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A COMPARATIVE ANALYSIS OF PALEOZOIC PETROLEUM SYSTEMS OF ILLIZI AND MURZUQ BASINS (ALGERIA AND LIBYA)

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A comparative analysis of the Illizi basin (Algeria) and the Murzuq basin (Libya) is presented based on recent exploration carried out by Repsol-Ypf. The main aim of the study is to compare and comment briefly on some critical elements of the Paleozoic petroleum system in each basin that could influence the future exploration in the region. The Illizi basin constitute a traditional area of exploration in North Africa where more than 4 billion barrels reserves of oil has been discovered, primarily in Devonian reservoirs with secondary Cambro-Ordovician and Carboniferous reservoirs. In addition, more than 20 TCF of gas has been found essentially in the Ordovician. The Murzuq basin remains comparatively under explored. Although petroleum exploration in the basin began in the 1950´s, difficult access due to extensive sand dunes together with remoteness from infrastructure diverted attention towards other areas of Lybia. In any case, more than 2 billion barrels reserves of oil have been proved in the basin mainly in Ordovician reservoirs. Significant gas discoveries are restricted to the northwestern margin of the basin, in the vicinity of Illizi (Atshan saddle).

The morphostructural configuration of Illizi and Murzuq is similar (fig. 1), with typical patterns of intracratonic sag flanked by regional highs (e.g. Hoggar, Tihemboka, Gargaf and Tibesti). Moreover, both basins constitute a single depositional domain during many stages of their multiphase evolution. Essentially, Permo-Mesozoic and Tertiary sediments overlie Paleozoic rocks truncated by the Hercynian uncorformity, with the Mesozoic truncated during the Alpine compression (fig. 2). Further to this geological similarity, the basins share most of the elements and processes that characterise the Paleozoic petroleum systems in North Africa. However, despite the general similarities and their proximity they present significant peculiarities that needs to be addressed during future investigation. Thus, exploration in Illizi is focussed primarily in a structural play concept whereas exploration of Murzuq combines structural and paleomorphological traps, the later represented by Ordovician paleohills developed as a result of glacial activity.

Successful structural traps found so far in both basins are associated with Paleozoic tectonic events (mainly Caledonian, Acadian and Hercynian phases), although they have usually been modified by later tectonic events. Thus the effects of Jurassic, Austrian and Alpine phases are observed throughout the area. The Paleozoic structures reflect the effects of intraplate deformation in cratonic settings. Thus, intense deformation is geographically limited and usually restricted to previous Proterozoic lineations. The regional delineation of these early structural

trends, and the assessment of the magnitude and timing of the different events in each basin requires further investigation. Paleomorphological structures also require further investigation in the Illizi basin.

Most of the oil discovered in the Illizi Basin has been found in Devonian reservoirs. Carboniferous reservoirs are of secondary importance whereas the Cambro-Ordovician is an objective mainly for wet gas. A inverse situation is found in Murzuq, where the Cambro-Ordovician reservoirs constitute the main producing interval with good porosity and permeability values (porosity in the range of 12 –20% and permeability 100-1000mD in some Ordovician intervals in the El Sharara Field) compared with low values found in Illizi where fracturing is usually needed to enhance the characteristics of this reservoir. These differences are related to depositional and diagenetic patterns and significant research is being focussed on this matter. Sealing efficiency of the overlying units is a matter poorly considered so far but reveals an interesting field of research. The low GOR ratios found in the accumulations of Murzuq suggest that a process of leakage of the lighter compounds is possible.

It is well known that two main source rocks characterise the Paleozoic petroleum systems of North Africa. These are radioactive ("hot") shale units developed at the base of the Silurian and in the Frasnian-Fammenian interval. Significant advances have been made during recent years in the investigation of these source rocks including their detailed geochemical characterization and the development of specific kinetics. Both units constitute excellent sources for oil. TOC values up to 17 % wt have been found regionally and samples gave excellent pyrolysis yields. The kerogen is sapropelic and plots on a Van Krevelen diagram predominantly as (oil prone) type II. It is accepted that both sources have contributed to the hydrocarbon accumulations in Algeria. However, the similarities between the kerogens that constitute most of the organic assemblages of these source rocks prevent a clear differentiation of the real role of each source. The oils found are similar, typically mature, light, non–sulphurous, high in saturates and showing typical features of Lower Palaeozoic oils such as high tricyclic terpane contents and a dominance of C29 steranes over C27 and C28. Further work is therefore needed to define the contribution from Silurian and Devonian.

In addition, significant advances have been made in mapping the distribution of the source rocks. Detailed work carried out in the Murzuq basin has demonstrated a remarkably discontinuous distribution of the Lower Silurian Hot Shale in oxygen deficient troughs. Additional work is needed to improve definition of the depositional patterns of this Hot Shale, especially in Illizi.The possibility that the Silurian shales (Argiles à Graptolites/Tannezuft) may contain organic-rich horizons above the basal Hot shale is under discussion. In the past, no significant source potential has been attributed to the interval but new data indicates the possibility of organic-rich horizons, which do not exhibit the seismic or wireline characteristics of the "Hot" shales. Furthermore, the presence of effective Devonian source rocks has not been demonstrated in the Murzuq basin, and it could be absent to the E-SE of Tihemboka high.

Significant variations in maturity and transformation ratio of the source rocks have been found. The Silurian Hot shale is mature for oil in most of Illizi and Murzuq. Transition to late maturity for oil and gas is found in SW Illizi and NW Murzuq. Pre-Hercynian transformation ratio is low except in these zones of higher maturity where thick Palaeozoic deposition occurred. Nevertheless, high maturity in these areas can reflect Palaeozoic burial or Mesozoic-Tertiary

thermal anomalies (hot spots). Thermal and fluid flow modelling indicates mainly a Mesozoic critical moment of the petroleum system in both basins. A relatively short lateral up-dip migration is the most likely migration mechanism. However, a late long distance migration of gas is also possible from the Berkine/Ghadames to the Illizi basin. Sensitivity analyses indicate that maturity of source rocks and timing of generation is very sensitive to the amount of Hercynian, Mesozoic and Alpine erosion and to the thermal history of the basin. The timing and magnitude of uplifts and thermal events are still poorly constrained

All the uncertainties discussed suggest that further work is needed to improve our knowledge of the Paleozoic petroleum systems of Illizi and Murzuq. New impetus in the investigation of these basins with the application of new technology to petroleum system analysis will contribute considerably to reduce exploration risk. In addition, it is demonstrated that most of the remaining questions in each basin cannot be solved on the basis of studies focussed independently. A regional and multidisciplinary approach considering both basins together and open discussion is needed to fully understand the remaining potential of these prolific petroleum systems.

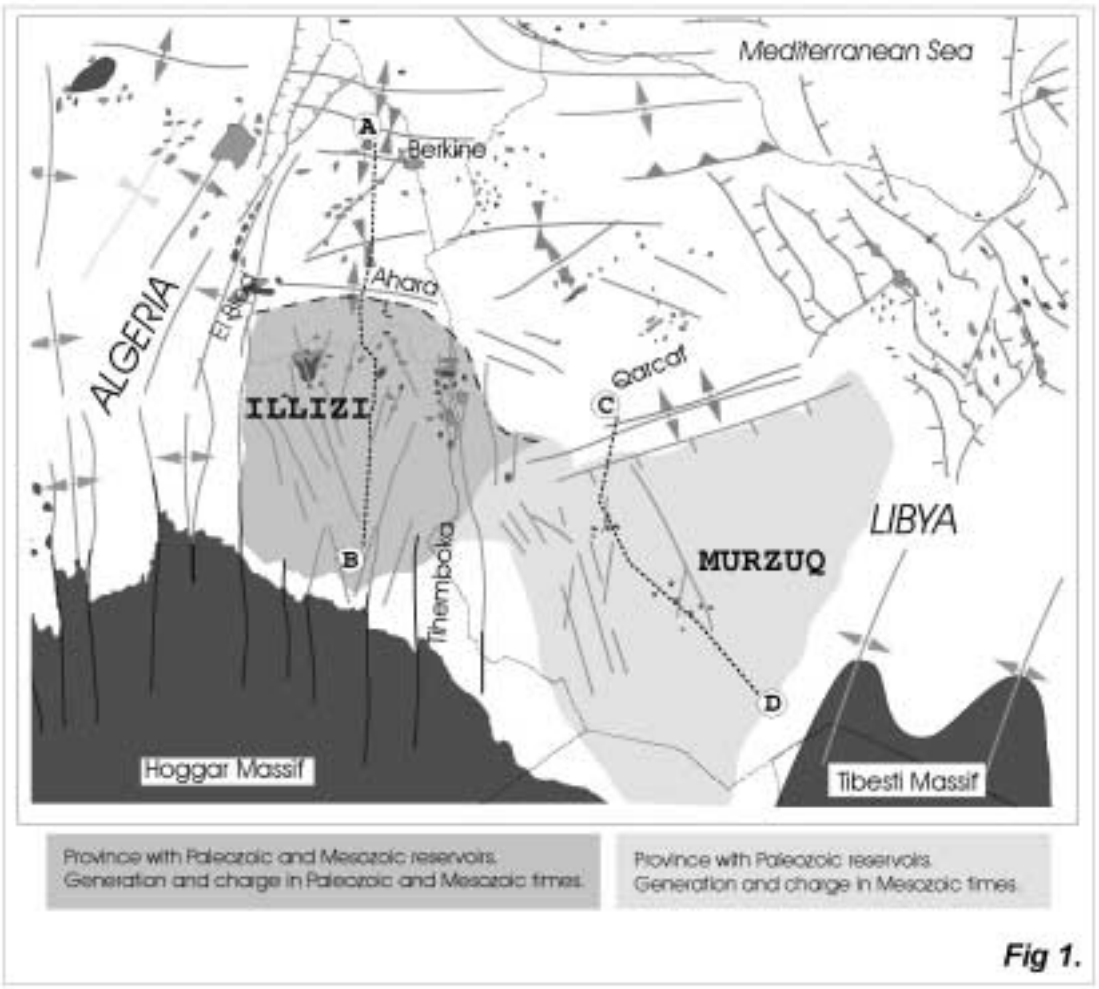
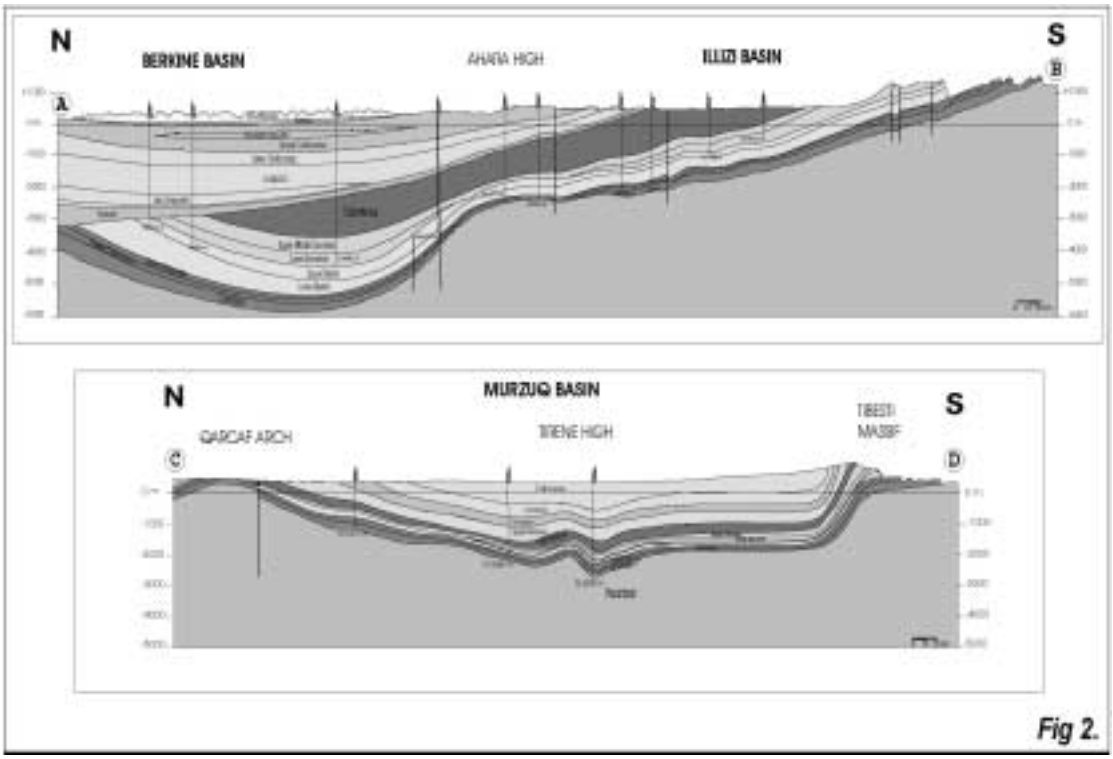

Mediterranean Sea
A
Berkine
Ahara
ALGERIA
El Biod
ILLIZI
Qarcaf
C
LIBYA
MURZUQ
B
Tihemboka
D
Hoggar Massif
Tibesti Massif
Province with Paleozoic and Mesozoic reservoirs.
Generation and charge in Paleozoic and Mesozoic times.
Province with Paleozoic reservoirs.
Generation and charge in Mesozoic times.

Fig 1.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BERKINE BASIN
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ILLIZI BASIN
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A
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Fig 2.