

BIOTIC RESPONSE TO MASS EXTINCTION: THE LOWERMOST TRIASSIC MICROBIALITES

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1 INTRODUCTION

A report on lower Triassic stromatolites as post-mass extinction disaster forms have been presented by SCHUBERT & BOTTJER (1992). But the main description concern late Olenekian (Spathian) stromatolites of the Great basin (NW USA) and not the lowermost Triassic microbialites.

"Tethys just after the end of Permian mass extinction" was the subject of a presentation at the Pangea Conference in Calgary (BAUD 1993). Working on upper Permian paleomap (BAUD et al. 1993a and BAUD et al. 1993b), we can show that one of the main characteristic of the upper Permian paleoenvironment of the Tethys is the growth of giant shallow carbonate platforms. High diversity marine fauna and flora with proliferation of calcareous algae, foraminifera, echinoderms, bryozoan, brachiopods, bivalves characterize the carbonate factory. The latest Permian second order T-R cycle is well recorded on the NW Cimmerian margin (BAUD, 1993) in S Armenia (Vedi, Sovetachen), adjacent NW Iran (Dorasham, Dzhulfa, Ali Bashi, ROSTOVTSEV & AZARIAN 1973, KOTLYAR et al. 1983), Elburz (ALTINER et al. 1980) and in central Iran (Abadeh, IRANIAN-JAPANESE R.G., 1981).

The natural boundary between Permian and Triassic corresponds to the maximum regression, that is the maximum basinward shifts of coastal onlap. Large shallow shelves exposure which dramatically reduced the habitat area, oxidation of a great amount of organic carbon, release of gas hydrates give way to a hyper-weakening of the ecosystem and a devastating extinction. These events and global change, recorded in the large $d^{13}C$ shift (BAUD et al. 1989), strongly affected the carbonate productivity, stratal patterns and biofacies. A bloom of disaster forms: -fungi (Eshet et al. 1995), -cyanobacteria, -blue-green algae is the intrinsic biotic response to the mass extinction.

During the first step of the very rapid and large scale lowest Triassic transgression, we note in different areas (S Alps, Taurus, Turkey, S Armenia, E Elburz, Iran, Central Iran and Central Afghanistan) the growth of domal stromatolites, thrombolites and other microbial structures. At the dawn of Triassic time, the carbonate factory was dominated by non-skeletal species and by microorganisms able to precipitate carbonate. True reef communities were absent in the earliest Triassic strata and they were locally substituted by microbialite mounds. In fact since reefs are composed of stenotopic organisms they are very vulnerable to changing environmental conditions, but not when they are formed by eurytophic organisms (HALLAM, 1994). In the following chapter, we will examine three cases showing different macro and microfabrics according to palaeoenvironmental setting: the Curuk Dagh profile, a shallow carbonate platform on the Gondwanian margin, and the Sovetachen and Vedi profiles, a pelagic carbonate ramp on the NW Cimmerian margin. We will give a comparison with the Abadeh area (Central Iran).

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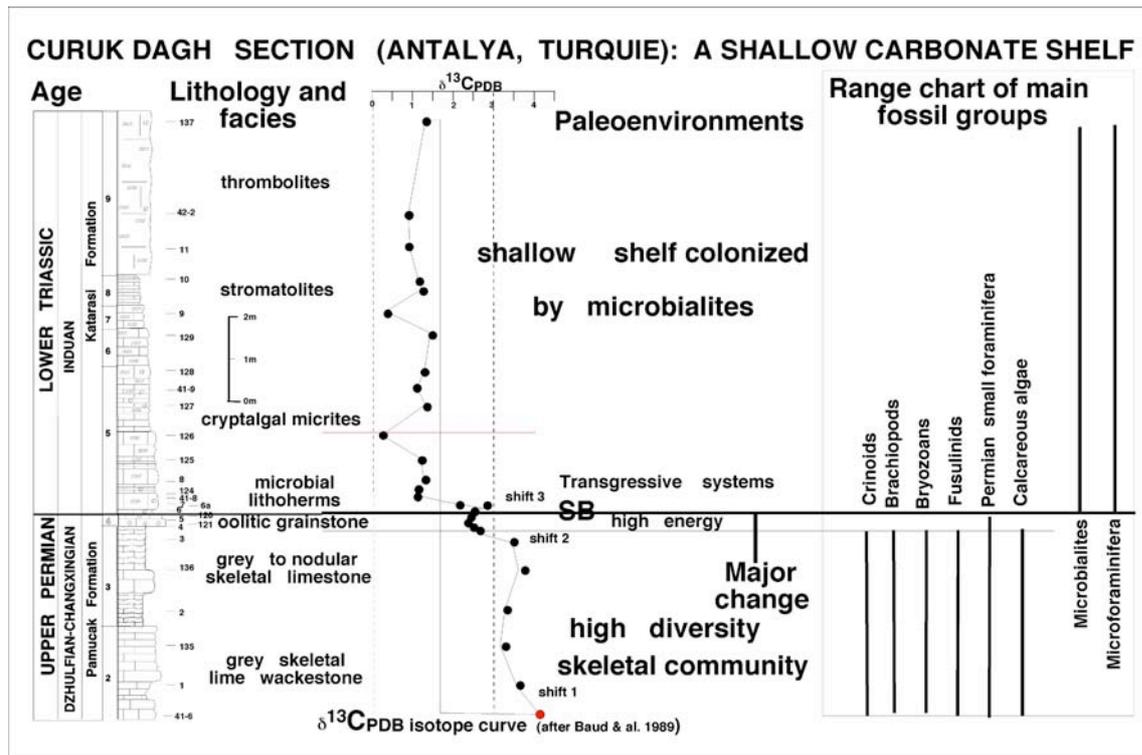


Fig. 1: detailed stratigraphy, $\delta^{13}\text{C}$ isotope curve, facies and paleoenvironments of the Permian-Triassic boundary section at Curuk Dagh (Antalya, Turkey)

2 MICROBIALITES ON A SHALLOW WATER CARBONATE PLATFORM

2.1 Setting

The Curuk Dagh section (fig. 1) is situated at about 15km Northwest of Kemer (Antalya nappe, SW Turkey). A general description is given in MARCOUX & BAUD (1986) and MARCOUX et al. (1986) and stable isotope results in BAUD et al. (1989). The upper Permian Pamucak Formation consists of dark, partly cherty, nodular lime wackestone (1 in Pl. 1/1) with three levels in the upper part rich in brachiopods. Based on fusulinids, small forams and brachiopods, the age is late Dzhulfian - early Changhsingian. This Formation is capped 30-60cm of oolitic grainstone (2 in Pl. 1/1) affected by vadose diagenesis. Directly above begins the Kokarkuyu Formation with the first level showing typical domal stromatolitic structures about 40-60cm in thickness (3 in Pl. 1/1). The following beds are thicker (up to 1m) and show thrombolite textures. Abundant lower Induan (lower Triassic) microforaminifera of the genera *Rectocornuspira*, *Earlandia*, *Cyclogyra* and *Ammodiscus* characterise these basal Kokarkuyu deposits. The stromatolitic-microbialites deposits are concentrated within the first 12m of the Kokarkuyu Formation. The main observed textures are described below.

2.2 Macro- and Microfabrics

In this section, microbialites form mounds up to 40cm thick. This type of microbialite can have a planar or stromatolitic (LLH-type like) growth formed by microbial laminae with fenestral fabric; it consists of regular alternations of layers of cements with dark micrite (Pl. 1/3). The intercalated layers are composed of dark fine grained bioclastic micrite containing peloids, ostracods, small forams, and/or clotted micrite with remains of twisted filaments and with pseudo-peloids, cemented by microsparite and sparite. The larger cavities are bordered by microspherulitic cements (*Rivularia*-like microbial colony) and completely infilled by micrite or peloidal micrite and/or fine grained bioclastic micrite (Pl. 1/4). Fringe cements (2 or more generations) and/or drusy cements infilled the remaining fenestral porosity. Small forams (*Cornuspira mahajeri*-*Rectocornuspira kalhori* assemblage) and *Earlandia* spp. are abundant and sometimes trapped within crystals, or accumulated parallel to the laminations (Pl. 1/5). Ostracods and gastropods are also present; the latter are often coated by several generations of fringe cements. Synsedimentary microfractures are present, infilled by the intercalated fine sediment and by fragments of the layers of cements. They testify to early cementation due to biochemical processes. The associated thrombolite type is composed of clotted micrite which shows traces of straight to undulose micritic filaments, sometimes forming oncoidal-type fabric (Pl. 1/6).

3 MICROBIALITES ON A PELAGIC CARBONATE RAMP

3.1 Setting

The Sovetachen and the Vedi profiles (Transcaucasia, S Armenia) are situated in Armenia, about 45 and 60km SE of Yerevan. They have been described by KOTLYAR et al. (1983) and by ASLANIAN (1984) and works on stable isotopes by BAUD et al. (1989).

In the Sovetachen section, red marls corresponding to the latest *Pseudotirolites* zone of the Permian overly the *Paratirolites* red nodular limestones. The following basal Kara Baglyar Formation (Induan, lower Triassic) consist of bedded platy lime mudstone in alternation with microbialites, and its base is dated as the lowermost Triassic *H. parvus* zone.

In the Vedi profile, overlying the *Paratirolites* limestones (1 in Pl. 1/2) are locally about 5 cm of red marls, corresponding to the latest *Pseudotirolites* zone of the Permian. The following basal Kara Baglyar Formation (Induan, lower Triassic) consists of 2m of domal microbial biolithite (2 in Pl. 1/2), overlain by bedded platy lime mudstones and microbial limestones. *H. parvus* also occurs in this section.

3.2 Macro and Microfabrics

In these two sections microbialite carbonate are present as isolated small patches associated with the more common thrombolite types.

Locally, microbialites form massive mud mounds up to 2m high (Vedi section). Laterally, lime mudstones frequently contain floatstones of fine and medium coarse debris sourced from the microbialite mounds.

In Sovetachen section they come in nodules within reddish and greysh wackestone/packstone. In some cases they represent reworked material coming from lateral *in situ* mounds: crystals are often broken, folded, and disoriented (Pl. 1/8); in other cases, the gradual passage between nodules and matrix and the crystal orientation suggest an *in situ* growing of the elongated crystals in small fan arrays within the muddy matrix.

In Vedi section, microbial textures exhibit the presence of elongated crystals in fan arrays; they form around single filaments or as bundles of parallel filaments (Pl. 1/7). Higher, bedded platy lime mudstones shows clotted micrite with recognizable cyanobacterial filament remains, sometimes arranged to form oncoidal type-like structures. Fenestral cavities are filled by sparitic cements. This type of microbialite usually encrust muddy sediments (wackestone and mudstone, rarely packstone) containing ammonoids, thin shelled bivalves, ostracods, small gasteropods and rare foraminifers.

Plate 1 The Lowermost Triassic Microbialites

Fig 1 Permian-Triassic boundary (top of GSA scale = 10cm) at the Curuck Dag section. 1 nodular limestone of the Pamucak Formation (top of level 3 in fig. 1). 2 "Tesero type" oolitical grainstone (level 4 in fig. 1). 3 Domal stromatolites (base of level 5 in fig. 1)

Fig. 2. Permian-Triassic boundary (top of the hammer) at the Vedi 2 section. 1 *Paratirolites* grey nodular limestones. 2 Base of the of 2m thick domal microbial biolithite

Fig. 3. Curuk Dag section - Microbial laminae showing fenestral fabric composed by regular alternation of layers of cements with dark micrite. Cements are formed by elongated crystals growing in fringes and/or in fan arrays. The intercalated layers are composed of dark fine grained bioclastic micrite containing peloids, ostracods, small forams, and/or clotted micrite and pseudo-peloids. Synsedimentary microfractures are present, infilling by the intercalated fine sediment and by fragments of the layers of cements. (Magnification x6)

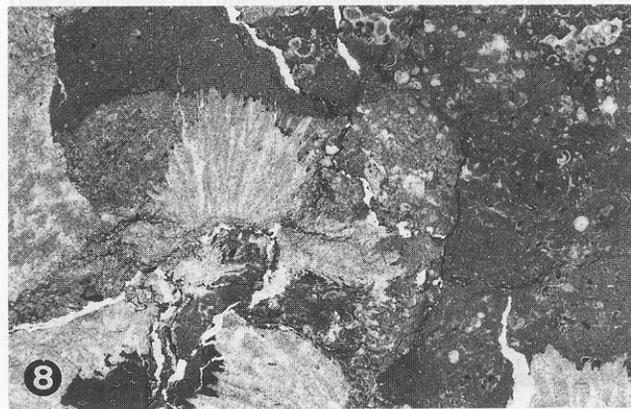
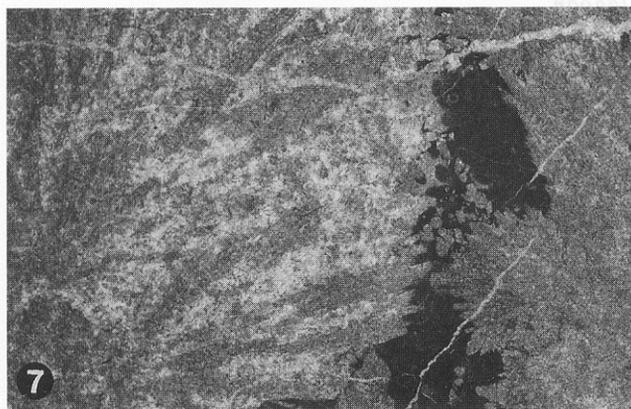
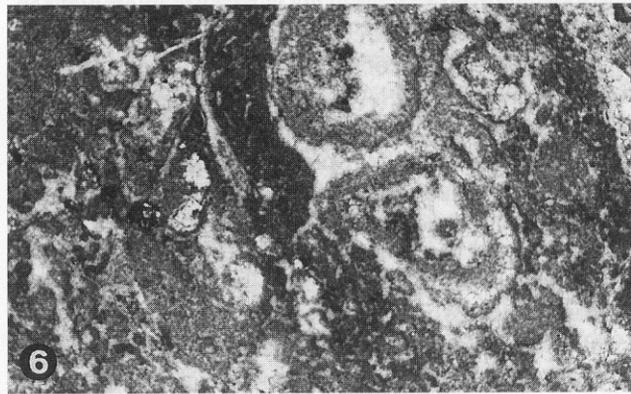
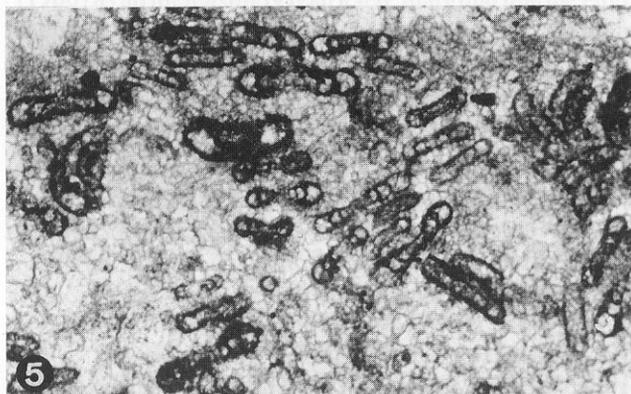
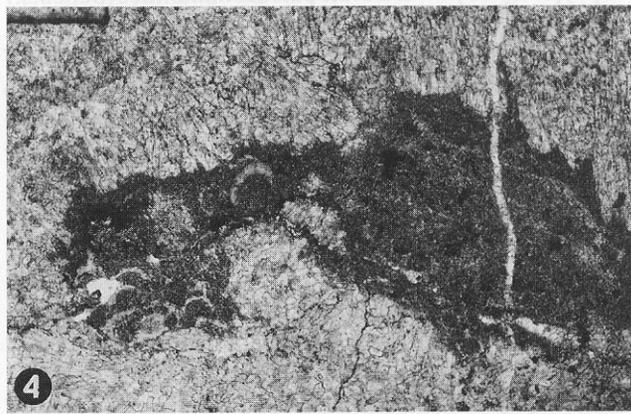
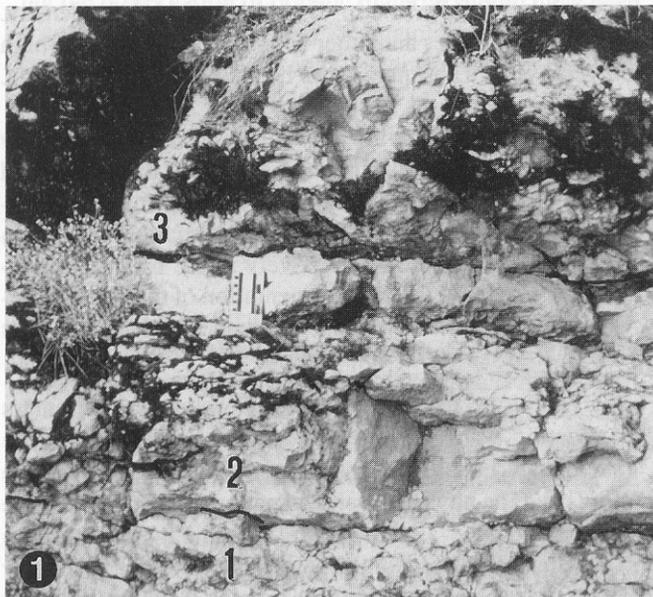
Fig. 4. Curuk Dag section - The larger cavities are bordered by microspherulitic cements (*Rivularia*-like microbial colony) and completely infilling by micrite or peloidal micrite and/or fine grained bioclastic micrite. (Magnification x18)

Fig. 5. Curuk Dag section - Small forams (*Cornuspira mahajeri*-*Rectocornuspira kalhori* assemblage) and *Earlandia* spp. are abundant and sometimes trapped within crystal or accumulated parallel to the lamination. (Magnification x85)

Fig. 6. Curuk Dag section - oncoïd-type masses formed by clotted micrite which shows traces of micritic filaments straight or ondulos. The sediment is cemented by microsparite to sparite.(Magnification x10)

Fig. 7. Sovetachen section - Small digitate microbial stromatolite, composed of alternating lamellae. They exhibit a primary or early diagenetic radial fibrous fabric, which presumably formed around single filaments or a bundle of sub-parallel filaments.(Magnification x10)

Fig. 8. Sovetachen section - Small microbial patches come in nodules within the reddish and greysh wackstone/packstone. They represent reworked material coming from lateral in situ mounds: crystals are often broken, folded, and disoriented.(Magnification x6)



4 COMPARAISON WITH ABADDEH (CENTRAL IRAN)

A detailed survey of the Permian-Triassic boundary beds in the Abadeh area (Central Iran) has been published by IRANIAN-JAPANESE R.G. (1981). As in Transcaucasia, there is a plurimetric thick zone of "algal biolithite" with *H. parvus* just above the latest Permian *Paratirolites* limestones. Profiles through the "stromatolites-thrombolites" unit are given in fig. 11 and microfacies illustrations in plate 5 of IRANIAN-JAPANESE R.G. (1981). We can emphasize the great similarity with the Sovetachen section which is located about 1500km to the NW. BAGHBANI (1993) call this basal Triassic unit the "Thrombolite zone". According to this author, this "Thrombolite zone" occurs also in the basal Dalan formation of the Zagros Range. This indicates the widespread occurrence of microbialite within the basal Triassic sediments.

5 MASS EXTINCTION AND THE CONQUEST BY DISASTER FORMS

Post-mass extinction aftermath and recovery periods may be times when metazoan-imposed barriers to the nearshore normal marine environments were removed, so that the opportunities for microbial communities to thrive in such settings might increase. Their presence indicates for the Early Triassic a period characterized by drastic diversity reduction and elimination of major taxa from shallow water carbonate environments. As eurytrophic and/or primitive groups, microbial communities emerged from stressed palaeoenvironments to recolonize the relatively vacant normal marine settings (r-selected generalists and opportunists). The main causes of their rapid and wide colonization by microbial communities of marine environments could be summarized as follows:

- The absence or great reduction in diversification of metazoans; it resulted in an ecologic relaxation caused by the diminution of natural selective pressures (predation and competition, VERMEIJ, 1987). In these palaeoecologic conditions biofilms and microbial mats could spread in environments where extreme conditions exclude most of the most evolved species. The absence of predation and of intense bioturbation allowed the preservation of microbial laminated structures (AWRAMIK, 1990).
- Decreased space competition for substrate colonization. Following the Permian-Triassic mass extinction, the proliferation of disaster forms should occur in the habitat where extinctions were most pronounced. Microbial communities were facilitated to spread in marine environments depauperated by invertebrate paleocommunities (SCHUBERT & BOTTJER, 1992).
- Low sedimentation rate, due to reduced amount of skeletal debris and biogenic carbonate sediments linked to the severe biotic crisis; it prevented the burial of microbial mats and it resulted in an increase of the organic matter concentration. The higher concentration of organic compounds on marine bottoms provides a highly satisfactory nutrient source for the growth of microbial communities (SCHULTZE-LAM et al., 1993).
- Major changes in atmospheric and water column oxygen content and/or sea water carbonate concentration; biofilms and microbial mats occur in environments where extreme physical and chemical conditions exclude most of the most evolved species. This is because microbial ecosystems form complex communities which have developed a wide spectrum of metabolic functions: autotrophic or heterotrophic species, aerobic or anaerobic species. These characteristics confer on the microbial world an extraordinary capacity to proliferate quickly in media-fluctuating physico-chemical conditions and to adapt themselves to a various kinds of environments.

The microbial conquest of the earliest Triassic marine bottoms had three main effects as immediate consequences.

- 1- Producing copious mucus and including filamentous microbes, microbial communities trapped and bound detrital grains, strengthen the cohesion of sediments and build biolaminated deposits and microbial mounds. The covering and the mucilage of the microbial mats stabilized sediments and favoured preservation of non-skeletal structures.
- 2- The microbial proliferation gave way to a oxygen-deficient environment. On the bottom of stagnant water masses, the microbial communities brought anoxic conditions which led, in extreme conditions, to the sedimentation of bituminous shales. In this sense, the early Triassic anoxic event (HALLAM, 1994) is a consequence of the mass extinction, not the cause. The earliest Triassic rocks are either completely devoid of benthos or have thin horizons containing fossils low in diversity and high in

density. Reef communities and other benthic communities of high diversity were absent in these deposits (Reef gap, FLÜGEL, 1994).

3- Inducing mineralizations the microbial community plays a leading part during the first steps of diagenesis and during fossilization, particularly by promoting the preservation of soft-bodied organisms. Precipitation of calcium carbonate is first induced actively in the bacterial membranes providing the early cementation of the entire structures (LEADBEATER & RIDING, 1986; SCHNEIDERMANN & HARRIS, 1985; REITNER, 1993; GALL, 1995).

The biotic recovery after the Permian-Triassic mass extinction was very slow and the full recovery of the skeletal carbonate factory did not occur until the middle Triassic.

The physico-chemical parameters influenced the nature and the availability of refuges and the composition of the taxa available for the new radiation. The entire early Triassic was characterized by simple, cosmopolitan, low diversity, low complexity paleocommunities (SCHUBERT & BOTTJER 1995). Diversification and regrouping of stable, ecologically complex associations does not really happen until stenotopic organisms emerge from refuge (k-selected organisms)

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