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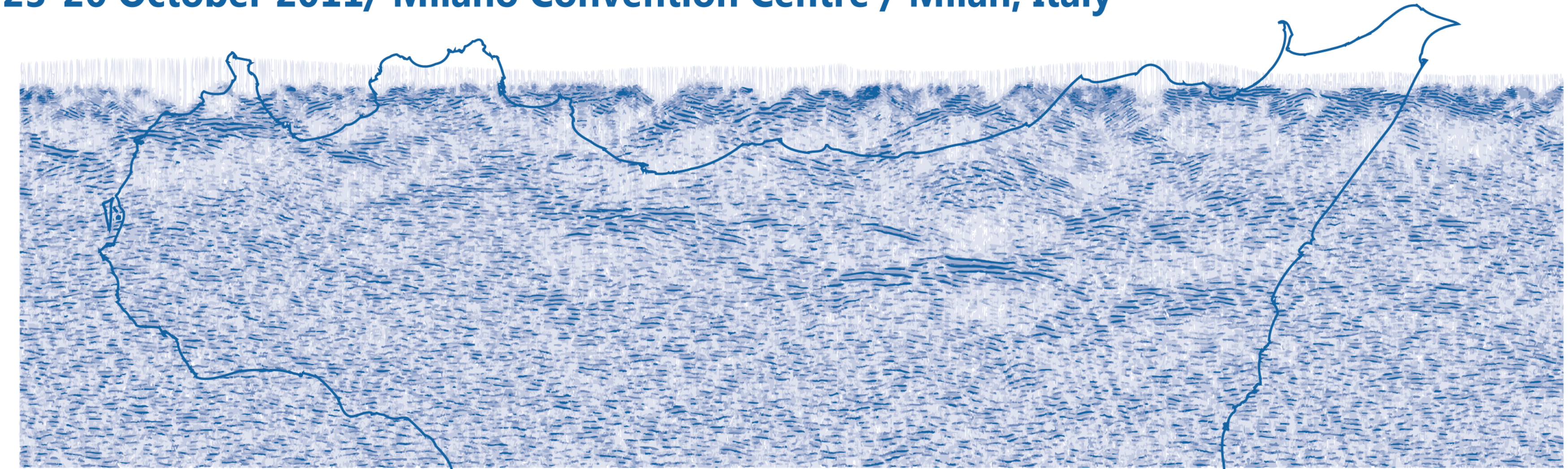

Walking along a crustal profile across the Sicily Fold and Thrust Belt

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UNIVERSITÀ DEGLI STUDI DI PALERMO

Dipartimento di Scienze della Terra e del Mare - DiSTeM

GFT - Geological Field Trip

Walking along a crustal profile across the Sicily Fold and Thrust Belt

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APPENDIX II: Carbonate Platform/Basin system during the Mesozoic: stratigraphic evolution, erosional surfaces and sequence stratigraphy framework

Luca Basilone

Introduction

Most of the carbonate successions of the Mesozoic-Cenozoic shallow- and deep-water facies outcrop in western Sicily in two main areas: the Termini Imerese-Madonie Mts. and the Western Sicily belt, spanning between the Palermo Mts. and the Sciacca deformed foreland (Fig 1).
In detail these regions are the places where well preserved outcrops and intense facies analyses and stratigraphic studies have recognized rocks pertaining to different paleogeographic domains originally located along the Southern Tethyan continental margin.
To understand the relationships between the two major Panormide and Imerese paleodomains we will discuss their sedimentary evolution and the main patterns, describing and comparing the Imerese Upper Triassic-Lower Oligocene pelagic carbonates, radiolarite mudstones with reworked shallow-water facies deposits, widespread outcropping in the Termini Imerese and western Madonie Mts., and the Panormide Upper Triassic-Eocene, mainly shallow-water carbonate successions (shelf environment), with thick, deeper water facies intercalations well exposed in the Palermo Mountains region and in the eastern Madonie sector (Fig. 2).

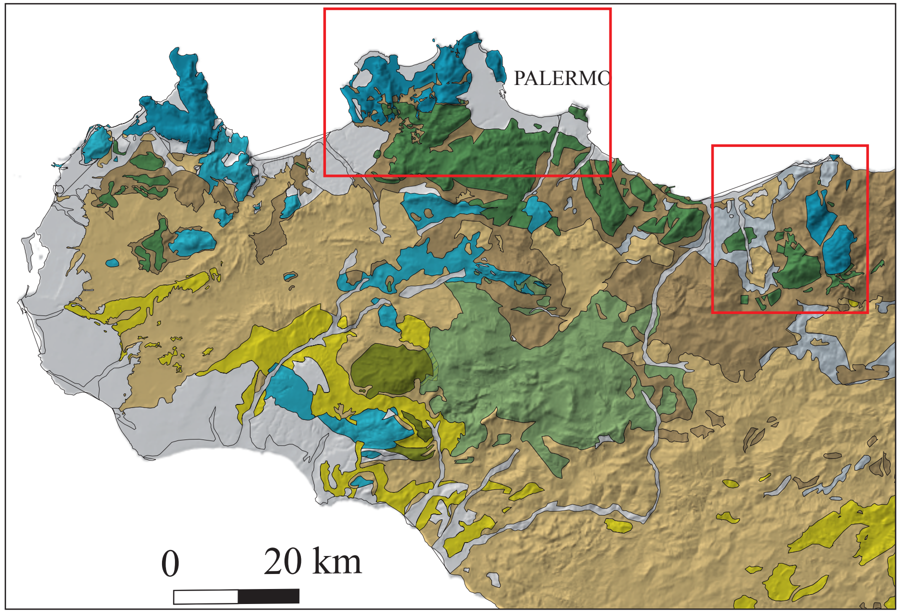


Fig. 1 - Location of the study areas in the structural map of western Sicily (modif. from Catalano et al., 2004).

Stratigraphic evolution

Palaeoenviromental reconstruction refers the deposits of the Panormide Carbonate Platform succession to a Bahamian-type carbonate platform (Catalano et al., 1974), with rimmed shelf-margin (Late Triassic and Late Jurassic) and open-platform with ramp geometries (Late Cretaceous and Late Eocene). Common fossils include corals, sponges, hydrozoans, rudists and benthic macroforaminifera. The Imerese deep-water succession is dominated by spectacular gravity-flow deposits which include: a) breccias, megabreccias and megaconglomerates, b) bioclastic turbidites, c) laminated fine-grained limestones (dilute turbidites). The strata display a typical example of a carbonate platform margin, characterized by reworked facies with progradational stacking patterns (Basilone 2000; 2009).

Although it is not known whether the location of the Imerese Basin is internal or external with respect to the Panormide Carbonate Platform, there is general agreement about an original adjacent location of the two paleodomains (Broquet, 1968; Catalano & D'Argenio, 1978, Catalano et al., 1996, 2004; Montanari, 1989; Nigro & Renda, 2000).

The investigated rock bodies are incorporated into the Sicilian fold and thrust belt that originated from the deformation of the Mesozoic-Cenozoic sedimentary cover of the Sicilian sector of African continental margin. The resulting tectonic units were stacked during the Miocene-Pliocene, verging south and south-eastwards (Catalano et al., 2000 and reference therein).

The accurate sediments correlation that have been synchronously deposited at the margin of carbonate platforms in shallow- and deep-water environments is required in order to reconstruct ancient oceanic environmental conditions and sea level changes (Fouke et al., 1996; Whalen et al., 2000; Eberli et al., 2004; Schlager, 2005, and among others). Unfortunately, accurate correlation between these types of sedimentary units is full of difficulties for several reasons, including: (1) physical destruction of the rocks during syn- and post-depositional tectonics and associated differential erosion; (2) differences in the quality and resolution of the biostratigraphic records preserved in basinal and

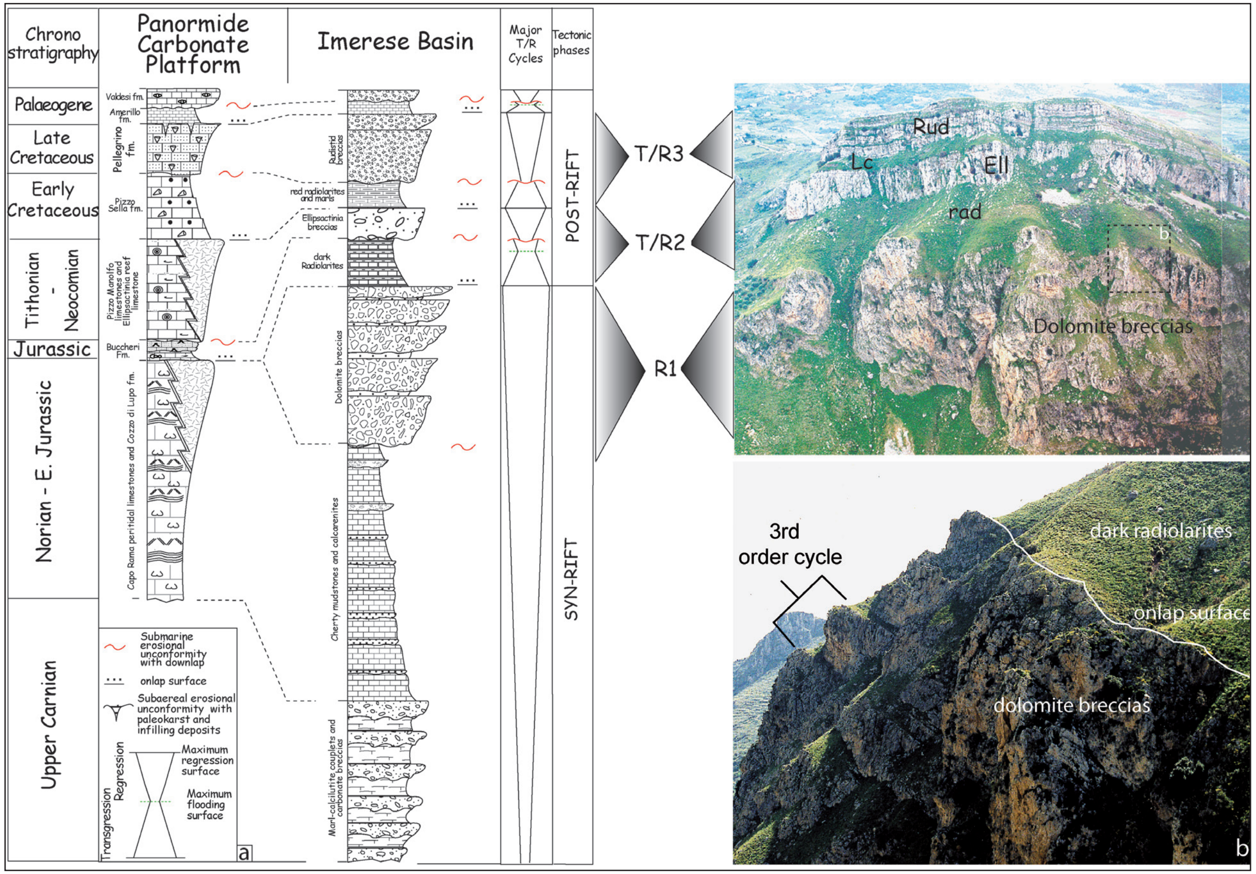


Fig. 2. a) Cyclic organization of the Imerese succession, viewed on the northern side of Cozzo Famo (Termini Imerese Mountains.) and correlation with the Panormide carbonate platform succession. Legend: dolomite breccias of the Fanusi Formation, rad: dark radiolarites, Ell: Ellipsactinia breccias, Lc: red radiolarites and marls, Rud: Rudistid breccias b) third order cycles of the lower Jurassic dolomite breccias of the Fanusi Formation.

platform limestones (Bralower et al., 1994; Erbacher et al., 1996); 3) synsedimentary tectonic effects of the original sedimentary basin.

The lack of a well-preserved physical continuity between Sicilian carbonate platform and basinal facies domains, that has been described in other studied margins (e.g. the Maiella section, [Bernoulli et al., 1992; Vecsei et al., 1998); Vercors Mountains (Jacquin et al., 1991; Everts et al., 1995; Fouke et al., 1996); Cantabrian Mountains (Della Porta et al., 2004); Great Bahama Bank (Eberli et al., 2004) means that the shelf and basin successions should be study separately. Correlation between isolated basin and platform stratigraphic sections can be accomplished using changes in sedimentological composition and using the main unconformity surfaces (Everts et al., 1995, Everts & Reijmer, 1995; Whalen et al., 1993; Fouke et al., 1996).

The comparison and correlation between the unconformity surfaces, facies and geometric stacking patterns, recognized both in the shelf and basin successions, have let to restore the stratigraphic architecture of the Mesozoic shelf-to-basin system (Basilone, 2009). This study has revealed a close relation between sedimentary evolution and cyclicity. The tectono-stratigraphic features recognized (e.g. tilted fault block of the Triassic shallow-water limestones, subaerial erosion, see Figure 2), point out a tectonic influence in the sedimentary evolution of the Panormide/Imerese platform-to-basin system. The tectonic control on sedimentation has been related to the syn-rift and post-rift phases that involved the Tethyan continental margins during the Mesozoic (Castellarin, 1972; Bernoulli & Jenkyns, 1974; Patacca et al., 1975; Catalano & D'Argenio, 1982 b; Eberli, 1988; Alvarez, 1990; Santantonio, 1993, 1994; Basilone 2009 b).

Unconformity surfaces

The main unconformity surfaces, largely characterized by widespread erosion or non deposition, are recognized both in platform and basin succession and correlated each one:

a) The Upper Triassic peritidal carbonates of the Panormide succession are cut by a subaerial erosional surface. This surface is, generally, accompanied by karst processes, continental sedimentation (bauxites), large erosion and block faulting and tilting (Fig. 3). In the Imerese basin the time equivalent cher-

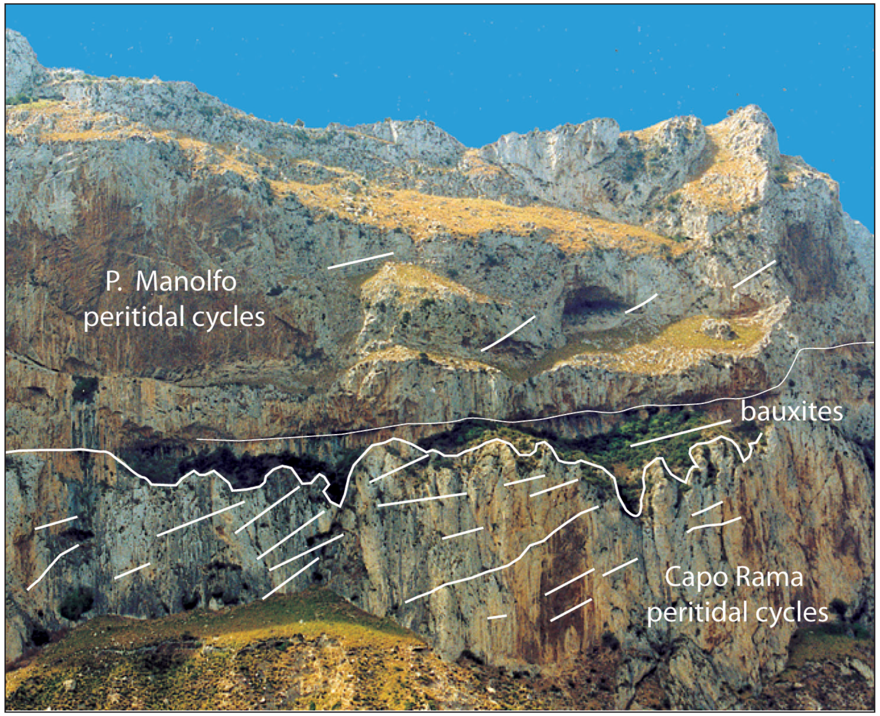


Fig. 3. Angular unconformity between Upper Triassic Capo Rama Fm. peritidal limestones and the upper Jurassic Pizzo Manolfo peritidal limestones. On the irregular erosional and karstic unconformity surface, bauxite deposits are presented (northern side of Monte Gallo, Palermo Mountains)

ty limestones (Scillato Fm.) are cut, upwards, by a submarine erosional surface, accompanied by widespread downlap stratal termination of the Lower Liassic prograding dolomitic breccias (Fanusi Fm., Fig. 4); the breccia's elements consist of shallow-water fragments derived by the dismantling of the adjacent platform sedimentation domain. These surfaces are strictly related to the tectonic fragmentation of the Tethyan platform domains (Bernoulli & Jenkyns, 1970) and to the sea level fall (Vail, 1984; Hallam, 1987; Haq et al. 1987; Jacquin et al., 1997).

b) The top of the Upper Triassic/Lower Liassic shallow-water deposits and the top of the dolomitic slope breccias is often characterized by Fe-Mn oxides crusts (hardground), accompanied by onlap stratal termination of the above Jurassic Rosso Ammonitico beds (in the carbonate platform domain) and radiolarian cherty limestones (in the basin). These non-depositional surfaces are related to a widespread transgression and sea level rise occurred during the Jurassic (Fig. 4).

c) A correlative platform-to-basin submarine erosional surface, separating Jurassic deep-water deposits (Rosso Ammonitico and radiolarian cherts) from Tithonian-Neocomian aggrading-to-prograding Ellipsactinia reef limestones and their lateral reef-derived debris (Ellipsactinia breccias mb.), grows towards the slope of the carbonate shelf deposits (Figs. 5, 6 and 7).

d) The upper boundary of the previously described Tithonian - Neocomian Ellipsactinia deposits appears, in platform setting, as an erosional surface, slightly tectonically enhanced, associated with fractures and neptunian dykes and a ma-

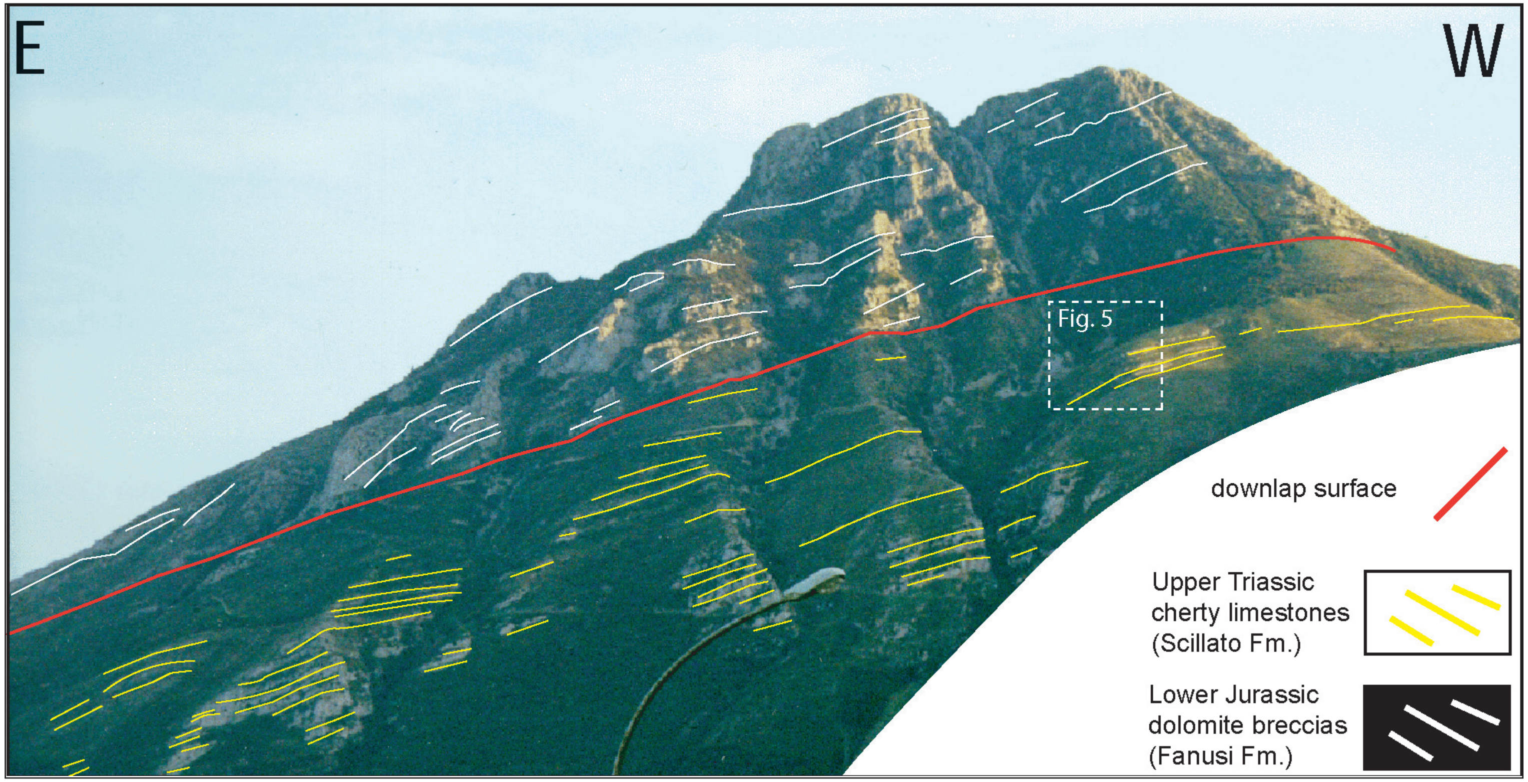


Fig. 4. Downlap relationships between the megabeds of the lowermost Jurassic dolomite breccias (Fanusi Fm.) and upper Triassic cherty limestones (Scillato Fm.). San Calogero Mountain (Termini Imerese Mountains.).

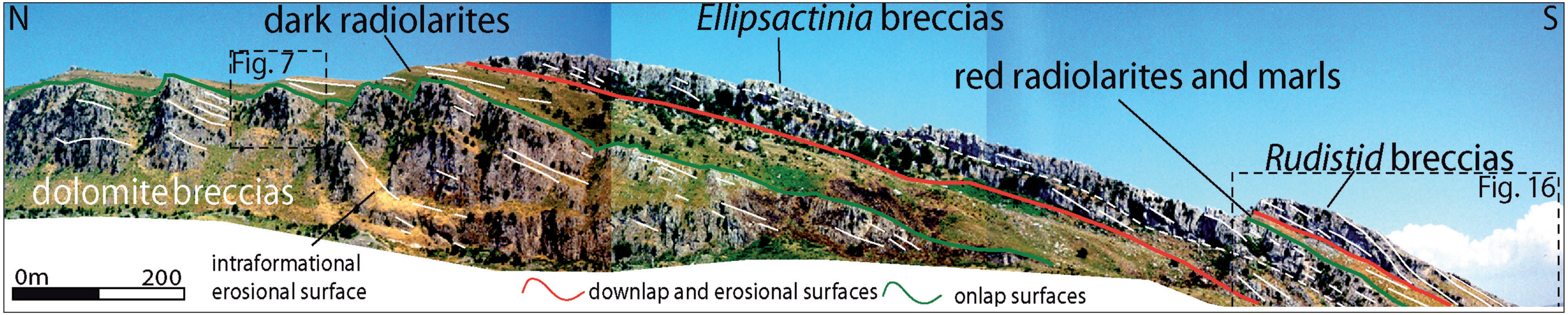


Fig. 5. Physical-stratigraphic relationships of the Jurassic-Cretaceous Imerese succession viewed in a panoramic photomosaic of the western flank of Rocca di Mezzogiorno (S. Calogero Mountain, Termini Imerese Mountains). It is possible to see the onlap and downlap surfaces of the major T/R facies cycles.

ximum regression surface in basinal setting. This surface may evolve either into a drowning surface with neptunian dykes filled by upper Cretaceous pelagic limestone (Amerillo Fm.), or, along the inner platform succession, into an onlapping unconformity surface covered by Barremian-Aptian shallow water deposits (Monte Gallo, Palermo Mts.). A transgressive surface (Figs. 5 and 7), with onlap terminations (Fig. 8), between lower Cretaceous radiolarian pelagic deposits (red radiolarites and marls mb. of the Crisanti Fm.) and the regressive Ellipsactinia breccias mb., marks the lower boundary in the basin.

e) A major downlap surface, associated with submarine erosion and hiatus observed both in platform and in slope settings, characterize the lower boundary of the Upper Cretaceous (mostly Cenomanian) rudistid limestones and associated prograding reworked deposits in the basin (Fig. 9, Rudistid breccias).

f) The upper boundary of the Late Cretaceous deposits is a tectonically-enhanced erosional unconformi-

Fig. 6. Erosional contact between the Ellipsactinia breccia mb. and the Jurassic black radiolarites mb. of the Crisanti Fm. (Cozzo Petroso, Trabia Mts).

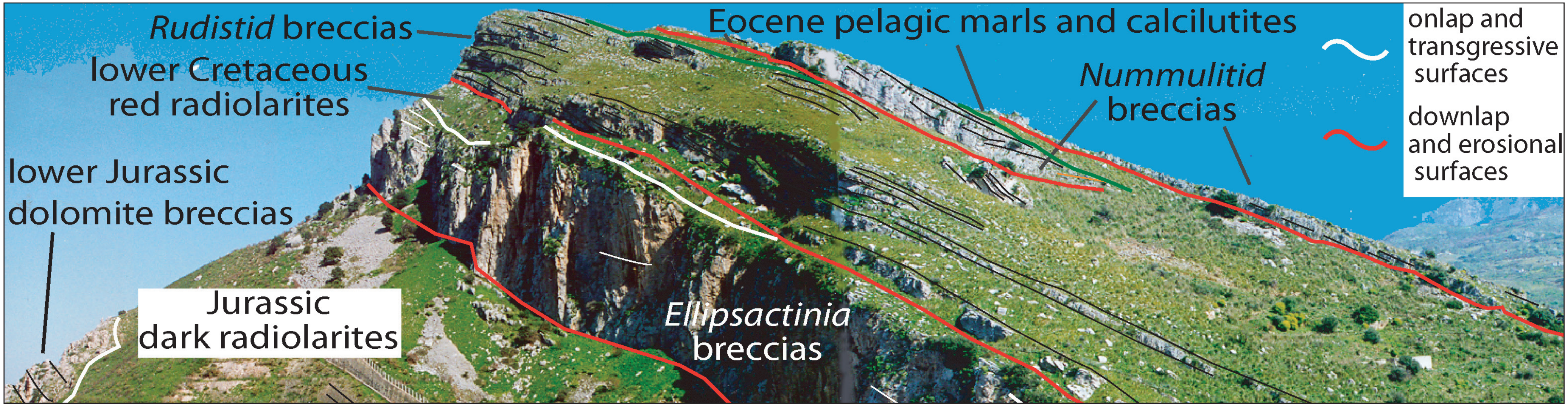
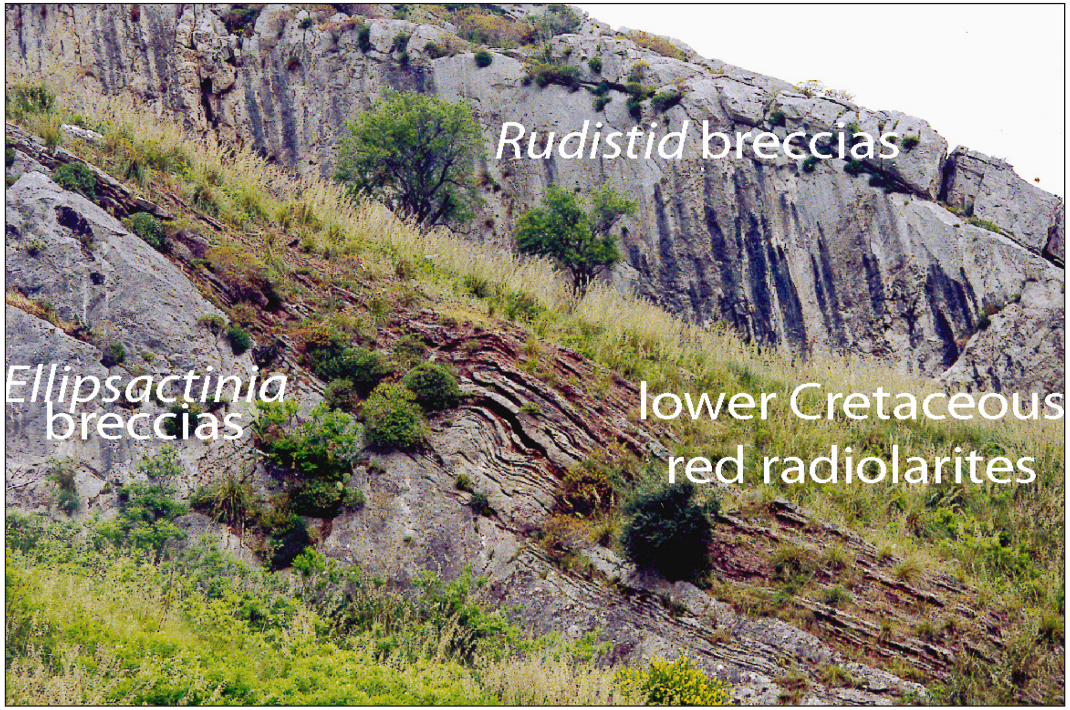


Fig. 7. Panoramic view of the western side of Cozzo Famo (Termini Imerese Mountains), where the geometric relationships of the Jurassic-Eocene units of the Imerese slope succession are visible. The lower Cretaceous red radiolarites and marls mb of the Crisanti Fm is here 5 metres thick and, laterally, disappear.



ty, evidenced by the occurrence of several dykes, cutting the top of the Upper Cretaceous platform deposits; the correlative surface, in the basin, is a maximum regression surface on top of the Upper Cretaceous Rudistid breccias. This boundary is associated with a drowning unconformity, overprinting the Maastrichtian erosional surface, characterized by hiatuses, palaeokarst features and neptunian dykes and onlap stratal termination of the Eocene planktonic foraminifera bearing-mudstone (Amerillo and Caltavuturo Fms. deposits).

Fig. 8. Onlap relationships between the Lower cretaceous red radiolarites and marls member with the Ellipsactinia breccia mb. of the Crisanti Fm.

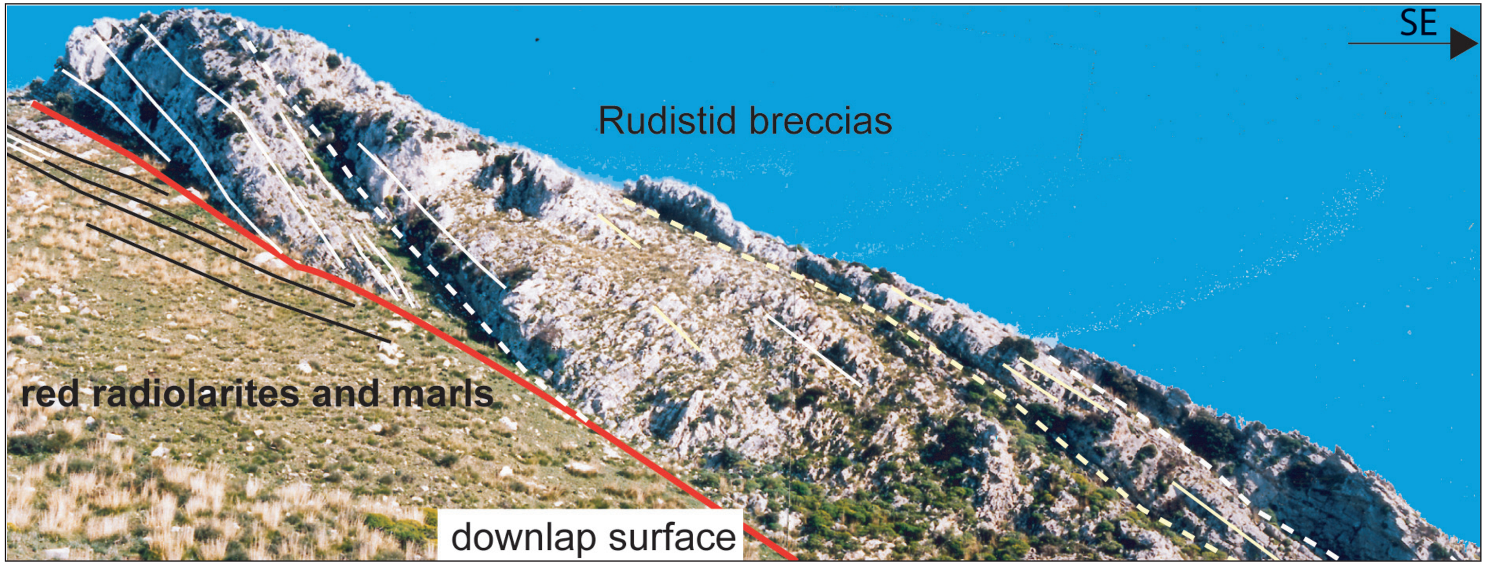


Figure 8. Panoramic view of the southern side of Rocca di Mezzogiorno. Erosional unconformity at the base of the breccias and turbidites (Cenomanian Rudistid breccias mb. of the Crisanti Fm.) highlighted by downlap geometry; truncation of the older strata (Lower Cretaceous red radiolarites and marls mb. of the Crisanti Fm.) is, also, present. The white dashed lines are the sequence boundaries of the 3rd order cycles.

Cyclicity

Sequence stratigraphic studies of the Triassic through Paleogene carbonate successions of platform, slope and basin in western Sicily (Palermo and Termini Imerese Mountains) have identified a sedimentary cyclicity mostly caused by relative sea-level oscillation (Fig. 2). Physical stratigraphy and facies analysis appear as powerful methods to reconstruct the stratigraphic architecture and the sedimentary evolution of the Sicilian Mesozoic-Paleogene carbonate rock units deposited on a shelf-to-basin system (e.g. Panormide-Imerese).
Results of the study have shown that the occurrence of correlative strata from shelf to basin are organized in four major transgressive/regressive cycles which span from late Triassic to Eocene time. These cycles are characterized, both in platform and basin setting, by transgressive deposits that onlap older regressive deposits. The latter, characterized by progradational geometries, downlap the older transgressive deposits (Basilone, 2009).
The platform-to-basin system original physiographic profile was interrupted by scarp-margins and discontinuities, produced during the major tectonic events.
The whole slope succession consists of more than 50% of shallow water (mostly reef) derived debris. Sedimentary evolution, of the slope-to-basin depositional systems, was partially guided by vertical and lateral growth and retreat of the carbonate platform margins. The sedimentary evolution of the carbonate platform was controlled by long-term relative sea-level change (tectonic subsidence and eustasy).
The main tectonic events, obtaining by means of the analysis of the stratigraphic relationships and the help of biostratigraphy, appear frequently, syncronous to the sequence boundary of the major T-R Sicilian cycles.