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Determination of mineral chemistry, temperature-pressure gaugeand depth of emplacement of granitoid magmas in the Ardestan region

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Abstract

Felsic intrusions in the studied area are post Eocene and this region is located in the northeast of the Esfahan province. This area belongs to Uremia - daughter magmatic belt in Central Iran. Composition of Felsic intrusions are granodiorite and tonalite. The main minerals include: quartz, plagioclase, alkali feldspar and ferromagnesian minerals are amphibole are biotite. Most of ferromagnesian minerals alterated to chlorite and epidote. On the base of geochemical studies, granitoids are ranging from sub-alkaline, meta aluminous, magnesium series and I-type igneous rocks .Mineral chemistry study shows that rock formation pressure between 1 and3 plagioclase-amphibole minerals Kylubar budhcouple the rmome terand the temperature of700to 750° C for the bulk of the show. Felsic magma are generated partial melting of crustal protoliths and mantle-derived basaltic magmas emplaced into the lower crust. These felsic intrusions rocks have mineralogical field and geochemical characteristics typical of volcanic arc granites related to an active continental margin. Probably, the Ardestan granitoids are the result of the subduction of neo- Tethyan oceanic plate below the Lutmicrocontinent and this oceanic residual plate during Mesozoic to Cenozoic time. Dehydration of subducted oceanic crust and partial melting of mantle wedge caused partial melting of sub continental lithosphere, which resulted in the formation of metasomatized and enriched mafic arc magmas, and led to the formation of the Ardestan granitoid. These rocks enriched of LILE such as Rb, Ba, K, Ce and depletion of HFSE such as Y, Nb and Zr. REES chondrite normalized patterns indicate moderate to high enriched LREEs [(La/Yb)N= (1.27-18.22)] and a relatively depleted of HREEs [(Gd/Yb)N=)1/02-3/32)] with Eu Negative anomalies [Eu/Eu*= (9.55-9.57)].

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Introduction

Most granitoids of significant volume occur in areas where the continental crust has been thickened by orogeny, either continental arc subduction or collision of sialic masses. Many types of granite, however, may post date the thickening event by tens of millions of years. Geological map of the study area rectangle 1: 100,000 is Ardestan. In the region, in the north-east of Isfahan. The geographical range of lengths 30 o 52, 52 o and 30 033 and 00 033 northern latitudes. Tehran, Bandar Abbas, the main road connecting the area with the rest of the way. In order to achieve geological outcrop area can pave the way for the Eastern District Ardestan- Nain, Isfahan Ardestan- in Central, South and Ardestan- Zafargand- Zefreh in Natanz in the northern part of the region. Many of the roads are dirt roads branching makes possible the access to the entire area (Fig. 1).

Crystal chemistry and chemical properties of minerals important information about us the applicability of this information complements the microscopic features of mineral properties will be Hence, considerable ability minerals such as plagioclase, pyroxene and characterization of magmatic masses is considered. Used Zhadeitstandards for sodium, calcium wollastonite, alkali feldspar, potassium and aluminum, Enstatite formagnesium, iron and manganese Faialit for apatite is for phosphorus.

Plagioclase composition depends on the primary magma. Since feldspar have higher amounts of elements K, Na, Al, Ca and mineral crystallization takes place at different depths. The high ratio of Ca / Al Anorthite the formation of plagioclase with more and more deep.

Amphibole in igneous rocks are abundant and their frequency is due to crystallographic sites for all major cations so that they can be easily removed from the magma, there hornblende igneous rocks reflecting the depth of the magma Katazunal with plenty of water with moderate water and magma and magma Mzuzunal Zunal epithelium consists of a minimum amount of water. So there magmas amphibole relatively low average water is considered magmas epithelial Zunal and mzuzunal . Chapel and White (1974) I and S are the origin of granitic rocks CaO contents are higher in type I and lead to the crystallization of hornblende. The purpose of this article is to help the results of the analysis of minerals to determine the peak pressure and temperature at the time of Tblirsng be addressed.

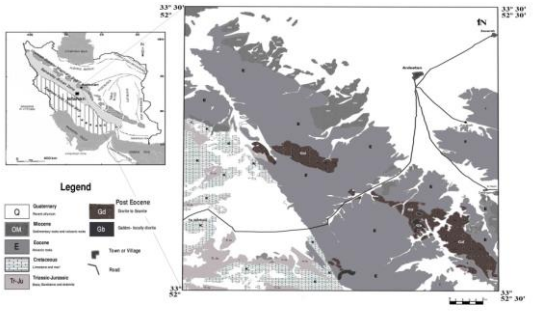


Fig. 1. Geological map of the study area (adapted from Radfar, 1998 with changes).

Materials and methods

The area under study

The general trend in the granitoid intrusions Ardestan, NW-SE and generally follow the main trends in the area of the fracture. Many of these masses of sedimentary and volcanic rocks are cut by Eocene (Imam, 1981). So when magma injection should be given after the Eocene age 16-19 million years, this time also is consistent with geological evidence (Darvish Zadeh, 1992). Intrusive rocks in the direction of the pole basic composition (gabbro) to pole acid (granite) swing (Pilgrims, 2007). The extension to monzodiorite diorite intrusive rocks in the rock that is part of the mountains in the East Village Jvgnd Marbyn- Solomon Heights Dovarjin Abad village in the south and southwest of the fault Marbyn- Gnyan Rangan up area .mass monzodiorite about 50-52 square kilometers (Radfar, 1997). Also in the north and south of the village Avanjan Bideshk, Shahin Shahr and Meymeh village and part of the mountain Jougand, small and large masses of granitic rocks of granodiorite is seen that grainy texture to

Micro pegmatite graphics and the minerals quartz, alkali feldspar, plagioclase, biotite and amphibole (hornblende type) with secondary minerals apatite and titanite are formed. Enclaves in small and large masses of diorite in abundance in different parts of the region are sparse and moderately acidic (same source).

Ardestan in some areas, the granitoid masses of copper minerals malachite and azurite visible. By proceeding tectnomagma other porphiri copper mineralization zone of urmia - daughter magmatic belt metal mineralization associated with igneous rocks is very high.

Sampling and analysis

During field visits parts of un altered granite, 135 rock samples were taken and then Thyh 90 thin sections and study them with a microscope Polarizing, studied chemistry of minerals with 80 spot analysis of minerals in the rock studied in laboratory research center for processing minerals were Karaj, Iran. (Analysis of relevant tables is provided)

Result and discussion

Petrography

Composition of intrusive rocks ardestan using modal analysis, granodiorite totonalite to granodiorite. The main minerals include quartz, potassic feldspar, plagioclase, and amphibole types and biotite is ferromagnesian minerals. The mostim port anttissues, including granular texture, Puyiis Klitik and mirmikit. Itis generally coarse-grained rocks in hands pecimen and color ful coefficient proportional to the abundance of mafic mineralsis variable.

Mineral chemistry

EPMA analysis of plagioclase in the intrusive ardestan was 40 points. Plagioclase composition depends on the initial magma The results in Figure Ab-An-Or (Deer and Howie, 1991) also represents a type of feldspar is plagioclase in the intrusive ardestan oligoclase to and esine and rich component within the rangeofits internals anidine with rich component are.

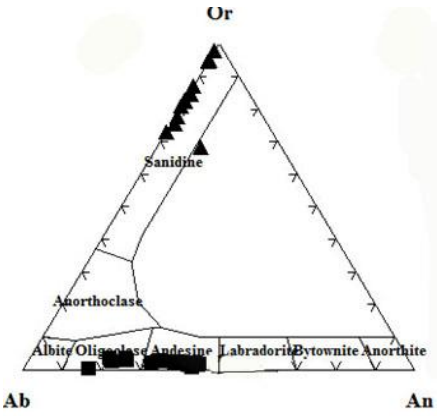
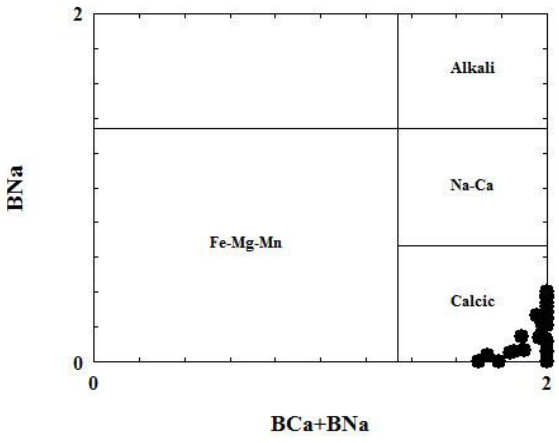


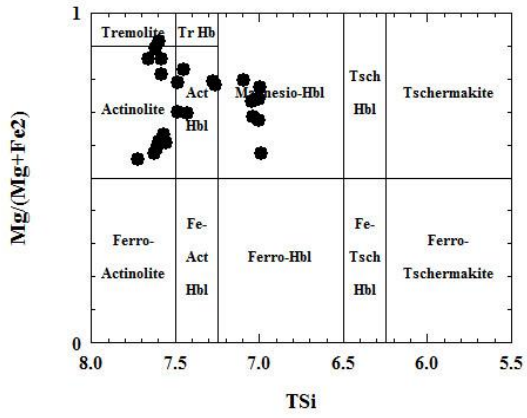
Fig. 2. Classification of feldspars (Deer and Howie, 1991).

All these amphibole classification according to Lake *et al.*, In calcic amphiboles are calcic amphiboles in the opinion of many researchers in granitoid rocks represent the dependence of the I-type granitoids rocks in combination amphibole granitoids of magnesian hornblende to actinolite alteration that has been changed in agreement with petrographic studies. Amphibole active role in the igneous crystallization and melting processes are within the composition of the liquid remaining in control. As a measure of the physicochemical conditions of magma systems are-

According to the classification of plutonic amphibole ardestan Lake *et al* in calcic amphiboles are intrusive. Calcic amphibole, amphibole Monoklinik which the (Na + Ca) B> 1and Na B <0.5 usually Ca B>1.5, which represents the dependence of the I-type granitoids rocks.



(A)



(B)

Fig. 3. A. Diagram BNa - Bca + BNa, B. Chart of the total content of Mg + Fe + 2(TSi) Si (Lake *et al.*, 1997).

Geo thermobarometry amphibole

Best amphibole minerals for Temperature-Pressure Hy-alkaline igneous rocks, because almost all intrusive manner-regardless of alkaline compounds, basic, intermediate and acid crystallizes. This mineral is also a wide range of pressure-temperature from1 to 23 kilobars and is stab leat temperatures of 400to 1150° C and (Stein, Ditl, 2001).

The manometric amphibole

Amphibole granitoid widely used to estimate the pressure and the replacement of granitoid massesare (Hamrstram, 1986 and Schmidt, 1999).Methods for determining the depth and pressure influence on the mass of the Alamphibole, because the amount of All indirect connection with the adoption of the masses. The Al content in amphibole is greater than the calculated value will be higher. It should be noted that the pressure crystallization in granitic rocks tightly controls the amount of this element.

Inallo the methods' of estimating

The pressure on Anderson and Schmidt (1992) only the amount of aluminum in hornblende and regardless of other parameters such as temperature can be calculated. Mentioned above and apply more pressure measurement values obtained at low pressure, sometimes less) and negative (pressure error rate formula of pressure polls.

Use the diagram on the parameters of the Al total Fe*/(Mg + Fe*) is designed (Schmidt, 1999) can be seen that amphiboles granitoides the study area range from 1 to 3 kilobars pressure crystallized.

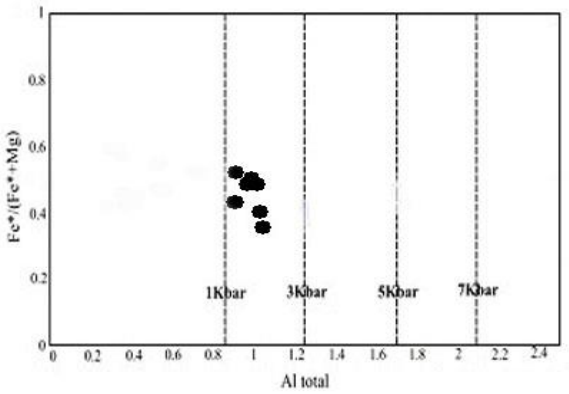


Fig. 4. Graphs the parameters of the Al total Fe*/(Mg + Fe*) indicates that the formation of the granitoid masses.

Temperature fields survey amphibole

Using the diagram proposed by Johnson and Rutherford (1989) and Schmidt (1992) amphibole formation temperatures can be achieved in granitoid rocks. According to this chart, mineral formation temperature of 700° C is estimated to be.

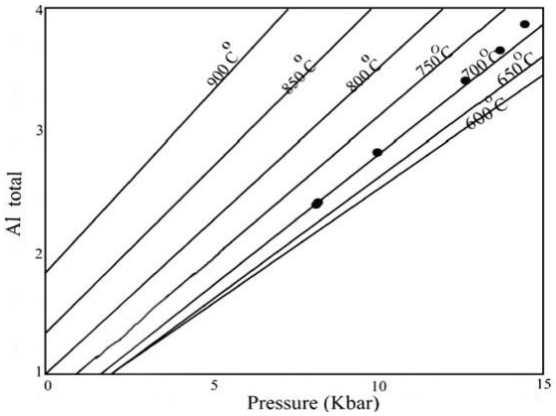


Fig. 5. Graphs kilobars pressure according to Al total, amphibole formation temperature of about 700° C granitoid rocks.

Ground temperature measurement pair Plagioclase-mineral hornblende

The thermometer couple of hornblende-plagioclase no consensus among researchers, but one of the most common methods for thermometry in igneous rocks are calc) blonde and Helland, 1990, Stein and Ditl, 2001). There are three methods for mineral thermometry the coupleare:

Method blonde and Helland (1990)

Blonde and Helland on the reaction adenitis-tremolite, plagioclase the rmometry-Hurnblnd have proposed the following relationship. Thermometerin felsic and intermediate igneous rocks containing quartz, plagioclase, with 0/92>An and amphibole with pfu 0/02 0/6 <Si <7/8, NaA>and pfu 1/8 AlVI<applications and for temperatures between 500 to 1100° Cis used. It shoulde noted that this methods should contain plagioclase zoning requirements. Therefore only used when no zoning plagioclase and the amphibole that the manometric temperature have to be quite friendly.

T [±311° K] = 0.677 P [Kbar] – 48.98 + YAb/0.0429 – 0.0083144 Ln (Si -4)/ (8-Si)XAbPlag

The relationship between the equilibrium temperature T in K, P pressure on kilobars, Si silicon cations in the structural formula of amphibole, Xab Plag proportion of plagioclase is albite. Yab the following equationsare obtained.

XAb> 0.5, YAb = 0
XAb< 0.5, YAb= 8.06 + 25.5 (1- XAb)2
The temperature of formation of the granitoid 750°C.

Method Vynhal et al (1991)

Vynhal and also the relationship between the pressure and fugacity1-20 Kilubar HM-QFM for hornblend essym biotice quilibrium temperature of plagioclas epresented.
T=654.9+25.3*P

According to this formula granitoid formation temperature of 757° Cisthe temperature obtained by the method of blonde and Helland (1990) close.

Determine the tectono-magmatic setting using amphibole

The geochemical characteristics of different magmatic amphibole Check tectono especially subduction environments (subduction) and the plate (intraplate), the amphiboles related to subduction (S-Amph) Na2O and TiO2 lower than the range of pages (I-Amph)are graph classification based on tectono-magmatic setting) Schmidt, 1992).Amphiboles range of amphiboles (I-Amph) are.

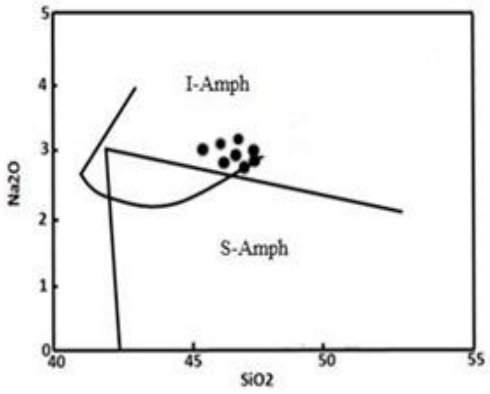


Fig. 6. Classification diagram tectono-magmatic setting amphibole (Schmidt, 1992).

Conclusion

The data obtained from the analysis of minerals ingranitoid samples in the region, information on(EPMA) amphibole and plagioclase feldspar alkaline mineral chemistry electron Ryzkav provided by the parser. Using diagrams and mathematical relationships, mineral chemistry was determined. Based on the results obtained in the granitoid rocks oligocelase plagioclase to andesine and alkaline feldspars Sandidn within or outside of the rich component are located. Calcic amphibole in scope and that the alteration of hornblende mansion actinote have become.

The presence of calcic amphibole rocks in dependence on the type granitoids rocks was, I magma that

formed as a result of orogenic phase. According thermometry granitoid rocks of the study area in the temperature range 700 to 750 ° C and a pressure of 1 to 3 kilobars formed.

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