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

Mohsen Akbari Moghaddam[1],Nematollah Rashidnejad Omran[2],Rahim Dabiri[1],Mitra Ghaffari[1]

1: Department of geology, Faculty of sciences, Islamic Azad University of Mashhad Beanch

2: Department of geology, Faculty of sciences, Tarbiat Modares University

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 Siahkoh) 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 aplitic dikes with considerable thickness are occurred in the margins of plutonic rocks and exploiting as industrial soils. Granitoid plutons have calc alkaline, meta aluminous, 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).

Granitoid rocks of NW Kashan city occur in the volcano-plutonic and Cu- bearing belt of Iran (Stocklin, 1967; Darvishzadeh, 1991; Moinvaziri, 1998; Nowgol, 1985; Berberian; 1981).

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 $\boldsymbol{f}\,H_2O$ 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 SiO_2 range from 57 to 76 wt %. The ranges of other major elements are shown in table 1. MME have Al_2O_3, CaO and Na_2O values higher than that of the host rocks. Moreover, values of SiO_2, Na_2O and K_2O increase towards the inner part of the pluton, while, Al_2O_3, CaO, MgO and FeO^t 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, TiO_2, Al_2O_3 and P_2O_5 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- P_2O5, Th-Zr, Th- U, K_2O- 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 microporphyry; 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 pridotitic mantle source. It seems that the plutonic suite of the area had generated from partial melting of amphibolite- eclogite 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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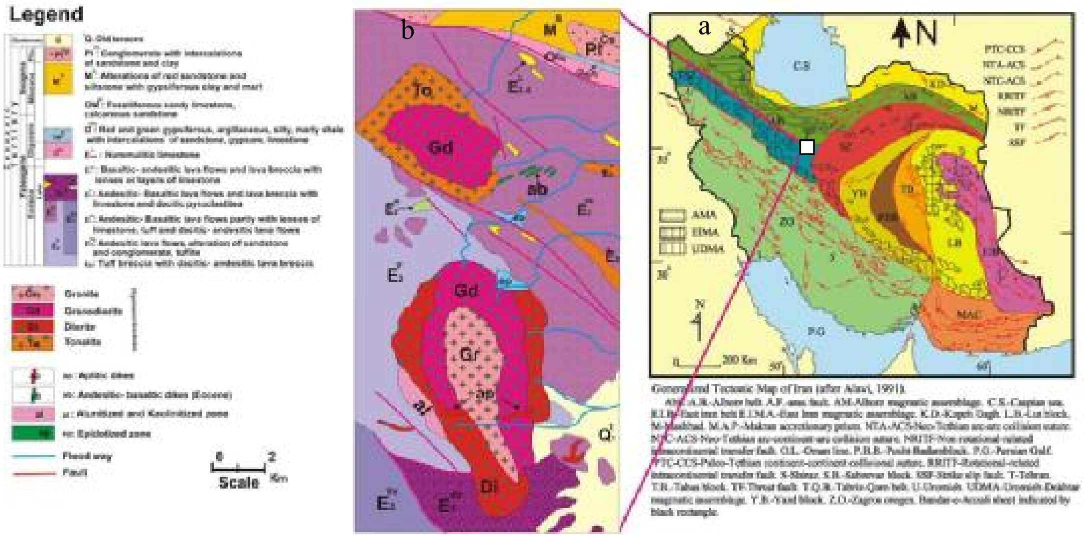

Fig.1. (a) Geo tectonic map of Iran (after Alavi, 1991) and (b) geological map of the study area.

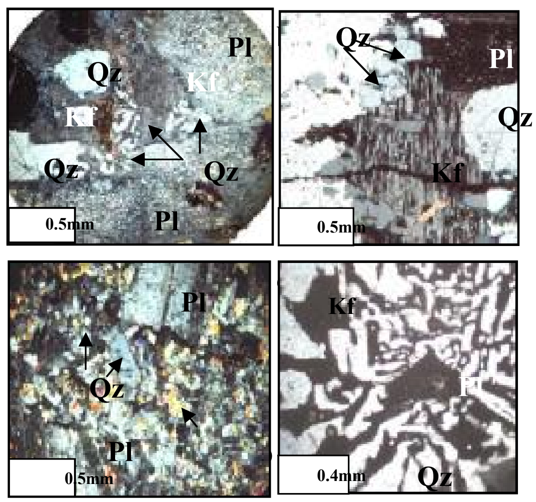

Fig. 2. Microphotographs of granitoid and related rocks,
a) granophyric texture in granites,
b) perthite in granodiorite,
c) porphyritic texture in tonalite and
d) graphic texture in granodiorite,

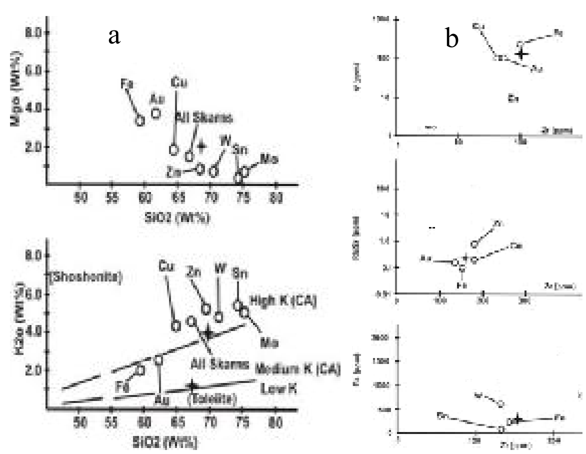

Fig.3. a) Harker type diagram of MgO vs. SiO2 and K2O vs. SiO2, Classification of alkaline (A), calc-alkaline (CA) and tholeitic (Th) nature of plutons of NW Kashan (stars show mean value), open circles indicate the average values for different ore deposits (Meinert, 1995). Amounts of K2O in the Leucogranites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