AAPG HEDBERG CONFERENCE
"*Paleozoic and Triassic Petroleum Systems in North Africa*"
February 18-20, 2003, Algiers, Algeria

Late Ordovician Palaeovalleys And Glacitectonics On The Gargaf Arch, Libya: Reservoir Heterogeneities And Implications For Development In The Murzuq Basin

Le Heron, D.P.[1], Bourgig, K.[2], Craig, J.[3], Sutcliffe, O.E.[4], & Whittington, R.J.[1]

1: Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, Ceredigion, UK SY23 3DB.
2: Petroleum Research Centre, Tripoli, Great Socialist People's Libyan Arab Jamahiriya.
3: ENI-LASMO, Bowater House East, Knightsbridge, London, UK SW1X 7BN.
4: Badley Ashton and Associates, Winceby House, Winceby, Horncastle, Lincolnshire, UK LN9 6PB.

The upper Ordovician Mamuniyat Formation is the most important reservoir in the Murzuq Basin, SW Libya and together with the underlying, clay prone Melaz Shuqran Formation, was deposited in glacially influenced, generally shallow marine settings during the Hirnantian glaciation. The influence of glacier-related processes on deposition has added significant complexity to the understanding of these rocks. Outcrop observations on the northern margin of this basin provide appropriate analogues for these rocks in the subsurface. Three features are described that have important implications for evaluating the nature of reservoir heterogeneities in the Mamuniyat Formation (or other upper Ordovician reservoirs of Gondwana). These are: (1) a sub-glacial tunnel valley complex, (2) sub-glacial to ice marginal thrust and fold belts, and (3) a km-scale glacioisostatic sag basin with superimposed half graben and marginal uplifts.

In outcrop, a 30km long ***tunnel valley complex*** comprises 2 major incisions (4km in width) into the Melaz Shuqran Formation, filled by sediments belonging to the Mamuniyat Formation. Incision was of the order of 100m. The scale and fill of the palaeovalley complex resembles other Gondwanan examples, namely those in Saudi Arabia (Vaslet, 1990), SE Algeria (Beuf *et al*, 1971; Hirst *et al*, 2002) and Mauritania (Ghienne and Deynoux, 1998). The valley margins display soft-sediment striations, resulting from abrasion of the soft substrate by ice. The margins are also characterised by stratal dips of 18-25° toward the valley centres interpreted to be a result of progressive loading of ice into the valleys during their incision. The tunnel valleys were initially lined with ice-proximal debris during ice sheet retreat, and subsequently filled by sandy high density turbidites in water depths of at least 80m, during the deposition of a south to north axially prograding submarine fan. The course of the tunnel valley complex was partly controlled by faults in pre-existing strata. Similar subsurface valley systems are recognised in concession NC174 in the Murzuq Basin, Libya (Smart, 2000).

In the Mamuniyat Formation, ***syn-sedimentary thrust and fold belts*** evolved during the advance of the ice sheet in response to subglacial shear from the overriding ice sheet and from ice-bulldozing processes in ice-marginal settings. The ice-marginal fold-thrust belts extend along strike for 3-4km, and display over 100m of lateral displacement of the Melaz Shuqran over the Mamuniyat Formation. This syn-sedimentary thrusting has juxtaposed different facies

associations over several hundreds of metres down depositional dip. Subglacial deformation is characterised by high strain zones. The presence of such fold-thrust belts within potential reservoirs in the subsurface would strongly influence hydrocarbon migration pathways and act as baffles to fluid flow.

Thirdly, a ***km-scale sag basin*** developed in response to stresses caused by ice loading followed by deglaciation of the shelf and the associated glacio-isostatic rebound. Minor half grabens are superimposed on the sag basins that are flanked by broad warp-like uplifts that probably represent tip-line folds. These half graben developed in response to syn-sedimentary, broadly E-W oriented extension that was parallel to the basin axis. Subsidence was accomplished by pulsed movement along N-S striking faults. This pulsed slip behaviour is reflected in the fill by sandstone bodies bounded by truncations/ discordances and hence implies a process distinct from simple growth faulting. The fill of the half graben comprises up to 60m of clean, quartzarenitic sandstones, forming punctuated coarsening up, shoreface deposits that may represent potentially good reservoirs. However, the connectivity and lateral continuity of these deposits will be limited by the nature of the syn-sedimentary tectonics during isostatic rebound.

In summary, outcrop data from the Murzuq Basin, Libya, provide vital information for the nature of reservoir heterogeneities in the upper Ordovician glacigenic rocks of the Murzuq Basin but furthermore has implications for petroleum resources in the contiguous successions of other basins in North Africa and Saudi Arabia.

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