Lower Miocene Isili carbonate factories (South-eastern Sardinia, Italy)

MARCO MURRU, LUCIA SIMONE and MARIO VIGORITO

M. Murru - Dipartimento di Scienze della Terra,Università di Cagliari, via Trentino 51, I-09127 Cagliari; murrum@unica.it
L. Simone, M. Vigorito - Dipartimento di Scienze della Terra, Università di Napoli "Federico II", Largo San Marcellino 10, I- 80138 Napoli; lusimone@unina.it, m.vigorito@libero.it

Miocene syn-rift carbonate deposits crop out in south-eastern Sardinia (Italy) along the eastern margin of the Plio-Quaternary Campidano Trough. Here the down-faulted margins of the Oligo-Miocene Sardinia rift-basin crop out with a complex alignment of smaller subbasins (Fig. 1) in which highly active tectonics (Cherchi & Montadert, 1982, 1984), relative changes in sea level and localizaed ecological factors combined to control the formation of complex depositional architectures. In the related sequences, carbonate sediments frequently intercalate with and/or associated with immature terrigenous deposits.

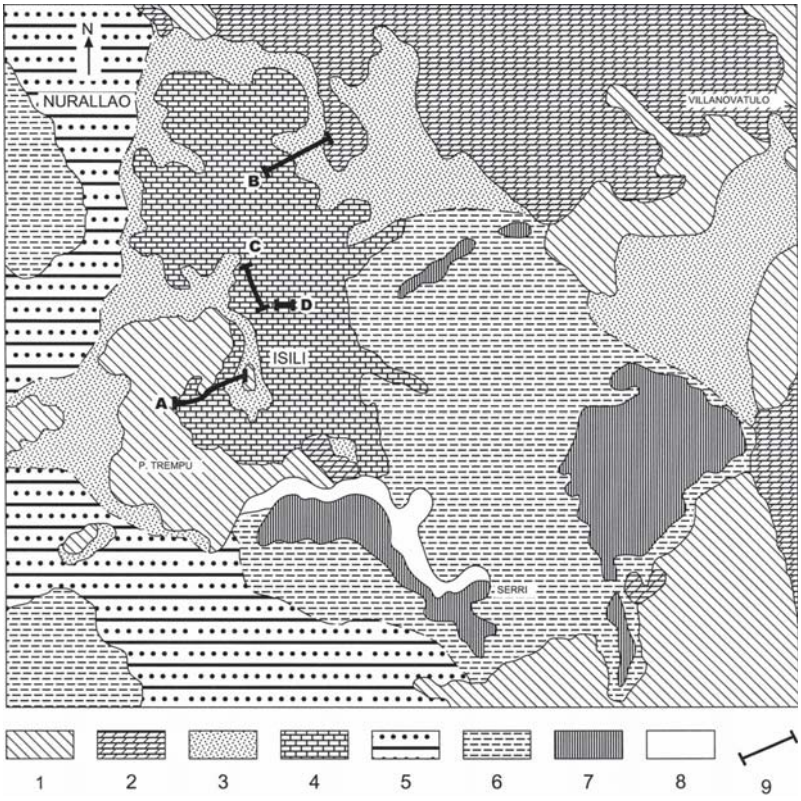

Fig. 1 - Geological sketch-map of the Isili area: 1) Palaeozoic substratum; 2) Jurassic dolostones; 3) Miocene clastic deposits; 4) Miocene limestones; 5) Miocene silty-marls; 6) Miocene marls; 7) Pliocene basalts; 8) Quaternary deposits; 9) Section traces: A=Punta Trempu, B= Industrial area, C=Isili limestones; D= Carbonate channel network.

STOP A - Panoramic overview of the Miocene Isili carbonate factory

Location — Panoramic point of view from the Isili terrace (Piazza Funtana Manna). View of the Miocene neritic succession (Punta Trempu section) cropping out west of the village (Fig. 1).

Historical outline

Previously reported by Cherchi & Montadert (1982, 1984) the succession has been described in detail by Cherchi *et al*. (2000).

Lithology

About 200 m of Miocene neritic limestones are well exposed resting on the Palaeozoic metamorphites (Fig. 2) overlain by a few meters of discontinuous breccia . The latter consist of coarse, polygenic, variously sized breccias with 10-120 cm subangular to angular clasts embedded in a reddish sandy matrix. Breccia deposits have erosive basal boundaries and are normally graded passing to fine conglomerates and breccias with a marine skeletal grainstone-rudstone matrix intercalating into tuffaceous layers (Fig. 3). Early marine conditions can be recognised in these clastic wedges. In the skeletal matrix ostreid and pettinid fragments associate with internal calcite molds of pristine aragonite mollusc shells. *Ostrea* banks intercalate into the upper terrigenous succession resulting in stabilised substrata. Coarse sands with microconglomerate lenses intercalate into the first calcareous strata underlying 180 m of pure skeletal limestones. Repeated and complex, reddened surfaces and, in some cases, well-developed bored hard-grounds intercalate into the succession defining discontinuity surfaces.

Lithofacies within the sequences reflect open-shelf, foramol deposits rich in red algae and pelecipods (rhodalgal assemblages *sensu* Carannante *et al.,* 1988).

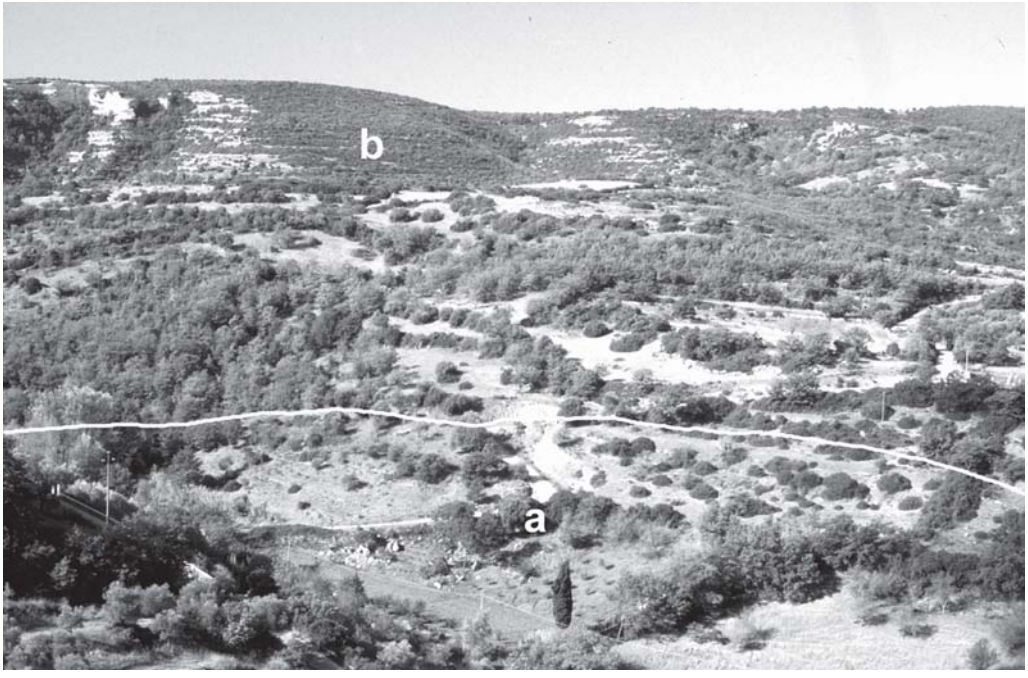

Fig. 2 - Photo-panorama of the Punta Trempu sampled section: (a) Palaeozoic substratum, (b) Miocene foramol limestones.

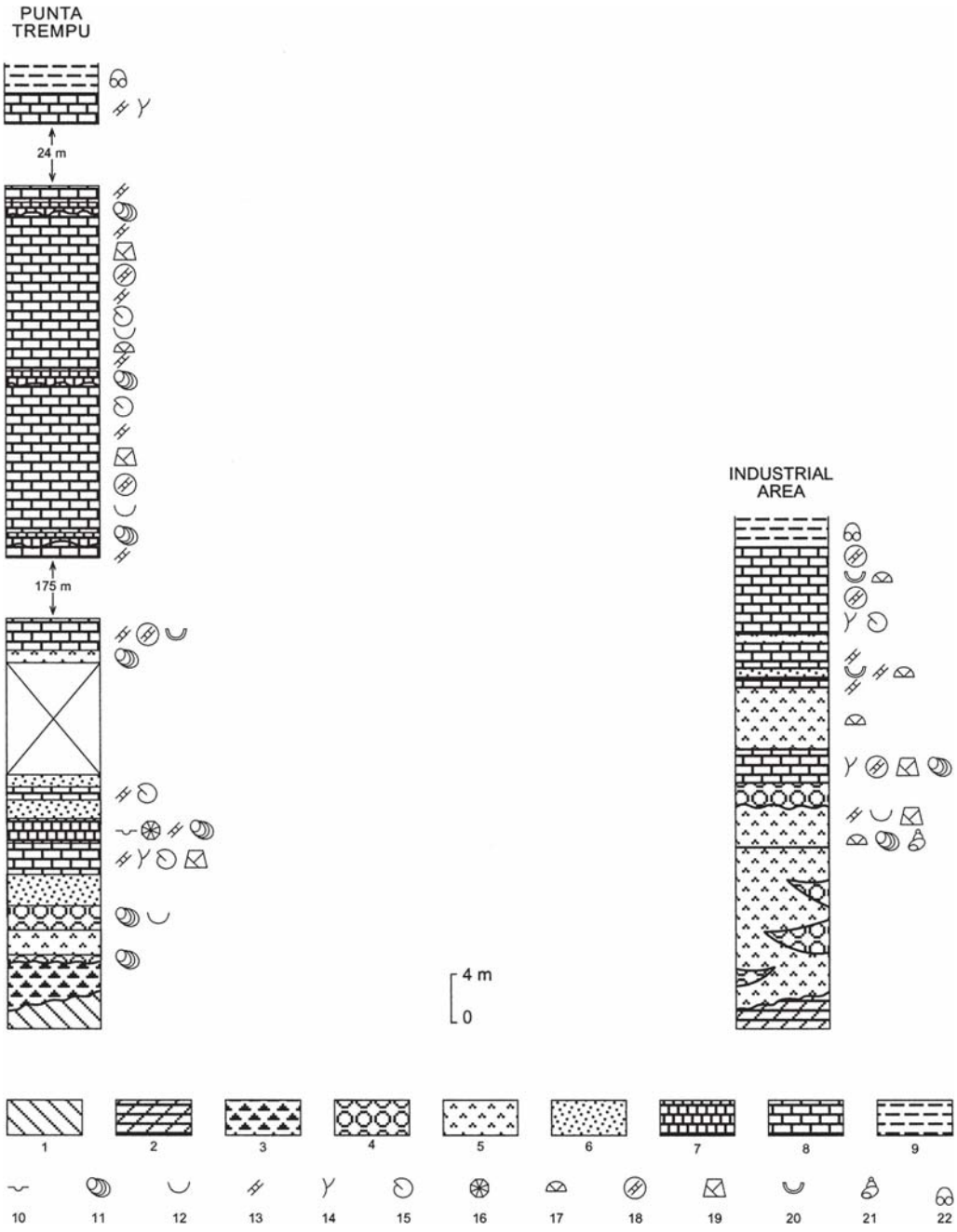

Fig. 3 - Lithological columns of the Isili area (Punta Trempu and Industrial area sections): 1) Paleozoic metamorphics; 2) Jurassic dolostones; 3) Breccias; 4) Conglomerates; 5) Tufaceous sanstones; 6) Sandstones; 7) *Ostrea*-rich skeletal rudstones; 8) Red algae-rich limestones; 9) Marls; 10) Lithophagid bore holes; 11) Ostreids; 12) Bivalves; 13) Red algae; 14) Bryozoans; 15) Benthonic foraminifers; 16) Corals; 17) Echinoids; 18) Rhodoliths; 19) Barnacles; 20) Burrow traces; 21) Gastropods; 22) Planktonic foraminifers.

STOP B - Calcareous beds in early marine siliciclastic deposits of the Isili industrial area

Location — The industrial area section crops out along the road that connects the village of Isili with the Colonia Penale area, located on the easthern sector of the Isili subbasin (Fig. 1).

Historical outline

Previous description can be found in Cherchi *et al.* (2000).

Lithology

In this locality the pre-Tertiary basement crops out with Jurassic dolomites covered by about 20 m of poorly-lithified tuffaceous sandstones with lenses of paraconglomerates (Fig. 3). Clasts are usually well-rounded but poorly sorted and primarily mesozoic dolomites, with frequent pelecipod borings, to a lesser extent palaeozoic metamorphic rocks. A few calcareous clasts are composed of Miocene skeletal rudstones containing fragments of *Pinna*-type shells and bryozoans. A rich benthonic assemblage, made up of molluscs (preserved ostreid shells plus small pristine aragonite-shelled pelecipod and gastropod molds), echinoids, barnacles and red algae are evidence of marine dwelling on sandy bottoms which periodically received terrigenous input often in the form of coarse fractions.

A marine interpretation for these terrigenous wedges is clearly substantiated by admixed marine skeletal material in the matrix and by the large number of pelecipod borings in the conglomerate clasts.

Meter thick intercalations of skeletal limestones characterise the next 20 m of tuffaceous sandstone strata. The latter exhibit a general fining upward trend with only subordinate intercalations of microconglomerate.

Limestones are algal floatstones in a deeply burrowed matrix of silty skeletal packstones. The main constituents are small rhodoliths and fragments thereof. Encrusting bryozoans and foraminifera are major rhodoliths builders. Bryozoans, ostreids and barnacles abound in the silty-arenitic matrix.

This neritic succession terminates with a 10 m thick calcareous bank containing abundant rhodoliths, up to several centimetres in size, and bryozoan fragments.

A sequence of alternating laminated silty marls and sandstones follows. The sandy graded laminae contain poorly rounded quartz grains and smaller amounts of skeletal fragments of benthonic organisms. In the thin pelitic intercalations rare planktonic foraminifers have been observed (top N5 zone, early-middle Burdigalian).

STOP C - Rhodalgal lithofacies of the Miocene Isili limestones

Location — The illustrated limestones crop out (Fig. 2) along the road that connects the villages of Isili and Nurallao (from km 50 to Km 52).

Historical outline

Previous description can be found in Cherchi *et al.* (2000).

Lithology

The Miocene Isili limestones are coarse rhodolith-rich skeletal grainstones to rudstones with a grainstone and silty packstone matrix. The skeletal matrix constituents are

fragmented red algae, bryozoans, barnacles, benthonic foraminifers and, in some cases, planktonic foraminifers (Fig. 4). Locally, thick-shelled ostreids and, to a minor extent corals that have preserved their life position, appear to have dwelled in increasing amounts in the sediment.

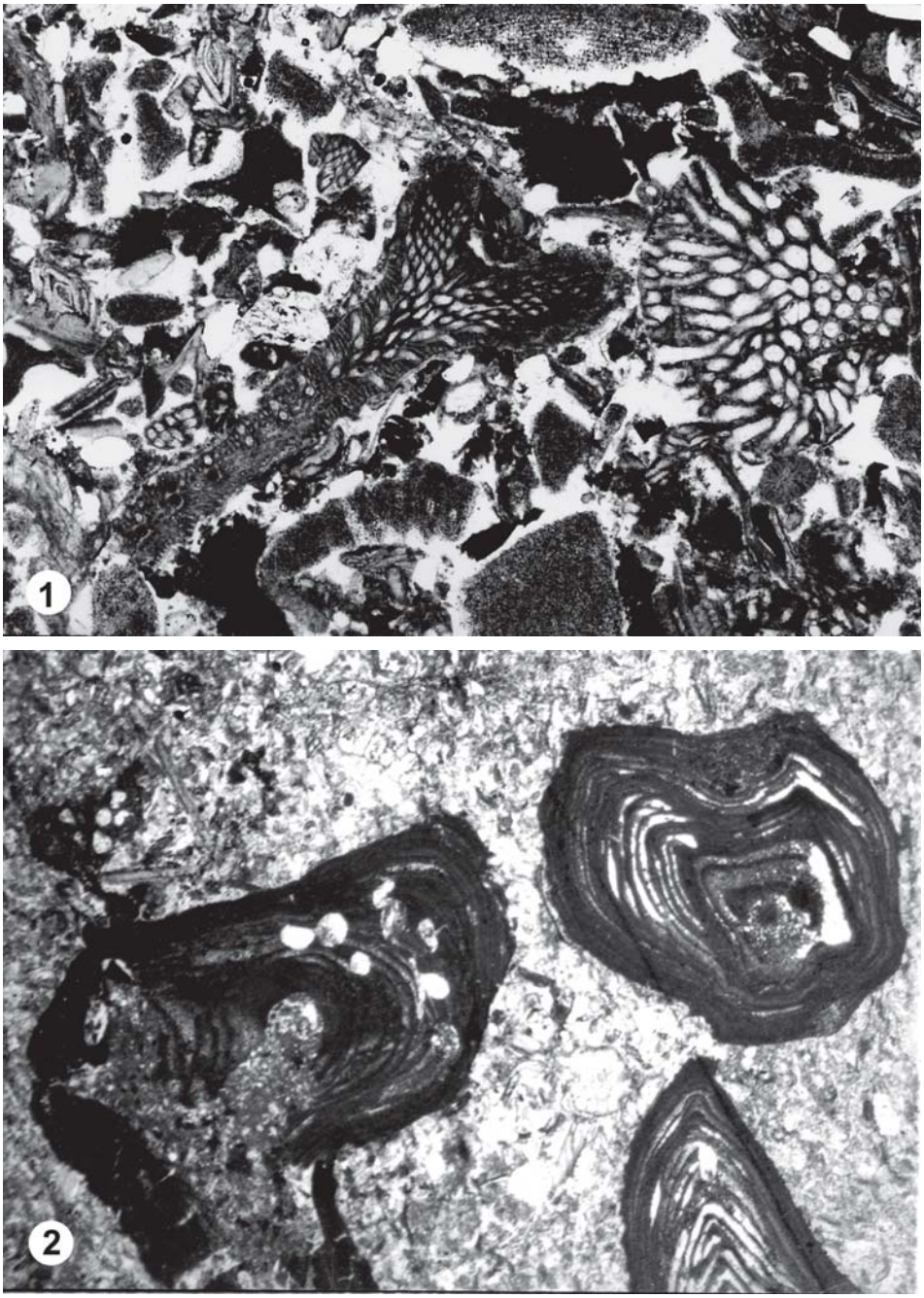

Fig. 4 - 1. Bryozoan-rich rudstones-floatstones in a matrix of skeletal grainstones, x 20,9; 2. Rhodolithic floatstones in a matrix of skeletal grainstones, x 16,3.

STOP D - Overview of the complex carbonate channel network cropping out north-eastward of the Isili village.

Location Panoramic point of view at km 50 of Isili-Nurallao road (Fig. 1).

Historical outline

Previous description can be found in Cherchi *et al.* (2000), Murru *et al*. (2001) and Simone *et al.* (2001).

Lithology

On a large scale the observed carbonate succession is 40 m thick and is tabular bedded cut by a large flat bottom incision in the middle and most convex portion of the section. Strata geometry and interpretation are shown in Fig. 5, while the described sequences are correlated in Fig. 6. Detailed analysis of both facies and internal geometry allowed to interpret the area as corresponding to the right channel margin-levee complex of what is thought to be the Miocene Isili Channel. Multiple hardgrounds as well as erosive and reactivation surfaces indicate that multiple construction phases occurred throughout channel life. Two logs were carried out in this section, described below and illustrated in Fig. 6.

Log. 1 (Fig. 6) was carried out on the side of the northern section 100 m north of the railway dam. Up to 2.5 m thick oyster banks, were found at the base of the carbonate sequence. The latter rest in paraconformity on tuffaceous sandstones and rapidly peter out southward. Parallel and tabular cross-bedded rudstones and floatstones, rich in red algae and bivalve fragments, follow upward. These are up to 10 m thick and locally heavily bioturbated. Echinoids in life position are common locally and a crude Ta-c Bouma's interval is developed in the very first beds. Scouring and cut and fill structures are the most obvious sedimentary structures creating an extremely wavy base.

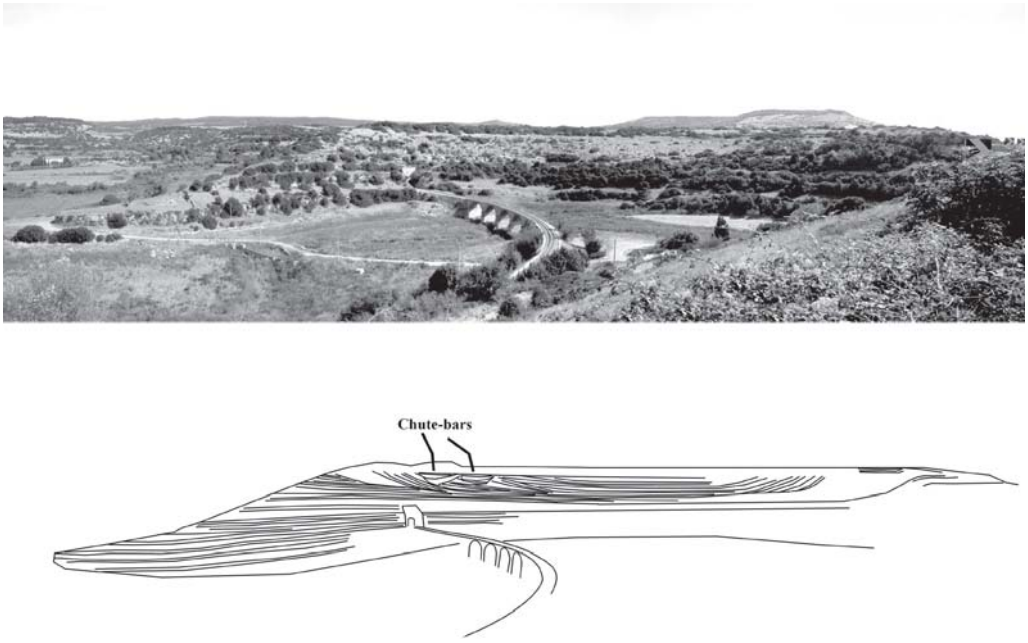

Fig. 5 - Photo-panorama of the Isili railway dam.

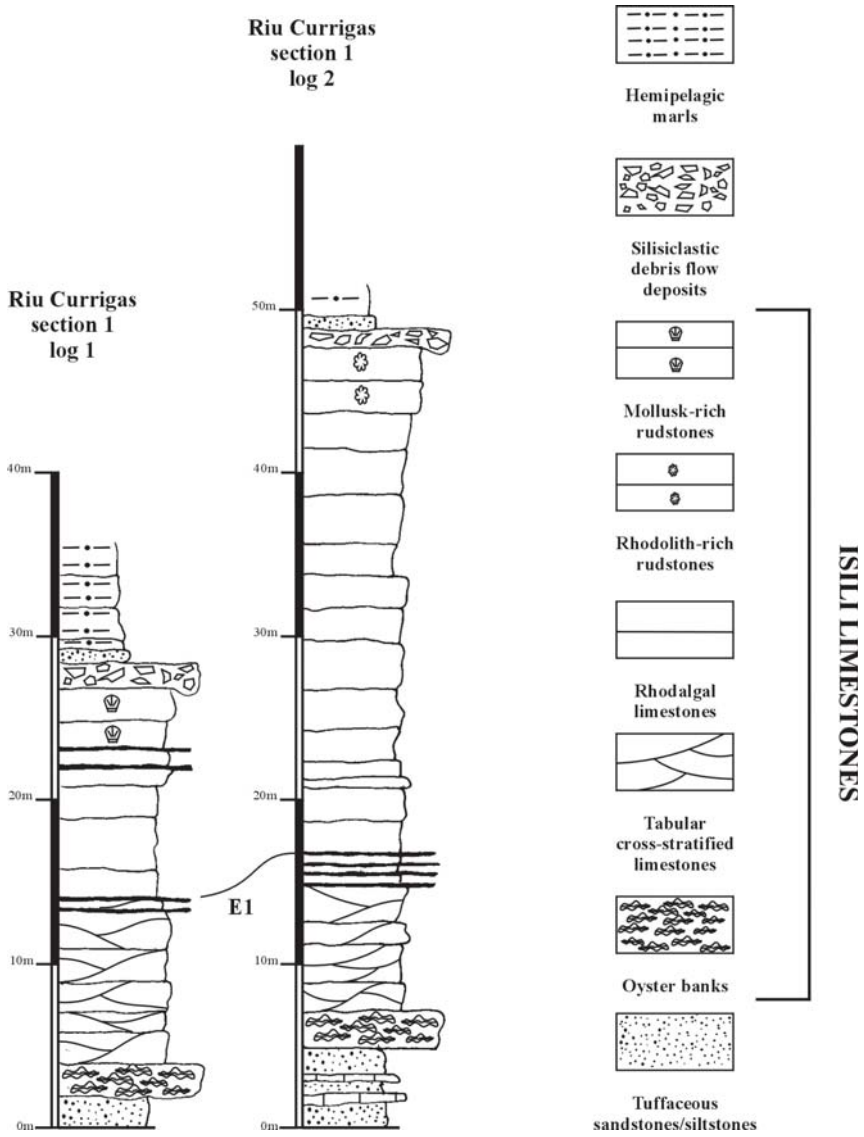

Fig. 6 - Lithological columns of the Isili railway dam.

About 7 m of packstones and fine floatstones follow upward. These rest on a reddened surface encrusted with thick shelled oysters; bedding is parallel with rare small scale scours. Large scale cross stratification is locally developed in the last few metres of these strata. A sharp increase in bivalve fragments is recorded in the following bed package. This is essentially made up of 4-6 m of rudstones and rarely floatstones, so rich in bivalve fragments or shells as to completely outnumber the other constituents. These rudstones are parallel stratified and pass upward to coarse carbonate-clastic rudstone with large floating pebbles; these are both palaeozoic and mesozoic clasts locally associated to wood fragments. A few decimetres of fine silty-sandstones followed by thinly bedded marls cap the succession, marking the demise of carbonate sedimentation in the area.

Log. 2 (Fig. 6) was carried out in the centre of the concave-up structure shown in Fig. 5.

The basal portion of this logged sequence is made up of about 5 m of bioclastic limestones (red algae rich wackestones and rarer packstones) and tuffaceous sandstones locally very rich in echinoids in life position. An oyster bank up to 2,5 m thick overlies this basal portion, in turn overlain by about 8 m of bioclastic limestones (packstones and floatstones) rich in fragments of branching red algae, bryozoans and molluscs. An intensely bioturbated level occurs in the central portion of this interval, while rhodolith-rich bioclastic limestones with sharp basal surfaces prevail in the upper portions.

About 2 m of early-lithified bioclastic limestones follow upwards. These are reddened and locally fractured, bored and encrusted with thick-shelled oysters. Large and thick shelled pettinids also occur. These early-cemented limestones pass upwards to about 15 m of grainstones and packstones (rarely wackestones) rich in branching red algae, bryozoan and mollusc fragments locally, with very frequent serpulid remains. This layer is overlain by fine to medium grained bioclastic limestones, about 12 m thick. These are moderately to well sorted and very rich in branching red algae and, subordinately, mollusc fragments. The carbonate sequence is capped by 4 m of rhodolith-rich rudstones/floatstones sealed by mixed carbonate-clastic debris deposits and finally by silty sandstones and marls.

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