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Geochemical composition of oils in the Dunga Field, western Kazakhstan: Evidence for a lacustrine source and a complex filling history

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ABSTRACT

The onshore Mangyshlak Basin, located in western Kazakhstan along the eastern coastline of the Caspian Sea, is a prolific hydrocarbon province and home to numerous oil and gas fields. The primary reservoirs are Jurassic clastic sandstones, but the Dunga Field contains hydrocarbons in Lower Cretaceous (Valanginian, Barremian, Aptian, Albian) clastic and carbonate reservoirs. The general perception is that these petroleum accumulations were charged from marine source rocks of likely Middle Triassic age. A detailed organic geochemical investigation of oils from the Cretaceous reservoirs of Dunga Field suggests that all were generated from the same lacustrine source rock facies (organofacies C) in mature kitchens in the offshore Mangyshlak Basin, followed by a complex filling history. The oils are characterised by relatively high wax content, low sulfur content (mainly < 0.2 wt%), typical lacustrine tricyclic terpane ratios (high T26/T25, high T24/T23, low T22/T21) and low H31R/H30 hopane ratios. Maturity of the source rock that generated the oils would tentatively correspond to a VR of ~0.9–1.1 %Ro. The oils are non-biodegraded, but some minor water washing might have occurred. Diamondoid data suggest that the Barremian reservoir contains a mixed oil pool composed of the non-cracked lacustrine oil and another charge of oil that is cracked from 79% to 83% and likely also to be slightly fractionated. This requires a complex filling history of the Dunga Field involving two hydrocarbon charges, likely from two different fetch areas. One charge of non-cracked oil migrated into all four reservoirs whereas another charge was 'hoteled' and cracked before remigration to the Barremian reservoir only and mixed with the non-cracked oil.

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1. Introduction

The Dunga Field is located in the Mangyshlak Basin on the eastern coastline of the Caspian Sea, western Kazakhstan (Fig. 1). The field was discovered in 1957, but oil production first started in 2002 and about 17,000 boe/day are produced currently. The Mangyshlak Basin is known to contain oil and gas in Jurassic clastic sandstones (Ulmishek, 2001), but the Dunga Field has proven oil within Lower Cretaceous (Valanginian, Barremian, Aptian and Albian) clastic and carbonate reservoirs (Fig. 2). The carbonate section is several hundred meters thick and extends from the Upper Jurassic into the Lower Cretaceous. The predominant producing interval is the Aptian shallow marine heterolithic sandstone reservoir, which contributes around 90% of the current daily production level. Secondary reservoirs developed within Valanginian carbonates (single horizontal well) and Albian clastics (dual vertical well) make up the remaining oil contribution. The Albian reservoir belongs to an overall prograding marine sandstone interval (Dujoncquoy et al., 2017). Hydrocarbons have also been discovered within Barremian (oil and gas) and Middle Jurassic (gas) fluvial sandstones, but these reservoirs are not currently part of the field development scope. The Cretaceous reservoirs are named in correspondence to their stratigraphic age (i.e., Valanginian, Barremian, Aptian and Albian).

A regional oil family study (Maersk Oil, unpublished) has shown the presence of several active source facies in western Kazakhstan based on statistical correlation and interpretation of standard biomarker parameters and $\delta^{13}C$ isotopic data (Fig. 1). Two major oil groups are recognised: one group occurs in fields north of Dunga at the margin of the Pre-Caspian Basin and is primarily composed of oils charged from marly marine and anoxic source rocks

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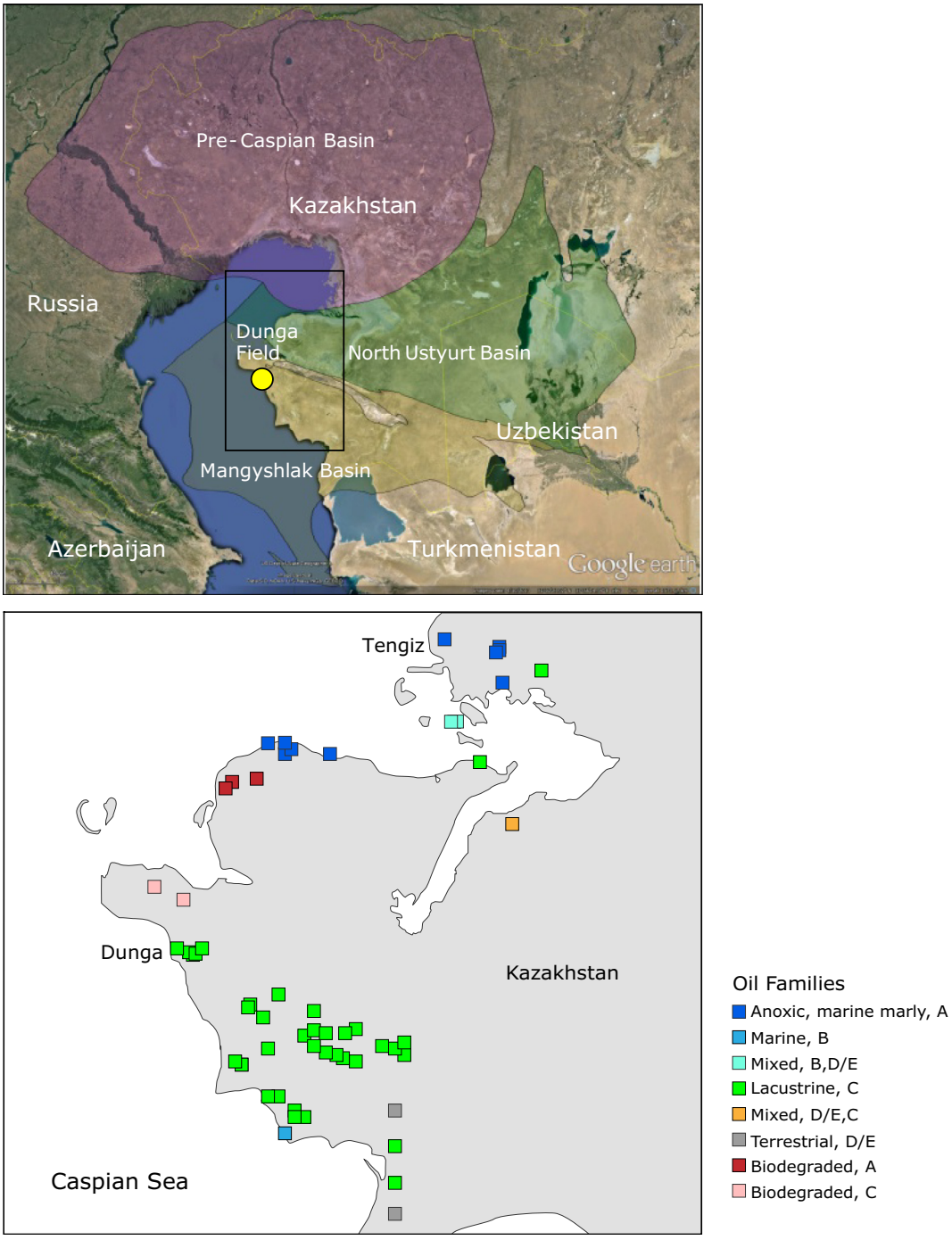

Fig. 1. Top: Location of the Dunga Field in the Mangyshlak Basin at the western coastline of Kazakhstan. Bottom: Oil families onshore western Kazakhstan with lacustrine oils dominating in the Mangyshlak Basin.

designated organofacies A, another group includes the Dunga Field and fields to the south-southeast and is composed of oils charged from lacustrine source rocks designated organofacies C. A minor number of fields appear to have been charged from terrestrial, marine or mixed source rocks, whereas others contain biodegraded oils (Fig. 1). The Pre-Caspian Basin is a prolific petroleum province, including the giant Tengiz and Kashagan fields, where Upper Carboniferous–Lower Permian marine shales and limestones are proposed as the major source (Yensepbayev et al., 2010). The Devonian Domanik shales also have been suggested as a potential major source (Lisovsky et al., 1992; Schoellkopf and Hallager, 1998; Ulmishek, 2001). The organofacies A oils are characterised by relatively low API gravity (mean: 26°), enhanced S content (mean: 1.30 wt%), relatively low Pr/Ph ratio (mean: 1.10) and tricyclic T24/T23 and T22/T21 ratios intermediate between the typical values for marine shale and carbonate oils (see Peters et al., 2005). These parameters support generation from a marly source rock or perhaps dual sourcing from shale and limestone source rocks. In line with this scenario, Patterson et al. (1994) suggested that the Tengiz Field was co-sourced from Carboniferous carbonates and Permian shales, while Warner et al. (2007) suggested that the Tengiz Field received two charges of oil where the final one was accompanied by high H_2S contents derived from thermochemical sulphate reduction (TSR).

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