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Facies, depositional sequences, and biostratigraphy of the Oligo-Miocene Asmari Formation in Marun oilfield, North Dezful Embayment, Zagros Basin, SW Iran

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Abstract

The Asmari Formation in Marun oilfield (south-west Iran), is about 440 m-thick marine carbonate succession with subordinate siliciclastic rocks, characterized by abundant benthic foraminifera (perforate and imperforate). Foraminiferal biostratigraphy indicates that this unit is Oligocene–Miocene in age. The distribution of benthic foraminifera and other components have led to the recognition of three siliciclastic and ten carbonate facies that were deposited in inner ramp (shoreline, tidal flat, restricted and open lagoon and shoal), middle and outer ramp sub-environments. Based on vertical facies trends, three third-order sequences in the Oligocene and three third-order sequences in the Miocene sediments have been identified. These depositional sequences are bounded by both type 1 and type 2 sequence boundaries. The transgressive systems tracts (TST) of sequences show deepening-upward facies trend with a gradual upward increase in perforate foraminifera, whereas the highstand systems tracts (HST) have a shallowing-upward facies trend and contain predominantly imperforate foraminifera. Deposition of these depositional sequences (DS) were controlled by both eustasy and tectonic subsidence.

Keywords: Asmari Formation; Perforate foraminifera; Imperforate foraminifera; Sequence stratigraphy; Marun oilfield

1. Introduction

This paper deals with the Asmari Formation (a giant hydrocarbon reservoir), an Oligocene–Miocene carbonate unit with subordinate siliciclastic successions in the Marun oilfield in the Zagros foreland basin, southwest Iran. Unlike several published works, including those of Marun oilfield, which are based on Wynd (1965) and Adams and Bourgeois (1967) biostratigraphy, in this manuscript we adapted Laursen et al. (2009). The latter is based on strontium isotope analyses and radiometric dating, which can provide a more precise framework for biostratigraphic and sequence stratigraphic analyses. Also, high-resolution facies analysis and sequence stratigraphy on the Asmari Formation in the Marun oilfield have not been published yet. Ehrenberg et al. (2007) and Van Buchem et al. (2010) have published regional biostratigraphic works rather than local detail studies. This work, while fully acknowledged their findings, is focused on a more local scale of Marun oilfield.

The purposes of this study are (1) to present comprehensive biostratigraphic criteria based on recent strontium isotope stratigraphy and benthic foraminifera biozones (Laursen et al., 2009), and to revise the time interval framework used earlier, based mostly on the Adams and Bourgeois (1967) biostratigraphic classification; (2) to integrate sedimentological and benthic foraminifera data to interpret the depositional setting in the Marun oilfield; (3) to delineate sequence stratigraphic units and boundaries based on vertical facies trends and gamma ray logs and compared these sequences with those recognized

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in other areas of the Zagros Basin, and in the Arabian plate; and (4) to interpret relative sea-level curve during deposition of the Asmari Formation and delineate main factors controlling the generation of Asmari depositional sequences. The integrated work presented here can contribute to a better understanding of reservoir characteristics. In addition, the work can serve as a basis for further analyses of diagenetic processes and reservoir characterizations in the Iranian giant oilfields such as Marun oilfield.

2. Geological setting

Based on sedimentary sequences, magmatism, metamorphism, structural setting and intensity of deformation, the Iranian Plateau has been subdivided into eight continental fragments including Zagros, Sanandaj-Syrjan, Urumieh-Dokhtar, Central Iran, Alborz, Kopet-Dagh, Lut and Makran (Heydari et al., 2003; Fig. 1A). The Marun oilfield is located in the Dezful Embayment (Fig. 1B) and includes four subsurface sections: MN068, MN281, MN292, and MN312 (Fig. 1C).

The present day morphology of the Zagros Mountains is the result of the Permian–Triassic rifting, opening of the NeoTethys Ocean, spreading of basin floor towards the northeast during the Jurassic–Early Cretaceous, a first compressive phase with subduction to the NE and obduction in the Late Cretaceous, and finally, a second compressive phase with collision during the Neogene (Sherkati and Letouzey, 2004). The Asmari Platform was developed during the late compressive phase and closing of the NeoTethys Ocean (Homke et al., 2004). During the Oligocene and Miocene, initially deposition was controlled by the palaeo-topography of the Jahrum Platform (Eocene) (Fig. 2A). This platform was connected to the NeoTethys embayment, which was extended toward the north Iraq (Van Buchem et al., 2010). At this time in the central part of the basin, shales of the upper part of the Pabdeh Formation were deposited (Fig. 2A). Global sea-level fall during the Late Eocene (Sharland et al., 2001) resulted in the platform exposure, which was followed by a sea-level rise and deposition of the Asmari Formation on the mentioned sequence boundary. In the early Miocene time, the whole study area had already been drowned by a shallow marine setting when the carbonate platform of the Asmari Formation reached its maximum development (Fig. 2B). Different facies, including lithic sandstones (Ahwaz Member) and evaporites (Kalhur Member) were deposited during the late Oligocene–early Miocene times (Fig. 3) (Ahmadhadi et al., 2007). Subsequently, a sharp transition from carbonates of the Asmari Formation to evaporites of the Gachsaran Formation is indicative of the restricted foreland basin (Heydari, 2008).

In the southwestern part of the Zagros Basin, the Asmari Formation overlies the Pabdeh Formation, whereas in the Fars and Lurestan regions it covers the Jahrum and Shahbazan formations (Fig. 3). The maximum thickness of the Asmari Formation is found in the northeastern corner of the Dezful Embayment. The thickness of the Asmari Formation varies from area to area and the base of the formation varies in age within the Zagros Basin. For instance, in most localities near the Fars area, the thickness of the unit is almost 180 m and the base of the unit is Rupelian in age; whereas in the Dezful Embayment, the thickness of the unit is almost 450 m and the base of the unit ranges from Rupelian to Chattian in age (Fig. 3) (Motiei, 1993). In most places, top of the Asmari Formation is Burdigalian in age. But, toward the coastal and interior parts of Fars, it is Chattian in age.

3. Methods and study area

This study involved four subsurface sections (wells) from the Asmari Formation in the Marun oilfield, north of the Dezful Embayment (Fig. 1). Samples were analyzed in approximately 1500 thin sections. Thin sections were partly stained using Alizarin red S (Dickson, 1966) in order to differentiate calcite from dolomite. Facies definitions were based on core descriptions and facies descriptions under microscope, including depositional texture, size and composition of grains and fossil content. The classification schemes of Dunham (1962) and Embry and Klovan (1971) were used to describe carbonate rocks, and the scheme of Mount (1985) was used to describe mixed siliciclastic-carbonate rocks. All thin sections were studied for biotic components, with special attention to the distribution of benthic foraminifera. Biozonation and age determinations were based on strontium stratigraphy, recently established for the Asmari Formation (Ehrenberg et al., 2007; Laursen et al., 2009; Van Buchem et al., 2010). Sequence stratigraphy of the Oligocene–Miocene Asmari Formation was interpreted by analyzing facies (based on methods proposed by Wilson, 1975; Carozzi, 1989; Flügel, 2010), biostratigraphic information and gamma ray logs (gamma ray are expressed by American Petroleum Institute unit, API). Sequence stratigraphic techniques and concepts developed by many workers were used in this study to delineate sequence boundaries (unconformities) and maximum flooding surfaces (e.g., Sarg, 1988; Van Wagoner et al., 1988; Emery and Myers, 1996).

4. Biostratigraphy

The biostratigraphic framework of the Asmari Formation was established by Wynd (1965) and revised by Adams and Bourgeois (1967), both in unpublished reports. The Asmari was divided into lower (Oligocene), middle (Aquitanian), and upper (Burdigalian) parts. Recent strontium isotopic studies (Ehrenberg et al., 2007; Laursen et al., 2009; Van Buchem et al., 2010) have enabled the introduction of a new biozonation scheme for the Asmari Formation and clearly differentiated between the Rupelian and Chattian intervals (Fig. 4). Based on the Asmari Formation biozones described by Ehrenberg et al. (2007), Laursen et al. (2009) and Van Buchem et al. (2010), four foraminiferal assemblages have been recognized in the studied area (Fig. 4).

4.1. Assemblage zone 1

This assemblage is determined by the presence of *Globigerina* sp., *Eouvigerina* sp., *Eulepidina* sp., *Lepidocyclina* sp., *Nephrolepidina tournoueri*, *Operculina* sp., *Operculina*