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Evolution of the Pliocene to Quaternary Fluvio-Deltaic Sequence in the West Turkmenistan Basin: the Geometry and Depositional Architecture of Channel Sand Bodies in the Burun Field, Onshore Turkmenistan

INTRODUCTION

The Burun Field is located within the West Turkmenistan Basin, on the continental margin of the southeastern Caspian Basin, onshore Turkmenistan (Figure 1). The West Turkmenistan Basin is a large intramontane trough, within a compressional zone, with an active E-W trending wrench system. To the north is the Balkan foldbelt and Turan block, to the south the Kopet Dag fold belt. The Apsheron-PreBalkan Trend runs through the northern part of the basin, producing a series of anticlinal features that form significant hydrocarbon traps. Late Tertiary sediments of western Turkmenistan contain significant reserves of oil and gas in fluvial and deltaic reservoirs. Oil has been produced from the area commercially for over 100 years, initially from shallow hand-dug wells targeting oil seeps. The discovery of the Nebit Dag field in 1929 heralded the main exploration phase, and drilling from 1948 to 1957 led to the discovery of further fields along this trend.

Figure 1. Location of the Burun Field on the eastern margin of the Caspian Sea in western Turkmenistan.

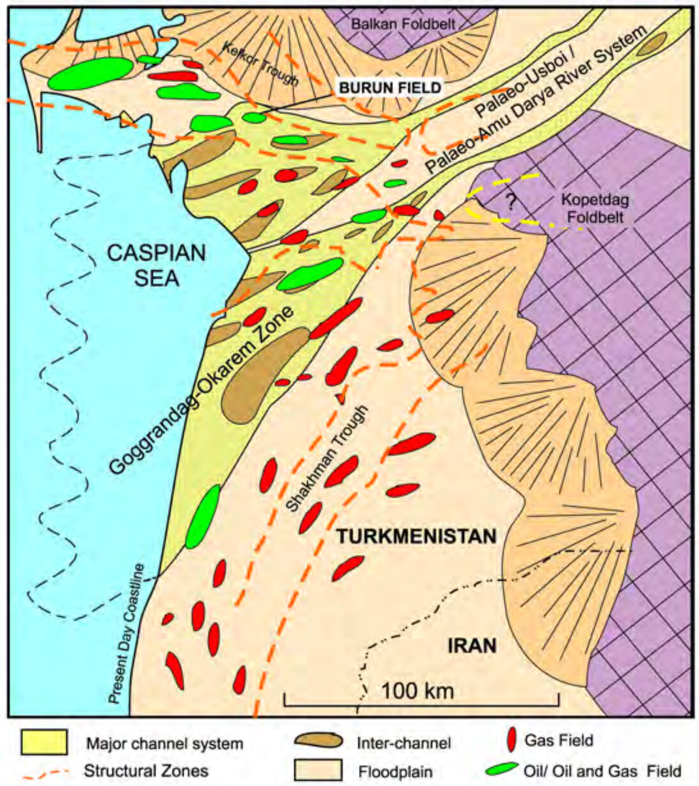

Figure 2. Sedimentological environments of the Burun field area.

Modified from Reynolds 1998

The Burun Field was discovered in 1967 and currently produces 1550 m^3 of oil per day (9750 bopd) of 33° API sweet crude and 1 MMm^3 of gas per day (35 MMscf/d) from 88 wells (as of Jan. 2003). The field is approximately 10 km by 3 km and comprises stacked reservoirs of Neogene age, with an overall anticlinal structure developed as a result of dextral shear. Over 200 wells have been drilled on the structure, with 50 currently on production. Reservoirs are stacked channel to delta front sandstones at a depth of 1000 m to 4400 m. The Pliocene to Quaternary Red Series, Akchagylian and Apsheronian suites form the main reservoirs, deposited in a variety of fluvio-deltaic to shallow marine environments.

This research is being undertaken on a dataset comprising 162 km^2 of 3D seismic acquired in 1998 and over 200 wells. Initial studies have concentrated on seismic mapping and facies analysis. Where amplitude contrast is strong, horizon slices exhibit variations in amplitude associated with channel-like features of varying width and depth. Detailed mapping has revealed multi-story channels, together with significant inter/intra channels facies that may act as barriers and baffles to vertical fluid flow. The architecture of the channel fill has been characterised and integrated with available well data to determine the channel morphology, orientation and evolution and determine the facies with highest reservoir potential.

REGIONAL SETTING

The collision of the Arabian and Indian plates and closure of Tethys is associated with the Late Miocene dramatic fall in base level, estimated at between 600 to 1500m (correlatable to the late Messinian eustatic sea level fall, Reynolds et al. 1998). This isolated the Caspian Basin from the Paratethys Sea, producing the fresh water Caspian palaeo-lake. Sedimentation into the lake came from major river systems fed by the rapidly uplifting hinterland. The Palaeo Amu

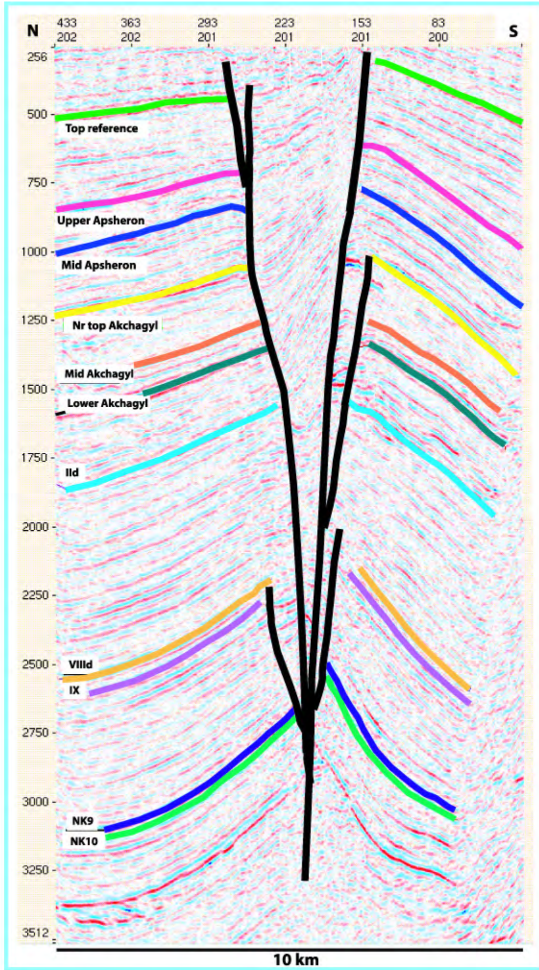

Figure 3. North-south seismic section illustrating the Burun structure and thickness variations across the wrench zone.

Darya River (Figure 3), sourced from the uplifting collision belt to the east, fed through the West Turkmenistan Basin. Depositional environments include fluvial channel sandstones and associated sheet flood and overbank deposits, and deltaic to shallow marine conditions during base level rise. The onshore portion of the south-eastern Caspian basin comprises relatively flat lying, poorly consolidated Pliocene to Holocene marine and continental deposits. At least 10 km of Neogene sediment accumulated in the South Caspian Basin.

BURUN STRUCTURE

A series of east-west wrench faults cut the Burun Field, producing an overall anticlinal feature. This is one of a number of east-west trending shear zones that cut the West Turkmenistan Basin. A subordinate series of NW-SE Reidel shears can also be identified, indicating a right lateral displacement. The main faults display a scissor-like displacement over time, with the depocentre shifting through time. Changes in thickness of stratigraphic units over the wrench system are also interpreted as the result of the lateral displacement. South of the wrench system, there is thickening towards the southern limit from VIIId to IId, yet thickening near the wrench system from Mid to Near Top Akchagyl (Figure 3).

CHANNEL MORPHOLOGY

A number of large channel features can be identified on 3D seismic on the basis of amplitude response and internal

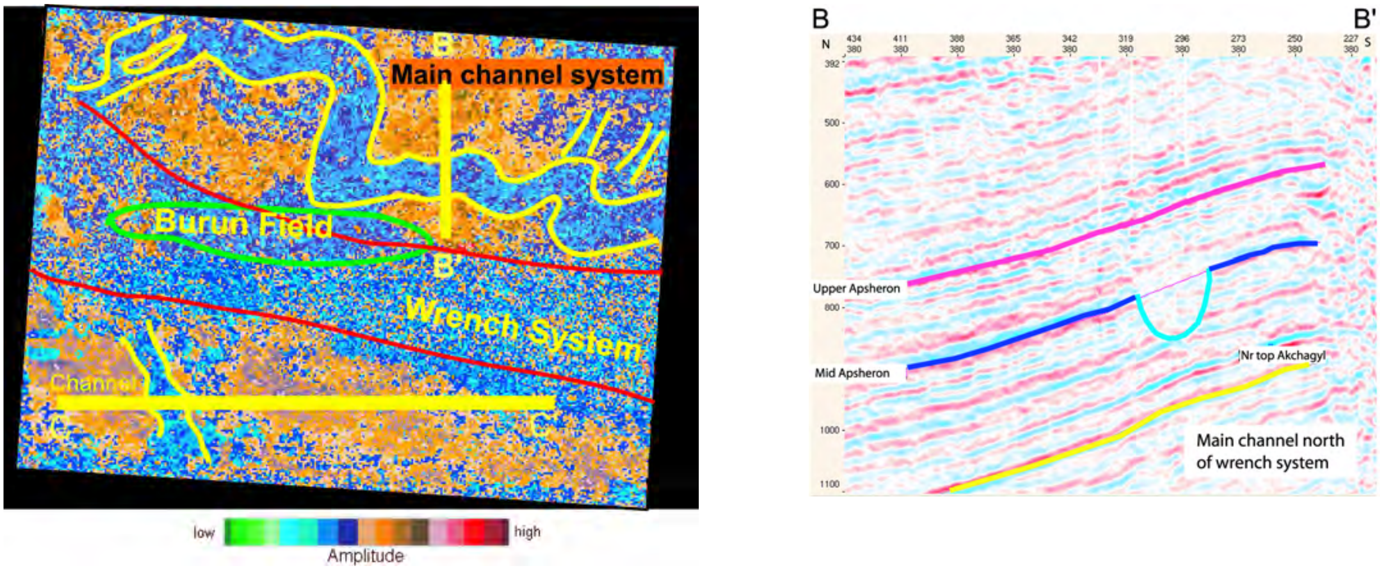

Figure 4. Amplitude display on the Mid Apsheron horizon and associated seismic section (B-B') showing channel location and shape.

character. A systematic change in channel morphology, (width, depth and sinuosity) occurs through the succession, with each stratigraphic unit having distinct characteristics. Channels currently recognised within the Lower Red Series have low sinuosity, range from 400 to 600m wide, and are oriented N-S. The north channel on NK 9 is approximately 520 m wide. Akchagylian channels are also of low sinuosity but wider and appear to be an amalgamation of comparatively shallow channels. They are oriented NE-SW and the channelised zone can be up to 1.8 km wide. In the Apsheronian most channels are of high sinuosity, significantly narrower and are deeply incised. The north channel (Figure 4) cutting the Mid Apsheron horizon is 840m wide.

The central wrench zone is highly faulted, thus obscuring location of channel sand bodies in the most prospective part of the survey. The ability to identify channels north and south of the wrench, especially in the lower, most affected zones such as NK9, may help to locate reservoir sands in the producing field.

CONTROLS ON SEDIMENTATION

Variations in seismic facies and channel morphology are interpreted to reflect changes from dominantly fluvial, both low and high sinuosity, to deltaic and marine environments resulting from regional variations in relative sea level and sediment input rates from the mountains to the north. Climatic cycles produce sea-level change and result in periodic flooding of the entire area with shale. Regional tectonic activity produces major uplift and erosion over an extensive catchment area to the east of the field. Significant amounts of sediment have been transported over time via the Palaeo-Amu Darya River and Delta to the Burun area.

Uplift and erosion of mountains just north of the survey supply sediment to an alluvial fan system extending southward (Figure 2). Periodically, the effect of this fan system is displayed as distal, channelised fan deposits at the northern limit of the survey. Progradation of this fan appears to control position of an east-west drainage system by Akchagyl time.

The regional depositional controls are modified locally following periodic movement along the Apsheron-PreBalkan Trend, which, within the Burun Field, is an E-W oriented wrench system.

A series of isochrons illustrate the periodic movement along the wrench system and the intimate control this has on channel orientation. Notably, at higher levels in the stratigraphy, the main channel systems do not cross the Burun structure, but migrate around the anticlinal feature, which was clearly a palaeo-high for much of the Neogene (Figure 4).

ONGOING WORK

The original objective was to evaluate the depositional processes and to help better characterise the fluvial architecture and evolution of the Red Series to assist in reservoir modelling of the Burun Field. The study is being continued by Dr Dorothy Satterfield and researchers at Oxford Brookes University. Ongoing projects include evaluation of the contribution of the Riedel shears to sedimentation and timing of sedimentation pulses from alluvial fans to the north. Further data may allow examination of a fault system south of the present survey and assessment of movement there on the changing thickness patterns in the southern area.

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