Komatiite Basalts of Sefid Sang (Fariman)

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Abstract
Sheet of Sefid sang is in N 60˚- 60˚ 30 and E 35˚ 30˚ - 36˚ in the northeast of Iran. village of sefid sang is near to fariman.
Sefid sang has about 35 kilometers distance to fariman and about 100 kilometers to mashhad. In road of Sefid sang to Shahan garmab village and senjedak village, we can see group of mafic and ultramafic rocks in sides of road, that Include: Wehrlite, Dunite Gabro, Microgabro and Basalat (Pillow Lava). With petrography and geochemistry of basalt rocks in this locality we can say: they are komatiite basalts with spinifex textures.

Key words: Sefid sang - Komatiite basalts - Spinifex textuers.

Introduction
Komatiites:
Komatiites were first recognized in the late 1960s in the Barberton Mountainland greenstone belt in South Africa (Viljoen & Viljoen, 1969a,b). They have extremely high MgO contents; 18-30 wt.% compared to 10-15 wt.% for the most mafic mid-ocean ridge basalts (MORB) or ocean-island basalts (OIB, Figure 1). The MgO contents of magmas is proportional to their melting temperatures (higher MgO means hotter magmas) and the first experiments on komatiites (Green, 1975) were interpreted to imply melting conditions in excess of 1600°C. see also Temperature and Mantle temperature pages. Subsequent dating showed the Barberton komatiites to be 3.5 billion years old (Lopez-Martinez et al., 1992) and so the high temperatures inferred for the komatiite source region fit nicely with the concept of a hot early Earth.
Komatiites from the Superior province in Canada (the Munro komatiites) were the next to be well studied (Arndt, 1976; Pyke et al., 1973). These are younger (2.7 Ga) than the Barberton komatiites and have lower MgO contents (up to ~ 24 wt.%). This also fit well with the idea of a cooling Earth. At the time, there was still some debate about the tectonic setting of komatiites. A whole range of settings was considered, e.g., mid-ocean ridge, plume, giant impact and magma oceans.
Komatiites are higher in MgO than boninites, and one cannot make a direct comparison. However, there are similarities. High SiO$_2$ for given MgO, very low TiO$_2$ (Figure 1).

**Basalts of Sefid Sang**

There are amafic lava flows with pillow and brecciated features, and in a detail petrographic studies of them we have found varieties of disequilibrated textures including pyroxene spinifex textures in mafic samples, and as there are special geochemical criteria introduced for komatiitic rocks in the Northeast of Sefidsang, we have recognize them so. It may be that mafic rocks have been olivine fractionated products of ultramafic parent melts which have their out crops in the same area, as there is a close spatial and time relationship between them and regard to some petrographic evidences in the cited area ultramafic- mafic rock out crops are observed as lava flows sills, rarely as small dikes and they have contained an unique collection of disequilibrated textures.

Here we have described disequilibrium textures in mafic and ultramafic rocks of Sefid Sang's samples and attributed their formation to an unusual high temperature of their ultramafic parent magma.
figure 2- spinifex texture (xpl)

spinifex texture(ppl)- figure 3
Economic importance
Basalts of Sefid Sang in some locations have economic elements include: Au, Cu, Ni, Ag, and Co. The economic importance of komatiite was first widely recognized in the early 1960s with the discovery of massive nickel sulfide mineralization at Kambalda, Western Australia. Komatiite-hosted nickel-copper sulfide mineralization today accounts for about 14% of the world's nickel production, mostly from Australia, Canada, and South Africa. Komatiites are associated with the nickel and gold deposits in Australia, Canada, Iran, South Africa and most recently in the Guiana shield of South America.

Conclusion
With petrography and geochemistry of mafic rocks (basalts) in this locality (Sefid Sang) we can say they are komatiite basalts with spinifex textures.

References


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Introduction of Alunite mineral of Mashhad Granitoids

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Abstract
The acidic mass from granodurite to tonalite material is at 17 km west-north Mashhad at Binalood Structural zone that has penetrated in the ophiolite series and zone regional metamorphic rocks and it has resulted a contact aureole at it's around at pyroxen - horenfels facies limit. The microscopic and chemical evidences indicate the existence of alunite mineral in these masses. This mineral which belongs to aluminum sulfate minerals group indicating that these masses have a type S and have been emerged from upper Crust rocks. The chemical analysis from a Region masses indicates that these masses belong to per-alumina group and have emerged with a combination of Calc - Alkaline at continental collision zone.

Key words: Alunite – Mashhad – Granodurite – Tonalite _ type S

Introduction
Mashhad geology sheet area at 1:100,000 scale is located at East North of Iran and at distances limit of 59°,30´_60° longitude and 36° _36°,30 ´ latitude. The set of Granitoids rocks consisting Granodurite – Tonalite and Monzogranite have expanded at Vakil Abad – Bande Golestan – Dehno Shandiz and Koohsangi (figure 1). An along with the detailed field studies, a systematic sampling has been performed from rock of these areas. These samplings have been issued based on a geology maps by the state geological organization and at 1:100,000 scale from Mashhad and Torqabeh regions have been performed. These rocks having mass structure have had a little alteration and they include mafic mineral like: Biotite and Hornblende.

Discussion
At field studies, 50 samples have obtained from the above Granitoids. These rock which have resulted rather high morphology in this region, are seen at dry color at a fresh level. At some of theme are seen a little weathering and at other are seen a severe weathering. The existence of minerals such as Chlorite – Epidot – Zuezit – Sersite and Kaolen in these rocks indicate a low to high weathering.
The existing pieces of mafic and Ultra mafic and also Schist inside of these rocks indicate that Granitoids are a younger than them. These rocks have resulted a contact metamorphism at a region.

The use of different diagrams of geochemistry like diagram (figure 2) shows that these mass are from Calc – Alkaline type. These rocks have been used from a different geochemistry diagrams in order to review Tectono – Magmatic.

Diagrams (figure 3) and (figure 4) indicate that these Granitoids belong to continents concurrence range zone.

The petrography studies of these masses that have textures such as Myrmekite and Graphic indicate the existence of Quartz, Plagioclase (Oligo Clause), Feldspat from Ortuz and Microcline type as a main minerals and also Biotite, Mosquite and Hornblend as an usual minerals and also Sphen, Apatite and Zircon as minor minerals in these rocks. The petrography evidences (figure 5) and (figure 6) show Alunite mineral at longitudinal and transverse in these rocks, that the existence of Alunite mineral is one of the important evidences of petrography at these rocks.

Alunite or white alum that is refered as rock alum, is from Aluminum Sulfate family with chemical formula as $\text{KAl}_3(\text{SO}_4)_2(\text{OH})_6$ that has devitrified at Trigonal system and includes Hydroxil agent (OH).

There are $K_2O = 11.4\%$, $\text{Al}_2\text{O}_3 = 30\%$, $\text{SiO}_2 = 38.6\%$, $\text{H}_2\text{O} = 13\%$ at it’s chemical compound.

Alunite is melted with Cobalt Nitrate and become a blue color, that it indicates the existence of Aluminum. It easily dissolve at sulfuric Acid; but it slowly dissolve at Chloridric Acid. A crystalline masses as fine granule of this mineral may confuse with some white hydrated minerals, and the best way of it’s recognition is the use of chemical tests for this reason we have found the existence of Alunite mineral at Tonalite and Granodurite rocks at Mashhad X-ray diffraction (figure 7) and (figure 8) and also magnetometry experiments (figure 9) and (figure 10) and (figure 11). This mineral is an important source for preparing alum aluminum sulfate. Table 1 shows a chemical analysis of region Alunite acidic rocks that the chemical analysis of rock samples has been performed by ICP method at Canada.

**Economic cases and Alunite consumption**

At the past, from Alunite was used for preparing Alumina and Potassium Sulfate. The Alumina Sulfate is used at paper – making and tektilte industnes and Potassium Sulfate is used for preparing chemical fertilizers. Now it is used from Alunite for preparing Aluminum and also Potassium Sulfate and Sulfuric Acid.

**Conclusion**

The existence of Alunite mineral is one of the important petrography evidences at Mashhad Granitoid rocks that we can mention to this problem using it, that these acidic masses are Pre-Alumina and belong to type S granite; and it is possible that are resulted from upper Crust melt. With regard to Alunite economic cases, we can do more study in the future.
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Tabale 1: ICP result of chemical analysis of samples having Alunite at Mashhad Granitoids

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Y1 Rock pulp | <0.1 | <0.5 |
D2 Rock pulp | 0.3 | <0.5 |
Figure 1: Geology map of Mashhad Granitoids

Figure 2: AFM ternary diagram for determining series of Magmatic of under study area rocks

Figure 3: Discrete diagram of region Granitoids tectonic site

Figure 4: Discrete diagram of region Granitoids tectonic site

Figure 5: A: Longitudinal and transverse cross-section Alunite at (PPL) light.

Figure 5: B: Longitudinal and transverse cross-section Alunite at (XPL) light.
Figure 6: Zircon crystal inside region Alunites

Figure 7: General XRD analysis of Granitoides sample having Alunite at region B.

Figure 8: XRD analysis indicating Alunite peak at region Granitoides

Figure 9: A: Alunite peak at high magnetometry (Magnetism separation) (UP)
Studying Brittle Deformation of Taknar Zone, Central Iran by Calculation of the Statistical and Fractal Characteristics on the Structural Fracture Map

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Abstract
Structural Fracture Map of Taknar Zone in Central Iran has been drawn using 6 applied remote sensing methods. In this paper detected fractures were classified to 6 main directions. Then rose diagrams of the fractures were drawn for 5 different regions of the zone. Most of the fractures and variety of them were concentrated in the central and southern part. In the next part of the study, Length values (L) of the fractures were calculated and classified in 3 main classes. It was found that the number of each fracture set decreased exponentially by increasing the length values. Calculating Spacing (S) values of each set and comparing them with the number of fractures showed similar conclusions: the number of each set decreased exponentially by increasing the spacing values. The other two calculated factors were Intensity (I) and Density (ρ). Most of the frequencies of the both factors were concentrated in the central and southern part. The next important calculated factor was “Fractal Dimension” (D). For the whole zone “D” was linear, which demonstrates the self-similarity of the fractures in different scales. In addition, it was found that the most values of “D” were related to the central and southern fractures. Based on above, reliability of remote sensing techniques for detecting faults has been demonstrated. It also seems that Doruneh Fault has had the main effect in the recent structural deformation and fracture development of Taknar Zone.

Introduction
Studying statistical and fractal characterizations of fractures and faults has been frequently noticed recently. Taknar Zone, in the northern edge if Central and Eastern Iranian Continental Microplate (Muller & Walter 1983) was chosen for these two reasons: first, Taknar is highly fractured (brittle) and mainly alluvium uncovered. Second, for being prone to have metal ore reservoirs, particularly massive sulfides (Karimpour et al. 2004) that can be oriented spatially by the structural fractures (Trip & Vearncombe 2004). Based on above, Structural Fracture Map of Taknar Zone was drawn using 6 applied remote sensing methods, based on local morphological and structural characteristics. In this paper detected fractures will be classified after studying their distribution in the related diagram. Then some statistical and geometrical parameters of the fractures will be calculated. Finally, fractal model of them will be studied and used with the other results for interpreting the brittle deformation related to the main faults of the Zone.

Classification of Fractures
Fig 1 shows the rose diagram of all the fractures of Taknar zone. As it can be seen, the main directions of them are N-S and NE-SW. To classification of fractures by their orientations, first they were divided into 4 main directions: N-S, E-W, NE-SW, NW-SE. The fractures in the first two diagrams were well oriented and in the last two ones they were not. So, each of
the foregoing two directions was classified to 2 equal smaller directions again. Therefore 6 directions were finally resulted: N-S, E-W, NNE-SSW, ENE-WSW, NNW-SSE, and WNW-ESE. Next, diagrams of the whole fractures were drawn for 5 selected small regions of the zone, for finding how each group of the 6 sets has been distributed. It can be easily seen that most of the fractures and variety of them were concentrated in the central and southern part of the zone (Fig 2). Hence it can be said that the fractures of the zone have been developed mostly around Doruneh Fault.

Calculation of Length and Spacing Values
In this part of the study, Length values (L) of the fractures were calculated and classified in 3 main classes: short fractures (0.01-10 km) with the frequency of more than 250; medium fractures (10.01-20 km) with the frequency of about 50, and tall fractures (20.01-50 km) with the frequency of about 10. It was found that the number of each fracture set decreases exponentially by increasing the length values. This fact has been shown in histogram of Fig 3. Calculating Spacing (S) values of each fracture set and comparing them with the number of fractures showed similar conclusions: the number of each set decreases exponentially by increasing the spacing values, as it has been shown in histogram of Fig 4. These two relations show structural “maturity” and well developing of the fractures in usual.

Calculation of Intensity and Density Values
The other two calculated factors were Intensity (I) and Density (ρ). “I” is sum of the lengths of the fractures in a specific area over the same area (area unit), and “ρ” is the number of fractures in a specific area over the same area. So, for calculating these two spatial parameters a network of 90 4×4 km square cells was drawn, covering all over the zone. Then the calculations were done for each cell. The resulted values were plotted on the area map via contour diagrams (Fig 5 & 6). Most of the frequencies of the both factors were concentrated in the central and southern part of the zone, as it has been shown in the maps. These two facts demonstrate that Doruneh Fault has had the main rule to reform and distribute the fractures of the zone.

Calculation of Fractal Dimension
The next important calculated factor is “Fractal Dimension” (D). This factor shows values of “Self Similarity” of the fractures of a specific zone in 2 or more scales. The method used in this research is called “Box Counting”; almost the whole zone was split into 27 separate 10×10 km square shaped areas (boxes), each box overlapped %50 of the adjacent one to gain the maximum precision (some alluvium covered part of the zone in the SW was eliminated to avoid any probable inaccuracies). In each box “D” was calculated in 5 different scales and compared with those of the other boxes. A line chart (logarithm of the number of cells which the fractures have entered them over the logarithm of the number of cells in one side of the box) for each box was drawn to calculate D (or the line slope) and its spatial variations, also to find how much the fractures are “self-similar” which depends directly to the linearity of the points (5 points = 5 scales of calculation). All the 27 related graphs were linear, demonstrating well self-similarity of the fractures. Fig 7 shows 2 typical diagrams of all. In the next step, contour diagram map of all calculated D values was drawn as it has been shown
in Fig 8. It was found that the most values of $D$ are related to the central and southern fractures of the zone. Based on above, reliability of remote sensing techniques for detecting faults has been demonstrated. The mean of $D$ values of Taknar zone was calculated to be 1.46 and the most $D$ value of Taknar zone was 1.6. This value is the upper limit of $D$ for a mature and highly developed zone (Hirata 1989). Thus Doruneh Fault seems to have the main effect on fracture development, recent structural deformation and evolution of Taknar zone, comparing with Taknar (Rivash) Fault.

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![Fig 1. Rose diagram of all the fractures of Taknar zone; the dominant orientations of fractures are N-5-E and N-55-E.](image)
Fig 2. Variations of distribution and orientation of the fractures in Taknar zone; both the number and variety of fractures increase in the center and south of the zone.

Fig 3. Histogram of length (L) variations by the number of fractures of Taknar zone; the most fractures are the “short” ones and vice versa.

Fig 4. Histogram of spacing (S) variations by the number of fractures of Taknar zone; the most fractures are the “near” ones and vice versa.
Fig 5. Contour diagram map of intensity (I) variations of Taknar zone; the most values of I are relevant to the central and southern parts of the zone.

Fig 6. Contour diagram map of density ($\rho$) variations of Taknar zone; the most values of $\rho$ are relevant to the central and southern parts of the zone.

Fig 7. Typical “D” graphs for 2 areas of the 27 selected areas (boxes) of Taknar zone; D (= line slope) is linear in all of the boxes.

Fig 8. Contour diagram map for studying spatial variations of $D$ values; the high values are relevant to the central and southern parts of the zone.
Introduction of Active Tectonic in Urmia – Silvana Region

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Abstract
Urmia – Silvana region is located in north – west of Iran in west azarbaijan state (west of Urmia Lake). The purpose active tectonic surveying in this zone is surveying of relative vulnerability from view point of geology moves and activations. This subject studied by G.I.S method and finally relative vulnerability of ourmiya – silvana region is evaluated. At first map of fault zones are prepared and finally by using of G.I.S their active limitation and map of active fault zones are afforded. In next stage land slides of zone are identified from 1: 20000 photo map and last are digitized then with considering their magnitude the map of slide zones then landslides are prepared finally map of zones is prepared. In next stage are geology parameters (Tectonic geomorphology of Escarpments and Mountain Fornts & Use of Surficial Earth processes & Stream gradient index & ratio of the width of valley floor to valley hight & ..) are prepared and those maps are assimilated with seismological map (prepared from magnitude of earthquake) and relative vulnerability zone of Urmia – Silvana is prepared. Finally prepared : hazard map of Urmia – Silvana west azerbaijan province, has a survey about 12863 square kms and is located between Oshnavieh’s active faults in south and salmas active fault on north. From the viewpoint of politic divisions, it includes considerable part of Urmia city. For preparing the risk fullness map and staging active tectonic of the region, several information layers have been used that finally have been recognized after mixing these layers using geographical information systems of special regions with different geognosy features that will be mentioned after general indications about region in following lines.

generaliesties
This province is bounded to the north by autonomous republic of Nakhjavan, from east to east Azerbaijan province and from south to Kurdistan province and from west to Turkey and Iraq countries. The highest place of the province is avrin peak with the height of 3622 meters in Khoy city and the lowest one with 710 meters height from the sea level is located next to Aras river in Maku city. shows the location of the province in country and the location of project limit in west Azerbaijan province. The climate of province is generally affected by cold north airflow and polar Siberia and also polar naval and torrid naval. The maximum absolute temperature is about 44 degrees centigrade and the minimum is about -34. The average amount of rainfall in the region is about 300-400 mls, and because of the mountainous condition of the region, most of downfalls are snow. In moving from center part of province to the half north, downfall range decreases and in going to half south it increases. (Maku and Sardasht 250-800 mls). Population structure of Urmia has had considerable changes from 1335 to 1385 in a 50 year period and this has led new residential regions to be built so city's limit has increased multiple times during this period and this happens when population increases from 67,6 thousand to 604 thousand people. Thus this requires more exact surveys on the residential regions to prevent from natural disasters like flood, earthquakes which threats residential regions and mankind societies in a way.
General geology of the project region

This region is a part of ophiolite and changing belt of Sanandaj-Sirjan zone according to division of sedimentary-constructive units of Iran by Eshtoklini (1968). Farcies of this region include part of Zengine and ophiolite. Eshtampli (1978) has put this region on the north of Volkanomus hole of Iran and finally has named Magma serves of this region in the zone of Urmia-dokhtar magma zone and Alborz magma series. This region which is a part of west Azerbaijan province is the westernmost part of geognosic state of Iran that has previous percambery formations and has been covered with younger sediments has a considerable width that Silvana’s complex sediments have been put on them. Banider and Soltanieh builders haven’t been known and constructor sediments have given a distinctive lean on the constructor.

Cretaceous stone have a considerable development by three complex chemistry and ruin facies. Palsos sediments haven’t been recognized but other sediments of different constructions of tarsir with high development are ready in the region. Alluvions mostly include detrital sediments in sorts and sandstone. Olgius-mius alluvions include 200 meters of lime stones similar to Qum constructors. Quatormoz constructions mainly include Traverten, young geyser rocks, waterways and cones that veil origins with low batopography. In next chapters, areas faults that have tremble potential are evaluated. Among the most important of them we can mention Urmia fault, Drik fault, Silvana’s fault, Oshnavieh fault and other active faults in project region. Each of these faults has experienced stirs during last years and creates some risk for residential areas.

In regard of fault's activities, special structural micro zones in the region established, as Salmas zone, Bakhtar zone of Urmia lake, Miandoab zone and southern islands of Urmia lake have Varieties of tectonic qualities shows fault's situation in the area and area's faulty width. Among all important and several implement that we can find out in one area's structure land, using implements and data that are for minimizing toll and finally comparing them together that can help to recognize variant areas. For this, important elements are Topography maps of ethnic area that have more usages and can be used in some methods like: Hyposometring integral, Drain asymmetry, Mountain frontal waving, Width of valley bed.

Results have been prepared in form of tables and have been edited that collected data in G.I.S system have been converted to a series of maps that have been used in preparation of active polls.

In quaking subject, statistics and data related to happened machinery earthquakes during years 1980 to 2007 are registered and finally relation of these earthquakes with active faults are coincided and prepared in basis of depth and magnitude of earthquake's risk with plans. As a result, extant faults are categorized.

Map earthquakes that have happened in pattern realm and vibrating fountain width in realm. Data layers of area's earth slips are prepared using surveying pneumatic pictures of 120000 project realm and transmitting them on the topography maps by conformity of data layers related to faults and landsliding, it's absolute that the most important element of bulk movement is related to fault's moving area. In this chapter, too, the sensibility of rocky units of project area with usage of riskability plans of the region in viewpoint of landsliding is completed with use of area's pendant plan. Surveying deposit phenomena is one of the most important geognosy phenomena that uses the methods of data statistics related to underground...
water tables nutrition in two areas of Silvana flat and their depletion has been assessed. Finally it's assessed again with usage of radar picture methods and absolutely it has less importance in phase of project's range deposit. Another important phenomena is geyser that has less emphasis in this case Some of area's most important geysers are Sahand and Sabalan in the east of Urmia lake and Ararat in north of province in ridge of Iran and Turkey that they don’t have significant influence in project's region. Constructed and under construction dams’ breakings and intaking Urmia city, spate's diffusion sheets and dam's sediment are important parameters that their situation and flood trapping width and sediment trapping with use of G.I.S methods are estimated. Ultimately by using collecting riskability plans and preparing widths of risk by different aspects of studied area's geognosy dangerous comparative are prepared that are shown in map No 4.
Neoproterozoic tectonomagmatic evolution of the NW Indian craton: implications for paleogeographic reconstruction

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Abstract
Neoproterozoic has been heralded as an eventful period of global tectonics due to rapid movement of crustal blocks that amalgamated to form the supercontinent Rodinia during early Neoproterozoic. This supercontinent subsequently fragmented during later part of Neoproterozoic. It was also a period of changes in global climatic conditions and the end the Neoproterozoic is marked by the explosion of life during Cambrian. It is, therefore essential to evaluate various events in crustal blocks of Rodinia to model its assembly and break-up history. The northwestern Indian craton offers an suitable conditions to investigate the Neoproterozoic events present as a well-preserved record from 1 Ga to the Precambrian – Cambrian transition. The Precambrians of this region include an Archean basement (3.3 to 2.5 ga) over which two supracrustal sequences, Aravalli (Paleoproterozoic) and Delhi (Mesoproterozoic) supergroups were deposited. Both these belts are complexly deformed and variably metamorphosed. The 1 Ga Grenvillian event in this region is represented by Delhi Orogeny marked as the collision between Aravalli craton in the east and an unknown one in the west, the latter also known as Marwar craton. The 1 Ga event is marked by calc-alkaline granites and diorites and development of ophiolites in a linear zone along the western margin of the Delhi Fold Belt. At ~870 – 830 Ma vast acid magmatism has been witnessed in the region which is called as Erinpura Granite, which at places shows migmatitic characters. This is followed by a vast acid magmatic event called the Malani magmatism which has been described as the third largest acid magmatic province in the world. It has now been precisely dated at 770 – 750 Ma. This also forms the basement for the shallow tidal sedimentary sequence of Marwar Supergroup which is essentially arenaceous in the lower part, calcareous in the middle and argillaceous – arenaceous in the upper part. C-isotopic characteristics of the carbonate facies suggest Precambrian – Cambrian transition which has further been supported by the recent report of trilobites from the uppermost part. In the conventional paleogeographic reconstructions, India – Australia – Antarctic have been shown as coherent tectonic trio even during pre-Rodinia times. Recent paleomagnetic studies undertaken in this region have shown a latitudinal difference of 45 degrees between Indian and Australia during Neoproterozoic, suggesting that they were amalgamated only during pan African Gondwana assembly.

Key words: Neoproterozoic, NW India, Gondwana, Paleomagnetism, Rodinia.

Introduction
The Neoproterozoic can be called as one of the most dynamic periods in the history of the Earth in many ways. It was a period of large-scale perturbations in the atmospheric oxygen, rapid movement of continental blocks resulting in amalgamation and subsequent break-up of supercontinent Rodinia, and temperature fluctuations that ultimately led to the explosion of life in the Early Cambrian. Extreme climatic conditions and ‘Snowball Earth’ have also been associated with this period and Neoproterozoic glacial deposits have been recorded from
many parts of the world, even from close to equatorial regions, implying severe cold climatic conditions (Kirschvink, 1992; Evans, 2000, Hoffman and Schrag, 2002).

In the Indian context Neoproterozoic record from 1 Ga to the end Proterozoic is well-documented in NW part of Indian peninsula, also known as the Aravalli Craton. A well-preserved geological record offers a unique opportunity to study these rocks and moreover, this terrane is also known as one of the key crustal blocks in the plaeogeographic reconstruction of supercontinent Rodinia. Arid climatic conditions have ensured that the rock-types are fresh and well-preserved, and generally free from alteration. The Neoproterozoic events in the Aravalli craton are described in this paper and their implications on the global paleogeographic reconstructions are discussed.

Regional Geological Setting
Precambrian geological history of the Aravalli craton in the northwestern territory of Indian shield has centered along an Archean basement (called as Banded Gneiss Complex – Heron, 1953; Bhilwara Supergroup – Gupta et al.,1980) over which two major accretionary fold belts, Aravalli and Delhi fold belts, were developed (Fig. 1). The basement rocks have been reliably dated at 3.3 to 2.5 Ga using U – Pb zircon methods (Wiedenbeck et al., 1996; Roy and Kröner, 1996), however, there are no direct ages available for the fold belts on account of non-availability of suitable rocks for dating. Indirect evidences suggest Paleoproterozoic and Mesoproterozoic ages for these fold belts, respectively. The Delhi Fold Belt, forming the most prominent geomorphic feature of this terrain as the Aravalli Mountain chain, extends across Rajasthan and northern Gujarat along a NNE-SSW trend. The Delhi Supergroup as envisaged by Heron (1953) is deposited in northern and southern domains, separated from each other by the Sambhar – Dausa lineament (Bakaliwal and Ramasamy, 1987). The acid magmatism with two distinct age clusters (1700 – 1500 Ma in northern domain) and (=800 Ma in southern domain) has led to the suggestion of diachronous evolutionary history for the Delhi Fold Belt. The diachronous sedimentation history has, however, been contested by some later workers (Roy and Jakhar, 2002). Temporal distinction between granitoid emplacement events between northern and southern domains is not very clear (Sinha Roy et al., 1998). Delhi Supergroup shows a complex evolutionary history involving polyphase deformation and up to amphibolite facies metamorphism. Delhi orogeny coincides with the globally recorded Grenvillian events at ~ 1 Ga, manifested in collision of Marwar Craton in the west and Aravalli Craton in the east.

Calc-alkaline magmatism (~1 Ga)
The Neoproterozoic geological history in this region began with the intrusion of 1Ga continental collision manifested in 1000 Ma diorites and gabбро in Ranakpur (Tobisch et al., 1994) and 967 Ma old calc-alkaline granitoids in Sendra area (Pandit et al., 2003). Sendra and related granitoids occur linearly along the western flank of the Delhi Fold Belt in the southern domain. Geochemical and mineralogical characteristics of Sendra Granite suggest an I-type source and subduction setting (Pandit et al. 2003). The western margin of the Delhi Fold Belt is marked by linear exposures of mafic – ultramafic rocks called Phulad Ophiolite Suite which also corresponds with the Western Margin Fault. The rocks of Phulad Ophiolite suite
are interesting in the sense that they represent fragments of Ancient Ocean. The WMF also marks a shear zone called Phulad Shear Zone.

**Erinpura Granites (870 – 830 Ma)**

A vast granitoid terrance to the west of southern domain of Delhi Fold Belt is popularly known as Erinpura granite. First described by Heron (1953), the Erinpura granite occurs along the western flank of southern Delhi Fold Belt further continuing beyond Ajmer in the northeast. The Erinpura granite is extremely variable in texture, ranging from porphyroblastic to gneissic and even migmatitic (with granophyric and myrmekitic intergrowth of quartz and feldspar). Mineralogical and textural variations in Erinpura granites allow their classification as granite gneiss, true granite to granodiorite and suggest more than one pulse of magmatism. Chief mineral phases are quartz, plagioclase, K-feldspar and biotite with minor amounts of muscovite, epidote, sphene, zircon and Fe-Ti oxides (Chattopadhyaya et al., 1982). Overlapping I- and S-type characteristics of Erinpura granite have led to contradictory source composition models envisaging an igneous protolith (Bhushan, 1995) to a meta-sedimentary parent material (Gangopadhyay and Lahiri, 1984). Keeping in view the large areal distribution of the ‘Erinpura’ granite, no generalized model of magmatism is possible and the Erinpura granite are a result of complex petrogenetic history involving variable sources and processes. Paucity of the geochemical information has further rendered such interpretations merely subjective and valid for a restricted part only. ‘Erinpura Granite’ is used as a basket term, however, the rocks are best exposed in the type area around Sirohi and Sumerpur. For a considerable time Erinpura Granite has been described as 830 Ma in age on the basis of limited whole rock Rb – Sr ages (Choudhary et al., 1984). Some of the more recent studies based on structurally controlled monazite dating have shown a much wider range of magmatism (870 – 830 Ma) in Erinpura rocks (Jana et al., 2010). At least one phase of Erinpura Granite can be considered as mineralized with occurrence of tungsten mineralization in a NE-trending linear belt. Some of the known deposits include Balda near Sirohi in the south, Degana in central part and Tosham in the north. In between the Erinpura Granite terrane and the southern part of the Delhi Fold Belt occurs the Mt. Abu batholith which stands approx 1200 m above the ground level. Mt. Abu is a fault bounded NE elongated composite granitoid body which comprises a granite gneiss rim and a relatively undeformed granitoids in the middle. The latter granitoids, also described as ‘pink granite’ (Gupta et al., 1997) include a range of textural variants. Available ages indicate 800 – 780 Ma for Mt. Abu granitoids. For a considerable time the Mt. Abu granitoids have been described as late orogenic with respect to Delhi Orogeny and separate from the undeformed granites and felsic volcanics of the Malani Igneous Suite. On the basis of magnetic fabric, de Wall and Pandit (2007) have shown that the deformation in these rocks is syn-intrusional and not related to the Delhi orogeny.

**Malani Igneous Suite (MIS)**

Spread over an area of >51, 000 km² in the state of Rajasthan (NW India), the MIS is considered to be the third largest felsic volcanic province of the world. However, the magmatism is polyphase in nature with predominant felsic volcanics (at places with minor basic flows at the base) with granites and a wide array of dyke rocks (rhyolite, trachyte, dolerite/gabbroic) that intrude the earlier lithologies. For a long time the available ages were
based on whole rock Rb–Sr data with contradictory results which included 100 million years span of magmatism (780 – 690 Ma) to a single event at ~725 Ma. More robust U–Pb zircon geochronologic results (Gregory et al., 2009; van Lente et al., 2009) have shown a 770 – 750 Ms duration for Malani magmatism. These results place the MIS rocks in the coeval time window of the Seychelles and northern Madagascar. MIS felsic rocks (volcanics and granites) can be discriminated into peraluminous and peralkaline types, both the varieties defining a systematic spatial relationship with each other, however, the former is the predominant one. Geochemical features such as high abundances of silica, alkalis, LREE, HFSE, LILE and a high Fe/Mg ratio, with extreme enrichment of such elements in the peralkaline rocks have been considered as a basis to call them anorogenic or A-type. The other model includes an Andean type setting on the basis of decoupling of LIL and HFS elements and lack of evidence of continental interior setting. The geochemical features do indicate derivation from high temperature melting of a lower-crustal amphibolitic source with addition of some juvenile material (Ashwal et al., 2002).

**Marwar Supergroup (Precambrian – Cambrian transition)**

The MIS rocks form the basement for a shallow sag basin which developed during the later part of Neoproterozoic. This shallow basin, called as Marwar basin extends E – W and shows sedimentation under subtidal conditions indicated by predominant arenaceous facies Jodhpur Group (gritty at the base). This was followed by platform deposition of a calcareous facies rocks of Bilara Group in the middle while the youngest unit is Nagaur Group which comprises argillaceous and arenaceous facies sedimentation. These rocks are generally undeformed and sub horizontally disposed, however, minor tilts are observed at places. Age of the Marwar supergroup has remined contentious and in the classical sense it has been correlated with Upper Vindhyan and even assigned Cambrian age on the basis of presence of evaporates. However, such contentions could not be substantiated due to absence of body fossils. Pandit et al. (2001) carried out systematic C- and O-isotopic studies of the Bilara Limestiones (the middle unit of Marwar Supergroup) and reported Precambrian – Cambrian transition on the basis of extreme fluctuations in the C-isotopic record. Some of the more recent paleontological studies have reported fossil trilobites from the Nagaur Group (upper most unit). However, such claims should await substantiation.

**Implications for Paleogeographic reconstructions**

The final assembly of supercontinent Gondwana has been estimated at ~550 Ma and paleogeography within Gondwana is reasonably well established. However, individual continental paleolocations prior to final Gondwana suturing are often poorly constrained. It is generally accepted that the components of western Gondwana were not a coherent group while east Gondwans formed a coherent assembly of India – Antarctic – Australia even prior to Gondwana assembly. An alternative model suggests assembly in a more complex manner in the late Proterozoic with the suturing of Gondwana. New paleomagnetic and geochronologic data from the Malani Igneous Suite (MIS), Rajasthan, Central India, improve the paleogeographic reconstruction of the Indian subcontinent between dispersal of the supercontinent Rodinia and Neoproterozoic assembly of Gondwana (Torsvik et al., 2001; Gregory et al., 2009). A virtual geomagnetic pole from 4 mafic dikes has a declination=358.8°
and inclination=63.5° (with \( k=91.2 \) and \( \hat{I}=9.7 \)). This normal polarity direction includes a fine-grained mafic dikes that showed a reversed direction with declination=195.3° and inclination=-59.7° (\( k=234.8 \) and \( \hat{I}=8.1 \)) and also records an overprint of normal polarity from the larger dikes. Synthesizing the paleomagnetic data on rhyolitic flows and mafic dykes a mean paleomagnetic pole of 67.8°N, 72.5°E (\( A=8.8 \)) is obtained for the MIS. A comparison of 755 ±3 Ma Mundine Well dykes in Australia and MIS, and equivalent Seychelles at 750 Å±3 Ma indicates a latitudinal separation of nearly 45° between the reconstructed Indian plate (plus the Seychelles) and its location in a traditional Gondwana fit. This suggests that East Gondwana was not amalgamated at c. 750 Ma and therefore that these two cratons were assembled later into the Gondwana supercontinent, possibly during the Pan-African c. 550 Ma Kuunga Orogeny.

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Petrography and mineralogy of ultramafic rocks in Nain Ophiolite
(Central Iran)

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Abstract
This area has been divided into three geological units: An ophiolitic mélange zone consisting a mixture of ophiolite, limestone and radiolarites trending North-North west through the middle of the area; A Tertiary volcanic zone in the west; A Tertiary sedimentary zone in the east (Davoudzadeh, 1976; Alaie Mahabadi & Foudazi, 2005). The ophiolitic mélange zone consist of ultramafic rocks, isotropic gabbros, diabasic dikes, sheeted dikes, pegmatoid gabbroic dikes, pillow lavas and sheet flows, radiolarian cherts and pelagic limestone which have Upper Cretaceous microfunas, and metamorphic rocks are amphibolites and glaucophan schists (Alaie Mahabadi & Foudazi; 2006, 2009). The ultramafic rocks consist of peridotite predominately tectonised harzburgite that locally grade into lherzolite, harzburgitic dikes bearig plagioclase, serpentine, wherlitic dikes, dikes of dunite and pyroxenite.

In petrographic study most of the harzburgite have granular, xenomorphic granular, schistose, and mylonitic texture. In the eastern part of the ophiolitic melange zone one to several kilometer harzburgite bodies with very low lenses of dunite are situated along the major North-North west trending faults. In these rocks olivine are partly serpentinised (chrysotile and lizardite) and clinopyroxene have been very low altered to tremolite-actinolite, chlorite and talc.

Harzburgites consist of olivine (Fo93.76Fa6.24), orthopyroxene (En89.9Fs8.4Wo1.56), exsolution lamellae of clinopyroxene (En48.3Fs3.7Wo47.9), and subhedral to euhedral chrom spinels.

Lherzolites have porphyroblastic texture; they consist of olivine, orthopyroxene, clinopyroxene, and Cr-spinel.

Harzburgitic dikes bearing plagioclase have been cut serpentinised peridotites and isotropic gabbros. These rocks have cumulate texture, and consist of olivine (Fo94Fa6) , orthopyroxene (En86.4F83.0Fs0.6), in rim to (En89.3Fs7.8Wo2.8) in center and very low plagioclase (anortite).

Serpentinites formed by serpentisation of various kinds of peridotite (spatially harzburgites) and essentially occur as a main of the mélange in this area. These rocks have mesh texture well developed by alteration of olivine (Forsterite). In serpentinites occurrence of bastite derived from total alteration of orthopyroxene is distinguished.

Dunite can be found as thin dikes or in lenticular form in harzburgite, and consist mostly of olivine (Fo93.76Fa6.24).

Wherlite and pyroxenite (websterite-olivine websterite) occur as small dikes in this ophiolitic melange zone and have been cut isotropic gabbros and sheeted dikes. Pyroxenite have granular texture, and consist of orthopyroxene, clinopyroxene and very low serpentinised olivine in olivine websterites.

Pyroxenites have been cut isotropic gabbros consist mostly of clinopyroxene (En89.0Fs7.9Wo2.9) and orthopyroxene (En86.3Fs10.6Wo2.8), and pyroxenite have been cut sheeted dikes consist of clinopyroxene (En52.7Fs6.2Wo41.4) and orthopyroxene (En89.0Fs7.9Wo2.9).
Introduction

Iran enjoys a unique stance in terms of ecological and geological issues. Remains of the oceanic crusts (Ophiolites), Thethys and Neothethys found in different parts of the country including North of Nain (Central Iran), Eastern Iran (Birjand, Nehbandan, Zahedan), Northeastern Iran (Torbat Heidarieh, Fariman, Sabzevar), Western Iran (Khoy), Southern Iran (Esfandagheh, Minab), and Northeastern Iran (Mashad ) (Fig. 1).

*Geological map of ultramafic and mafic rocks in Iran* (Pessagno, E.A; Ghazi, A.M; Kariminia ,M; Duncan,R.A; and Hassanipak, A.A; 2005) (Fig. 1)

*Satellite map of Nain Ophiolite and ophiolitic melange; Tertiary volcanic zone in the west; A tertiary sedimentary zone in the east* (Fig. 2)

Geology

The Nain ophiolite comprise of mantle and crustal sequences. The mantle sequence consist of lherzolite, harzburgite which mark mantle deformation, cut across by plagioclase-bearing harzburgite, wherlite and pyroxenite dikes and dunitic pods.

The isolated diabasic dike cut all of the mantle sequence. The plutonic part of crustal sequence contain isotropic gabbro, diabase sheeted dike complex and pegmatite gabbro. The extrusive sequence comprise of pillow lavas and sheet flows, radiolarite, chert and pelagic limestone which have Upper Cretaceous microfunas.

*Fig. 1) Serpentinitization in peridotites*

*Fig. 2) Mantle deformation in harzburgites*
Petrography and mineralogy of ultramafic rocks

In Nain Ophiolite serpentinite rocks has mesh texture (Fig 5a), and serpininisation has been taken place in two phases in harzburgenite tectonised rocks. In the first phase, serpininisation has been occurred in a static condition and no mechanical transformation has taken place in these rocks. In the second stage, serpininisation has been occurred with dynamic phase resulting from pressure of faults which has formed cracks and crevice and the non-economic mineral of asbest is replaced in little amount inside veins and veinlets. Mineral such as magnesite, chromite, amphibole and talc are in relation with these rocks. These minerals have been formed in different temperatures and pressures.

Base of the microscopic studies, most of harzburgite have granoblastic and porphyroclastic textures which confirm their mantle deformation (Fig 5c). Olivine is partly serpentinized, chrysotile and lizardite and clinopyroxene is fresh but locally altered to tremolite-actinolite, chlorite and talc.
Fig 5. (a) Mesh texture in serpentinite peridotites. (b) Olivine cut across by carbonate vienlet in serpentinitised harzburgites. (c) Porphyroclastic harzburgite showing a deformed orthopyroxene porphyroclast with kink band, under crossed nichols. (d) Porphyroclastic harzburgite showing exsolution lamellae of clinopyroxene in orthopyroxene crystal. (e) Unhedral chrom spinel in serpentinitised peridotites. (f) Cumulate texture in plagioclase bearing harzburgitic dikes.

In harzburgite the microprobe analysis of minerals indicate that the olivines mostly have forsterite composition (Fo$_{93.76}$Fa$_{6.23}$). The orthopyroxene have enstatite (En$_{89.9}$Fs$_{8.4}$Wo$_{1.56}$), bear exsolution lamellae of clinopyroxene with diopside composition (En$_{48.3}$Fs$_{3.7}$Wo$_{47.9}$) (Fig 5d). The Cr-spinel formed as subhedral to euhedral. The plagioclase-bearing harzburgitic dikes have cumulate texture, and consist of olivine with forsterite composition (Fo$_{90.0}$Fa$_{6.0}$), orthopyroxene with enstatite composition (En$_{86.4}$Fs$_{10.3}$Wo$_{1.3}$). The plagioclase have anorthite composition (AN=90). Dunite have granular to granoblastic texture and mostly composed of olivine with forsterite composition (Fo$_{92.15}$Fa$_{7.85}$). Pyroxenites have granular texture, and consist of orthopyroxene, clinopyroxene and very low serpentinized olivine. The clinopyroxene have diopside composition from (En$_{58.6}$Fs$_{17.2}$Wo$_{24.2}$) to (En$_{52.2}$Fs$_{16.2}$Wo$_{31.4}$) and orthopyroxene have enstatite composition from (En$_{86.3}$Fs$_{16.8}$Wo$_{2.9}$) to (En$_{90.3}$Fs$_{17.9}$Wo$_{2.9}$).
Conclusion

Olivine with high grade mantle deformation (Fo%90-93), Orthopyroxene (En%89) bearing exsolution lamellas of clinopyroxene with diopside composition (En48%), subhedral and unhedral Cr-spinel, very low elements in microprobe study specially Nicle Oxide from Olivine in harzburgites and dunite (NiO=0.04wt%), Aluminium Oxide (Al₂O₃=2.8-3.4wt%), Titanium Oxide (TiO₂=0.015-0.04wt%), (Na₂O=0.16-0.4wt%) and (K₂O=0.045wt%) show that mantle sequence of Nain Ophiolite is dominated by residual lherzolite. The chondrite-normalized spider diagram of harzburgite show a depleted source for Nain peridotite but the cross cutting peridotite with cumulative character are moderately enriched.

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Relationship between Petrology of Granitoids and Mineralization in NW of Kashan, Iran

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Abstract

The study area is a part of Urmieh-Dokhtar volcano-Plutonic belt located in NW of Kashan. Urmieh-Dokhtar belt consist of acid to basic volcanic and pyroclastic rocks (Tertiary) and basic, granitoid and subvolcanic plutons (late Eocene to early Miocene). Volcanic and pyroclastic rocks are composed of acid to basic and contain dacite, andesite, basalt, tuff, breccial tuff and ignimbrite. Also some interstitial limestone occurred in them. Granitoid plutons are composed of granite, granodiorite, tonalite, quartz diorite, quartz monzodiorite, monzodiorite and diorite, but granodiorite and tonalite are predominant. These plutons (Anarboneh and Siakhoh) are compositionally zoned and become more felsic towards centre of pluton. Subvolcanic plutons, with dacite to rhyodasite composition, have copper-pyrite (gold) mineralization and product skarn at the contact with limestone. Mafic magmatic enclaves (MME) with >20 centimeter in diameter exist in the granitoid margins. Also aplite dikes with considerable thickness are occurred in the margins of plutonic rocks and exploiting as industrial soils. Granitoid plutons have calc alkaline, metaluminous, chiefly sodic, active continental margin environment, cordilleran I-type, and ACG (amphibole bearing calc alkaline granitoids) characteristics. Trends of elements in the variation diagrams show magmatic evolution of hybrid magma under plagioclase control and then biotite, hornblende and alkali feldspar. AFC, MASH and back mixing processes are important in magmatic evolutions of these plutons. Enclaves are corresponding with host rocks in evolution diagrams. Accessible data show similarities between these granitoids and adakitic magmatism, but certainly need to be studied more. These granitoids have very similarities (such as geodynamic environment, petrographic composition, and compositional zoning) to Tuolumne intrusive rocks that are zonated toward center and placed in Sierra Nevada. WSMF and magma bellows are most important processes in fractionation and emplacement of these plutons. Geochemical data and field evidence show that granitoids have enough potential to create Fe, Cu (Mo), and Au (skarn, hydrothermal and porphyry type) mineralization. The felsic parts of Anarboneh granitoid have potential for Sn-W mineralization.

Introduction

Granitoid rocks are common and accessible intrusive rocks of the earth. Their study is very important for understanding the evolution and growth of continental crust, recognition of processes that occurred in the mantle and the earth crust and related economic mineralization. Many of researches have worked for relationship between volume and composition of these intrusions with geodynamic conditions (Pitcher, 1983; Lameyr, 1988; Barbarin, 1990), crust nature (Vielzeuf et al., 1990; Chappel and White, 1974), orogeny and metamorphic environment (Hall, 1973), enclaves that are related to these intrusions (Didier, 1973; Didier and Barbarin, 1991) and related mineralization (Pirajno, 1992).

Petrological compositions range from granodiorite, tonalite and quartz diorite and even from granite to diorite. In this study attempt to consider the petrography and petrology of these intrusive rocks, related enclaves and mineralizations by field observations, microscopic studies, and chemical analysis.

**Local Geology**

The study area is a part of Uromieh- Dokhtar volcano- plutonic zone (Stocklin, 1968) or copper belt of Iran. It is located in NW of Kashan city (Fig.1). This zone is composed of acid to basic volcanic- pyroclastic rocks (Tertiary) and granitoid intrusions (Late Eocene to Early Miocene) that intruded them. The host rocks of granitoids include dacite, andesite, basalt and tuff, ignimbrite, volcanic breccia, attributed to Eocene (Emami et al., 1996).

In the study area, intrusive rocks are zoned and mainly granodiorite, tonalite, quartz diorite and diorite in composition (Fig. 1). Granite is an inner part of the intrusion. Small acid subvolcanic domes and aplite-pegmatite veins have cropped out in the margins of the granitoids. Mafic magmatic enclaves (MME) are observed in the internal margins of granitoids. Their size ranges from a few cm to 20 cm.

Injection and emplacement of intrusions and subvolcanic rocks that sometimes are controlled by tectonic structures, followed by ore bearing volatiles, alterations and mineralizations of Cu and pyrite (Au- bearing), Fe-Mn oxides, barite and Pb-Zn-Ag in the top of granitoids and/or within their host rocks. Mineralizations are mainly disseminated and vein-type, and rarely economic. Aplitic veins are being exploited as industrial rocks.

**Petrography**

Intrusive rocks, lithologically range from granite to diorite, but mainly are of granodiorite-tonalite-quartz diorite suite. The leucogranite constitutes the minor part of the plutons. The main lithologies consist of Pl, Qz, Kf, Hb, Bio and Cpx (diopside- augite). Apatite, zircon, sphene, and Fe-Ti oxides are the accessories and opaque minerals. Epidote, sericite, kaoline, chlorite and actinolite are the secondary ones, have formed during alteration of original minerals.

The plagioclase (35-55 wt %) is fine microlitic to medium grained, euhedral to subhedral and sometimes zoned. It is altered into sericite and epidote. Quartz (5-40 wt %) occurs within the interstitial spaces of the minerals. Kf is not abundant within the main suite, but its presence in leucogranite as coarse-grained microcline, in part perthitized, is common.

Biotite and hornblende, as the main mafic minerals, consist of 2-7 percent of these rocks. The main texture of the granitoids is granular- seriate, but inequigranular- porphyritic texture, and locally granophyric, graphic, myrmekitic and poikilitic textures are common (Fig. 2).

Intergrowth textures have controlled by the $f$ H2O when the felsic melt was becoming cold under the loss of volatiles and relatively fast crystallization (Shelley, 1992).

MME are always fine-grained and more mafic than their hosts (Didier and Barbarin, 1991; Barbarin, 2005). They are mainly rounded and elliptical and have magmatic textures. Mineralogically they have the same composition as the host, but richer in mafic minerals. Their lithology ranges from diorite to quartz diorite, with phenocrysts of plagioclase and in part hornblende.
Geochemistry

Samples of granitoids, MME and their hosts were analyzed by XRF method. Some samples analyzed by ICP-MS method.

Granitoids and MME covering a SiO₂ range from 57 to 76 wt %. The ranges of other major elements are shown in table 1. MME have Al₂O₃, CaO and Na₂O values higher than that of the host rocks. Moreover, values of SiO₂, Na₂O and K₂O increase towards the inner part of the pluton, while, Al₂O₃, CaO, MgO and FeO decrease.

Lithochemical classifications revealed the main lithologies as granodiorite- quartz diorite- tonalite suite. Geochemical congruency of MME with their hosts, and negative linear relationships of CaO, MgO, TiO₂, Al₂O₃ and P₂O₅ with increasingly SiO₂ contents is obvious on the harker- type diagrams, while alkaline elements (Na, K) and, in part, Fe have disperse distributions.

Positive correlations between TiO₂- P₂O₅, Th-Zr, Th- U, K₂O- Rb, and in part CaO- Sr presented on variation diagrams. Contemporaneous crystallization of apatite, monazite, Fe- Ti oxides and titanite- zircon could control the variations of P, Ti, Zr, Th and U behavior. But variations of K, Rb, Sr, Ca and Na have mainly been affected by the crystallization of biotite and feldspars. Furthermore, the triangular diagram is indicative of plagioclase role than Kf and biotite, on controlling of crystallization. Condrite normalized REE patterns of granitoids and MME shows inclined and flat patterns in LREE and HREE respectively. It indicates differentiation of these elements. At the other hand, the similarity of MME and their hosts patterns shows that they are co-magmatic.

Mineralization

In the volcano-plutonic belt of Uromieh- Dokhtar, introduced several mineral deposits such as porphyry Cu-Mo, vein type Cu-Co, Fe-Cu skarn, base metal, epithermal gold deposit, volcanogenic- sedimentary Fe and Mn, vein type Mn and non metal kaolin, barite, industrial soils, silica and bentonite etc.

Mineralizations in the study area are related to intrusive rocks and related fluids, and contain disseminated and vein type Cu-Pyrite, vein type Fe-Mn and barite. Mineralization often occurred in the top of intrusive rocks, especially acid subvolcanic domes (rhyolite to rhyodacite), and in the margins of intrusive rocks and within volcanic- pyroclastic rocks. Most of them are not economic. Some Cu-Pyrite ores have a little gold, up to 0.5 ppm. Geochemical studies (Geological society of Iran) have confirmed the presence of Au in samples, and introduced some anomalies. Limited lithogeochemical sampling from these anomalous areas have indicated 0.5 ppm Au. It is possible the presence of a small Cu-Au porphyry-type mineralization in relation to small rhyodacitic dome in the area, but it is necessary more precise study.

With take into account that granitoid rocks of study area are mainly meta-aluminous, expected mineralization are mainly porphyry Cu-Mo (Clarke, 1992) and related skarn deposits, vein-type and epithermal gold mineralization. Many of Cu-Fe, W-Sn and Au etc. mineralization have recognized in related to skarn deposits that associated with intrusive rocks (Meinert, 1995).

With regard to compositions of intrusive rocks in the study area, these intrusions have potential to create Fe-Cu -Au and sometimes Sn-W skarn deposits (Fig. 3).
Discussion and conclusion

Plutonic rocks of NW of Kashan city lithologically constitute the suite of granodiorite-tonalite-quartz diorite. Granitic composition constitutes a small inner part of pluton. MME are quartz diorite, monzodiorite to diorite in composition. These enclaves have magmatic textures, separated from the hosts with a fine grained and lighter color margins. Their geometry is rounded and elliptic. Texturally they are microgranular to microporphry; while, they hosts are granular-seriate to porphyry. MME are darker than their hosts and richer of mafic minerals (amphibole, biotite and pyroxene).

Geochemically, the plutonic rocks are calc-alkaline, magnesian, meta-aluminous and low-k types (except leucogranites).

There are many works on MME (Barbarin, et al., 1963; Didier, 1984, 1987; Vernon, 1984; Hill et al., 1985; Didier and Barbarine, 1991). Magmatic textures and mineralogical composition of MME similar to their hosts indicate that MME crystallized from magma (Didier and Barbarin, 1991). Textural, mineralogical and in part geochemical congruencies of MME with the host rocks suggest that they may be autolite (Barbarin, 1986; Didier, 1978); but their clear light and fine-grained margins tell us that they are probably a mafic magma (Huppert and Sparks, 1988) intruded within the silicic magma chamber.

On the nature and origin of calc-alkaline granitoids of volcano-plutonic areas related to subduction zones, there are many of works and data (Clarke, 1992; Pitcher, 1995; Barbarin, 1992; Frost et al., 2001). These plutonic rocks show a spectrum role of mantle-crust interactions. Can either differentiate or crystallize from a mantle-derived mafic magma contaminates with crustal rocks, or from a mixed magma. The tonalite-granodiorite-suite is the type of secondary granitoids (Clarke, 1992), based on the number of partial melting events from an original plidotitic mantle source. It seems that the plutonic suite of the area had generated from partial melting of amphibolite-ecllogite crustal rock types, were mixed with mantle derived mafic magma due to back-mixing events. This mingled/ mixed hybrid magma produced the well-known tonalite-granodiorite suite. Trends of elements on variation diagrams and lithogeochemical nature of the granitoids indicate that ACF/MASH processes, under controlling of crystal-melt differentiation as an effective process, have played important role on magmatic variations. The presence of rounded to elliptic shape MME which separated with a fine-grained and light color margins from the hosts, and geochemical signatures which share between felsic-mafic magmas, are indicative of this genetic scheme.

Mineralizations in the area are of granitoid related types. These granitoids, potentially favorite for Cu-Fe-Au- and sometimes W-Sn mineralizations (fig. 3). In some cases, the felsic end-member of this suite can potentially have W-Sn mineralization.

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Fig. 1. (a) Geotectonic map of Iran (after Alavi, 1991) and (b) geological map of the study area.

Fig. 2. Microphotographs of granitoid and related rocks, 
(a) granophyric texture in granites, 
(b) perthite in granodiorite, 
(c) porphyritic texture in tonalite and 
(d) graphic texture in granodiorite.

Fig. 3. a) Harker type diagram of MgO vs. SiO2 and K2O vs. SiO2, Classification of alkaline (A), calc-alkaline (CA) and tholeiitic (Th) nature of plutons of NW Kashan (stars show mean value), open circles indicate the average values for different ore deposits (Meinert, 1995). Amounts of K2O in the Leucogranites and other granitoids are about 4 and 1wt% respectively, b) trace-trace diagrams.
Palynofacies and Sedimentary Environment of Sarcheshmeh Formation on Dodanloo Village Section

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Abstract

Sarcheshmeh Formation is one of lower Cretaceous formations of Kopet-Dagh sedimentary region located at northeastern direction of Iran. A profile of the formation was studied through Dodanloo Village section, palynologically. The formation has 312 m diameter over Dodanloo Village and its lithology is consisted of grey marls, dark grey shale with calcareous slim intra-strata. Organic shreds including Macerals, Playnomorphs and unstructured organic matters which have been prepared in the framework of 135 slides out of 27 samples of the section were studied in order to identify and determine sedimentary environment. Subsequently, two types of Palynofacies were determined. A shallow and proximal environment was suggested for Sarcheshmeh Formation at the mentioned section after determination and perception of palynofacies.

Introduction

Sarcheshmeh Formation is consisted of two informal parts and a key strata at the pattern section with 310 m diameter (Aghanabati, 2005), underneath part of the formation is consisted of 178 m grey bluish harmonized marl. Upper part is consisted of 132 m dark grey calcareous shale with slim limestone intra-strata. It's underneath common border with Tiregan Formation and its upper border with Sarcheshmeh Formation are in the same inclination (Afsahr Harb, 1994).

Sarcheshmeh Formation is on latitude 58º:52':50ºN and longitude 21º:2': 37º E.

Dodanloo section is located at 77-km of Mashhad-Ghochan Road through Aliabad road. It is accessible after passing 2 km of the road and its location is near the Dodanloo Village. Sarcheshmeh Formation in this section is consisted of grey marls and calcareous shale.

Organic shreds including phytoclasts, marine palynomorphs and SOM were analyzed for determining palynofacies during playnologic studies. Eventually, palynofacies and sedimentary environment of the formation were determined subsequent to counting, making percentage, taking pictures and matching them with Tyson Diagram (Tyson 1993).

Discussion

Based on classification of organic matters, organic particles presented at palynologic slides are divided into two Allochthonous and Autochthonous (Van der Zwan, 1978), Allochthonous particles including Palynomacermals and terrain palynomorphs such as spores and pollens and Autochthonous includes dinofellagelate cysts, acritarchs, SOM and inner cover of foraminiferans. SOMs are some unstructured organic particles which are created through dissection of organic materials by bacteria (Wavern & Visscher, 1994).
After preparing palynologic slides, a number of 300 particles out of organic particles including dinofellagelate cysts, Palynomacerals and SOM were counted randomly through selecting various sight fields. After making percentage and distinguishing palynomorphs at Tyson's ternary diagram, its palynophacies were determined.

The results of separation of two types of palynofacies are as follows:

**Palynofacies I:** Palynomacerals of this kind of palynofacies are more than 90 percent, SOM percent is very low and is about 5 percent and marine palynomorphs are between 2-5 percent. Most samples are categorized in this palynofacies and it covers 1, 2, 4, 6, 8, 9, 10, 13, 14, 16, 18, 19, 22, 23, 25, 26 and 27 samples. This playnofacies is concomitant to playnofacies type I of Tyson classification and it can be considered as a part of basin's initial environment.

(highly proximal shelf or basin) this palynofacies shows sedimentation at oxygenated condition.

**Palynofacies II:** In this type, percentage of palynomacerals is over 80 percent and they consist dominant particles here, SOM amount is between 5 to 13 percent and palynomorphs are about 6-12 percent, playnomacerals are of same-dimension type. Spore and pollen are found in this Palynofacies. Again it is concomitant with Tyson's Palynofacies II classification. It shows dysoxic-anoxic marginal basin. This kind of Palynofacies is seen at 3, 5, 7, 11, 12, 15, 20, 17, 21, and 24 samples. High percent of palynomacerals which are of same-dimension shows a marginal and shallow proximal environment and introduces SOM deficiency along with low oxygen amount, however presence of inner cover of Foraminiferans in some samples shows that the condition had some oxygen (Van der zwan, 1990).

**Conclusion**
1. Analyzing playnologic slides in this section implies two palynologic profiles I and II.
2. Sedimentary environment of Sarcheshmeh Formation of the section is a coastal and shallow environment.
3. Spore and pollens in most samples focuses on shallow environment across the coast.
Tyson’s Ternary Diagram and Samples Positions in it

Palynofacies1

palynofacies2
Reference


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Calculation of shear displacement using strain analysis, in Qaleh-Zari mine, (south of Birjand)

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Abstract
Mineralization in Qaleh-Zari mine is in the dextral shear zone with N135 trend. In this paper, shear displacement has determined by Mohr circle method and using available formula. Calculation of shear strain and volume change in studied area, indicate dilatation for this zone. With regard to shear strain and volume change values at different distances for 4300m lengths of shear zone, the measured shear displacement is about 2021m.

Key words: Qaleh-Zari mine shear zone, shear displacement, volume change, shear strain value.

1. Introduction
Qaleh-Zari mine is located in longitude between 58º 58'-59º 1’ east and latitude between 31º 46'-31º 49’ north, almost 180km south of birjand. This area is in east of lut block and so follows of structural treatment of it. Mineralization in this mine is as vein in the fractures of shear zone.

The determination of shear displacement is a basic object of structural geology. The Qaleh-Zari mine shear zone is dextral with N135 trend. The shear zone is 4.5km in length and 50m in width. Trend of shortening is N and stretching is W. Statistical amounts of longitudinal strain and shear strain and descriptive components of strain ellipsoid (supposed that primary sphere has unit radius) for various points in the area have gotten, then shear displacement in studied area has determined.

2. Construction of Mohr circle method for calculation of strain and volume change value
For 3-D finite strain analysis in the area can be used Mohr circle diagram because that fractures have crossed each others. So location, trend and dip.direction of cross vein planes are needed. Strain ratio ($\lambda_2/\lambda_1$) has been measured for 30 instances of fracture cross (Fig 1, 2).

For determination of volume strain values, it’s necessary calculating strain ratio (R) according to equation 1, at principal strain planes.

\[ R_{xy} = R \cdot \cos \alpha \]
\[ R_{xz} = R \cdot \cos \beta \]
\[ R_{yz} = R \cdot \cos \gamma \]

\( \alpha, \beta, \gamma \) are polar angle of plane and x, y, z axis respectively.

\[ \text{equation (1)} \]
Application of shear strain is for introduction of angle variations on two perpendicular directions and it is:

\[ \gamma = \tan \psi \]  

equation (2)

Follow equation has been used for measurement of maximum finite shear strain:

\[ \gamma = \sqrt{R_{xz}} - \frac{1}{\sqrt{R_{xz}}} \]  

equation (3)

Maximum strain ratio (R_{xz}) can be written as follow:

\[ \frac{S_x}{S_z} = \frac{1 + e_x}{1 + e_z} \]  

equation (4)

3. Calculation of shear strain and volume change determining shear displacement of Qaleh-Zari mine shear zone

The spectrum of \( \Delta \) and \( \gamma \) can be obtained repeating the above process at different distances (X) and X-\( \gamma \) curve chart may be drown. The area between the curve and X-axis is shear displacement.

The detailed values of \( \Delta \) and \( \gamma \) are shown in table 1. Fig3 is X-\( \gamma \) curve chart. It shows that in the distance of 4300m of the zone, the total shear displacement is about 2021m.

4. Summary

On determining the shear displacement of Qaleh-Zari mine shear zone with volume change (dilatation), the shear strain and volume change in plane have been calculated using Mohr circle diagram, and measurement of strain ratio for different points of fracture (vein) crosses along the shear zone.

The area between the curve and X-axis, in the X-\( \gamma \) curve chart shows shear displacement that in the distance of 4300m of the zone, is about 2021m.

References

1 - Ramsay, J.G. and Huber, M.I., 1983, the techniques of modern structural geology, V.1: Strain Analysis, Academic Press, London,

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3 - Schwerdtner, W. M., Calculation of volume change in ductile band structures, J. Struct. Geol., 1982, 4(1)

Table 1. Calculated data of the Qaleh-Zari mine shear Zone by Mohr circle diagram.

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Fig1. vein cross and calculation of strain ratio, by Mohr circle diagram

Fig2. determination of strain ratio \((R)\) by Mohr circle method.

Fig3. \(X\gamma\) curve chart on the Qaleh-Zari mine shear zone. The measured shear displacement is about 2021m.
Synthesis process of forsterite refractory by Natural Serpentine

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Abstract
Mg-olivine (forsterite) is used in the manufacturing industry vastly and plays a significant role especially in refractory and foundry industry. Most principal usage of this mineral is providing of Brazen, Fe, Al, and Ti- sandy molding alloys and also Fire-brick, roof clay and Mn bearing steel. In many countries Magnesite with enstatite are blended one another and heated till 1650°C for processing artificial forsterite. Experimental studies indicate that serpentine decomposition to forsterite in high temperature. Serpentine has been expanded in Iranian ophiolitic rocks. Testing Neyriz ophiolitic rocks shows that forsterite has been produced from heating of serpentine in 600°C. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry. The test results show that, Dehydration reactions on serpentine started at approximately between 100 to 150°C and dehydroxilation reactions started at approximately 550-700°C. As a result of thermal reaction the decomposition of serpentine will take place and then changing in to olivine (forsterite). Crystallization of olivine (forsterite) will start at 600°C.

Keywords: olivine, forsterite, serpentine, refractory, XRD, DTA-TG

1- Introduction
Refractories are defined as materials having the ability to retain their physical shapes and chemical identities when subjected to high temperatures. They are resistant to corrosive solids, liquids and gases at temperatures of greater than 1500°C. They are used to manufactures furnaces, driers, parts of jet engines, missiles and spacecraft (De Waele and Simasiku, 2002). Forsterite (Mg₂SiO₄) is a kind of main mineral phase in refractory, which has the properties of nice creep stability and high refractoriness temperature under load (Song, 1978). It is a kind of thermal insulation and heat preservation refractory because its heat conductivity is low (about 1/3-1/4 of the pure MgO) (Xu and Wei, 2005). Therefore, it can be used in steel-making as drainage sand, and in casting models as metallurgy accessories (Pan,1982 Harvey et al, 1938; Birch et al, 1935). As a kind of high-temperature refractory, the products of forsterite can be used in torpedos, ladles, continuous casting tundish, non-ferrous metal smelting, glassmaking, rotary cement kiln and so on (Mitchell et al., 1998; Pack et al.,2005). In many countries Magnesite with Enstatite are blended one another and heated till 1650°C for processing artificial forsterite (Newman, 2006). Experimental studies indicate that serpentine decomposition to forsterite in high temperature (Frank et al, 2005). Serpentine has been expanded in Iranian ophiolitic rocks. Testing Iranian ophiolitic rocks shows that forsterite has been produced from heating of serpentine. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry.
2- Material and Method

This work was conducted as three stages: petrographical studies, X-ray analyses and DTA-TG analyses. In petrographical studies, mineral paragenesis and textural properties of rocks were described and classifications of Wicks and Whittaker (1977) which were later developed by O’Hanley (1991, 1996) were used. X-ray analyses of 7 samples from the Neyriz Ophiolite Complex (SW Iran) were made with Philips Xpert brand X-ray diffractometer at Iranian Mineral Processing Research Center (IMPRC) (fig.1). Before the X-ray analyses, dried samples were left in furnace for about one hour at temperatures of 200°C, 400°C, 550°C, 600°C, 650°C, 700°C, 750°C, 850°C and 1100°C. DTA-TG analyses, which give information on phase transformations in parallel to temperature increase and the amount of mass loss, were performed with NETZSCH STA 409 PC Luxx brand device. During the analyses which were conducted at temperatures between 20°C and 1100°C, temperature increase was selected as 20°C/minute and 100 mg sample was used for the analyses.

3- Petrography

In petrographical studies, source rock of serpentines was found as harzburgite. In completely serpentinized rocks with pseudomorphic texture, serpentine ± talc ± magnetite. According to classification of Wicks and Whittaker (1977) and O’Hanley (1991, 1996) on the basis of textural features under microscope, lizardite ± antigorite and vein-type chrysotile were found in samples of pseudomorphic texture (fig.2).

4- X-Ray Analyses (XRD)

In order to determine mineralogical changes as a result of thermal reactions, samples that were heated at certain temperature were subjected to X-ray analyses (fig.3). Results of routine analyses are conformable with those of petrographic studies and lizardite was the main mineral observed. There was no mineralogical change in analyses of all samples conducted at 200°C, 400°C and 500°C while only a little decrease was observed in the lizardite abundance with temperature increase. It was observed that the lizardite abundance was continued to decrease at 550°C and olivine (forsterite) started to crystallize. At 600°C, lizardite abundance was significantly decreased and forsterite continued to crystallize and its abundance was increased. At 650°C, lizardite was mostly disappeared and forsterite continued to crystallize. In analyses performed at temperatures higher than 700°C, forsterite continued to crystallize and their abundances were increased. Considering the analyses conducted at 550°C, 600°C and 650°C, a significant amorphousization was detected.

5- DTA-TG Analyses

Thermal reactions in lizardite are developed in parallel to temperature increase and at 100°C temperature, free water in samples and absorbed water on the surface are lost due to dehydration. Examination of DTA and TG curves reveals that there is such a change in all samples at 100°C (fig.4). Lizardite peaks in all samples are observed as endothermic at 700°C and exothermic at 810°C. As shown in DTA curves, dehydroxilation was occurred at about 550°C to 700°C. As determined by the X-ray analyses, reactions associated with dehydroxilation resulted in formation of forsterite from lizardite (Mg3Si2O5(OH)4) at temperatures above 550°C, lizardite were lastly found at 650°C and considering the results of
both DTA and XRD analyses reveal that lizardite can be stable at temperatures mostly 650°C-700°C. At temperatures higher than 700°C which defines the upper stability limit of lizardite, forsterite continued to crystallize and this new mineral formation was recorded on DTA diagrams as one exothermic peaks at around 810°C. As a result, all these mineralogical changes determined with the XRD studies are found to be conformable with DTA analyses. According to results of TG analyses, 13% mass decrease was found in samples.

6- Results and Discussion

This study indicates that serpentine decomposition to forsterite in high temperature. Serpentine has been expanded in Iranian ophiolitic rocks. Testing Neyriz ophiolitic rocks shows that forsterite has been produced from heating of serpentine in 600 °C. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry. In this study, serpentine minerals were subjected to thermal treatment to investigate the upper stability limits of these minerals and resulting new mineral paragenesis. Considering the results of XRD analyses, lizardite can be stable until a temperature range of 650°C-700°C but its abundance decreases depending on reactions associated with temperature increase. In analyses at temperatures above 550°C, the amount of lizardite was further decreased and forsterite started to be formed. lizardite + forsterite association at temperatures above 550°C was continued until 650-700°C and lizardite was removed at higher temperatures. Results of DTA analyses which were conformable with X-ray determinations indicated that lizardite dehydroxilation reactions were started at 550°C and continued until 700°C. According to results of DTA analyses, endothermic peak shown at 810°C following the dehydroxilation at 700°C correspond to formation of forsterite. Examination of XRD analyses conducted at 550°C, 600°C and 650°C reveal the presence of amorphousization that is observed in all samples. The amorphousization is thought to be derived from silica that is released during the thermal reactions.

7-References


Figure 2: Microphotographs of representative magmatic rocks from the Neyriz ophiolite complex. OL: olivine (forsteite) and S: Serpentine.

Figure 3- XRD block diagram of samples at different temperatures (Liz: lizardite, Fo: forsterite)
Figure 4- DTA-TG curves of samples.
The Petrology and Petrogenesis of Tertiary Volcanic Rocks of Jasb Area

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Abstract

The Jasb area is located about 230 Km. South of Tehran (10 Km of the N-NE of Delijan) in Urmiyeh-Dokhtar magmatic belt. The scattered volcanic rocks belong to Eocene, Miocene and Pliocene, and they can be classified into two groups: intermediate to basic lava flow and pyroclastic rocks. The volcanic rocks’ type variations are rhyodacite, dacite–andesite, andesite and basaltic andesite. The petrographic studies revealed that the textures of volcanic rocks are mainly porphyritic. The andesite rocks belong to Eocene and Miocene and these rocks are located in the middle of the area that was investigated in this study. Some kinds of this lava are riched in Al₂O₃, Sr, and Ba. The subvolcanic-Volcanic domes of Pliocene that locally cut the upper red formation (Miocene) deposits. The petrographic study shows that they are rhyodacite and that there are euhedral phenocrysts of plagioclase and amphibole in these kinds of rocks. The high viscosity magma had formed the rhyodacite domes. The magmatic series of volcanic rocks except basaltic andesite types that are toleitic are calc alkaline. The change in abundance of minerals such as pyroxene, magnetite, amphibole, biotite, plagioclase and feldspar in the volcanic rocks, indicates the successive process of differentiation in intermediate magma; the same change created variation in lithology. Pyroclastic rocks belong to Eocene and have acidic composition (i.e., dacite lithic-crystal tuff); they were formed by explosive volcanic eruptions and were deposited in shallow sea environment. The pattern of Rb/Yb+Nb diagram of the volcanic rocks in the study area shows the similarities with magmatism of Volcanic Arc regions. Based on the analyses results, the geochemical diagrams were drawn and interpreted. Defining the lithology of volcanics, the tectonomagmatic setting condition, magmatic series, and geochemical variations are the results of geochemical and petrological studies of volcanics in the area.

Keyword: Petrography, Geochemistry, Volcanic rocks, Jasb, Tectonomagmatic setting, Calk alkaline magmatic series

1. Introduction

The Jasb area is located in the end part of East part of Markazi province, about 230 Km. South of Tehran (fig1). This paper describes petrography, geochemistry and evolution of different types of volcanic rocks.

2. Geological setting

Jasb extrusive bodies are located in the region of the N-Ne of Delijan in central part of Iran (fig. 2). The first major events in the Tertiary volcanic history in area include the eruption of various basic to intermediate flows, tuffs, and volcanic breccias. The volcanic rocks consist of several separate outcrops with an elongate northwest-southeast trend relatively. All of these volcanics (ranging from basaltic andesite through to rhyodacite) lie within the Urmiyeh-Dokhtar magmatic belt as a part (subzone) of Iran-E-Markazi zone. Emami (1981), Schroder
(1994) and Ghalamghash (1996) studied the stratigraphy, petrology and structural geology of the region. The Jasb area is in the geological quadrangle map of Kahak at a scale of 1:100000 on 1998 by Ghalamghash.J and Emami.M.H (fig2). The extrusive rocks in the area are belonging to Eocene, Miocene and Pliocene. There are some rhyodaciteic dome structures in Honda Mountain and around of Ravanj village. There are subvolcanic – volcanic dome which replaced in Neogene deposits and cut the Miocene sedimentary rocks obviously. The form of magmatic structures, depth of replacement, deformation of around rocks is influenced by magma and specially differentiation of viscosity of these kinds of rocks with other kinds of rocks in this region (Emami1981). The outcrop of andesite and dacite are the middle and the north of the investigated area which have seen with tuff and volcanic breccia. Pyroclastic rocks mainly lie in middle and east part of this area.

3 – Petrography

Crystals in volcanic rocks give clues to processes and time scales of magma evolution (Bacon &Loewenstrom 2005). The scattered volcanic rocks belong to Eocene, Miocene and Pliocene, and they can be classified into two groups: intermediate to basic lava flow and Pyroclastic rocks. The volcanic rocks’ type variations are rhyodacite, dacite–andesite, andesite and basaltic andesite. The rhyodacite rocks (Plr) are subvolcanic–volcanic domes that were formed in western part of investigated region. The color of rhyodacite in hand samples in new broken part is green. The rhyodacite minerals are composed of low-medium grained plagioclase, quartz, amphibole and alkalifeldespar (fig.3.a). The composition of the plagioclase in this rock is oligoclase-andesine and that of amphibole is hornblend, which has been altered to chlorite in some samples. The amount of alkalifeldespar is less than other minerals. The outcrop of dacite-andesite (Mtv) is NW in the investigated area. The color of its in fresh parts is grey-brown. These samples show porphyritic texture. The primitive minerals of these kinds of rocks are plagioclase, alkalifeldespare, amphibole (hornblende) and pyroxene (rare). The composition of plagioclase is albite-oligoclase and in some cases andesine. Pyroxene mineral (hypersthenes and some cases ugrite) altered to serpentine and chlorite.

The volcanic rocks undertook the hydrothermal alteration during the waning stages of the explosive activity and include secondary minerals such as albite, chlorite, calcite, epidote, hematite, and quartz. The change in abundance of minerals such as pyroxene, magnetite, amphibole, biotite, plagioclase and feldspar in the volcanic rocks, indicates the successive process of differentiation in intermediate magma; the same change created variation in lithology. Pyroclastic rocks belong to Eocene and have acidic composition (i.e., dacite lithic-crystal tuff); they were formed by explosive volcanic eruptions and were deposited in shallow sea environment.

4. Analytical method and results

For this research about 95 volcanic rocks samples were collected. Having completed petrographical studies, x-ray fluorescence spectroscopy (XRF) was used to analyze 19 volcanic rock samples for major elements and the selected trace elements. The determination were carried out on a Phillips PW 1480 and 1400 x-ray spectrometer fitted with radium (Rh) tube at Kansaran Binaloud and at Ministry of Geological Survey of Iran. Results of the major and analyzed trace elements are listed in table 1.
5. Geochemistry
The intermediate and relatively basic rocks probably formed as lava flows in the different volcanic processes. The intermediate rocks of the area exhibit a wide range of silica SiO2 content (55to70 wt. %). Mg is highly depleted in most samples. According to Na2O+K2O/SiO2 diagrams (Lebas et al 1986), a majority of the volcanic rocks in the area fall in the andesite district. Major-element Harker (1909) variation diagrams reveal the expected linear variation for a group of co-genetic lavas. MgO and CaO correlate negatively with SiO2 (fig.5) and the trends are smoothly decreasing. Consistent with petrographic observations, it is likely that the trends indicate the fractionation of clinopyroxene, and Ca-rich plagioclase. Na2O and K2O correlate positively with SiO2 concentration (fig.5), while P2O5 shows initial enrichment and then depletion at ~50 wt% SiO2 (fig5). The depletion of P2O5 is probably indicative of apatite crystallization. Similarly, after initial enrichment, TiO2 and Fe2O3 concentrations simultaneously decrease, indicating the crystallization of Ti-bearing clinopyroxene and Fe-Ti oxides.

Trace element data provide additional petrogenetic information. The volcanic rocks samples contain relatively low concentration of the HFS elements, and some degrees of concentration in the LFS (Sr, Br, and Rb). Some trace elements such as Sr, Rb and Ba are concentrated in the silicate phase rather than in accessory minerals. Therefore, Sr, Ba and Rb have positive trends (fig.5). These elements can enter biotite and alkali feldspar (Wilson1989). According to (Na2O+K2O) /SiO2 and FAM diagrams (Irvine & Baragar 1971), all of the samples in the area fall in the sub alkaline and calc-alkaline type except basaltic andesite samples (fig.6).

6. Tectonic setting of volcanic rocks
The samples which studied in this paper provided a window into different processes in volcanic rocks. The Bidhand major fault with N-S trend was influenced on volcanic rock’s magma uplifting. The magmatic settings can classified on chemical method (Pearce1976). The pattern of Rb/Y+Nb(Pearce et al 1984) diagram of the volcanic rocks in the study area shows the similarities with magmatism of Volcanic Arc regions (fig.7). The calc-alkaline magma is for completely mature and the board of active continental (Rollinson1992). Based on diagram of ANK/ANCK the compositions of volcanic rocks show meta aluminous nature (Maniar &Piccoli 1989); therefore, the volcanic rocks of area are related to orogenic setting.

7. Conclusion
The scattered volcanic rocks belong to Eocene, Miocene and Pliocene, and they can be classified into two groups: intermediate to basic lava flow and pyroclastic rocks. The volcanic rocks’ type variations are rhyodacite, dacite–andesite, andesite and basaltic andesite. The pyroclastic rocks are tuff and ignimbrite. The high viscosity magma had formed the rhyodacite domes. The magmatic series of volcanic rocks except basaltic andesite types that are toleitic are calc alkaline. The volcanic rocks in the study area show the similarities with magmatism of Volcanic Arc regions. Based on diagram of ANK/ANCK the compositions of volcanic rocks show meta aluminous nature; therefore, the volcanic rocks of the area are related to orogenic setting.
References


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Fig. 1. Simplified geographical map of the area (the investigated area is shown in the frame)

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</table>

Fig. 2. The geological map of Jasb area; showing the geological setting and lithological units of the Jasb volcanic suite as a part of geological map of Kahak sheet No.6158 (GSI-scale: 1:100000)
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Seismotectonic kabir koooh fault, zagros

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Abstract
folded belt and thrust of zagros is an active structure which sets the present border between the Arabic plate at the south and west of the central Iran continent at North East. The folded Zagros basin (south of Pole-Dokhtar) includes a thick sequence of sediments from the Jurassic to the Pliocene periods which the compressional deformation along the NE-SW bearing has caused its folding and faulting. The general alignment of the corrugations is NW-SE. This folded assemblage has been cut off by numerous faults. The main fault in the region as an activated structure has had the major role in the deformation of this terrance. The structure of the dextral and sinistral lateral slip faults which are positioned in the western South and Eastern south of Pole-Dokhtar respectively have a significant impact on the neotectonic movements. Kabir Kooh fault plain includes the group of dextral strike-slip faults with a bearing of North West – South West. This plain’s faults are mostly tectonically active. The Kabir Kooh fault as the most important fault of this plain having the highest level of displacement is the most known feature in this collection. The division of the deformation pattern, which usually is present in the lateral slip structures, can be observed along the bearing of this fault as strike-slip movements along the fault and dip-slip movements (thrust) at the fault terminal. The Quaternary and Neogene juvenile sediment deformation in the plain near Pole-Dokhtar can be the result of the thrust faulting at the Kabir Kooh main fault terminal. The division of the deformation at other plain faults, including mountain-front fault is detectable to the south of the eastern region.

Introduction
The folded Zagros plain as a geo-structural unit and a seismotectonic province is situated in the south west of the country in the form of a folded belt and thrust. Post-Cretaceous compressional deformations have lead to the formation of the structural condition of the folded Zagros in the form of corrugations and faulting. These deformations are still extant at the present. The lateral-slip faulting has happened in a large area of the southern plain of the Pole-Dokhtar. The main Kabir Kooh fault as an activated structure inside the basin controls the deformation patterns. The structure of the dextral and sinistral lateral-slip faults plays an important role in the tectonic movements. The dextral lateral-slip faults which affect a significant portion of the surveyed region, are juvenile phenomena and understanding and identifying the activity and the features produced by them is of significant importance in identifying and understanding the neotectonic and seismotectonic structures. In this article, we discuss the structural characteristics of the strike-slip faults in Kabir Kooh. Also, the drift change in the lateral-slip fault terminal will be investigated and introduced as a factor explaining their mechanism of change.
The Geological Position of the Surveyed Terrane

Zagros folded belt and thrust with a post-Cretaceous age is an active structure. The surveyed area which is situated at the south of Pole-Dokhtar is demarcated in the north by Maleh-Kooh anticline, and in the south and west by Ilam Province (the city of Dare-Shahr), and in the east by Khuzestan Province. This region included a thick sequence of the Jurassic-Pliocene sediments which was formed after the orogenic movements of the middle Seymarain (??), i.e. at the time of the marine closing of the neothyrs. This sedimentary sequence is placed on the older layers as a disconformity. The region is covered with Mesozoic and Tertiary sedimentary units. The thickness of these sedimentary units at some areas amounts to 3000 meters. The post-Miocene compressional deformation has been the cause of extensive corrugation of the North West - South East to East West. A balanced cross section with the length of 100 km with a North West- South East bearing shows a 30 percent shortening via corrugation. 20 percent of the calculated shortening is due to the pure compressional component at a bearing of 045 N degrees and the other 10 percent is due to the pure dextral component at a bearing of 110N degrees for the East.

The convergence rate for a 6-million year period is about 1-1.2 cm/year. This convergence rate is equal with the relative motion of the 2.7 on the Iran-Arabic plate. The present 2700 meter height of the Pliocene sediments to the south west of Pole-Dokhtar also indicates an uplift equal to 0.45-0.65 mm/year which shows the crust accretion is the result of the convergence of the Iran-Arabia blocks. In general, the aforementioned region has a bearing of 145 degrees N. The general alignment of the corrugations in this folded assemblage is cut off by numerous faults which can be divided into two groups. The first group consists of the basement faults which were active during the sedimentation and played a crucial role in the face change in the rock units and sedimentary gaps (breaks). This group of the faults which are widespread in the south western part of the area and include three faults with a general drift (trend) of north west – south east. These faults have been active in the recent orogenic phases, and with a reversal of the mechanism, have caused a thrust faulting and corrugation with a northward slope.

The second group includes faults which were activated during the Alpine orogenic phase and act as strike-slip faults and are active at the present and have an important role in the neotectonic movements. This group can further be divided into two subgroups: The first subgroup includes the system of the dextral lateral-slip faults with a NNW-SSE drift which are present at the eastern and central area (around Dare-Shahr). The second group consists of the system of sinistral lateral-slip faults with a NE-SW drift (trend) which are present at the western area. These two groups of strike-slip faults are part of the region’s main fault system (Mountain-Front Fault) which are formed under the Riddle (??) arrangement. The evidence shows that the presence of the Kabir Kooh fault as an activated system at the boundary of the basin controls the deformation pattern.

1. The system of the strike-slip and thrust faults (f1):

Mountain front fault (MFF) limits the Zagros simple folded belt and the Eocene-Oligocene outcrops to the south and south west. MFF is a buried, fragmental, thrust radical lateral-slip fault with important structural, topographic, geomorphologic, and seismotectonic characteristics. It is important to note that in places where thick sequences of the Gachsaran
Miocene evaporations have precipitated (settled), no Eocene-Oligocene formation outcrops or Mesozoic rocks to the south west of this radical topographic-morphological feature on the front slope of Zagros have been observed. From the erosion of the uplifted mountains of Zagros (the simple folded belt and the raised Zagros) in the north east of MFF, destructive material has been produced which has settled in the frontal slope region of Zagros in the south west of MFF. The slumping of the frontal slope of Zagros and the Dezful depression together with the accretion of the Post-sediments (the Neogene vaporizations in Gachsaran and the mollase simultaneous with the orogenesis in Aghajari-Bakhtiari) provides some evidence regarding the relative movement along MFF and the Dezful fault slumping during the early Miocene. The geological evidence based on the current location of the upper Eocene-Oligocene which has been collected from stratigraphical, seismic, and borehole information, demonstrates a vertical displacement of more than one kilometer along this thrust. Because of the vertical movement along MFF, the southern edge of the simple folded belt of Zagros, especially along the lower MFF, has uplifted and the asymmetrical frontal surface corrugations have been placed on it.

Additionally, some evidence has been provided by the terraces produced by the burrowing river system. The Karoun river terraces have reached observable heights above the current level of the river flow. The major factor causing the observable burrowing and the change in the river curvature and the slope produced by Karoun and the other major rivers which pass through the rock-bed structures, is the reverse active movements and the uplifting along MFF. MFF is a combination of the assemblage of discontinuous thrust blocks with the length of between 15 to 115 km and the total length of 1350 km in Iran. Fault blocks in depth together with the asymmetrical folds adjacent to them are separated from each other by gaps and steps in the surface topographical and morphotectonic features. These fault blocks form two expansive arcs in Fars (south east of Zagros) and Lorestan (North West of Zagros) and are arranged as in a covering left and right stepping en echelon to the east and west of these two arcs respectively. Because the majority of the observed frontal asymmetrical surface folds which bury (hide) the blocks adjacent to MFF have a length of less than 115 km, are not prone to the creation of large earthquakes (M =8).

MFF is a radical topographic feature which is characterized by a 500 meter contour line on the surface in the east by the Kazeroon-Borazjan reverse fault in the Fars Province and in the west by Kabir Kooh in the Lorestan Province. MFF continues the 1000 meter contour line to the south of the Bakhtiari heights (to the north of the Dezful depression) between the active Kazeroon-Borazjan fault towards the east and the Kabir Kooh anticline in the west. MFF often forms large topographic steps and follows the reverse and sheared amplitudes to the south west of the asymmetrical anticlines on the south west edge of the Zagros simple folded belt. The core of these anticlines is revealed by this same fault. MFF has been dextrally displaced for 140 km by the transverse and active fault of Kazeroon-Borazjan. This displacement has changed the height of the surface outcrops for about 500 meters (500 meters eastward and 1000 meters westward towards the active strike-slip Kazeroon-Borazjan fault). Surveying the masroseismic areas with the earthquakes having the magnitude of medium to large along the different MFF blocks shows that the surveyed earthquakes have been concentrated in the successive fractures of folds on the surface. This means that earthquakes whose sources (origins) are near the gaps or spacings of the basal faults along different MFF
blocks control these sequences and folds. For example, we can mention the following earthquakes: ……

Apparently, the source of these ruptures is near the gaps and spacings; That is, the hypocenter and the ruptures originate from the proximity of the gaps and spreads from there. In general, the depth mechanism of earthquakes along MFF shows a thrust fault with nodal planes almost parallel to the region’s geological structures and MFF. The mechanism in the nodal planes correspond with the north-south and north east-south west drift (trend) and the MFF slope which have been calculated based on morphotectonic and structural data. Block lengths become shorter from the north west to the south west respectively. Each fault block at south east end has bent towards a fault plane with a bearing of NNW-SSE and expands into the mountain range. Therefore the block between the two ranges of Jologir and Mazhin bends towards a fault plane near the south east of the Seimareh plain. A narrow and longitudinal basin with a bearing of NW-SE which separates Dareh-Shahr from the Maleh-Kooh mountain ranges is called the Dareh-Shahr – Maleh-Kooh lineation. This basin is almost parallel to the main Kabir Kooh fault and indicates a radical basement rock structure (of the normal fault type), which is clearly visible on the aerial geophysical maps.

2. The System of Transverse Strike-Slip Faults

The corrugations of the Kabir Kooh mountain range have been cut off and displaced by a post-Alpine fault system. These lateral-slip faults are called the diagonal fault system which basically consists of dextral faults with a bearing of NNW-SSE and sinistral faults with a bearing of NE-SW and are accompanied by peripheral E-W thrusts at some points.

The NNW-SSE dextral faults with an average bearing of 40 N degrees north are situated in the Eastern parts of Kabir Kooh and can be seen individually or in the form of fault plains with a length of about 120 km and in the south east terminal bend toward the Jologir-Mazhin (east) lineation. This characteristic can express the structural dependence of these faults on the aforementioned fundamental elements. The flexure of these faults in the south east terminal toward east causes a change in their mechanism from strike-slip to thrust. The function of these faults causes a displacement in the in the corrugations in an expansive plain. The most important among these faults in terms of length and the amount of displacement, are located at the Pole-Dokhtar – Dareshahr plain which both in terms of structure and seismicity are among the major elements of the folded Zagros range. The Pole-Dokhtar – Andimeshk fault plain is located at a region with a width of 70 km with a north west – south east drift to the north of Andimeshk up to the south of Pole-Dokhtar. The length of this plain in Iran is about 65 km. This plain consists of about 7 strike-slip dextral faults which with a bearing of north – north west are parallel to each other and cause the displacement of the fold axis.

This plain’s faults which were activated after or almost at the same time as the corrugation, have displaced the western block in comparison with the east, for about 29 km toward north west. Falcon (??) (1935), too, using a north west-south east narrow and long syncline, at the core of which the Ilam formation has been preserved, calculated this plain’s displacement as being 21 km. Therefore, if we consider the time of the faulting to be 45 million years ago, the average displacement rate in this plain would be 2-5 mm a year and the highest level of displacement has happened along the alignment of the region’s major fault and at about 7 to 8 km.
The deformation pattern in the strike-slip faults and the formation of a thrust at the fault terminal.

The Kabir Kooh fault is one of the most important faults in the Pole-Dokhtar plain. The length of this fault is about 150 km. This fault’s alignment is visible as a quite clear lineation on satellite and aerial images and photos. The Kabir Kooh fault has cut off many streams and ridges along its path. As a result of the Seimareh earthquake, all the length of this fault has been affected by failure. This failure hasn’t show a clear sign of strike-slip movement and only the north eastern part has been affected by stand-up in comparison with the south west. The southern end of the Kabir Kooh fault in the Abdanan plain has not continued in a straight line and it seems as if it has changed its path toward the south east. This change in direction causes a change in mechanism from strike-slip to thrust and vice versa. This kind of fault terminal, is a necessary consequence of the strike-slip faults which can clearly be seen in other lateral-slip systems including in the eastern parts of Iran. In the majority of the cases, these faults exist as buried thrusts. The displacement of the thrust faults which branch out from the strike-slip faults, is reduced with an increase in distance, for example, a thrust can be mentioned that branches out from the northern F2 dextral fault terminal toward the north west.

The elevation and tilt of the Neogene sediments at the end of the F2 fault can be connected to the function of the thrust that has branched out from it. This elevation and tilt creates peripheral basins among the structural reliefs. Also another branched fault could exist at the continuation of the F2 fault toward the south, that is, at a place where new sediments have been affected by tilting and folding again. The presence of some branched thrust faults can express a longitudinal growth in the lateral-slip fault with the passing of time. Considering the role of the lateral-slip intracontinental faults at the convergent location which one of them is a division of the oblique convergence to the lateral-slip and thrust components, the presence of these structures in this part of the active F3 belt is not considered improbable.

The macroseismic plain of the aftershocks exactly corresponds with the location of thrust faults. This issue explains this point that the occurrence of these earthquakes is related to a movement along the thrust or buried thrust faults. The possibility of the occurrence of a deformation as a lateral-slip and thrust faulting in the terminal exists in the other faults of the Seymareh plain. The F3 plain is another major fault in the Seymareh plain which is located to the east of the F2 fault. This fault has also cut off a large part of the Seymareh plain but has a smaller displacement in comparison with the F2 fault. The F4 fault with a length of more than 21 km is positioned at a distance of 2 km from the surveyed region and shows a thrust mechanism with a listric plane and the historical Seymareh earthquake has been attributed to this fault.

The juvenile and present-day activity of the faults in the Seymareh plain, given the structural and morphological reasons and also the occurrence of numerous earthquakes, is definite. The important point is that this activity is neotectonic which knowing and understanding it shows a high level of significance. In this case, the continuation of the studies seems necessary in order to help with gaining a more exact knowledge of the details and the functioning modes of these structures.
Conclusion
The Seymareh (Pole-Dokhtar) plain is an active fault plain with special neotectonic and seismotectonic characteristics. The evidence shows that a main part of the major faults in this region are active and have a high seimogenic potential. The division pattern of the deformation along these faults, like other similar lateral-slip systems, is in the form of a strike-slip movement along the fault and thrust at the fault terminals. The study and investigation of the deformation of the new sediments and the accompanying geomorphological phenomena, clarifies the patterns and factors related to the deformations. The presence of deformation in the Neogene and Quaternary sediments of the Seymareh plain, indicates that the activity of the thrust fault in the major strike-slip fault terminals. It is possible that thrusts exist under a deformed sedimentary covering in a buried form. Thrusts like these, as we have noticed in other parts of the country especially in the south east of Iran show a great potential in seismicity. Correctly understanding the characteristics, the mechanism of activity and the functioning mode of these active structures depends on the exact and complete knowledge we can gain about them and is of paramount im.

References
### Characteristics of the major faults in the surveyed range

<table>
<thead>
<tr>
<th>Row</th>
<th>Fault name</th>
<th>Fault length</th>
<th>The nearest distance to the surveyed region</th>
<th>Maximum Seismicity Magnitude</th>
<th>Mechanism</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>F1</td>
<td>150</td>
<td>15</td>
<td>6.8</td>
<td>Reverse fault</td>
</tr>
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<td>F2</td>
<td>8</td>
<td>8</td>
<td>4.2</td>
<td>Thrust fault</td>
</tr>
<tr>
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<td>F3</td>
<td>12</td>
<td>7</td>
<td>3.8</td>
<td>Thrust fault</td>
</tr>
<tr>
<td>4</td>
<td>F4</td>
<td>21</td>
<td>2</td>
<td>6.7</td>
<td>Reverse fault</td>
</tr>
</tbody>
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**Pictures of the big landslide in Seymareh**

**The major fault in Kabir Kooh**
Pole-dokhtar landslide; implication one of the most complex and greatest landslid in world

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Abstract
The study of area is a portion of folded – zagros zone which geomorphologically position located in middle zagros in south pole – dokhtar city . in lorestan province . In vestigation in area to indicate amega failure at north limb kabir kohrang. This phenomeno to called seymareh landslide by learned persons. in the area a portion of north limb of kabirkuh which to be formed of: Ilam , sarvak and pabedeh . Gourpi formation ( meso zoic ) and Asmari-shahbazan formation by various and mrgent of stress ( earthquake ) . Geology and topography in the area with average, 15km width and 8 km Length and 300 meters thickness displacement at 20 km and settle mpper adjaceat area.

Key words: seymareh, landslide, kabir–koh–range, pole- dokhtar.

Introduction
Scientific and complete landslide phenomenon in today world from different sights is important.
Landslide is the slides of the earth of the site of gradient or falling amass of stone or combination of stone and soil (shariaty afari 1375).
Also the landslides shows that an order of the phenomenon originally in the name of mass movement (moves that depends on the mass) they are mentioned different.
Factors the same as specialty of geology (lithology, rate of aeration structural and earthquake) the hydrology conditions, topography situations.
Morphology and climate is effecting to stability of a gradient and can cause landslide. (Shoaei & anyeli et al. ahzyomian 1998-2004 )
The phenomenon landslide in the south west of Iran has been much and it can be mentioned in siyahkuh.
Dena, Oushtorankuh, kabirkuh and mongeshtkuh (Izeh) can be mentioned because of their famous and back ground. ( Sayar pour and ghobadi 1378 )
One of the ancient and important of this phenomenon is big landslide of seymareh (with the width) of 64 miles that it has been happen in the south west of pole dokhtar.
This earthquake has not been as big as other areas and also in comparing with other landslides of Pamir, Alp, and Middle East is very marvelous. The biggest anticlines of zagros the same as kabirkuh because of folded and the crash of sheet Arabic and Iranian with the rate of cm/year (Alavi-1991).

With the process of north west – south east in the extensive area from west to west of Iran it has been progress red.

The instability of tectonics at this area, and the existing of asmari lime with the high slope and situation of it on the unstable sheets and enormous of gap and sutures that is very suitable for landslide and many of blocks landslides in the height area of kabirkuh (especially in the area of seymareh pool and the dareshshahr area) in the formed asmari has been fallen. Because of the big landslide seymareh the big sheet of asmari maker with the length of fourteen km. and the width of 300 m from the limb of kabirkuh has been separated and has moved to the slope of the mountain. (Ghazban 1385).

Also the sheet vibration in the asmari lime with high slope in the south of Daveshare has been happened by the estimating about 800m$^3$ from the asmari lime has been flown in the seymareh valley and only a catastrophe move or mere speed is able to move the same volume of big stones to a for distance (Watson & Wright 1969).

The material scope this landslide at first was known as moron (demorgan 1895).

But after evaluating the original of these sedimentation was observed (Falcon & Harrison 1938) (Harrison & falcon 1937).

- The geology and clay-wall area for study:

the area that is used for study between the east length 47 degree and 37 minutes till 47 degree and 47 minutes and 33 degree till 33 degree and 3 minutes north at the distance of about 5 km south of pole–dokhtar with the approximate 300 km$^2$ with maximum length 20 km and maximum 15 km the seymareh river is going through it has been situated (figure 1).

This area with name has been mentioned the pole-dokhtar landslide is called to a total broken stones that is because of vibration north limb kabirkuh that has been fallen on maker gachsaran.

Because of geological that studying area is at the point zagross folded with big anticline and big syncline they are arranged. With the 150 till 250 km in the north–west and south–east has been situated. (Darvishzadeh 1380, Aghanabzti 1383)

So that it from south and west south to chenaran anticline and the chenaran mahore and gachsaran and from west to plates between cham- mehr point and is limited. The formed lithology landslide is originally performed kabirkuh and for this reason for considering the landslide is necessary.

The clay–wall column kabirkuh and sedimentation 2 a group is divided resistance.

Asmari lime makers and bangestone that has a very landslide potential resistance exits and makers pabdeh. gourpi shills and garu unit as an un resistance and flexible can be named. the performed makers with the area of studying are the same as: sarvak, Ilam, gourpi, pabdeh, amiran, talehzang, kashkan, asmari, shahbazan, and Aghajari ( Mac lead 1970, Darvishzadeh, Aghanabzti 1383 ).
Sarvak maker is extensive and with high width in the south area is limited for kabirkuh, anticline and it’s appearance is on the shale makers and its upper maker is on the mania lime Ilam.

This maker has shown itself from the other makers and it has folded at the longest anticline kabirkuh has been seen. The Ilam maker obviously can be separated from sarvak at south and west south landslide and at the limb of the kabirkuh.

In the pole-dokhtar landslide there is no any evident of this maker. Geography formation north lake kabirkuh is same as a tribune.

At the time of landslide the gourpi system has been affected but because of erosion signs. It has not been seen at landslide earthquake this maker has not been seen at kabirkuh and instead of it pabedeh is obviated the Kashkan formation is located at the alongside of Kashkan river and it is formed from conglomerate stone, sands, silt and red stone. At the area of study especially the landslide of pole-dokhtar there is no any sign from broken stones. And there is not any sign from the Kashkan systems. The formation of pabedeh at kabirkuh has some appearance, but at the anticline halekhuh and Chenaran, there is not any appearance and buy the amiran makers.

Talezang and Kashgan. It has been replaced the formation Shahbazan at kabirkuh and also the anticline of kabirkuh has been shown at this situation. And the pole-dokhtar particles error moistly has been found at this place.

And at the north of Seymareh river and at the of the landslide, the original parts and broken stones enable found the main broken parts same as cubic square or cubic rectangular the size of stones is a bout some centimeters till 10 meters and from some grams till hundred of tones.

In the raining season, that the level of underground landslide water is coming up some of this hole is fuelled with water and the water remains at them until the first dry season (Alimardani 1380).

It is necessary to be mentioned that the pole-dokhtar landslide is located under the jaydar plain.

That the depth of them has been found by drilling of the water holes. In some places that the depth of landslide is few and the maker Gachsaran is located under of it the symptoms of landslide and pressure is on it.

Landslides obviously are one of the main geomorphic processes that lead to slope rarest.

How are as has been noted by idea and okunishi (1983).

The geomorphic significance of landslide or the average rate of denudation has most been evaluated because they occur irregularly and discontinuously in time and space. In spite of this, landslides researches can reasonably estimate the volumes of most individual large landslides and they know that landslides triggered by major earthquakes or volcanic activity can denude and hundreds or even thousands of square kilometers of earth surface. For example, keepers (1994). Has modeled the long-term sediment production of earthquake – triggered landslides for 12 seismically active regions. His modeling indicated that rates of sediment production by earth quake induced landslides have been very high (200m^3/km^2/yr).

In four of the studied regions. Less is known a bout rate of recession of natural Slopes that are affected by many smaller landslides acting over larger areas. Particularly those caused by heavy rainfall. Modeling methods for expected slope retreat have been offered by Mitchell.
and bubezel (1980). And methods for expected slope retreat have been offered. Slope retreat due to landslide actively from that due to erosion and other factors.

Such studies of landslide – caused slope recession are presented in tables 1 it must be remembered that it is difficult to separate slope recession.

By noticing to the map of landslides extensive map of lorestan province. The most concentration of earthquakes is in the North – and East north and south and west – south are situated.

The south and west – south portion of lorestan province the area affected by mega – failure of kabirkuh the seymareh earthquake with more probability. They are caused by the mega–failure in kabirkuh. This Earthquake in kabirkuh is one of the biggest earthquakes of Zagross Mountains.

This earthquake has fallen at the sefidghaleh village at the 2 km distance and also from the earthquake total with the distance 1.5km from the limb north kabirkuh. That the rate of landslide of it is about 1.5km and it is area is about 1.5 kilometer square. The broken stones and parts of it are confirmed from an asmarı, shahbazan and with the maker aghajary evaporation has been a rounded and by fact it is on the landslide.

It is necessary to be mentioned that the distance between ghalehsefid landslide and total sefied with wave action serving as the primary trigger landslide, activity is the main process in the retreat of coastal cliffs.

The most common landslides types in the failure of coastal cliffs are rock–and sail fall slides and alvalanches.

However, topples and flows also occur occasionally many examples of coastal cliff retreat have been documented in the literature table 2 presents several of the best- documented.

Examples in terms of quantitative measurement of retreat, with values being given in meters prayer of cliff recession. The mount of retreat is based primarily on the type of geologic material from which the cliff is composed and the strength of wave action the values in table a range from approximately is composed and the strength of wave action. The values in table arrange from approximately zero to thousands m/yr.

With the low values generally being for cliffs compassed of resistant rock and the higher values for chefs formed of very soft rock or soils (mostly glacial drift).

landslide kalegah – this landslide is about 3.5km in the south of kale village that it is about 21km long and with of 2.5 km and about 20km. landslide darehshahr 3 and 12km in the west of landslide darehshahr 2 with approximate 52.5 km . and maximum moving medium 3.5 km inside the limb north kabirkuh , on the maker Ilam gourpi and pabedeh has been fallen and the substance of its combining particles are made of lime, stone. The lake of darehshahr: this lake is one of the biggest and longest lakes that there has been happen Pole-dokhtar landslide. The long of it is about 40km and it's with medium is about 6km.

That there is about 4 islands in it. This lake from East is to heloush and from west to talk hob is connected and from the south by the north kabirkuh limb and from the north by the organization of gachsaran is rounded. The water of this lake is from river seymareh .
Conclusion
By noticing the statement the results are as bellow:
in the area of kabirkuh study, there has been happen about 9 landslide and the most important of them is the landslides of pole-dokhtar.
That is the biggest and complicated block landslide that has been known in the world.
The entire landslide has been happen of the long side of mega-failure of kabirkuh and it is movement and it has been caused with the help of reasons geological topography is very big accident.
Because of this pole-dokhtar landslide many lacked about separating from each other has been formed.
So that, they are linked to each other so that, all of them can be named seymareh big lake and also there are eleventh pole of pole-dokhtar that they are remaining from this big lake.

References
Landsat Image of seymareh landslide

Geological map
Rock falls in jaidar plain