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Determine Stress Field of the Shirband Area by Geometric and Kinematic Analysis of Faults and Folds (North Damqan, Iran)

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Abstract

In this paper faults and folds of shirband area (north of damqan) investigated to determine the orient of the stress field. The study area is limited between the two faults with E-W strike and northward slip. Investigations result show major faults of the area have sinisteral mechanism. Waterways displacement and slicken slip of faults approve this issue. Three main folds of area has approximately same trend along major faults (E-W). Orientation of stress field investigated and classified by using from some large and medium scale faults and folds. Analysis of stress field investigated by inversion method show that compression axis in the study area have approximately NE-SW strike.

Keywords

Structural Analysis, Stress Field, Faults, Folds, Astaneh Fault, Eastern Alborz, Shirband Area

1. Introduction

Continental collision involves brittle and coeval compressional, extensional and strike-slip faulting in the upper crust. This broad depiction emerges from the consistency between active fault systems and the location and focal mechanisms of earthquakes, for example in Asia [1] [2] [3]. This paper presents paleostress tensors calculated from fault planes and striations measured along two main faults and two minor faults of the eastern alborz, in north of Iran. Finally investigation on three fold has supplementary rule to determine stress field of study area.

There are several different ways (methods) to analysis stress tensors from slicken lines of faults. Final Results of these methods determine the position of stress field in study area. Using from these methods and investigate the structural element of study area, show direction of stress field in study area [4] [5]. However, faults and slicken lines of faults is a key to find out orientation of paleostress in study area [6].

1.1. Location

The study area (**Figure 1**) is located in the northern range of Damqan in the eastern Alborz Mountain. Alborzmountain belt with several thousand kilometers between the Caspian Sea and the Central Iran has situated. It is a part of the Alpine-Himalaya belt that located between Eurasian and Cimmerian plates [7] [8].

Alborz Mountain is a result of the above collision since the late Triassic. Extensional phases in Alborz Orogeny in the study area have created a collection of volcanic rocks, including lava flows, and pyroclastic generally entitled Karaj formation [9].

The stratigraphic succession of the Alborz [10] spans the whole Phanerozoic

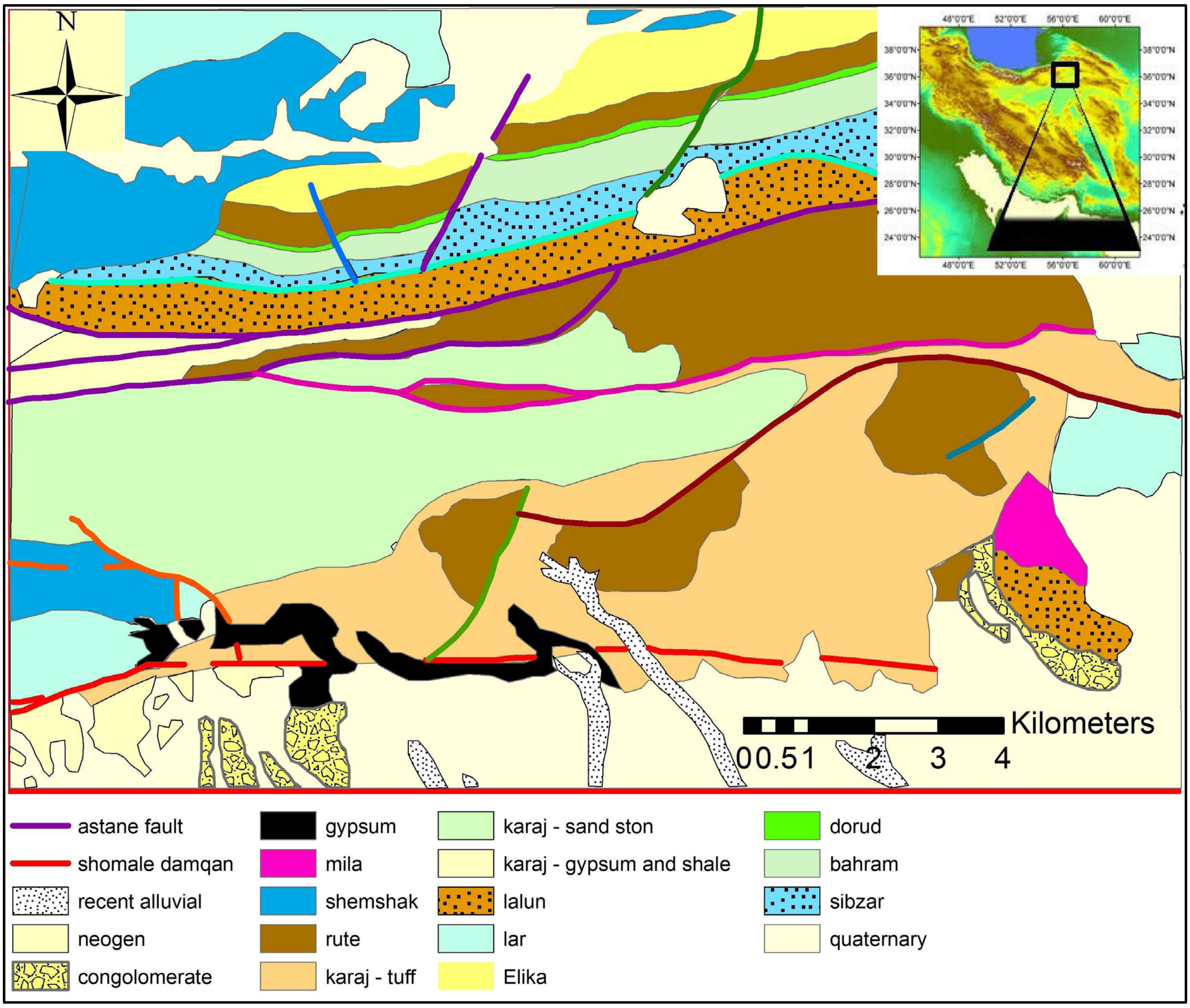

Figure 1. Schematic tectonic map of Iran (insert map) and schematic geological map of the North Damqan region.

and it is about 11 to 13 km thick. The Precambrian and Cambrian succession is represented by coastal sandstones and dolostones, with continental deposits [11] [12]. The latest Precambrian to Middle Triassic succession is unconformably covered by the Shemshak Formation, up to 4000 m thick, deposited after docking of the Iran microplate to the Eurasian margin. The formation consists of continental sandstones, shale and coal passing upward to shallow marine deposits blanketing the Eo-Cimmerian orogen and itsforeland. The Eo-Cimmerian unconformity is particularly evident in the Shemshak area, where the basal beds of the formation lie directly on the Permo-Carboniferous units [13].

They are succeeded by the Eocene volcanic and volcaniclastic complex of the Karaj Formation, more than 3000 mthick. The Karaj Formation records the activation, in an extensional regime, of an intracontinental volcanic arc related to northward subduction along the Zagros suture [14]. The Miocene succession (up to 200 m thick) consists of coastal fine-grained terrigenous units with evaporites and limestones.

1.2. Tectonic Setting

The study area has located in Eeastern Alborz-Lesser Caucasus physiographic province (**Figure 1**). Dominant structural trend in this area is E-W, NE-NW. From tectonics view, it contains deformed zone (fold and thrust belt) of Cimmerian miniplate that formed in northern active margin until late Triassic. Then it has rifted by tension in a back arc basin of Neotethyiansubduction zone in the south margin of Cimmerian miniplate. Development of that rift stopped in the late Cretaceous and then, renewed in the Eocene by spreading in submarine arc basin of Neotethyiansubduction zone. In other words, this hinterland is a result of a magmatic arc system spreading in the evolutional back arc basin. After that, East-Central Alborz and Lesser Caucasus hinterland has formed by deformation and regional uplift from SE part of Caspian Sea to Black Sea [15] [16]. Based on previous works on the salt and mud diapirism [17] [18] and neotectonic regime in Iran [19] [20] [21], Zagros in south Iran is the most active zone [22] [23]. Then, Alborz [24] [25] and Central Iran [26] [27] have been situated in the next orders.

Central Alborz region have already affected by several strong structural tectonic events. There are some different ideas about its latest activities. This study utilities multiple inversion method for paleostress phase separation and structural analysis in the North Damqanfault zone (north of Damqan).

The latest activity of the Damqan fault system on karaj formation, have printed by slickenside on the fault planes, so the result of analyses is reasonable to recognize and analyze of fault function and extend the results to the recent structural activities. The method enables us to determine the position of the principal paleostress axes and the geometrical shape of the stress ellipsoid for reconstruction of paleostress regime dominating the tectonic events by solving reduced stress tensors.

There is evidence of two young tectonic phases during Cenozoic in study area.

The first phase in late Eocene in the posterior with compressional stress has been N-Strend, and the second phase in the Middle Miocene (Sarmatin) compressional phase has been SW-NE trend that caused the evolution of the thrusts with N-S trend in this area. The tectonic events causing the Eocene to the Quaternary have been the formation of the current morphology of this part of the crust of Iran block. In this area, structural trend has changed from Northeast-Southwest to the East-West. The tectonic evidence of the region shows that the west sector (West block) has been stretched in the mid Paleocene and after the collision with Arabian plate, a depression has created towards the Eastern block. This depression has located widely under the volcanic scrambling that formed the northern part of Damqan. This scrambling volcanic-magmatic has been extremely high since the late Paleocene and throughout the early Eocene. Then, it has decreased in the Miocene and Oligocene and there was a big scrambling under the influence at the beginning of the Quaternary across the study area. Morphotectonic units of the study area can be separated and classified as following from South to North (**Figure 2**):

1) Neogen and quaternary sediment is the youngest sediments in south. North Damqan fault is northern border of this part.

2) Part 1 of the Eocene Karaj formation that contain gray-green vitric tuff and restricted between North Damqan fault and Shirband fault.

3) Part 2 of the Eocene Karaj formation that contain dark gray tuffaceous limestone and restricted between Shirband fault and Tamuza fault.

4) Limestone of ruteh formation that restricted between Tamuza fault and Astaneh fault.

5) High height mountain range (Permian to Jurassic) in the northern part of area.

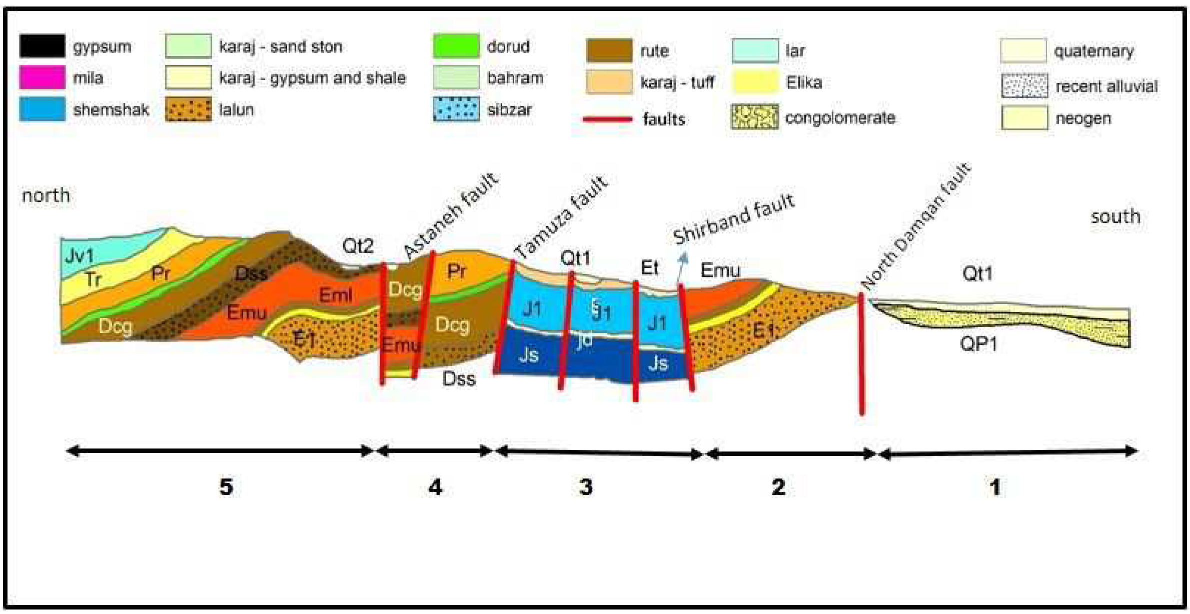

Figure 2. Schematic of the structural represents the main structural elements from the North Damqan mountains can be seen in it study the area.

2. Material and Methods

For studies of stress by examining the geological maps and satellite images and field operations 6 sites which they fault and fracture surfaces are visible and were selected and measured data page was picked up fractures (**Figure 3**). Then the data was processed and value and with the use of the software Fault Kin, Tectonic FP data for import into software was ready for Win Tensor, and for each region were paleostress analysis [28].

In order to investigate the structural evolution and paleostress analysis of the study area, north of Damqan, geometry and kinematics of the faults and folds were measured. Following these measurements, the stress tensor and variation of stress directions in different rock units were calculated. For this purpose, 60 fault surfaces and slicken lines from 6 sites were selected and measured (**Figure 4**). The results of the dynamic analysis using Angelier's (1991) inversion method indicated that the stress direction changed during Eocene. They also show some changes in the stress field direction, which occurred after Eocene. According to our dynamic analysis on the faults, we classified the tectonic events in the study area. The principal stress axes and their directions for all sites are calculated using Angelier's software. The results of our study indicate that the main stress dominated in this area is acompression after Eocene. Analysis of the obtained data from this part of the Eastern Alborz Mountains (north Damqan), indicates a major NE-SW compression in the after Eocene sandstone and limestone sedimentary rocks.

In order to investigate the structural evolution and paleostress analysis of the study area, 4 major faults of area measured. Most of the faults has been reverse

Figure 3. (A) and (C) R and R' fractures along with the fault step, (B) and (D) the amount of the rick angle and scratches line on the surface of the fault.

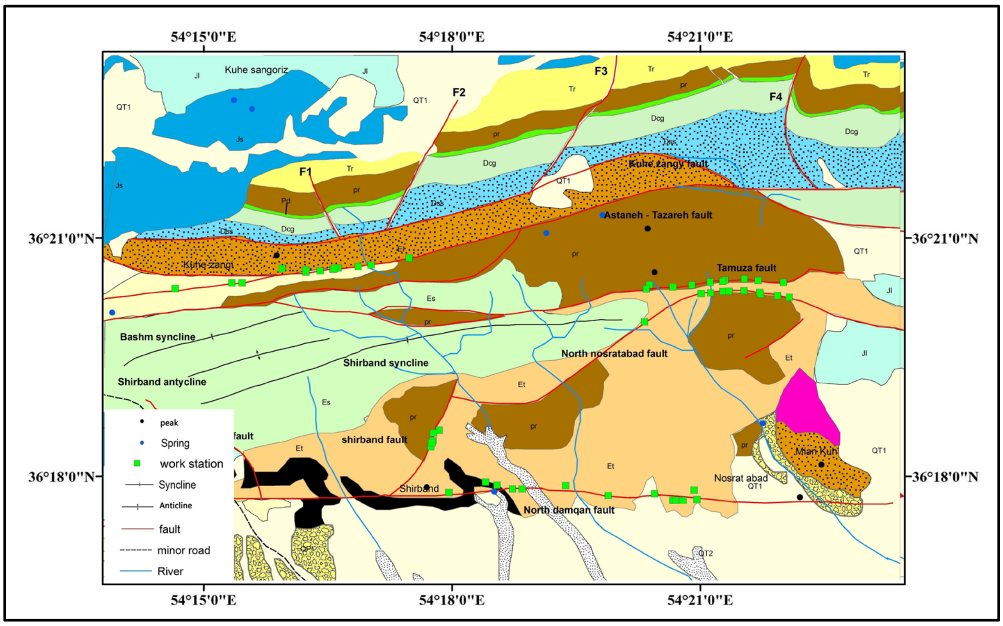

Figure 4. The position of picked up stations for sampling paleostress.

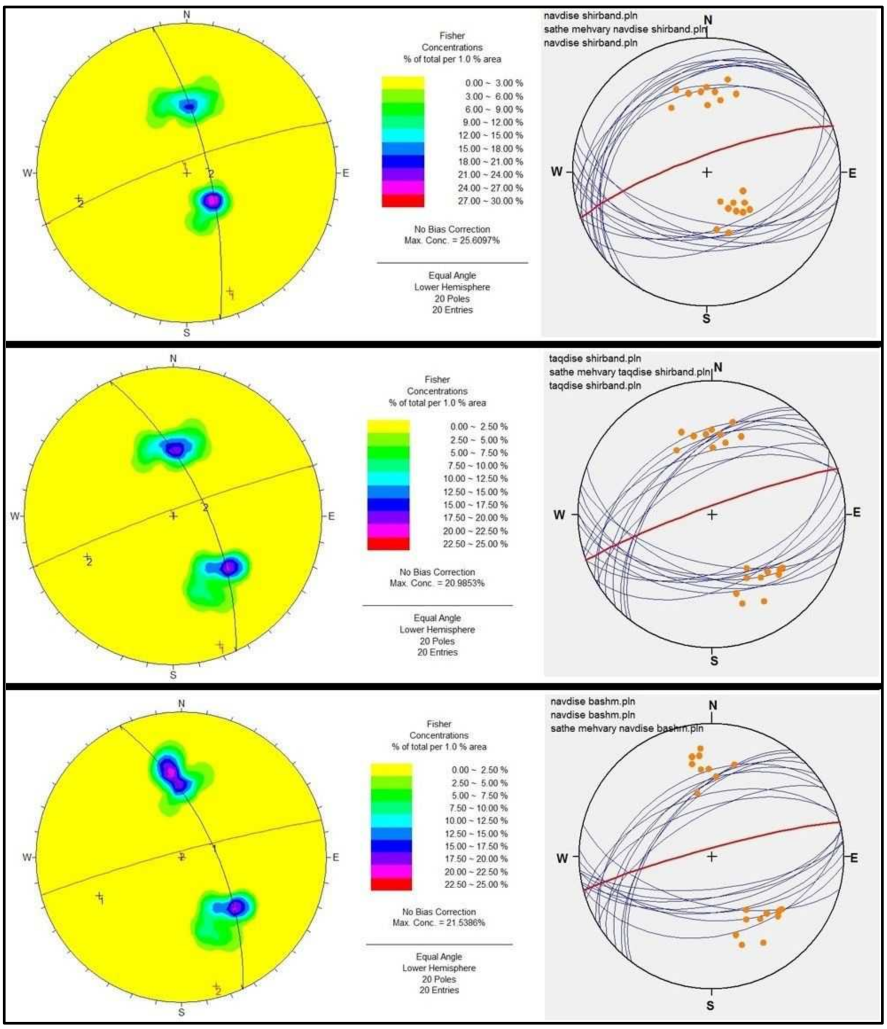

Figure 5. Streographic characteristics of major 3 folds in north of Damqan.

and strike slip mechanism. This evidence show that area has been in compressional condition. All characteristic of faults (such as length, strike, dip) measured to the determine paleostress (**Table 1**). In next step, we use from folds parameters to compare paleostress field that obtained from faults. There is 3 main fold with approximately NE-SW strike in study area (**Figure 5**). **Table 2** shows all characteristic of this folds.

3. Results and Discussion

The purpose of this paper is Geometric and kinematic analysis of the Shirband area faults and folds to determine stress field in study area. The faults of study area cut off quaternary sediment. This means faults are active in current days and determined stress field is related to current time [29].

In an overview, same and similar trend between the major faults and axial plan of folds show specific stress field trend [30]. In the study area, from about 6 sites, in the longitude the range of 36˚18' to 36˚24' samples were that's part of the North Damqan Mountains and Eastern Alborz belt (**Figure 4**). Stations in place of the North Damqan Mountains turns bending in place rotate the belt East Alborz and changing trend of the structures of the NE-SW to the E-W in north of Damqan city.

Structural analysis of fault with angelier inversion method show main stress field is near the NE-SW trend (**Figure 6**). In next step, collected date from folds

Table 1. Structural characteristic of faults in study area.

Fault Name	Length (KM)	Strike	Dip	Dip Direction	Trend	Plunge	Mechanism
North Damqan	15	N90E	70	0	50	60	reverse and dextral
Astaneh-Tazareh	15.1	N80E	80	350	80	0	dextral and reverse
Shirband	2.8	N25E	70	295	13	30	sinistral
Tamuza	10	N80E	89	350	80	20	Dextral

Table 2. Structural characteristic of folds in study area.

Fold name	Southern limb dip	Northern limb dip	Axial plane dip	Axial plane strike	Hinge line dip	Hinge line trend	Interlimb angle
Shirband syncline	30	50	80	340	20	250	100
shirband anticline	50	52	85	340	18	250	80
Bashm syncline	52	55	85	345	15	254	70

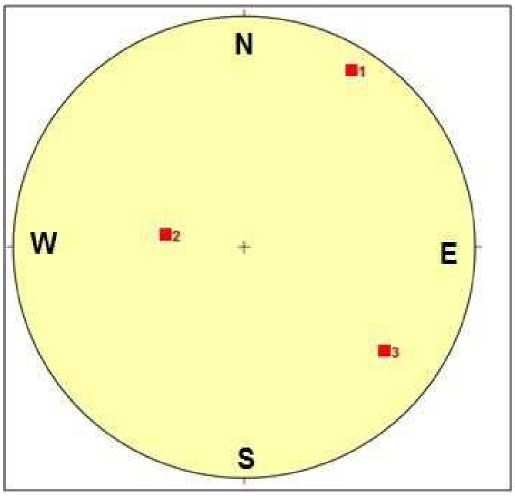

Figure 6. The image of the main axes of the paleostress field in study area that measured by fault planes(1 = σ_1, 2 = σ_2 and 3 = σ_3).

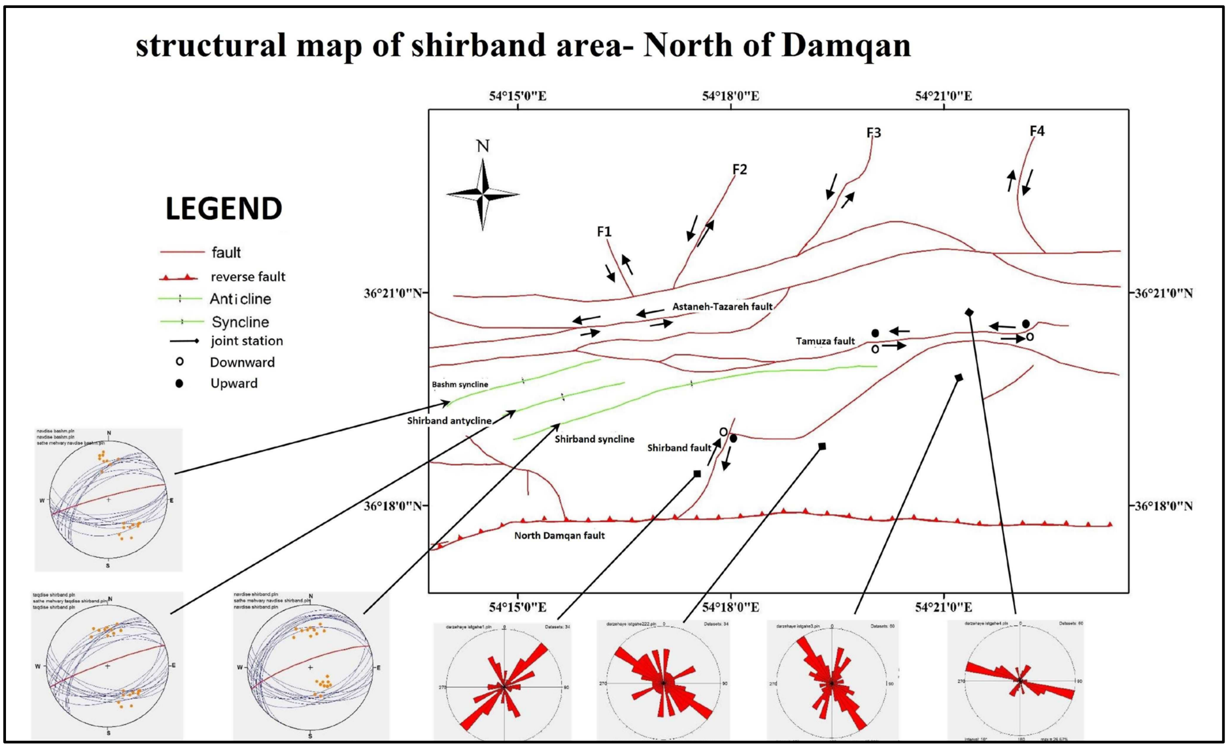

Figure 7. Structural map of shirband area-North of Damqan. 3 right sreograms show structural charecteristic of folds and 4 right roz diagram show four station of joints that related with faults.

and joints approve that the main stress field has been approximately N-S strike (**Figure 7**).

4. Conclusions

Our reconstruction of the successive paleostress states allows accurate determination of the fault behaviours in the eastern Alborz, which cannot be obtained from geometric analyses of seismic profiles and well data interpretation and therefore provides better understanding of the Permian to Cenozoic tectonic processes. There are two main fault with two dominant strikes (North East-South West and East-West) and the main conclusions of this research are:

- In general view, same trend between faults line and axial plan of folds demonstrate special trend of stress field in north Damqan region.
- The direction paleostress field that measured by fault plane is approximately NE-SW.
- The trend of paleostress field measured by fault plane is similar to the paleostress field that measured by folds of study area.

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