Petroleum Res. J. Vol. 12 (2000); P. 19–24, 8 Figs.

Seismic Interpretation of Gargaf Group Palaeostructures, NW of Concession 6, Sirt Basin, Libya

Senusi M. Harsha* and Falah H. Owaina*

التفسيرات السيزمية للتراكيب القديمة لمجموعة القرقاف في شمال غرب عقد الامتياز رقم 6، وسط حوض سرت، ليبيا

السنوسي محمد حرشة وفلاح حسن عوينة

تم تفسير تتابع مجموعة القرقاف ذات العمر (الكامبرو - أوردوفيشي)، وأعدت هذه التفاسير على هيئة خرائط زمن وسرعة وعمق.

أمكن التعرف على وجود منطقتين مهمتين من الناحية النفطية، الأولى تعد منطقة مكمن غازي حيث تم حفر معظم الآبار الغازية المنتجة منها والواقعة بالجزء الشرقي من منطقة الدراسة، أما المنطقة الثانية فهي واقعة في الجزء الغربي، وتعد منطقة مؤملة على الرغم من أنها بحاجة إلى دراسات تأكيدية إضافية.

توضح خريطة السمك لتكوين الباهي وجود توافق جيد بين منطقة المرتفع القديم المتمثلة بمنطقة عدم الترسيب ومنطقة المكمن الغازي في الجزء الشرقي، كما أظهرت مطابقة جيدة بين موقع المرتفع ومواقع الآبار المنتجة.

Abstract: *The top sequence of the Cambro-Ordovician Gargaf Group in NW of Concession 6 is interpreted. Time, velocity and depth contour maps were constructed.*

Two prospects were mapped in the studied area, one is well defined with many gas producing wells located to the east, the other, which was newly defined, is located to the west of the area. The second prospect appears to be an attractive one, but needs to be confirmed by further seismic survey.

The isopach map of the Bahi Formation shows a good coincidence between the structural closure and the Cretaceous palaeohigh structure of the area. Similar coincidence exists between produced well locations and the palaeohigh.

INTRODUCTION

The Sirt Basin is located in the north central part of Libya. It is a young-rifted intracratonic basin. An active subsidence and block faulting as a result of the collapse of the Sirt Arch in late Early Cretaceous time developed this basin. Marine sediments accumulated following the initial arching and rifting of the Sirt Basin. They unconformably overlie the igneous and metamorphic rocks of Precambrian basement, Cambro-Ordovician Gargaf group and/or Nubian Sandstone (Gumati, 1985).

The study area is located between the Hagfa and Wadayat troughs in the northwest of

* Department of Geophysics, Faculty of Science, Al-Fateh University, P.O. Box. 13379, Tripoli, Libya.

Concession 6 (Fig. 1), and is represented by a gas field. Three of the thirteen drilled wells were dry. The important structural element in the area of study is the major northwest-southeast trending normal fault, which extends along the southern flank of the area.

The objective of this study is to evaluate the field through mapping of the subsurface structures.

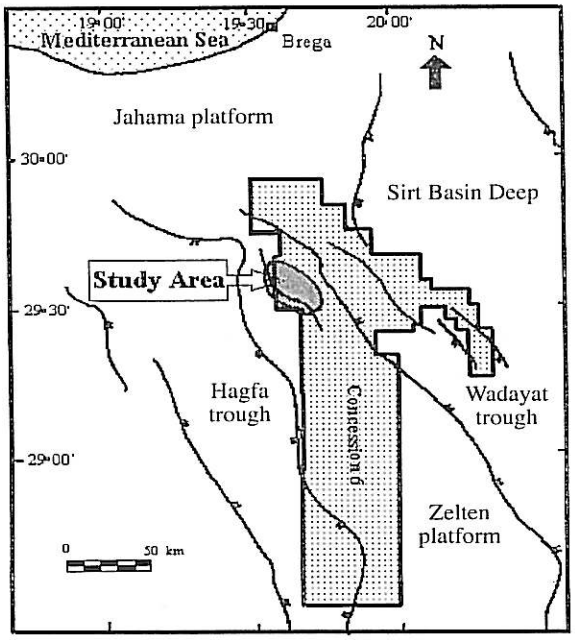


Fig.1. Location map of the study area.

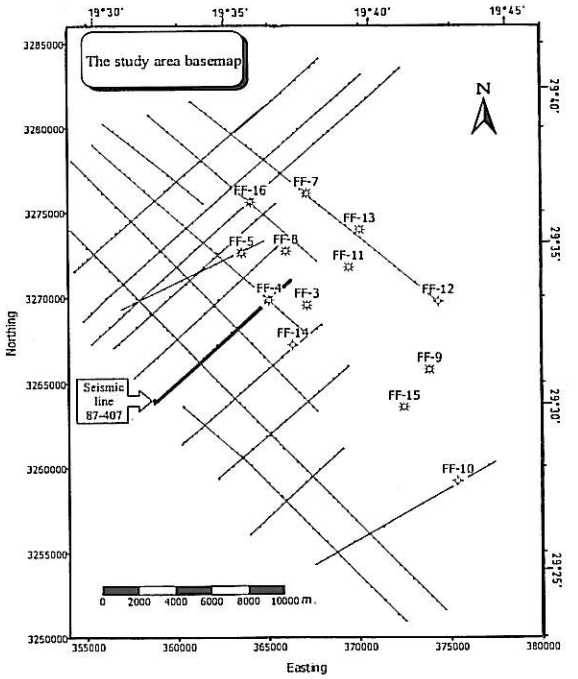


Fig. 2. The base map of the study area, the bold seismic line is the line 87-407, its interpretation is illustrated in Fig. 4.

All of the well logs and eighteen seismic lines were used to examine the tectonics and subsurface geology of the study area (Fig. 2). The top of the Gargaf sequence was chosen to be the interpreted seismic event. It was picked on the seismic sections and mapped in time and depth. Depth conversion was preformed using an average velocity function.

The available data provide a background information for the present geophysical interpretation. The analysis has resulted in the construction of time and depth contour maps for the top of Cambro-Ordovician Gargaf quartzites, which are identified as the principal reservoir.

GEOLOGICAL AND STRUCTURAL SETTING

The graben effects in the Sirt Basin started in the Late Cretaceous and ended with the downwarping of the interior sag in the middle Late Eocene (Parsons *et.al.*, 1979).

A number of transgressive and regressive cycles occurred during the Phanerozioc. The sedimentary sequences are dominated by marine shale, carbonates and evaporites in the Sirt Basin (Gumati *et.al.*, 1996).

The Sirt Basin within the vicinity of the area under study underwent regional uplift and tensional faulting, this has resulted in a northwest (NW) trending horst and graben structural style of considerable relief. The horsts were weathered and eroded with accumulation of sediments in the graben.

SEISMIC INTERPRETATION

The Sirt Oil Company (SOC) has provided us with the essential data for this study. It includes eighteen final stacked seismic sections obtained in 1987 and two synthetic seismograms for wells FF7-6 and FF12-6. The quality of the seismic data ranges from poor to good with low seismic resolution especially for deep reflectors. The data was non-migrated 2-D seismic sections. The mapping was conducted without any support of seismic interpretation workstation.

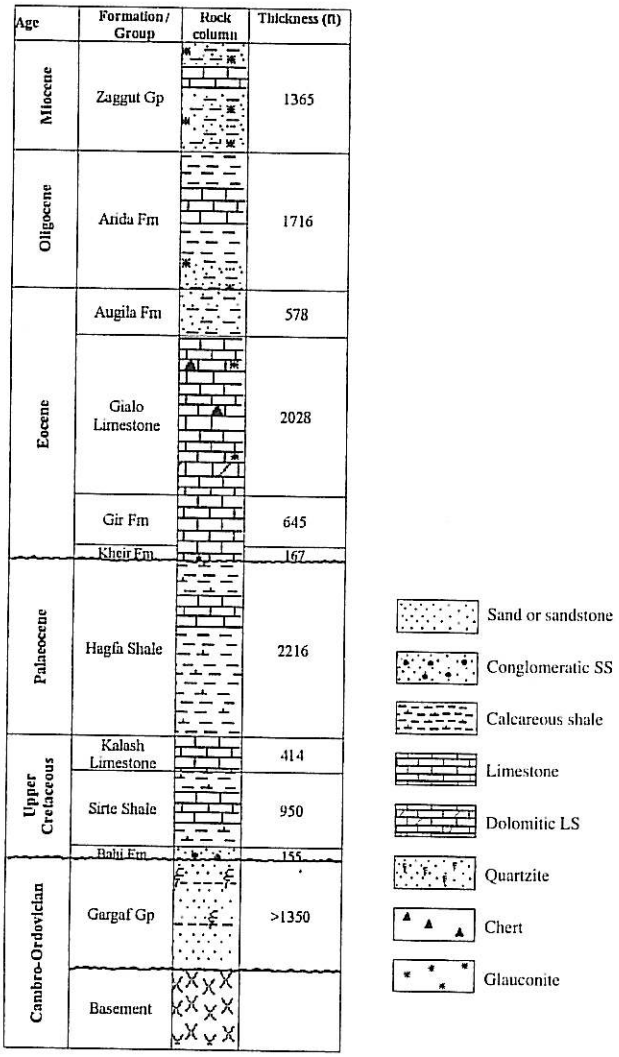


Fig. 3. A composite stratigraphic column of the study area.

Since the Bahi sandstone is overlying the Gargaf quartzites, the seismic event of the top of Gargaf Formation is marked by a weak amplitude peak on the synthetic seismograms of the available wells in the study area, this weak amplitude is an indication of poor reflection coefficient.

The top of the Gargaf horizon has fair to good continuity. It was difficult to pick, in many places, on the seismic and no mistie was recognized on the cross lines (Harsha, 1997). This horizon is overlain by different Upper Cretaceous sequences in the study area. The Kalash Limestone unconformably overlies it in wells FF8-6 and FF3-6. On the other hand, the horizon is overlain by the Sirte Shale as indicated in wells, FF10-6, FF9-6, FF11-6, FF5-6, FF16-6, and by the Bahi Formation in wells FF15-6, FF14-6, FF12-6, FF13-6, FF7-6, and FF4-6. The Gargaf horizon has reflection time of about 2.532 seconds in well FF12-6.

Only normal faults, were recognized on the seismic sections. They represent the rifting criteria that have taken place during the Sirt Basin building episode. They represent the dip line direction and are very clear in the SW-NE lines. Figure 4 is part of the interpreted seismic section ((87-407) which illustrates these structures. It shows the picked horizon, the graben and the horst structures that are existing in the area. Varying thickness on two sides of normal faults indicates growth fault mechanism.

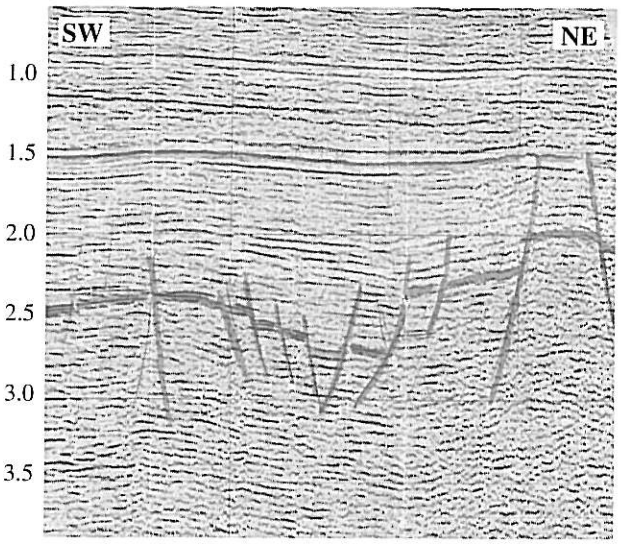


Fig. 4. Part of the seismic section (87-407) showing the normal fault system of the area, the horst, the graben and the picked seismic event of top Gargaf quartzites.

The major and minor faults, shown on the contour maps, follows the major NW-SE trending faults in the Sirt Basin. The faulting separated the area into three blocks. The first is a horst located on the east side of the area, the second is a graben located in the middle of the area and the third is another horst located on the west side. The south flank of the area is comparatively steep.

The time contour map shows a structural high in the centre of the area, with a contour range from 2450 to 2000 milliseconds (Fig. 5). The other structural high is in the west of the study area.

The average velocity map, which was constructed from the available well data, shows small lateral variations in the top of Gargaf velocity. The contour patterns on the average velocity map are sufficiently similar, and the contours show that the velocities differ by 150 m/sec. from one side of the area to the other (Fig. 6). Generally the velocity is increasing towards the southwest. The lowest velocity region (northeast) is 2800 m/sec, and the highest region (southwest) is 2950 m/sec. This gentle variation of the average velocity is very normal and accepted for depth conversion.

Gargaf depth below sea level. The closure contours vary from 3000 to 3500 m in the middle of the area, in particular over the structure. They show clearly the trend and the shape of the structure, which is a northeast – southwest trend. The area becomes slightly deeper away from the closuring contours, especially in the southwest where depth reaches 4000 m.

Most of the producing gas wells were drilled in the east block. However, an attractive structure appears west of the area. Even with the limited amount of information available it is easily shown that the structure in that part of the area will be very interesting.

The Bahi Formation isopach map was constructed based on information from thirteen wells (Fig. 8). It lies unconformably over the lower Palaeozoic sandstone from which it seems to have been derived. At wells within a Palaeozoic structural high, the Bahi Formation is missing, and in this area the Sirte Shale unconformably overlies the Lower Palaeozoic rocks. From the isopach map, it was recognized that the Gargaf Formation blankets the two sides of the study area, and is separated by NW-SE trending local post- Cretaceous high (Fig. 8). Thickness varies considerably within a short distance. It indicates thinning and non-deposition over the high. There is a good correlation between the eastern horst of Gargaf depth map and the palaeohigh as indicated by the Bahi isopach map. This result supports the conclusion of the relation between palaeohigh and the oil entrapment at the Gargaf reservoir level.

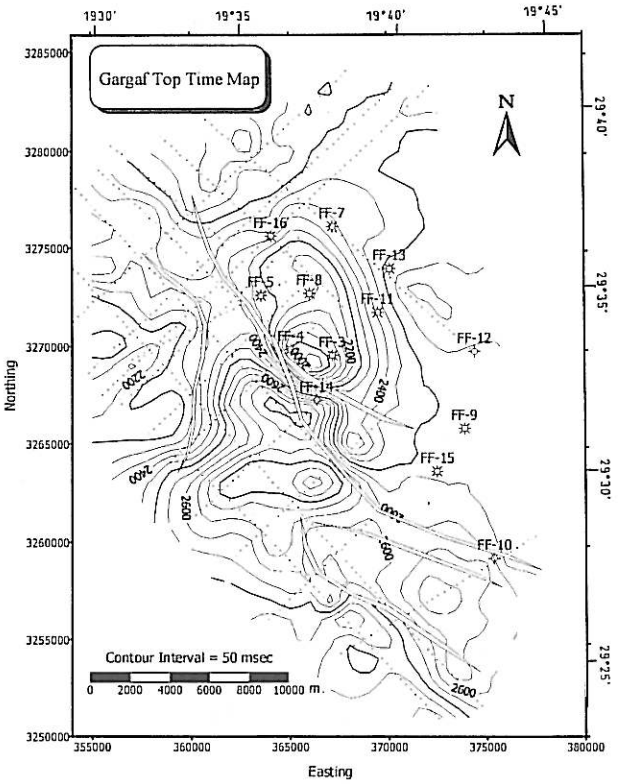


Fig. 5: Gargaf time contour map represents the interpretation of the picked horizon with the interpreted normal fault system of the area. The map was constructed using Surfer software.

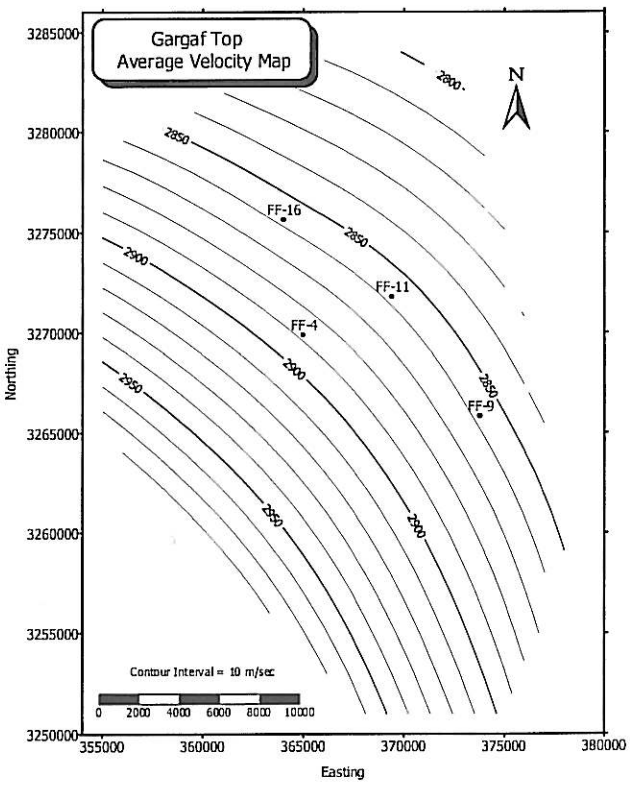


Fig. 6. Top Gargaf average velocity map. The velocity surface was constructed using four wells located in the middle part of the area.

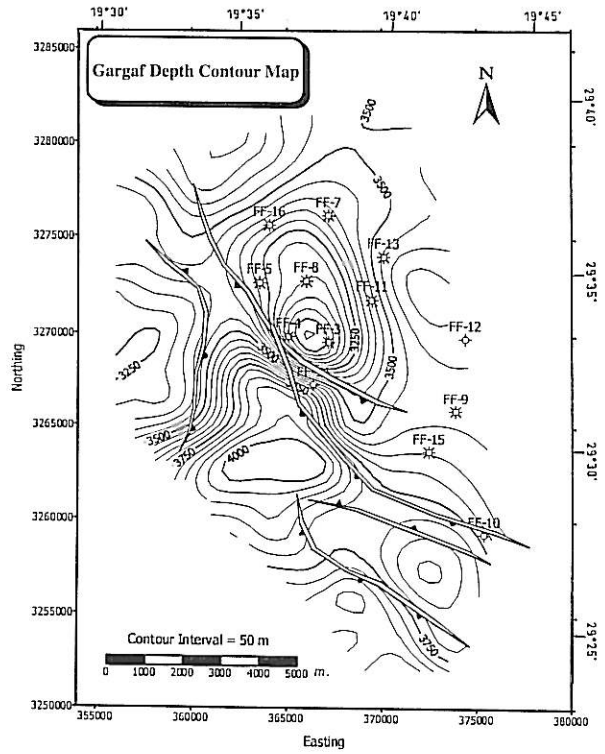


Fig. 7. Top Gargaf depth contour map. The fault system was not migrated in the spacial domain. The map covers the main horst structure, and shows all of the producing wells in the field.

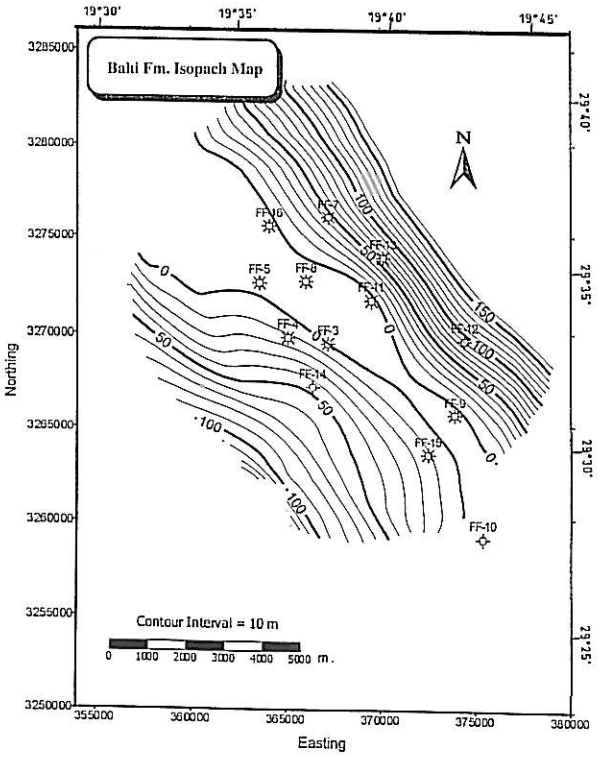


Fig. 8. Bahi isopach map. The Gargaf Formation blankets the two sides of the study area. NW-SE trending post-Cretaceous high separates them.

CONCLUSIONS

Major northwest-southeast trending normal faults are, an important structural element in the area, separating the area into three blocks. The most important structure in the study area is represented by a palaeohigh structure (Pre-Cretaceous high). All of the producing wells are located on the palaeohigh structure, while the three dry wells are located away from it.

The agreement between depth contour map and Bahi isopach map is represented by this palaeohigh.

There is an attractive structure in the west of the gas field, its dimension may exceed 5x5 km with more than 200 m of relief. This closure, may have the same reservoir characteristics of the productive field. Even from the limited available amount of information it is easily shown that this structure could be an important prospect.

The Cambro-Ordovician Gargaf sandstone and the Upper Cretaceous Bahi Formation represent the principal gas reservoir of the area. The Upper Cretaceous Sirte Shale is regarded as the main hydrocarbon source rock of the Cretaceous reservoirs and the underlying Gargaf sandstone.

ACKNOWLEDGEMENTS

The authors wish to thank Sirt Oil Company, Libya for providing the essential data for this paper. Thanks are also extended to Mr. Ross McCullough for his English language reviewing.

REFERENCES

Gumati, Y. D., 1985. *Crustal Extension, Subsidence, and Thermal History of the Sirte Basin, Libya*, Unpublished Ph.D. thesis, Earth Sciences and Resources Institute University of South Carolina, USA.

Gumati, Y. D., Kanes, W.H. and Schamel, S., 1996. An evolution of the hydrocarbon potential of the sedimentary basins of Libya. *J. Petrol. Geol.* **19**(1), 92-112.

Harsha, S. M., 1997. *Stratigraphic Correlation and Seismic Interpretation of Attahaddy Field, Sirt*

Basin, Libya, Unpublished Ph.D. thesis, Faculty of Physical and Applied Sciences, University Kebangsaan, Malaysia, Bangi-Malaysia.

Parsons, M. G., Zagaar, A. M. and Curry, J. J., 1979. Hydrocarbon occurrences in the Sirte Basin, Libya, In: *Facts and Principles of World Petroleum Occurrence. Mem. Can. Soc. Petrol. Geol.* **6**, 1-15.