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Biostratigraphy of the Garau Formation (Berriasian?–lower Cenomanian) in central part of Lurestan zone, northwest of Zagros, Iran

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ABSTRACT

Deposition of organic rich black shales and dark gray argillaceous limestones in the Berriasian–Turonian interval has been documented in many parts of the world. Northwest of Zagros, Iran (Lurestan zone), thin bedded black shales and marls, dark gray argillaceous limestones and fissile limestone layers, having bitumen, of the Garau Formation are deposited. For biostratigraphic studies two stratigraphic sections including one surface section (Kuzaran) and one subsurface section (Naft well) were selected, respectively. In this study, 61 foraminiferal species belonging to 17 genera have been identified, and 12 biozones were recognized. Based on fossils distribution and biozones identification, the age of the Garau Formation is Berriasian?–early Cenomanian. In addition, the micropalaeontological study demonstrated a variety of widespread morphological changes in planktonic foraminifera assemblages (e.g., the elongation of the final chambers, appearance of twin chambers in the last whorl). These changes coincide with deposition of argillaceous limestones and marls rich in organic matter, indicating oceanic anoxic events. On this basis, three oceanic anoxic events such as OAE1a, OAE1b and OAE1d were recognized in Naft well section and two (OAE1b and OAE1d) in Kuzaran section.

1. Introduction

The Garau Formation (northwestern Zagros, Iran) is composed of black shales rich in organic matter and dark gray argillaceous limestones containing bitumen. From Lurestan zone (Fig. 1) toward Dezful embayment and Fars basin this formation gradually passes into carbonate platform strata of the upper Khami Group. The average TOC (total organic carbon) content of the Garau Formation is between 2% and 9% in shaly intervals (Bordenave and Burwood, 1990).

The early to middle Cretaceous sequence, characterized by deposition of black shale intervals rich in organic matter in deep marine environments, is recognized in most oceanic deposits of that time-interval, especially in Tethys (Arthur et al., 1990; Leckie et al., 2002; Baudin, 2005).

The concentration of CO_2 in atmosphere reached the high levels during early to middle Cretaceous, leading to the greenhouse climate and significant changes in marine ecosystems (Arthur et al., 1985). According to Larson (1991), these conditions were triggered by increasing sea floor spreading, oceanic crustal production and submarine volcanism (Fig. 2). The sea level also rised universally coincident with these warm and humid conditions (Haq et al., 1987) and persisted across the Aptian–Turonian interval (Wilson et al., 2002). It has been supposed that deposition of black shale layers rich in organic matter took place during these conditions which are evidence of oceanic anoxic events (Schlanger and Jenkyns, 1976; Coccioni et al., 2006). Marine biota, especially planktonic organisms (planktonic foraminifera, calcareous nannofossils and radiolarians) are sensitive to environmental variations (Premoli Silva and Sliter, 1999; Coccioni et al., 2006) what resulted in remarkable evolutionary trends and major changes during oceanic anoxic events (Tappan and Loeblich, 1973). The diversity and morphological changes and particularly chamber elongation of the last whorl in planktonic foraminifera repeatedly and continuously coincide with deposition of black shales and are considered as a reaction to anoxic to dysoxic conditions in the upper water column (Schlanger and Jenkyns, 1976; Coccioni and Luciani, 2004, 2005, 2006). The objectives of this study are to establish a biostratigraphic framework for the Garau Formation in the Naft well and Kuzaran sections and to investigate the relationship between widespread morphological changes in planktonic foraminifera and oceanic anoxic events.

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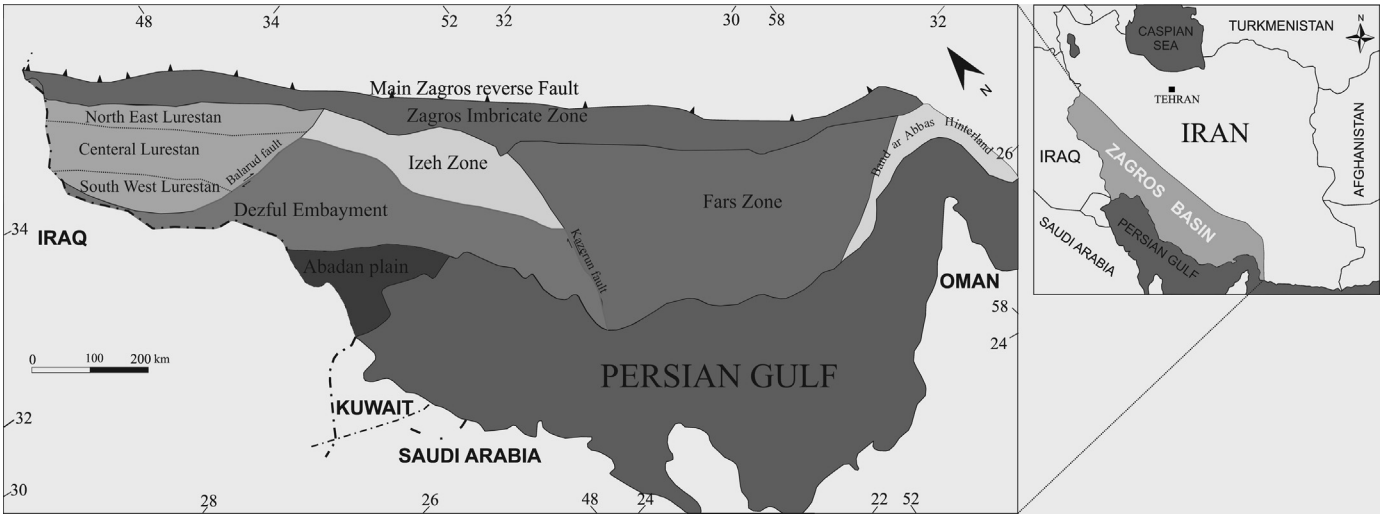

Fig. 1. Location map of the Zagros Basin (modified after Farzipour-Saein et al., 2009).

2. Methods

In this study, a total of 140 samples of hard rocks from Kuzaran surface section were collected and 166 thin sections were prepared. A total of 1150 thin sections of Naft well were analyzed for their foraminiferal content. The classification of planktonic foraminifera adopted here follows: Robaszynski and Caron (1979a,b), Caron (1985), Verga and Premoli Silva (2002), Premoli Silva and Verga (2004). In biostratigraphic studies, 61 foraminiferal species belonging to 17 genera were identified and 12 biozones recognized in these two sections. Nine of them are distinguished based on the zonal scheme proposed by Caron (1985), and three biozones were locally defined.

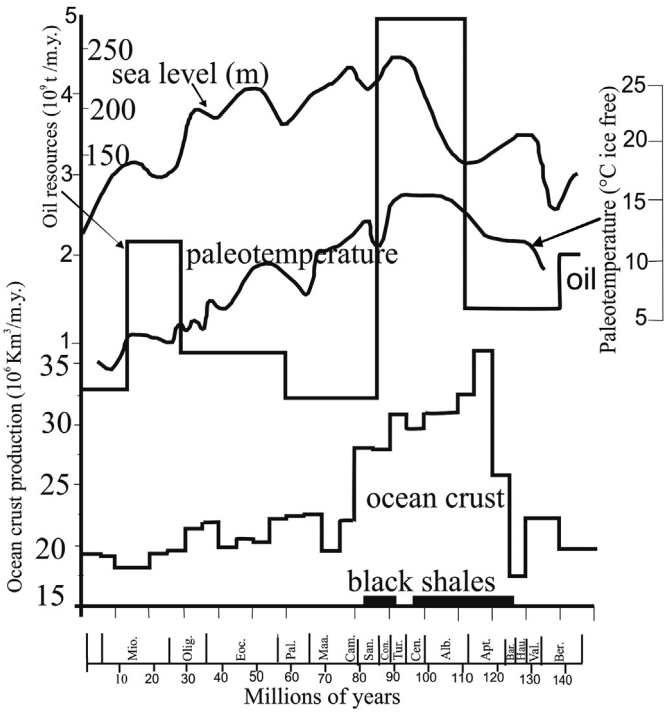

Fig. 2. The link between OAEs, sea level changes, ocean crust production and deposition of black shales rich in organic matter (modified after Larson, 1991).

3. Geological setting of studied sections

The Zagros orogenic belt of Iran, as part of the Alpine–Himalayan mountain chain, extends for about 2000 km in a NW–SE direction from the East Anatolian fault of eastern Turkey to the Oman line in southern Iran (Alavi, 1994). Lurestan basin is part of Zagros Fold and Thrust Belt (Alavi, 2007) which are limited to Main Zagros Reverse Fault and Dezful Embayment in northeast and southeast, respectively (Fig. 1). The type section of the Garau Formation was measured on the southwestern flank of Kabir Kuh in southwestern Lurestan about 10 km northeast of the village Qaleh Darreh. The Garau Formation in the type section underlies the Sarvak Formation while in Emam Hasan well, the Sarvak and Surgah formations have also graded into the Garau which underlies the Ilam Formation in this area (Motiei, 1993). The age of the Garau Formation in Emam-Hassan well No. 1 was established as Neocomian to Coniacian (Wynd, 1965), but it was subsequently changed to Cenomanian by NIOC, 2009 (unpublished revision of Wynd chart); the Turonian–Coniacian part of this Formation is equivalent to pelagic Sarvak and Surgah formations.

For micropalaeontological and biostratigraphical study of the Garau Formation in Lurestan zone, two stratigraphic sections Naft well and Kuzaran were studied (Fig. 3). The petrographic analysis of the Garau Formation reveals that these sediments contain 6 open marine facies (Ezampanah, 2012). On the basis of main components, textures, and microfossil associations these facies are thought to be deposited in a shelf carbonate platform (Ezampanah, 2012).

3.1. Naft well section

This section is situated in Naft anticline, approximately 40 km south–southeast the town of Kermanshah (Fig. 3). The thickness of the Garau Formation in this section is up to 485 m. The Garau Formation consists here mainly of dark gray argillaceous limestones, thin bedded black shales and marls, and fissile limestones with bitumen. The lower boundary of the Garau Formation cannot be established in this section due to lack of drilling at the bottom of the section; its upper contact with the Sarvak Formation is conformable.

3.2. Kuzaran section

This section is exposed in Dayar anticline in northwestern part of Kermanshah province, south of the village of Nilava. The