Exploration History of Messla Oil Field, Sirt Basin, North Central Libya

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Abstract

The exploration history in Libya started in the western part of Libya near the border to Algeria by Esso Company one of the Seven Sisters hopefully that the oil accumulation will extend from El Hasi El Masoudi in Algeria. The first well drilled (Wildcat) was Al Atshan well. There were only oil shows in this well. It was plugged and abandoned. Then Esso Oil Company was given a concession in Sirt Basin in the early fifties by the Libyan Ministry of Petroleum. The exploration history in Messla Oil Field started by drilling the wildcat HH1-65. The field was discovered in 1971 and was located in the southeastern part of the Sirt Basin approximately 40 km northwest of the supergiant Sarir Oil Field. Although in an early stage of development, the field is estimated to contain approximately 3.25 billion bbl. of original oil-in-place. The field was a seismically defined stratigraphic accumulation located on the east-dipping flank of a broad Precambrian basement high. The reservoir is in the Lower Cretaceous fluvial Sarir Sandstone, which wedges out westward on the basement and is truncated by a basin-wide unconformity at the base of the capping Upper Cretaceous marine shales (considered to be the source rocks) and by the seal Busat Formation (Anhydrite Cap). The reservoir consists of two sandstone units separated by a continuous shale bed (Red Shale). Porosity values average 17% and the permeability 500 md. The oil column averages approximately 90 ft., and is productive from an average depth of 8,800 ft. Over 200 km². Early 1978 production is in excess of 100,000 bbl/d of 40° API oil with a cumulative production of 45 million bbl.

Keywords: Messla Oil field, Exploration, Geophysics, Sarir Sandstone, Sirt Basin, Libya.

مقدمة

أطلق اسم ماسلا في ليبيا في الجزء الغربي من ليبيا بالقرب من الحدود الجزائرية من قبل شركة Esso كإحدى التحققات السريعة على أمل أن يتم تراكم النفط من الخزان المسعودي في الجزائر إلى ليبيا. حيث كان أول بئر تم حفرها (Wildcat) كان العطاشان ولم يكن هناك سوى النفط في هذا الربع لنا تم توصيله. تم حصول الشركة على أولي على احتراق في حوض سرت في أواخر الخمسينيات من قبل وزارة البترول الليبية. بدأ تاريخ الإكتشاف في حقل ماسلا النفط من خلال حفر الاستكشاف 65. تم اكتشاف الحقل في عام 1971 وكان يقع في الجزء الجنوبي الشرقي من حوض سرت على بعد 40 كم شمال غرب حقل سير النفطي العقار. على الرغم من أن الخزان قد يتراوح مداً حوالي 25 مليون براميل من الزيت الأصلي في المكان. كان الخزان عبارة عن تراكم متحدد زرائياً يقع على الجانب الشرقي للخزان في أعلى مستوى من قبو ما قبل الكرمي. يقع الخزان في الحجر الرملي السفلي من العصر الطباشيري (التي تدعى صحران الكرمي) و بواسطة الخزان Busat يتم الناقد على مستوى الحوض عند قاعدة الصخور البحرية العليا الطباشيرية (التي تعرف بصحرا الكرمي) بواسطة الخزان Red Shale. تشكل في الماسلا غطاء. يتكون الخزان من وحدتين من الحجر الرملي بفضل بينهما سرير من الصخور الرملي (Anhydrite).
1. Introduction

In 1961 British Petroleum, in partnership with Nelson Bunker-Hunt, discovered the multi-billion barrel Sarir C-Main field. Production was extended northward with smaller but significant discoveries in 1963 of C-North, and in 1964 of the Sarir L field (Sanford, 1970) (shown in Figures 1 and 2).

![Figure 1. Location of Messla Oil Field (orange arrow) (Clifford et al., 1980)](image)

In 1971, HH1-65, the 38th wildcat in 8,200 km² area of Concession 65, was drilled approximately 8 km north of the "L" field. HH1 was located on a seismic-mapped southeasterly plunging nose. The location was based on the geologic concept that the Lower Cretaceous Sarir Sandstone, productive in the "L" field, wedged out toward the west and northwest. direction a prominent Sarir bald basement high had been encountered by earlier wildcats. The discovery well penetrated 110 ft. of net oil bearing Sarir Sandstone through the interval 8,768 to 8,896 ft. and was potential-tested at a rate of 10,900 bbl/d of 38° API oil (Clifford et al., 1980). Subsequent delineation drilling showed the accumulation to be stratigraphically trapped by a westerly pinch-out of the Sarir Sandstone onto the basement, in conjunction with a regional unconformity at the top of the Sarir Sandstone.
2. Structure

The Messla field lies along a broad northeast dipping structural flexure that houses a weak eastward plunging anticlinal nose near its southern extremity. Over a major part of the field the structure is a homocline, with a rather constant strike of N 40° W and eastward dip of 0.5 to 1°. The gentle dipping homocline terminates at a regional syncline 15 km northeast of Messla (Clifford et al., 1980). (Figures 3, 4, and 5). The variations in strike across the field, as indicated by contours on the unconformity surface (Figure 6, are tentatively considered to be eastward flowing drainage patterns rather than structural depressions, as these strike variations are not evident on an intra-Sarir Sandstone zone. As much as 100 ft. (30 m) of possible erosion has occurred in these narrow "channels." A "channeling" interpretation is not, however, supported by all the data, and until additional drilling in these features is available, other causes, particularly faulting, are believed possible. Faulting has not been recognized within the Messla field, which is surprising due to its frequency in the Sarir fields (El-Hawat et al., 1993). Only at the southern boundary of the field is there a defined zone of westerly trending cross faults. These faults, downthrown on the south side, interrupt the southern flank of the nose and parallel the shallow syncline which separates Messla from the anticlinal and fault-controlled "L" field (Clifford et al., 1980).
Figure 3. [Color] West to east cross section of line A-A\(^\prime\), Messla oil field, showing wedge out and truncation of Sarir Sandstone (Clifford et al., 1980).

Figure 4. [Color] West to east cross section of line B-B\(^\prime\), showing wedge out and truncation of Sarir Sandstone (Clifford et al., 1980).

Figure 5. [Color] North to south cross section of line B-B\(^\prime\), Messla oil field, showing a partly truncated and faulted section of Sarir Sandstone (Clifford et al., 1980).
3. Geophysics

Various geophysical surveys were carried out in the years prior to the drilling of HH1-65. Airborne magnetometer and gravity surveys showed an eastward plunging basement nose in the general area of the field, (Abadi, 2002). Reconnaissance single fold reflection and basement refraction seismic refined the interpretation of the nose but it was not until the 1969 completion of a 600% analog reflection survey that a comprehensive deep structural picture emerged (Clifford et al., 1980). The additional information obtained from the initial discovery and early delineation drilling was used in a 1974 reinterpretation of the existing seismic data, which yielded a detailed structure map of a deep time event associated with the top of the Upper Cretaceous Rakb-4 Formation. This map forms the basis for the structural interpretation of the Messla field, and only a slight modification in its detail resulted from a 208 km, 1,200% digital reflection survey in 1975. Subsequent drilling has confirmed the map's reliability. The field area is characterized by good reflection results (as shown in Figure 7) (Clifford et al., 1980).

4. Stratigraphy

The stratigraphic sequence in the Messla field is divided into two major depositional periods by a pronounced intra-Cretaceous unconformity (Gras and Thusu, 1998), (as shown in Figure 8). The pre-unconformity sediments of the Lower Cretaceous age are predominantly non marine, and average 500 ft. (152 m) in thickness. The post-unconformity Upper Cretaceous and Tertiary form a thick succession of deep-marine to near-shore deposits, averaging 8,800 ft. (2,682 m) in thickness. Significant lateral facies variations within the field occur only in the Paleocene, which exhibits a strong north to south facies change (Peter and Dana, 2003).
5. Reservoir Properties

Petrographic and SEM analysis demonstrate that a series of early cementation and compaction events, in combination with late burial diagenesis, have occluded most of the porosity in these sandstones (as shown in Figures 9 and 10). Early chlorite rims, pore-filling chlorite, calcite, dolomite, and anhydrite cements have pervaded the primary pore network. Bitumen coatings
on chlorite rim cements record an early episode of oil migration. Consequently, most diagenesis post-dated oil migration. Sublitharenites containing rock fragments have the highest frequency of chlorite cement. This suggests that rock fragments sourced the iron and magnesium for the authigenic chlorites in Sarir sandstones (Tucker, 2001). Following precipitation of chlorite and pervasive cementation by non-Ferroan carbonates and anhydrite, the influx of corrosive fluids created secondary porosity by partial to complete dissolution of labile framework grains and intergranular cements. These secondary pores have been cemented with kaolinite and later Ferroan carbonates. Hence, this dissolution event did not improve reservoir character (Kosceć and Gherryo, 1998). Late burial diagenesis of Sarir siliciclastics, by analogy with other Gulf of Sirt basin formations, occurred at elevated temperatures (100 to 150°C) based on the presence of abundant detrital feldspars. The pervasive distribution of late pyrite in some Sarir Formation cores provides evidence of thermochemical sulfate reduction. The Sarir Formation diagenetic system is inferred to have been semi-closed because components needed for the formation of several diagenetic phases (e.g., chlorite, kaolinite, and pyrite) appear to have been derived internally. Diagenetic alteration of rock fragments, detrital feldspars, and authigenic anhydrite liberated ions that re-precipitated in situ as cements. However, the sodium required for albitization, as well as the calcium and magnesium needed for precipitation of pervasive carbonate cements, most probably had an extra formational source (Moore, 2002).

Figure 9. [Color] Net pay Isopach map, Sarir Sandstone, Messla field, Libya.
5. Conclusion

The nature of the sandstone facies provided reasonable reservoir rocks. The shale facies of the Red Shale member represents a well-developed break between the Lower Sarir Sandstone and Upper Sarir Sandstone members; it also provides a good seal for the underlying sandstone of the Lower Sarir Sandstone. The nature of the shale facies, (i.e. lack of organic content, and presence of oxidizing conditions indicated by iron oxides color), indicate that they are not a significant source of hydrocarbons.

However, in the open system of nature well developed ideal models are limited; the studied Sarir sequence in the Messla area can be considered, in a general since, an example of petroleum producing fluvial deposits.

This study, hopefully, enhances the understanding of the nature of the rock sequence in an important giant oil field. It is a contribution to the geology of the region; and it can be of great help in the exploration of similar examples locally around the Messla high and regionally. Although, this study reasonably covered the Sarir Sequence in the Messla Oil Field, further follow-up study, that covers more wells and expands to adjacent areas, will be very useful.

References


