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A composite foraminiferal biostratigraphic sequence for the Lower Miocene deposits in the type area of the Qom Formation, central Iran, developed by constrained optimization (CONOP)

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ABSTRACT

Benthic foraminifera species commonly outnumber planktic species in the type area of the Lower Miocene Qom Formation, in north central Iran, where it records the Tethyan link between the eastern Mediterranean and Indo- Pacific provinces. Because measured sections preserve very different sequences of first and last occurrences of these species, no single section provides a completely suitable baseline for correlation. To resolve this problem, we combined bioevents from three stratigraphic sections into a single composite sequence by constrained optimization (CONOP). The composite section arranges the first and last appearance events (FAD and LAD) of 242 foraminifera in an optimal order that minimizes the implied diachronism between sections. The composite stratigraphic ranges of the planktic foraminifera support a practical biozonation which reveals substantial local changes of accumulation rate during Aquitanian to Burdigalian times. Traditional biozone boundaries emerge little changed but an order of magnitude more correlations can be interpolated. The top of the section at Dobaradar is younger than previously thought and younger than sections at Dochah and Tigheh Reza-Abad. The latter two sections probably extend older into the Aquitanian than the Dobaradar section, but likely include a hiatus near the base of the Burdigalian. The bounding contacts with the Upper Red and Lower Red Formations are shown to be diachronous.

1. Introduction

Biostratigraphic correlation of strata becomes more challenging as it is attempted at finer resolution and between different sedimentary environments. Attempts to resolve finer increments of time inevitably encounter more contradictions in detail between the locally recorded successions of species first and last occurrences.

The discrepancies result from well-known biological and environmental factors that cause dynamic and patchy distributions of living organisms and incomplete preservation of their fossil counterparts. The ages of strata containing the local first and last occurrences of a fossil taxon cannot be expected to correlate exactly. The variety of sedimentary facies and faunal provinces generally increases with geographic distance, leading to greater discrepancies and even total dissimilarity in coeval faunal records.

Facies changes within the Miocene Qom Formation of north central Iran (Fig. 1) present this same problem within its relatively small type area. No single section alone provides a suitable baseline for correlation and we adopt a solution more often applied to larger areas: build a regional composite section from the oldest first-occurrences and the youngest last occurrences for all taxa in the region. Fifty years ago, Alan Shaw (1964) introduced a graphical optimization technique to find the sequence and spacing of events that best fits all the local sections. His method allows missing information from one section to be "filled in" by observations in other sections. As the number of taxa and/or localities increases, however, the volume of information eventually overwhelms Shaw's manual method. Beginning in the 1970s and continuing today, biostratigraphers developed computer programs that automate correlation at high precision and with large datasets. Some automated Shaw's method; others added new logic.

The Qom sedimentary basin is considered Tethyan. It is a key to

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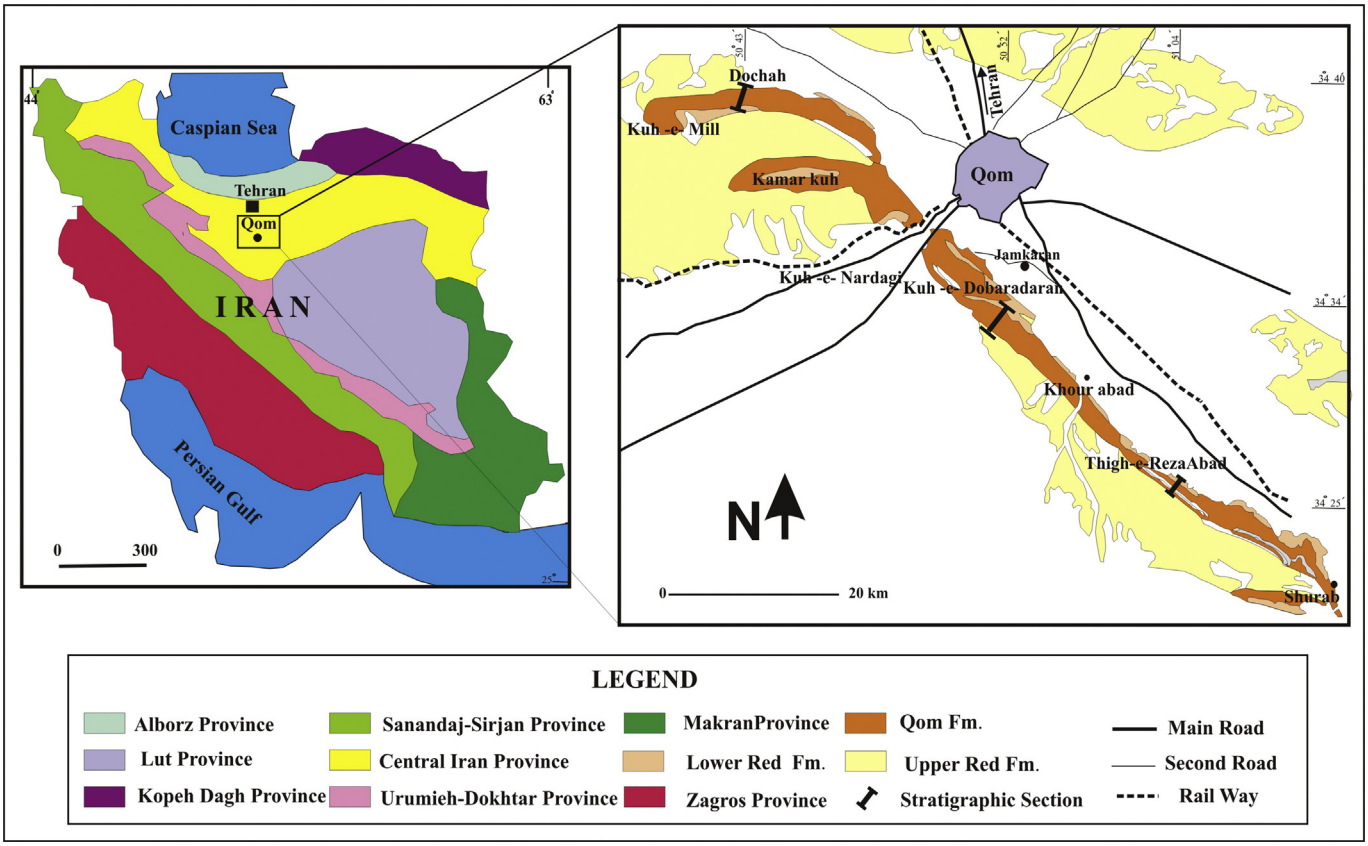

Fig. 1. Location map of the studied sections in Type area (modified from geological map of Qom by Emami, 1991 and Aran by Emami, 1992. and General map of Iran showing the eight geological provinces which modified from Heydari et al., 2003.

understanding the relationship between the Mediterranean Sea and the Indian Ocean, or Western and Eastern Tethys. The complex and extreme facies changes in the type area of the Qom Formation in central Iran occur across short distances and are associated with differences in thickness and fossil content. Although, other ages have been suggested for this formation, the commonly accepted age is Oligocene to Miocene. Zhu et al. (2007) for the first time suggested an Eocene age for the Qom Formation based on microfossil assemblages including calcareous nannofossils, dinoflagellate cysts, benthic foraminifera and ostracods. However, many researchers (for example Reuter et al., 2009; Daneshian et al., 2008; and Daneshian and Aftabi, 2010) rejected their Eocene age model for the Qom sediments for many reasons, including omission of the relevant facies and an extensive stratigraphic literature supporting an Oligocene–Miocene age for the Qom Formation. Correlation of the Qom Formation is difficult, both within central Iran and from there to adjacent territories of Iran and other countries (Table 1).

To build a composite biostratigraphic time line for the Qom Formation from three detailed but contrasting sections in its type area, we experimented with two computer programs: one that assists with Shaw's procedure for building a composite section, by adding one real section at a time (SINOCOR); and one that fully automates the incorporation of information from all sections at the outset (CONOP). The two-section crossplots generated by SINOCOR quickly revealed that the Qom Formation violates an assumption of Shaw's method. Because the ratio of accumulation rates is not constant from section to section in the Qom Formation, the thickness of the best section cannot be used as an acceptable proxy for the time scale. Consequently, we present here the results of a setting of the CONOP procedure that optimizes only the sequence of

Table 1
Some middle eastern correlatives of the Qom Formation known to be at least partly of Early Miocene age (Alsharhan and Nairn, 1997; Aghanabati, 2004, 2013; Stocklin and Setudehnia, 1991; Sharland et al., 2001).

Countries		Rock units (Formation)
Iran	Central Iran	Qom Fm.
	Zagros	Pabdeh, Razak, Asmari, Gachsaran, Mishan fms.
Iraq	Southern	Ghar Fm.
	Northern	Euphrates, Serikagni, Dhiban, Jeribe fms.
Jordan		Qirma, Dana fms.
Syria		Dhiban, Lower Fars fms.
Kuwait		Ghar, Lower Fars fms.
Bahrain		Jabal Cap Fm.
Qatar		Lower Fars Fm.
United Arab Emirates		Gachsaran, Mishan fms.
Oman		Miocene clastic and carbonate sequence
Saudi Arabia		Hadrukh, Musayr, Yanbu, Al Wajh, Jizan, Jabal Kibrit, Burqan fms.