

Microbiostratigraphy and Paleocology of Permo-Triassic Deposits in NW Iran (Kuh-e-Alibashi)

Parvaneh Rezaei Roozbahani , Wolfgang Mette

Abstract

Ostracod faunas from Upper Permian to Lower Triassic shelf deposits of Northwestern Iran were investigated with respect to their stratigraphical range, palaeoecology and extinction patterns. Faunal changes caused by sea level rise are recorded in lower and upper Dorashamian. The global End-Permian mass extinction event is recorded by a complete ostracod faunal turnover in the uppermost Dorashamian (*C. meishanensis* - *H-praeparvus* Zone) and disappearance of the deep neritic communities. The lithofacies and micropalaeontological data show that there was no shelf anoxia in studied section in Northwest Iran during the P/T Boundary (PTB) interval and earliest Triassic. Ostracod extinction patterns indicate that the Late Permian mass extinction was not directly affected by the onset of shelf anoxia. According to quantitative palaeobiogeographical results faunal exchange of neritic ostracods in the Palaeo- and Neotethys was very limited during the Late Permian. Occurrences of closely related species at the PTB and in the lowermost Triassic of Iran, Taurus and South China however, suggest that these regions were connected by shelf migration routes during this time interval.

Key words: Paleocology , Microbiostratigraphy , Permo-triassic, Alibashi, Iran

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Introduction

The Early Triassic record of these survivors has been extensively studied during the last years (Crasquin-Soleau et al. 2004 a,b, Crasquin-Soleau et al. 2005, Crasquin-Soleau and Kershaw 2005). Comparatively little is known about the Upper Permian ostracod extinction pattern and the question if their extinction was a short term and globally synchronous event or a more gradual process. This question can only be answered by means of more detailed biostratigraphical correlations and analysis of the ostracod range, palaeobiogeography and associated biotic and abiotic events. The Dzhulfian and Dorashamian of Northwestern Iran (Alibashi section) yielded diverse ostracod assemblages, which could be dated in detail by rich conodont faunas. Furthermore, a number of ostracod faunas from PTB interval and the lowermost Triassic are documented herein for the first time. Their ecology and biogeography may yield some important implications for the Late Permian mass extinction event.

Discussion

The studied section is located in Northwest Iran, 22km north of Zal village (text-fig. 1). This area belongs to the Sanandaj-Sirjan thrust belt, a geological province which extends in southeastern direction to Central Iran and the Gulf of Oman. The Sanandaj-Sirjan thrust belt is interpreted as part of the Cimmerian microcontinent (terrane), which was detached from the African-Arabian plate during the Permian. The studied section is a westward facing slope of 800m width exposing upper Dzhulfian to lowermost Triassic strata. The Upper Permian consists of the Jolfa Formation (Dzhulfian) which is 36.8m thickness and the Ali Bashi Formation (uppermost Dzhulfian-Dorashamian) of 15.7m thickness. The Jolfa Formation is conformably underlain by the Middle Permian Khachik Formation and the Ali Bashi Formation is conformably overlain by the uppermost Permian-Lower Triassic Elika Formation. The macrofossil assemblages and biostratigraphy of the Ali Bashi Formation and the Elika Formation were extensively studied in the Julfa section (Kuh-E-Ali Bashi). Recent conodont analysis proved that the studied section represents a biostratigraphically complete Permian-Triassic succession (Korte et al. 2004, Kozur 2005)

The Lithostratigraphy of Ali Bashi Formation

The Dorashamian to Lower Triassic strata have been investigated about 400m southeast from studied section. In its lower and middle part the Ali Bashi Formation consists of grey, grey-green and pink shales, marls and micritic limestones with few bioclasts (unit 1). The macrofaunas are more sparse and less diverse than in the Jolfa Formation and they reflect a drastic decrease of benthic elements in favour of ammonoids and nautiloids. Brachiopods, crinoids and bryozoa were rarely encountered. Microfossils are relative abundant but the faunas consist of only a few species of smooth-shelled ostracods, conodonts, fish teeth and rare

foraminifera. A lithologically uniform and cliff-forming unit of reddish wackestones with crinoids, ostracods and filaments of ammonoids which is well-known as *Paratirolites* Beds (unit 2) builds the upper part of the Ali Bashi Formation. The 0.1 to 0.3m thick beds are strongly bioturbated and nodular. Bedding planes are typically irregular and partly stylolitic. The depositional environment of the Ali Bashi Formation was a deeper well oxygenated shelf, probably below storm wave base. Indications of syndepositional reworking by water turbulence have not been found. In the upper part (*Paratirolites* Beds) the sedimentation rate was much lower than in the Jolfa Formation probably because of a greater distance to the shoreline and reduced input of siliciclastic sediment. A fossil analogue of this type of sediment is the *Ammonitico Rosso* Limestone of the southern Alpine region (Garrison and Fischer 1969). Recent sediments with similar characteristics are reported from the 300-800m deep slope of the Bahama platform (Mullins et al. 1980). Kozur (2005) reported the occurrence of a few *Acanthoscapha* and other *palaeopsychrosphaeric* ostracods and concluded a water depth slightly greater than 100m. According to the conodont biostratigraphy, the Ali Bashi Formation comprises the uppermost part of the Dzhulfian (*C. longicuspidata* Zone) and most of the Dorashamian (*C. hambastensis* to *C. hauschkei* Zone).

The Lithostratigraphy of Elika Formation

The lower Elika Formation at the studied section is subdivided into 4 distinct lithostratigraphical units. The lowermost unit 1 is the Boundary Clay, which consists of a 0.4m thick reddish-brown shale and a 0.1m thick greyish-white silty marl at the top. The conodont assemblages prove this unit to belong to the lower *C.meishanensis* – *H. praeparvus* Zone (Korte et al. 2004). The Boundary Clay is also well-known from the other Permian-Triassic sections in Northwest (Jolfa) and Central Iran (Shareza, Abadeh; Iranian-Japanese Research Group 1981). In the sections of Northwest Iran as well as in the sections of Central Iran (Shareza, Abadeh) reworked pebbles of the underlying *Paratirolites* Limestone occur at the base of the Boundary Clay (Kozur 2003, Kozur 2005, Korte and Kozur 2005). This reworking event was also proved biostratigraphically by reworked conodonts of the *C. praemeishanensis* Zone and *C.iranica* Zone. According to the latter author (Kozur 2003, p. 35) reworking occurred however “only on the scale of a few millimetres” at the studied section. Whereas the Boundary Clay is devoid of macrofossils a low-diversity ostracod assemblage with abundant *Indivisia* was isolated from the greyish-white marl. The deposition of the Boundary Bed reflects a much higher sedimentation rate compared to the upper *Paratirolites* Limestone which is strongly condensed (Kozur 2005). This was deduced from the lithostratigraphical thickness of the conodont zones compared to coeval sediments in South China (Meishan section). The base of the Boundary Bed was thus interpreted as a sequence boundary. The Boundary Clay is overlain by a 1.35m thick succession of pale reddish-grey, thin-bedded to very thin-bedded limestones (mud- and wackestones) (unit 2). They are partly flaser bedded and their weathering colour is brownish. The thin limestone beds are intercalated with marls a few centimeters thick. Some bedding planes are completely covered by densely packed *Claraia* or ostracods. The ostracod mass occurrences are often associated with micro-gastropods. Ammonoids were also recorded but they are very rare and indeterminable due to poor preservation. Furthermore, some of the micritic limestones are interspersed with filamentous algae. At the present section the PTB is marked by the first occurrence of *pustulose* ostracods which probably belong to *Praezabythocypris* sp.1. This horizon where the first *pustulose* representatives of *P. sp.1* occur corresponds stratigraphically to the base of the *H. parvus* Zone (Kozur, written communication, 1.5.2005), recorded in a parallel section (Korte et al. 2004, Kozur 2005). The Permian part of unit 2 belongs to the upper *C. meishanensis* – *H. praeparvus* Zone s.l.. Kozur (2005) established the *Merrillina ultima* – *Stepanovites mostleri* Zone for this stratigraphic interval. It is characterized by a cold water conodont fauna dominated by *Merrillina ultima*. The third lithostratigraphic unit is a 9.5m thick succession of planar and thin- to medium bedded grey micritic limestones (mudstones) which are almost devoid of fossils. A characteristic feature of this unit are several intraformationally reworked horizons. They contain intraclasts, peloids and spherical grains with concentric (microbial) fabrics which look similar to oncoids. The components with recrystallised concentric fabrics are 3 to 5mm in diameter; they are transported and partly fragmented. These limestones are succeeded by 6m of very thick-bedded grey finely laminated micritic limestones (unit 4) which are devoid of fossils. In the upper part of unit 4 occurs a 0.8m thick intercalation of thin- to medium bedded micritic limestones with layers of peloids, intraclasts and rounded components with concentric fabrics. The units 3 and 4 build a 0.8km long and prominent cliff which separates the Upper Permian from the younger Triassic strata at the studied section. According to the litho- and biofacies characteristics such as intraformational erosion and reworking, filamentous algal fabrics and mass accumulations of bivalves and ostracods on bedding planes, the lower Elika Formation was accumulated in an open marine environment above the storm wave base and within the photic zone. The uppermost part of the Boundary Clay probably accumulated at relative shallow water depths, possibly a few tens of meters. This

suggestion is supported by the composition of the conodont faunas, particularly the disappearance of pelagic conodonts in the upper Boundary Bed (H.Kozur, written communication, 24.5.2006) and the character of the ostracod assemblage.

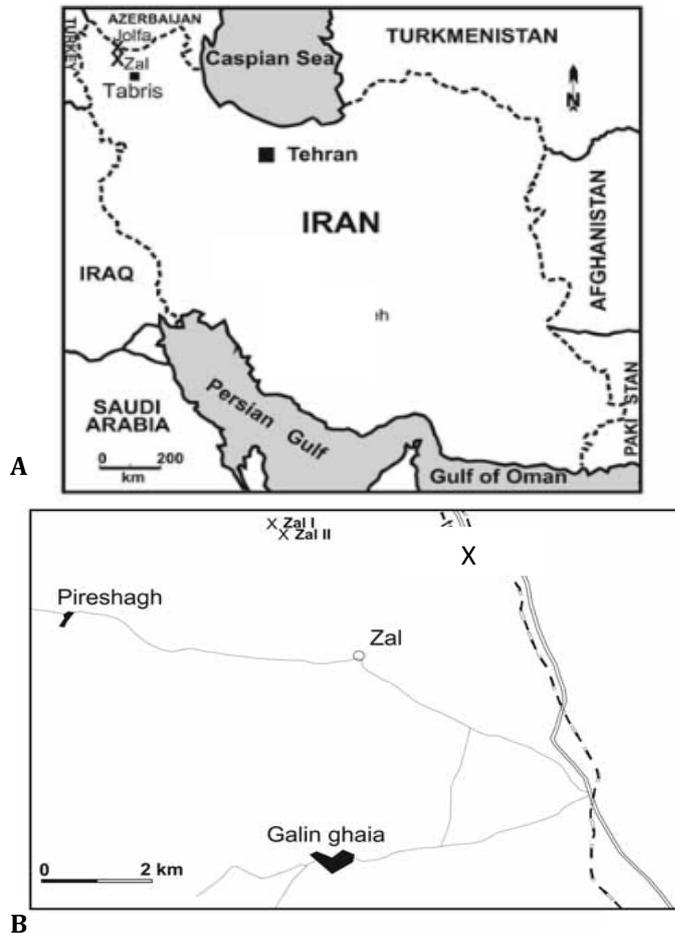


Figure 1

A: Location of the investigated section in NW Iran

B: Study area in detail.

Ostracods of the Ali Bashi Formation (Uppermost Dzhulfian - Dorashamian)

The faunas of the lower Ali Bashi Formation differ from faunas of the upper Jolfa Formation by the appearance of *Cladocopina* (*Discoidella* cf. *suprapermiana* Kozur 1985) *Permoyoungiella* (*Permoyoungiella* sp.) and a higher abundance of *Fabalitypris parva*. Furthermore, a new genus of the *Kirkbyoidea* (*Iranokirkbya*) occurs for the first time in the lower Ali Bashi Formation (Kozur and Mette 2006). The occurrence of *Permoyoungiella*, which was formerly only known from the Dzhulfian of the Bükk Mountains in Hungary (Kozur 1985), is the first record of this genus from the Dorashamian. In the upper Ali Bashi Formation a diversity decrease is recorded. The *Paratirolites* Limestone yielded only two species of *Bairdioidea* (*Bairdia* aff. *intermedia* Belousova 1965, *Fabalitypris parva*). *Hollinella* disappears in the lower *Paratirolites* Limestone. These faunistic changes clearly reflect a progressive deepening of the depositional environment. This interpretation is in accordance with the lithofacies of the Ali Bashi Formation and palaeoecological characteristics of the macrofauna which were noted above. According to conodont data from the Abadeh section (Kozur 2005) the deepening started at Abadeh in the lower-most Dorashamian and the greatest water depth was attained during the middle-upper Dorashamian with the deposition of the *Paratirolites* limestone (*C. bachmanni* Zone to *C. hauschkei* Zone). This corresponds to the ostracod data from studied section.

Ostracods of the Elika Formation (Uppermost Dorashamian -Induan)

The white silty marl of the upper Boundary Bed yielded a low diversity ostracod fauna which is probably the first record of an uppermost Permian post-extinction ostracod assemblage. The taxonomical composition is completely different from the faunas of the upper Ali Bashi

Formation (*Paratirolites* Limestone) and reflects a rapid faunal turnover in the uppermost Dorashamian. The assemblage is strongly dominated by a small and poorly preserved species of *Kloedellocopina* (*Indivisia* sp.2) accompanied by *Bairdioidea* (*Praezabythocypris* sp.1) and a few species of *Cypridoidea* (*Haworthina* spp.). This biotic change is due to the Late Permian global mass extinction event, and it was controlled by strong environmental perturbations. Ecological stress is indicated in the upper Boundary Bed by the high percentage (85%) and almost monotypic occurrence of *Indivisia* sp.2. Changes in the composition of conodont faunas in the Boundary Bed (disappearance of low latitude taxa, immigration of high latitude elements, disappearance of pelagic elements) are suggestive of a strong cooling event at the base of this horizon (Kozur 1998, 2003, 2005) and decrease in water depth at the top. Representatives of the *Kloedellocopina* are also often recorded from shallow marine palaeoenvironments. Ecological stress in the Late Permian was also concluded by Kozur (2005) from the very short duration of conodont zones calculated in the Upper Permian of NW and Central Iran. The strong climatic cooling in the latest Permian was probably followed in the Early Triassic by a dramatic warming event which is indicated by oxygen isotope analysis (Holser et al. 1989), palaeobiographical data (Kozur 1998, Wignall and Newton 2003) and sedimentological characteristics of palaeosoil deposits (Retallack 1999). Another faunal change occurs within the thin-bedded reddish-grey limestones at the PTB and in the lowermost Triassic. *Indivisia* sp. 2 disappears and *Praezabythocypris* sp. 1 becomes the dominant faunal element in the lower Induan (*H. parvus* Zone). Thus, it is the only species which obviously straddles the PTB in NW Iran. It is associated with other representatives of the *Bairdioidea* (*Praezabythocypris* sp. 2, *Liuzhinia* ? sp. 1 and sp. 2), *Cypridoidea* (*Haworthina* spp.) and *Platycopina* (*Sulcella* sp., *Cavellinidae*? sp.). The percentage of filter-feeders (*Platycopina*) of determined samples is between 19% and 22% which indicates, according to the model of Lethiers and Whatley (1994) a well oxygenated milieu. Similar ostracod assemblages with high percentages of *Praezabythocypris* sp. 1 are recorded from the same stratigraphical level at the Shareza section strongly suggesting oxic conditions.

Ostracod assemblages and Ecology

With respect to the percentage composition the Upper Permian and lowermost Triassic ostracod assemblages of Northwest Iran (studied section) are dominated by *Bairdioidea*, *Hollinelloidea* and *Cavellinoidea*. Although *Kirkbyoidea* are represented by relatively few specimens, they are among the most diverse superfamilies besides the *Bairdioidea*. Significant changes in the taxonomical and proportional composition of the faunas are recorded in the base of the Ali Bashi Formation and Elika Formation.

Ostracod Paleobiogeography

Palaeobiogeographical analysis of Upper Permian ostracods is difficult because the stratigraphical range patterns are still poorly known due to a lack of detailed biostratigraphical data and taxonomical problems. Some general trends, however, were found by means of a comprehensive quantitative biogeographical analysis for the Upper Permian of Palaeo- and Neotethys regions. This analysis has been carried out using the Jaccard and Simpson indices. The data were obtained from the following publications: Hungary: Kozur 1981, 1985a, 1985b, Zalani 1974; Turkey: Crasquin-Soleau et al. 2004a, 2004b; Greece: Crasquin-Soleau and Baud 1998; Israel: Gerry et al. 1987, Honigstein et al. 2005; Sicily: Kozur 1991; Arabia: Crasquin-Soleau 2003, Crasquin-Soleau et al. 2005; Russia: Belousova 1965; South China: Wang 1978, Chen and Shi 1982, Guan 1985, Shi and Chen 1987, Hao 1992a, 1993, 1994, 1996, Wei et al. 1998. From the Russian Platform only marine ostracods of Middle Permian age (Kazanian) are recorded. In the likewise Middle Permian Tatarian of the Russian Platform only non-marine ostracods are known (Schneider 1948, Schneider 1966, Kotchetkova 1968). For the palaeobiogeographic analysis of Lower Triassic ostracods data from Arabia (Crasquin-Soleau et al. 2005), Turkey (Crasquin-Soleau et al. 2004a, 2004b), South China (Zheng 1976, Wang 1978, Wei 1981, Hao 1992b, 1994, 1996, Crasquin-Soleau and Kershaw 2005), Western Australia (Jones 1970) and Pakistan (Sohn 1970) were available.

The Ostracods in boundary of Permo-Triassic

The ostracods from the P/T Boundary interval and the lower-most Triassic show a different picture than the Dzhulfian-Dorashamian assemblages. In the uppermost Dorashamian (*C. meishanensis* - *H. praeparvus* Zone s.l.) and the lower Induan (*H. parvus* Zone) of Northwestern Iran faunal links to the Lower Triassic of Western Turkey (Taurus) and South China are recorded by the occurrence of *Praezabythocypris*. This genus has originally been described from the Dzhulfian of Hungary (Kozur 1985). In the studied section it is represented by 3 species. The most abundant species is *Praezabythocypris* sp.1, which appears in the upper Boundary Clay. Mass occurrences of this species were recovered from the lower Elika

Formation. Almost monotypical assemblages of *P. sp.1* were also found in the Boundary Clay of Shareza in Central Iran. This species is conspecific or closely related to *Bairdiacypris ottomanensis* Crasquin-Soleau 2004 from the Lower Triassic (Induan) of western Taurus and *Bairdiacypris ventralis* Chen 1982 from the uppermost Permian of South China. *B. ottomanensis* Crasquin-Soleau 2004 was recently also reported from the Lower Triassic (*H. parvus* Zone) of South China (Crasquin-Soleau and Kershaw 2005). *P. sp.1* has the same carapace outline like *B. ottomanensis* and *B. ventralis* and also shows a strong variability in the lateral carapace inflation (sexual dimorphism?). In contrast to the species from Turkey and South China the Iranian species is accompanied by specimens with a pustulose ornamentation of irregularly arranged small tubercles. Since the carapace outline of the pustulose specimens is identical to that of *P. sp. 1*, it is questionable if they are conspecific or belong to different species. The two other species, *Praezabythocypris sp.2*, and *P. sp.3* appear stratigraphically a little later at the PTB and are less abundant than *P. sp.1*. *P. sp.2* differs from the latter species in the stronger convex dorsal margin and stronger lateral carapace inflation. Some specimens of *P. sp.2* do also show a pustulose ornamentation. *P. sp.3* differs from *P. sp.1* in the posterior angulation of the dorsal margin and the laterally compressed anterior and posterior margins. Furthermore, *P. sp.2* and *P. sp. 3* do not show variability in lateral carapace inflation. Mass occurrences of *P. sp. 1* after the Late Permian mass extinction and the co-occurrence of closely related species in contemporary deposits of widely separated Tethyan regions suggest these taxa to be opportunistic forms which were able to tolerate strong ecological stress and populate extensive shelf areas in comparatively short time. Ecological stress is particularly indicated by the sudden appearance and disappearance of ostracods with pustulose ornamentation at the PTB. Furthermore, the palaeobiogeographical distribution of *P. sp. 1* and related neritic ostracod species is consistent with modern palaeogeographical reconstructions which also show that the terranes of Sandandai-Sirjan and Taurus were part of a single microcontinent (Cimmeria) (Stampfli and Borel 2002). The presence of these species in South China shows that Cimmeria was probably also connected with South China by shelf habitats during the latest Permian and Early Triassic. It seems therefore conclusive that these regions constituted a larger Tethyan terrane at that time. Ostracod biogeographical links to the uppermost Permian of Iran are also recorded from the uppermost Permian of Oman (Crasquin-Soleau et al. 2005) and the Lower Triassic of Pakistan (Sohn 1970). In these regions 2 species occur which are at least closely related or possibly conspecific with *Cavellinidae* ? sp. from Iran. The Iranian species was left under open nomenclature because of the low number of specimens and inaccessibility of internal features. Its carapace morphology and outline however is, very similar to *Kloedenellitina sp.1* Crasquin-Soleau 2005 and *Reubenella* ? sp. Sohn 1970.

Conclusions

Ostracod faunas from Ali Bashi Formation in Northwest Iran display gradual variations in their taxonomical composition and diversity decrease during the lower Dzhulfian (*C. leveni* Zone), the lower Dorashamian (*C. hambastensis* Zone) and in the upper Dorashamian (*C. changxingensis* – *C. deflecta* Zone). These changes are accompanied by litho- and biofacies trends which reflect deepening of the shelf environments. Palaeoecological interpretations of Dorashamian ostracod assemblages suggests that very high percentages of filter-feeding taxa can occur in normal marine settings and are not necessarily related to oxygen deficiency, when the fauna is diverse. In the uppermost Permian (*C. meishanensis* – *H. praeparvus* Zone) of Northwest Iran the global mass extinction event is recorded by a complete ostracod faunal turnover. The microfaunas of the Boundary Clay indicate strong environmental perturbations such as rapid shallowing and strong temperature decrease but they do not reflect oxygen deficiency. Ostracods from the lower Elika Formation also prove that Northwest Iran was not effected by shelf anoxia at the PTB and during the earliest Triassic (*H. parvus* Zone). Similar assemblages from Central Iran suggest a well oxygenated milieu during formation of digitate carbonate crusts at the PTB and in the earliest Triassic. The mass extinction in the Late Permian of Iran was thus not causally linked with the onset of shelf anoxia. The Upper Permian ostracods from Northwest Iran and other Palaeo- and Neotethys regions have remarkable few taxa in common. Palaeobiogeographical data from post-extinction ostracod assemblages suggest more intensive faunal exchange and shelf migration routes between Iran, Western Turkey and South China during the PTB interval and in the earliest Triassic. The common and widely distributed representatives of *Praezabythocypris* are probably opportunistic taxa which were able to colonize the extensive shelf habitats in a comparatively short time interval.

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Parvaneh Rezaei Roozbahani, department of Geology, Khorramabad Branch, Islamic Azad University, Khorramabad, Iran.

Wolfgang Mette, Institute of Geology and Paleontology, University of Innsbruck, Innrain 52, 6020 Innsbruck