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# THE PERMO-TRIASSIC BOUNDARY IN THE ANTALYA NAPPES (WESTERN TAURIDES, TURKEY)

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CONTENTS



ABSTRACT

The Antalya nappes (western Taurides-Turkey) consist of several tectonic units which document the Southern Neotethyan paleomargin from the Arabo-African shallow shelf to the oceanic crust.

The Kemer Gorge Units (Upper Antalya nappes) show a full stratigraphical succession from Ordovician to Late Cretaceous. A carbonate platform regime appeared during Late Permian times and existed up to the early Middle Triassic. For detailed investigations on the Permo-Triassic boundary, two lithostratigraphic profiles have been selected: the Çürük dağ and the Kemer Gorge sections.

The main results presented in this paper are:

1) the Late Permian Pamucak Formation (Midian-Dzhulfian) consists of calcareous algae-foraminiferae bearing black limestones, locally rich in brachiopods, crinoids and bryozoae;

2) this black limestone is overlain by an oolitic grainstone. In the Çürük dağ section, the oolitic horizon is capped by a thin level of calcrete type; emersive conditions are also inferred by a strong diagenetic change within the oolitic deposit;

3) the first Early Triassic fossils, appearing within or above the oolitic grainstone, are microforaminifera and *Pseudoclaraia wangi* (late Griesbachian in age). In the Çürük dağ, a rich Early Triassic microforaminifera association seems linked to a microbial lime boundstone facies;

4) the overlying unfossiliferous lime mudstone, the oolitical thick bedded grainstone, the variegated marly limestone and the vermicular limestone facies are present not only in southern Turkey but seem constant through the entire peri arabo-african platform.

Striking similarities appear between the studied profiles and the Bellerophon-Werfen succession in the Southern Alps.

RIASSUNTO

Le falde di Antalya (Tauri occidentali, Turchia) sono composte da diverse unità strutturali, che rappresentano parte del paleomargine meridionale sudtetidiano, dalla piattaforma continentale Arabo-Africana alla crosta oceanica.

L'Unità della Kemer Gorge (Falde superiori di Antalya) contiene una successione stratigrafica completa dall'Ordoviciano al Cretaceo superiore. Un regime di piattaforma carbonatica si impostò durante il Permiano superiore e continuò sino alla porzione inferiore del Triassico medio. Sono stati scelti due profili per studiare in dettaglio il limite Permiano-Triassico: le sezioni di Çürük dağ e della gola di Kemer.

I principali risultati sono i seguenti:

1) La Formazione Pamucak del Permiano superiore (Midiano-Dzhulfiano) è costituita da calcari scuri con alghe calcaree e foraminiferi, localmente ricca anche in brachiopodi, crinoidi e briozoi.

2) Ai calcari scuri succedono calcari oolitici (oolitic grainstone). Nella sezione Çürük dağ questo livello oolitico è ricorperto da un sottile livello di calcrete. Condizioni di emersione sono pure deducibili da importanti modificazioni diagenetiche entro i calcari oolitici.

3) I primi fossili del Triassico inferiore, che compaiono entro o sopra i calcari oolitici, sono rappresentati da microforaminiferi e da *Pseudoclaraia wangi* di età tardo Griesbachiana. Nella sezione Çürük dağ, l'associazione ricca in foraminiferi del Triassico inferiore sembra collegata a una facies di «boundstone» carbonatici di origine microbiologica.

4) A queste unità seguono «mudstone» carbonatici non fossiliferi, «grainstone» oolitici in strati massicci, calcari marnosi policromi, e calcari bioturbati. Questa sequenza sembra presente non solo nella Turchia meridionale, ma anche nell'intera piattaforma continentale arabo-africana. Significative analogie sembrano esservi tra le sezioni studiate e la successione Formazione a Bellerophon-Formazione di Werfen nelle Alpi Meridionali.

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KEY WORDS: *Turkey, Taurus, Antalya Nappes, Permo-Triassic boundary, litho- and biostratigraphy.*

## INTRODUCTION

In south-western Turkey, the Antalya nappes (LEFEVRE, 1967), belong to the Western Taurus structural system (BLUMENTHAL, 1960; BRUNN *et alii*, 1971, 1976; GUTNIC *et alii*, 1979). The upper slices of the nappe edifice, referred to the Antalya Calcareous Nappes (A.C.N.) or Upper Antalya Nappes, are dominantly calcareous series. More precisely, the sections described in this paper which document the Permo-Triassic boundary belong to the Kemer Units of the A.C.N. (DELAUNE-MAYERE *et alii*, 1977; MARCOUX, 1979; RICOU *et alii*, 1985). The main trends of the lithostratigraphy are described in MAR-

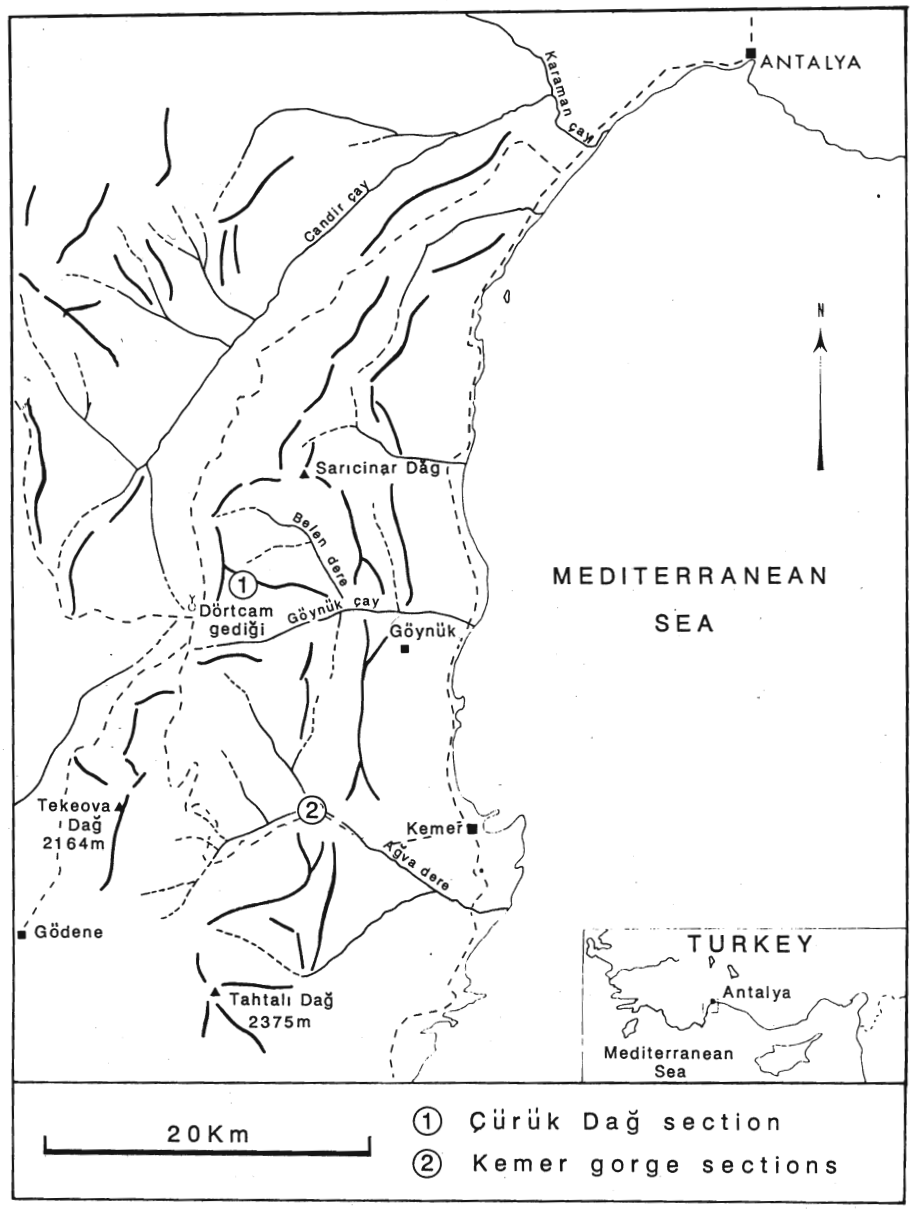


*Fig. 1* - Sketch map locating the Çürük dağ and Kemer gorge sections.

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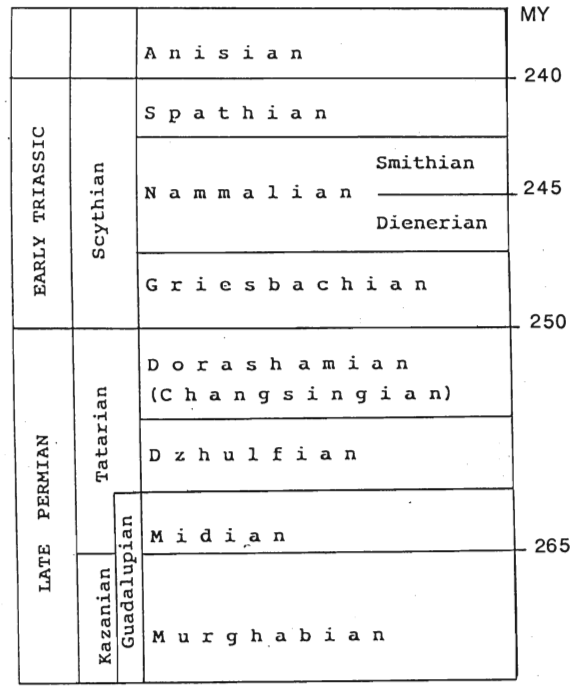
COUX (1979) and ARGYRIADIS *et alii* (1980). The Late Permian biostratigraphy of the Pamucak Formation type section has been previously described by LYS & MARCOUX (1978).

More recent publications give new data on the Late Permian and the Permo-Triassic boundary as observed in the Taurus belt and its adjacent arabic platform (ALTINER, 1981, 1984; FONTAINE, 1981; ÖZGÜL, 1984; TEKELI *et alii*, 1984).

This paper gives new data about the litho- and biostratigraphy of the Permo-Triassic boundary. Because the South Neotethyan continental margin was probably not initiated in Late Permian-Early Triassic times, we do not present any palinspastic reconstructions of the margin, inasmuch as this problem was largely debated in a special volume edited by DIXON & ROBERTSON (1985).

TABLE 1

*Stratigraphic chart used in this paper. Absolute age after* HAQ *et alii* (1987).




## THE ÇÜRÜK DAĞ STRATIGRAPHIC SECTION

The Çürük dağ section (fig. 1) has been sampled by one of us (J.M.) (fig. 2) and part of the micropaleontological content has been already described by LYS & MARCOUX (1978). This section has been resampled in detail (in 1986) and studied again to determine more precisely the Permo-Triassic boundary and the facies evolution.

The stratas analyzed belong to the upper part (40m) of the Late Permian Pamucak Formation defined in the same area by LYS & MARCOUX (1978) and to the lower part of the Early Triassic Kokarkuyu Formation defined near Pinarbasi in the Central Taurus by ALTINER (1981). The Pamucak Formation consists of a 400-600m thick succession of inner to outer shelf limestones ranging from the Murghabian (Capitanian) to the Dzhulfian (Late Permian) (table 1), corresponding to well-bedded dark and cherty limestones. This are rich in calcareous algae (*Gymnocodium* and *Permocalculus*) and small foraminifera (fig. 2). This limestones (1, 2-1, 3-2, 3-3 on fig. 3) are overlain by 12m of a mainly nodular black mudstone to wackestone with local accumulation of brachiopods shells. Calcareous algae (*Gymnocodium* and *Mizzia*) and foraminifera are also present in these beds (21 species, fig. 3). The brachiopods have been kindly examined by K. NAKAMURA who determined *Spinomarginifera helica* (ABICH) and *Sp. spinocostata* (ABICH) which range from Murghabian to Dzhulfian in age and *Orthothetina sp. A & B* found also in the Dzhulfian of Julfa (NW Iran) and which seems to be restricted to this stage (K. NAKAMURA written communication, 1986). The rich foraminiferal assemblage has been kindly determined by M. LYS for the general section (fig. 2) and by C. JENNY for the detailed profile (fig. 3). This assemblage corresponds to the youngest assemblage IV of ALTINER (1984), with the key species *Paradagmarita monodi* LYS, and *Ichtyolaria latilimbata* SELLIER DE CIVRIEUX & DESSAUVAGIE and *Cryptoseptida anatoliensis* SELLIER DE CIVRIEUX & DESSAUVAGIE. The microfauna is correlated with Midian to Dzhulfian assemblages older than the new proposition of ALTINER (1984). The topmost part (30 cm) of the Pamucak Formation (3-4 on fig. 3) shows a facies change from a low-energy skeletal wackestone to a high-energy skeletal grainstone. The biota with Late Permian foraminifera is roughly the same, but the skeletal debris (mollusks, brachiopods) are affected by a strong diagenetical alteration (solution-cementation). The skeletal grain-

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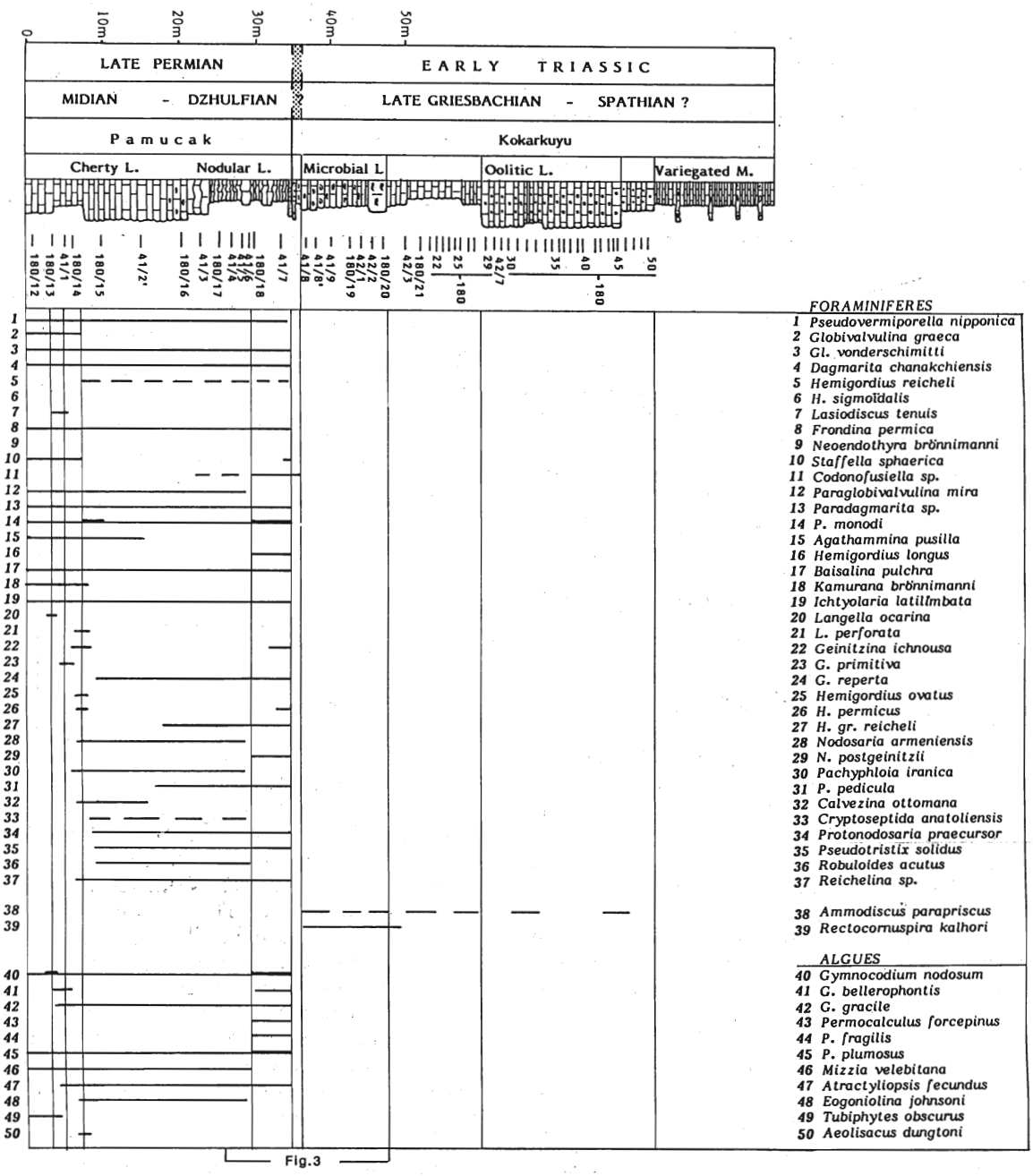


*Fig. 2* - Çürük dağ general section; fossils determination by M. Lys.

stone is followed by 30 cm (4-5 on fig. 3) of oolitical grainstone diageneticaly strongly altered, and by 20 cm of «dismicrite» interpreted as a paleocaliche horizon. These two last beds belonging to the base of the overlying Kokarkuyu Formation are characterized by a sudden and complete desappearance of the rich late Permian biota that correponds to an important facies change and a stratigraphic event.

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reflexion of the microstructure of the algal coenose (MONTY, 1976). Similar diagenetic structures have been illustrated by CROSS & KLOSTERMAN (1981) from the Wolfcampian of the Sacramento Mts (USA) and also observed by one of us (A.B.) in the first Triassic strata overlying the classical Dorashamian of Transcaucasia in the Vedi and Sovetachen sections (S.S.R. Armenia). Near the top of the microbial bindstone succession, the level 8-10 is very rich in the microforaminifera *Ammodiscus parapriscus*. It seems to be the result of a symbiose between the blue-green algae, bacteria and microforaminifera which is indicative of an unusual type of environment. The microfaunistic assemblage is apparently the same as in other stratigraphic sections of the Taurus belt (ALTINER, 1981) and as in the Elika Formation (STAMPFLI *et alii*, 1976) of North Iran. Its age is Late Griesbachian to Nammalian.

About 10m (42/3 to 180/27 on fig. 2) of well bedded dark euxinic calcilutites indicating starved conditions of deposition are overlying the microbial limestone. With an abrupt change, the next 20m (180/29 - 42/7 to 180/50 on fig. 2) consist of well sorted, high-energy oolitical grainstone containing very few skeletal grains and rare *Ammodiscus parapriscus*.

In the upper part of the Kokarkuyu Formation appear the typical facies of variegated marls and «calcaires vermiculés» (BAUD, 1976) with local lenticular edge-wise conglomerate, micro-gastropods and micro-bivalves accumulations.

## THE KEMER GORGE STRATIGRAPHIC SECTION

Two complementary sections coming from both the right and left sides of the Gorge (fig. 1) are analyzed. The first section has been sampled by one of us (J.M.) on its right (south) side. The microfossils have been analyzed by M. LYS: a list and a stratigraphic chart are given on fig. 4. The upper 50m of the Late Permian Pamucak Formation can be divided in three parts. The 30m lower thick one (A 110 and 111 on fig. 4) (shallow shelf limestone), consists of a succession of well-bedded skeletal wackestone to packstone rich in calcareous algae (*Mizzia*) and foraminifera (43 species). If a part of the deposits consists of high-energy, graded and laminated rythmites (distal tempestites), an other part is low-energy skeletal wackestone, showing a strong postdepositional bioturbation. The overlying 10m (B 112 to 113-1 on fig. 4) are breccias showing angular fragments of lime mud in a muddy matrix, and dense foraminiferal-calcareous algae packstone intercalations. The uppermost 8m (C 113-2 to 114-6 on fig. 4) of the Pamucak Formation consists mainly of a skeletal wackestone to packstone, rich in calcareous algae and small foraminifera. The key species *Nodosaria armeniensis* EFIMOVA, *Ichtyolaria latilimbata* SELLIER DE CIVRIEUX & DESSAUVAGIE and *Paradagmarita monodi* LYS are those of the assemblage IV of ALTINER (1984). The boundary with the Triassic Kokarkuyu Formation is faulted and tectonically discontinuous. The other side (northern) of the Gorge is not disturbed and has been sampled for this study (fig. 5).

From the uppermost 1 m of the Pamucak Formation, three samples (A7, 8 & 9, on fig. 5) are showing about the same facies as on the right side: dark, bioturbated algal - foraminifera wackestone to packstone. A great facies change occurs within the next 1 m (B10, B11 on fig. 5) thick bedded oolitical grainstone at the base of the Early Triassic Kokarkuyu Formation. The solution and recrystallization structures indicate a vadose diagenesis. We note a drastic reduction of the skeletal carbonate and the complete disappearance of diagnostic Permian microfauna and flora. The overlying 4 m (B12 & B13 on fig. 5) of the section consist of light sandy calcarenites with thin yellow marly lime mudstone intercalations. The calcarenite microfacies are resedimented oolitic wackestone to packstone with detrital quartz sand and glauconite grains. The Early Triassic microforaminifera *Rectocornuspira kahlori* BRÖNNIMANN *et alii* and *Cyclogyra* (?) *mahajeri* BRONNIMANN *et alii* appear in sample 13 (fig. 5).

About 5 m (C on fig. 5) of beige shales and marlstones separate this lower limestone of the Kokarkuyu Formation from the overlying light grey, 10 m (D14 to D19 on fig. 5) thick and well-bedded lime mudstones. Partly recrystallized, these mudstones are interrupted by rare rythmite deposits of thin shelled bivalves and microgastropods. In the middle part of the D level (fig. 5), we found a good specimen of *Pseudoclaraia wangi* (PATTE) of Late Griesbachian age, kindly deter-

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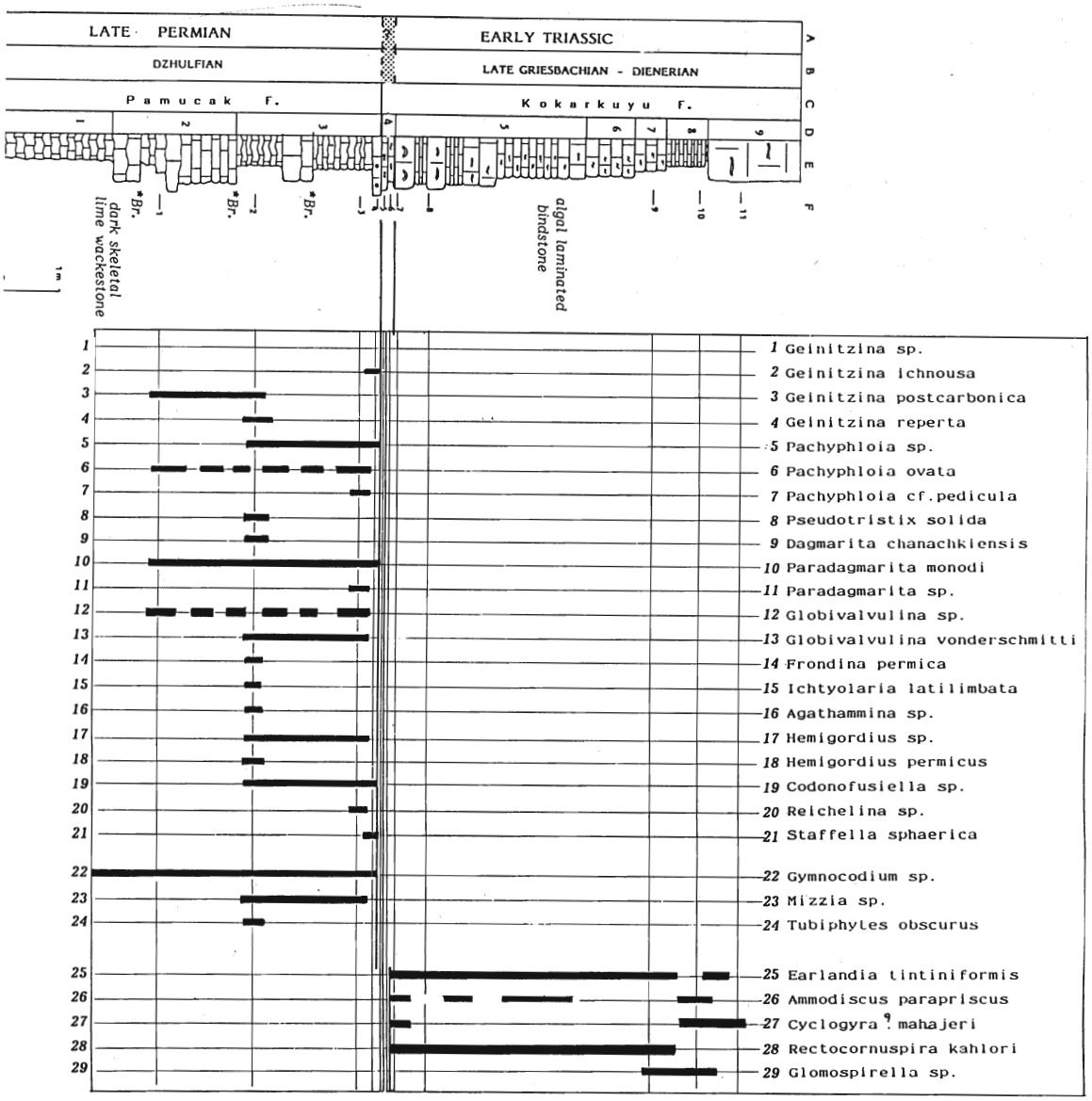


*Fig. 3* - Çürük dağ detailed profile of the Permo-Triassic boundary; fossils determination by C. JENNY (Br. = Brachiopods).

The facies of the next level (5.7 on fig. 3) consists of domal stromatolitic lime bindstone with a large number of Early Triassic microforaminifera of the genus *Rectocornuspira*, *Cyclogyra?*, *Earlandia* and *Ammodiscus*.

The Permo-Triassic boundary can be placed between the top of the skeletal grainstone horizon and the top of the «caliche» horizon (4 in fig. 3).

This cryptalgal facies forms the next 12 m of the section with a succession of domal structures, of flat laminated structures and also recrystallized micrite without apparent structure. This non skeletal bindstone, a testimony of a symbiosis between blue-green algae and bacteria, shows a very peculiar diagenetic change. It consists of the growth of calcitic radial fibrous fan arrays that is the

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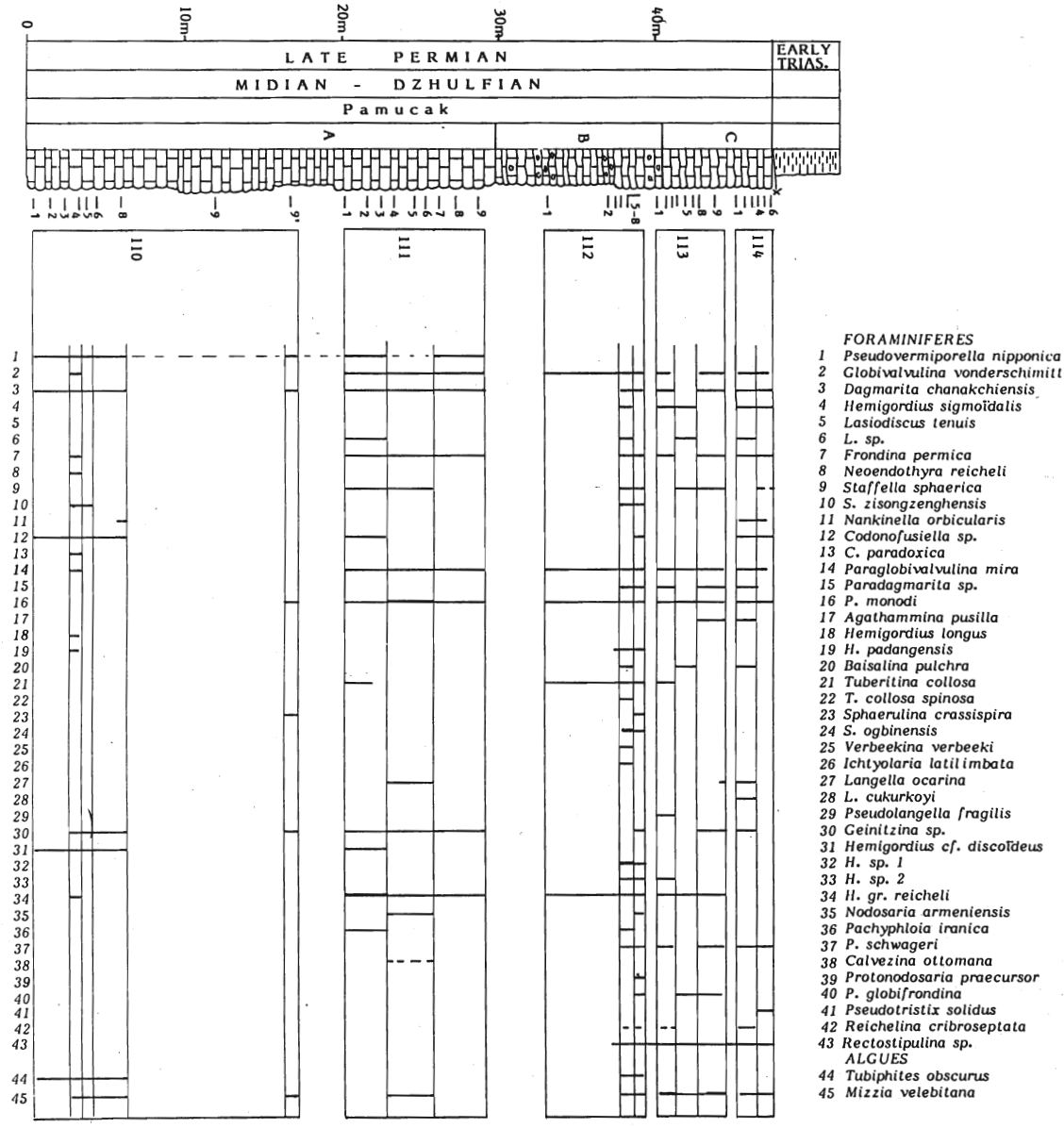


*Fig. 4* - Kemer Gorge: right (South) side section; fossils determination by M. LYS.

mined by YIN HONGFU. Next level E, a thin bedded lime mudstone with marly mudstone intercalations, is overlain by a thick succession of variegated shales (fig. 5).

## COMPARISON AND DISCUSSION

In detail, the two studied profiles show some differences. In the Çürük dağ section the upper part of the Pamucak Formation is characterized by a low-energy facies corresponding to the «biomicrites à algues» of ALTINER (1981). In the Kemer Gorge sections, the correlated deposits are mainly higher in energy with frequent graded skeletal packstones corresponding to storm-dominated sedimentation. The foraminiferal content is also more diversified.

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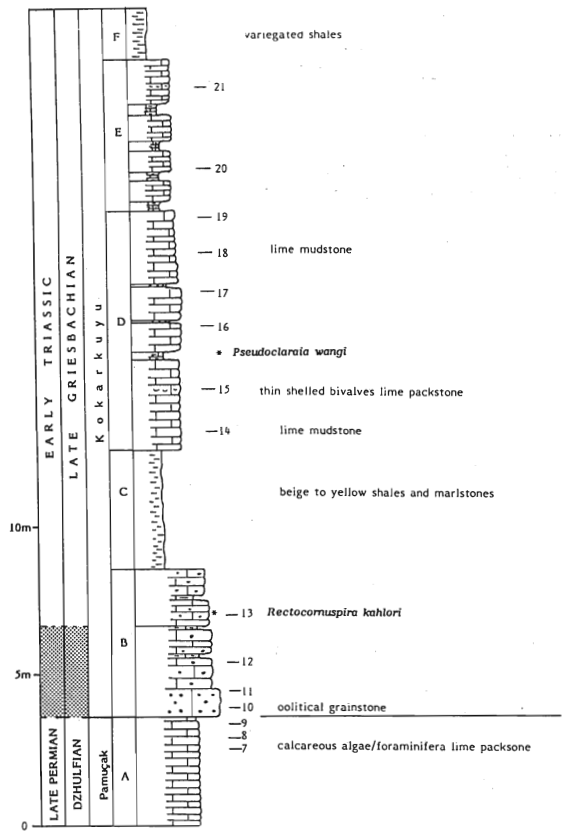


*Fig. 5* - Kemer Gorge: left (north) side section.

During the Late Permian, shelf deposits rich in calcareous algae and foraminifera occur all along the Taurides-Anatolides platform (ALTINER *et alii*, 1980; ALTINER, 1981, 1984; FONTAINE, 1981; ÖZGÜL, 1984; TEKELI *et alii*, 1984). In these two sections as in the South-Turkey Arabo-African platform, there are neither Permo-Triassic transition beds, nor transitional fauna. The highly fossiliferous calcareous Late Permian deposits are directly and abruptly overlain by oolitical grainstone with very poor and non-diagnostic fauna, and by microbial boundstone or graded oolitical packstone/grainstone with Early Triassic microforaminifera. This oolitical horizon marks the base of the Kokarkuyu Formation and seems present over a large area in South-Turkey (ALTINER, 1981, 1984; FONTAINE, 1981; ÖZGÜL, 1984; TEKELI *et alii*, 1984). It must be distinguished from the oolitical biomicrite containing Late Permian microfauna and flora described by LYS & MARCOUX (1978), that belongs to the underlying Pamucak Formation and from the thick oolitical grainstone deposits that appear higher up in the Kokarkuyu Formation (Çürük dağ section 1). There are no continuous oolitical deposits between the Late Permian and the Early Triassic as reported by LYS & MARCOUX (1978, p. 1418, coupe 4).

Strong diagenetical changes, with solution, late cimentation and recrystallization, indicating vadose influence or subaerial exposures, affect the oolitical deposits at the base of the Kokarkuyu Formation and the skeletal grainstone at the top of the Pamucak Formation in the Çürük dağ section.

In the two sections, the Early Triassic sedimentary evolution is slightly different. The depositional environment is more restricted in the Çürük dağ with 12 m of microbial bindstone rich in microforaminifera and more open in the Kemer Gorge with the *Pseudoclaraia wangi* macrofauna. Consequently, the position of the Kemer Gorge seems more distal with respect to the shelf sedimentation. For this section, we have no idea of the origin of the terrigenous quartz and clay influx in the late Griesbachian carbonate sedimentation.

The Permo-Triassic succession described here in South-Turkey, shows many similarities with the Bellerophon-Werfen succession in the Southern Alps, and in particular with the oolitical grainstone at the base of the Werfen Formation. But the main difference is that the sedimentation and the fauna changes are progressive and transitional in the Bellerophon-Werfen succession (BROGLIO LORIGA *et alii*, 1986), which is not the case in South-Turkey.

## CONCLUSIONS

The study of the Permo-Triassic boundary in 2 sections of the Antalya nappes (W. Taurides, SW Turkey) emphasises the following points:

1) The very rich foraminifera association of the upper part of the Late Permian Pamucak Formation belongs to the assemblage IV of ALTINER (1984), the youngest Permian assemblage observed in the Taurides. The age, as determined from brachiopods, is Dzhulfian and not Dorashamian as proposed by ALTINER (1984).

oolitical biomicrite containing Late Permian microfauna and flora described by LYS & brachiopods, is Dzhulfian and not Dorashamian as proposed by ALTINER (1984).

2) Significant facies changes occur at the base of the overlying Kokarkuyu Formation with drastic reduction of the skeletal carbonates content and deposition of high-energy oolitical grainstone. Strong diagenetic transformations with subaerial alteration or vadose solutions are the result of an unstable environment with shallowing of the sea. This regression stage is of very broad extension and has been found all over the Tethys (BAUD, 1985).

3) The oolitical grainstone horizon shows great similarities, and can be correlated, with the Tesero Member of the Southern Alps Werfen Formation.

4) In the Çürük dağ section, the algal laminated bindstone with diagenetic radial fibrous calcitic fan arrays, shows striking similarities with the microfacies of the basal part of the Early Triassic deposits of Transcaucasia (Vedi and Sovetachen sections) (A.B., unpublished data).

5) The discovery of a *Pseudoclaraia wangi* about 12 m above the base of the Kokarkuyu Formation in the Kemer Gorge section lets us assume a late Griesbachian age for the Early Triassic transgression. It corresponds to a large scale transgression well documented on the Gondwanian margin of Neotethys (BAUD & MARCOUX, 1982).

6) Microfauna of the lower part of the Kokarkuyu Formation is the same all along the Taurus platform; it is very similar to the microfauna of the Elika Formation (BRÖNNIMANN *et alii*, 1972; STAMPFLI *et alii*, 1976) in North-Iran and to the microfauna of the Mazzin and Siusi Members of the Southern Alps Werfen Formation (BROGLIO LORIGA *et alii*, 1986).

7) As in other Permo-Triassic sections of the Taurides, a stratigraphic gap comprising the Dorashamian and the Early Griesbachian seems to exist in the Antalya area.

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