Geological Quarterly, 2019, **63** (2): 215–229
DOI: http://dx.doi.org/10.7306/gq.1464

Identification of the Oligocene-Miocene boundary in the Central Iran Basin (Qom Formation): calcareous nannofossil evidences

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Parandavar, M., Hadavi, F., 2019. Identification of the Oligocene-Miocene boundary in the Central Iran Basin (Qom Formation): calcareous nannofossil evidences. Geological Quarterly, **63** (2): 215–229, doi: 10.7306/gq.1464

Associate Editor – Wojciech Granoszewski

A diverse Late Oligocene to Early Miocene calcareous nannofossil assemblage was examined from the Qom Formation in the Central Iran Basin, and the Oligocene-Miocene boundary was identified based on the quantitative analysis of the assemblages in 303 smear slides. Eleven well-established calcareous nannofossil bio-events are delineated in the Upper Oligocene through Lower Miocene. The results clearly show that the Highest Occurrence (HO) of *Sphenolithus delphix* is the closest bio-event to the boundary as traditionally delineated on the lithostratigraphic criteria, and provides a distinct biohorizon below it. The Lowest Occurrence (LO) of the species *Discoaster druggii* is the oldest Miocene bio-event that is observed shortly after the HO of *S. delphix*, showing that calcareous nannofossils are well suited for approximating the Oligocene-Miocene boundary in the Qom Formation. The Oligocene-Miocene boundary is placed in the upper part of Sub-member "c1" in all three sections studied here and it is traceable throughout the Central Iran Basin, which makes a potentially reliable marker horizon for sequence stratigraphic and hydrocarbon studies in the area.

Key words: Oligocene-Miocene boundary, calcareous nannofossils, biohorizons, Central Iran Basin, Qom Formation, "c1" Sub-member.

INTRODUCTION

Identification of the boundary between the Oligocene and Miocene has been often difficult in geological records (Shackleton et al., 2000). Berggren (1969) defined an age of 22.5 Ma for the Oligocene-Miocene boundary and demonstrated that it could be correlated approximately to the magnetochrone C6An. Then, Berggren et al. (1985) reviewed the boundary criteria and determined an age of 23.8 Ma for it based on the last appearance of the nannofossil species of *Reticulofenestra bisecta, Reticulofenestra scrippsae* and *Cyclicargolithus abisectus*. Steininger et al. (1997) assigned an age of 23.8 Ma to the boundary placed at the base of the C6Cn.2n magnetozone to define the GSSP for the base of the Neogene. Lourens et al. (2004), Palike et al. (2006) and Gradstein et al. (2012) in their new synthesis have proposed an age of 23.03 Ma for the base of the C6Cn.2n magnetozone.

Several climatic changes have been reported at the Oligocene-Miocene transition from various locations in the Tethyan and equatorial realms (Zachos et al., 2001; Allen and Armstrong, 2008; Beddow et al., 2016). The main cause for such environmental changes is massive tectonic displacements which led to reduction in atmospheric pCO2 (Pagani et al., 1999; Pearson and Palmer, 2000), and changes in palaeoclimate and palaeoenvironmental conditions (Zachos et al., 2001).

The Arabia-Eurasia collision and the closure of the Tethys ocean gateway is one of the global tectonic events that span from the Late Eocene to Miocene (Allen and Armstrong, 2008; Sadr, 2017). Previous studies based on the palaeoecology and palaeoclimatology of the Oligocene to Miocene transition suggested that fluctuations in global ice volume and eustatic sea level, and temperature variations during glacial or interglacial periods have resulted in the biological-environmental crises (Miller et al., 1991; Zachos et al., 2001; Billups et al., 2002). Moreover, multiple shifts in the value of ^{18}O and ^{13}C isotopes were reported during this interval from various sites (Zachos et al., 2001; Pekar et al., 2002; Wade and Palike, 2004; Beddow et al., 2016). They are referred to as Oi- and Mi-events. These changes and the global cooling trends have led to the biological crisis in the biota assemblages of the Late Oligocene to Miocene (as shown for instance in the Oligocene-Early Miocene range charts in Perch-Nielsen, 1985). Differences in the occurrences of these biological events (recorded or not at different sites), and more specifically differences in their chronostratigraphic position from one site to another, have resulted in problems in precise delineation of the Oligocene-Miocene boundary. Because of these problems, identification and introduction of major bio-events, and chronostratigraphic dating of the

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Received: February 24, 2018; accepted: November 9, 2019; first published online: May 17, 2019