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Lithofacies and sequence stratigraphic analysis of the Upper Jurassic siliciclastics in the eastern Kopet-Dagh Basin, NE Iran

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ABSTRACT

The Upper Jurassic (Oxfordian-Kimmeridgian) Mozduran Formation is the most important gas reservoirs of the northeast Iran. Siliciclastic facies of this formation in eastern most parts of the basin have not been studied yet. Therefore, four stratigraphic sections of Mozduran Formation have been selected in the Kole-Malekabad, Kale-Karab, Deraz-Ab and Karizak to interpret depositional history and analyze depositional sequences. Based on texture and sedimentary structures, 14 slilciclastic lithofacies were identified and classified into four categories, including conglomerate (Gms, Gp, Gt), sandstone (Sh, Sp, St, Sr, Sl, Sm, Se), mud rock (Fl) and intermediate sandstone-mud rock (Sr (Fl), Sr/Fl, Fl (Sr)). Identified lithofacies formed four architectural elements CH, SB, LA and FF. Lithofacies characteristics and architectural elements with mostly bimodal pattern of paleocurrents show that the majority of Mozduran lithofacies deposited in the coastal environment (tidal influence). Sequence stratigraphic analysis shows that the Kole-Malekabad section consists of two depositional sequences while other sections are characterized by three depositional sequences. The lower and upper sequence boundaries of the Mozduran Formation in all stratigraphic sections are SB1 that are distinguished by paleosol and sometime conglomerate horizons. Most of depositional sequences in studied sections are composed only of TST and HST. The TST deposits consist mostly of quartzarenite and litharenite petrofacies that have been deposited in the tidal zone. HST packages are mostly including mud rocks with interdeds of sandstone lithofacies that are deposited in supratidal setting. The LST facies is recognized only in the DS3 (equivalent to the second depositional sequences of the Kole-Malekabad), which consist of conglomerate facies. Instead, the Kole-Malekabad section is often composed of supratidal gypsiferrous shales, indicating sea level fall in the study area.

1. Introduction

The Kopet-Dagh inverted sedimentary basin (Allen et al., 2003) extends from the east of Caspian Sea through northeast Iran, Turkmenistan and northern Afghanistan (Afshar-Harb, 1979; Buryakovsky et al., 2001). This basin separates Central Iran from the Turan plate (Jackson et al., 2002). In the eastern Kopet-Dagh Basin, a sedimentary sequence, exceeding 6000 m, deposited from Mid Jurassic through Miocene time (Afshar-Harb, 1979). The Paleozoic basement and Triassic rocks are unconformably overlain by Jurassic to Cenozoic carbonates and siliciclasts in the basin (Ulmishek, 2004). In spite of decline of several oil fields in traditional oil provinces during the 21st century, the new fields will emergence in under explored basins especially in the Upper Jurassic secession (Mozduran Formation).

The Upper Jurassic succession in the Kopet-Dagh Basin is well exposed in the southern parts of the basin and consists mainly of limestones, dolomites and subordinate marl/shales, sandstones and evaporites that form a reservoir rock (Fig. 1). The Lower Cretaceous Shurijeh Formation comprising siliciclastic deposits is also considered as a reservoir in the basin. The Middle–Upper Jurassic shales and carbonates of the Chaman-Bid Formation are the main source rocks in the Kopet-Dagh Basin (Afshar-Harb, 1979; Mahboubi et al., 2001; Kavoosi, 2014). There is also a possibility that Upper Bajocian to Bathonian mudstones of the Kashafrud Formation have hydrocarbon generation potential (e.g., Poursoltani and Gibling, 2011; Sardar Abadi et al., 2014) (Fig. 1).

Reliability of sequence stratigraphic analysis based on surface studies depends on well-exposed outcrops on which recognition

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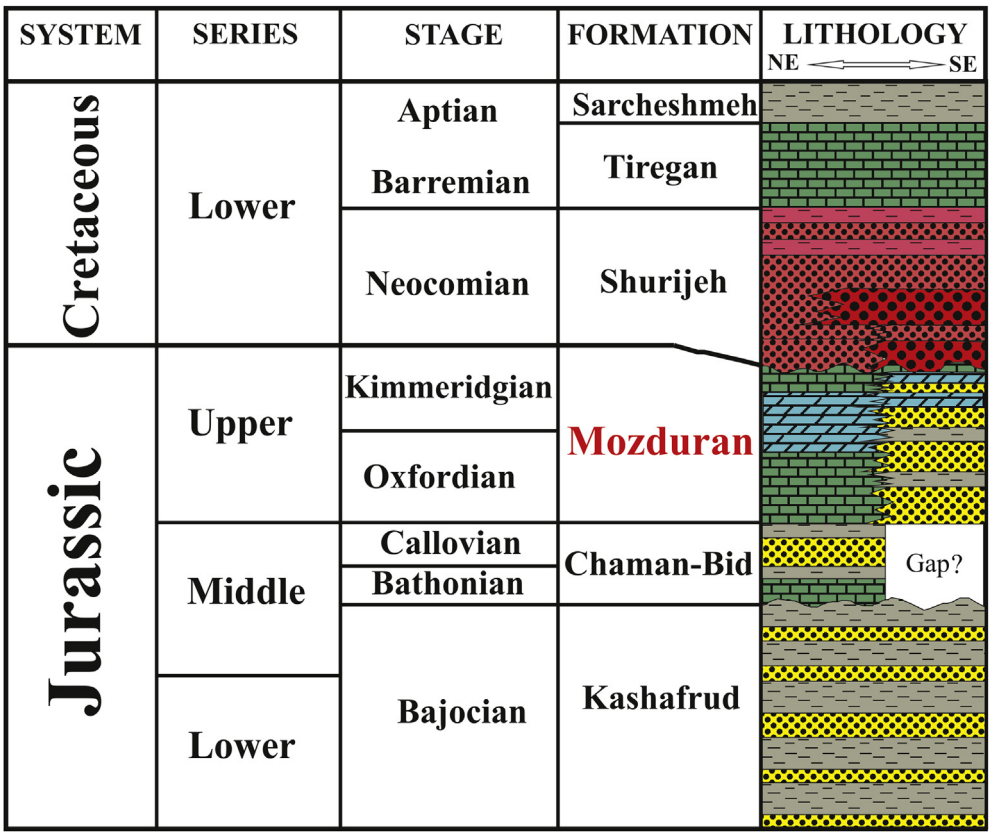

Fig. 1. Stratigraphic nomenclature for the Jurassic and Lower Cretaceous in the eastern Kopet Dagh Basin (modified from Kalantary, 1987). Lithologies of Chaman-Bid, Mozduran and Shorijeh formations are modified with our observations.

and tracing of bounding surfaces and lithofacies can be carried out. In this paper, we focus on four outcrops of the Upper Jurassic successions of Mozduran Formation that is dominantly siliciclastic rocks in eastern most parts of the Kopet-Dagh Basin (south of Aghdarband in Fig. 1). Thus, the aim of this paper is to analysis facies, interpret depositional environments and delineate sequence stratigraphy of the Upper Jurassic sediments of the Mozduran Formation. Since, these silisiclastic successions have not been previously studied in detail; therefore it is very important to evaluate these silisiclastic rocks equivalents to the carbonate reservoir in the north. We believe that this study can be used as a key to future stratigraphic analysis and petroleum reservoir evaluations in this region as well as understanding paleogeography of the Late Jurassic time in the NE Iran.

2. Geological setting

The Kopet-Dagh intracontinental Basin developed after closure of the Paleotethys during the Middle Triassic (Alavi et al., 1997) and the opening of the Neotethys in the Early to Middle Jurassic in north central and northeast Iran, southern Turkmenistan and Afghanistan (Buryakovsky et al., 2001) and resulted from the convergence of the Iran and Turan plates (Berberian and King, 1981; Sengor, 1984; Ruttner, 1993; Alavi et al., 1997; Wilmsen et al., 2009). The erosional window of Aghdarband indicates the basement of the Kopet-Dagh with pre-Liassic age and is located along the Kashafrud river about 100 Km ESE of Mashhad and consists of Devonian to Triassic sedimentary and igneous rocks which were highly deformed by the Hercynian and Cimmerian orogenic phases (Baud and Stampfli, 1989; Shahriari et al., 2005). This area is unconformably covered by Late Liassic marine siliciclastic and carbonate rocks (Ruttner, 1986). During the Early to Middle Jurassic, the Kopet-Dagh Basin developed in an extensional regime. Five main transgressive–regressive sequences (Moussavi-Harami and Brener, 1992) recorded with relatively continuous deposition, uninterrupted by volcanism (Afshar-Harb, 1979; Kalantari, 1969, 1987) from Jurassic though Eocene time. During the Jurassic, basin subsidence began along main E–W longitudinal faults (Afshar-Harb, 1979, 1982). However, Moussavi-Harami and Brener (1992) proposed that in the eastern Kopet-Dagh Basin, the post-Jurassic subsidence was mainly resulted from sediment rather than tectonic loading. The Kashafrud Formation with siliciclastic sediments deposited in a marine paleoenvironment during the Middle Jurassic time (Poursoltani et al., 2007; Sardar Abadi et al., 2014). Also, in the Callovian, from the NW, a marine transgression led to sedimentation of the Upper Jurassic carbonates of the Mozduran Formation that overlies the Bajocian–Bathonian Kashafrud Formation (Lasemi, 1995). Although the carbonate deposition was established in the eastern Kopet-Dagh basin during the Middle to Late Jurassic time (Adabi and Rao, 1991; Lasemi, 1995; Adabi, 2009; Kavoosi, 2014), but at the same time siliciclastics were deposited in eastern most parts of the basin in coastal environment (Moussavi-Harami, 1989; Kavoosi et al., 2009). In the eastern parts of the Kopet-Dagh Basin, the boundary between the Kashafrud and Mozduran formations is unconformable, whereas towards the central and western parts of the basin, the boundary is conformable between the Kashafrud and the Bathonian to Oxfordian deeper-marine carbonates and shales/marls of the Chaman-Bid Formation (Fig. 1).

Following marine transgression in the Late Jurassic, the sea