Global warming and environmental changes across the Permian-Triassic boundary in Iran

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Abstract

The end-Permian mass extinction event represents the most severe biodiversity loss of the Earth history which causes are still controversial. The present study aims to contribute to this debate providing data from two well-known and significant key sections for investigating the global phenomena occurred at the PTB: Abadeh (Central Iran) and Zal sections (NW Iran), continuously exposed for thousands of metres, spanning from Cisuralian to Lower Triassic. Robust multidisciplinary data from literature based on biostratigraphy (e.g., ammonoids, conodonts, brachiopods, bivalves, foraminifera among others) and chemostratigraphy (e.g, stable and radioactive isotopes) well constrain the PTB. The whole Permian sequence deposited under a transgressive event, linked to the opening of Neo-Tethys ocean along the eastern margin of Gondwana. In this scenario, Northwestern and Central Iran were part of the Cimmerian terranes which detached from northeastern Gondwana (Arabian margin), progressively drifting northward with the spreading of Neo-Tethys. In the two sections, the basal units are represented by Cisuralian siliciclastic deposits with thin- to thick-bedded sandstones and minor conglomerates and siltstones (Vazhnan and Dorud formations at Abadeh and Zal, respectively). The overlying stratigraphic units encompassing the Permian-Triassic interval, investigated for the purpose of this study, may be schematized, in ascending order, as follows. At Abadeh section, the Wordian-Capitanian Surmaq Fm (782 m thick) is represented by thin- to thick-bedded dark limestones and dolostones with chert intercalations. This unit is paved by the Capitanian Abadeh Fm (446m thick) which consists of fossiliferous massive limestones alternated with muddy limestones and rarer marly limestones. They pass upwards to dark shales interbedded with limestones and cherty limestones, followed by dark thick-bedded bioclastic limestones in the uppermost part. The overlying Lopingian Hambast Fm (35 m thick) comprises alternation of thin- bedded shales/marls and bioclastic limestones frequently containing ammonoids and conodonts. Brachiopod bearing beds are present at the lower part. At the Zal section, the Wordian Gnishik Fm (350 m) records the start of the carbonate sedimentation, being composed of dark-grey thin- to thick-bedded bioclastic limestones with marl and shale intercalations increasing at the boundary with the overlying late Wordian-early Capitanian Arpa Fm (320 m). This latter comprises light-grey medium- to thick-bedded bioclastic limestones grading to the Capitanian-earliest Wuchiapingian Khachik Fm (360 m) characterized by thin- to medium-bedded limestones and cherty limestones with shale intercalations. Nodular and marly limestones interbedded with grey to reddish shales dominate the early Lopingian (Wuchiapingian) Julfa Fm (33 m).

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This is capped by the latest Permian (Changhsingian) Ali Bashi Fm (16 m) marked by a lower member (Zal Mb, 11 m thick), mostly consisting of red shales, followed by the *Paratirolites* Limestone Mb (5 m thick) with abundant ammonoids. At both sections, a thin (about 0.28 and 0.90 m, in Abadeh and Zal, respectively) reddish-greenish clay interval (Boundary Clay *Auctt*), represents the base of the Elikah Fm, marking the end-Permian mass extinction event. It is overlain by earliest Triassic yellow-grey, thin-bedded marly limestones, containing abundant bivalves and microbial bindstones (*Claraia* beds). The PTB lies at the base of this unit, as indicated by the first occurrence (FO) of the conodont *Hindeodus Parvus*. Based on integrated facies, microfacies, palynofacies and biostratigraphic data, the main results of this study are: 1) the depositional setting of the Permian units can be referred to homoclinal mixed carbonate-siliciclastic ramps evolving to more distal and deeper conditions upwards, characterized by different siliciclastic input according to their distance from the land masses; 2) the demise of carbonate sedimentation is characterized, in both cases, by a marked increase of fine siliciclastics approaching the PT transition; 2) the Lower Triassic microbial bindstones of the Elikah Fm represent the first stage of recovery of marine level-bottom communities in the immediate aftermath of the end-Permian mass-extinction; 3) the stacking facies and palynofacies vertical changes and microflora indicate a global warming event across the PT transition, related to the onset of the Siberian Traps, a potentially massive source of CO2; 4) a sequence stratigraphic interpretation is attempted and framed in the Permian-Lower Triassic paleogeographic scenario of this sector of the Gondwana domain. The overall results highlight the role of both global and regional climate changes as main controlling factors for the relative sea-level changes and, in turn, for the evolution of the depositional settings.

Keywords: Permian, Triassic, stratigraphy, paleoclimate, Iran