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Palynostratigraphy of Middle Cambrian to lowermost Ordovician stratal sequences in the High Zagros Mountains, southern Iran: Regional stratigraphic implications, and palaeobiogeographic significance

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Abstract

A palynological investigation of Cambro-Ordovician stratal sequences in the High Zagros Mountains of southern Iran permits the definition of a series of successive acritarch assemblage zones of chronostratigraphic significance, much improving the current knowledge of the Lower Palaeozoic stratigraphy of this important area for oil exploration. The five acritarch assemblage zones can be readily correlated with previously established palynostratigraphic schemes constrained by co-occurrence of independent age evidence, confirming the utility of organic-walled microfossils for the detailed biostratigraphic characterization of sedimentary units. The proposed biozonation will facilitate accurate dating of the southern Iranian Cambrian sequences during future drilling of deep test oil wells. Acritarch assemblage zone I (Middle Cambrian), occurs at the base of Member C of the Mila Formation; assemblages zone II (late Middle to earliest Late Cambrian) extends through the middle and upper part of the same lithostratigraphic unit; zone III (early Late Cambrian in age) characterizes the lower part of the Ilebeyk Formation; zone IV (middle Late Cambrian up to Cambrian/Ordovician transitional levels) occurs in the middle and upper part of the Ilebeyk Formation; finally, acritarch assemblage zone V ranges through the basal part of the Zardkuh Formation and proves an early Tremadocian age for the latter unit. The Mid-Late Cambrian acritarch associations show a marked Avalonian palaeobiogeographical affinity, also sharing a high proportion of taxa with typical Baltican and North Africa–Gondwanan assemblages; on the other hand, they are clearly different from known Laurentian (North America) fossil microphytoplankton suites. These results are in general agreement with current palaeogeographical models which place Avalonia, Baltica, and the North African part of Gondwana, all at relatively high southern palaeolatitudes, in contrast with the sub-equatorial position of Laurentia. However, the presence of many typical "Avalonian" taxa in the Iranian Mid-Late Cambrian assemblages would suggest a closer position of Iran to Avalonia than currently envisaged. The observed breakdown of acritarch biogeographic differentiation in earliest Ordovician times possibly represents a major disruption of oceanic current patterns and a lessened palaeolatitudinal thermal gradient.

Keywords: acritarchs; biostratigraphy; Middle-Late Cambrian; Tremadocian; palaeobiogeography; High Zagros Mountain Range; Iran

1. Introduction and historical perspective

An almost complete sequence of Cambrian through Lower Ordovician strata is exposed in the Zagros Basin, southern Iran, cropping out in three main localities: Zardkuh (Tang-e-Ilebeyk section), Kuh-e-Garreh (Tang-e-Darreh Doon section) and Kuh-e-Dinar (Tang-e-Putak section), immediately southwest of the Zagros Crush Zone, a zone of intense faulting and tectonic disturbance (Fig. 1). These remote areas are very difficult to access and were first surveyed during early expeditions by J.V. Harrison in the years 1930–31 (Bakhtiary mountains survey; Harrison et al., 1932) and in 1933–34 (Kuhgalu country survey; Harrison et al., 1935), and later by A. Setudehnia and A. Kheradpir, in 1971–75. These early surveys included the geological mapping, lithostratigraphic description, and preliminary, low resolution, biostratigraphic dating of the Palaeozoic units in these areas, which are known for their potential as important

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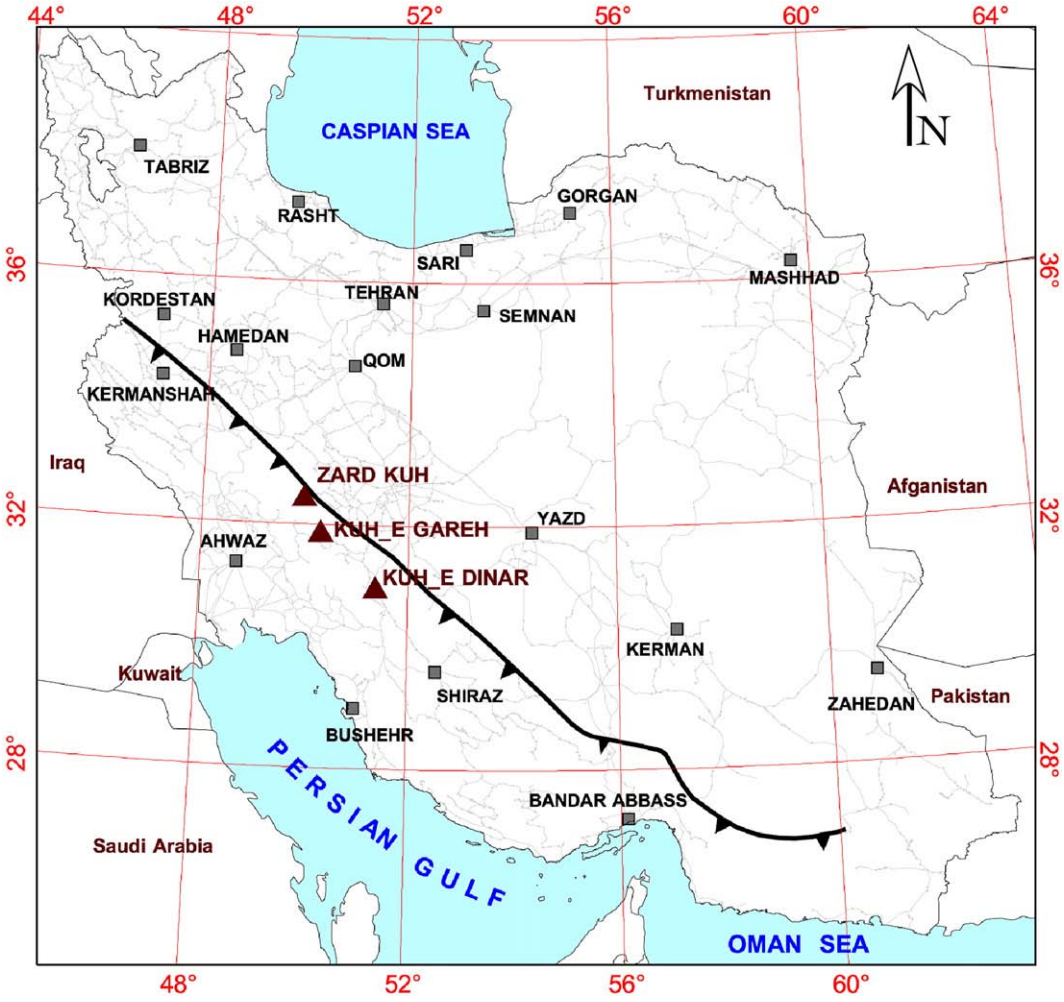

Fig. 1. Geographic setting and location of study sections.

hydrocarbon reservoirs. Before the present study, the stratigraphic relationships between the Mila Formation, the underlying Zaigun and Lalun formations and the overlying Ilebeyk and Zardkuh formations were imprecisely known.

The Early Palaeozoic (Cambrian–Ordovician) palaeogeographic position of the terrane or terrane assemblage comprising the Iranian plate is also uncertain; palaeomagnetic data are not available in this area, and (macro)palaeontological data are still scarce or not adequately discussed in terms of taxonomic and palaeogeographic significance (Popov, pers. comm., 2007). Although a certain consensus seems to exist on the fact that Iran has been part of the Gondwana palaeocontinent at some time during the Palaeozoic (Scotese and McKerrow, 1990 and references therein), the few and old available previous reports on Cambrian faunas of the study area (e.g., King, 1930) refer to a clear non-European faunal affinity, *de facto* excluding a peri-Gondwanan Cambrian palaeoposition for the Iranian terrane. One of the authors of the present paper (Ghavidel-syooki) investigated the Zardkuh area (and in particular the Tang-e-Ilebeyk section) in 1982, collecting a complete series of palynological surface samples from the Zardkuh and Ilebeyk formations in order to improve the biostratigraphic datings and existing plaeobiogeographic concepts. Herein, we report the results of such palynological analyses with the aims of:

1) refining the biostratigraphic dating of the Mila, Ilebeyk and lowermost Zardkuh formations;
2) establishing a local palynozonation that may be used for the identification of the Cambrian–Ordovician formations in the subsurface of southern Iran during oil exploration deep drilling test wells in the future;
3) assessing the palaeobiogeographic significance of southern Iranian Cambrian–Ordovician palynological assemblages.

2. Regional stratigraphy

In the study area (Fig. 1), the Precambrian and Lower Palaeozoic strata have been subdivided into the Barut, Zaigun, Lalun, Mila, Ilebeyk, Zardkuh, and Seyahou formations. The present analysis concerns only three of these formations (Mila, Ilebeyk, Zardkuh; Fig. 2), but we give here a brief description of all the pre-Permian units cropping out in this little known area of Iran.

The Barut Formation (Upper Proterozoic–lowermost Cambrian) is well-exposed in Kuh-e-Dinar where it reaches 150 m in