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MIDDLE TRIASSIC (LADINIAN) DEEP-WATER SEDIMENTS IN SICILY: NEW FINDINGS FROM THE MADONIE MOUNTAINS

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Abstract. A section of carbonate megabreccias grading upward to deep-water *Daonella* limestones is described from the locality of Sant'Otiero, near Petralia Sottana, in the Madonie Mountains (Sicily). The megabreccia mainly consists of neritic elements containing dasycladalean algae (*Diplopora annulatissima* Pia) along with benthic foraminifers and problematics. The overlying calcilutitic strata are characterized by *lumachella* intercalations containing the bivalve *Daonella tyrolensis* Mojsisovics suggesting an early Late Ladinian (*Protrachyceras longobardicum* ammonoid zone) age. We informally name the *Daonella* limestone as the calcare di Sant'Otiero (Sant'Otiero limestone).

The *Daonella* limestones along with the neritic megabreccia extraclasts with *Diplopora annulatissima* represent a previously unknown component of the pre-Carnian stratigraphy from the paleo-Alpine Sicily.

Riassunto. Viene descritto per la prima volta in Sicilia un affioramento di calcari che origina un suggestivo picco nella Valle di Petralia Sottana, sul fianco meridionale di Monte San Salvatore, uno dei rilievi dei Monti delle Madonie (Sicilia). Il rilievo, noto come Pizzo di Sant'Otiero, espone una sezione costituita, nella porzione inferiore, da megabrecce carbonatiche contenenti elementi neritici con alghe dasycladali quali *Diplopora annulatissima*, associate a foraminiferi ed organismi problematici. Nella parte alta della sezione sono presenti calcilutiti pelagiche con intercalazioni di fittissime lumachelle a *Daonella* spp. fra le quali è stato possibile determinare *Daonella tyrolensis*. Verso l'alto la sezione passa alle tipiche alternanze di marne e calcilutiti della Formazione Mufara.

La sezione costituisce la porzione inferiore di una unità strutturale derivante dalla deformazione della scarpata del Dominio Panormide. I calcari a *Daonella*, qui indicati informalmente come calcare di Sant'Otiero sono riferibili alla parte inferiore del Ladinico superiore (zona a *Protrachyceras longobardicum*).

La presenza degli elementi di megabreccia con *Diplopora annulatissima* confermano l'esistenza, nella Sicilia paleo-Alpina, di un articolato substrato carbonatico mediotriassico che è stato profondamente eroso in diverse fasi e, successivamente, scollato e deformato durante l'orogenesi Maghrebide.

Introduction

Carnian deep-water sediments from Sicily mostly consist of clays and marly clays interbedded with radiolarian and *Halobia*-bearing calcilutites. In several sections, skeletal and lithoclastic carbonates of shallow-water origin and/or siliciclastic material can be also found. Basaltic sills and pillow lavas intercalated within these Carnian sediments have been described from different localities (Mascle 1974, 1979; Grasso & Scribano 1985). Taken together, these sediments are grouped in the Mufara Formation (Schmidt di Friedberg 1962). This formation occurs along floor thrusts of Triassic to Miocene basin-derived thrust-sheets (so called Imerese and Sicanian structural units). Moreover, Carnian strata are, in places, tectonically inserted in imbricate thrusts of Oligo-Miocene Numidian Flysch (e.g. Monte Altesina) (Grasso & Scribano 1985; Di Stefano et al. 1998). It is largely accepted that the Mufara Fm. has served as a major décollement zone during the Neogene stacking of the Apennine Maghrebian fold and thrust belt in Sicily (Catalano et al. 1996; Di Stefano & Gullo 1997).

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Older (pre-Carnian) strata are rarely preserved in the Sicilian Chain. Gemmellaro (1887) was the first to describe blocks of *Fusulina* limestones of Permian age from the Sosio Valley; the Permian limestones have been object of several important studies over the past century (Flügel et al. 1991 and references therein). More recently, Catalano et al. (1988b, 1991, 1992) described Permian to Middle Triassic deep-water sediments from the Torrente San Calogero section in close proximity to the Permian limestones. In particular, Catalano et al. (1988a, 1990) identified a thin succession of Ladinian nodular limestones, containing a rich conodont fauna dominated by the genera *Pseudofurnishius* and *Budurovignathus.* A Ladinian age of deep-water sediments attributed to the Mufara Formation has been reported by Carillat (2001) and Carrillat & Martini (2009) on the basis of the finding of conodonts in the Monte Mufara and Vicari sections.

Shallow-water sediments of Middle Triassic age are well known from a carbonate apron in the Mufara Formation, that crops-out at Cozzo Paparina (Altofonte) near Palermo, where Anisian?-Ladinian pebbles of neritic derivation containing *Diplopora annulatissima* Pia were described by Senowbari-Daryan & Abate (1986).

Apart from these findings of pre-Carnian sediments, another debate concerns the so-called Lercara Formation, a flyschoid succession exposed between Vicari and Roccapalumba, in central-western Sicily. This unit is considered either as a lithostratigraphic unit of Ladinian-early Carnian age containing reworked Permian fossils (Montanari 1968; Montanari & Panzanelli Fratoni 1990; Carcione 2007) or as a tectonic mélange derived from the Neogene deformation of the Permian and Triassic sedimentary substrate of the Maghrebian units (Di Stefano & Gullo 1997) (see also Catalano et al. 1991 for a complete discussion).

In the present paper, we report the first discovery of *Daonella*-bearing deep-water limestones of Ladinian age from the Madonie Mountains in northern-central Sicily. This unit is here informally named and described as the calcare di Sant'Otiero (Sant'Otiero limestone). This finding represents a new element for the reconstruction of the pre-Carnian sedimentary substrate of the deep-water basins located on the rifted margin of the Ionian Tethys. Moreover, the peculiarity of this outcrop, that is unique in Sicily, permit inclusion of the Sant'Otiero locality among the peculiar geosites of Sicily.

Geological setting

The studied area is located in the southern zone of the Madonie Mountains near the village of Petralia Sottana along the eastern slope of Monte San Salvatore (Fig. 1). The Madonie Mountains are a segment of the Apennine-Maghrebian chain in northern-central Sicily. The structural setting of this area has been object of several contributions since the 1960s (Ogniben 1960; Broquet 1968, 1972; Grasso et al. 1978; Abate et al. 1982). It consists of a complexly deformed thrust pile which is the result of the Neogene compressional and transpressional stacking of a Mesozoic carbonate platform-basin system (known as the Panormide Platform and the Imerese Basin) and its Cenozoic, mostly terri-

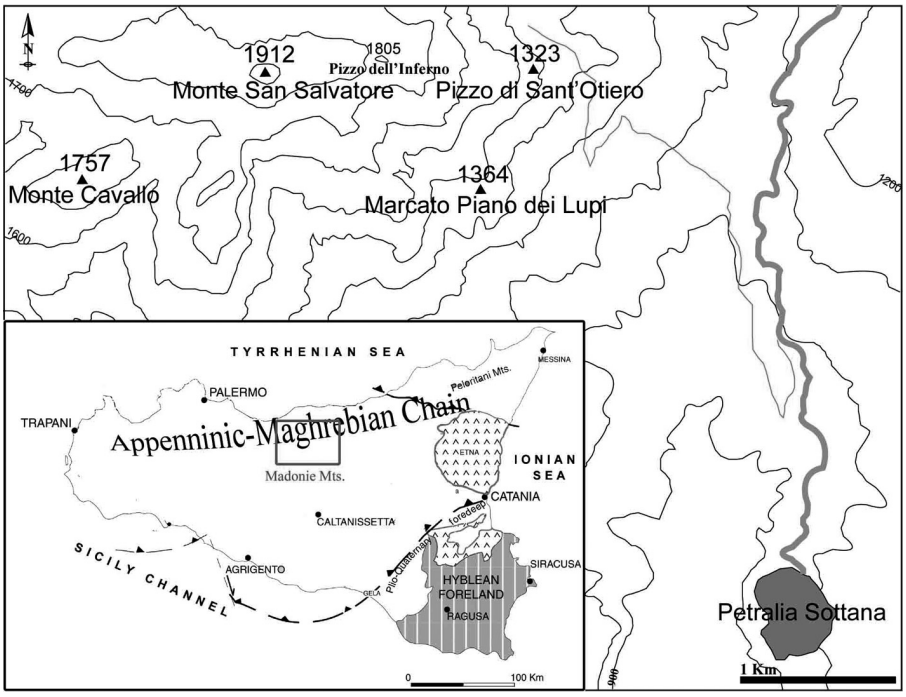


Fig. 1 - Location of the Sant'Otiero peak in the Madonie Mountains near Petralia Sottana.

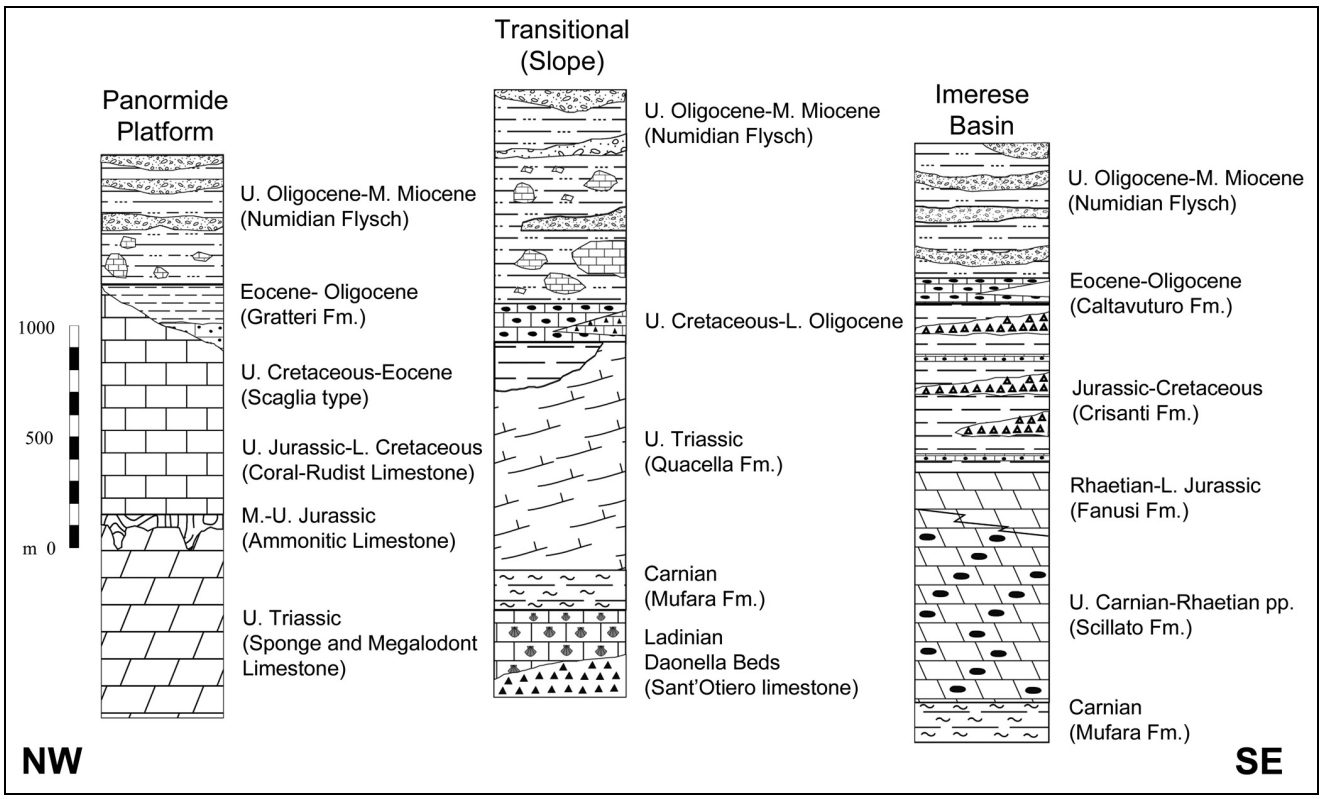


Fig. 2 - Schematic stratigraphy of the paleogeographic units forming the Panormide/Imerese carbonate platform to basin system deformed by the Maghrebian orogeny, as reconstructed by the different thrust sheets cropping out in the Madonie Mountains (modified from Renda et al. 1999). The *Daonella* limestones represent the lowermost zone of the transitional successions.

genous, cover (Renda et al. 1999). Neo (or Alpine) Tethyan-derived allochtons known as Sicilidi units (Ogniben 1960) are also involved in the collisional complex.

The Panormide Platform consists of Upper Triassic to Eocene shallow-water carbonates, affected by deep erosional unconformities (Zarcone & Di Stefano 2010). The Imerese Basin fill consists of Carnian to lower Oligocene slope to deep-water carbonates and bedded cherts (Fig. 2). During the late Oligocene-early Miocene, a thick siliciclastic turbidic formation, the Numidian Flysch of Wezel (1970, 1975), was deposited onto both the Panormide and Imerese paleogeographic sectors, contemporaneously with the rotation of the Corsica Sardinia block and the opening of the Algero-Provençal basin (Renda et al. 1999).

Stratigraphy of the carbonate platform-basin system

The stratigraphic succession of the Panormide-derived thrust sheets consists of Upper Triassic peritidal cyclothems (megalodont and stromatolitic limestones and dolostones) laterally passing into Dachstein-type sponge reefs (Fig. 2). These peritidal carbonates are unconformably overlain by Upper Jurassic and Cretaceous coral-algal and rudist limestones. Thin intercalation of Middle Jurassic ammonitic calcilutites are preserved in few localities between the Triassic and Upper Jurassic shallow-water sediments. Upwards Upper Cretaceous-Eocene pelagic calcilutites (Scaglia-type) and upper Eocene to lower Oligocene turbidites with nummulitids and algae follow (Gratteri Fm., Ogniben 1960). The topmost zone of this succession consists of argillites, glauconitic sandstones and quartzarenites (Numidian Flysch).

The base of the Imerese succession shows three units of Upper Triassic age: from oldest to youngest they incude: i) the Carnian Mufara Formation (see above), ii) the Scillato Formation (Schmidt di Friedberg 1964-65) consisting of upper Carnian to lower Rhaetian cherty calcilutites, and iii) the Fanusi Formation (Schmidt di Friedberg 1964-65), a thick package of dolostones of Rhaetian to earliest Jurassic age. The Jurassic-Cretaceous interval is characterized by bedded cherts with thick intercalations of carbonate breccias (Crisanti Fm., Schmidt di Friedberg 1964-65). These sediments are overlain by calcilutites with intercalations of skeletal turbidites (Caltavuturo Fm., Schmidt di Friedberg et al. 1960), followed in turn by the Numidian Flysch.

A third succession consists of Carnian calcilutites and marls (Mufara Fm.) overlain by slope dolostones (known as the Quacella Formation, Ceretti & Ciabatti 1965). Numidian Flysch sediments follow on a deep erosional surface. The Numidian sediments in this suc-

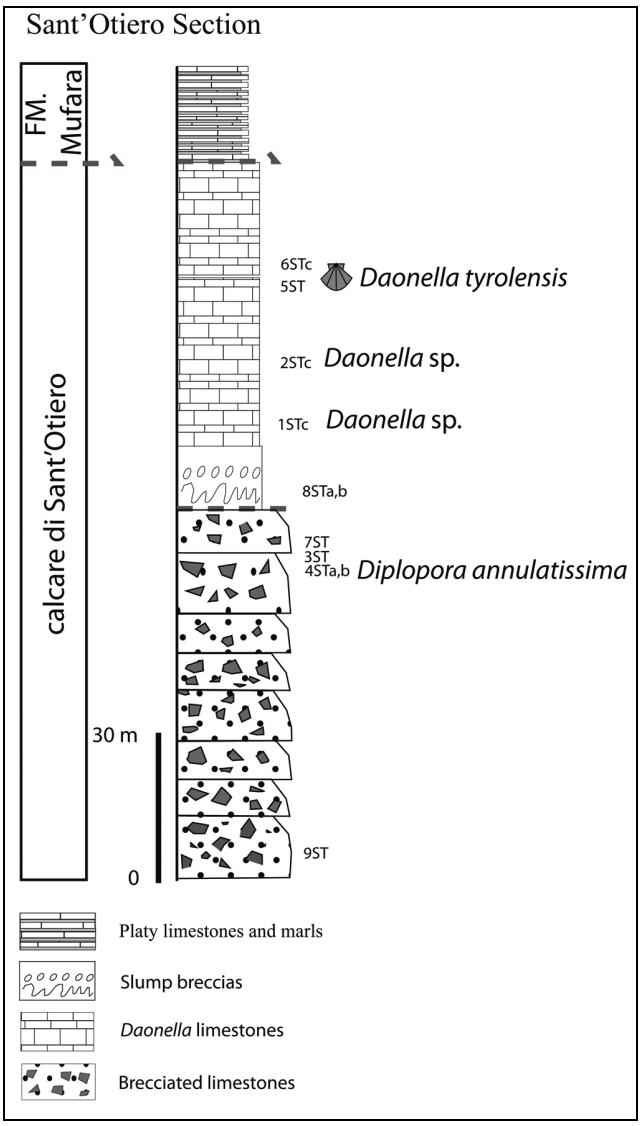


Fig. 3 - Columnar section of the Sant'Otiero succession and position of the studied samples.

cession contain thick intercalations of platform-derived carbonate megabreccias and have been named as Wildflysh di Monte San Salvatore (Ogniben 1960), Argille di Portella Mandarini (Grasso et al. 1978), and as Flysch a Megabrecce (Abate et al. 1982). This peculiar succession is interpreted to be derived from the slope between the Panormide Platform and the Imerese Basin (Renda et al. 1999). The significant megabreccia intercalations can be related to large-scale slope failures from a fault-controlled submarine escarpment involving the Mesozoic carbonates during late Oligocene times.

In the Monte San Salvatore area, several thrust sheets showing a similar stratigraphic succession are exposed. The dark gray *Daonella*-bearing calcilutites, the object of the present paper, occur at the base of a thrust sheet with a similar sedimentary succession. They are exposed at the Sant'Otiero locality near Petralia Sottana (Fig. 1, coordinates of the Sant'Otiero peak WGS84 37°50'12"N, 14°04'35"E).

The Sant'Otiero section

The section at Sant'Otiero (Figs. 3 - 4a,b) exposes from the base about 60 m of dark grey brecciated limestones forming the nearly vertical slope of the Sant'Otiero peak, followed upward by about 50 m of dark-gray calcilutites (Figs 3, 4). Access to the section is made difficult due to steep terrain, detrital cover and dense vegetation. Moreover the observation of the brecciated lower part is hampered by weathering processes and speleothems.

Some facies details of the brecciated limestone could be observed on top of the peak. Here, coarse calcareous breccias with centimeter to decimeter-sized angular pebbles surrounded by a calcilutite matrix occur (Figs. 4d,e).

The upper part consists of thick parallel-bedded dark-grey calcilutites. Between the calcareous breccias and the calcilutites a détachement surface can be observed (Fig. 4a). In the lowermost part of the calcilutitic zone, some wedge-shaped beds consisting of pebbly mudstones can be observed (Fig. 4c). Upsection, beds of thin-shelled bivalve *lumachella* are irregularly intercalated to the grey calcilutites. A well exposed bed with a *Daonella lumachella* occurs close to the very top of the Sant'Otiero peak (Fig. 4f). Samples of the *lumachella* occur also in float blocks at the base of the Sant'Otiero peak. This limestone has been used as dimension stone for the construction of a small tool shed for park-rangers in which parallel and transverse sections of densely-packed daonellid shells can be observed along the walls. The *Daonella* limestones are overlain by the typical Mufara sediments consisting of alternations of clays and platy calcilutites. They are in turn overlain by the Quacella dolomites and by the Numidian Flysch containing thick megabreccia intercalations.

The lateral extension of the *Daonella* limestones and of the underlying brecciated limestones is limited to the Sant'Otiero peak. At the base of the section typical Mufara alternations of marly clays and calcilutites occur as well. These last beds overthrust in turn Numidian Flysch argillites.

The interpretation of these strata within the complex tectonic setting suggests at least two different solutions: i) the *Daonella* limestones occur as a large olistolith in the Mufara Formation; ii) the *Daonella* limestones are in conformable succession. Although an olistolith origin for the *Daonella* limestones may explain the narrow lateral continuity of the Ladinian outcrop, a conformable succession is supported by similar bed-

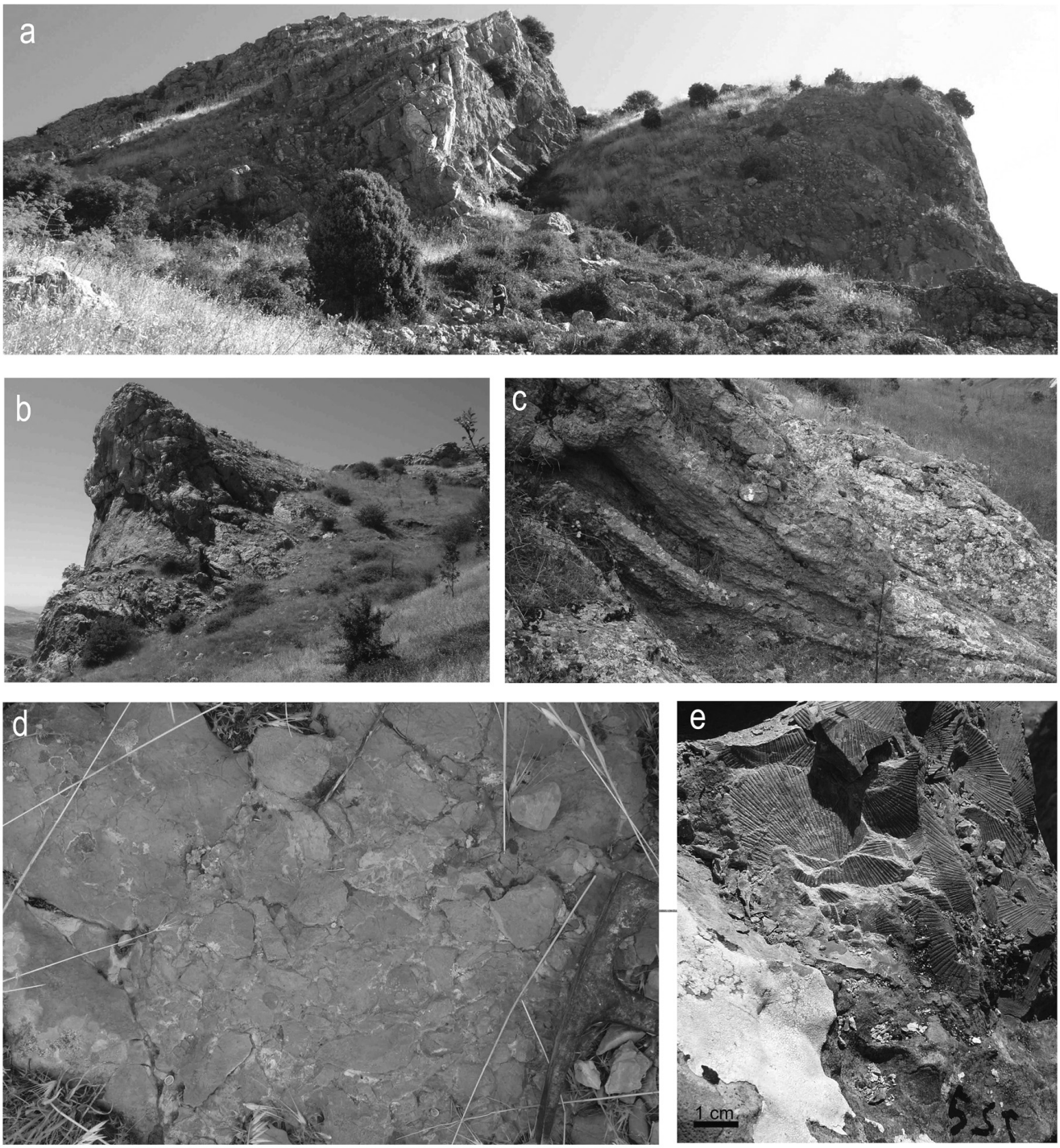


Fig. 4 - Field view of the calcare di Sant'Otiero: a) panoramic view of the section from SW showing the brecciated zone (right) and the overlying well bedded one (left); b) view from NE of the Sant'Otiero peak; c) pebbly mudstones organized in wedge-shaped beds. d) brecciated texture in the upper part of the lower zone of the section; e) The *lumachella* with *Daonella tyrolensis* in the uppermost zone of the calcare di Sant'Otiero (samples 5 and 6 ST).

ding orientation of the *Daonella* limestone and the overlying Mufara beds, as well as by the presence of a transitional zone between the brecciated lower zone and the calcilutitic upper zone consisting of wedge shaped beds of intraformational conglomerates (pebbly mudstones). Moreover, it is very difficult to explain the sliding of already lithified Ladinian pelagites down into a Carnian slope. In this hypothesis, the Mufara beds that occur at the base of the Sant'Otiero section could represent a splay in the frontal part of the nappe. We do not consider a third hypothesis of a tight overturned anticline with the *Daonella* limestones acting as nucleous as the bed attitude and the facies sequence is not consistent with this solution. Even though we prefer the second solution for the Sant'Otiero outcrop, we leave open the interpretation as the purpose of the present paper is to

document the presence of the Ladinian limestones and their regional relevance.

Microfacies in the calcare di Sant'Otiero

The microfacies analysis of samples collected along the section (see Fig. 3) is consistent with macroscopic observations discussed above. The lower part of the section consists of a clast-supported megabreccia containing boulders to fine grained extraclasts of carbonate platform origin. The elements of this breccia are generally sub-angular and poorly sorted with a fine grained matrix of either very-fine peloidal-skeletal grainstone (Fig. 5m) or a dark gray micrite with fragments of thin-shelled bivalves. Four different microfacies can be recognized:

a) Dasycladalean grainstone (sample ST4b, Fig. 5 a-d). This microfacies is characterized by a skeletal grainstone with abundant *Diplopora annulatissima* Pia, associated with small indeterminate dasycladalean fragments, rare benthic foraminifers (Duostominiadae), gastropods, and fine-grained partly micritized skeletal debris.

b) Peloidal grainstone (sample ST7). This microfacies is the most common in the studied material and consists of a fine peloidal grainstone with small benthic foraminifers (Fig. 5e-h) and *Tubiphytes* (Fig. 5k).

c) Algal boundstone. This microfacies consists of problematic bioconstructions made of clusters of circular or semi-circular elements associated to micritic patches and cavities filled with sparry calcite cements (Fig. 5i). These structures were firstly described in lagoonal facies from St. Salvatore in Ticino (Switzerland) as *Problematikum* 1 (Zorn, 1971; 1972) and later from Sicily as *Zornia obscura* (Senowbari-Daryan & Di Stefano 2001). More recent findings are from Latemar (Emmerich et al. 2005) and northeastern Hungary (Velledits et al. 2011).

d) Micritic limestones with calcispheres and filaments (Fig. 5m). This facies type commonly occurs as small lithoclasts that are often associated to algal and peloidal extraclasts. It suggest that also deep-water limestones were involved in the re-sedimentation phenomena of the megabreccia.

The upper zone of the Sant'Otiero section with parallel bedded calcilutites shows mud-dominated microfacies types such as dark-gray mudstone or wackestone with thin-shelled bivalves and rare calcispheres. In the observed material the bivalve shells (among which *Daonella tyrolensis* Mojsisovics, 1874) do not show a preferential orientation. In places a shelter porosity can be observed which becomes more common in the *lumachella* beds (Fig. 5l).

Discussion

The carbonate megabreccias with *Diplopora annulatissima*, *Zornia obscura*, *Tubiphytes* and benthic foraminifers in the lower part of the calcare di Sant'Otiero, support a provenance from the dismantling of an older carbonate bank. The micritic matrix with thin-shelled bivalve fragments between the elements indicate a deep-water (slope or toe-of-slope) environment for the megabreccia accumulation. Moreover, the presence of lithoclastic grains with the same microfacies, suggests the presence in the source areas of already litified pelagites.

In Sicily the occurrence of extraclasts with *Diplopora annulatissima* and *Zornia obscura* in carbonate megabreccias has been already documented from Cozzo Paparina, a locality near the village of Altofonte, in the Palermo Mountains (Senowbari-Daryan & Abate 1986; Senowbari-Daryan & Di Stefano 2001). In this locality, the megabreccia occurs as an intercalation within the Mufara Formation.

The occurrence of extraclasts consisting of skeletal grainstone and packstone with *Diplopora annulatissima* and *Zornia obscura* in the Sant'Otiero section represents further evidence of carbonate platform development in Sicily during Anisian or lower Ladinian time (Di Stefano & Gullo 1997). Moreover, the tectonostratigraphic setting of the Sant'Otiero megabreccia confirms that the most likely source area for the extrabasinal carbonate supply is the Panormide domain and the related slope to peribasinal areas, as already suggested by Di Stefano et al. (1998) on the basis of the clastic carbonates of shallow-water derivation interbedded into the Mufara Formation.

With respect to the sedimentological development of the upper part of the Sant'Otiero section, the occurrence of wedge-shaped beds consisting of intraformational conglomerates (pebbly mudstones) intercalated with megabreccia and the overlying calcilutites suggests a gradual shifting of the depositional environment from a slope setting dominated by clastic sedimentation, to a fully pelagic environment. Moreover, the thick succession of *Daonella* calcilutites (up to 50 m) indicate that the pelagic conditions were not an ephemeral event. As reported in the systematic description (see below and Schatz 2004), the presence of *Daonella tyrolensis* in the topmost samples of the calcare di Sant'Otiero indicates the early Late Ladinian *Protrachyceras longobardicum* ammonoid zone.

The new finding of pelagic limestones with *Daonella tyrolensis* in the Madonie Mountains adds a new substantial element to the reconstruction of the pre-Carnian stratigraphy of Sicily. Pelagic limestones of Ladinian age have been already described from the Sosio Valley (Torrente San Calogero Section) by Catalano et al. (1988a; 1990). In this section, reddish nodular lime-

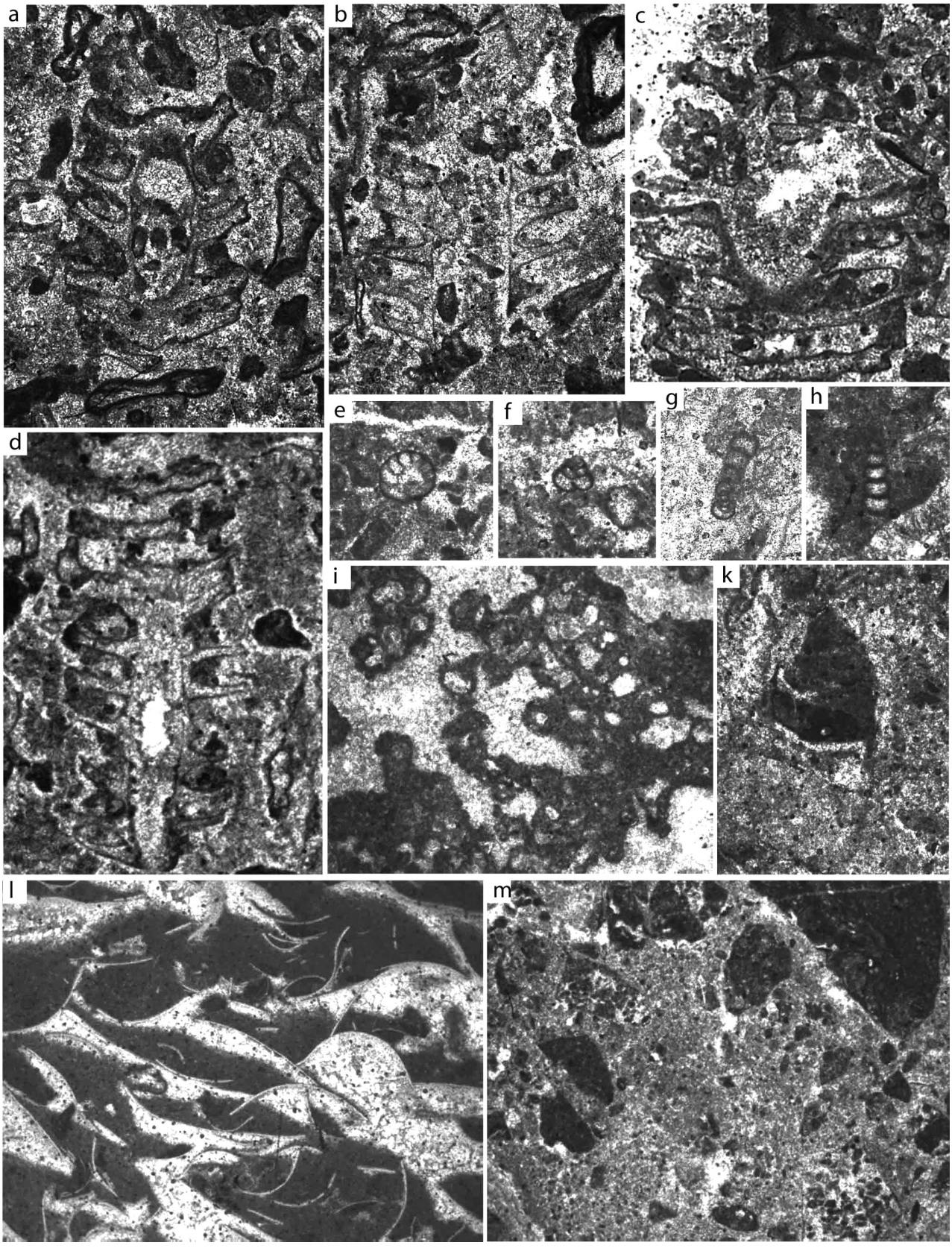


Fig. 5 - Microfacies types from the calcare di Sant'Otiero: a, b, c, d) skeletal grainstone with *Diplopora annulatissima* Pia. (Sample ST4b x16); e, f, g, h) foraminifers in the lithoclastic elements from the megabreccia; e) *Diplotremina* sp. (Sample ST2, X50); f) *Duotaxis* sp. (Sample ST7, X50); g) *Endoteba* sp. (Sample ST4b, X 50); h) *Endotebanella*? sp. (Sample ST7, X 50); i) micritic patches with round-shaped elements and cavities filled up by sparry calcite cements (Sample ST2, x 16). This structure is comparable to *Zornia obscura* Senowbari-Daryan & Di Stefano; k) a small lithoclast with *Tubiphytes obscurus* Maslov in a peloidal grainstone (Sample ST7, x50); l) *Daonella* packstone showing a shelter porosity (Sample ST3 x16); m) fine peloidal grainstone with small lithoclasts of deep-water mudstone/wackestone with filaments (Sample ST8b, x 16).

stones yeld a rich conodont fauna characterized by *Pseudofurnishius* spp. associated with other conodonts, thin-shelled bivalves (*Daonella* sp.) and radiolarians. The presence of benthic foraminifers including *Meandrospira dinarica* Kochansky-Devidé & Pantic in these deposits has been later reported by Di Stefano & Gullo (1998). In particular the lowermost beds of this section yielded a conodont association with *P. huddlei* Van Den Boogard & Simon, *Budurovignathus hungaricus* (Kozur & Végh) and *B. mungoensis* (Diebel) that indicates the *B. mungoensis* A.-Z. of middle Longobardian age (Gullo & Kozur 1989; Catalano et al. 1990).

Systematic Paleontology

Repositories. GBA, Geologisches Bundsanstalt, Vienna; MGUP, Museo Geologico Gemmellaro, Dipartimento di Scienze delle Terra e del Mare, Università, Palermo.

Class **Bivalvia** Linnaeus, 1758

Order **Pterioida** Newell, 1965 [emended Waller, 1978]

Superfamily Posidonioidea Frech, 1900 [emended Waller, in Waller & Stanley, 2005]

Family Halobiidae Kittl, 1912 [emended Waller, in Waller & Stanley, 2005]

Genus *Daonella* Mojsisovics, 1874

Daonella tyrolensis Mojsisovics, 1874

Figs. 6, 7

1874 *Daonella tyrolensis* Mojsisovics, p. 14, pl. 1, figs. 8, 10.

2004 *Daonella (Arzelella) tyrolensis* Mojs. - Schatz, p. 300, fig. 2 [see for complete snyonomy]

Type Specimen: Schatz (2004: 301) designated as lectotype the original specimen of Mojsisovics (1874, pl. 1, fig. 8; GBA 1874/01/0013) from the upper Ladinian "Knollenkalke" of the Upper Buchenstein Beds in Val Badia (Alto Adige, Italy).

Material: The collection consists of four fairly well preserved and nearly complete specimens including three right valve exteriors (MGUP-DS.1, 2, 4), a left valve interior (MGUP-DS.3), and numerous fragments from hundreds of individuals in packed *Daonella lumachella*. All from Sant'Otiero section on eastern slope of Monte San Salvatore near the village of Petralia Sottana (Samples 5ST and 6STc, Fig. 3).

Description. Adult shell moderately large (maximum height = 46 mm, maximum length = 51 mm), semicircular nearly as long as high (length:height = 1.0-1.2) with beak centrally located and slightly raised above moderately sloping hinge line. Outline slightly changing from weakly posterior elongate form with an oblique growth vector in juveniles to equivalved and acline growth in adults. Valves densely plicate (12-15 primary plicae measured across a 45° arc in the central region of disk 10 mm from beak). Primary plicae beginning approximately 2-4 mm from beak, slightly curved towards anterior in early ontogeny and become straight in adult growth. Plicae generally subround in early growth stages becoming more flattened towards disk margins and separated by narrow (0.1-0.2 times the width of ribs) rounded furrows that are somewhat stronger and more rounded on anterior third of disk. Primary ribs unevenly divide into secondary and, tertiary ribs at varying distances (0.6-2 mm) from beak and are separated by shallower and narrower furrows. Surface covered with weak commarginal folds, more prominent and more closely spaced in early growth (up to approximately 4 mm from beak) and becoming weaker and more widely spaced in adult stages (Fig. 6). Very fine and faint tightly packed unsculpted commarginal lirae that may represent sub-annual growth increments. Lirae intersect with much stronger radial plicae to create a weak reticulate pattern observable only on the better-preserved shell exteriors. On some of the better-preserved specimens, lirae appear to be bundled into alternating bands (< 2 mm thick) of lighter and darker shell that may reflect relict pigmentation patterns (Fig. 7e). Posterior dorsal triangular field weakly demarked with subdued but relatively straight and undivided ribbing, approximately 22-25° in angular breadth. Valve interior of one specimen (Fig. 7b) shows possible posterior adductor scar 20 mm in diameter positioned posterior-ventrally 80 mm from beak. Details of hinge and ligament system unknown.

Remarks. Specimens of *Daonella tyrolensis* from the calcare di Sant'Otiero are nearly identical to, and certainly fall within the range of morphological variation exhibited by the lectotype and those from coeval

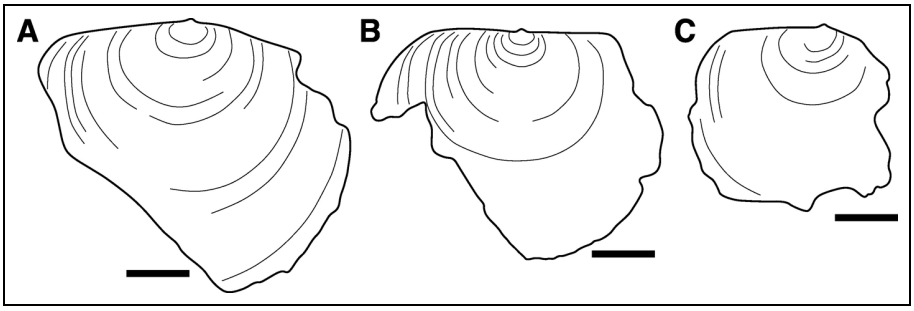


Fig. 6 - Outlines and commarginal ornament of *Daonella tyrolensis* Mojsisovics, 1874 from calcare di Sant'Otiero, Sant'Otiero section, Monte San Salvatore, Sicily. a) MGUP-DS.1; b) MGUP-DS.2; c) MGUP-DS.3. Scale bar: 1 cm.

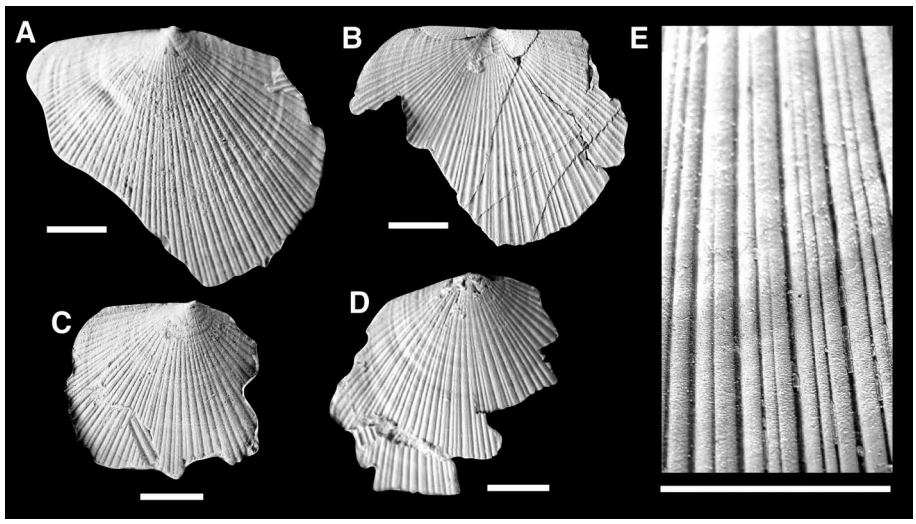


Fig. 7 - *Daonella tyrolensis* Mojsisovics, 1874 from calcare di Sant'Otiero, Sant'Otiero section, Monte San Salvatore, Sicily. a) MGUP-DS.1, right valve exterior; b) MGUP-DS.2, a left valve interior; c) MGUP-DS.3, right valve exterior; d) MGUP-DS.4, right valve exterior; e) MGUP-DS.5, central disk of a right valve exterior showing detail in plicae and faint commarginal lirae. Scale bar: 1 cm.

localities in the Southern Alps. An extensive discussion and synonymy of *D. tyrolensis* was made by Schatz (2004) who recognized allometric growth in which individuals exhibited a change from posteriorly elongate and oblique juveniles to equivalved acline adults. According to Schatz (2004), the failure to recognize the allometric growth in *D. tyrolensis* led many previous workers to incorrectly assign individual specimens from different growth stages to different species-level taxa.

Daonella tyrolensis is distinguished from similar tyrolensiform daonellids in the strength and density of its trifurcated plicae, valve outlines and allometric growth. Apart from the several species that already been synonymized with *D. tyrolensis* (e.g., *D. badiotica* Mojsisovics 1874, *D. triparita* Kittl, 1912, and most likely *D. bulogensis* Kittl, 1912 and *D. indica* Bittner, 1899), is perhaps most similar to *D. reticulata* Mojsisovics, 1874 which is poorly known from the Füreder Limestone of Bakony, Hungary (Kittl 1912), from the Wettersteinkalk near Innsbruck (Kittl 1912) and possibly Turkey (Arthaber 1914). Although the illustrated specimens of *D. reticulata* shares with the Sicilian material the reticulate pattern caused by the intersection of plicae and the fine commarginal lirae (discussed above), *D. reticulata* exhibits slightly more oblique and posteriorly elongate form later in ontogeny and also slightly greater curvature in the plicae that exhibited in *D. tyrolensis*.

Daonella tyrolensis is easily distinguished from *D. paucicostata* Tornquist, 1901 by its greater rib density and from *D. taramelli* Mojsisovics, 1874 by exhibiting fewer primary plicae and having less a posteriorly elongate and oblique shape in adult stages. *Daonella frami* Kittl, 1907, is similar in many regards, and likely closely related to *D. tyrolensis*, but exhibits only two-fold rib division rather than the trifurcation pattern characteristic of *D. tyrolensis*. *Daonella indica* Bittner, 1899 is also very similar to, and possibly conspecific with *D. tyrolensis*. Although Bittner (1899) erected *D. indica* for generally smaller specimens that lack trifurcate plicae, larger specimens attributed to this species clearly exhibit tertiary plicae at later growth stages typical of *D. tyrolensis* (e.g., *D. indica* illustrated by Krumbeck 1924, pl. 8, fig. 21 and Khúc et al. 1991, pl. 8, fig. 19; see also Schatz 2004). This is especially true for upper Ladinian specimens from the Southern Alps (e.g., Bagolino and Seceda sections discussed by Brack & Rieber 1993) originally regarded as *D. indica* have confidently been placed in synonymy into *D. tyrolensis* by Schatz (2004).

Age and Occurrence. *Daonella tyrolensis* is among the most widely distributed Ladinian *Daonella* in Alpine Europe and is well-established biostratigraphic marker of the Late Ladinian *Protrachyceras longobardicum* ammonoid zone (Brack & Rieber 1993; Schatz 2004; McRoberts 2010). As summarized in Schatz (2004) many examples are known from Northern Calcareous Alps, Carpathians and eastern equivalents (e.g., Austria, Hungary & Romania), Southern Alps (Italy), Apennines (Italy), and Balkans (Slovenia and Bosnia and Herzegovina). This is the first report of this species (and of any *Daonella*) from Sicily and the lack of co-occurring biostratigraphic indices (e.g., ammonoids and/or conodonts) does not permit independent age assignment for the *Daonella* beds from the Sant'Otiero section. In the Southern Alps (Trentino-Alto Adige and Lombardia) where it is best represented, *D. tyrolensis* (= *D. indica* of previous authors from these areas as per Schatz 2004) is known from several localities within the "Knollenkalke" of the upper Buchenstein beds and co-occurs with *Protrachyceras* ammonoids and *Daonella pichleri* (Brack & Rieber 1993; Brack et al. 2005; Schatz 2004). From sequences in the Lagonegro Basin of the southern Apennines, De Capoa Bonardi (1970) noted similar forms from the Monte Facito Formation and attributed them to the

lower Ladinian although biostratigraphic control in these sections is lacking. Likely synonymous taxa (e.g., *D. indica*) from Turkey, Himalaya, southeast Asia and Japan are widespread from the upper Ladinian (e.g., Bittner 1899; Diener 1908; Arthaber 1914; Krumbeck 1924; Kobayashi & Tokuyama 1959; Khúc et al. 1991).

Conclusions

The finding in the Madonie Mountains from Sicily of a Ladinian *lumachella* with daonellids including *Daonella tyrolensis,* associated with a megabreccia formed by neritic elements with *Diplopora annulatissima*, provide new data permitting a more precise reconstruction of the pre-Carnian sedimentary basins of Sicily during the early-Alpine stage. The presence of pelagic limestones of Ladinian age and their tectonostratigraphic location, reinforce previous data on the existence of a Middle Triassic carbonate platform to basin system which more or less corresponds to the Panormide and Imerese paleogeographic units.

The *Daonella* beds show distinctive characters from the typical Mufara beds (as can be observed upsection). They lack of clayey or marly intercalations and are relatively thick bedded limestones with a different morphotectonic behavior. Given these differences, we prefer not to assign these beds to the lower zone of the Mufara Formation, but to a different unit we informally name as the calcare di Sant'Otiero.

The tectonostratigraphic setting of the Sant'Otiero locality confirms that the pre-Carnian successions have been detached by older strata, and deeply deformed by the Maghrebian orogeny during late Oligocene and Miocene times. The peculiar and unique geological characters of the Sant'Otiero peak underscores its importance in the Mesozoic stratigraphy and paleogeography of Sicily and of the Madonie Geopark.

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