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Integrating data from Remote sensing Technology and Geological Field work observation for the Gharain area, North West Libya

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Abstract

The present paper deals with the integration of field work information and remote-sensing data to improve the structural knowledge of the Gharian area, northwest Libya. Remote sensing Technology is used for geological mapping and the faults and fractures. Data presented here are based upon a detailed field work mapping and remote-sensing data.. The results of this study confirm that the Gharian escarpment is the expression of major normal faults which from a small part of large rift system faults .The integration and interpretation of the results indicate that Tertiary volcanic activity (intrusions and extrusion) of the Gharian area are clearly structurally controlled in their emplacement but not in any signification manner affect the geometry of the geology . Given the large rollover anticline at Gharian called the Jabel Uplift.

Keywords: Field work, remote sensing, normal faults, Gharian area , NW Libya

I. Introduction

The aim of this paper is to describe and quantify the geological structure of the Jabel Nafusah region, specifically in the Gharian area. This is achieved through remote sensing , mapping, field observation of large and small scale geological structures (faults, joints and folds), and the analysis of fault orientation data (in order to investigate fault trends). There is limited geological research on the Gharian area and this work has been done a long time ago. By the early 1960s two schools (Italian and French) had studied the Mesozoic stratigraphy of Jabel Nafusah. North western Libya is located at the eastern flank of the south Atlas fold belt adjacent to the Saharan flexure or lineament (Antketell and Ghellali 1991). This lineament system bifurcates near the Gulf of Gabes where it appears to underlie the Trabules Basin in the off shore and Jafarah Basin to the south on land (Anketell 1996). According to Anketel and Ghellali (1991) and Gabtni (2009) the southern branch represents the line of the Hercynian Jafarah flexure, which is dominated by basement structural features of northwest Libya and southern Tunisia. Gabtni et al (2009) showed from subsurface data the major fault within the system related to Mesozoic rifting. There are three major fault systems in north-western Libya.. The first one, a coastal fault system that strikes parallel to the coastline and the second major fault system is the Al Aziza fault system (NW-SE) (Desio et al., 1971; Gary, 1971; Boote et al., 1998; Swire and Gashgesh, 2000). The third major fault system runs from west to east near Al Aziza town, where it joins the SE trending Wadi Ghan Fault Zone. This system has played an important role during deposition of Mesozoic rocks (Anketell and Ghellali 1991). The thickness of Mesozoic rocks increases north of the Al Aziza fault suggesting that this fault has played an important role during deposition of Mesozoic rocks in the region. Desio et al., 1963; Gary, 1971 interpreted the Jabel Nafusah region as a large dome. Recently published evidence from the continuation of the Nafusah escarpment into Southern Tunisia (Saad et,al., 2008 : Saad et,al., 2009 and Alfandi 2012) it is strongly suspected that the major master faults have a listric geometry and cut significantly down into the underlying Triassic and older units. consequently, no clear explanation of the Jabel Nafusah escarpment itself.

Location of the study area I.1.

The study area is located in northwest Libya, about 60 km south from the Mediterranean coast with Wadi Ghan to the east, and 56 km from Kiklah to the west (Fig. 1). The Gharian area is bounded by the Ghadamis Basin in the south and the Jafarah Basin to the north. Mesozoic strata outcrop in northern Libya and south-eastern Tunisia where an almost complete sequence from Triassic to Cretaceous is known, one of the few areas in the whole African continent (Bishop,1975)

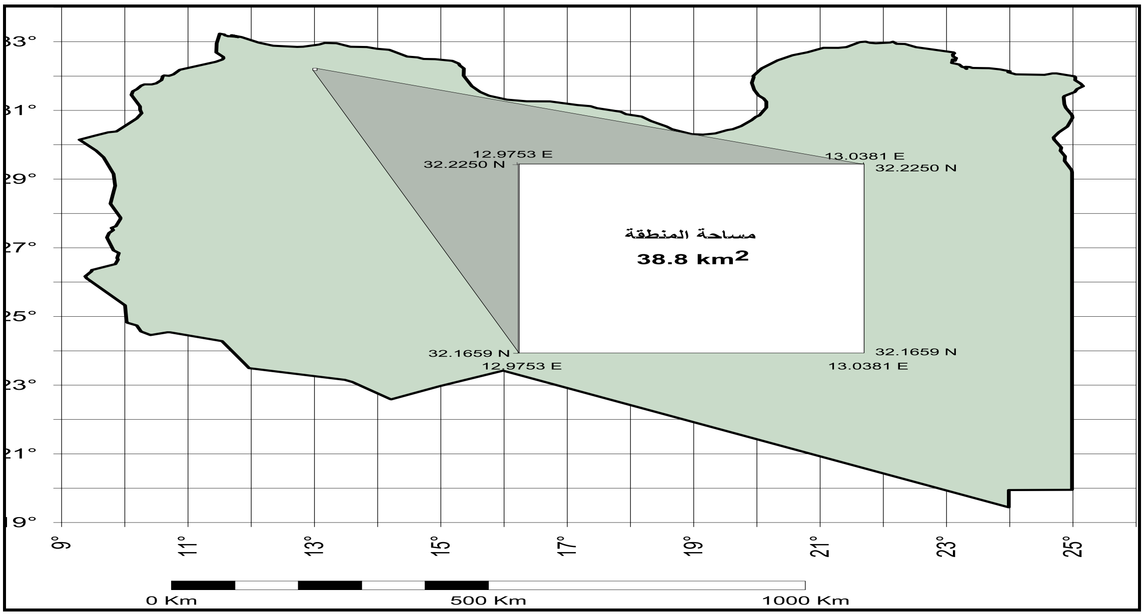

Fig.1 location of study area .

II. Material and Methods

Documentation and materials used are :

- A Google earth, satellite image maps, Geologic map and the 1:50,000 scale topographic map sheet numbers 3/1989 was obtained from the Industrial Research Centre of Libya.
- Field Investigation**,**

Standard geological fieldwork techniques as outlined in McClay (1987) and Tucker (1982, 2003) were applied in measuring and describing the field sections. Reading of grid reference defining data collection sites or field localities use UTM coordinate, derived from a Global Positioning System (GPS) and also from field cross-referencing with topographic maps (Longitude and Latitude. Photographs and field sketches were taken for several purposes and were developed during the fieldwork.

III. Results And Discussion

1. Large-scale faulting

The most common structures in the Gharian area are faults and anticlines (Fig 2 and Fig. 3). Faults are one of the most characteristic features of the region, particularly in the Gharian area, however, a number of NW-SE and NE-SW trending faults have been recorded during field work. Further west in Wadi Gabel (Fig 2) a major fault trending north west, has been postulated to explain the northward displacement of the Al Aziza Formation against the Abu Shaybah Formation. However, there are no subsurface data available to estimate the cumulative throw of this fault (Fig. 2) . Large fault was located on the top of Abu Ghaylan Formation and on the north flank of the Sid as Sid Formation. The strike of this fault is E-W and beds are dragged to nearly vertical dip 88 and this fault has displacement >10 m in length. A large scale fault is located on the eastern side of Abu Rashad road (N 32 11.643 E01300.310). This fault plane comprises dipping beds of Al Aziza Formation in contact with the Abu Shaybah Formation. Another fault, trending NE and dipping to 62N, is located at few meters westward of the previous one (Fig.2). A large fault was located on the top of Al Aziza Formation and on the north flank of Wadi Abu Shaybah. The strike of this fault is E-W and beds are dragged to a nearly vertical dip (60-90). This fault has an unknown displacement (Fig. 3). In the central part of the Gharian area (between Wadi Au Shaybah and Wadi Gabel), normal faults outcrop one of strikes NW, and is responsible for the formation of a half graben (Fig. 3). Furthermore, faults continue for several kilometres to the north, indicating that the normal faults control in some way the location of Abu Ghannush volcanic rocks in the central part of the Gharian area. Along the Gharian-Tripoli highway, synthetic and antithetic faults were observed (Fig 4). Therefore, the Gharian area is a good example of a small horst block. Another fault trending NW drops down the Kiklah formation and then the Abu Ghaylan Formation to the northeast, is located a few hundred meters west of the previous one (Fig.4) .

Fig 2. Normal faults showing **a**) significant offset of the Abu-Shaybah-Al Aziza boundary on the Wadi Gabel and **b**) an unbreached anticline overlying JN faults in Wadi Au Shaybah**.**

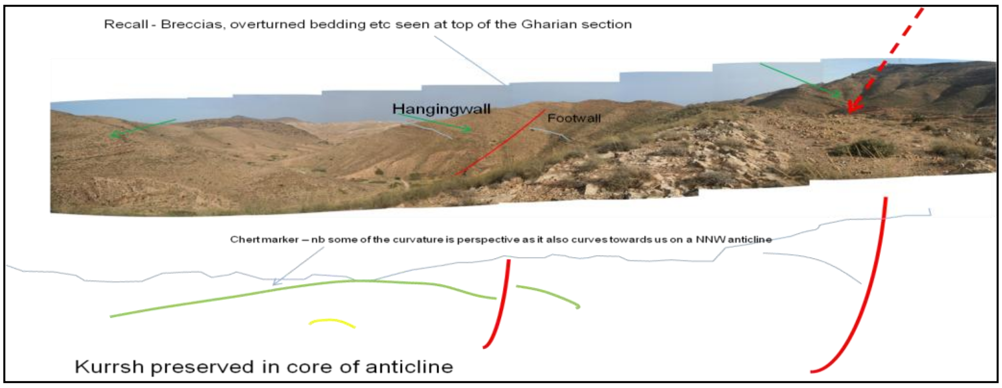

Fig. 3 The Gharian rollover showing Al Aziza Formation in the core of the structure immediately north of Gharian viewed looking east.

Fig 4. Nafusah escarpment north of the village of Abu Ghaylan. Kiklah Formation displaced by two major normal faults of the Jabel Nafusah system and forming a broad, low amplitude anticline between them.

Outcrop scale fault2.

Normal faults are very common at outcrop-scale and occur in sediments that range from Triassic to Late Cretaceous in age (Table.1). These are dominated by limestone, dolomite, and sandstone. A boundary fault cuts middle Triassic to Cretaceous sediments at a quarry exposure near the village of Qosam (Fig.5). Here some of the small outcrop scale faults are presented. Note that 99% of the observed small out crop scale faults are a normal faults .In the central part of the Gharian area (between Wadi Au Shaybah and Wadi Gabel), normal faults outcrop. One of them strikes NW dips 68 SW and has 18 cm displacement. Another strikes NE, dips 66 SW and has 22 cm displacement. Several normal faults were identified near the Italian buildings, the Wadi Gebel (Fig .5). The faults are high angle (59° and 66°) and strike NW-SE and NE-SW. A normal fault was observed in Wadi Abu Shaybah near the old quarry of Abu Shaybah Formation. The fault strikes 152/66SW, the displacement is small (tens of centimetres). Another normal fault was observed the along the Gharian-Tripoli highway, the fault strikes 121/51 NE and also there is angular unconformity was observed between the Kiklah Formation and the Sidi as Sid Formation. The displacement is about 6 m.

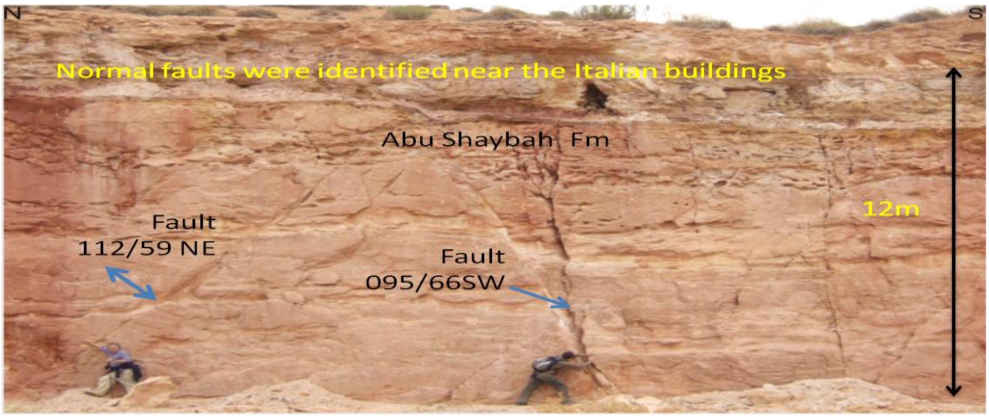

Fig 5. Photograph showing the dips and strikes of the faults in the Abu Shaybah Formation, Wadi Gabel. Note that this outcrop is a good example for the timing of faulting. The upper package of strata is not cut by the fault, therefore fault was moving during the deposition.

Several normal faults were identified to the west of the Abu Rashad road where they have a strike NW and low dips suggesting that they have been rotated after formation. Another fault trending NE and dipping to N, is located a few hundred meters west of the Kurrush Formation (Fig.6.). Two faults have been identified in the north-western part of the Gharian area near the town of Al Aziza . These strike NW-SE and have a small displacement (tens of centimetres). Another fault trending NW and dipping to south, is located 1.5km west of the Al Aziza town (Fig.6). In the east of the study area, near Qosam village (Fig. 4.15 and 4.8), numerous normal faults have been observed, striking

NW, dipping to south and with offsets of between 8.38 cm and 12.2cm. Another fault, located at few metres southwest of the previous one, trends NE-SW and dips to north.

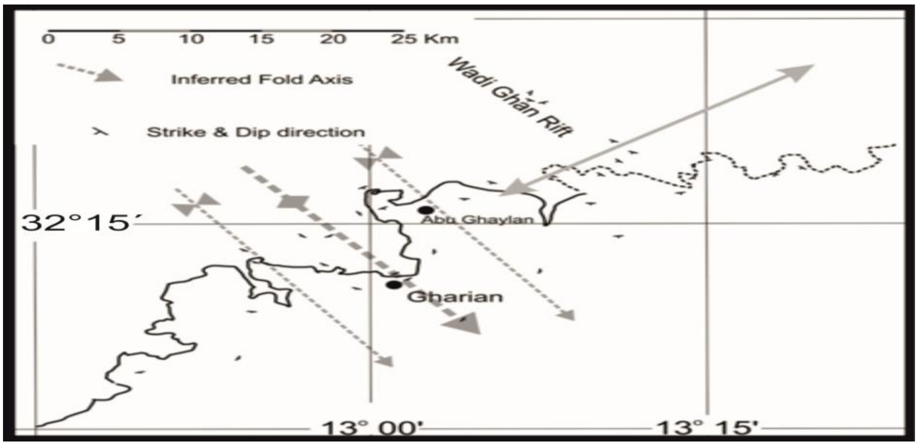

Fig 6 Summary of the major NW structures in the Gharian area

Formation Name	N-S	NE-SW	NW-SE	E-W
Kurrush Fm		✓		
Al Aziza Fm		✓	✓	✓
Abu Shaybah Fm			✓	✓
Abu Ghaylan Fm		✓	✓	
Sid as Sid Fm		✓	✓	
Gharian Fm		✓	✓	✓

Table 1
Summary of the main faults trends in the Gharian area by age.

***Fault Plains and Joints* 3.**

The faults are oriented at NW-SE and NE-SW. These faults follow the overall trend of the Al Aziza fault system and Wadi Ghan fault system. During the field investigation it was noted that the location of the Gharian area was controlled by three fault orientations (NW-SE, NE-SW and EW-NS). phonolite and basalt cones in parallel lines with the dominant fault trends (NW_SE) indicates that the volcanic activity is related to the tectonic activity of the Jabal Uplift. These findings are in good agreement with previous authors. In their recent analysis of lineament patterns from DEMs and existing geological maps Saadi et al. (2009) report the NW-SE trending. Moreover, in the Gharian area numbers of smaller synthetic and antithetic faults have formed a small hors (Fig.7) . Generally, two fault systems that trend NW-SE and NE-SW are responsible for forming the half graben in the Gharian area .

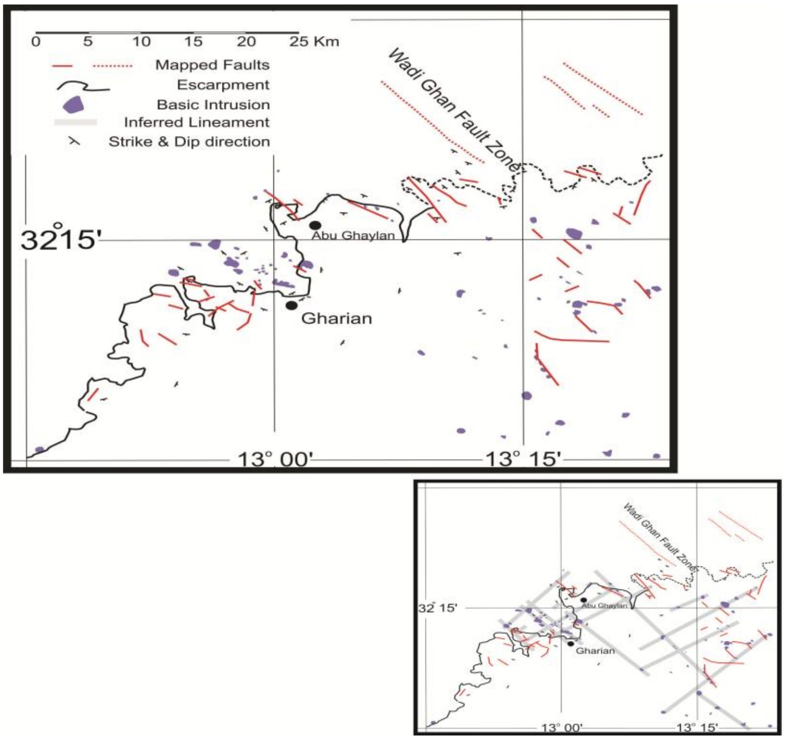

Fig7. Location of igneous intrusions around Gharian from the 1:25, 00 scale geological maps (Sheet NI 33.13R, Tarabulus, 1975.Their interpretation as being located at the intersection of NW-SE Hun Graben faults and NW-SE Jabel Nafusah faults.

4.Fault orientation data

In total 89 fault measurements were made on fault planes in the field area. The order of movement, faults and joint data were grouped and plotted on stereographic projections as planes to poles using Stereo Net programmer. The component faults display two dominant trends: NW-SE and NE-SW. Some E-W faults also occur (Fig. 8). Thus, the majority of the faults trend parallel either to the Al Aziza Fault system or the Wadi Ghan Fault system. When all of the data are considered together (Fig 8), the majority of faults strike between 030° and 340°. The majority of the faults in the Gharian area have an angle of dip greater than 60° (Fig. 9). There is an apparent relationship between the NE strike and the low angle of dip as seen in Figure 9.

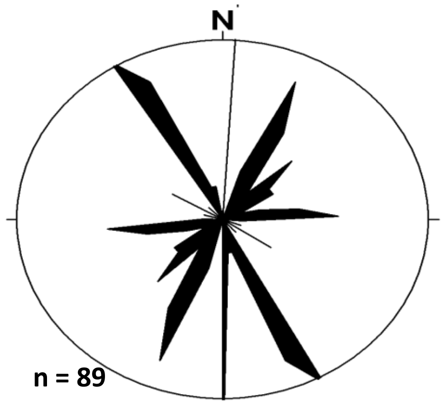

Fig.8.Rose diagram showing the strike of all fault planes measured in the Gharian area.

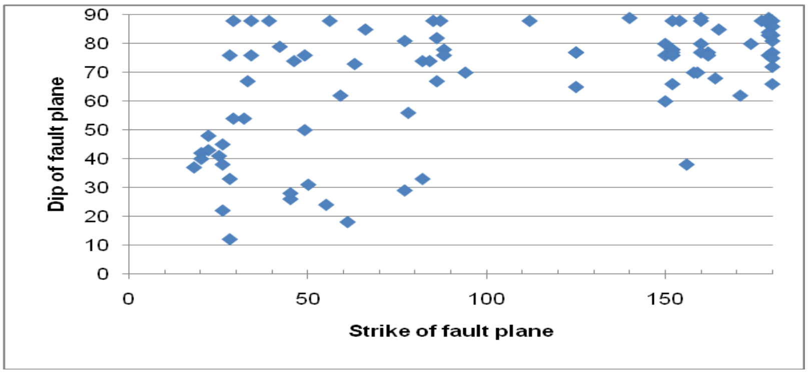

Fig.9. Graph showing the strikes a plot of faults against their dips in the Gharian area

IV. Conclusions

The integration of results shows that three faults trends were recognized in the study area. The NW-SE trend related to the to the Ghadamis Basin during the Early Palaeozoic time, when deposition was effected by the NNW-SSE uplifts of the Tamboka in the west and the Tripoli- Tibisit Arches. The NE-SW fault trend related to movement led to the uplift of several ENE-WSE arches and erosion of the lower Palaeozoic rocks, particularly along the Dahar –Nafusah uplift in NW Libya and central Tunisia. The E-W fault trend related to the third major fault system that runs from west to east near Al Aziza town, where it joins the SE trending Wadi Ghan Fault Zone. However the phonolitic intrusive and the unique intensity of Faulting associated with the Gharian dome are clearly structurally controlled in their emplacement but not in any signification manner affect the geometry of the geology . Given the large rollover anticline at Gharian called the Jabel Uplift.

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