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A Model for Active Tectonics in Kope Dagh (North-East Iran)

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Abstract: Kope Dagh folded belt is a part of Alp-Himalaya orogeny belt in west Asia, Which forms the Northeastern boundary of Iran platue. This belt is located on Southwestern margin of Turan (Turkmenistan) continental crust and forms its epi-Hercynian deposits. Movement of Iran Plate toward Kope Dagh plays a fundamental role in folding of Mesozoic and Cenozoic formations in this region. The present folding pattern in Kope Dagh is the result of orogenic activities and crust shortening in Late Pliocene. In the model, described in this paper, it has been shown that the geometry of collision edge of Iran plate with that of Turan is as such that a converging strike slip shear fault zone has been formed in Kope Dagh region. In this zone, at first, ENE double plunge anticlines have been produced. Then, dextral strike-slip faults, which have led to the displacement and cross cutting of fold axes, were formed. Finally, sinistral faults have been developed, those that are less significant as far as the extent and the amount of displacement is concerned.

Key words: Active tectonics . Kope dagh . Iran . Turan

INTRODUCTION

Iran is a part of Alp-Himalaya orogeny belt which is compressed between two shields of Arabian (in the Southwest) and Turan plate (in the Northeast). The GPS measurements show that the Arabian plate moves 23 mm/year towards North [1, 2]. The tectonic characteristics of Iran have been studied by many researchers (Afshar-Harb [3-5], Allen *et al*. [6, 7], Berberian *et al*. [8-10], Eftekharnejad *et al*. [11], Hollingtsworth *et al*. [12], Jackson *et al*. [13], Lyberis *et al*. [14], Stampfli [15-17], Stocklin [18-20], Tchalenko [21], Trifonov [22, 23], Varnant *et al*. [2]). Iranian plate has been classified into a number of tectono-sedimentary units by above mentioned authors. One of the mentioned tectono-sedimentary units is Kope Dagh which is located in the Northeast of Iran (Fig. 1). Lyberis *et al*. [14] have calculated 75 Km shortening in N-S direction comprising the Western part of Kope Dagh using balanced geological section during last five million years. This value proposed 16 mm/y shortening rate in the Kope Dagh belt. The high rate of shortening and convergence, results to the morphotectonic active feathers in the study area. The folds and faults are the important structural elements, formed by tectonic activities. The goal of this study is presenting an active model based on the mapping of folds and faults relationships.

For this, the main structural trends and their altered directions and the relationship between faults and fold axes have been studied using the satellite images and aerial photographs. In order to determine the geometry and mechanism of faulting, detailed field observations and data collection were carried out.

Geological setting: The study area is a part of the tectonic unit of Kope Dagh central zone (Fig. 2). Kope Dagh mountain ranges are located in the northern part of Khorasan (Iran) and Turkmenistan. This sedimentary basin occupies an extensive area in northern of the Iran. Geologically point of view, it lies in northern margin of central Iran unit, Alborz unit and the southern edge of Touran plate in central Asia. This zone forms the northern end of Iranian part of the Alpine-Himalayan orogeny [11]. In this basin thick Tertiary-Mesozoic sediments (8,000 m in Iran, 17,000 m in Turkmenistan) have been accumulated in a narrow sedimentary trough and have been intensely affected by the young alpine Neogene-Quaterner phases and were folded. Northern section of Kope Dagh ends to a basement related fault zone which delineates Touran plate boundary with Kope Dagh [14, 21]. This fault zone, in a northwest-southeast direction, passes through Kazenjick and Kizilarvat and dissected in Bakhardian. One tributary with similar direction passes from south of Ashkabad and the second tributary intersects Kope Dagh

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Fig. 1: Iranian major tectono-sedimenary units illustrating an inhomogeneous collision region between Arabian and Eurasia. After Berberian [8]

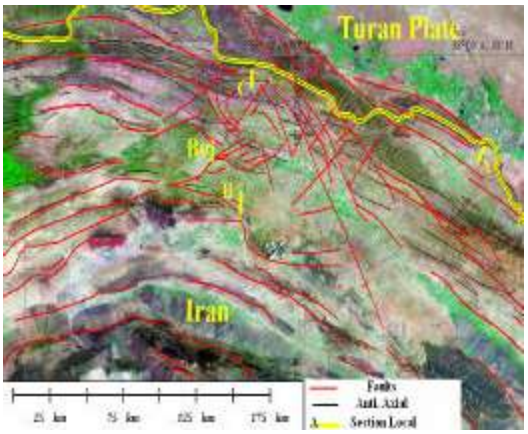

Fig. 2: Faults and fold axes at Satellite images of Kope Dagh Bojnord (Boj)

Mountains which can be followed up until the south of Qouchan. This last zone forms a 30° angle with Kope Dagh basement fault and has a general trend of N150.

Folds: Folds trends in the west of Kope Dagh are ENE-WSW and they are NW-SE in the east. East and west trends of Kope Dagh in central part change with gentle arcs to E-W trend [3]. The predominant trend of Kope Dagh is in close association with the edge of Touran plate. Fold hinge lines in the northwest of Kope Dagh have a 30° angle with Ashkabad fault and in the southeast section are parallel to it. However, due to the interference of northern edge of Lut-Core, as a secondary factor, a recognizable arc with northern curvature has been produced within them (Fig. 2). The main folding stage after Miocene has caused Neogene's layers in both north and south of the concordant landscape to fold while preserving their sedimentary sequence.

In this study, the morphotectonic evaluations confirm that the structural elements (fold and fault) are the main controlling factors of the geomorphology of the region. The most elevated points on the ground surface superimpose on the elevated points on folded areas. The high rate of river erosion and deep V form channels, shown that the uplifting rate is faster than the rate of erosion and the folds is currently active.

Faults: Kope Dagh belt complex has been intersected by numerous faults. These faults can be divided into two groups: 1) basement faults that were active during the deposition and 2) Faults that have been activated during orogeny [5, 21]. The second group exhibits strike slip mechanism and have young tectonic movements. They can further be classified into two groups:

The first set is the sinistral strike slip faults with north-northwest trend and second set are dextral strike-slip faults with north-northwest trend.

Active tectonic (folds and faults formation) in the study area: The rate of inclined convergence of the Iranian and Turan plates estimated ranges from 22-50 mm/y by many reasearchers [2, 6, 24-26] (Fig. 2). Also the shortening rate of Kope Dagh along the north-south has been reported about 16 mm/year [14]. Tchalenko [21] illustrate the Kope Dagh tectonic and its fault formations based on the movement of Iranian plate in reference to Touran plate and supports NNE compression (Fig 4). In this model, Kope Dagh is thought of as an analogue to Zagross with Quaternary active structures which supports the NNE movement of Arabian plate related to Iran. Quaternary movement of faults is associated with earthquakes and seismic patterns. Fault shapes in this model (crossed over faults) are as such that are strike slip shear faults are NNW, dextral are NE and EW and NNE are trust and normal faults, respectively. Tchalenko models don't explain folding mechanisms and their relation with faults.

The northward motion vectors of central Iran in arc-wise shape of southern part of Kope Dagh can be divided into vertical (north-east) and tangential (north-west) components. The tangential vector in the south of Kope Dagh, along with the vector movement of main Kope Dagh fault, forms a stepover shear zone in the

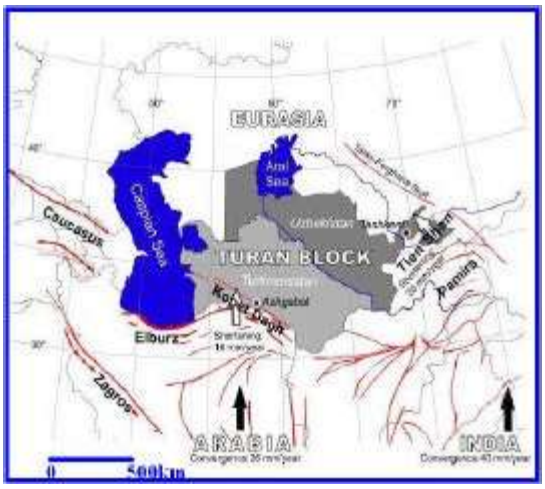

Fig. 3: Turan block and its surroundings map, tectonically active regions, convergence rate and shortening relative to Eurasia [6, 25]

Fig. 4: Tchalenko model's [21] for Kope Dagh

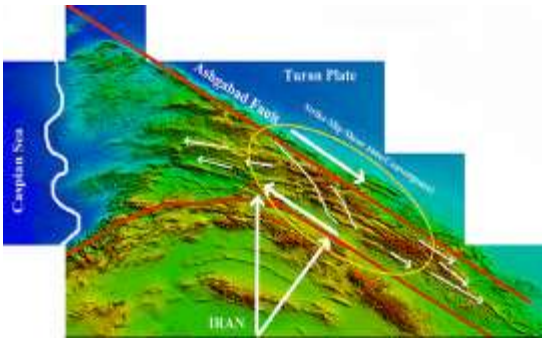

Fig. 5: Aanalysis of motional vector of Iran plate and the formation of converging strike slip shear zone

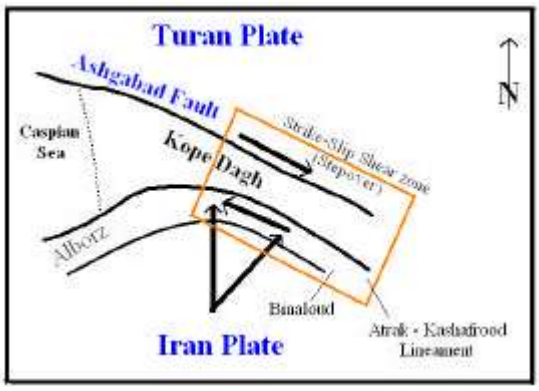

Fig. 6: Proposed model for the active tectonic and the formation of converging strike slip shear zone

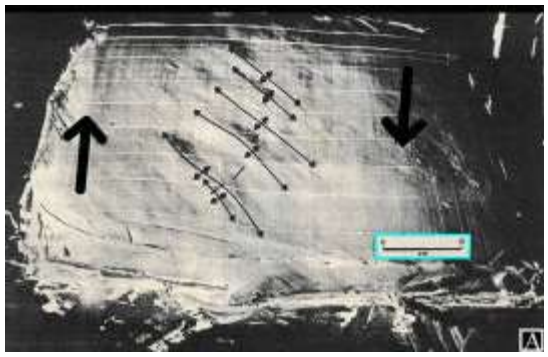

Fig. 7: Strike slip shear zone, sinistral-converging with laboratory clay. The first stage is accompanied with the formation of parallel double-plunge folds

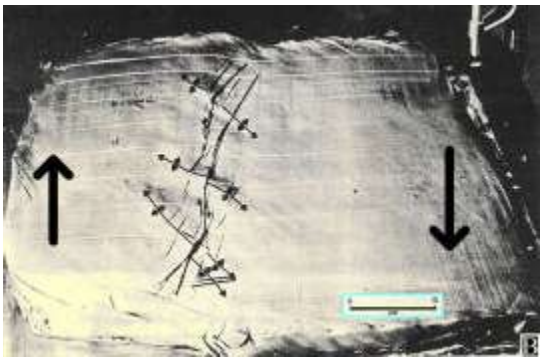

Fig. 8: During the later stages, strike slip shear faults are formed which intersect and displace folds

region (Fig. 5 and 6). The Simulation of strike slip shear zone through laboratory clay shows that during the first stages of strike slip displacement, double plunges and parallel folds are formed throughout the

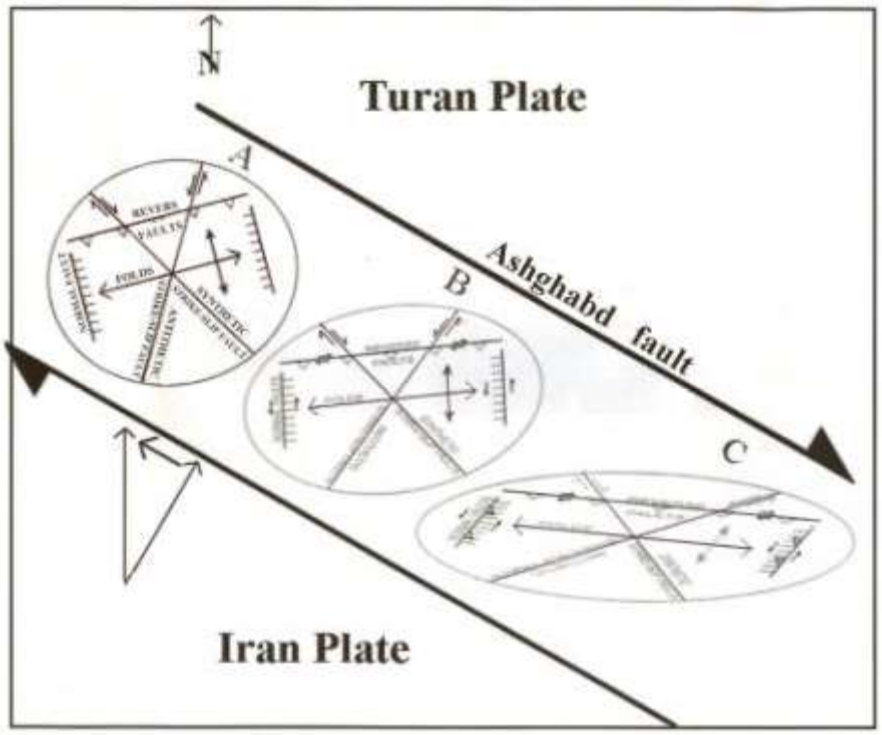

Fig. 9: The proposed model for the formation of folds, strike slip faults in the Kope Dagh strike slip shear zone

entire central region. With progress in the displacement, a number of fractured are formed (synthetic faults). At later stages, folds are intersected and displaced along the original synthetic faults. With further development, a small number of antithetic faults are also produced which are insignificant in this deformity [27] (Fig. 7 and 8).

In this study area, folds present are double plunged in nature. Fold axes have been crossed and displaced by sisnistral motion of Qouchan-Bukhardian fault zone. Topographic setting of the regions demonstrates that fold uplifting is maximum along the Qouchan fault (with most displacement) and folds are inclining towards both sides, ESE and WNW. The double plunged natures of the folds form the individual catchments in both side of longitudinal curvature axis. The dextral faults with NE trend have less length and displacement compared to the Qouchan faults zone. These faults that have a minor effect in deformity of the area classified as antithetic faults. The trends of fold axes are progressively rotated in a clockwise in agree with the direction of sinistral shear zone movement. The rotations of axes folds are depended to the fault displacement and regional deformity because of the influence of the shear zone. According to the above description, the active tectonic model of the study area illustrated in Fig. 9.

CONCLUSION

The present study shows that the northward movement of Iran plate, which is due to the movement of Arabian plate, has been formed converging strike slip shear zone (stopovers), at the intersection of Touran plate. The motion of this shear zone, due to its specific geometric characteristics, first leads to the formation of double plunge folds and then with continue of movements the NW sinistral strike slip faults are formed, that intersect and displaced the folds' axis. Finally, The NE dextral strike slip faults with insignificant dis placement are created.

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