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Hydrocarbon discoveries and remaining potential of the Paleozoic play of the Murzuk Basin, Libya

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Summary

The Murzuk Basin lies some 800 km south of Tripoli and covers an area of 350,000 km^2. It is one of a number of Paleozoic interior sag basins which lie on the Saharan Platform, and are separated from one another by inter-basin structural highs controlled by underlying basement fault zones.

Several discoveries have been made in the northern part of the basin, among which are two giants, A-NC115 (Sharara) and Elephant, operated by Repsol and ENI-Lasmo respectively. Nowadays the basin is considered to be the one with the highest remaining hydrocarbon potential among all the basins of Libya. The central and southern parts of it are still under-explored and it is likely that the exploration activity will be intense for several years to come. Agip North Africa has recently made a detailed evaluation of the hydrocarbon potential of these areas.

Geology

The Murzuk Basin (Fig.1) represents the erosional remnant of a much wider Paleozoic intra-cratonic sag basin located on the Saharan Platform. It is bounded to the east and west by highs related to the Tibesti and Hoggar Massifs respectively, which also converge to form the southern margin (in the northern Niger). The northern boundary is formed by the Gargaf Arch. The sedimentary fill is mainly Paleozoic to Mesozoic in age and reaches a thickness of about 4000 meters in the basin center. The Paleozoic infill is mainly marine. During early Paleozoic time, NNW trending horst and graben structures controlled far-reaching transgressions to the south and southeast of the Saharan Platform. In this context, the Cambrian to Ordovician are siliciclastic sediments, mainly continental to transgressive shallow marine and open marine. The topmost Ordovician deposits (Memouniat Fm.) consist of backstepping and transgressive coastal and shallow marine sandstones and represent the main target reservoir of the oil exploration. During the early Silurian, marine shales with source rock potential up to several tens of meters (‘Hot Shales’) were deposited in the basin. In the late Silurian-middle Devonian time the Caledonian orogeny gave rise to a generalized fault re-activation and to the uplift and erosion of the Gargaf arch area. During the Permo-Triassic the collision of Gondwana and Laurasia (Hercynian phase) caused E-W compression to occur in the basin with local transpression and uplift along the basin margins and the previous intra-basinal structures. The Mesozoic infill is mainly continental and corresponds to an uplift trend.

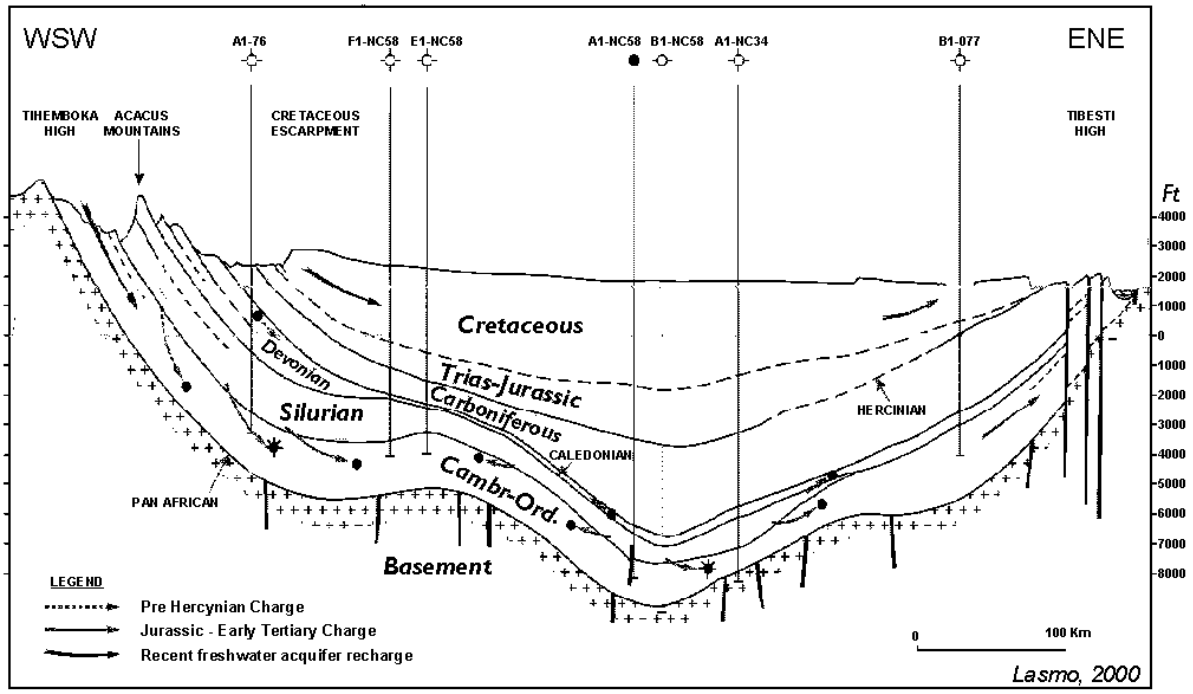

Fig. 1. Regional cross section with possible timing of HC generation.

During Late Jurassic and Cretaceous, progressive uplift and erosion affected the basin margins while thick continental deposits accumulated in the basin center. Austrian-Alpine orogenic phases caused tilting and inversion tectonics: lower Cretaceous deposits show a major unconformity at the top (upper Cretaceous deposits are in fact not preserved). The Tertiary Alpine orogeny resulted from the collision of Africa and Eurasia and led to the strongest regional uplift and erosion in the history of the basin.

Petroleum system

The hydrocarbon system in the Murzuk Basin is relatively complex and is controlled by a number of different factors including structural evolution and timing-location of oil generation. The primary petroleum play consists of the upper Ordovician sandstones (Memouniat and Haouaz Fm.) as reservoir, and of the Tanezzuft Shales as source rock and seal (lower Silurian). The Ordovician sandstones bear the main discoveries of the Murzuk Basin (i.e. in NC-115 and NC-174 Concessions) and generally have good lateral continuity and thickness.

The source rock is the 'Hot Shales' interval, which is located at the very base of the Tanezzuft Fm. (earliest Silurian) and is usually present in the inherited late Ordovician paleo-lows. The Hot Shales consists of anoxic radioactive shales with good TOC (>5-10%) and a type I-II kerogen.

Traps are structural and mainly consist of gentle 4-way-dip folds and fault-bounded folds, with basement involvement. The regional seal is the Tanezzuft Fm.

The oil generation and charge system is considered to have been active since the pre-Hercinian time although the main phase occurred during the Jurassic to Early Tertiary. Charge occurs from the Hot Shales down to the underlying Memouniat reservoir. Secondary migration can be effective for several kilometers.

A secondary play is the middle Devonian sandstones, which are draped and sealed by the upper Devonian shales (Aouinet Ouenine).

Exploration history

Exploration for hydrocarbons within the Murzuk Basin commenced in 1957 with the awarding of several concession agreements to foreign companies. The first campaign was disappointing although several wells, located mainly in the northern portion of the basin, were drilled (Gulf Oil – the most active – drilled 9 wells): by 1974 all licenses were released. In 1974 a new campaign was started by Occidental and Braspetro but it met with only marginal successes. In 1980 Rompetrol and BOCO signed for two new acreages, NC-115 and NC-101 respectively. Between 1984 and 1986 a total of 29 wells were drilled by Rompetrol (12 wildcats and 17 appraisal wells). These wells resulted in the discovery of six oil fields (named Sharara as a whole), three of which were declared commercial and three sub-commercial. One of the fields (A-NC115) is regarded as a giant with in place reserves in excess of one billion barrels. In the period 1981-1985, BOCO drilled a total of 18 wells (16 wildcats and two appraisals) which resulted in seven oil discoveries: however, due to the terms of their agreement they were not considered commercial.
The development of the three Rompetrol operated commercial fields started in 1993: however, probably due to the inability of Rompetrol to fund the development expenditures, the operatorship of the fields, as well as the Rompetrol stake, passed to Repsol in late 1994. The development was completed in 1999 with the construction of the 30” Murzuk- El Hamra pipeline. Todays’ production of the Sharara fields is in the range of 160,000 bbl/day. Encouraged by the results of the recent operators, in 1990 Lasmo had signed an exploration agreement for the NC-174 concession. Afterwards and until 1997 Lasmo drilled 5 wells with only limited success. It was in September 1997 when the company made the big discovery of Elephant (well F1-NC174), testing up to 3000 bbl/day of 38° API oil in the Memouniat Fm.

The NC-174 Concession

ENI entered the NC-174 joint venture by signing a Farmout Agreement in August 1996. The new joint venture was formed by Lasmo, operator, PEDCO (later replaced by KNOC) and Agip North Africa, a Libyan subsidiary of ENI Group. In December 2000, following the take-over of Lasmo, ENI became the operator of the concession (the new status of the joint venture, however, is still under the consideration and waiting the approval of the National Oil Corporation of Libya).
Soon after the discovery, four appraisal wells were drilled on the Elephant structure. On the basis of their results, the estimated recoverable reserves were upgraded from 300 Mbbl, made after the discovery, to the today’s 680 Mbbl, the oil in place being estimated to be more than 1200 Mbbl. Development operations to connect Elephant to the Sharara field (NC-115), thus to the Sharara-El Hamra-Al Zawia pipelines system, have started.
In the meantime exploration has still to be carried out in the remaining part of the NC-174 Concession. The exploration phase has expired in December 1998 and negotiations for the re-licensing of the concession are still ongoing with the National Oil Corporation of Libya. Meanwhile, the overall residual prospectivity of the concession has been

already evaluated. Some faulted anticlines, e.g. Hyena and Rhino, have been already outlined. Despite the nearby discovery of Elephant, the exploration risk of the NC-174 untested structures is relatively high due to the irregular distribution of the source rock and to the possibility of leakage through the prospect's bounding faults. South Scorpion, one of the largest and apparently most promising structures, was tested dry by Lasmo in 1994.

Residual potential of the Murzuk Basin

Following the discoveries made in its northern part, the Murzuk Basin is nowadays considered as having the highest residual hydrocarbon potential among all the basins of Libya. The central and southern portions are still virtually unexplored and foreign companies are rushing in an attempt to get new acreages. ENI, Repsol and Totalfinaelf are the most active companies operating in the area.
Agip North Africa has made a detailed evaluation of the hydrocarbon potential of the south and south-eastern part of the Basin. Here, the highest exploration risk is the presence of the source rock. The areal distribution of the Hot Shales interval is in fact rather irregular due to its complex depositional pattern. The few wells drilled in the area have not encountered it, but one well, A1-NC34, has probably penetrated a thin interval which may represent the eastern fringe of a local depocenter of the source. To the south, in the northern Niger, the well Kouana-1 has penetrated what appears to be a time equivalent of it. Moreover, a few seismic lines located southwest of A1-NC34 display some high reflectivity at the base of the Tanezuft Fm., which indicate that, there, the hydrocarbon source rock is possibly present.
In terms of traps for hydrocarbon accumulation, the current available seismic does not allow to detect any structure, especially in the far south, where data is completely absent. However, as the result of geological field trips and of studies on satellite imagery, some prospective although shallow anticlines have been outlined in the Gebel Ati area, an area close to the border with Niger. These anticlines could have been charged by hydrocarbons migrated from a source lying in a local depocenter situated to the north and/or in one situated to the south (northern Niger).
In conclusion, the hydrocarbon potential of the southeastern margin of the Murzuk Basin appears to be relatively high: the acquisition of new seismic and geological data will hopefully confirm the existence of a real prospectivity in the area.

Acknowledgments

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