIMERMAN, 1969 and Praearchaia sp. These assemblages characterize SBZ 21 of CAHUZAC & POIGNANT (1997).

The FO of Nephrolepidina marks the upper Rupelian (SBZ 22A). Specimens referred to this orbitoidiform taxon was even found displaced in some clay layer. Six populations were isolated and megalosphaeric embryo were biometrically investigated (BENEDETTI & PIGNATTI, in prep.) and, according to the parameters and factors proposed by DE MULDER (1975), all the sampled population can be referred to N. praemarginata (DOUVILLE, 1908) and so the whole top of the Caltavuturo Fm. can be referred to the Late Rupelian. These assemblages are characterized by the dominance of N. praemarginata with subordinate presence of Eulepidina formosoides DOUVILLE, 1924 and Halkyardia maxima. Specimens of Sphaerogypsina globulus (REUSS, 1848) and Planorbulina sp. are common from the Late Eocene to the top of the Caltavuturo Fm.

### IV. ON THE FLOWS ORIGIN

In the past, several hypothesis were developed about the direction and the origin of the flows which originated the Caltavuturo Fm. and the Numidian Flysch in general (BROQUET, 1968a, b, 1972; BROQUET & DUEÉ, 1967; OGNIBEN, 1963; WEZEL, 1966, 1970). The prevailing opinion suggests an African origin, whereas for the French school the material comes from the north.

Imbrication of resedimented larger foraminiferal tests shows a direction of the flows parallel to the dip of the strata. According to CHANELL et al. (1990), OLDOW et al. (1990) and SPERANZA et al. (2003) the rotation in the Madonie Mts. is approximatively 93-98° clockwise, so it is preliminarily possible to assume a N-S paleodirection of the flows.

### V. SYSTEMATIC

The suprageneric classification of LOEBLICH & TAPPAN (1987, 1992) is followed in this work. For each species has been drawn up a synonymic list, the most complete possible. The synonymic list of the taxa assigned to a species by an exclusive biometrical investigation, is necessarily incomplete, because of the necessity to compare other populations with the same methods.
Fig. 3: Distribution of the main larger foraminifera in the section PC. The presence of SBZ 18 at the base of Paleogene succession is uncertain; no SBZ 20 (Late Priabonian) markers were found.

Fig. 4: Distribution of the main larger foraminifera in the section MM. The lack of the upper Eocene markers at the base of the Caltavuturo Fm. is noteworthy.
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Superfamily Orbitolinacea MARTIN, 1890
Family Orbitolinidae MARTIN, 1890
Genus Palorbitolina SCHROEDER, 1963
Type species: Madreporites lenticularis BLUMENBACH, 1805

Palorbitolina sp.
Pl. I, fig. 1

Material: 5 specimens from 2 samples.
Description: low conical test, relatively small. No megalosphaeric specimens are found in the thin sections analysed.

Family Involuitinidae BÜTSCHLI, 1880
Subfamily Involuitininae BÜTSCHLI, 1880
Genus Trocholina PAALZOW, 1922
Type species: Involutila conica SCHLUMBERGER, 1898

Trocholina aff. alpina (LEUPOLD) sensu ARNAUD-VANNEAU, BOISSEAU & DARSA, 1988
Pl. I, fig. 2


Material: 9 specimens from 2 samples.
Description: test large, conical consisting of a sphaeroidal proloculus and a tubular second chamber trochospirally coiled around the axis.
Remarks: T. alpina is smaller than Portella Colla specimens, whereas T. cf. alpina ARNAUD-VANNEAU et al., 1988 has a closer apical angle (Fig. 5).

Fig. 5: Height vs width scatter diagram with biometrical comparison between conical and low-conical trocholines (modified after ARNAUD-VANNEAU et al., 1988).

Superfamily Alveolinacea EHRENBerg, 1839
Family Borelidae SCHMARD, 1871
Genus Borelis de MONTFORT, 1808
Type species: Borelis melo FICHTEL & MOLL., 1798

Borelis vonderschmitti (SCHWEIGHAUSER, 1951)
Pl. I, figs. 3-4


Material: 2 specimens from 2 sample.
Description: small sphaeric form, with a diameter ranging from 0.43 to 0.54 mm, initially streptospirally coiled. Septula are continuous and not alternated.

Borelis inflata ADAMS, 1965
Pl. I, fig. 6

1947. Neoalveolina haueri (D’ORBIGNY). – BURSCH, p. 26, pl. 1, fig. 20, pl. 2, figs. 8, 11, text fig. 7, 8.

Material: rare specimens from the samples PC8, PC9, PC14 and MM5; one isolated specimen from MM3.
Description: small subsphaeric form, strictly coiled and with a diameter ranging from 0.6-0.9 mm. The index of elongation is low and varies between 1.13 and 1.27.
Distribution: Oligocene (HOTTINGER, 1974), SBZ 21-22 of CAHUZAC & POIGNANT (1997); at Portella Colla B. inflata occurs in the SBZ 21 assemblages.

Borelis pygmaea HANZAWA, 1930
Pl. I, fig. 5

1930. Borelis (Fasciolites) pygmaea HANZAWA, p. 94, pl. 26, figs. 14, 15.
1974. Borelis pygmaea HANZAWA. – HOTTINGER, p. 68, pl. 101, figs. 7, 8 (cum syn.).

Material: 2 megalosphaeric specimens from PC8 e PC12; 1 specimens from MM3.
Description: test small and fusiform with an axial length reaching 1.57 mm and equatorial diameter of 0.58 mm at the 7th whorl. The index of elongation ranges from
Type species
Distribution: in SBZ 21 in the Caltavuturo Fm.

Superfamily Soritacea EHRENBerg, 1839
Family Soritidae EHRENBerg, 1839
Subfamily Archaiasinae CUSHMAN, 1927
Genus Praearchaias SIReL, 1996
Type species: Praearchaias diyarbakirensis SIReL, 1996

Praearchaias sp.
Pl. I, figs. 7-8

Material: some transversal and tangential sectioned specimens from the samples PC9 and PC12.
Description: lenticular test, peneropline-type coiled. The megalospheric specimens consist of a small spheroidal proloculus (68-117 μm) followed by an early stage of few undivided chambers that become arcuate and subdivided in chamberlets by intraseptal pillars in the adult stage with a peneropline-like coiling.
Remarks: The wall of the investigated specimens is decalcified and recrystallized with glauconite, so the bad preservation of the test prevents detailed observation on the internal structures, such as septula or intraseptal pillars and the determination at specific level.
Distribution: Praearchaias was founded by SIReL (1996) on material from Priabonian and Early Oligocene. At Portella Colla Praearchaias is restricted to the assemblages of the Early Rupelian.

Superfamily Planorbulinacea SCHWAGER, 1877
Family Planorbulinidae SCHWAGER, 1877
Subfamily Planorbulininae SCHWAGER, 1877
Genus Planorbulina D’ORBIGNY, 1826
Type species: Planorbulina mediterranensis D’ORBIGNY, 1826

Planorbulina sp.
Pl. II, figs. 1-2; Text-fig. 6, figs. 1-5.

Material: 29 equatorially sectioned megalospheric specimens from 10 samples.
Description: test discoidal, flattened, early chambers arranged in a low trochoid spiral consisting of 7-9 chambers; later chambers have two apertures producing numerous spirals. The length of the embryonic chambers (d1-2) varies from 70 to 130 μm.
Distribution: Planorbulina sp. occurs from the upper Eocene to the upper Rupelian of the Caltavuturo Fm.

Family Cymbaloporidae CUSHMAN, 1927
Subfamily Halkyardiinae Kudo, 1931
Genus Halkyardia HERON-ALLEN & EARLAND, 1918
Type species: Cymbalopora radiata HAGENOW var. minima LIEBUS, 1911

Halkyardia maxima CIMERMAN, 1969
Pl. II, figs. 3-4; Text-fig. 6, figs. 7-8
1969. Halkyardia maxima CIMERMAN, p. 296, pl. 57, figs. 1-11 (cum syn.).

Material: 44 specimens from 10 samples.
Description: lenticular, concave-convex, more rarely planoconvex or biconvex (D=0.32-0.81 mm; H=0.14-0.41 mm). The dorsal side is always convex with the quadrilocular embryo on the apex side formed by a sphaeroidal protococh (d=35-78 μm), a deuteroconch (d=37-107 μm) and two primary auxiliary chambers, later chambers are arranged in numerous cycles. A perforate plug fills the umbilical region. In the investigated axial sections the umbilical angle varies from 78° to 87° and 8-12 chambers are visible for each side.
Distribution: originally described from the Oligocene of Poland (CIMERMAN, 1969). The FO of H. maxima marks the lowermost Oligocene.

Halkyardia minima (LIEBUS, 1911)
Pl. II, fig. 5; Text-fig. 6, fig. 6
1911. Cymbalopora radiata HAGENOW var. minima LIEBUS, p. 952, pl. 3, fig. 7.

Material: 1 specimen in subaxial section from the sample PC4.
Description: test small biconvex. The dorsal side is usually more convex and without ornamentation and granulation. In the marginal region of the ventral side ring-arranged tubular chambers radially distributed occur. In the central part of the ventral side an umbilical spine is visible.
Distribution: Late Eocene-Early Oligocene (CAHUZAC & POIGNANT, 1997); at Portella Colla H. minima is rare and restricted to the uppermost Eocene sediments.

Family Victoriellidae CHAPMAN & CRESPIN, 1930
Subfamily Carpenteriinae SAI DOVA, 1981
Genus Gyroidinella LE CALVEZ, 1949
Type species: Gyroidinella magna LE CALVEZ, 1949

Gyroidinella magna LE CALVEZ, 1949
Pl. III, fig. 1
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1949. Gyroidinella magna Le Calvez, p. 27, pl. 6, figs. 103-105.
1979. Eorupertia magna (Le Calvez). – DroBne et al., pl. 4, fig. 9.

Material: rare fragmented specimens from the samples PC2 and PC4.
Description: Test large (d=1.8-2.5 mm), planoconvex and trochospirally coiled, with a flat spiral side. The umbilical side is subconical with partially fused pillars in umbilical position. Numerous chambers in the last whorl with thick septa. Rounded periphery; wall calcareous, thick and optically radial.
Distribution: middle-late Eocene (Le Calvez, 1949).

Subfamily Victoriellinae Chapman & Crespin, 1930
Genus Victoriella Chapman & Crespin, 1930
Type species: Carpenteria proteiformis Goës var. Plecte Chapman, 1921 = Carpenteria conoidea Rutten, 1914

1914. Carpenteria conoidea Rutten, p. pl. 7, figs. 6-9.
1959. Victoriella conoidea (Rutten). – Glaessner & Wade, p. 199, pl. 1, figs. 1-5, pl. 2, figs. 1-5, 7-10, pl. 3, fig. 3.

Material: 3 specimens from the sample PC8.
Description: Conical test, trochospirally coiled. The juvenile stage is low trochospirally coiled, in the adult stage 3-4 globose chambers per whorl increasing rapidly in size. Thick perforated wall, characterized by pustules covering the adult stage.
Remarks: according to Glaessner & Wade (1959) Victoriella plecte (Chapman) and V. aquitanica Debourle & Delmas are fully synonymous of V. conoidea (Fig. 7).
Superfamily Acervulinacea SCHULTZE, 1854
Family Acervulinidae SCHULTZE, 1854
Genus Sphaerogypsina GALLOWAY, 1933
Type species: Ceriopora globulus REUSS, 1848

Sphaerogypsina globulus (REUSS, 1848)

Pl. II, fig. 8

1848. Ceriopora globulus REUSS, p. 33, pl. 5, fig. 7.

Material: many specimens from 8 samples in the section PC.
Description: sessile form with a subspherical test with hyaline, smooth and finely perforated wall. Quadrangular flattened chamberlets arranged in concentric regular layers; the chamberlets of the last whorls are alternated in radial direction.
Distribution: known from the Paleocene to Recent.

Superfamily Rotaliacea EHRENBerg, 1839
Family Chapmaninidae THALMANN, 1938
Genus Chapmania SILVESTRI, 1931
Type species: Chapmania gassiensis SILVESTRI, 1905

Chapmania gassiensis (SILVESTRI, 1905)

Pl. II, fig. 7


Material: some specimens and fragments from the samples PC2 and PC4.
Description: conical test with weakly convexed base, the maximum measured diameter is 1.56 mm and the maximum height is about 1 mm. The proloculus measures about 80 µm in diameter and the first chambers are arranged in a very short and not visible trochoidal initial coiling, followed by uniserial series of discoidal chambers. For each chamber a peripheral row of chamberlets occur. Wall test calcareous.
Distribution: Late Eocene to earliest Oligocene (CAHUZAC & POIGNANT, 1997). At Portella Colla C. gassiensis occurs only in the upper Eocene and it wasn’t found associated with Nummulites vascus in the SBZ 21 assemblages.

Family Nummulitidae DE BLAINVILLE, 1827
Genus Heterostegina d’ORBIGNY, 1826
Type species: Heterostegina depressa d’ORBIGNY, 1826

Heterostegina reticulata italica HERB, 1978

Pl. III, fig. 3; Text-fig. 8, fig. 1

2008. Heterostegina reticulata italica HERB. – LESS et al., p. 338, fig. 15D-K.

Material: 2 specimens from the sample PC2.
Description: thin test, planispiral involute coiling. Relatively big embryo (d=0.18 mm) followed by one single operculinid (undivided) chamber. Later chambers are subdivided by septa generating subrectangular chamberlets. Nine chamberlets occur in the 14th chamber and the diameter of the first whorl reaches 1.13 mm.
Distribution: Priabonian (SBZ19-20) of Mossano, Possagno (Italy) and Hungary (HERB, 1978; LESS et al., 2008).

Material: 51 specimens isolated from the sample PC8 and rare specimens from other samples.
Description: thin and flattened test, planispirally coiled. Small embryo (mean proloculus diameter=0.11 mm), followed by 0-4 undivided (operculinid) chambers. In the 14th chamber 3-11 chamberlets are present (M=7.74).
Distribution: in association with N. vascus and N. fichteli in the early Rupelian.
Genus *Nummulites* LAMARCK, 1801

**Type species**: *Camerina laevigata* BRUGUIÈRE, 1792

*Nummulites fichteli* MICHELOTTI, 1841

**Pl. III, fig. 6; Text-fig. 8, figs. 15-16**

1841. *Nummulites fichteli* MICHELOTTI, p. 44, pl. 3, fig. 7.
1848. *Nummulites garancianus* JOLY & LEYMERIE, p. 38, 66, 67, 70, pl. 1, figs. 9-12, pl. 2, fig. 8.
1850. *Nummulites intermedia* d’ARCHIAC, p. 416, pl. 9, figs. 23, 24.
1853. *Nummulites garancianus* JOLY & LEYMERIE. – d’ARCHIAC & HAIME, p. 101, pl. 3, figs. 6a, 7a-g.
1900. *Bruguiéra intermedia* A. [Bruguiéra fichteli (MICHELOTTI)]. – SILVESTRI, p. 643-650, pl. 21, fig. 9, 13, 14, 15, 16.
1911. *Nummulites fichteli* MICHELOTTI. – CHECCHIA-RISPOLI, p. 295-296, pl. 1, fig. 5-9. (A) (cum syn., partim) (B)
1911. *Nummulites intermedia* d’ARCHIAC. – CHECCHIA-RISPOLI, p. 296-297, pl. 1, fig. 5-9.
1981. *Nummulites fichteli* MICHELOTTI. – SCHAUB, p. 128, pl. 50, figs. 5-18; tb. 15, k. 1.

**Material**: two megalospheric specimens in equatorial section from the sample PC8; some others subaxial specimens from thin sectioned samples.

**Description**: small and lenticular test, circular in outline. Smooth surface with a slight bulge in the periphery, in proximity of the marginal cord (“lama trasversa” of ROVEDA, 1970). 
*N. fichteli* is a reticulate form, characterized by superficial grid formed by the intersection of primary septal filaments. A circular protoconch embraced by a deuteroconch halfmoon shaped. Septa are straight or weakly bent, bending few degree respect to the vertical. The chambers are larger than high. The chamber wall is thinner than the test wall.

**Distribution**: SBZ 21-SBZ 22B (CAHUZAC & POIGNANT, 1997; SIREL., 2003).

*Nummulites ex gr. incrassatus* DE LA HARPE, 1883

**Pl. III, fig. 5; Text-fig. 8, fig. 8**

1883. *Nummulites vasca* var. *incrassatus* DE LA HARPE, p. 140, pl. 7, figs. 27, 28.

**Material**: rare megalospheric specimens from the sample PC4.

**Description**: small bulged test, with acute margin. The thickness/diameter ratio is about 1/3. The subsphaeric embryo of the form A is followed by subrectangular chambers formed by thin septa.

**Distribution**: Late Eocene, SBZ18-20 of SERRA-KIEL et al. (1998).

*Nummulites vascus* JOLY & LEYMERIE, 1848

**Pl. III, fig. 7; Text-fig. 8, figs. 9-10**

1848. *Nummulites Vasca* nobis, JOLY & LEYMERIE, p. 171, 186, 215, 217; pl. 1, fig. 15-17; pl. 2, fig. 7.
1853. *Nummulites vascus* JOLY ET LEYM. – d’ARCHIAC & HAIME, p. 145; pl. 11, fig. 11 a-d, 12.
1879. *Nummulites vascus* J. & L. – DE LA HARPE, p. 9; pl. 1, fig. 3: 1-3. (B)
1879. *Nummulites Boucheri* DE LA HARPE, p. 10; pl. 1, fig. 4: 1-10. (A)
1883. *Nummulites Boucheri* DE LA HARPE. – DE LA HARPE, p. 179; pl. 7, fig. 33-46 non fig. 47-59. (A)
1888. *Nummulites variabilis* TELLINI, p. 193; pl. 7, fig. 7a-c. (A)
1907. *Paronaec Boucheri* DE LA HARPE var. *variabilis* (TEL-LINI). – PARISCH, p. 81, pl. 1, fig. 36-40. (A)
1911. *Nummulites vasca* JOLY ET LEYMERIE. – CHECCHIA-RISPOLI, p. 291, pl. 1, fig. 3-4. (B) (cum syn., partim).
1981. *Nummulites vascus* JOLY & LEYMERIE. – SCHAUB, p. 123-124; pl. 53, fig. 1-6; tbl. 15, fig. e. (cum syn.)

**Material**: some megalospheric free tests from the samples PC8 and MM3. Several subequatorial and subaxial sections from 9 samples. A and B forms from the sample PC8.

**Description**: Form A: lenticular, biconvex test with acute periphery; the diameter of the test ranges from 1.9 to 3.2 mm, the thickness varies from 0.9 to 1.1. The septal filaments, where visible, are weakly sinusoidal. Large embryo, protoconch (d=0.18-0.27 mm) and deuteroconch have a similar size. Spiral growth regular; septal filaments, where visible, are weakly sinusoidal. Large embryo, protoconch (d=0.18-0.27 mm) and deuteroconch have a similar size. Spiral growth regular; thin septa are backwards-curved forming subrectangular chambers.

**Distribution**: known in literature for the whole Oligocene (CAHUZAC & POIGNANT, 1997); at Portella Colla the FO of *N. vascus* marks the early Rupelian and is not present in the Nephrolepidina assemblages.

**Genus Operculina** d’ORBIGNY, 1826

**Type species**: *Lenticulites complanatus* DEFRANCE, 1822
Fig. 8: 1. *Heterostegina reticulata italica*, PC02_He01; 2-7. *Heterostegina* sp. (2. PC08_He28; 3. PC08_He18; 4. PC08_He55; 5. PC08_He24; 6. PC08_He57; 7. PC08_He53); 8. *Nummulites* ex. gr. *incrassatus*, PC4; 9-10. *Nummulites vascus*, PC8; 11-14. *Operculina complanata* (11. PC08_Op04; 12. PC08_H43; 13. PC08_H39; 14. PC08_Op03); 15-16. *Nummulites fichteli*, PC8. Scale bar=0.5 mm.
Operculina complanata (DEFRANCE, 1822)

Pl. III, fig. 2; Text-fig. 8, figs. 11-14

1822. Lenticulites complanatus DEFRANCE, p. 453
1826. Operculina complanata D’ORBIGNY, p. 281, pl. 14, figs. 7-10.

Material: 9 isolated specimens from the sample PC8, some specimens from the samples PC9, PC10, PC14, MM3 and MM4.
Description: test flattened with planispiral evolute coiling, oval in outline, with a bulgedumbo in correspondence of the embryo in excentric position. The protoconch diameter ranges from 54 to 132 μm (M=82), the diameter of the first whorl from 0.33 to 0.69 mm (M=0.49 mm). The chambers are undivided and are 7-9 in the first whorl, 19-27 in the second whorl. At the base of the latest chambers the septal flaps create some folds generating protosepta.
Distribution: from SBZ 21 to SBZ 26 according to CAHUZAC & POIGNANT (1997); at Portella Colla rarely occurs in the Early Rupelian assemblages.

Family Discocyclinidae GALLOWAY, 1928
Genus Discocyclina GÜMBEL, 1870

Type species: Orbitolites pratti MICHELIN, 1846

Discocyclina dispansa dispansa (SOWERBY, 1840)
Pl. IV, fig. 1

1840. Lycophris dispansa SOWERBY, p. 327, pl. 24, fig. 16a-b.
1987. Discocyclina dispansa dispansa (SOWERBY). – LESS, p. 163, pl. 13, figs. 9, 12, pl. 14, figs. 3, 6.

Material: one megalospheric specimens from the sample PC4.
Description: semi-nephrolepidine to trybliolepidine type embryo (d=499 μm), with rectangular and elongated “archiaci” type equatorial chamberlets sensu LESS (1987).
Distribution: SBZ 19 (SERRA-KIEL et al., 1998).

Family Orbitoclypeidae BRÖNNIMANN, 1945
Genus Orbitoclypeus SILVESTRI, 1907

Type species: Orbitoclypeus himerensis SILVESTRI, 1907

Orbitoclypeus varians (KAUFMANN, 1867)
Pl. IV, fig. 3

1867. Orbitoides varians KAUFMANN, p. 158, pl. 10, figs. 1-10.
2007. Orbitoclypeus varians KAUFMANN. – ÖZCAN et al., p. 504, pl. 2, figs. 12, 14, 19; pl. 3, fig. 15, pl. 5, figs. 7-8, text-fig. 15.

Material: one specimen from sample PC4.
Distribution: Late Eocene (SERRA-KIEL et al., 1998).

Family Lepidocyclinidae SCHEFFEN, 1932
Genus Nephrolepidina DOUVILLE, 1911

Type species: Nummulites marginata MICHELOTTI, 1841

Nephrolepidina praemarginata (DOUVILLE, 1908)
Pl. IV, figs. 5-6; Text-fig. 9, figs. 1-4

1908. Lepidocyclina praemarginata DOUVILLE, p. 91-92, figs. 1, 2, 4a.

Material: 176 equatorially sectioned megalospheric specimens from 8 samples and several others specimens axially and subaxially sectioned.
Description: test lenticular with a diameter ranging from 0.2 to 0.5 mm and thickness from 0.05 to 0.2 mm. The embryonic apparatus consists of a large circular protoconch (d=181-586 μm) and a reniform deuteroconch (d=211-789 μm) embracing the protoconch. Two auxiliary chambers are directly on contact with the two embryonic chambers. The number of adauxiliary chambers on the deuteroconch varies from 1 to 4. The grade of enclosure of the deuteroconch on the protoconch (parameter A of VAN DER VLERK, 1959) ranges from 27 to 41 % (mean=33-36 %). The equatorial chamberlets are rhombic or ogival with a very short common wall length.
Distribution: the FO of N. praemarginata marks the Late Rupelian (SBZ22 A of CAHUZAC & POIGNANT, 1997).

Genus Eulepidina DOUVILLE, 1911

Type species: Orbitoides dilatata MICHELOTTI, 1861

Eulepidina formosoides DOUVILLE, 1925
Pl. IV, figs. 7-8; Text-fig. 9, figs. 5-9

1925. Lepidocyclina (Eulepidina) formosoides DOUVILLE, p. 71, pl. 3, figs. 2-4.

Material: 8 megalospheric specimens from 8 samples.
Description: lenticular test with a bulgedumbo in correspondence of the large embryo consisting of a subsphaeric protoconch (d=430-895 μm) and very large deuteroconch (600-978 μm). The grade of enclosure varies from 56 % to 72 %. The equatorial chamberlets are arcuate in outline.
Distribution: SBZ22 A (CAHUZAC & POIGNANT, 1997).
Fig. 9: 1-4. *Nephrolepidina praemarginata* (1. Ps0_N13; 2. Ps0_N24; 3. PC060620_N11; 4. PC0_15); 5-9. *Eulepidina formosoides* (5. PC16_eu02; 6. PC16_eu06; 7. PCs0_Eu01; 8. PCs0_Eu02; 9. PC17_eu01). Scale bar=0.5 mm.
Remarks: Montanari (1980) reported E. formosoides as a junior synonym of E. raulini Lemoine & Douvillé, 1904, differing only from the marked ornamentation of E. formosoides. Douvillé (1924) suggested that E. formosoides has an evident smaller embryo in respect to E. raulini.

VI. CONCLUSIONS

The displaced larger foraminifera tests occurring in some turbiditic layers into the clays of the Caltavuturo Fm, provide the opportunity to furnish the biostratigraphical pattern of an investigated outcrop at Portella Colla (Madonie Mts., Sicily).

The occurrence of larger foraminifera is due to the frequency of the turbiditic events and so the lack of turbiditic layers at the base of the investigated sections prevents a detailed biostratigraphic resolution of the Late Eocene.

According to the zonation proposed by Cahuzac & Poignant (1997) and Serra-Kiel et al. (1998) three biozones were surely recognized in the Caltavuturo Fm clays: Borelis vonderschmitti, Discocyclina dispensa, Orbitoclypeus varians, Halkyardia minima and Heterostegina reticulata italica assemblage marks the SBZ 19, no SBZ 20 markers were found for the uppermost Priabonian. The lower Rupelian (SBZ 21) assemblages are dominated by Nummulites vascus with N. fichteli, Operculina complanata, Heterostegina sp., Halkyardia maxima, whereas the FO of Nephrolepidina prae- marginata marks the upper Rupelian (SBZ 22A).

A detailed biometrical investigation on Nephrolepidina populations from the investigated sections is still in progress with the aim to implement the biostratigraphic resolution of the Late Rupelian sediments (Benedetti & Pignatti, in prep).

The imbrication of the Nephrolepidina tests points out on the N-S paleodirection of the flows, but it’s impossible recognize the origin of these flows.

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Plate II

Fig. 1: Planorbulina sp., PC2 ;
Fig. 2: Planorbulina sp., PC10 ;
Fig. 3: Halkyardia maxima, PC10 ;
Fig. 4: Halkyardia maxima, PC9 ;
Fig. 5: Halkyardia minima, PC4 ;
Fig. 6: Victorilella conoidea, PC8 ;
Fig. 7: Chapmanina gassinensis, PC4 ;
Fig. 8: Sphaerogypsina globulus, PC4.
Scale bar=0.5 mm.


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Plate III

Fig. 1: Gyroidinella magna, PC4;
Fig. 2: Operculina complanata, PC9;
Fig. 3: Heterostegina reticulata italica, PC2;
Fig. 4: Heterostegina sp., PC9;
Fig. 5: Nummulites ex. gr. incrassatus, PC4;
Fig. 6: N. fichtelti, PC8;
Fig. 7: N. vascus, PC6;
Fig. 8: Reworked Orbitoides in the sample PC7.
Scale bar=0.5 mm.
Plate IV

Fig. 1: Discocyclina dispansa dispansa, PC4;
Fig. 2: Discocyclina sp., PC4;
Fig. 3: Orbitocyclus varius, PC4;
Fig. 4: Orbitocyclus sp., PC4;
Fig. 5: Nephrolepidina praemarginata, PC17;
Fig. 6: Twin embryos in N. praemarginata, MM13;
Fig. 7: Eulepidina formosoides, MM9_eul06;
Fig. 8: E. formosoides, MM9_eul04.

Scale bar=0.5 mm.


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