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## PRIMARY FINDINGS OF ALTERATION MINERALS IN THE PERLITE DEPOSITS IN YUKARIEMIRLER (ANKARA-CENTRAL ANATOLIA): CHARACTERIZATION OF HYDROTHERMAL FLUID

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### ABSTRACT

Çubuk site is located in Ankara (Turkey) and is known for its agate which is a semi-precious mineral and is found extensively in the region. In addition to the agate minerals, the perlite quarries in the region are also operated as industrial raw materials. Perlites are products of the Middle-Miocene aged Susuz volcanic, containing rhyolite, dacite, tuff, and ignimbrite. A perlite quarry extends approximately SW-NE that is currently open pit operated for perlite raw material is located between Kuyumcu and Yukariemirler villages.

A clay formation by the effect of hydrothermal solutions was detected around a fault in the NW-SE direction in the quarry. Systematic sampling was made from the fault, and it was aimed at the characterization of clay minerals and detecting changing alteration levels according to the varying distance. The mineralogical-petrographical studies of the perlite reveal that perlitic texture "onion-skin like fractures" is the main characteristic texture and is observed in all of the studied samples. Euhedral feldspar and anhedral quartz minerals were observed in some thin-section. In addition, argillization and iron-oxidation were detected in the perlite samples. In the XRD analysis; Smectite and quartz minerals are enriched on the fault zone samples but smectite minerals are increased away from the fault. Feldspar mineral increases as further away from the fault zone. All these preliminary mineralogical and petrological information provide that the hydrothermal solution composition, which causes alteration in the quarry, was an alkaline character.

**Keywords:** Agate, Hydrothermal Alteration, Perlite, Smectite, XRD

### Introduction

The study area is located in the Çubuk district of Ankara province, the region is known for its rich agate formations and therefore there is much research on the mineralogy and characteristic properties of agates (Hatipoğlu and Dora 2000; Daşcı, 2011; Hatipoğlu et al., 2011; Bostancı, 2014). All of these agate formations developed in relation to the hydrothermal fluids associated with the extensive magmatism in the region during the Eocene to Neogene. These hydrothermal solutions produced locally argillisations related to hydrothermal alteration besides agate minerals in and around the Çubuk region. Clay mineralizations in the region; kaolinizations (kaolinite), smectitizations (montmorillonite) and illitizations. All of these alteration minerals took place by the alteration of feldspars and volcanic glass as a result of the alteration of the host rock by the upflow of the hydrothermal solution the fault and crack zones (Besbelli and Varol, 2002).



The aim of this study is to determine and characterized an argillization associated with locally occurred hydrothermal alteration in the perlites in the Mid-Miocene Susuz volcanics. Thus, we purpose to obtain initial information about the composition of the effective hydrothermal solution in the region. For this purpose, field studies, mineralogical and petrographic studies were carried out.

### **Geology of the Study Area**

In the study area, Triassic - Paleocene age rocks belonging to Sakarya Zone, Upper Cretaceous aged, ophiolite, ophiolitic melange, and sedimentary rocks belonging to İzmir-Ankara-Erzincan Zone, and Tertiary aged volcanic and sedimentary rocks forming their cover rocks are located. The Çubuk volcanics are, from bottom to top, Paleocene aged Sarıkoz volcanite, Middle Eocene aged Kurtsevri volcanics, Sele volcanics, Ömercik volcanics, It consists of Susuz volcanites, Yukarıemirler volcanics and Lower-Middle Miocene Aydos basalts (Dönmez and Akçay, 2016) (Figure 1). The volcanic rocks were grouped as tuff, acid lava and basic lava flows Meşeli, Aşağı Emirler and Dedeler regions in the Ankara-Çubuk region (Figure 1), and it was stated that there were small-scale perlite formations in the region (Suludere, 1976). Susuz volcanics consist mainly of gray, white, brown, rhyolite, dacite, tuff, ignimbrite and partly perlite (Dönmez and Akçay, 2010). In Susuz volcanics, which constitute an important element of Çubuk (Ankara) volcanics, ignimbritic flows and rhyolitic- dacitic domes are observed and these products are probably derived from the Çubuk caldera (Dönmez and Akçay, 2016). K-Ar geochronology was yielded  $43.1 \pm 1.7$  Ma age data for the Susuz volcanics and it is suggested that the age of the unit is Middle Eocene (Dönmez and Akçay, 2010). Within the unit, especially around Kapaklı village, agate, chalcedony and perlite formations are observed.

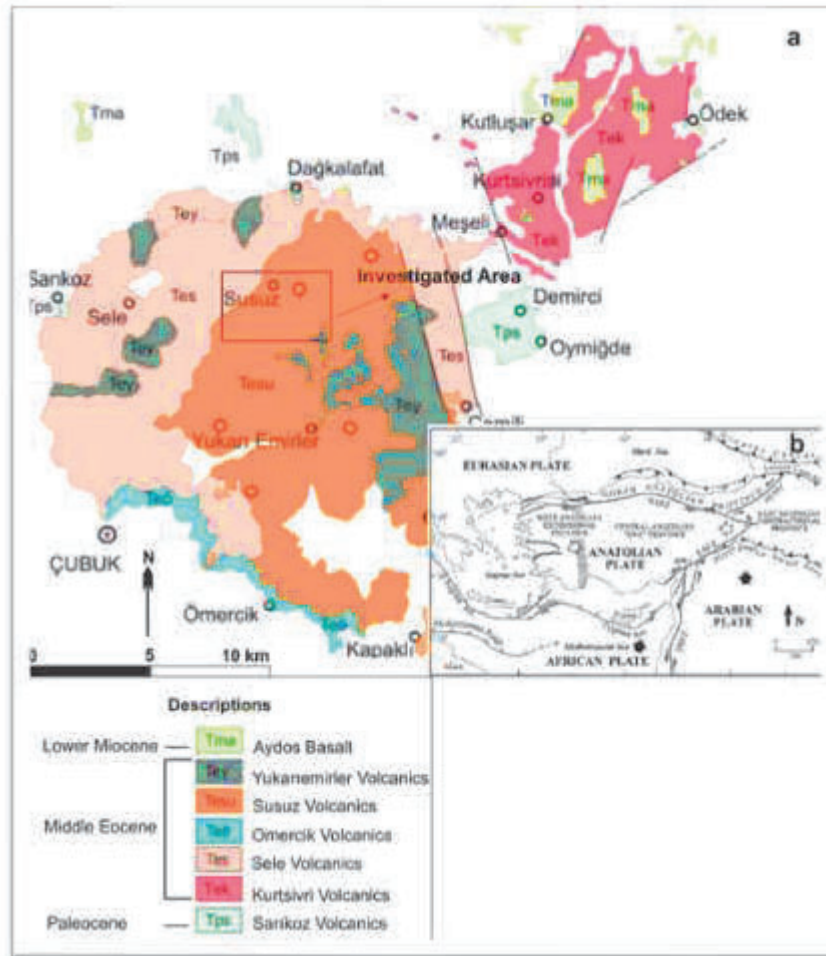


Figure 1 Geological map (Dönmez and Akçay, 2010) and (b) Location map of the investigated area on the Turkey's tectonic units diagram (Bozkurt, 2001).

## Material and Methods

Within the scope of this study, 5 thin sections were made from the most representative samples collected in the Yukarıemirler Perlite deposit from Çubuk region-Susuz volcanics. Detailed petrographic examinations (modal mineralogical composition, texture, classification, alteration) of the samples, whose thin sections were obtained at the Thin Section Laboratory of Konya Technical University, were carried out with the help of polarizing microscopy in Konya Technical University Geological Engineering Department. XRD analyses were performed at Konya Technical University, Central Research Laboratories, in GNR EUROPE 600 XRD model device, CuK $\alpha$  radiation (0.1540596 nm), 40 mA, 40 kV operating conditions, 0.005° scanning speed, 0.250 mm slit interval and 2 $\theta$  in the range of 2.0– 55.0°.

## Results

### *Lithological Characteristics of the Yukarıemirler Perlite Quarry*

Yukarıemirler perlite quarry is located between Yukarıemirler and Kuyumcu villages in Çubuk district of Ankara province and covers an area of approximately 50m x 200m. The perlites in the quarry are light gray in color and massive. The perlitic texture (onion-like structure) is quite clearly observed in the hand samples. Parallel to the general faulting in the region, an NW-SE trending fault passes through the quarry and argillization occurred around this fault. The exact center of the fault is dark gray and rich in quartz. The quartz ratio decreases as the moves away

from the fault zone and however greenish clay increases. This clay-rich zone continues approximately 50 cm away from the fault zone, and then gradually transitions to gray-colored perlite (Figures 2-3). A banded agate vein was observed along a fracture nearly perpendicular to the NW-SE fault, but no argillization was detected around this fracture (Figure 3).



Figure 2 (a) Photo showing general view of the Yukariemirler perlitite deposit, (b) Alteration zone and fault of the Yukariemirler perlitite deposits with sample numbers, and locations.



Figure 3 General and detailed view of the banded agate vein in the Yukariemirler perlitite deposit.



### *Petrography*

It has been observed that the perlite outcropping in a limited area within the Susuz volcanics are cut by local faults, and various clay minerals are formed here the effect of the hydrothermal alteration (Figures 2-3-4). The fractures resembling the appearance of onion skin are known as perlitic texture. The perlitic texture is the most observed texture in all the studied samples (Figure 5). Investigated perlites exhibit large onion skin-like texture with fine spherulitic crystals (Figure 5 a-b). Some of them contain quartz, feldspar and iron oxide minerals(Figure 5 c-d)



Figure 4 (a) Field view of the sampled area,(b) Macroscopic view of the Çubuk perlite

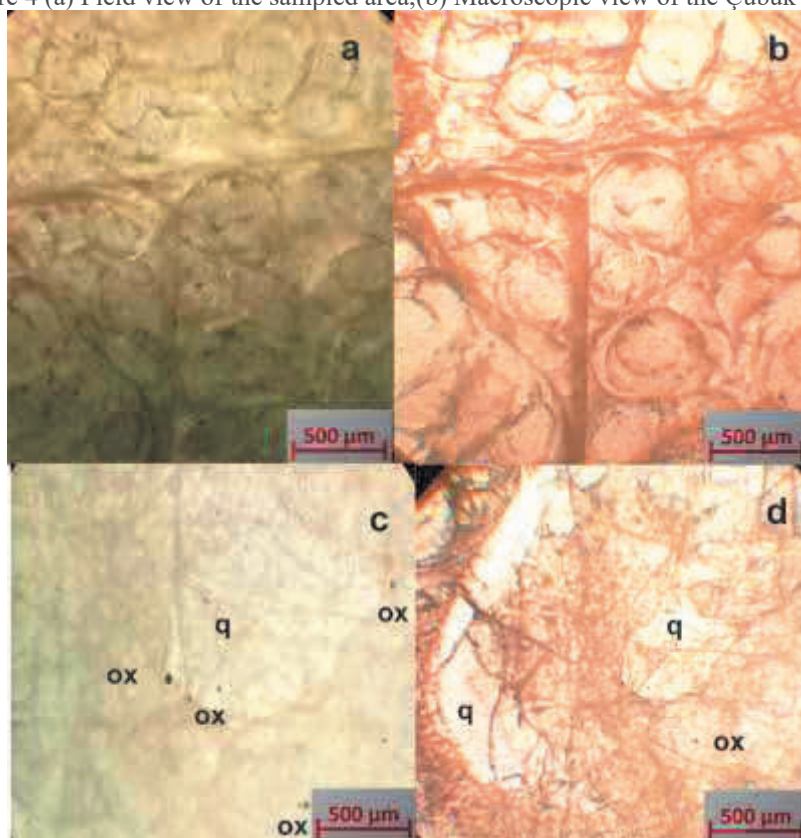


Figure 5 (a)-(d) Microphotographs of the samples under polarizing microscope.

### *X-ray diffractometer (XRD) Analysis*

A systematic specimen was handled from the alteration zones of the perlite deposit. Sampling was started at the midpoint of the fault with the P1 sample and continued by naming this sample P2 and P3 as it moved away from the fault. The distance between the sampling points is approximately 25 cm. The result of XRD analyses (Figure 6) shows that the P-1 sample which represents the midpoint of the fault zone contains quartz and smectite minerals. The quartz content decreased and smectite content increased in P-2 and P-3 samples, these samples are approximately 25 and 50 cm away from the fault midpoint, respectively. The smectite mineral decreased in the P-4 sample and it was replaced by the quartz and feldspar minerals, which are the primary minerals of the perlite.

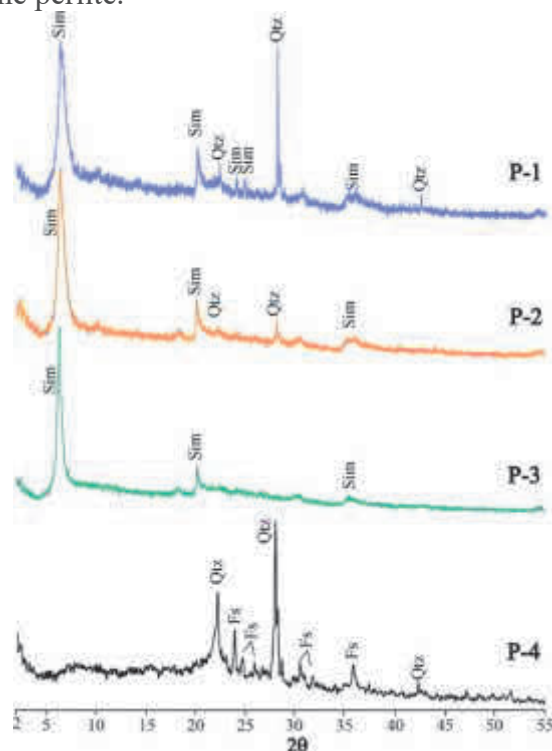


Figure 6 XRD patterns for rock samples from the Yukarıemirler Perlite deposit using CuK $\alpha$  radiation. Minerals identified include Smectite (Sim), Quartz (Qtz), and Feldspar (Fs). Patterns are representative of (P-1) Fault zone; (P-2 and P-3) Smectite-rich zone. P-2 and P-3 are from several cm (P-2: 5 cm and P-3: 20 cm from the fault zone; (P-4) less altered perlite zone, P-4 is taken 50 cm from fault zone.

## Discussion

Perlite is an amorphous volcanic rock that occurs naturally. It is formed from the hydration of obsidian and perlite is known to typically have high water content (Reka et al., 2019). Because of perlites' low density, easy commercial access, and low price is frequently preferred for many commercial applications such as; construction, manufacturing, filtration, biotechnology, and agriculture (Meisinger, 1979). Additionally, Turkey is one of the countries with high perlite reserves in the world (Summaries, 2021). Some of the perlites excavated from Turkey are extracted from the north of Ankara, Çubuk province (Taban et al., 2012). It has been observed that the perlites outcropping out in a limited area within the Susuz volcanics. The mineralogical-petrographical studies of the perlite rocks reveal that perlitic texture "onion-skin like fractures" is main characteristic texture and is observed in all of the samples. Quartz, feldspar, iron oxides, and also alteration minerals were observed in the petrographic observation of the perlite. Green argillization was detected along the NW-SE trending fault passing through the perlite quarry. Smectite group clays, quartz and feldspar minerals were detected in XRD



analysis. The midpoint of the fault zone is rich in quartz indicating that the end member of the hydrothermal solution is rich in SiO<sub>2</sub> (Ercan et al., 2022). It was determined that the smectite mineral increased, but the quartz content decreased away from the fault zone. At a distance of approximately 1 m from the fault zone, the alteration effect decreases, and the transition is made to perlite. The greenish color related to the alkaline alteration as away from this fault zone translate gray when it transitions to perlite. Smectite is a group of clay minerals of various swelling sheet silicates (phyllosilicates), which have a three-layer 2:1 (TOT) structure. Smectite group clays mainly form at slightly high pH, Si/Al and Na/K conditions (Kawano and Tomita, 1997; Barast et al., 2017). Hydration of the perlite fractures with the alkaline fluid affected the crystal structure and behavior of subsequent glass dissolution and thus smectite formation occurred in the Yukarıemirler perlite quarry. It manifests itself in a colour change from dark grey to dull brown or green. The further alteration of perlite occurs through glass dissolution and smectite crystallization along the perlitic cracks (Noh and Boles 1989). As alteration proceeds glass dissolution and smectite crystallization increase inwards from the cracks, eventually resulting in the central bead of remnant glass being completely dissolved. This alteration pathway is assumed to be appropriate for perlite however, the alteration minerals produced are likely to be different (Bagdassarov et al. 1999).

## Conclusions

As a result of the study aimed at identifying the clay minerals in the Ankara province, Yukarıemirler perlite quarry;

- It has been determined that the perlites found in the quarry have a perlitic texture.
- Argillization and iron oxidation occurred with the effect of the hydrothermal alteration process.
- Clay minerals which are the smectite group are formed along the fault zone passing through the quarry.
- Smectite group may indicate alkaline solutions with slightly high pH for the characteristic properties of the hydrothermal solution.

Much more detailed studies are needed for the characterization of smectite.

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