Petrography of Andesity Basalt Enclaves Associated with Scoriaceous Pyroclastic Deposits (Tephra) and Lavas of Diraklu Volcanic Cone, NE of Ghorveh

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Abstract: Volcanic cone located in the South East of Diraklu and 27 km of Ghorveh province and it is one of the volcanoes of Ghorveh-Tekab volcanic field with North West. This monogenic volcano formed by scoriaceous pyroclastic deposits and lavas and has strombolian type-like. In the scoriaceous pyroclastic deposits (Tephra) and lavas can be observe various enclaves. The main of research is investigation of petrography of enclaves, relation between host melts to enclaves and the analysis of exist microstructures in them. For performing research gathered 120 samples of enclaves, enclaves in cored bombs (or Composite) and scoriaceous pyroclastic deposits and lavas from volcanic cone. For study selected 80 No. among the gathered samples. Study of petrography indicated that additional to felsic enclaves (granitoid), which assigned majority enclaves in the under studied monogenic volcanic cone, other enclaves occur such as mafic cumulates, mantel nodules and metasomatised mantel xenoliths. Fragments of granitiods are tonalitic composition (Qtz+Pl±…), mafic cumulates are aggregates of Px±Phl±Am, and peridotitic mantel nodules are dunite. Partially influence of host melt into granitoid fragments by weak location for instance: micro-shear zones, formed micro-pool melts and generated special minerals in the vacancies and by totally formed siliceous melts or siliceous xenoliths-like melts. Influence of melts in other enclaves is very low. Based on, deformation microstructures in enclaves were grouped 4 include mylonitic granitoids, mafic cumulates, ultramylonitic peridotitic mantel nodules and mylonitic amphibole metasomatitites. Intend to several of enclaves can be presumed that mylonitic granitoid enclaves are not origin of basalitic andesite melts in the other words they are not basement. The existence of deformed peridotitic mantel nodules and amphibole metasomatitites indicate probably origins of melts are upper mantle.

Key words: Petrography, Scoriaceous lavas and pyroclastic deposits, Enclaves, Ghezelche kand, Ghorveh.

INTRODUCTION

Study of the enclaves associated with pyroclastics deposits (All crystalline, liquid crystalline nature and xenoliths) and has provided useful information to describe the processes of magma systems beneath the volcano, origin of magmatism, vertical distribution of the injection system or systems, the dynamic factors in the magma chamber and relations with the host rocks. It also helps us to identify the physical - chemical factors that done before the volcanic eruptions (Alletti et al., 2005). A number of studies done by researchers on the monogenic volcanic cone in SW of Diraklu but only have been able to identify and introduce felsic enclaves. In this study, a detailed field study conducted on the entire of cone consists of vertex and surroundings of the cone and then introduced and classified the enclaves. Mineralization and abundant of rock forming minerals were classified into four groups in these enclaves. The study cone is located in the SW of the Diraklu village and 27 kilometers NE of Ghorveh. This cone is belonging to the Ghorveh-Tekab volcanic bar with NW trending and is located in Sanandaj - Sirjan structural zone (Fig. 1).

Geology of the Ghorveh is divided into North and South parts. The study cone is located in the North parts and contains volcanic, pyroclastics and sedimentary rocks such as andesite to basalt, tuff, limestone, marl and clay rocks. Southern part of the Ghorveh, with different geology from the northern part, contains felsic and mafic intrusions with different phases of deformation (end members of magma mixing and mingling), Mixing zone and regional to dynamic metasomatised rocks. Cones have andesite basalt composition that belongs to the Quaternary and composed of the scoriaceousaceous pyroclastic deposits. Morphological study of this cone shows that it has tapered side openings and its shape is similar to the strombolian volcano (Fig. 2). From features of this volcano can be mentioned to lavas with low dispersion and different sizes of pyroclastics deposits. The most prominent features of this volcano are existing of the granitoid enclaves as a separate projectile inside of the bombs (cored or composite) and associated with lavas. Although other parts of the enclaves may be brought to the surface by one of the methods.
Research Methodology:
During the field observations, aimed to identify different types of enclaves and collected these parts with regard to changes in color, crystal size, histological changes, contact boundaries of enclaves with host molten and exist of enclaves in cored bombs (or Composite). The systematic sampling was performed on the top to down of cone, bomb enclaves (cored or Composite) and Tephra parts. The remarkable thing about many of the felsic enclaves is the influence of the host melt into them that prevents from produce thin sections from them. Total number of taken samples are 120 (including lavas, pyroclastics parts (Tephra) scoriaceous, enclaves carried by the molten and enclaves as the core of bombs). After studying the manual samples, 80 thin section preparation
and was studied with polarizing microscope. From the allocated enclaves, granitoid xenoliths are with frequency of approximately 70%, ultramafic xenoliths are with frequency of approximately 25% and metasomatic xenoliths are with frequency of approximately 5%. For studying the manual samples, at first paid attention to the scoriaceous pyroclastic deposits (Tephra), lavas and then to the enclaves.

Discussion:

Petrography of Lavas and Scoriaceous Pieces (Molten Host):

Scoriaceous pyroclastics deposits and lavas have andesite basalt combination, rich from enclaves with a gradual-porphryritic texture and glass mettle. These rocks color are seen black, gray and red tapes in terms of oxidant (oxidized bands). In down of the cone, scoriaceous are seen black and in top of them are seen respectively gray, red and gray. In the handy rocks can be seen the mica and pyroxene crystals, fragments of enclaves and alien crystals such as quartz and plagioclase. From the biggest crystals can be cited to pyroxene (augite and diopside) with an average size 1.2 μm, amphibole (brown hornblende) with a mean size 980 mm and mica with a mean size 1.9 mm. These minerals are different species and microstructures. mettle is in the glass form which can be seen pyroxene, amphibole, apatite and opaque minerals in it. Intensity of cavities based on the scattering and the volume divided to low, medium and large. Cavities with high intensity are in the inner parts of lavas and are diminished to the outside (Colo et al., 2010) (Fig. 3, A - D). Of alien crystals in these rocks can be mentioned to half-round to rounded single crystals of quartz with average size 750 μm and the reactive margins. Plagioclase (based on the light properties such as maximum angles are oligoclase to andesine type) is another type of alien crystals with an average size 880 μm, dissolution margins and granitoid (tonalitic) source that are scattered in the nature (Fig. 3, E and F, Fig. 4, A and B). Mingling and mixing glass clot is observed in the mettle of these rocks. Mixing glass clots have glass texture and mingling clots have aphyric texture and lower dispersion (Fig. 4, C - F).

![Fig. 3: A-D) the scoriaceous vesicles (pore size) and alien quartz crystal, D and E) alien quartz crystal with the inner and outer dissolution margins (the red Chinese) with growth of pyroxene in both margins. Pyroxene (Px), Amphibole (Am) and phlogopite (Phl). (A, C and E in XPL light), (B, D and F in PPL light).](image-url)
Fig. 4: Microscopic image of the alien plagioclase crystals, A and B microstructures of dissolution and Gulf margins and melt clots, C and D: Mixing glass clots, E and F: mingling clots with aphyric texture. (A, C and E in XPL light), (B, D and F in PPL light).

**Petrography of Enclaves in the Lavas and Scoriaceous Pieces (Host Melt):**

Based on petrographic studies such as volume percentage of rock forming minerals and post Magmatic microstructures, enclaves were classified into four different groups. These four groups included mylonitic granitoids, accumulation of ultramafic ultramylonit peridotite of mantle nodules and multimylonit amphibole.

**Petrography of Mylonitic Granitoids Xenoliths:**

The volume percentage of quartz, plagioclase (major minerals), biotite (dark minerals), titanit, apatite and opaque minerals (secondary minerals) shows that these are tonalitic type. These xenoliths with the angular to spherical shape and more than 70% frequency are the main components in the lavas. Scoriaceous pyroclastic deposits have the size of several microns to less than a meter. These xenoliths are seen within the bombs as cored (Sottili et al., 2010). Evidence of ductile deformation such as sigma ($\sigma$) type of cover porphyroclasts, quartz bands and strain cover can be inferred that these pieces were probably part of the tonalitic intrusion which the dynamic stresses influences in it. The simple and conjugate cover porphiroclast microstructures and quartz bands suggests a moderate to high levels of mylonit (Fig. 5, A - C). In other words, these pieces are given from the deeper parts to the surface. From the most prominent reaction microstructures with the host melt can be noted to mirmicite and semi mirmicite structures (Fig. 5, D). Semi mirmicites (false mirmicites) is created by substitution of the host melt in the primary mirmicites and subsequently influence of palagonit molten clots in it (Fig. 6, A and B). Immersion of these xenoliths in molten host causes the partial or complete influence of melt into them. Petrography study suggests that the influence of molten in forming minerals is especially in the
weakness zones. Melt influence in terms of partial influence created the diverse prisms of very delicate needles of orthopyroxen, zircon and opaque minerals (Bachmann et al., 2002). Prismatic crystals of needles orthopyroxen with rapidly cooled margins are result of the host molten contamination with the crust xenoliths (Chandrasekaram et al., 2000). Melt influence in terms of complete influence caused decay and tonalitic fragmentation that these decay minerals is associated with the host melt in the liquid crystalline - mettle form (liquid like siliceous xenoliths) (Corsaro et al., 2007). In the partial influence of melt, minerals have reacts margins (Fig. 6, C - F).

Fig. 5: Microscopic image of siliceous xenoliths (tonalite), deformation microstructures in cover porphyroclasts of plagioclase, A: simple, B: conjugate, C: quartz bands.D: mirmycites formed in the boundary between the melt and siliceous xenoliths. Titanit (Ttn), plagioclase (Pl) (in XPL).
Fig. 6: Microscopic image of the relationship between host melt and siliceous xenoliths (tonalite). A and B: The influence of palagonit molten clots in plagioclase and creation of semi mirmycites (false mirmycites). C and D: Melt influence in siliceous xenoliths with large size. E and F: in microsiliceous xenoliths. (A, C and E in XPL light), (B, D and F in PPL light).

-Petrography of the Ultramafic Cumulates:

These kinds of xenoliths have community of minerals such as clinopyroxene ± amphibole ± phlogopite with size of 200 μm to 1.2 mm that scattered in the scoriaceous natures. These xenoliths are seen as semi-angular to rounded shape. Based on petrographic studies can be identified two types of ultramafic cumulates. First type of xenoliths is completely formed from subhedral to euhedral clinopyroxene that based on optical characteristics is augite. Immersion of these xenoliths in the host melt caused partial or complete influence of melt into them. By full influence of host melt into these xenoliths, minerals are transferred to the surface with the melt as a decay community.

Against of the siliceous xenoliths that minerals formed in the space between the main mineralization, they were result of host melt influence and glass clots. In this type of xenoliths did not take place main mineralization and only can be noted formation of phlogopite clots in the space between formed minerals (Fig. 7, A and B). Other types of ultramafic xenoliths is composed of phlogopite ± amphibole ± clinopyroxene ± ..., that clinopyroxene is the main mineral and other minerals is formed in the space between them or on them (Fig. 7, C and D). Often clinopyroxene is seen with phlogopite (Carlson, 2005).

Fig. 7: Microscopic image of ultramafic cumulates xenoliths, A and B: clinopyroxene xenoliths and phlogopite clots. C and D: amphibole + phlogopite + clinopyroxene in ultramafic cumulates. (A and C in XPL light), (B and D in PPL light).
-Petrography of Ultramylonitic Peridotitic Mantle Nodules:

These xenoliths have very low abundance and average size 1.5 cm. They are another enclaves that carried by the molten rock. These pieces have rounded to semi rounded edges. The main constituent mineral of these parts is olivine with average size of 75 μm by round to elongated morphology that have been arrangements along the shear zones. Clinopyroxene has similar features to olivine, spinel and opaque minerals. Based on the abundance of constituent minerals in these xenoliths, they can be classified them of the spinel lherzolite peridotite to dunite rocks. Index structure of the shear zone can be cited to the deformation of round to elongated olivine crystals, dynamics recrystallization, olivine tapes and reduce the size of the olivine (more than 90 percent) (Fig. 8, A and B). In these mantle peridotite nodules, tiny vein ortopyroxens is observed in the needle and category shape. Needle ortopyroxens formed near the edge of the xenolithse and category one is in the inner part. The presence of these pyroxenes (needle and category one) is result of mafic magma ascent (Franz et al., 2002; Ishimaru et al., 2007; Bell et al., 2005) (Fig. 8. C and D). Against of the host peridotite structure with high strain, there is not found evidence of deformation in these tiny veins of ortopyroxens. In the space between the olivines are scattered very small clots of phlogopite and colorless amphibole. Around of these xenoliths is observed community of phlogopite, clinopyroxene and in some cases amphibole. These clinopyroxenes are formed in euhedral to unhedral shape with average size of 350 μm and phlogopites are formed in the surrounding of mantle nodules with size of several microns to 1.2 mm (Fig. 8, E and F). The presence of these peridotite nodules can be a waste of upper mantle partial melting and the existence of different ortopyroxens in and around of the different metasomatised xenoliths (Woodland et al., 2004; Nedli et al., 2010). Although, for further and closer study is required to the EMPA device to explore the variety of olivine, pyroxene, phlogopite and amphibole.

Fig. 8: Microscopic image of ultramylonitic peridotitic mantel xenoliths, A and B: olivine tapes, deformation olivine and clinopyroxenes. C and D: ortopyroxens community. E and F: elongated olivine, ortopyroxens composed during the second deformation fase and phlogopite in the mantel nodule margin. Olivine (Ol). (A, C and E in XPL light), (B, D and F in PPL light).
-Petrography of Mylonitic Amphibole Metasomatites:
This group is most complicated xenoliths in the study cone. The main creator minerals of this type of xenoliths are colorless amphibole, low spinel and opaque minerals. From amphibole characteristic can be mentioned to unusual feature of amphiboles (false shape) and phenomena related to deformation. Amphiboles obtain from advanced deformation has been replaced by spinel peridotite. Integration of the amphiboles in the study xenoliths suggests that the samples are single crystal. In other words, deformation of spinel peridotite is rich from olivine, spinel and opaque minerals that they have been replaced by deformation amphiboles before metasomatites. In some cases can be seen few remains of olivine. As a result of dynamic stresses can be identified two-phase of ductile deformation in these xenoliths. During the first phase, special microstructures of shear zones is observed with moderate to high strain such as spin of deformed coating porphyroclast (deformed amphiboles) from sigma (σ) type and sub-grain and emerging phenomenon (Trouw et al., 2010; Achenbach et al., 2011). The hand of this cutting shear is right. During the second phase, the shear zones have been twice deformed xenoliths that before deformation (Fig. 9, A - D). This shear zones in some cases are seen parallel and in others cases are cross. In the created shear zone spaces, during the second phase can be seen categories of ortopyroxen. The cutting angle of these phases is almost 35° to 75°.

Fig. 9: Microscopic image of mylonitic amphibole metasomatites. A and B: deformation of olivines by amphibole, C and D: porphyroclasts of opaque minerals during the different deformation phases. Opaque (Op), (A and C in XPL light), (B and D in PPL light).

The monogenic volcanic cone of the study area with lateral explosive openings has emerged from pyroclastics deposits with very high abundance and distribution. The stories have lower abundance and distribution than pyroclastic deposits. Fragments of the enclaves that associated with lavas and pyroclastics deposits have been brought to the surface. Siliceous xenoliths, ultramafic cumulates, ultramylocnitic peridotitic mantel nodules and mylonitic peridotitic mantel nodules show a different origin. The presence of spinel lerzolite peridotite to dunite xenoliths has been presumptions that the origin of basaltic anesite may be associated with the partial melting of these rocks. The plastic deformation of these xenoliths shows that they composed in the upper mantle. After formation of melt by partial melting of peridotite rocks and climbed, other rock fragments with different nature are associated with it. Fragments of mylonitic metasomatites amphiboles are a kind of xenoliths that have been formed metasomatites amphiboles and several phases of deformation before associated with melt. The extent of first deformation phase in these xenoliths is identical with siliceous deformation (or granitoid). Accordingly, the shear zone is affected the part of the upper mantle and lower crust. Second phase in these xenoliths have an extent region that shows the local and weaknesses of tensions. Presence of the tiny vein ortopyroxens in the mantle nodules and metasomatised peridotite have been suggests another deformation (second deformation) in the magma reservoir and then the fragments of ultramafic cumulates is
and phlogopite are seen around these xenoliths. Mylonitic metasomatites amphiboles xenoliths are other deformation. Veins of ortopyroxens in these xenoliths are free from created strain. Community of clinopyroxen dynamics recrystallization, olivine tapes and reduce the size of the olivine. Grade of strain is in high level of melting wastes. These xenoliths have deformation evidence such as round to elongated morphology of olivine, spinel lerzolite to dunite xenoliths. The presence of these xenoliths with very low frequency related to the partial xenoliths of mantle nodules are composed of olivine, clinopyroxene and spinel. These types of peridotite are clinopyroxene with amphibole and phlogopite is result of metamorphism processes in the host melt. Peridotite contamination processes. Ultramafic cumulate xenoliths are composed of phlogopite ± amphibole ± needles ortopyroxen are seen in the space between siliceous xenoliths that formed from magma that associated with minerals decay, melt components will raise to the surface as a social or individual. Crystals influence, melt material enters in the space between the main mineralization of xenoliths. In complete influence melt into the holes and weakness parts of them. Influence rates are in two shapes: partial and complete. In partial elements of the cored or Composite bombs. Immersion of these xenoliths in molten host causes influence of quartz bands and strain cover. The hand of this cutting shear is right. These xenoliths are the most important evidence of deformation are in the high strain region such as simple cover porphyroclasts, conjugate plagioclase, ultramafic, mantle peridotite nodules and metasomatised mantle enclaves. Siliceous xenoliths with clear study, these enclaves were classified into four groups. These groups included granitoids, accumulation of andesity basalt composition, composed of scoriaceous pyroclastics deposits and lavas. Based on detailed field study, these enclaves were classified into four groups. These groups included granitoids, accumulation of ultramafic, mantle peridotite nodules and metasomatised mantle enclaves. Siliceous xenoliths with clear evidence of deformation are in the high strain region such as simple cover porphyroclasts, conjugate plagioclase, quartz bands and strain cover. The hand of this cutting shear is right. These xenoliths are the most important elements of the cored or Composite bombs. Immersion of these xenoliths in molten host causes influence of melt into the holes and weakness parts of them. Influence rates are in two shapes: partial and complete. In partial influence, melt material enters in the space between the main mineralization of xenoliths. In complete influence that associated with minerals decay, melt components will raise to the surface as a social or individual. Crystals of needles ortopyroxens are seen in the space between siliceous xenoliths that formed from magma contamination processes. Ultramafic cumulate xenoliths are composed of phlogopite ± amphibole ± clinopyroxene ± and opaque minerals. Community of clinopyroxene single crystals that created pyroxene xenoliths have mantle origin and has been entered from environment into the melt. The community of clinopyroxene with amphibole and phlogopite is result of metamorphism processes in the host melt. Peridotite xenoliths of mantle nodules are composed of olivine, clinopyroxene and spinel. These types of peridotite are spinel lerzolite to dunite xenoliths. The presence of these xenoliths with very low frequency related to the partial melting wastes. These xenoliths have deformation evidence such as round to elongated morphology of olivine, dynamics recrystallization, olivine tapes and reduce the size of the olivine. Grade of strain is in high level of deformation. Veins of ortopyroxens in these xenoliths are free from created strain. Community of clinopyroxen and phlogopite are seen around these xenoliths. Mylonitic metasomatites amphiboles xenoliths are other

**Conclusion:**

The study cone is located in the SW of the Diraklu village and 27 kilometers NE of Ghorveh city. It has andesite basalt composition, composed of scoriaceous pyroclastics deposits and lavas. Based on detailed field study, these enclaves were classified into four groups. These groups included granitoids, accumulation of ultramafic, mantle peridotite nodules and metasomatised mantle enclaves. Siliceous xenoliths with clear evidence of deformation are in the high strain region such as simple cover porphyroclasts, conjugate plagioclase, quartz bands and strain cover. The hand of this cutting shear is right. These xenoliths are the most important elements of the cored or Composite bombs. Immersion of these xenoliths in molten host causes influence of melt into the holes and weakness parts of them. Influence rates are in two shapes: partial and complete. In partial influence, melt material enters in the space between the main mineralization of xenoliths. In complete influence that associated with minerals decay, melt components will raise to the surface as a social or individual. Crystals of needles ortopyroxens are seen in the space between siliceous xenoliths that formed from magma contamination processes. Ultramafic cumulate xenoliths are composed of phlogopite ± amphibole ± clinopyroxene ± and opaque minerals. Community of clinopyroxene single crystals that created pyroxene xenoliths have mantle origin and has been entered from environment into the melt. The community of clinopyroxene with amphibole and phlogopite is result of metamorphism processes in the host melt. Peridotite xenoliths of mantle nodules are composed of olivine, clinopyroxene and spinel. These types of peridotite are spinel lerzolite to dunite xenoliths. The presence of these xenoliths with very low frequency related to the partial melting wastes. These xenoliths have deformation evidence such as round to elongated morphology of olivine, dynamics recrystallization, olivine tapes and reduce the size of the olivine. Grade of strain is in high level of deformation. Veins of ortopyroxens in these xenoliths are free from created strain. Community of clinopyroxen and phlogopite are seen around these xenoliths. Mylonitic metasomatites amphiboles xenoliths are other
enclaves which are transported to the surface by melt. Integration of the amphiboles in these xenoliths show that rock before deformation was spinel peridotite.

In other words, being single crystal of peridotite samples and olivine remained from metamorphism is shown dunite peridotite. These xenoliths after amphibole metasomatites has been achieved of two deformation phase. The first phase has high extent and it is taken crust and upper mantle intrusive. This means that the microstructures in these xenoliths are consistent with siliceous one. Given the existence of mantle peridotite xenoliths, the origin of lavas and scoriaceous pyroclastic deposits can attribute to andesite basalt composition. In other words, origin of lavas and scoriaceous pyroclastics deposits is not granitoid rocks; its origin is intrusive mass that cover the magma reservoir (or reservoirs) and associated with the volcano.

REFERENCES


