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Comment on "Revision of the age of the Qom Formation in the Central Iran Basin, Iran" by Zhu et al. (Journal of Asian Earth Sciences, 2007, vol. 29, 715–721)

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1. Introduction

In the paper "Revision of the age of the Qom Formation in the Central Iran Basin, Iran", (Zhu et al., 2007) presented a new age model for the Qom Formation in Central Iran. Based on benthic foraminifers, ostracods, dinoflagellate cysts and calcareous nannoplankton assemblages from two sections in the Qom–Kashan area (sections 8 and 18 in Zhu et al.), the age of the Qom Formation was assigned to the Eocene. This is in clear disagreement with biostratigraphic results of many previous and subsequent studies, which all identified a middle Oligocene to Early Miocene age (e.g., Stöcklin and Stetudehnia, 1971; Rahaghi, 1973, 1980; Chahida et al., 1977; Schuster and Wielandt, 1999; Daneshian and Dana, 2007; Reuter et al., 2007). In the course of several research projects on Late Oligocene–Early Miocene circum-Mediterranean and Western Indo-Pacific palaeobiogeographic relations, we also studied a variety of fossil groups (planktic and benthic foraminifers, corals, gastropods, bivalves, echinoids, calcareous nannoplankton) from the Qom Formation. The studied sections are located in the Qom Basin as well as in the Esfahan-Sirjan Basin, amongst them the type section of the Qom Formation near Qom, which is close to section 18 of Zhu et al. (2007). The section SW Kashan close to the village Chalhegareh is equivalent to section 8 of Zhu et al. (2007). All studied fossil groups revealed an Oligocene–Miocene age, which is consistent with earlier studies as well as with the geodynamic development of the Middle East region and the sea-level curve of Hardenbol et al., (1998; Schuster and Wielandt, 1999; Schuster, 2002a,b; Harzhauser, 2004; Harzhauser et al., 2007; Reuter et al., 2007). In contrast, the biostratigraphic interpretations of Zhu et al. (2007) suffer from three clear shortcomings (literature data, taxonomy, sedimentology) that may explain their divergent age assignment for the Qom Formation. Nevertheless, we fully agree with Zhu et al. (2007). on the importance of a reliable age model for the Qom Formation. This would be a basic requirement for the study of the geodynamic evolution of the area, to elucidate the biotic relationships between the Mediterranean and western Indo-Pacific provinces, as well as for oil and gas exploration in Central Iran. All these aspects persuaded us to write this comment.

2. Previous literature

A general key criticism of the paper of Zhu et al. (2007) is that the authors fail to adequately consider the abundant previous literature on the Qom Formation that all assumed an Oligo–Miocene age. These data go back to the first half of the 20th century (e.g., Kuhn, 1933; Furon and Marie, 1939) and became more numerous and more elaborated in the second half (e.g., Furrer and Soder, 1955; Gansser, 1955; Abaie et al., 1964; Bozorgnia, 1966; Rahaghi, 1973, 1980; Chahida et al., 1977; Okhravi and Amini, 1998; Schuster and Wielandt, 1999). All these papers, along with the most recent ones (e.g., Schuster, 2002a,b; Harzhauser, 2004), represent sound studies with seriously documented data which cannot be simply neglected when dealing with this topic.

3. Taxonomy

The major problem of the biostratigraphic interpretation in Zhu et al. (2007) is that most of their taxonomic assignments are not meaningful for a reliable stratigraphy because they typically remained at genus level. Also at species level the frequent use of the attributes "aff." and "cf." reflects many uncertainties, conspicuously concerning foraminifers, for which no single species is unequivocally identified. Hence, the new stratigraphic assignment of the Qom Formation is based on affinities to Eocene faunal/floral assemblages from few localities predominantly located in Xizang (China) and unfortunately published in the Chinese language (Huang, 1975; He et al., 1976; He, 1991; Zhong, 1992). Even so, the similarities between the fossil assemblages from Iran and

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China remain only vaguely indicated because of the imprecise taxonomic identifications. The authors themselves even stated that the stratigraphic ranges of most taxa include also Oligocene and often even Miocene or younger records when localities outside China are taken into account. This applies for foraminifers and most ostracods (except for *Bairdia montiformis* and *Cytherella jonesiana*) as well as for dinoflagellates and calcareous nannoplankton (except for *Reticulofenestra dictyoda* (lower and middle Eocene: NP 12–16)) (Bramlette and Wilcoxon, 1967; Drugg and Loeblich, 1967; Bukry and Percival, 1971; Perch-Nielsen, 1985; He and Wang, 1990; Williams et al., 1993; Stover et al., 1996; Bown, 1998).

Moreover, the report of a crinoidal reef from the top of the f-Member limestones (Zhu et al., 2007: Fig. 2.) detracts further from the paper's reliability. Although such a facies is unusual for a Cenozoic inner platform (Hess, 1999), which is considered to be the depositional environment for the f-Member limestones of the Qom Formation (Okhravi and Amini, 1998; Reuter et al., 2007), it is not even documented in the paper by Zhu et al. (2007). More likely, the thick calcitic tubes of the teredenid bivalve *Kuphus* (Eocene-Recent (Savazzi, 1982)), that occur in situ in dense populations in the upper part of the f-Member in the Kashan area (Reuter et al., 2007: Chalhegareh Section), were misidentified as crinoid stems.

4. Sedimentology

The Qom Formation was deposited in several basins of central Iran on gently sloping ramps. The Qom area represents a more distal position than the Kashan area, where the Qom Formation reaches lesser thickness (Reuter et al., 2007). This is also well illustrated in Fig. 2 of Zhu et al. (2007). In both their sections (8 and 18) the general lithological succession of the Qom Formation is documented and correlates well with sections Qom (Qom region) and Chalhegareh (Kashan region) described by Reuter et al. (2007). All members (a-Member–f-Member) of Furrer and Soder (1955) are developed and the facies model of Reuter et al. (2007) is also reflected. Therefore, a confusion with factual Eocene sediments can be excluded although Eocene strata exist close to sections 8 and 18 (Zhu et al., 2007: Fig. 1).

The biotic assemblages discussed in Zhu et al. (2007) represent no bio/taphocenoses from distinct strata but are mixed assemblages from all sampled strata of each measured section. Assignments of taxa that apparently indicate Eocene age (*Reticulofenestra dictyoda*, *Bairdia montiformis*, *Cytherella jonesiana*) to distinct horizons and facies are therefore impossible. Only the captions of Figs. 3 and 4 provide more detailed information on the distribution of problematic fossils in sections 8 and 18. Fig. 4 refers to the occurrence of the calcareous nannofossil *Reticulofenestra dictyoda* at the top of the sandy marls of the b-Member in section 8 (sample 8-F30). These sandy marls, however, comprise a high content of re-worked bioclastic and lithic grains, indicating re-working of older strata and increased hinterland discharge. A similar taphonomic bias applies to nannoplankton-bearing samples derived from conglomeratic and bioclastic calciturbidites within the marl/limestone alternations of the c-Member in sections 18 and 8 (8-F20/3, 21, 18-F14). These formed during a low sealevel (Reuter et al., 2007). Ostracods of probably Eocene age show a corresponding distribution pattern. The caption of Fig. 3 reveals that the figured *Cytherella jonesiana* also derived from the marl/limestone alternation of the c-Member in Section 8 (8-F20/1). The illustrated specimen of *Bairdia montiformis* even comes from a section that is not explained in the text (9-F66/1).

Although the provided information is poor, Eocene fossils from sections 8 and 18 (Zhu et al., 2007) seem to originate from coarse clastic facies of the c-Member and predominantly occur in proximal settings (e.g., *Reticulofenestra dictyoda*, which is the strongest Eocene marker, is not mentioned from section 18 in Zhu et al. 2007). Contrarily, proven Oligo–Miocene planktic assemblages (e.g., Chattian: *Paragloborotalia opima opima*, *Globigerina ciperoensis*, *G. ouachitaensis*, *Tenuitella munda*, *Reticulofenestra abisecta*, *R. bisecta*, and *Zygrhablithus bijugatus*, Aquitanian: *Globoturborotalia woodi*, *Globigerinoides trilobus*, *Gs. immaturus*, *Gs. primordius*, *Gs. quadrilobatus, Globigerinella obesa, Catapsydrax unicavus, Cassigerinella boudecensis, C. chipolensis*) and larger benthic foraminifers (Chattian: *Lepidocyclina (Nephrolepidina) morgani*-type, *L. (Eulepidina) dilatata*; Aquitanian: *Miogypsinoides formosensis*, *M. bantamensis*) are bounded to the intervening mudstone facies and document the Chattian/Aquitanian boundary within the c-Member of the Qom Formation (Reuter et al., 2007). This is conspicuous evidence for re-sedimentation of re-worked Eocene biota in the Qom Formation.

5. Summary

In conclusion, we think an age reassignment of the Qom Formation from Oligocene–Miocene to Eocene is not supported by the biostratigraphic data presented by Zhu et al. (2007). The main points of critique are the poor taxonomy and omission of the relevant literature on the stratigraphy and facies of the Qom Formation. The reported biotic assemblages represent a mixture from all samples of a section. For their interpretation and comparison with other fossil assemblages, sedimentological data have not been considered. Most of the taxa reported by Zhu et al. (2007) range from Eocene to Oligocene or even Early Miocene. The poor information on the distribution of the few taxa which are diagnostic for the Eocene (*Reticulofenestra dictyoda*, *Bairdia montiformis*, *Cytherella jonesiana*) indicates that they are associated with coarse clastic deposits that formed during episodes of increased hinterland exposure and sediment supply. These deposits are intercalated with argillaceous mudstones of the c-Member of the Qom Formation, for which planktic assemblages and larger benthic foraminifers prove the Chattian/Aquitanian boundary (Reuter et al., 2007). Re-sedimentation of re-worked Eocene biota in nearshore settings of the Qom Formation during the Oligo–Miocene is therefore the most likely explanation for the occurrence of Eocene fossils. This possibility, however, has not been considered at all by Zhu et al. (2007) in their discussion on the age of the Qom Formation.

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