Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 (3) February 2014: 209-215

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Resultant Stress Field in Eastern Region of Taftan volcano

Pouya Sadeghi[1], Mohammad Mehdi Khatib[2]
[1]Tectonics Laboratory, Department of Geology, Birjand University, Birjand, Iran
[2]Tectonics Laboratory, Department of Geology, Birjand University, Birjand, Iran
Email: Pouya.Sadeghi@rocketmail.com

ABSTRACT
In southeastern Iran, across the eastern region of Taftan volcano, there is an interesting structural curvature in the strike of one the more famous active faults called Saravan fault. Also it seems a slender morph and thinning in the one end of igneous mass that lies to the east of Taftan volcano and Saravan fault system. By using analytical and numerical methods and the measuring of attitude of the structural elements such as strike and dip in faults and fractures in one side and fold axial plain, foliation and schistosity in the other side, we supplied a stress field upon the stress rate and maximum stress vector direction for this area.
KEY WORDS: Curvature, stress field, strike, dip

Received 12/12/2013 Accepted 21/01/2014

INTRODUCTION

Taftan volcano area is located in the Nehbandan- KHash structural zone [10] of sought east of Iran. However there are some other names for this zone such as Iran's East mountain [1], Sistan suture zone [4], Zabol- Baluch [3], Flysch [6], Makran Mountain and East of Iran [15]. Sistan suture zone has changed with a lot of tectonical events with high notability in a short timing [4]. A rifting system has parted Lut and Afghan block from each other. Subsequently an oceanic basin was found that its evidence is thick Flysch deposits. North east subdution beneath the Afghan block occurred in Maastrichtian and collision of Lut block and Neh complex happened in Eocene. Continuance of this convergence caused folding and conjugate strike slip faulting system of area that is visible on Oligocene and Miocene rocks [4]. Subdution have been to the east direction where Afghan block exists [16]. However the number of volcanoes of Afghanistan is trifle. About Taftan, it's believed that Taftan Mountain is a young and semi- active Pliocene-quaternary volcanic system that is located in 50 km far from Khash village in Baluchistan [7]. It's height from see level is 4050m and from surrounding planes is about 2000m. This volcano is occurred on Eocene Flyschs. The first eruption involved lava and dacite and rhyodacite pyroclastic rocks. The second activity of Taftan volcano consist upper Pliocene dacite and andesite lava in 10 km far from its cone that left widespread agglomerate layers. It is believed that Taftan volcano is due to the Arabian plate subdution beneath central Iran plate according to the geodynamics models fore closing of Neotethian Ocean. Also there are some important seismic evidences [2]. Among main seismogenic faults, Saravan fault is most important that is a reverse fault with a right lateral component in latest movements. The study area involves also Oligocene Grano- diorite Tonalite intrusive mass is called Kuhe- Sefid Mountains and Meta-Dacite extrusive rocks called Kuhe- Gazu Mountain the both lie to the east of Taftan volcano and of Saravan fault system.

MATERIAL AND METHODS

Geology and Geometry of main surrounded faults

For initial analysis, we purveyed simplified geological map of Narre- Now region map [11] to have a general view of geological setting from the east of Taftan volcano in macro view (Fig. 1).
This area bounded by several active faults that main of them is Saravan fault in East and Kaskin, Damand and Bamposht in west. From Landsat 4/5 (TM) image it can be obviously recognized a curvature in strike of Saravan revers fault (Fig. 2).

Field surveying and measuring orientation of structural elements

To have a more clear structural view from study area and have enough data for analysis, it should be measured the attitude of structural elements. Field study is important for both kinematics analysis of faults [9] and for estimating of stress distribute across an area. Here we measured classified data from each study subarea. Regarding to the high expansion of our study quadrant, the data are obtained so that their related location moderately cover the study are. Taken data in stereogram from fractures with their strike and dip rose diagrams for six major stations near villages Sangan, Pil Kushkan, Sabz gaz, Hasan Abad, Rankazan and Bayn besides a digit elevation satellite image is used to have a overall view of fault and fractures attitude in east region of Taftan volcano around of Saravan fault strike and to have an early estimation of dominant effective stress direction (Fig. 3). There were also several typical tension gashes that show shear sense of Saravan fault (Fig. 4). Saravan fault surface is obviously distinct in Fig. 5. Folding structures in this area is very disturbed. Also there are some synclines that classified as Over folds due to the continuance of compression tectonic and faulting from location of their axial plain.

Around Gazu village in N: $28^0 32'$, E: $61^0 25'$ there is a silty sandstone layer that has affected by more than one shortening direction. By putting together the survey data, it is concluded that we have a pattern of folding in this area as Refolded folds. The results include anticline with an axial plain of N5E/ 75NW that refolded again with an axial plain of N55W / 68NE. These folds are common in the Eocene flysch formations in the region Gazu that after exerting data in a 3d design environment it will be more tangible a three-dimensional reconstructed pattern as seen in Fig. 6.

RESULTS AND DISCUSSION

Stress analysis

Though contemporary stress field studies give us insights into mechanisms that drive plate motions [5] but when studies encompass a more time range, deductions will be difficult. 2d stress distribution studies can be performed in two states. The first state includes a plane with two horizon dimensions that is the aim in this study and the other one includes a plane with two horizon and vertical dimensions such as Islam et al (2012) [8] studies. Unlike to the deduction about stress distribution from global to the regional scale (Zhang et al., 2011) we directly deal to the gathering local data. There are different types of fault and fractures in eastern region of Taftan volcano.

Determination the type of fault and fractures is possible from different ways. Beside some folding and fracture related to the main faulting system can help us to estimation of influence of maximum stress in special direction [12],[13]. For example when we have Statistical abundance of conjugate fractures around our fault zone, that overlap other young structures in an area of several square kilometers, we can first estimate latest direction of max stress and Secondly we can calculate approximate stress rate from comparison the different domain of similar fractures from the point of view intensity and frequency. In other hand the dip of a local fault plane and measured orientation of displacement vectors are used for dynamic analysis. So stress rate can be estimated using analytical method based on multi- station method outlined in Mohr circle. The Basis for this purpose is NDA (numerical- dynamic analysis) method [14]. It is noted that the plots represents a dimensionless Mohr circle of the plane $\sigma 1$- $\sigma 3$. This means that it is not a criterion of the absolute values of $\sigma 1$ and $\sigma 3$ but the situation of $\sigma 1$ and $\sigma 3$, where the two small circles come together are valuable to estimate the stress rate. Fig. 7 shows some response for calculated stress rate from measured data in four main stations on a path In accordance with main strike of Saravan fault that mentioned before.

In an overall study about the orientation of the stress vector on the northeast Taftan, it can be obtained detailed data from Investigation on the fractures that occurred on the quaternary unites. The study subarea is located between longitudes 61° and 61°30′ and latitudes 28°30′ and 29°. In general view to the fractures of geology 1:100000 map of Taftan region, we recognized three major strikes. One category with strike NW-SE but N40E and N55E are the other two strikes that apparently are conjugate relative to each other. From Taftan volcano peaks to a radius of about 20 km, almost no significant faults and fractures, especially in eastern regions can be seen. According to the northeast fault scheme of Taftan, general orientation of the stress associated with faults are estimated (fig. 8). With a review of such faults in northeast and east of Taftan, the stress along N40E that is bisector of an acute angle from their intersection can be recommend. Fault related folding is also useful to estimate stress direction. Compression stresses within the river valleys of Sangan and Gazu villages where is called Darreh-Kouhestan, using attitude measurements of limbs and axial plane with Longitude and altitude 61°25′17″ and 28°32′36″ respectively is considerable. The attitude of axial plane in folds is N10W, 85NE-90 and fissility is parallel to the axial plane. After collecting data and relative numeric results of stress rate and its direction from the structural elements attitude, it can be possible providing a stress field for our study area in east of Taftan by running Matlab coding that can be seen in Fig. 9. With a smaller area and higher

frequency data, the stress field will be obviously more detailed than the large scale one. So far, we use general stress field for our scale. This field can be separated into two groups for study. The group 1 is around east and north-east and partly south-west east of the stress field that follows from unit stress source and group 2 is in the southeast part of the Taftan. There is a category identified as a source other than Taftan volcano. As it can be seen there is another stress field system influencing around Taftan volcano that has a different source. Notice to the characteristics of attitude collected from structural elements (Fig. 3) and plot them on the stress field net, it can be seen a significant correlation between obtained stress field and structural elements. But the important point is that there is an Incompatibility between structural elements and orientation of group 1 and Group 2.

In transition area between two groups, the discrepancy is less and structural elements are more compatible with the orientation of stress field. Where the stress field is perfectly compatible with the structural element, there will be a stress field that induced volumetric strain due to Taftan volcano. Thus, the volumetric strain in the first category must be taken seriously. So overlapping of the stress systems (superposition of stress system) led to greater complexity in this area.

If two stress fields fall on each other, it will change the size and orientation of the principal vector of stress. For example, if we have two groups of stress components in a region such that have a spatial orientation and coordination such as x, y and z, we must have a combination of stress field such as the following matrix:

$$\begin{bmatrix} \delta x_1 & \tau xy_1 & \tau xz_1 \\ \tau yx_1 & \delta y_1 & \tau yz_1 \\ \tau zx_1 & \tau zy_1 & \delta z_1 \end{bmatrix} + \begin{bmatrix} \delta x_2 & \tau xy_2 & \tau xz_2 \\ \tau yx_2 & \delta y_2 & \tau yz_2 \\ \tau zx_2 & \tau zy_2 & \delta z_2 \end{bmatrix} = \begin{bmatrix} (\delta x_1 + \delta x_2) & (\tau xy_1 + \tau xy_2) & (\tau xz_1 + \tau xz_2) \\ (\tau yx_1 + \tau yx_2) & (\delta y_1 + \delta y_2) & (\tau yz_1 + \tau yz_2) \\ (\tau zx_1 + \tau zx_2) & (\tau zy_1 + \tau zy_2) & (\delta z_1 + \delta z_2) \end{bmatrix}$$

So the maximum stress in group 1 is equal to the resultant vector of maximum stress before of volumetric strain (adapted with group 2) and maximum stress due to the volumetric strain. Then we can identify the stress field of group 2 as a resultant stress field. Therefore if we want to have a portrayal of stress vector in relating to general structural elements, we can perform it by using stress field in Fig. 9 and field data as shown in Fig. 10.

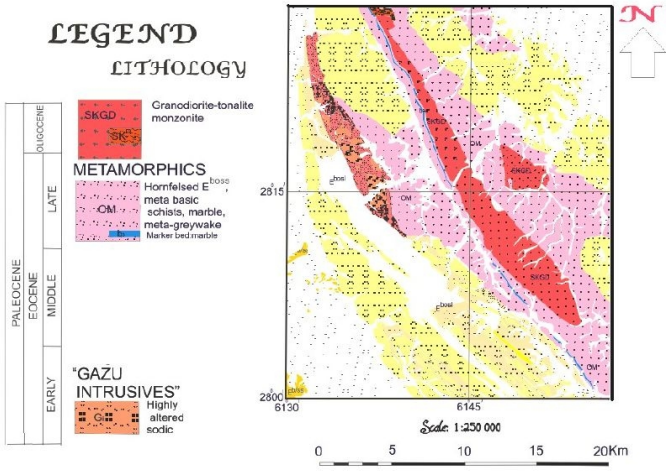

Fig. 1. Simplified geological map of Narre- Now. The scale is1:250,000.

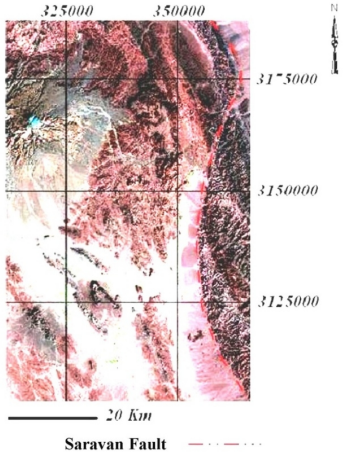

Fig. 2. Saravan fault curvature in Landsat image.

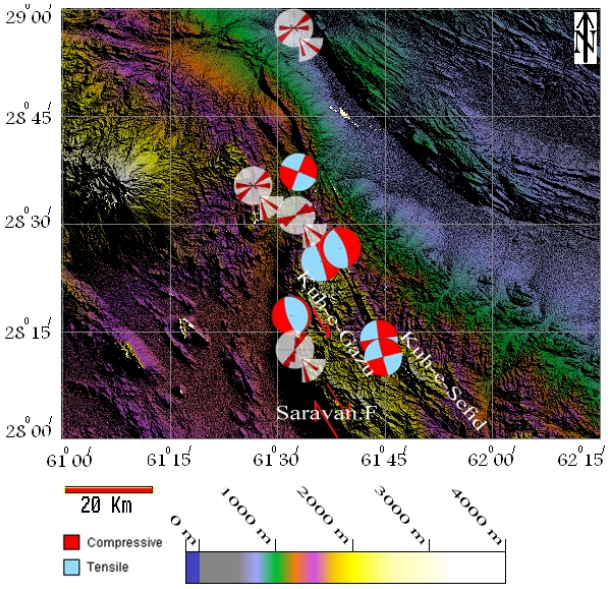

Fig. 3. Overall views of fractures orientations in east region of Taftan volcano along of Saravan fault. Rose diagrams show statistic strike and dip measurements.

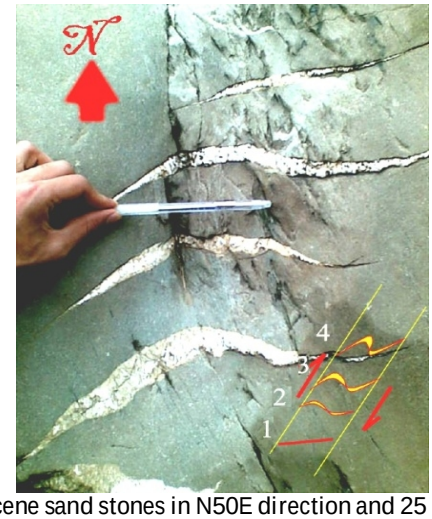

Fig. 4. Tension gashes in Oligo- Miocene sand stones in N50E direction and 25 km far from main crest of Taftan volcano.

Fig. 5. Saravan trust fault surface (N7W/80NE) in N: 28º15′, E: 61º35′.

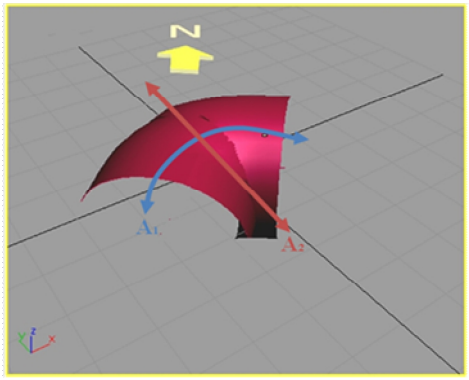

Fig. 6. Fold reconstruction around Gazu area based on attitude data taken in the field surveying. For details, see text.

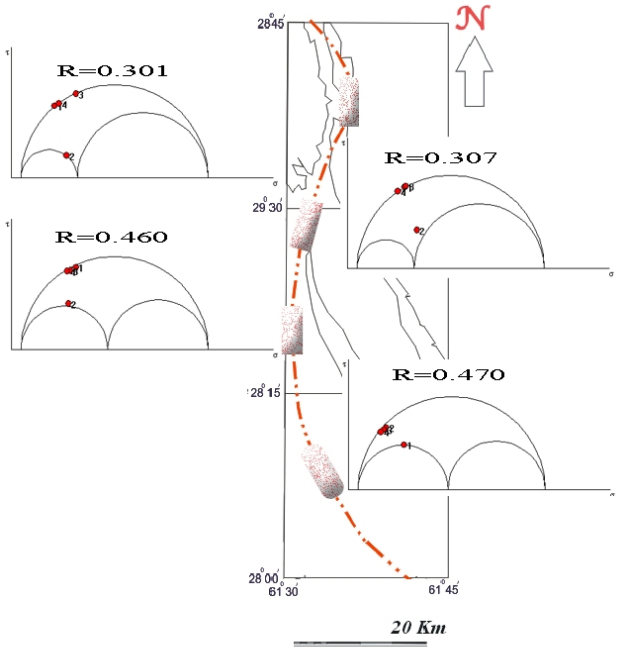

Fig. 7. Mohr circle NDA analysis of four stations on Saravan fault. Mohr circle is dimensionless and so the situation of σ1 and σ3 is what important we look for it. Stress rate is decrescent from north to the sought on the fault path.

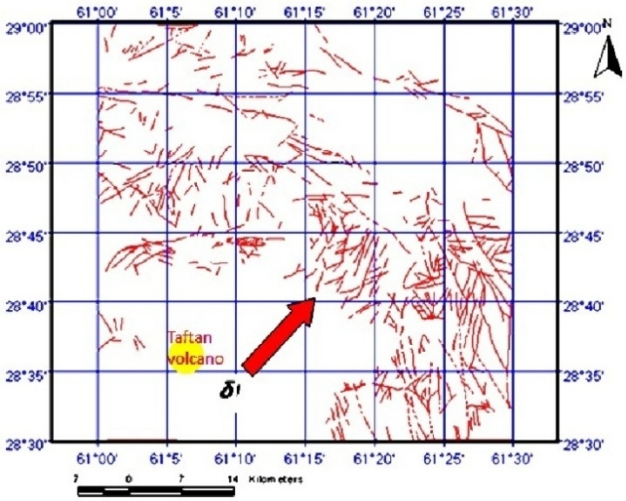

Fig. 8. Graphic Design Fault map of northeast Taftan. The effective stress direction can be estimated from fractures pattern. Bisector of acute angle in conjugate fractures is according to the maximum stress direction.

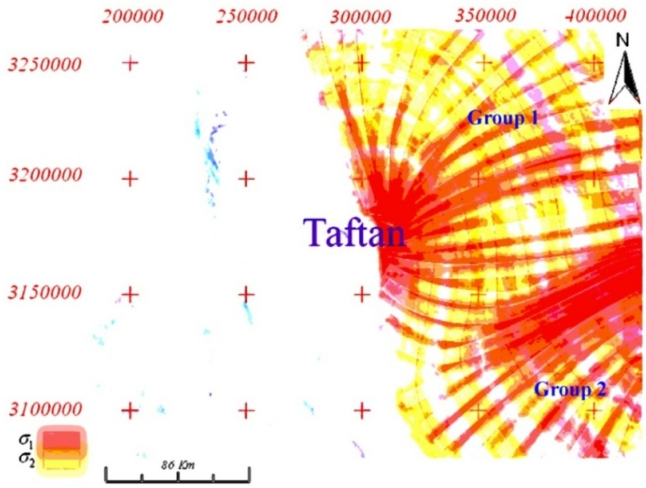

Fig. 9. General stress field for eastern region of Taftan by running Matlab coding. The Red spectrums imply to the maximum stress and yellow spectrum imply to the medium stress affecting to the region.

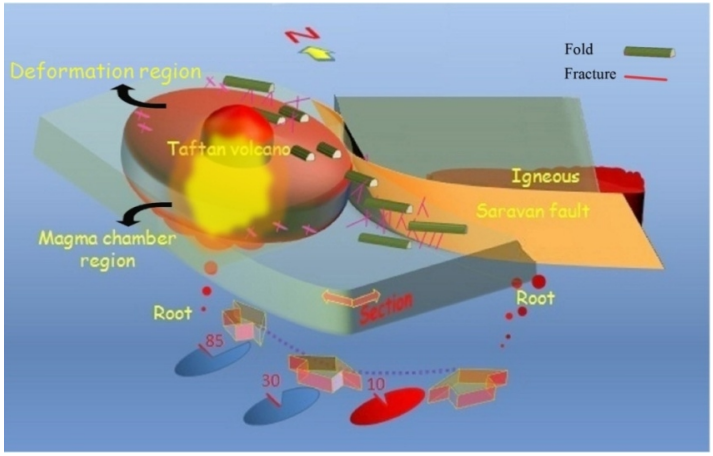

Fig. 10. Portrayal for structures have controlled with a range of influence stress that indicates to the changes of maximum stress direction with geology time. In southeastern area we have chiefly stress tensor in direction N10E. This trend of stress vector has been affected before infrastructure of Taftan volcano. By birth of Taftan our stress direction starts to rotate gradually from N30E to N85E that chiefly are in east and northeastern of Taftan volcano where volumetric strain has occurred**.**

CONCLUSION

Regarding to the curvature of Saravan fault in its strike in eastern outskirt of Taftan volcano, it was interesting for us to assess changes of stress field around Taftan volcano. In this context, it was tried to supply stress field based on chiefly field data and numerical- dynamic analysis data and then is shown as spectrums of indicators as σ1 and σ2. By this stress pattern it can be recognized two groups of stress field named group 1 and group 2. The first one is relating to the resultant stress due to a preexisting compression stress and superimposed volumetric strain but the second group is due to a net compressive stress. Also by drawing main structural elements as a portrayal it will be sensible the range of effective stress direction from Eocene until today. Toward north and Taftan stress field dominion, the structures that controlled with N20E until N85E was increasing and most of them are located on Oligocene until Quaternary formations and related to a dilatation source stresses whereas in southeast areas, stress vector is chiefly in N10E direction and is related to at least Eocene time.

ACKNOWLEDGMENTS

We thank A A Moridi and S Bagheri from Sistan and Baluchestan University and E Gholami from Birjand University who shared information about Saravan fault and acknowledgements about geology and initial access ways.

REFERENCES

1. Alavi, M. 1991. Tectonic map of the Middle East (1:2900000). Geo. Surv. Iran.
2. Ambraseys, N., Melville, C., 1982. *A History of Persian Earthquakes.* Cambridge: Cambridge University Press
3. Berberian, M ., King, G., 1981. Towards a paleogeography and tectonic evolution of Iran. *Canadian Journal of Earth Science,* 18: 210–265
4. Camp, V., Griffis, R., 1982. Character, genesis, and tectonic setting of igneous rocks in the Sistan Suture Zone, eastern Iran. *Lithos,* 15, 221-239
5. Dwivedi, S. K., Hayashi, D., 2010. Modeling the Contemporary Stress Field and Deformation Pattern of Eastern Mediterranean. *Journal of Earth Science*, 21: 365–381.
6. Eftekharnejad, J., 1981. Tectonic division of Iran with respect to sedimentary basins. *Journal of Iranian Petroleum Society*, 82: 19-28
7. Gansser, A., 1966. The Taftan Volcano (SE Iran). *Eclogae Geologicae Helvetiae*, *64*: 319–344
8. Islam, M. S., Shinjo, R., 2012. The Dauki Fault at the Shillong Plateau-Bengal Basin Boundary in Northeastern India: 2D Finite Element Modeling. *Journal of Earth Science*, *23*: *854–863*
9. Luth, S. W., Willingshofer, E., ter Borgh, M., et al., 2013. Kinematic analysis and analogue modelling of the Passeier- and Jaufen faults: implications for crustal indentation in the Eastern Alps. *Journal of Earth Science*, *102*: 1071–1090.
10. Nabavi, M., 1976. Introduction to Geology of Iran. *Geological Survey of Iran press*, in Persian
11. Odinga, M., Lloyd, B., Squire, A., et al., 1978. Geological map of Narreh-Now quadrangle (1:250000). Geo. Surv. Iran. Rep. No.M12
12. Sadeghi, P., Moridi, A. A., 2009. Strain rate calculation in eastern region granodiorites of Taftan volcano near to the Kuhrud fault. *The Seventh Iranian Students' Conference of Mining Engineering.* 429-434. Tabriz: Sahand University of Technology Press (in persian)
13. Sadeghi, P., Moridi, A. A., 2009. Calculation of stress and strain rate in linear structural elements around eastern Taftan volcano. *The 3thsymposium of geology of Payame noor University.* 199-202. Isfahan: Isfahan Payame noor University Press (in persian)
14. Spang, J., 1972. Numerical method for dynamic analysis of calcite twin lamellae. *Geological Society of America Bulletin*, *84*: 134-150
15. Stöcklin, J., 1968. Structural history and tectonics of Iran: a review. *American Association of Petroleum Geologists Bulletin*, *15*: 1229-1258
16. Tirrul, R., Bell, L., Griffis, R., et al., 1983. The Sistan suture zone of eastern Iran. *Geol. Soc. Amer. Bull*, *84*: 134-150

Citation of this article

Pouya S, Mohammad Mehdi K. Resultant Stress Field in Eastern Region of Taftan volcano. Bull. Env. Pharmacol. Life Sci., Vol 3 (3) February2014: 209-215.