

NEW BIOSTRATIGRAPHIC DATA FROM THE REITANO FLYSCH AUCT. (SICILY, ITALY): A KEY TO A REVISED STRATIGRAPHY OF THE SICILIDE UNITS

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Abstract. The study of palynomorphs and calcareous nannofossils recovered from the volcano-arenitic succession outcropping at Troina and Cerami (Sicily) documents Rupelian assemblages comparable to those published for the Tusa Tuffite. This new evidence, combined with petrographic, geochemical and sedimentological affinities documented in the literature, eventually proves the genetic relationships between these units. Accordingly, the new name Troina-Tusa Formation is proposed to include all these Rupelian volcano-sedimentary units and to replace inappropriate names formerly used.

The Troina-Tusa Formation conformably lies on a mixed siliclastic-carbonate turbidite succession, lacking volcanic detritus, reported in the literature with different names (Polizzi Formation, Varicolori Shales, Troina-Tusa Flysch) and different ages (ranging from Eocene to Early Miocene). Palynomorphs and nannofossils recovered from its uppermost part, indicate an earliest Oligocene age. The denomination Polizzi Formation is recommended for this unit that includes also the Varicoloured Shales (Eocene-basal Oligocene).

The appearance of conglomerates and volcano-arenites in the basal portion of the Troina-Tusa Formation, immediately above the top of the Polizzi Formation, marks a sudden reorganization of the Rupelian depositional systems related to the rise and erosion of a volcanic belt. Apparently, no biostratigraphically detectable hiatus is associated to this boundary.

Differences in the composition of sandstones, sedimentary features and relationships with the substratum do exist between the 'internal' Reitano Flysch, outcropping in the type-area on the northern slope of the Nebrodi Mountains, and the volcano-arenitic successions of Cerami and Troina, reported by some authors as 'external' Reitano Flysch. These differences are widely documented in the literature, where the 'internal' Reitano Flysch is shown to lack volcanic detritus and to rest unconformably on the deformed Monte Soro Flysch. Since the definition of the Troina-Tusa Formation now includes the external outcrops (Cerami, Troina, Ancipa Lake), the adjectives 'internal' and 'external' become disused, and the name Reitano Flysch is restricted to the successions lacking volcanic detritus exposed in the type-area of Reitano, Pettineo, Caronia and Capizzi. Palynomorphs and nannofos-

sils recovered from the Pettineo section, suggest a Rupelian age also for the Reitano Flysch.

Riassunto. Lo studio di palinomorfi e nannofossili rinvenuti nelle successioni sedimentarie vulcano-clastiche affioranti a Troina e Cerami (Sicilia) evidenzia associazioni tipiche dell'Oligocene inferiore confrontabili con quelle pubblicate per le Tufiti di Tusa. I nuovi dati, combinati con le somiglianze dei caratteri petrografici, geochimici e sedimentologici già documentate in letteratura, provano che queste successioni sono coeve e geneticamente legate. Pertanto si propone di identificarle col nome Formazione di Troina-Tusa, che sostituisce i nomi formazionali inappropriati usati in precedenza.

Nelle sezioni di Troina e Cerami, la Formazione di Troina-Tusa giace in conformità su una successione torbiditica mista terrigeno-carbonatica, priva di detrito vulcanico, riportata in letteratura con nomi diversi (Formazione di Polizzi, Argille Varicolori, Flysch di Troina-Tusa) ed età differenti (variabili dall'Eocene al Miocene inferiore). Palinomorfi e nannofossili qui documentati indicano un'età Oligocenica basale per la parte sommitale di questa unità, per la quale riteniamo appropriato l'uso del nome Formazione di Polizzi. Le Argille Varicolori dell'Eocene-Oligocene basale, note nel Complesso Sicilide, rappresentano una facies della Formazione di Polizzi.

La comparsa di conglomerati e arenarie vulcano-clastiche alla base della Formazione di Troina-Tusa, immediatamente sopra al tetto della Formazione di Polizzi, registra una brusca riorganizzazione dei sistemi deposizionali conseguente al sollevamento di una cintura vulcanica nell'Oligocene inferiore. Tuttavia nel record sedimentario non si evidenzia alcuna lacuna risolvibile biostratigraficamente in corrispondenza di questo evento.

Marcate differenze nella composizione delle arenarie, nelle strutture sedimentarie e nei rapporti con le unità sottostanti contraddistinguono invece il Flysch di Reitano 'interno', affiorante nell'area-tipo sul pendio settentrionale dei Monti Nebrodi, dalle successioni vulcano-clastiche di Troina e Cerami, riportate da diversi autori precedenti come Flysch di Reitano 'esterno'. Esse sono ampiamente discusse in letteratura, dove si dimostra che il Flysch di Reitano 'interno' è privo di detrito vulcanico e poggia in discordanza sul Flysch di Monte Soro già deformato. Poiché la definizione di Formazione di Troina-Tusa qui proposta ora include gli affioramenti 'esterni' (Cerami, Troina, Lago di Ancipa), si possono abbandonare gli aggettivi 'interno' ed 'esterno', e restringere la denominazione Flysch di Reitano alle succes-

sioni prive di detrito vulcanico affioranti nell'area di Reitano, Pettineo, Caronia e Capizzi. Le associazioni a palinomorfi e nannofossili rinvenute nella sezione di Pettineo suggeriscono un'età Rupeliana anche per il Flysch di Reitano.

Introduction

The volcano-arenitic succession outcropping at Cerami, Troina, Serro Scarvi and Ancipa Lake (north-eastern Sicily, Italy, Fig. 1) represents a problematic unit as it is reported in the literature under different names (i.e. Reitano Flysch *sensu* Ogniben 1960; Troina-Tusa Flysch *sensu* Guerrera & Wezel 1974; external Reitano Flysch *sensu* Cassola et al. 1992, Puglisi 1992; Arenarie di Troina Formation *sensu* de Capoa et al. 2000, 2004) and different ages (ranging from Rupelian to Serravalian) yielding controversial reconstructions in the timing of the deformation of the Maghrebian chain. Indeed, the correct chronostratigraphic attribution of these deposits has implications for the paleogeodynamic models of the Maghrebian orogenic system. The deposition of volcanoclastic turbidites in these basins is in fact unanimously considered coeval to the volcanism, hence conclusive evidences of a Rupelian age for the Troina and Cerami volcano-arenitic successions, consistent with

the Rupelian age already documented for other volcanoclastic successions outcropping in the southern Apennines (Baruffini et al. 2002), in the northern Apennines (d'Atri & Tateo 1994; Cibin et al. 1998; Elter et al. 1999) and also in the western Alps (Lateltin & Müller 1987), would eventually prove that volcanism was active in different sectors of the Alps/Apennines orogenic system during Early Oligocene times.

In the localities of Troina and Cerami, such a volcano-arenitic succession conformably lies on another problematic turbidite unit, characterised by the lack of volcanic detritus and by the presence of marly-calcareous beds intercalated with sandstones and shales (Ogniben 1960; Schilirò 1968; Gerevini 1969; Loiacono & Puglisi 1983; Puglisi 1992; Cassola et al. 1992, 1995). This lithostratigraphic unit belongs to the Sicilide Complex (Ogniben 1960) and was reported as Troina-Tusa Flysch (Lower Miocene) in the Geological Map of central-eastern Sicily (Carbone et al. 1991). However, in the literature it is reported under different names (Polizzi Formation, Varicoloured Shales, Troina-Tusa Flysch) and different ages (ranging from Eocene to Early Miocene).

In this controversial framework, in order to assess the precise age of these successions as a basis for their

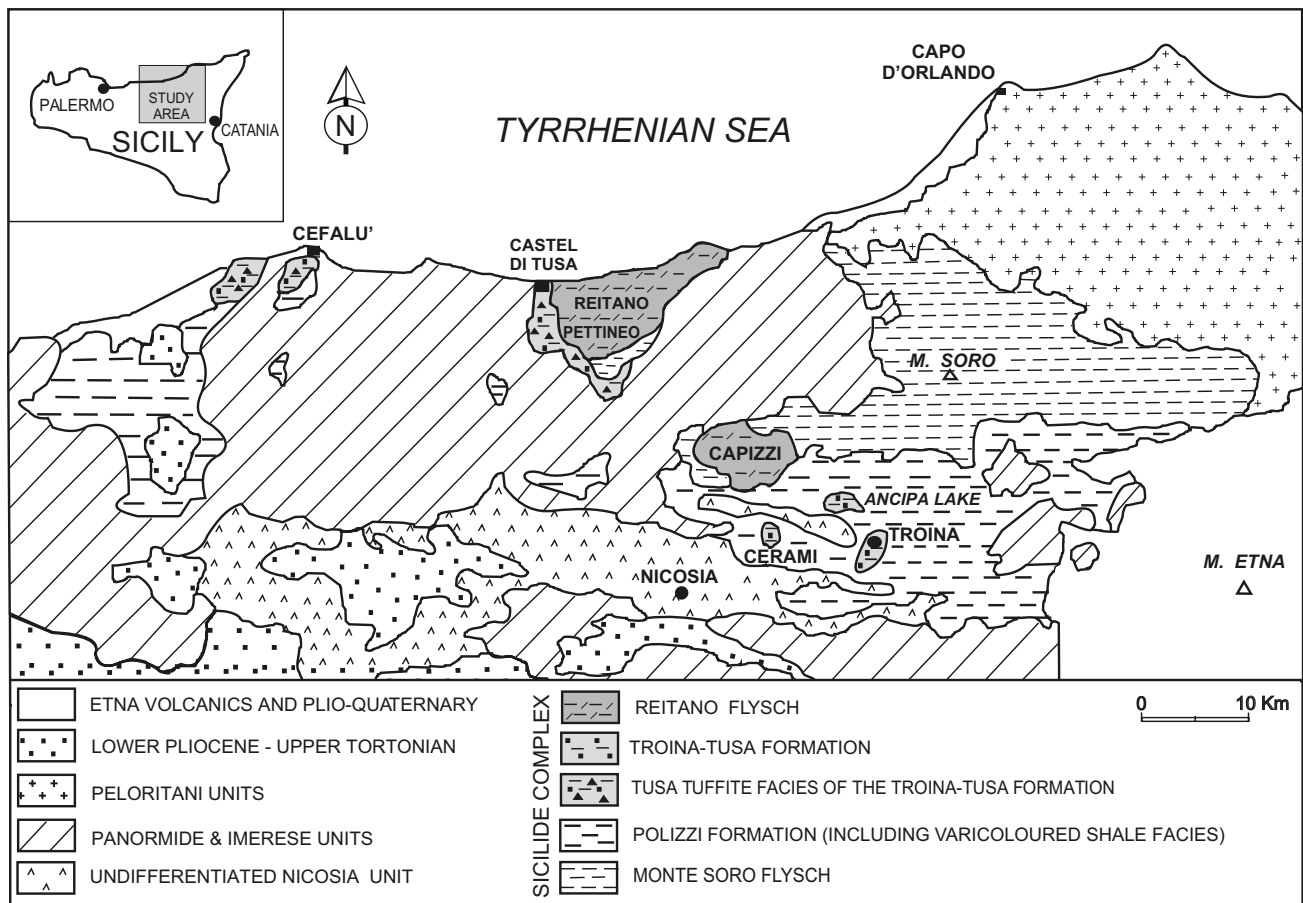


Fig. 1 - Geological sketch map of north-eastern Sicily showing the distribution of the units investigated in this study.

revision, we carried out a biostratigraphic study of key outcrops based on palynological and calcareous nannofossil analyses. A documentation of the analytical data, including occurrence-charts and photographic illustrations of selected microfossils, is presented in the following chapters along with their interpretation and discussion.

Geological framework

Eastern Sicily is part of the south-verging branch of the Apennine-Maghrebian chain, a segment of the collisional boundary between Africa and Europe. The tectonic pile which forms the eastern Sicily thrust belt can be divided into three major structural elements separated by detachment levels (Bello et al. 2000). They were emplaced during the Eocene to Early Miocene and re-deformed during the Miocene to Pliocene. The lower element is represented by the Hyblean unit. It is overlain by two allochthonous structural elements, namely the Imerese-Sicano unit with its Neogene clastic cover and the Sicilide Complex (Ogniben 1960). This study deals with successions belonging to the Sicilide Complex.

Material and methods

Samples for palynological and calcareous nannofossil investigations were collected from shale beds in the stratigraphic sections exposed at Troina, Cerami and in the lower segment of the Fiumara di Tusa valley, along the road to Pettineo (Figs. 2a-c).

Palynology. A standard palynological processing technique was performed in the Eni's laboratories and involved cold chemical treatment of 15 g of sediment with hydrochloric acid (HCl 36%) to remove the calcareous fraction and with hydrofluoric acid (HF 40%) to remove the silicates, heavy liquid separation with $ZnCl_2$, sieving with 250 μm and 15 μm meshes and centrifuging to concentrate the residues. No oxidation was required. Two slides were prepared for each sample using residues sized between 15 μm and 250 μm . Optical adhesive produced by Norland Inc. was used as mounting medium.

The analytical results are plotted in distribution-charts with absolute abundances obtained from a count of a single slide whereas the second slide of each sample was examined only to check for the presence of additional taxa. Although bisaccate pollen is abundant and spores and prasinophycean algae occur sporadically, this study concentrates on organic-walled dinoflagellate cysts as they provide more valuable information to assess the age of the investigated successions.

To determine the age of the strata based on the distribution of fossils, species ranges must be compared with those calibrated in previous studies. The main references used in this paper for the stratigraphic interpretation of dinoflagellate cyst distributions are the zonation schemes for the Oligocene of the Mediterranean region (Brinkhuis & Biffi 1993; Wilpshaar et al. 1996; Pross et al. 2010) and the events calibrated by Williams et al. (2004) against the Berggren et al. (1995) timescale.

Light photomicrographs were taken using a Zeiss Axioplan microscope and interference-contrast illumination (Pl. 1). The taxonomic allocation and authorship of dinoflagellate cyst species follow Fensome and Williams (2004), unless otherwise stated.

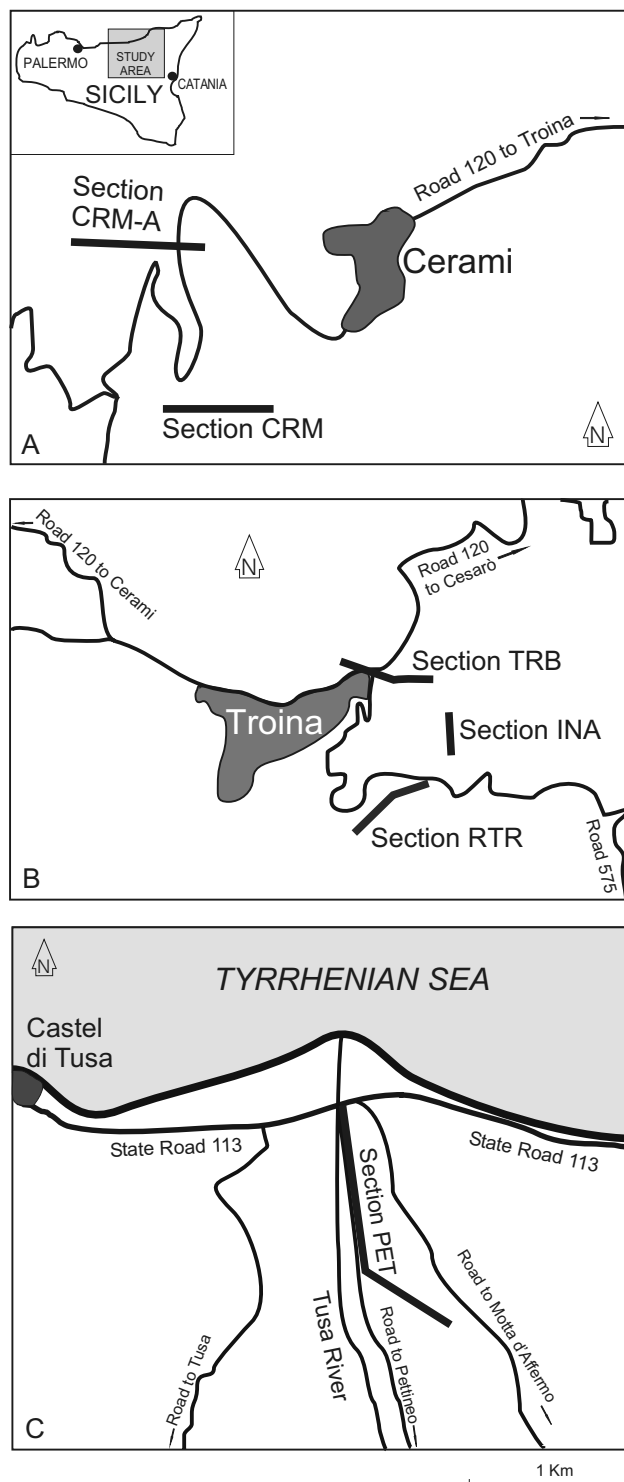


Fig. 2 - Schematic road maps with locations of the stratigraphic sections investigated in the present study.

Calcareous nannofossils. Samples were mechanically disaggregated and smeared onto slides without applying concentration techniques in order to retain the original nannofloral composition. Smear slides were permanently mounted using Norland optical adhesive. Analyses were carried out with a Zeiss Axioplan light polarising microscope at 1000x and 1250x magnification. Semi-quantitative analytical results are tabulated in the Stratabugs range-charts.

In interpreting analytical data, reference has been made to Cantanzariti et al. (1997) and Maiorano & Monechi (2006).

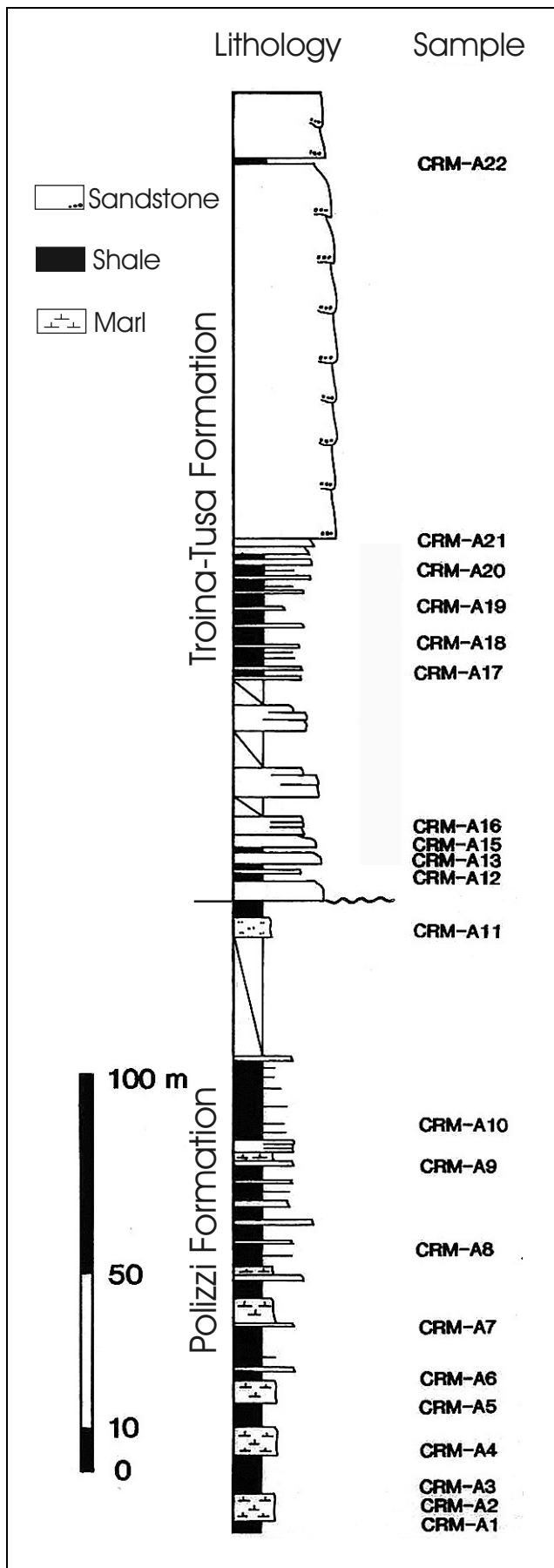


Fig. 3 - Stratigraphic log of the Cerami CRM-A section with sample position.

All the palynological and nannofossil slides examined in this study are housed in the collections of the Department of Stratigraphy, Eni Exploration & Production, San Donato Milanese, Italy.

Biostratigraphy of Cerami sections CRM-A and CRM

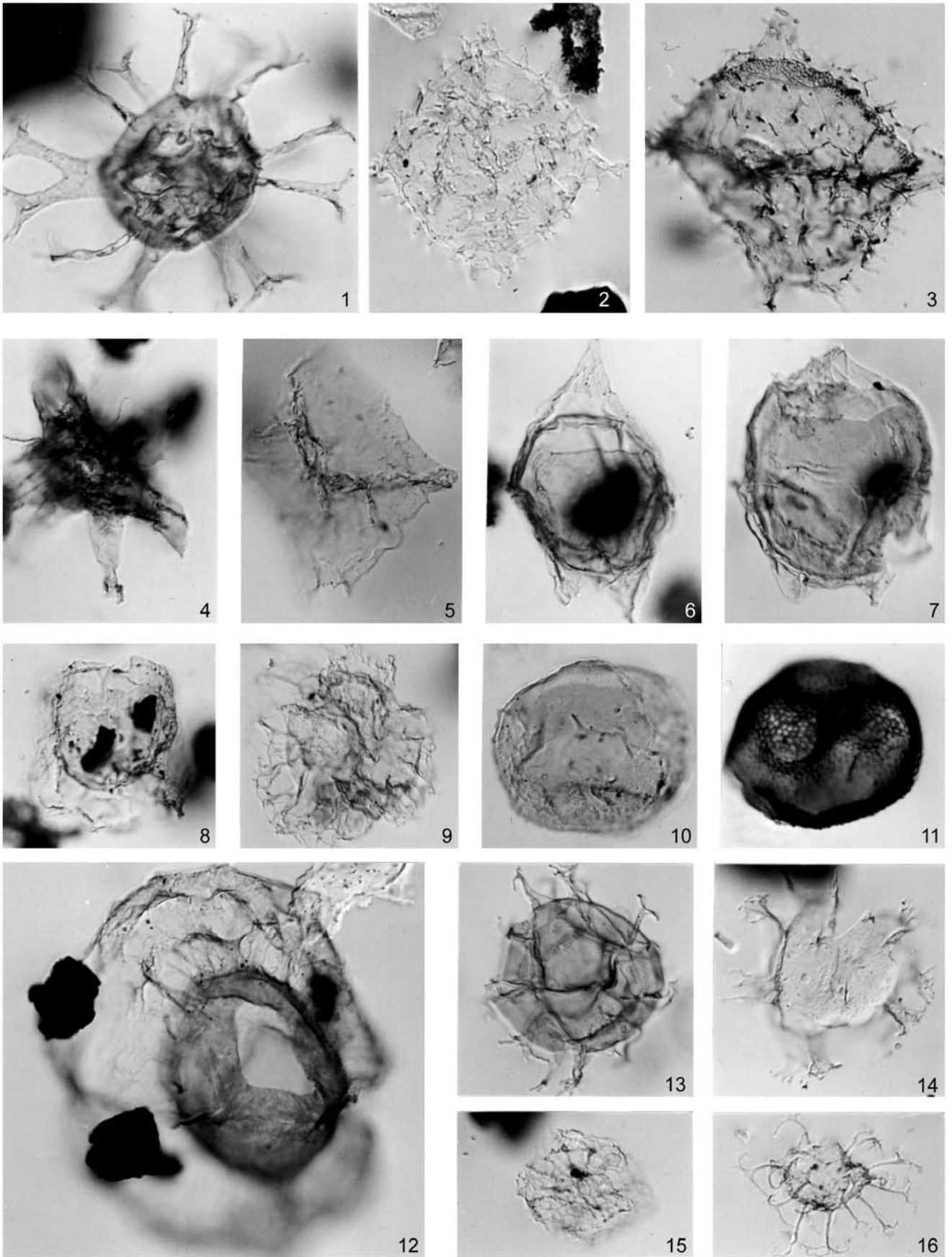
Both sections are located to the West of the town of Cerami (Figs. 2a, 3, 4). Section CRM-A spans the upper part of the Polizzi Formation and the lower part of the volcano-arenitic unit hereby named Troina-Tusa Formation. According to Cassola et al. (1992, 1995) the boundary between these two units is conformable, although sharp and defined by a remarkable difference in the lithology, mainly pelitic and/or marly-calcareous at the top of the Polizzi Formation and arenaceous, very coarse-grained up to conglomeratic at the bottom of the Troina-Tusa Formation. Results presented here show that, despite change in lithology, no relevant hiatus is detectable across this boundary and the sedimentary record is apparently continuous throughout.

Twenty-two samples were analysed for palynology from section CRM-A (Fig. 5). In general, samples from CRM-A 1 to CRM-A 11, representing the Polizzi Formation, are more fossiliferous than samples CRM-A 12 to 22 representing the Troina-Tusa Formation. Several age-diagnostic dinoflagellate cyst species occur in the assemblages from the Polizzi Formation, namely *Achomosphaera alicornu*, *Enneadocysta pectiniformis*, *Homotryblium oceanicum*, *Homotryblium tenuispinosum* and locally abundant *Deflandrea* spp. Moreover, two specimens of *Areosphaeridium diktyoplokus* have been found: the highest occurrence in sample CRM-A 9 is likely coincident with the extinction of this species, an event calibrated in the very basal Oligocene in the Northern Hemisphere (Williams et al. 2004; Pross et al. 2010). The earliest Oligocene age is strongly supported also by the lowest occurrences of *Wetzeliella gochtii* and *Glaphyrocysta semitecta* in sample CRM-A 11.

PLATE 1

Dinoflagellate cysts and prasinophycean algae from the Troina-Tusa Formation sampled at Troina section INA. Size reference is made to the scale bar = 40 μ m.

1) *Achomosphaera alicornu*; 2) *Wetzeliella gochtii*; 3) *Wetzeliella symmetrica*; 4) *Hystrichokolpoma eisenackii*; 5) *Rhombodinium* cf. *draco*; 6) *Deflandrea phosphoritica*; 7) *Deflandrea* cf. *heterophlycta*; 8) *Glaphyrocysta semitecta*; 9) *Glaphyrocysta* sp.; 10) *Deflandrea* cf. *heterophlycta*, internal body; 11) *Schizosporis* sp.1 sensu Brinkhuis & Biffi (1993); 12) *Thalassiphora pelagica*; 13) *Spiniferites pseudofurcatus*; 14) *Homotryblium vallum*; 15) *Reticulosphaera actinocoronata*, specimen with a complete reticulum; 16) *Enneadocysta pectiniformis*.



40 micron

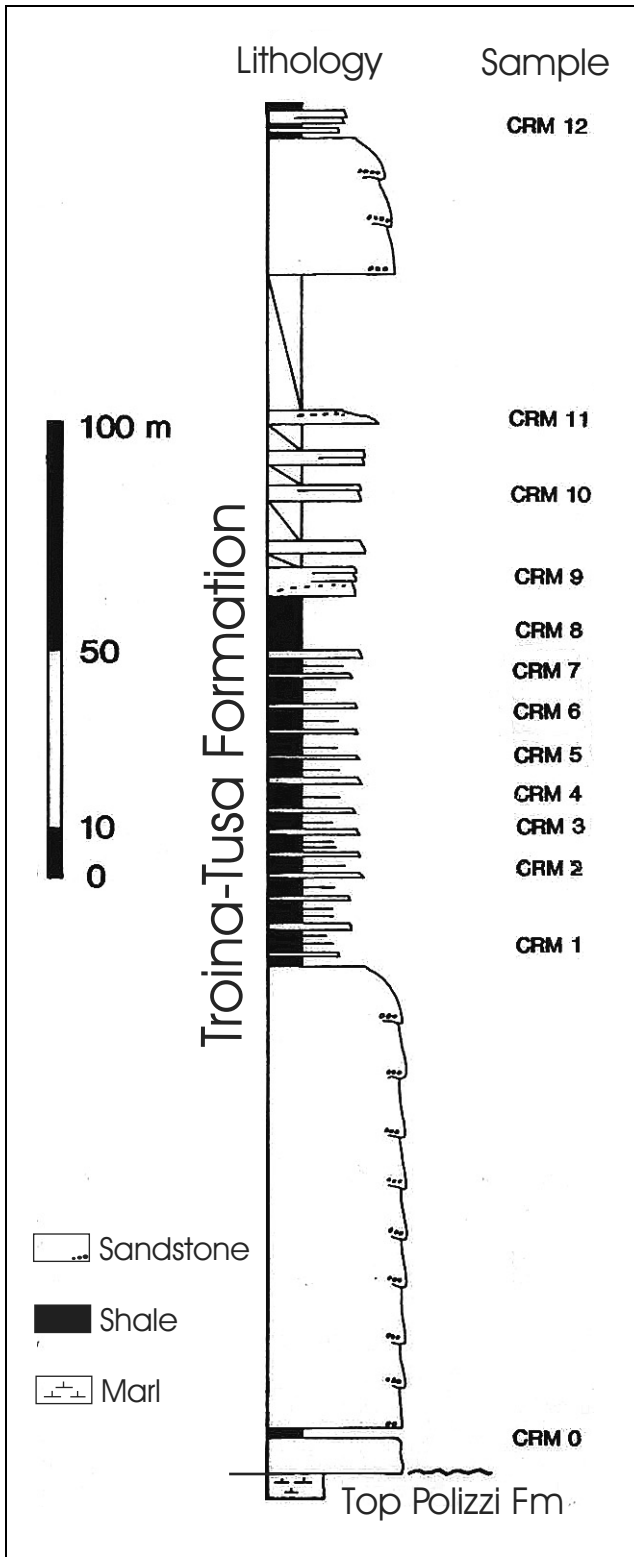


Fig. 4 - Stratigraphic log of the Cerami CRM section with sample position.

Assemblages recovered from the Troina-Tusa Formation are sometimes poor and scarcely diagnostic; nevertheless, the occurrences of *W. gochti*, *A. alcicornu*, *Thalassiphora pelagica*, *Distatodinium craterum*, *Defla-*

ndrea heterophlycta in samples CRM-A 20 and 21, as well as the absence of younger markers, clearly indicate an Early Oligocene age.

Eight palynological samples have been investigated from the Troina-Tusa Formation exposed in the CRM section. They yielded moderately diverse dinoflagellate cyst assemblages including typical Early Oligocene markers, namely *W. gochti*, *A. alcicornu*, *E. pectiniformis*, *Deflandrea* spp., *Reticulatosphaera actinocoronata* (with complete reticulum), *Rhombodinium draco* (Fig. 6). Prasinophycean algae *Schizosporis* and *Calyplocysta* are common throughout. Reworked Cretaceous forms are present and their abundance increases upwards. These palynological assemblages, characterised also by the absences of *A. diktyoplokus* (extinction in the very basal Rupelian) and *Chiropteridium lobospinosum* (inception in the middle Rupelian) indicate a Rupelian age consistent with the MNP22-23 zonal attribution obtained from nannofossils.

Nineteen samples were examined for calcareous nannofossils from section CRM-A (Fig. 7). Samples CRM-A 1 to 10 are very rich in nannoflora, with abundant calcite residues; specimens are often of large size and a diffused re-crystallization is present. Cretaceous and Eocene reworking is regularly present but not abundant. Relying on the frequent recovery of *Ericsonia fenestrata/obruta* together with *Ericsonia formosa*, *Reticulofenestra umbilica*, *Istmolithus recurvus*, *Dictyococites bisectus*, *Reticulofenestra daviesii*, *Cyclicargolithus floridanus*, common to abundant *Zygrhablithus bijugatus*, this interval can be assigned to MNP21b subzone (basal Oligocene).

Assemblages from samples CRM-A 11 to CRM-A 16 are diluted and less diverse. The absence of *R. umbilica* and the presences of single specimens of *I. recurvus* and *Helicosphaera recta* suggest that the lowermost part of MNP23 zone can be detected in CRM-A 16, whereas a questionable MNP22-23 zone can be inferred for samples CRM-A 11-15. Samples CRM-A 17 to 22 are barren.

Eight samples were studied from section CRM (Fig. 8). The nannofossil abundance is variable, with a peak in sample CRM 4. Assemblages contain elements typical of the Rupelian and suggest an attribution to MNP23 zone from sample CRM 1, where *Helicosphaera perch-nielseniae* and *Cyclicargolithus abisectus* larger than 10 μ m were first observed, to CRM 6. *Helicosphaera* cf. *recta* was detected in sample CRM 3. *R. umbilica* and *E. formosa* are common only in sample CRM 4, where they are likely reworked together with other Eocene elements, whereas they are rare in the other samples. Questionable specimens of *Sphenolithus distentus* and transitional *S. predistentus/distentus* morphotypes occur discontinuously.

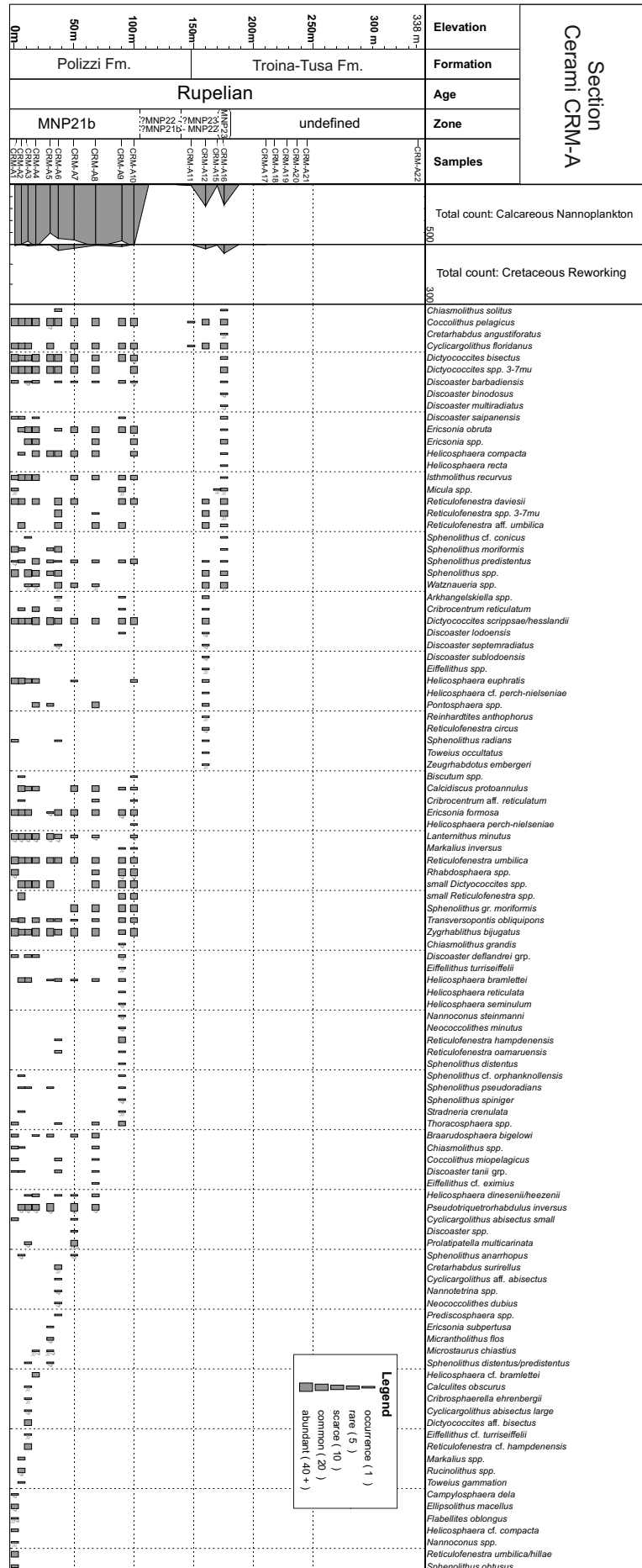


Fig. 7 - Range chart of nannofossils recovered from the Cerami CRM-A section. Elevation represents metres from the base of the section. Zones after Caranzarini et al. (1997). R stands for reworked.

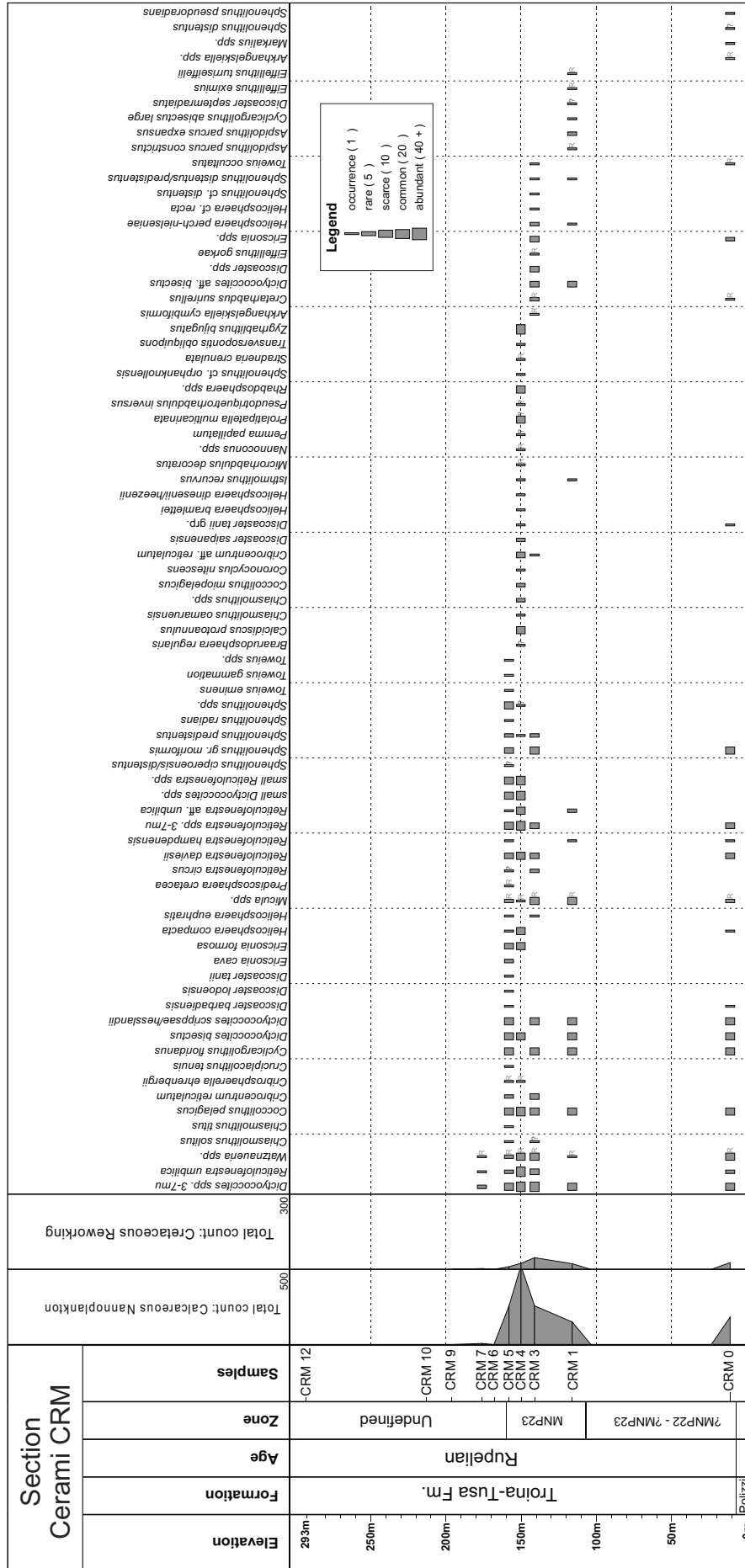


Fig. 8 - Range chart of nannofossils recovered from the Cerami CRM section. Elevation represents metres from the base of the section. Zones after Catanzariti et al. (1997). R stands for reworked.

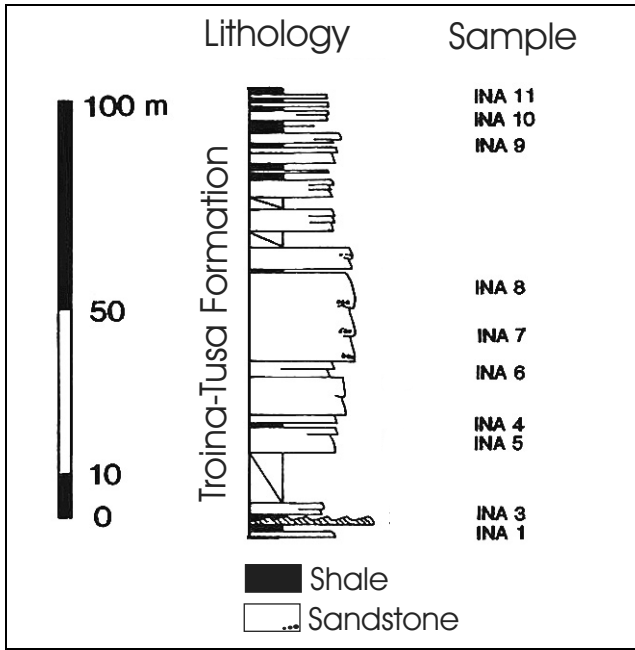


Fig. 9 - Stratigraphic log of the Troina INA section with sample position.

Biostratigraphy of Troina sections INA, RTR and TRB

The Troina sections INA, RTR and TRB (Fig. 2b) represent roughly equivalent portions of the lithostratigraphic unit hereby named Troina-Tusa Formation. It is the same succession outcropping at Cerami, characterised by a lower arenaceous massive body, very coarse-grained up to conglomeratic, lying on top of the Polizzi Formation. As it concerns the boundary between these two formations, the same considerations expressed above for the Cerami section CRM apply to the Troina area as well.

Section INA (Fig. 9)

This section was measured and sampled along the paved road that departs from the gate of Hotel Cittadella dell'Oasi towards the East.

Palynology. Five samples investigated yielded diversified dinoflagellate cyst assemblages indicative of Early Oligocene age (Fig. 10). The most diagnostic taxa are: *W. gochtii*, *R. actinocoronata* (specimens with a complete reticulum), *E. pectiniformis*, *A. alcornu*, *R. cf. draco*, common *Deflandrea* spp. and *G. semitecta* (Pl. 1). The presence of recycled Cretaceous taxa is consistent throughout the samples and bisaccate pollen is always abundant.

Calcareous nannofossils. Four samples were studied and proved to be barren or poor of age-diagnostic nannofossils (Fig. 11). INA 1 yielded an assemblage dominated by *Dictyococites bisectus*, *Dictyococites scrippsae/hesslandii* and *C. pelagicus*, with rare *S. predis-tentus* and a single specimen of *H. perch-nielseniae*. The absence of *R. umbilica* and *I. recurvus* could suggest that this sample is referable to the upper part of zone MNP23, i.e. above the extinction datums of these taxa calibrated in the lowermost part of the zone.

Section RTR (Fig. 12)

Palynology. Seven samples investigated yielded diversified dinoflagellate cyst assemblages indicative of Early Oligocene age (Fig. 13). The most diagnostic taxa are: *W. gochtii*, *R. actinocoronata* (with complete reticulum), *Pentadinium goniferum*, *E. pectiniformis*, *A. alcornu*, *R. draco*, *Charlesdowniea clathrata* and *Licracysta corymbus*. The occurrence of a single specimen of *Chiropteridium* in sample RTR 7 is also consistent with a Rupelian age, since the first appearance of this taxon in

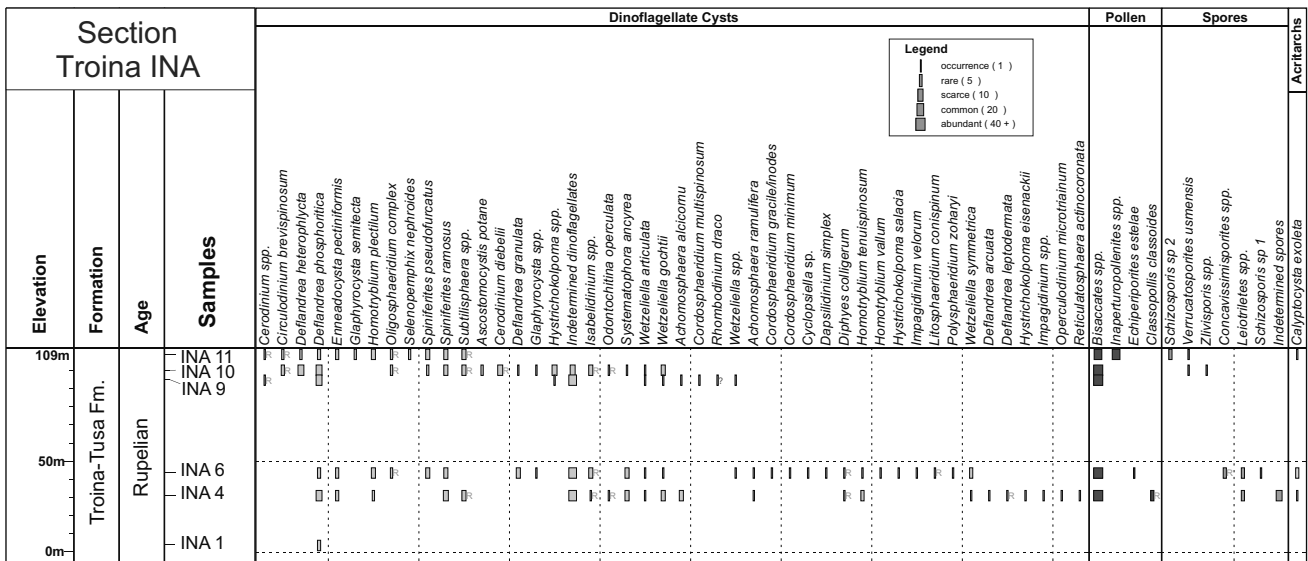


Fig. 10 - Range chart of palynomorphs recovered from the Troina INA section. Elevation represents metres from the base of the section. R stands for reworked.

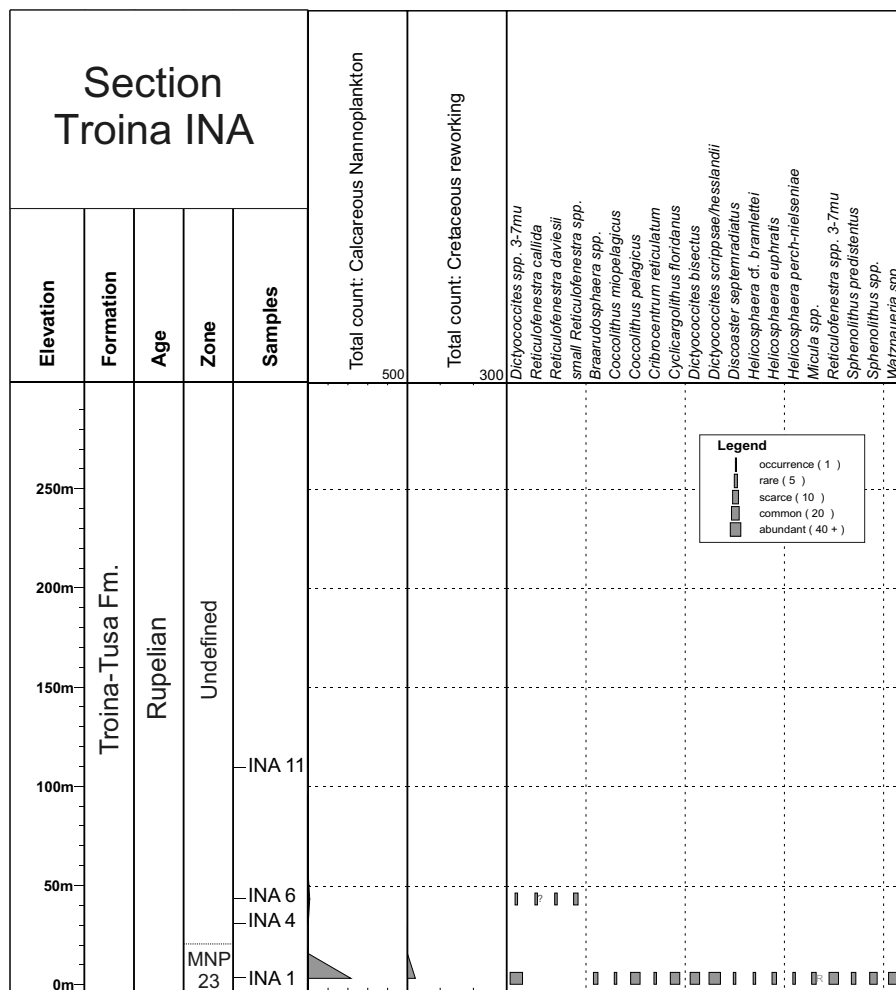


Fig. 11 - Range chart of nannofossils recovered from the Troina INA section. Elevation represents metres from the base of the section. Zones after Catanzariti et al. (1997). R stands for reworked.

the Mediterranean region is recorded within nannofossil zone NP23 (Williams et al. 2004). The presence of recycled Cretaceous forms is common and bisaccate pollen is always abundant.

Calcareous nannofossils. Eight samples were studied (Fig. 14). Cretaceous reworking is common and Eocene reworking is present as well. *E. formosa* (probably reworked), *I. recurvus* and *R. umbilica* are rare, except for sample RTR 7 where *R. umbilica* is common. *H. cf. recta* was observed from sample RTR 7, whereas *H. recta* is present in samples RTR 10 and 12 together with *C. abisectus* larger than 10 µm. Sporadic occurrences of *Reticulofenestra circus*, *H. aff. carteri* (= *H. ethologa*) and *Discoaster* gr. *tanii* were also detected: these taxa have their extinction datums calibrated within zone NP23. Relying on these observations, the RTR section can be firmly ascribed to MNP23 zone from sample RTR 10 upwards.

Section TRB (Fig. 15)

Palynology. Sixteen samples yielded generally poor dinoflagellate cyst assemblages indicative of Early Oligocene age (Fig. 16). The diagnostic elements are the

presence of *A. alcornu*, recorded in sample TRB 4, and the occurrences of *W. gochtii*, *E. pectiniformis* and several *Deflandrea* species particularly frequent in the upper part of the section. The presence of recycled Cretaceous forms is constant and bisaccate pollen is sometimes abundant.

Calcareous nannofossils. Thirteen samples were prepared for nannofossil analyses (Fig. 17). The nanoflora is generally abundant but preservation is often bad, as nannofossils are fragmented or partially dissolved. Cretaceous reworking is common. *H. cf. recta* is present from sample TRB 6, while *H. recta* has scattered occurrences from sample TRB 8 together with *C. abisectus* >10 µm. *E. obruta* is very rare and *I. recurvus* is missing. A peak in the abundance of *S. predistentus* occurs in samples TRB 6 and 7. *R. umbilica* is rare and scattered. *E. formosa* is generally rare except for sample TRB 6 where it is common: it possibly represents Eocene reworking as suggested also by the common occurrence of *C. reticulatum* in the same sample. A questionable specimen of *S. distentus* was observed in sample TRB 6. From sample TRB 6 to TRB 17 few specimens of *R. circus* and *R. circus lata*

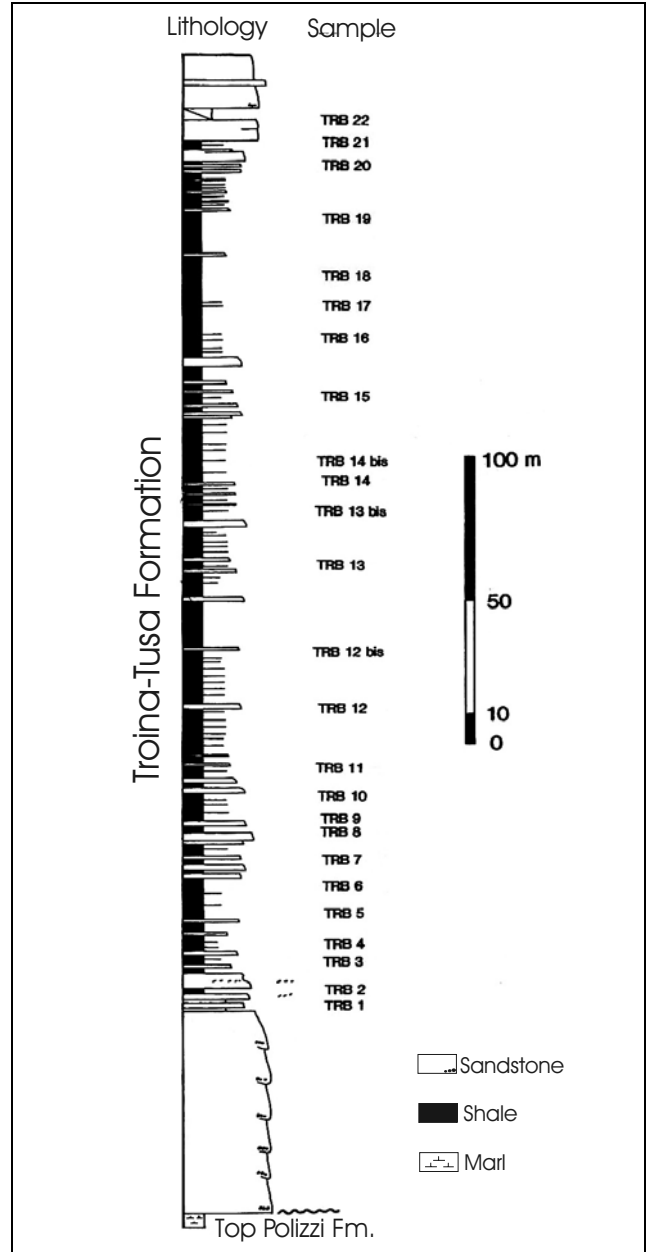
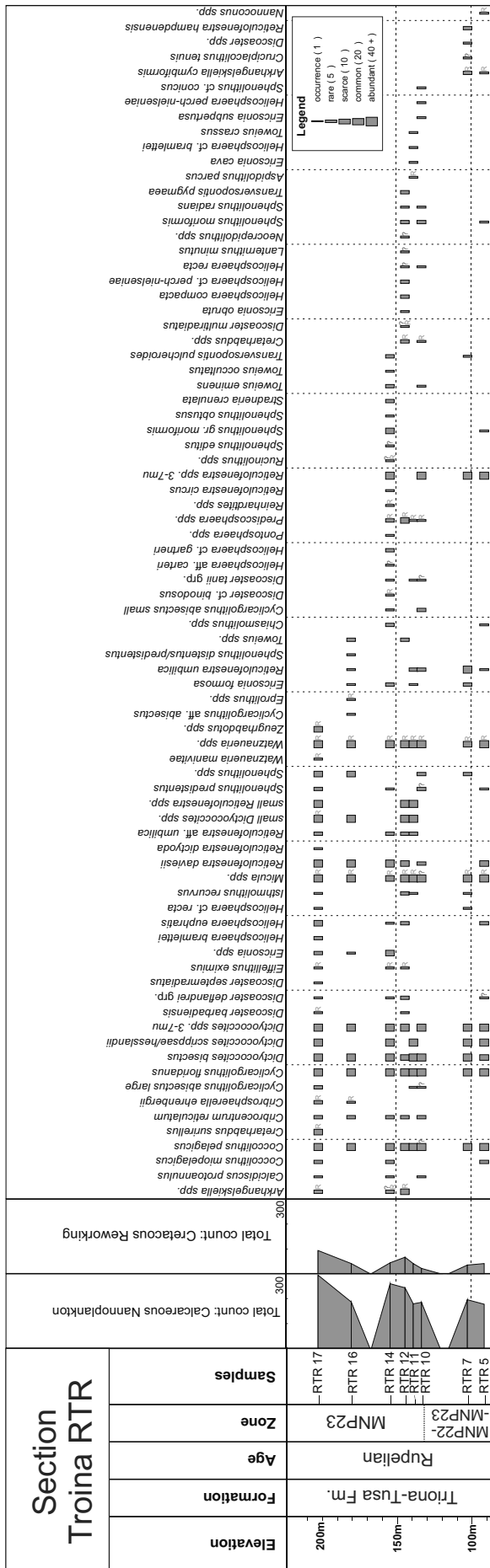


Fig. 15 - Stratigraphic log of the Troina TRB section with sample position.

by a Rupelian assemblage (re-increase of *E. formosa* and *I. recurvus*) affected by Eocene reworking. No firm specimens of *H. recta* were identified, apart from a questionable one in PET 17, while rare specimens of *H. perch-nielseniae* were observed in samples PET 17 and 18. Rare and scattered occurrences of *C. abisectus* larger than 10 µm were observed in sample PET 5, while *R. circus* was detected in samples PET 7 and 17.

In sample PET 18, one dissolved nannofossil resembling *R. pseudoumbilicus* was observed, but this

Fig. 14 - Range chart of nannofossils recovered from the Troina RTR section. Elevation represents metres from the base of the section. Zones after Catanzariti et al. (1997). R stands for reworked.

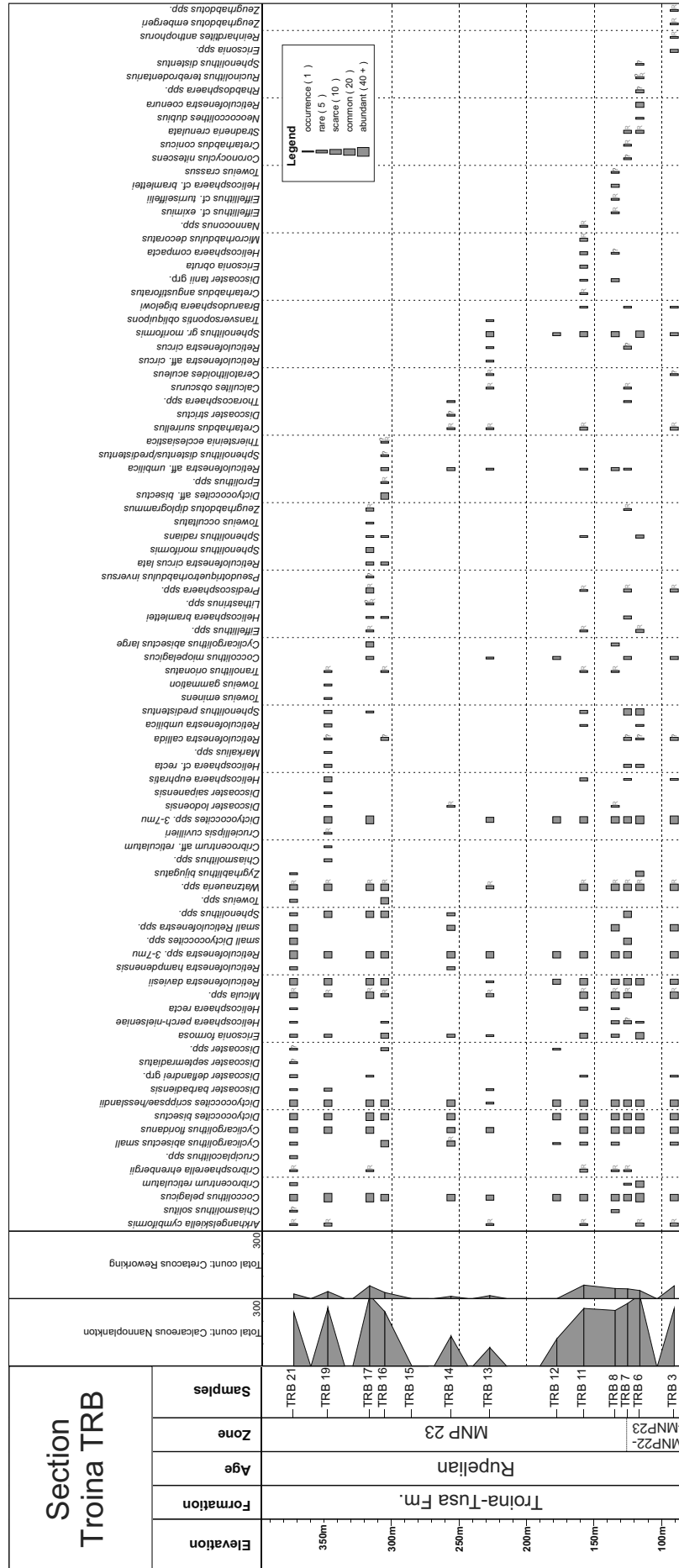


Fig. 17 - Range chart of nannofossils recovered from the Troina TRB section. Elevation represents metres from the base of the section. Zones after Catanzariti et al. (1997). R. stands for reworked.

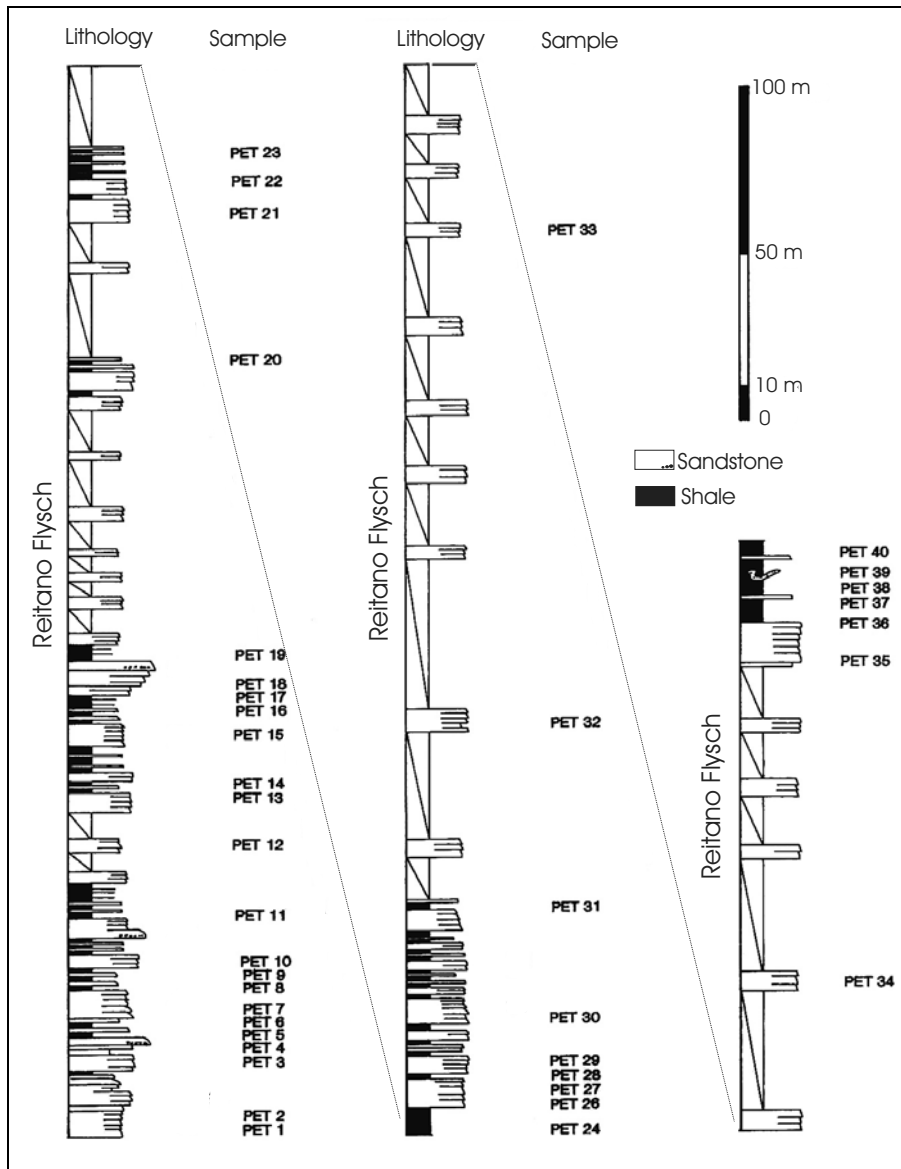


Fig. 18 - Stratigraphic log of the Petineo PET section with sample position.

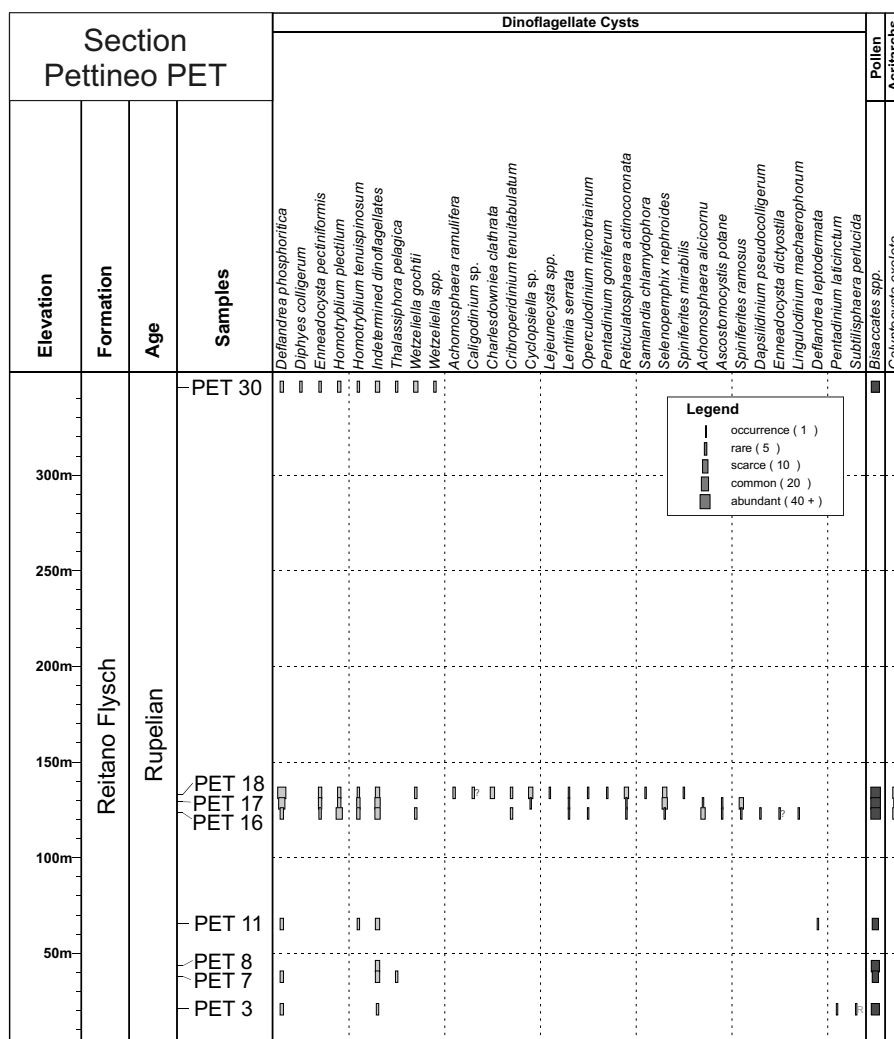
Tuffite, that can be ranked as a member characterised by a mixed siliciclastic-volcaniclastic-carbonate turbidite suite, and the Arenarie di Poggio Maria Formation *sensu* de Capoa et al. (2002), cropping out near Cefalù, that were ascribed to the 'external' Reitano Flysch by Casola et al. (1995).

It is worthwhile noting that several authors (Wezel & Guerrero 1973; Guerrero & Wezel 1974; de Capoa et al. 2000, 2002, 2004), in reconstructing the geodynamic evolution of the central-western Mediterranean, had already suggested heteropic relationships between the Tusa Tuffite and the volcanoclastic turbidites exposed at Troina, Serro Scarvi, Cerami, Ancipa Lake and Cefalù-Poggio Maria, although they erroneously considered these formations Miocene in age, hence younger than they actually are.

The Troina-Tusa Formation crops out in north-eastern Sicily and in the Calabro-Lucano area, and was deposited in the Early Oligocene in small isolated ba-

sins, fed by centripetal sediment fluxes from different sources including volcanic. Rise and erosion of volcanic edifices took place during the Early Oligocene (although with regional diachronism) in several basins along the Alps/Apennines orogenic system. This is documented by the Troina-Tusa Formation, the Averno-Petrignacola Sandstone of the Subliguride Domain, the Ranzano Sandstone of the Epiligurian succession and the Tavayanne Sandstone of Switzerland and Savoie (Baruffini et al. 2002; Elter et al. 1999; Cibin et al. 1998; Lateltin & Müller 1987). These volcanoarenitic formations have the significance of bridge-units between the subduction stage of the orogenic system (Cretaceous-Eocene) and the collisional stage, recorded by the earliest apenninic foredeep sequences represented by the Upper Oligocene Macigno Formation and the Numidian Flysch, in the northern and southern Apennines respectively.

Fig. 19 - Range chart of palynomorphs recovered from the Pettineo PET section. Elevation represents metres from the base of the section. R stands for re-worked.



In the localities of Troina and Cerami, the Troina-Tusa Formation conformably lies on a turbiditic succession lacking volcanic detritus and displaying consistent marly-calcareous intercalations (Ogniben 1960; Schilirò 1968; Gerevini 1969; Loiacono & Puglisi 1983; Puglisi 1992; Cassola et al. 1992, 1995). This lithostratigraphic unit is reported as Troina-Tusa Flysch in the geological map of central-eastern Sicily (Carbone et al. 1991) but in the literature it is reported by different authors under different names (i.e. Polizzi Formation, Varicoloured Shales, Troina-Tusa Flysch) and different ages (ranging from Eocene to Early Miocene). Palynological and calcareous nannofossil assemblages recovered in this study from the uppermost part of this succession indicate an earliest Oligocene age (MNP21b nannofossil Zone) and data from wells Fiumetto 1, 2D, 3D, 4D and Masseria Vecchia 1D, that penetrated this unit in the Fiume-di-Sotto-di-Troina Valley prove that it spans also the Upper and possibly part of the Middle Eocene. To identify this lithostratigraphic unit we recommend the name Polizzi Formation, as originally proposed by Ogniben

(1960). The Polizzi Formation exhibits high vertical and lateral lithological variability and the Varicoloured Shales (Eocene-lowermost Oligocene) reported in the literature from the Sicilide Complex of north-eastern Sicily are thought to represent a peculiar facies of the Polizzi Formation.

The Polizzi Formation is distinguished from the Troina-Tusa Formation essentially by the lack of volcanic detritus and by the consistent presence of marls and calciclastic lithologies. The sharp inception of conglomerates and sandstones at the base of the Troina-Tusa Formation overlying the Polizzi Formation in the Troina and Cerami sections, marks a sudden reorganization of the depositional systems related to the rise and erosion of a volcanic belt. However, no biostratigraphically detectable hiatus is associated to this boundary, as the oldest sample dated from the Troina-Tusa Formation in this study is referable to MNP22 nannofossil Zone. We infer that during the deformation and stacking of the Sicilide Units in the Maghrebian chain, minor adjustments occurred between hard lithologies (conglomerate-

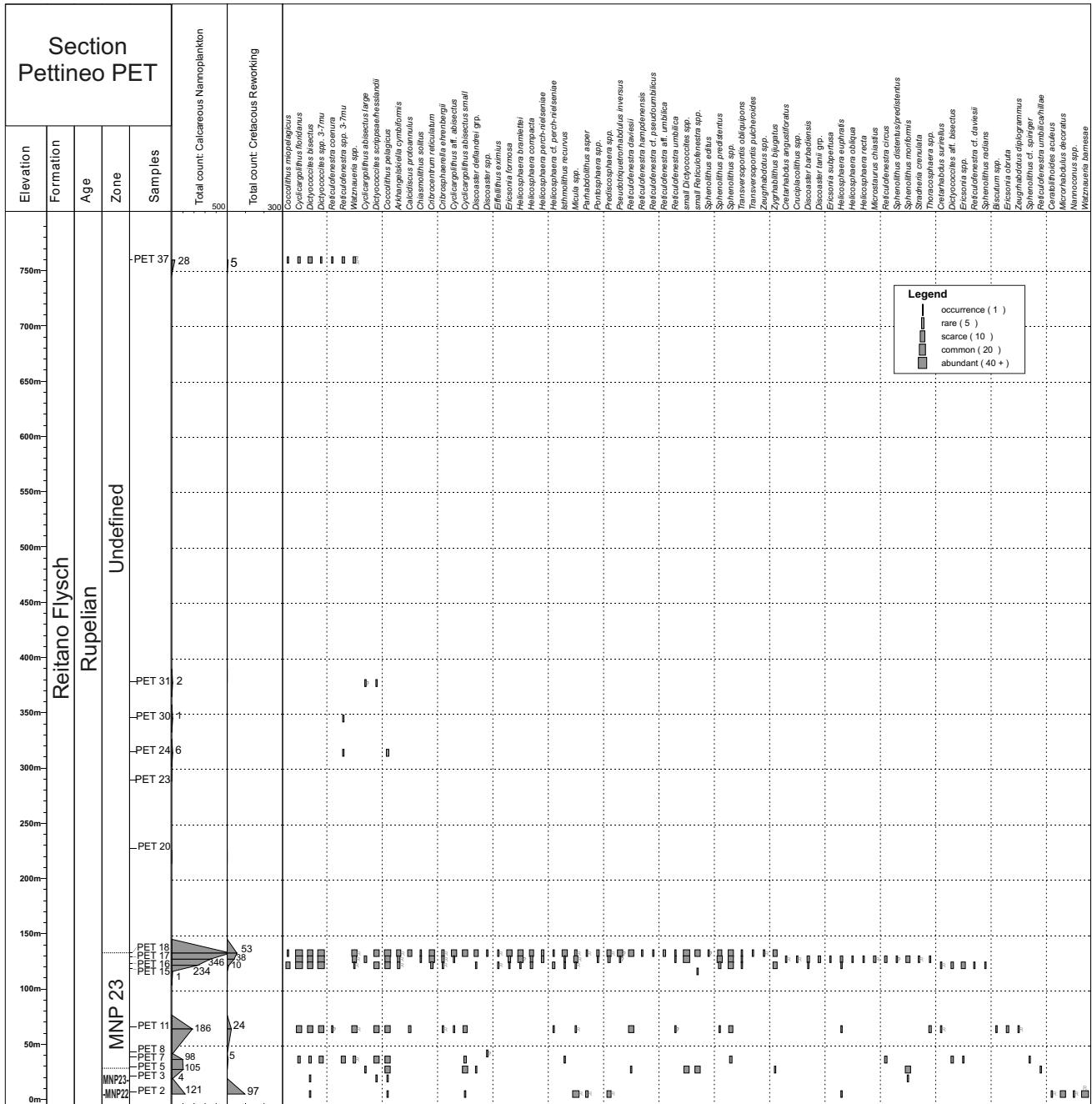


Fig. 20 - Range chart of nannofossils recovered from the Pettineo PET section. Elevation represents metres from the base of the section. Zones after Catanzariti et al. (1997). R stands for reworked.

ates and sandstones) at the bottom of the Troina-Tusa Formation and softer pelitic layers at the top of the underlying Polizzi Formation, originating apparent angular unconformities which led some authors (Bianchi et al. 1987; Carbone et al. 1991; Lentini et al. 1991) to consider erroneously as unconformable the boundary between these two units. These concepts are summarised in Fig. 21.

In conclusion, data presented in this paper, combined with data available from the literature, confirm the idea that slightly diachronic volcanic events oc-

curred during the Early Oligocene along the Alps/Apeninnes orogenic system and one of these events can be dated at about 33 Ma in the Troina and Cerami sections, where the inception of the volcanic debris in the basal part of the Troina-Tusa Formation is recorded within sediments assignable to the MNP22 nannofossil Zone.

Instead, differences in sandstone composition, in sedimentological features and in relationships with the substratum do exist between the 'internal' Reitano Flysch *auct.*, cropping out in the type-area on the

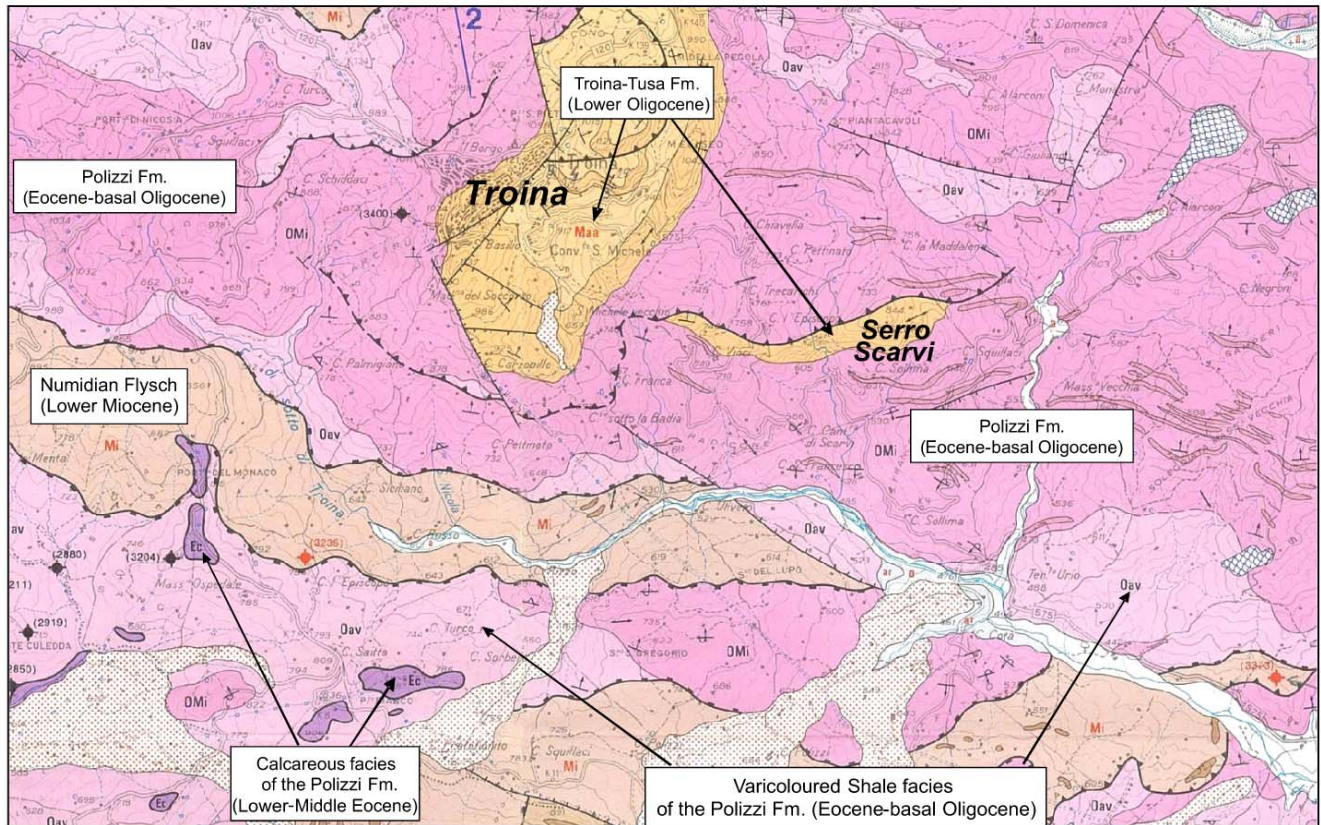


Fig. 21 - Geological map of the Troina area modified after Carbone et al. (1991) with new lithostratigraphic concepts developed in the present paper.

northern slope of the Nebrodi Mountains, and the 'external' Reitano Flysch *auct.*, cropping out at Troina-Serro Scarvi, Cerami, Ancipa Lake and Cefalù-Poggio Maria, hereby assigned to the Troina-Tusa Formation. These differences are widely documented in the literature (Puglisi 1979, 1992; Loiacono & Puglisi 1983; Cassola et al. 1992, 1995), where the internal Reitano Flysch is shown to lack volcanic detritus and to rest unconformably on the previously deformed Monte Soro Flysch (Lower Cretaceous).

De Capoa et al. (2000, 2002, 2004) proposed to use the name Reitano Flysch for the internal outcrops only, whereas they assigned the Troina, Cerami and Ancipa Lake successions to the Arenarie di Troina Formation. Here we agree in maintaining the name Reitano Flysch exclusively for the internal successions, lacking volcanic detritus, exposed in the type-area on the northern slope of the Nebrodi Mountains (Reitano, Pettineo, Caronia) and in the Capizzi area. The Reitano Flysch is likely coeval of the Troina-Tusa Formation, as palynological and nannofossil assemblages investigated in this study from the Pettineo section do not include taxa younger than Rupelian. Accordingly, a pre-Oligocene deformation must have affected the most internal por-

tion of the Sicilide Basin where the Monto Soro Flysch had deposited in the Early Cretaceous. The existence of a meso-Alpine tectogenetic phase (Eocene), recognised by Ogniben (1960), was afterwards confirmed by many authors (Courme & Mascle 1988; Roure et al. 1990; Puglisi 1992; Cassola et al. 1992, 1995) but rejected by others owing to incorrect dating of the successions involved (Carbone et al. 1991; Lentini et al. 1991, 1995; La Manna et al. 1995; de Capoa et al. 2000, 2002, 2004; Guerrero et al. 2005, 2007). In this regard it is questionable that the only palynological evidence reported by de Capoa et al. (2004) to support a Miocene age for the Reitano Flysch in the Pettineo area is the dinoflagellate cyst *Nematosphaeropsis labyrinthus*, that is instead a long-ranging species also reported from the Eocene London Clay of England (Williams & Downie 1966) and from basal Oligocene strata of central Italy (Brinkhuis & Biffi 1993).

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