Rivista Italiana di Paleontologia e Stratigrafia | volume 110 | no. 1 | pp. 15-22 | April 2004

SICILIAN JURASSIC PHYSIOGRAPHY AND GEOLOGIC REALMS (ITALY)

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Received October 30, 2002; accepted November 4, 2003

Key-words: Sicily, Jurassic, palaeogeography.

Abstract. Two tectono-sedimentary domains, which were deformed during the Neogene and evolved into two large structural sectors, characterize the Sicilian Jurassic: the Maghrebides and Peloritani. Africa margin sediments, passing downward to Triassic successions and perhaps originally to Paleozoic deposits, characterize the former. The latter belongs to the European "Calabrian Arc", where the Jurassic transgressively rests on a continental substrate (i.e. the crystalline Variscan basement).

These domains are characterized by four sedimentary facies: shallow platform-derived limestones; condensed seamount-type red limestones; nodular limestones with ammonites; deep radiolarites and shales. These facies are illustrated in a dozen of stratigraphic logs.

The drowning of most Triassic-Liassic carbonate platforms or ramps and the deepening of adjacent basins came with inferred Jurassic strike-slip tectonics, connected to the relative movement of Africa (Gondwanian part) vs. Europe (Laurasian part); the same strike-slip tectonics may have caused scattered intraplate volcanic seamounts found in Maghrebides.

During the Jurassic the Maghrebide realm was characterized by the interfingering of basins and carbonate platforms. During the Early and Middle Liassic, carbonate platforms and ramps were dominant. Since Toarcian either radiolarites in some basins or Ammonite-bearing calcareous muds developed with intervening basaltic flows, and were accompanied by condensed pelagic carbonates on the ensialic seamount-type highs.

The Peloritani realm displays similar characteristics, but with later transgression on the basement, several strike-slip basins and without any volcanoes.

Riassunto. Il Giurassico siciliano si riscontra in due domini strutturali deformatisi plicativamente dal Miocene secondo due catene ora saldate: il Maghrebide e il Peloritano (Fig. 1). Il primo è formato da sedimenti marini di margine gondwaniano-africano, in continuità deposizionale almeno dal Trias; il secondo è formato da sedimenti di margine laurasiano-europeo trasgressivi, sul basamento varisico e la sua sottile copertura continentale triassico-infraliassica, solo nel Lias inferiore.

I sedimenti giurassici di ambedue i domini sono espressi da quattro tipologie litologiche e in una dozzina di log stratigrafici emblematici: -calcari neritici di piattaforma e di rampa carbonatica; -calcari rossi di sedimentazione pelagica condensata; -calcari nodulari rosati (questi ultimi due assegnabili al "Rosso Ammonitico" l.s); -radiolariti ed argilliti.

Nel Lias inferiore e medio i due domini erano suddivisibili nel Maghrebide secondo piattaforme e bacini interdigitati ereditati dal Trias e nel Peloritano secondo piattaforme e rampe carbonatiche circondanti bacini probabilmente rombocasmici.

Ovunque, tranne rare eccezioni, le piattaforme subirono il noto annegamento giurassico, con tendenziale anticipo al Domeriano superiore nel Peloritano e uno più marcato e diffuso al Toarciano nel Maghrebide. Solo in quest'ultimo furono attivi vulcani sottomarini mediogiurassici.

Introduction

A palaeogeographic restoration of two Jurassic crustal sectors, each other frontal to the boundaries of the suggested oceanic domain of the Alpine-Tethys with the southern Neotethys one (cf. Stampfli et al. 2002), is here offered. The southern crustal sector is supposed to belong to Gondwana, from which the Maghrebide Chain originated. The northern sector is instead attributed to Laurasia, from which the materials of one or more microcontinents derived. The latter, eventually assembled in the Miocene, is here considered to form the Calabrian Arc, whose Sicilian part is the Peloritani region. This region is here assumed as an exotic "terrane" (Fig. 1).

For the two Sicilian sectors, characterized by a fold -and - thrust style, a palinspastic reconstruction is proposed, not strictly taking into account their present position (as suggested by Castany 1956; Zappaterra 1994, among the others), but considering, on the whole, the amount of shortening occurred. The sedimentary characters of them have been individuated on the basis of the research on the Sicilian Jurassic carried out since mid XIX century: namely the palaeontological and geological studies of G.G. Gemmellaro (Mid XIX century); Di Stefano G. (1887); Di Stefano & Cortese (1891); Fucini (1921);

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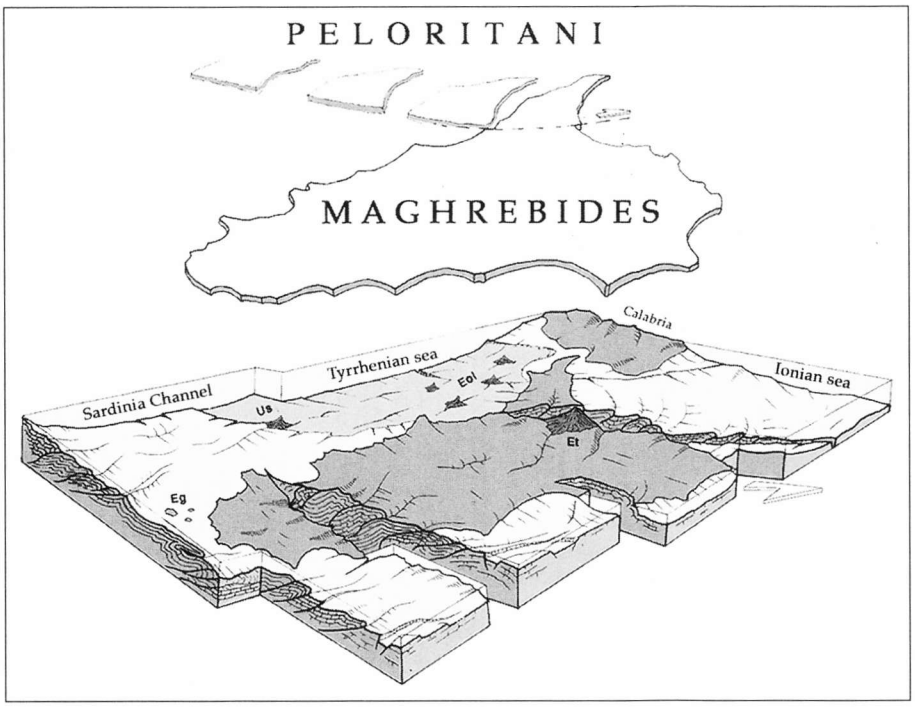

Fig. 1 - Structural scheme of Sicily; Us = Ustica Island, Eol = Eolian Islands, Eg = Egadi Islands, Et = Etna.

Maugeri-Patané (1924, 1932); Schmidt-Friedberg et al. (1960); Ogniben (1960); Wendt (1963, 1971).

From the Sixties of the last century micropaleontological contributions - initially by oil industry and Governmental Institutions - and facies analyses (Rigo & Barbieri 1959; Barbieri 1964; Montanari 1965, 1966) have been taken into consideration.

Jurassic framework

Our stratigraphic analysis on Jurassic sediments allows to individuate four deposits assemblages, corresponding to sedimentary environments (Fig. 2): neritic limestones; Cephalopoda-bearing red condensed pelagites; nodular white to reddish Ammonite-bearing limestones ("Rosso Ammonitico" or R.A. auct.); argillites and radiolarites.

Between the neritic limestones and the others, allodapic sediments may be found. Further paleoenvironmental information came from neptunian dykes (Wendt 1965) and from coeval hardgrounds (Jenkins 1970; Jenkins et al. 2002). All these lithofacies characterize several sedimentary "facies-domains" (Fig. 3). The first lithofacies pertains to carbonate platforms or ramps, which started to grow since the Late Triassic; their age extends from Early to Middle Liassic and sometimes up to Late Jurassic.

The depositional sites changed their characteristics in time. Till the Middle Liassic the platforms were elevated compared to the adjacent hemipelagic basins. Since the Late Pliensbachian (*spinatum* Zone) in the Peloritani domain and since the Early Toarcian (*falciferum* Zone) in the Maghrebian domain, almost all of them drowned, becoming sites for pelagic red Ammonite-bearing condensed limestones. The basins, which were adjacent to the platforms, are characterized by either

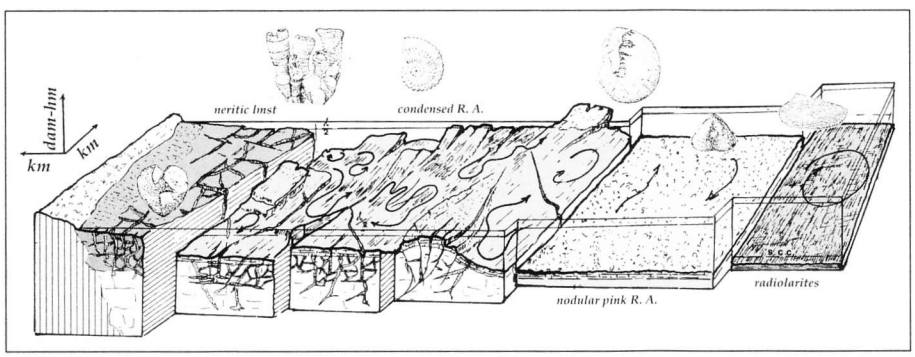

Fig. 2 - Four main Jurassic lithofacies associations. Note platforms and seamount-type structures with condensed Middle Liassic "Rosso Ammonitico" s.l. (R.A.) crossed by neptunian dykes. Black lines for inferred bottom currents; s.c.d. = saturation compensation depth.

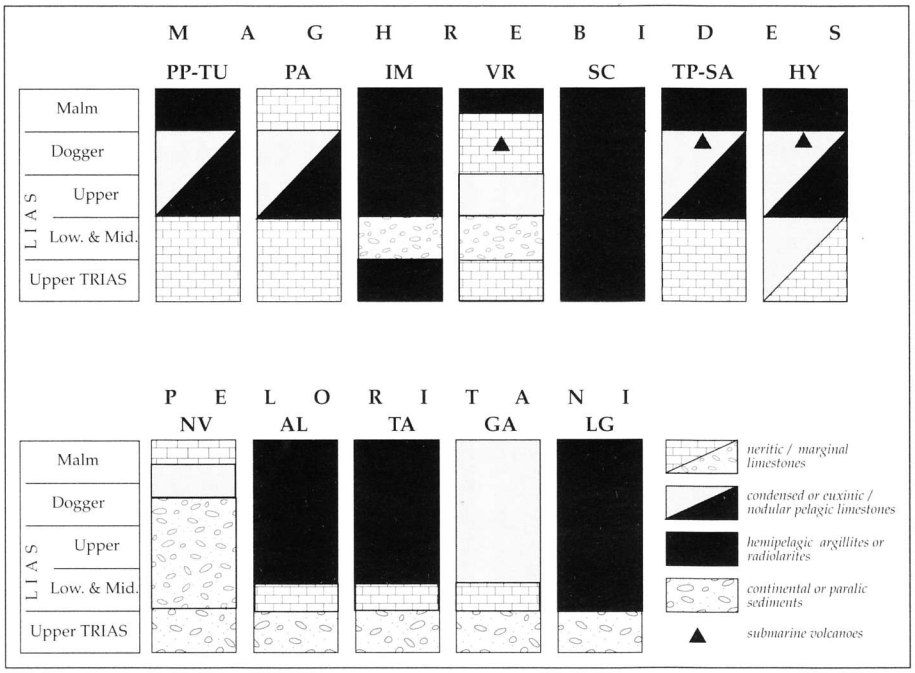

Fig. 3 - Schematic stratigraphic columns of the Jurassic facies domains. PP-TU = Prepanormide-Tunisian; PA = Panormide; IM = Imerese; VR = Vicarese; SC = Sicanian, TP-SA = Trapanese-Saccense; NV = Novara Sicula; AL = Alì; TA = Taormina; GA = Galati; LG = Longi.

nodular holopelagic limestones or hemipelagic radiolarites and argillites.

This paleoenvironmental mosaic was included in different paleogeographic frames by some Authors (Scandone et al. 1977; Catalano & D'Argenio 1978; 1982; Montanari 1989, 2000; Abate et al. 1993, 1997, 2002; Vai 1992)

The sedimentological difference between the Maghrebian and the Peloritanian domains decreased in the Late Jurassic times (*Calpionella*-bearing limestones in drowned zones) even though exceptions may be found in the Panormide domain (*Ellipsactinia*-bearing deposits) and in Peloritani ("Novara succession" with *Clypeina jurassica*-bearing carbonates). Since the Late Triassic large amounts of allodapic and intrabasinal breccias deposited in the basins. In many Maghrebian sectors (Fig. 3) pillow-lavas also occurred, suggesting an incipient rift, later aborted.

Structures and paleophysiographic analysis

It is necessary to distinguish autochthonous and allochthonous Jurassic rocks, either in deformed or undeformed sites. The structural position needs to be verified, to discriminate whether the rocks are true tectonic Klippen or if are resedimented exotic materials. For instance, Jurassic neritic rocks from Vicari, Roccapalumba, Pietrecadute in Western Sicily are remains of a Nappe overthrusting the Sicanian thrusts. Instead, in the Sicanian sequence, the megabreccia-swarms with Liassic white neritic limestones embedded in the white Cretaceous "Scaglia" (e.g. Adranone, near Sciacca and in the same Sicanian basin) are resedimented. Same resedimentation of Jurassic rocks in siliciclastic Miocene flysch occurs by Case Tita near Mistretta.

In the Peloritani, near Rocca Novara and Forza d'Agrò, Tithonian white clasts were resedimented as a breccia-like in the Oligocene varicoloured marls; many blocks of condensed Rosso Ammonitico are included in the "Scaglia" as well as in Miocene siliciclastic turbidites, suggesting a repeated mass slide.

Here we deal with the Jurassic domains, from the "internal" to "external" ones, according to the modern structural organisation of the deformed rock assemblages in a "cylindristic" framework of south-verging overthrusts, with a moderate transversal strike-slip tectonics.

Maghrebides

a) Prepanormide (PP)-Aegusean Tunisian (TU eg.) ("Aegusean" from the ancient Greek generic *Aegusae* for Egadi islands). The name is an informal compromise. "Prepanormide" was born as a nomen nudum (Catalano & D'Argenio 1982) suggesting another paleodomain between an internal realm (probably the "oceanic" Sicilide of Ogniben 1960) and an external Maghrebian-Trapanese realm.

Its stratigraphy was later considered analogous to that of the Tunisian realm (Catalano 1987). One of us (Montanari 1989) suggested therefore to change "Prepanormide" into "Tunisian", because of:

- the new opinions and data about the belonging of such domain to North-Africa, as Fabiani & Trevisan (1940) and Ruggieri (1973) had already suggested;
- stratigraphic differences from the "true" Panormide;

- the unclear use of the term "Panormide", which may induce confusion about its structural position, age and stratigraphy. AGIP staff (Antonelli et al. 1988) used this new nomenclature regarding " Tunisian".

Montanari (2000) divided "Tunisian" in two parts: the Aegusean (Egadi Isls. and Adventure Bank), and the Pelagian (the southernmost Mediterranean zone), owing to some differences in stratigraphic evolution (at least since the till now known Malm). The Aegusean lacks of Jurassic volcanoes, which are instead present in its Carnian and Upper Cretaceous successions. From Late Triassic to Early Liassic this domain not changed its calcareous-dolomitic rocks, while during the latest Domerian it passed to a new cycle with radiolaritic marly *Canavaria*-bearing limestones (Falcone Mb. in Abate et al. 1999) and prosecutes in similar conditions for the entire Jurassic.

Instead, the Pelagian during the Malm (deepest layers reached by commercial drills) owns dolomitized limestones.

b) Panormide. This domain shows a maximum extent of neritic conditions since the Carnian (Senowbary-Darian & Abate 1986). Its drowning took place from the Toarcian to Middle Malm (production of condensed reddish limestone), then it returned to neritic conditions, shedding material into the adjacent basinal Imerese domain, from the Late Triassic (Fanusi Fm.) to the Cretaceous at least (Crisanti Fm.). Also this domain lacks submarine eruptions during Jurassic.

c) Vicarese (Montanari 2000). This domain has some affinities with the Trapanese and Panormide ones. Its materials are found at East, near the Mistretta's neighborhood (by Case Tita). In the Middle Jurassic it is charaterized by neritic limestones with *Protopeneroplis striata* (Caflisch & Crescenti 1969) and by volcanic tuffs in the Bajocian (Fabiani & Ruiz 1933). Its Triassic carbonate material gave origin to megabreccias as at its margin during Early Liassic (M. Genuardo succession) and as, during the Upper Cretaceous, into the adjacent original Sicani basinal domain, where the pelagic Jurassic carbonate resediments are almost lacking (Di Stefano et al. 1996; 2002).

d) Trapanese. It is a well known domain, rich in Jurassic ammonites. To the south, it extends into "Saccense" prosecution, encircling hemipelagic Imerese and Sicanian embayments. Its Lower and Middle Liassic platform-carbonatic sediment (Inici Fm.) followed Triassic conditions. In the Toarcian it drowned and was occupied both by condensed pelagic Rosso Ammonitico limestones on seamount-type highs (M. Grande, Inici, Maranfusa, Kumeta, Busambra Mts e.g.) and adjacent nodular light

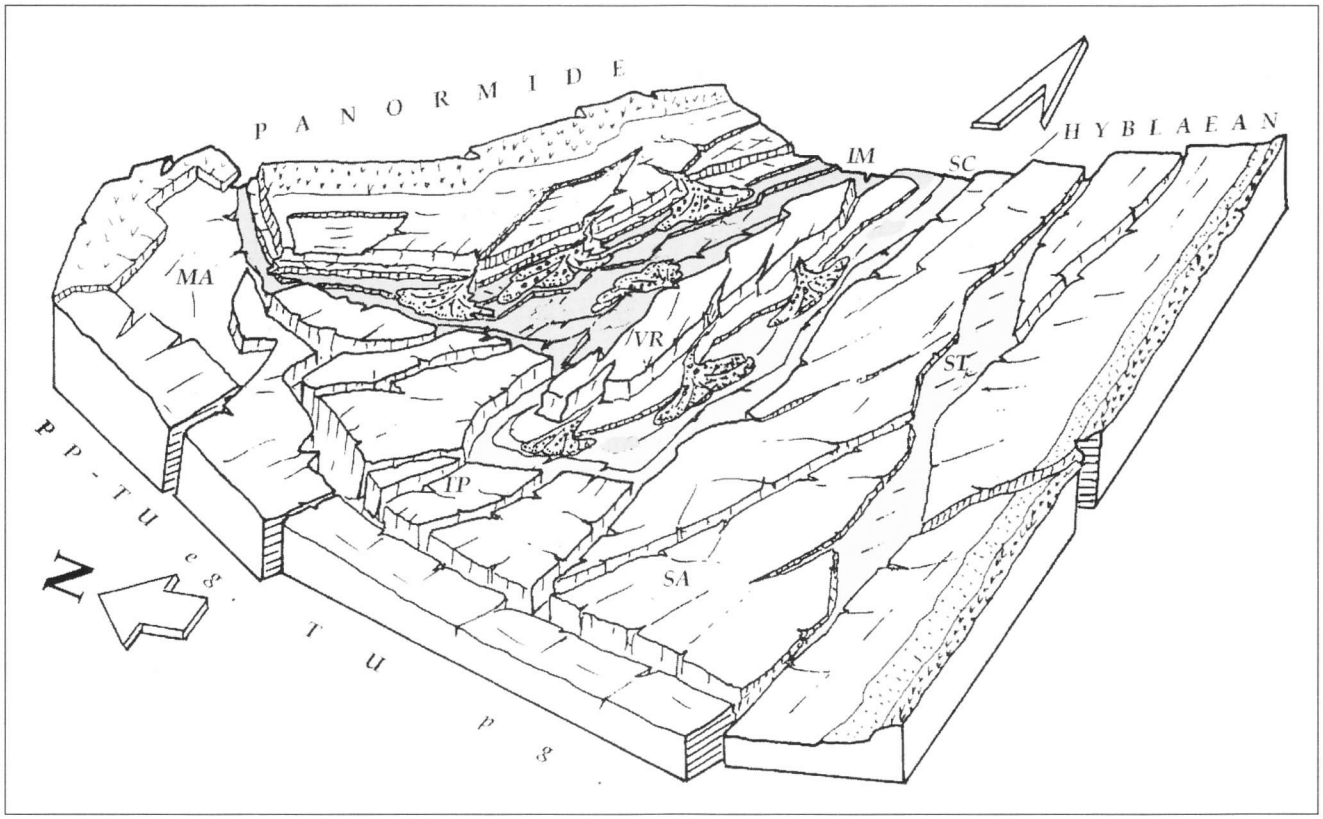

Fig. 4 - Conceptual physiographic model for the Maghrebides realm in the Early and Middle Liassic times (not to scale). The structures are inherited from the Late Triassic; carbonate platforms or ramps with interfingered basins were invaded by allodapic sediments. MA = Marettimo Isl. zone; IM = Imerese basin; SC = Sicanian basin; VR = Vicarese high; TP = Trapanese; SA = Saccense subdomain; ST = Streppenosa restricted basin; PP-TU eg. = Prepanormide-aegusean Tunisian; TU pg = pelagian Tunisian. Note the lack of submarine volcanoes; strike-slip movements are indicated by half-arrows.

Ammonite-bearing sediments. Submarine volcanic materials are here present in Jurassic time.

e) **Imerese and Sicanian** hemipelagic radiolaritic basins formed embayments within the Prepanormide-Tunisian and Trapanese domains. Probably, the Imerese and Sicanian basins were crossed by the Vicarese high, to meet towards the Apenninic Lagonegro basin. The Imerese received allodapic materials from the Panormide platform during the Late Triassic- Paleogene interval; the Sicanian one received similar material from the Vicarese during the Early Liassic and in the Late Cretaceous times. The Imerese has more expanded radiolarites than the Sicanian one. Submarine volcanic rocks are present in both the domains during Late Triassic and Jurassic times.

f) **The Hyblaean** domain corresponds to the present lightly-deformed Foreland in the SE corner of the Island. Only oil wells have reached the Jurassic. Some normal pelagic sediments alternate seamount-type condensed ammonitic limestones. From the commercial point of view, the greatest interest is in black-shales (Streppenosa Fm.), whose age extends from Late Triassic to Early Liassic (Frixia et al. 2000 and ref. herein). Volcanic Jurassic materials occur in this domain.

Peloritani

A thin continental or paralic infraliasic deposits ("Arenaria di Longi" or "Verrucano" Auct.) occurred on the Variscan basement. The most interesting outcrops with good stratigraphic columns are found in the Taormina, Galati and Longi neighborhood. Here carbonate ramps rimming the basins of Early Jurassic age drowned since Late Domerian, leaving scattered seamount-type structures with condensed Rosso Ammonitico. In the basins coeval cherty limestones deposited (Carcione et al. 2003). Only in the "Novara" succession a sporadic episode of Upper Malm neritic *Clypeina*-bearing shallow water sediment occurred. In any case, Peloritani lack of Jurassic volcanism.

Sicilides

The separation of Peloritani from Maghrebides is controversial.

It is supposed from literature that during Late Jurassic an oceanic trench separated Maghrebides from Peloritani, where varicoloured marls and shales ("Argille Sicilidi" auct.) developed.

The Sicilide domain (Ogniben 1960) shows deep pelagic sediments with a significant shale component. The most ancient deposits have been identified at the Jurassic-Cretaceous boundary and consist of red shales with small layers of *Calpionella*-bearing white micrite, followed by reddish and greenish shales with breccia lenses including Tintinnides and then "varicoloured marls" reaching the Early Langhian (Caire 1970; Lentini et al. 1987). The compositional affinity to the Apenninic "argille a palombini" is noteworthy, but in Sicily Jurassic basalts and ophiolithes from this internal domain lack, or are unknown.

Discussion and conclusions

Fig. 3 shows that two different depositional events occurred in the Jurassic.

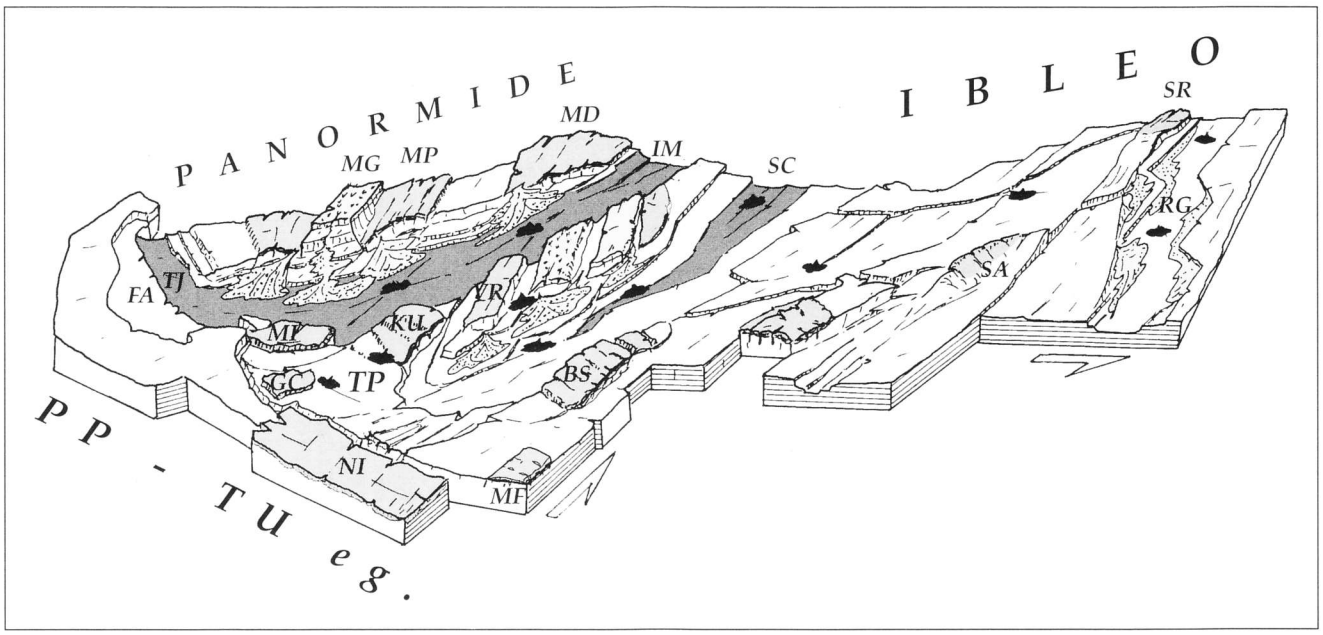

Fig. 5 - Conceptual physiographic model for the Maghrebian realm in the Middle Jurassic. Several platforms drowned and some parts became seamount-type structures with condensed pelagic Rosso Ammonitico limestones. FA = Mt. Falcone zone at Marettimo; TJ = Punta Troja basin at Marettimo; MG = Mt. Gallo; MP = Mt. Pellegrino; MD = Madonie Mts.; GI = Mt. Grande and Mt. Inici area; KU = Mt. Kumeta; BS = Rocca Busambra; MF = Maranfusa; NI = Nilde well zone; SA = Sciacca; SR = Syracuse; RG = Ragusa. Half-arrows for strike-slip movements. During the Miocene the Trapanese approached the Saccense zone because of a deep thrust.

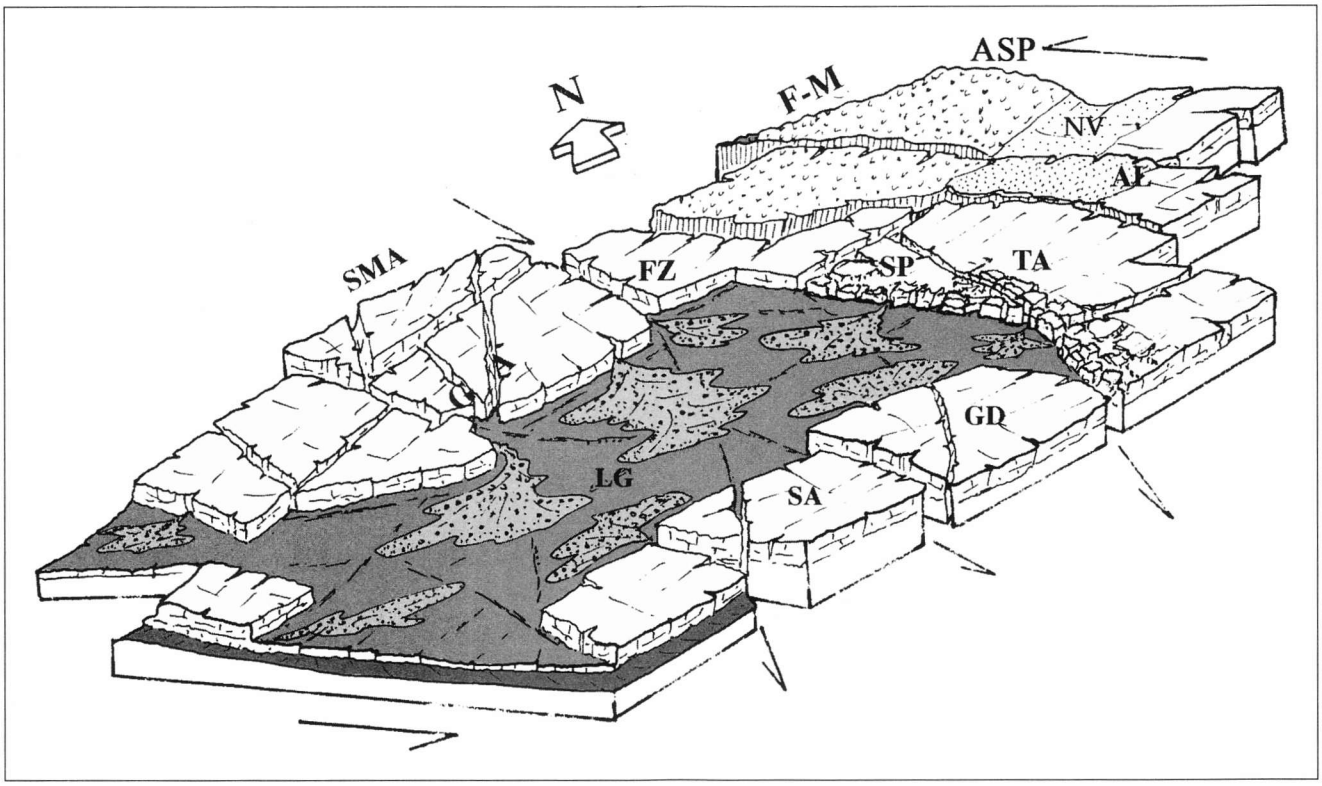

Fig. 6 - Conceptual physiographic model for the Early Liassic in the Peloritani's area: LG = Longi basin; GA, SMA, FZ, SP, TA, GD, SA = Galati, S. Marco d'Alunzio, Frazzanò, S. Pietro, Taormina, Gallodoro, S. Andrea carbonate platforms or ramps; AL = Alì gypsiferous and carbonatic shelf; F-M = Fondachelli-Mandrazzi-Mandanici zone; ASP = Aspromonte zone; NV = Rocca Novara zone. (modif. from Carcione et al. 2003).

- In Maghrebides, until the Middle Lias, the Triassic structure persisted with the presence of carbonate platforms, ramps and relative sediments. Few emersions occurred (one of these took place in the Panormide, at Mt. Gallo, with bauxites occupying the Early Lias-Early Malm interval (Di Stefano 2002)).

- In the Peloritani, both the transgression over the basement and its continental-Triassic cover occurred later (Lower Liassic). The correspondence between these two zones concerning Lower Liassic sedimentation was later reversed during two different times: at first the drowning took place by the Peloritan sector during Late Domerian, then during the Toarcian in the Maghrebian one. The latter occurred when the mainly carbonate sedimentation alternated with the radiolaritic-argillitic one. The few affinities between the two depositional areas are in the sporadic neritic occurrence at the top of the Jurassic (*Ellipsactinia*-bearing limestones in the Panormide, *Clypeina*-bearing limestones in the Novarese) and in the radiolarites both by the Imerese, Sicanian (Maghrebides) and by the Alì (Peloritani) sequence. This resembles parental relationships with the Sicilide rift, which was interposed between Peloritani and Maghrebides in the Jurassic-Cretaceous times.

Simultaneous distinct physiographic situations with different depositional typology, even to a small scale, and deep volcanism suggest a moderate structural dynamics.

Updated general models for the Gondwana-Laurasia boundary during the Jurassic, which includes the two Sicilian realms (Stampfli & Mosar 1999; Stampfli et al. 2002), as well as of some Authors (Muttoni et al. 2000) ones for the Gondwana sector, show widespread strike-slip tectonics. This latter one, foreseen by Catalano & D'Argenio (1982), may justify the contemporaneous presence of adjacent structural ups and downs (push-ups and rhombocasms), even if of reduced dimensions.

On the base of these considerations and data, and on the base of the mutual position of domains which were deformed during Miocene (e.g. by Catalano et al. 2000 for the Maghrebides; Lentini et al. 2000; Carcione et al. 2003 for Peloritani) we can suggest four conceptual physiographic models, for the Early Liassic (time of carbonate platforms) or the Middle Jurassic (time of their drowning).

As for Maghrebides, excluding the Jurassic Sicilide, the first time may indicate platforms and half-encircled basins (Fig. 4), where the Hyblaean euxinic basin of the Streppenosa Fm. suggests a potential indipendence of Maghrebides from Apulia.

At the second time (Fig. 5) the development of transcurrent structures owing to strike-slip tectonics

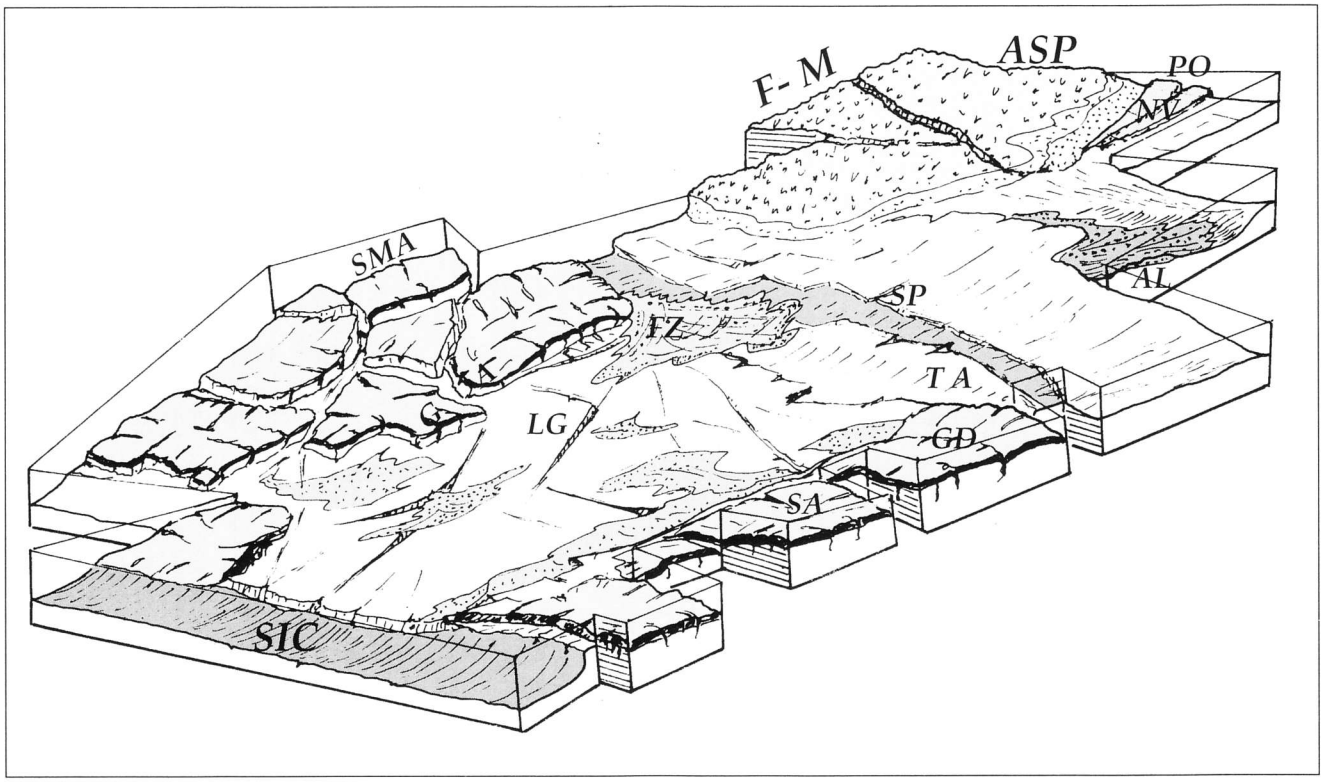

Fig. 7 - Middle & Late Malm physiography in the Peloritani area. Grey for seamount-type structures with condensed Rosso Ammonitico. SIC = Sicilide trench; other symbols and letters see previous figures. (modif. from Carcione et al.2003). During the Miocene northern and western sectors approached the southern ones because of several thrusts.

may show both transpressive seamount-like highs with condensed carbonate pelagic sedimentation and transtensive basins, these last ones with both pelagic normal Ammonitico Rosso, deeper radiolarites, and submerged volcanoes.

As for Peloritani, the Liassic occurrences suggest rimming carbonate platforms (Fig. 6), whereas in the Middle Jurassic these drowned and produced condensed pelagic carbonates (Fig. 7).

Acknowledgements. The authors thank the reviewers B. D'Argenio, G. Stampfli and M. Gaetani as well as the journal editorial staff for constructive comments. Financial support is based on MIUR contribution (ex 60% G. Lo Cicero).

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