2nd Conference on Sustainability in Civil Engineering (CSCE'20)

Department of Civil Engineering

Capital University of Science and Technology, Islamabad Pakistan

The Use of PALSAR (D.E.M.) for Mega Fracture Analysis of Dabbar Anticline, Sulaiman Fold Belt, Pakistan

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Abstract: The structural analysis has been carried out on the Dabbar Anticline using D.E.M. (Digital Elevation Model) data derived from Phased Array type L-band Synthetic Aperture Radar (PALSAR) of 12.5m resolution. The main structure is interpreted as upright, asymmetrical, gentle anticlinal fold based on the stereographic analysis. A total of three hundred fractures are marked across the Dabbar anticline having multiple lengths and orientations. One hundred and three fractures are marked on the Northern segment, sixty-one fractures are marked on the Central segment and one hundred and thirty-six fractures are marked on the Southern segment of the Dabbar anticline. Stereographic analysis and Rose diagrams show that the most major trend of lineaments is in NW-SE direction, parallel to maximum stress and termed as oblique fractures. This research in the Sulaiman Fold Belt indicates that mapping the structural features through D.E.M. data can provide a fair amount of geological information for understanding the characteristics of hydrocarbon reservoirs and engineering structures.

Keywords- PALSAR-D.E.M., Tensional fractures, Asymmetrical, Rose Diagrams.

1 INTRODUCTION

The breakage in a competent rock with no visible movement along its surface is known as a fracture. The Middle East is dominated by competent carbonate rocks, around 70% of the oil and 90% of the gas reserves are held within these fractured reservoirs [1]. Similarly, Pakistan also dominantly contain competent carbonates with hydrocarbon production history Figure 1 (C). Therefore, the knowledge of fractures is considered as very important in different kinds of geological studies (engineering structures, hydrocarbon reservoirs etc.) as they provide pathways for the fluid flow/transportation. In this context, types, trends, continuity, concentration and the origin of fractures are considered as important constraints [2]. To understand fractures, the present study is practiced on Dabbar anticline of the Sulaiman Fold Belt (SFB) by using D.E.M. data.

The Sulaiman Fold belt (SFB) is a lobate feature along the western margin of Indian plate mostly located in remote areas of Baluchistan, Pakistan Figure 1(A). This area is recognized as a prolific hydrocarbon province as well as seismically active, having exposed sedimentary strata from Permo-Triassic to Recent age of mostly platform origin. (Figure 1 (C), [3],[4],[5],[6]). The E-W trending Dabbar Anticline is a part of Western Sulaiman Fold Belt, lies between 30.02° to 30.11° N and 68.32° to 68.66°E. The surface geology of the anticline shows Dungan Formation of Paleocene age, which consists of competent limestone. It is bounded by strike-slip Khalifat Fault on its western side

Figure 1(B). Due to its location in the remote area of Pakistan, the Digital Elevation Model (D.E.M.) data is used in this study to obtain the following objectives.

1. Fracture orientation.
2. Fracture classification.
3. Fold classification.
4. Stress and fractures relationship

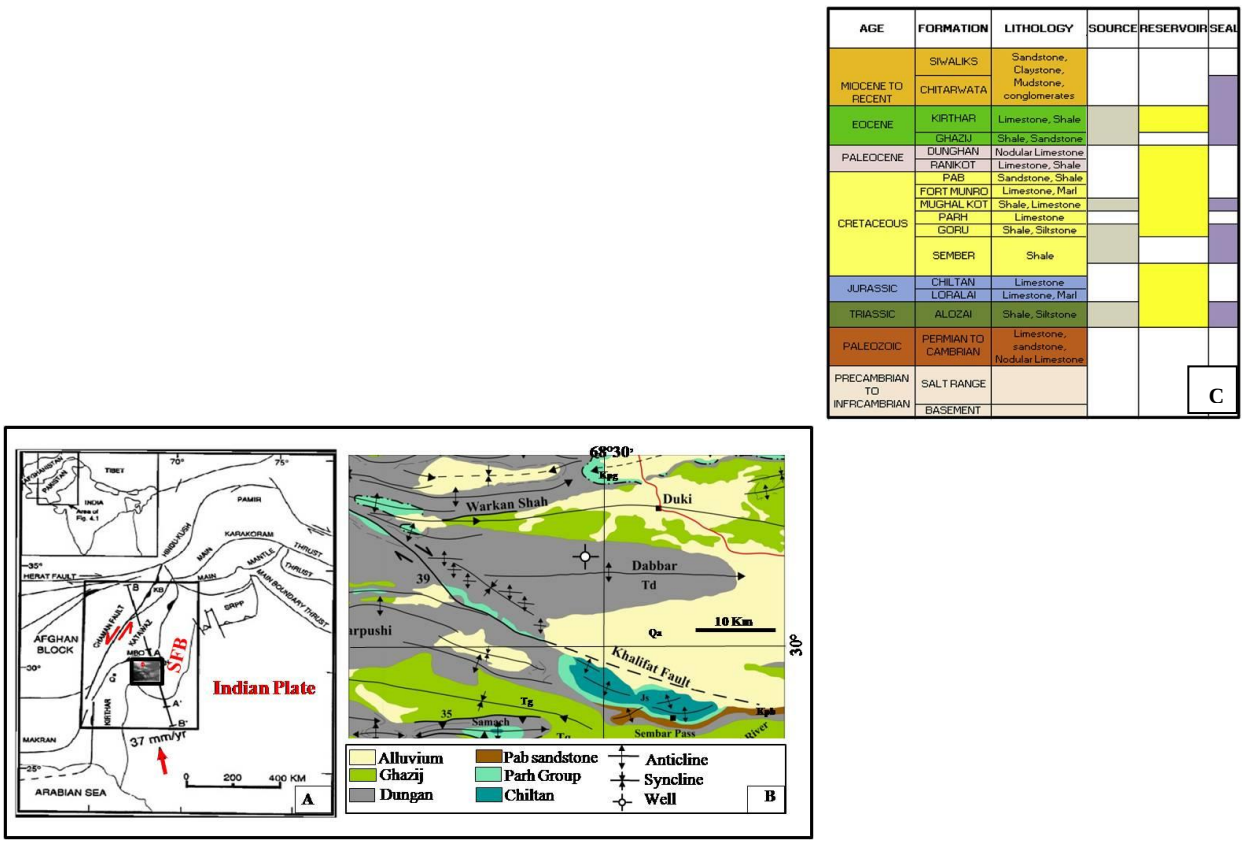


Figure 1: (A) Map showing the location [7], (B) Tectonic map [8], and,
(C) Stratigraphic column of the Sulaiman Fold Belt [6].

2 RESEARCH METHODOLOGY

The data and methodology are summarized in Figure 2 with details as follows:

2.1 Data set

The Digital Elevation Model data is a 3D representation of terrain surface used for structural analysis, physiographic mapping and neo-tectonic study. In this research, PALSAR data is used as a D.E.M. obtained from (https://www.asf.alaska.edu/).

2.2 Image processing

The image processing has been accomplished by using the following methods:

2.2.1 *Elevation Contouring*

3D data stored in PALSAR is utilized in ArcGIS to generate elevation contours of Dabbar anticline Figure 3.

2.2.2 *Image enhancement techniques*

The image is enhanced by changing a) sun azimuth angle, b) sun elevation (altitude) angle, and c) vertical exaggeration (z factor). Generally this technique is known as Hill Shade Tool (HT) and is available in ArcGIS. Different images are generated for the clarity of the structure for lineament marking.

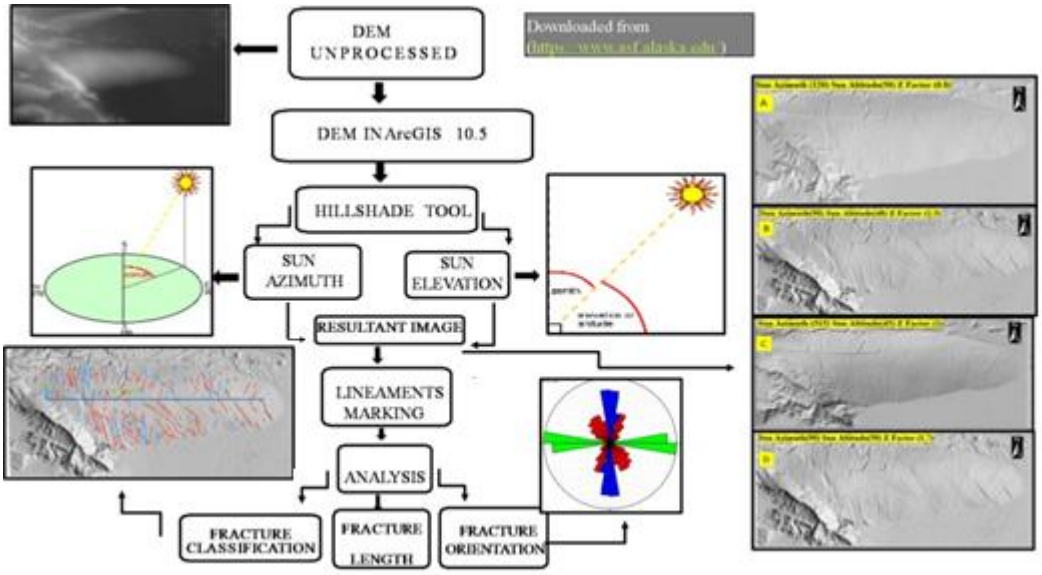


Figure 2: Workflow of the fracture analysis

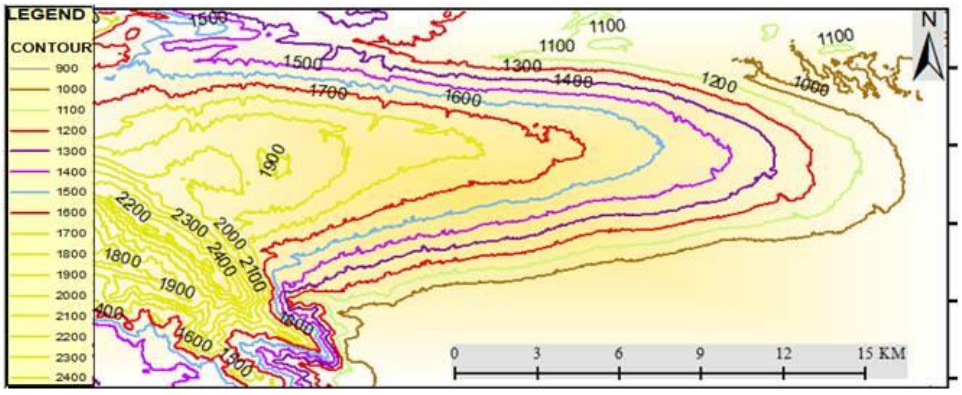


Figure 3: Elevation contour map of the Dabbar anticline

3 RESULTS

3.1 Fold analysis

The elevation contour map of Dabbar anticline is created by using a contouring tool in ArcGIS with a contour interval of 100meters (Figure 3). This helps in determining the strike and dip of northern and southern limb of Dabbar anticline using a three-point problem, which states that it is possible to calculate dip and strike of a horizon if the altitude of the horizon is known (Table 1,[2]).

3.2 Fracture analysis

The processed images are interpreted in ArcGIS to mark the mega fractures. The total number of mega-fractures marked across the Dabbar anticline was 300. After marking the fractures of Dabbar anticline we have calculated the orientation and length of lineaments using GIS software. This data is analyzed with Stereonet software (10.2.9) in order to make rose diagrams.

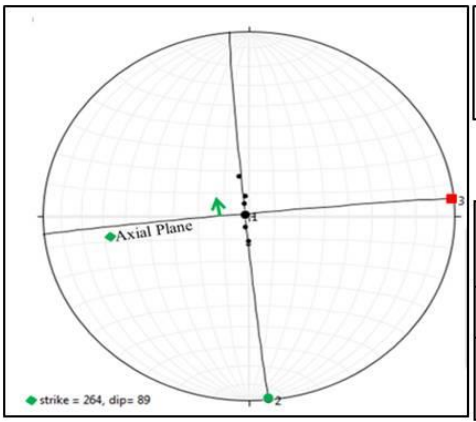
Table 1: Calculated strike/dip of the Dabbar anticline

	Western Part		**Central Part**		**Eastern Part**	
	Strike	Dip*	Strike	Dip	Strike	Dip
Northern Segment	91	12° NE	92	11° NE	108	5° NE
Southern Segment	78	18° SE	81	9° SE	73	6° SE

*Dip: Tan σ= change in elevation/ distance on map

4 DISCUSSION

Dabbar anticline is generally asymmetrical structure with a mean dip of about 10.1° of both limbs. The orientation of the fold axis is 84.5° with a plunge of 1.4°. Based on the inter-limb angle it is classified as gentle fold. Based on the axial plane, this fold is classified as upright fold. Generally, three types of fractures are observed to be developed across fold i.e. oblique, transverse (perpendicular to fold axis) and longitudinal (parallel to fold axis). In the case of the Dabbar anticline, the oblique fractures are dominantly observed with a general trend of NW-SE (Figure 5). The longitudinal fractures are rarely observed with the general trend of E-W direction.



Fold axis		Interlimb Angle	Fold Type
Trend	Plunge	IA	FA
84.5	1.4	135	Gentle

Figure 4: Stereographic analysis of anticline

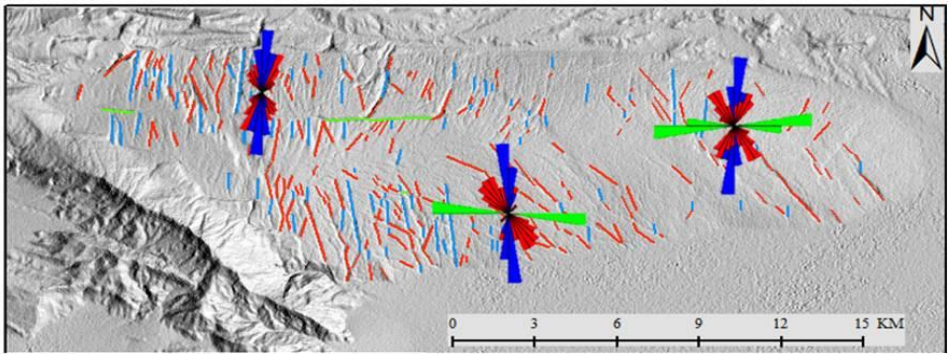


Figure 5: Fracture marking with their rose diagrams

5 CONCLUSIONS

This study is concluded with following points:

- The Sulaiman Fold Belt has hydrocarbon reserves with dominant carbonate reservoirs.
- Fractures play an important role in hydrocarbon production. Therefore, they were analyzed along an anticline. The analysis was carried out using PALSAR (D.E.M.) data and GIS software.
- The general trend of the anticline is E-W. Dabbar anticline is generally asymmetrical anticline with southern limb steeper (6°-18°) than the northern limb (5°-12°). The fold is classified as upright based on the axial plane and interlimb angle.
- A total number of 300 fractures were marked along this anticline and classified these fractures into oblique, transverse, and longitudinal sets based on relationship with anticline fold axis. The dominant fractures are oblique's sets with a general trend toward NW-SE.
- This research shows that the PALSAR (D.E.M.) data can be used for structural and fractures analysis in a remote and inaccessible area.

ACKNOWLEDGEMENTS

We acknowledge the support of Dr. Nangyal Ghani Khan, Assistant Professor and Dr. Faizan-ur-Rehman Qaiser, Lecturer, Department of Earth Science, CUI-Abbottabad Campus in this research work. We gratefully acknowledge the careful review and constructive suggestions by the anonymous reviewers.

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