INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 2, p. 439-446, 2015

RESEARCH PAPER OPEN ACCESS

Petrogenetic interpretation of Cu hosted Eocene volcanic rocks in southwest of Ardestan, East of Isfahan

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Key words: Beroni Village, Andesite volcanic rocks, Calc-alkaline, Active continental margin, Hydrothermal alteration, Southwest Ardestan.

Article published on February 09, 2015

Abstract

In the present study, study areas the part of Urumieh- Dokhtar volcanic belt. The main of rocks in this area are Eocene volcanic rocks consist of lava and pyroclastic rocks, with andesite and andesite basalt composition. These rocks are the most important cu-hosting ones in thisareaand have aporphyritic texture, cavity, flow, cellular foam, glomeroporphyritic, poikilitic and spherulitic textures, and in handy specimens are generally fine grained to fine to medium grained. From mineralogical perspective, these rocks include pyroxene, plagioclase, biotite, quartz and amphibole as well as secondary minerals such as epidote, chlorite, calcite and metal ores. These rocks are not immune from alteration and in some parts of very high intensity of alteration due to hydrothermal conditions being seen. Important of alteration kinds in this area are 2 groups consist of chlorite- epidote- calcite and silicate- sericite alteration that focused at andesitic lava and generation by hydrothermal solutions. On the base of minor and trace element geochemical data on diagrams, observations of minerals, rocks and geochemistry indicate that primary magma of volcanic rocks in the area was sub-alkaline, calc-alkaline series. Also the diagrams of the tectonic characteristics show that these rocks were generated in an active continental margin volcanic arc and it is thought that are affected by the subduction. Diagrams of trace elements in volcanic rocks normalized with chondrite and primitive mantle show that enriched of the light rare earths related to heavy rare earth element probably indicates a derivation from the metasomatic mantle.

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Introduction

Volcanism is the phenomenon of eruption of molten rock (magma) onto the surface of the Earth, where lava, pyroclastics and volcanic gases erupt through a break in the surface called a vent. It includes all phenomena resulting from and causing magma within the crust or mantle of the body to rise through the crust and form volcanic rocks on the surface.

In the present study, the analyzed region is in the south and southeast of Beroni, a village which is fourteen kilometers away from southwest of Ardestan in the east of Isfahan. This region is in the structural zone of central Iran and is regarded as a surrounding belt of sub-continent of central Iran (Aghanabati, 2007). Adestran is an interesting zone for the researchers due to its igneous rocks and distinctive petrologic and economic conditions. From geological perspective, Ardestan has volcanic and penetrative rocks of oligocene and Eocene eras (Darvishzade, 1992; Moinvaziri, 1997). From lithologic perspective, the surficial rocks of the analyzed region as shown in Fig. 1 include river terraces and quartz depositions to the present era, sets of Eocene volcanic rocks with a variation of andesite and gray andesite basalt lavas, acidic and pyroclastic volcanic rocks, and tuff originating fromEoceneera (Eftekharnejad, 1981; Radfar, 1998).

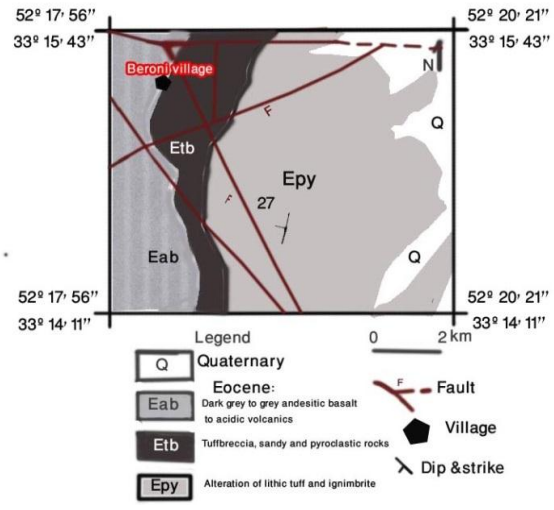

Fig. 1. Geological map of analyzed area (Eftekharnejad, 1981; Radfar, 1998).

This region is a zone of copper mineralization. The oxidative copper mineralization is in the form of malachite with silica and carbonate veinlets which cut across the andesite lava rocks from different directions. The aim of this study is analyses the geochemical, petrographic and alteration changes of volcanic rocks of southwest Ardestan as a representative of the zone.

Material and methods

Geological setting

This region is a zone of copper mineralization. The oxidative copper mineralization is in the form of malachite with silica and carbonate veinlets which cut across the andesite lava rocks from different directions. In the present study, the authors endeavor to analyze the geochemical, petrographic and alteration changes of volcanic rocks of southwest Ardestan as a representative of the zone.

Result and discussions

Petrography

The igneous rocks of the analyzed region are generally composed of Eocene volcanic rocks. A major proportion of the volcanic rocks of the region are pyroclastic rocks such as tuff. The other volcanic rocks of the zone include lava sets such as andesite, andesite basalt and highly alternated lava sets. From morphological perspective, the analyzed region consists of low-altitude hills with relatively aerated surficial rocks. The pyroclastic rocks compose a significant part of volcanic rocks of the region. The main minerals of litic tuff consist of quartz with cro-gene gulf texture. Quartz and plagioclase exist in the texture as small-sized crystals. The texture of these rocks is clastic. The most important secondary minerals are epidote, calcite and sericite as well as opaque minerals (see Fig. 2). In the analyzed region, the crystal tuff has more prevalence than other surficial rocks. In microscopic cross-sections, the main minerals include feldspars such as plagioclase; alkali feldspars and quartz (see Fig. 3). Sometimes, the main texture of rocks is made of microlytic porphyria and cryptocrystalline. The volcanic lava

rocks in the analyzed region has less prevalence compared pyroclastic sets but due to their hydrothermal alterations and secondary copper mineralization, these rocks are more significant from alteration, economic and geological perspectives. The lava volcanic rocks are divided into andesite and andesite-basalt types based on their level of pyroxene. The andesite-basalts of the region are less prevalent in comparison with andesite rocks and their primary mineral is plagioclase (see Fig. 4). The other minerals of such rocks are calcite, iron oxides and opaque minerals. The texture of these rocks is mostly intersertal. Andesites often possess different macro-crystal sets. These rocks are more prevalent than andesite basalts. Their primary minerals are composed of plagioclase and pyroxene and other minerals are calcite and opaque minerals (see Fig. 5. The rock textures are flow-microlytic porphyria and hyalopilitic. Of secondary minerals, one could point to sericite, epidote, calcite and chlorite.

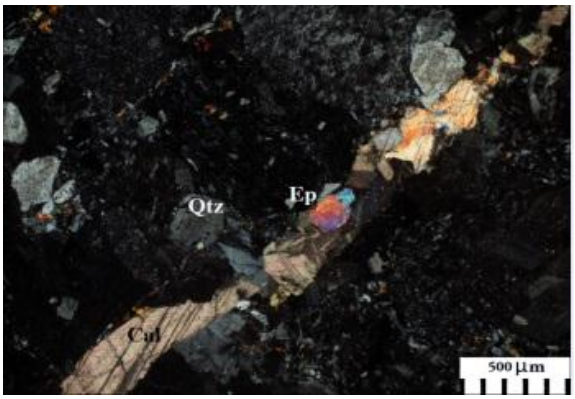

Fig. 2. A sample of litic tuff.

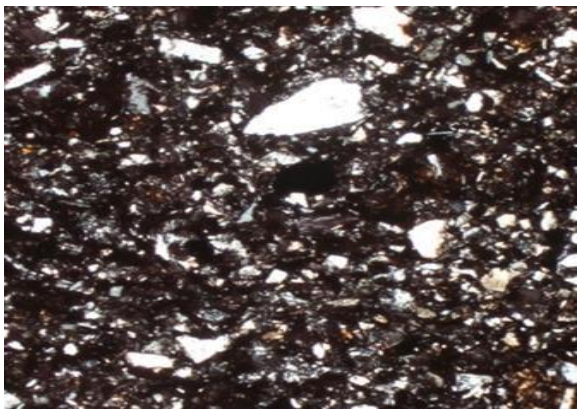

Fig. 3. A sample of crystal tuff.

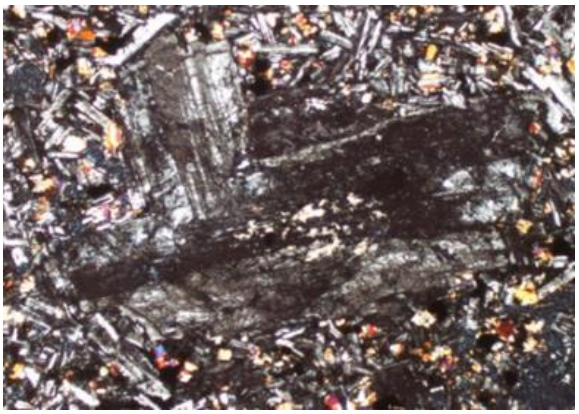

Fig. 4. A sample of andesite basalt.

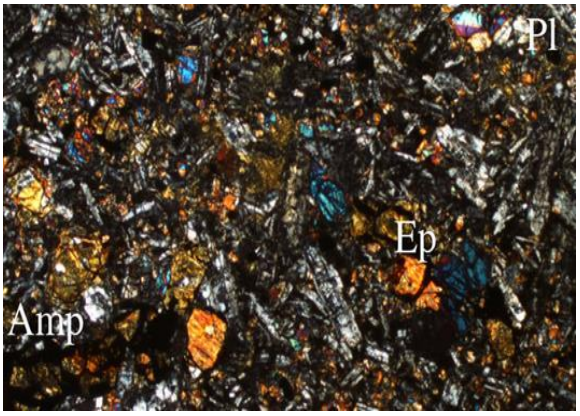

Fig. 5. A sample of andesite.

Geochemistry

In this section, the data of chemical analysis of rare elements and analysis of these diagrams are used to understand the lava changes during crystallization and differentiation. In this regard, different diagrams were used to categorize and name the volcanic rocks of the region which showed that the volcanic rocks of the region are mostly composed of andesite. The altered samples range from ryolite to dacite and ryodacite. The following fig. is an instance of diagrams provided by Le Bas, Harris and Tindle (1986).

Determination of Magmatic Series of Volcanic Rocks

To determine the magmatic nature of igneous rocks, different diagrams have been provided some of which will be introduced in the following. In a diagram of Na^2O+K^2O versus SiO^2 (Irvine and Baragar, 1971), the samples are in a sub-alkaline range (see Fig. 7). As

shown in triangular AFM diagram (Irvine et.al, 1971), the samples are in calc-alkaline range (see Fig. 8).

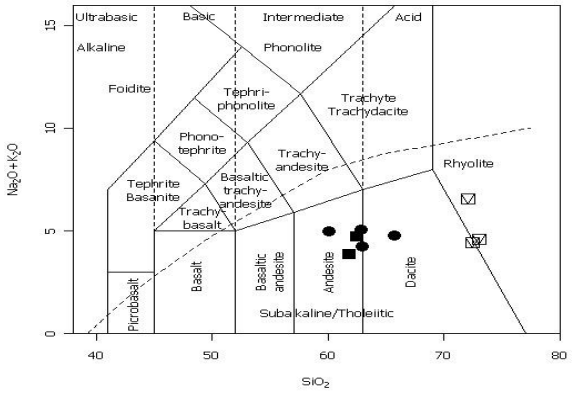

Fig. 6. Geochemical categorization and naming based on plot of alkali set versus silica.

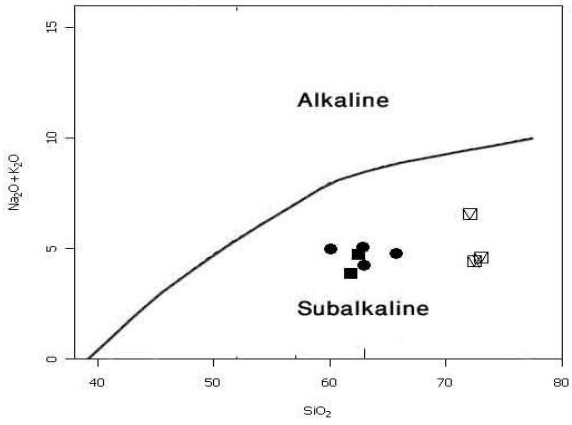

Fig. 7. A diagram of Na^2O+K^2O versus SiO^2 (Irvine et.al, 1971).

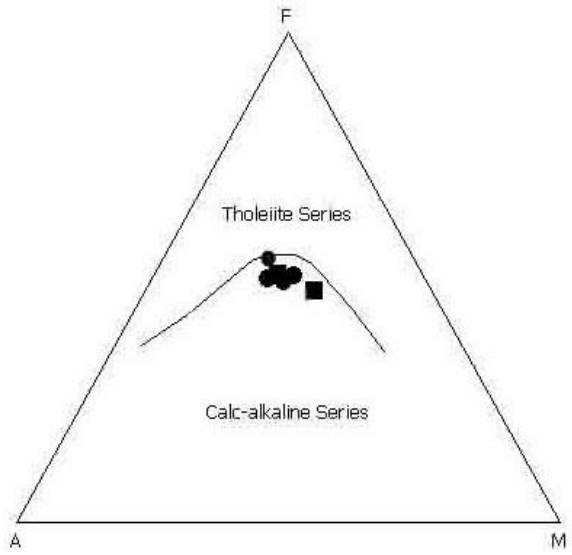

Fig. 8. A diagram of triangular AFM.

Spider Diagrams

Based on geochemical data on spider diagram which was first introduced by Wood (1988), all rocks of the region are relatively linear from the viewpoint of HFSs. But LILEs are enriched up to thousand times which show significant similarity with calc-alkaline rocks of volcanic arcs and old orogenic zones.

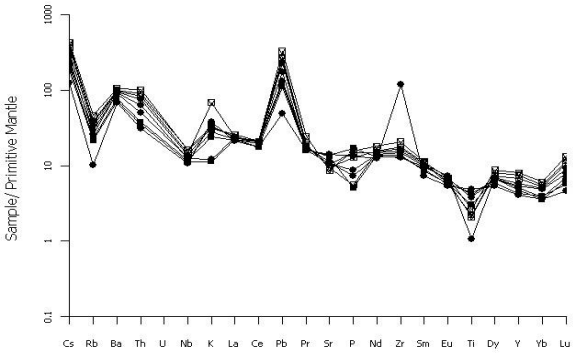

Fig. 9. Multi-element samples of volcanic rocks on spider diagram.

Determination of Tectonic Environment

To determine the tectonic environment, different diagrams are used and it is observed that the samples belong to a range of felsic igneous rocks of volcanic arcs (Pearce, 1984). As the following fig.s show, all samples are in a ranges of felsic igneous rocks of volcanic arcs (see Fig. 10).

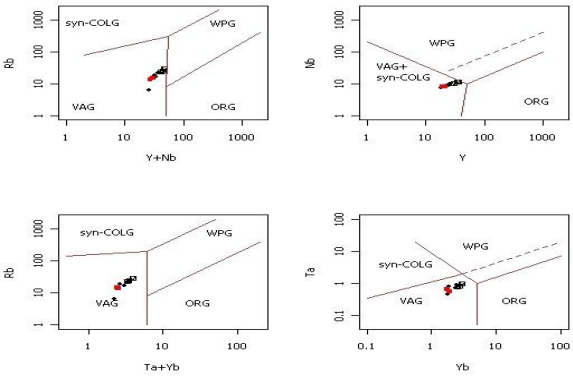

Fig. 10. Diagrams for determination of tectonic environment.

Alteration

During field studies of different parts of andesite lavas, twelve rock samples were obtained and a thin cross-section of all of them was prepared. All of these

cross-sections were analyzed through Polarizon Microscope. The andesite and andesite-basalt lavas were not as prevalent as pyroclastic rocks but they were geologically and economically significant. In the studied area and in eastern-western direction, the samples of volcanic andesite rocks were highly altered due to the motion of hydrothermal solutions. This has resulted in color change of volcanic andesite rocks ranging from green and gray to white and creamy. These altered rocks are more protruding than other rocks due to their high silicate content (see Fig. 11). The most severe type of alteration was accompanied by brighter colors and crush of stones which was distinguishable in desert due to bright yellow, red and brown colors around andesite horizons of oxidized copper (see Fig. 12). In general, two major groups of alteration including chlorite-epidote-calcite with green color and interwoven network of epidote veinlet are widespread and sparse in andesite rocks. The second group with silica-sericite minerals had a high level iron oxide which was limited to surrounding of horizon of silica alteration (Middle Most, 1991). This group gradually changes into andesite rock (see Fig. 13). The gaps and veinletsmade by alteration are filled with epidote, chlorite and calcite. The effects of malachite and azurite made by scour of copper from top parts are accompanied by alteration. In microscopic images, epidote, chlorite and calcite along with a high quantity of opaque minerals were observed which shows the invasion of hydrothermal solutions enriched with iron and magnesium (see Fig. 14). Based on microscopic studies, it was verified that the andesite lava rocks were cut by silica veins and veinlets but they were gradually substituted by micro-crystal silica aggregates so that the initial texture was not distinguishable.

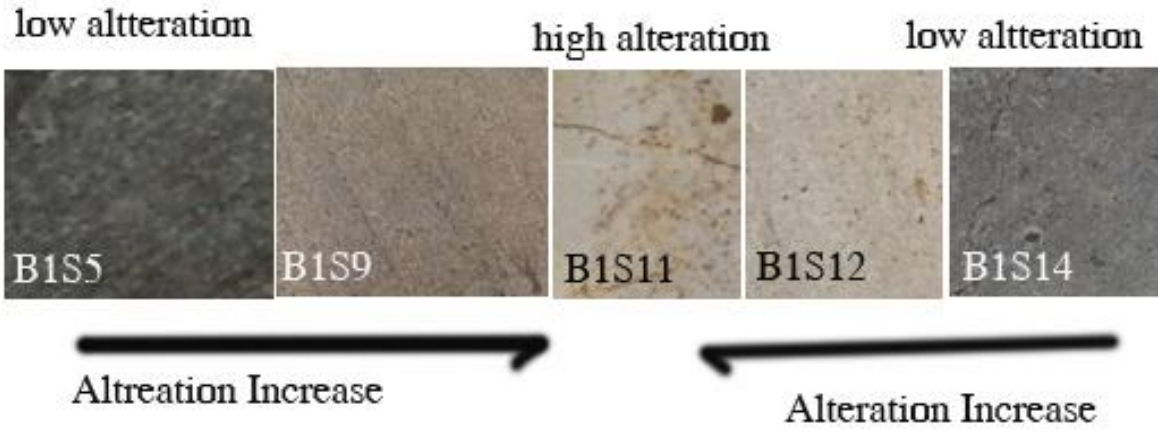

Fig. 11. Alteration intensity of surficial rocks.

Fig.12. Alteration of rock surfaces in the analyzed area.

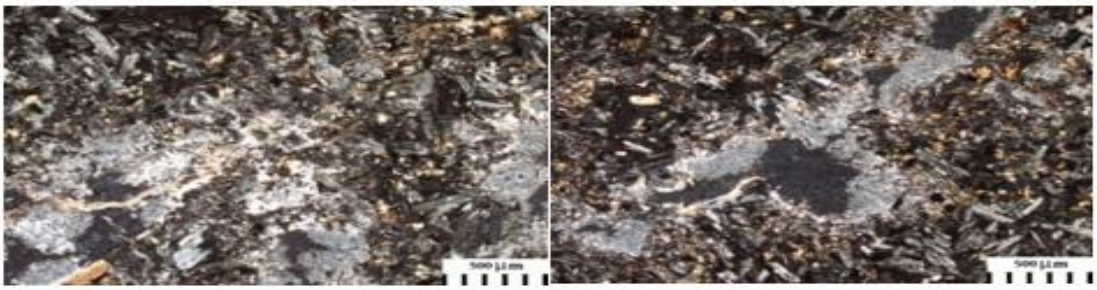

Fig. 13. Presence of micro-crystal silica veinlets in andesite rock in onset of silica horizon in microscopic view.

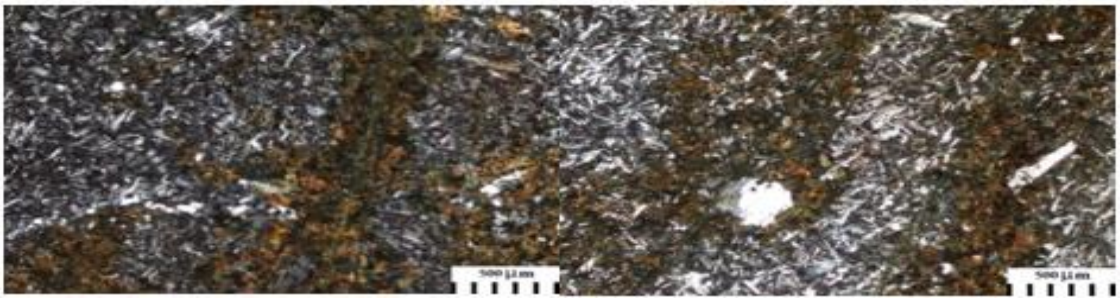

Fig. 14. Presence of veinlet networks with epidote-chlorite with concentrations of oxidized opaque minerals in andesite rocks (XPL light).

The analyzed region is made of pyroclastic volcanic and lava rocks which date back to Eocene era. Due to presence of copper mineralization,this region is economically significant. In despite of their less prevalence, the andesite lavas are more significant due to hosting copper mineralization. In andesite rocks, the alteration of chlorite-epidote-calcite is easily distinguishable due to prevalence of chlorite, epidote and calcite. This alteration is accompanied by dark green color and presence of an interwoven network of vein lets composed of epidote and chlorite which are sparsely distributed in andesite rocks of the deserts and manually collected samples (see Fig. 15). The silica-sericite alteration is accompanied by high level of silica. A high level of opaque minerals along with oxidized iron oxides were sparsely distributed in the rock which can be regarded as an equivalent of felsic alterations. This type of alteration is observable in desert and manually collected samples due to bright and red colors of rocks (see Fig. 16). This alteration set can be attributed to an epithermal alteration system.

Fig. 15. Accompaniment of malachite and azurite with chlorite-epidote-calcite alterations in desert surfaces and collected samples.

Fig. 16. Altered rock surfaces with bright and light colors in desert and altered and red-colored silica rocks in collected samples.

Conclusion

In Beroni Village, the volcanic rocks are of sub-alkaline and calc-alkaline types. As the geochemical and tectonic-magmatic diagrams show, these rocks belong to a volcanic arc with convergent or active borderlines. This is integration between and oceanic layer and a continental one. Around these borderlines, a high level of andesite and dacite magma is produced. These rocks have calco-alkaline properties. This region is a part of Urmieh-Dokhtar volcanic belt which are also called "Sahand-Bazman Volcano Chain". Based on geochemical evidence, the magma of volcanic rocks of south and southeast parts of Beroni Village is composed of mafic mantle magma and magma of continuous melting.

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