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IMAGING OF SPECTRAL PROPERTIES OF DENDRITIC AGATE FROM DEREYALAK VILLAGE (ESKİŞEHİR) – NW OF TURKEY USING SENSOR DATA

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ABSTRACT

In this study, agate mineralizations from Dereyalak village, Eskişehir, northwest Turkey are selected for imaging of spectral properties of agate mineral using sensor data. Based on field study, the agates occur as nodules in the Pliocene polymictic conglomerates, northwest of Dereyalak villages. Macroscopically, agates are mainly white and black colors range approximately from 5 to 30 cm in diameter and show a zoned macrostructure. An opal-rich zone is present nearest the outermost rim. The host rock of agates is Pliocene volcano genetic conglomeras unconformable overlie an Upper Cretaceous ophiolite complex. This tectonic contact, which trends E–W, is accompanied by another NE–SW-trending major fault. The agate mineralizations are intensively present along these fault zones. XRD analyses showed that alpha quartz (chalcedony), opal-CT (pseudocrystallinecristobalite), Opal-C (pseudocrystallinetridymite) and moganite as the main mineral constituents of the agates. SEM images also revealed different textures in agates that confirm the presence of a zoned structure in the agates. Based on previous studies the Dereyalak agates might have formed by sepiolite replacement by Low-T silica-rich hydrothermal solutions that circulated along the fracture systems. In addition, remote sensing of different sensors for natural mineral mapping and data acquisition were successfully used. Especially, in order to explore spatial distribution of the dendritic agate, opal and conglomerate formations, spectral analysis of satellite data were evaluated.

Keywords: Mineralization, Spectral property, Agate, Quartz, Hydrothermal alteration.

1. INTRODUCTION

Remote sensing is a reliable and widely used method for studies related with geology of the earth and other planets (e.gDes Marais et al., 2002). Remote sensing satellites can be used for the exploration of resources. These satellites are equipped with different sensors sensitive to radiant energy that is reflected or emitted by an object interacting with atmosphere, designed in different wavelength. Each object has a special reflectance and emittance characteristic with respect to the shape, size, and physical, chemical attributes.

In this study, Dereyalak region was selected for imaging of spectral properties of dendritic agate using one of the remote sensing satellite system, namely, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). It has sensors working with Visible Near Infrared (VNIR), Shortwave Infared (SWIR) and thermal Infrared (TIR) bands.

The challenge we had was that agate occurrence did not present any vein or massive structure, but rather happened tobe a spatially distributed surface coverage.Disseminatedagates accumulated around the conglomerate unit which also act as a source rock. Therefore, we focused on the conglomerate unit to locate agate-spilled areas. Our study indicates that SWIR bands has someinformation to delineate the conglomerates.

2. GEOLOGY

The field study area is located 45 km southwest of the city of Eskişehir (Fig. 1a). The geologic units in the study area range in age from Mesozoic to Quaternary. These units, listed from oldest to youngest, consist of Triassic (Gözler et al., 1996) İnönümetamorphics (metaquartzite), an Upper Cretaceous ophiolitic unit (mainly serpentinite), a Pliocene (Gözler et al., 1996) volcanogenetic sedimentary sequence (volcanogenetic conglomerate, volcanogenetic sandstone, and basalt), and Quaternary alluvium (Fig.1b).

The basement in the study area, the Triassic İnönü metamorphic unit, consists of metabasic rocks and metaquartzite. Calcschist also is present as bands within metaquartzite and metabasic rocks. This metamorphic sequence outcrops in the northeast part of the Eceköy district in the study area. The ophiolitic unit, lying tectonically on the İnönü metamorphic unit, is mainly composed of serpentinite. Magnesite and listwaenite are observed in serpentinite (Çalık and Arzoğulları 2008, 2014). The ophiolites are thought to have formed during closure of the neo - Tethys in the late Cretaceous (Göncüoğlu et. al., 2000), although a Triassic age and a paleo - Tethyan connection for this unit was also proposed by Okay et al., (2002). ??

The Pliocene volcanogenic sedimentary sequence outcrop widely in the study area. The Pliocene volcanogenic sedimentary sequence consists of mainly volcanogenic sandstone (at the base) overlain by a volcanogenic conglomerate (polymict volcanic conglomerates) The polymict volcanic conglomerates are also the host rocks of the dendritic agates. The volcanogenic sandstone overlie the ophiolite unit (serpentinites) with a discordant contact. Basalt lava flows cut this sequence (Figure 1b). The Quaternary deposits are represented by alluvium along the streams and between the ridges (Çalık and Arzoğulları 2008, 2014).

The main tectonic features of the study area are an E - W trending fault that places the serpentinites in fault contact with the Pliocene volcanogenic conglomerates and a NE - SW trending fault (Fig 1b). Magnesite and listwaenite are observed in serpentinite mainly in the fault zone. The magnesite deposits developed as stockwork veins along the E - W trending fault in the study area. The intensive mineralisation resulting in the agate formation is also observed along these fault zones, which provided the necessary permeability for ascending geothermal waters, in the study area (Çalık and Arzoğulları 2008, 2014).

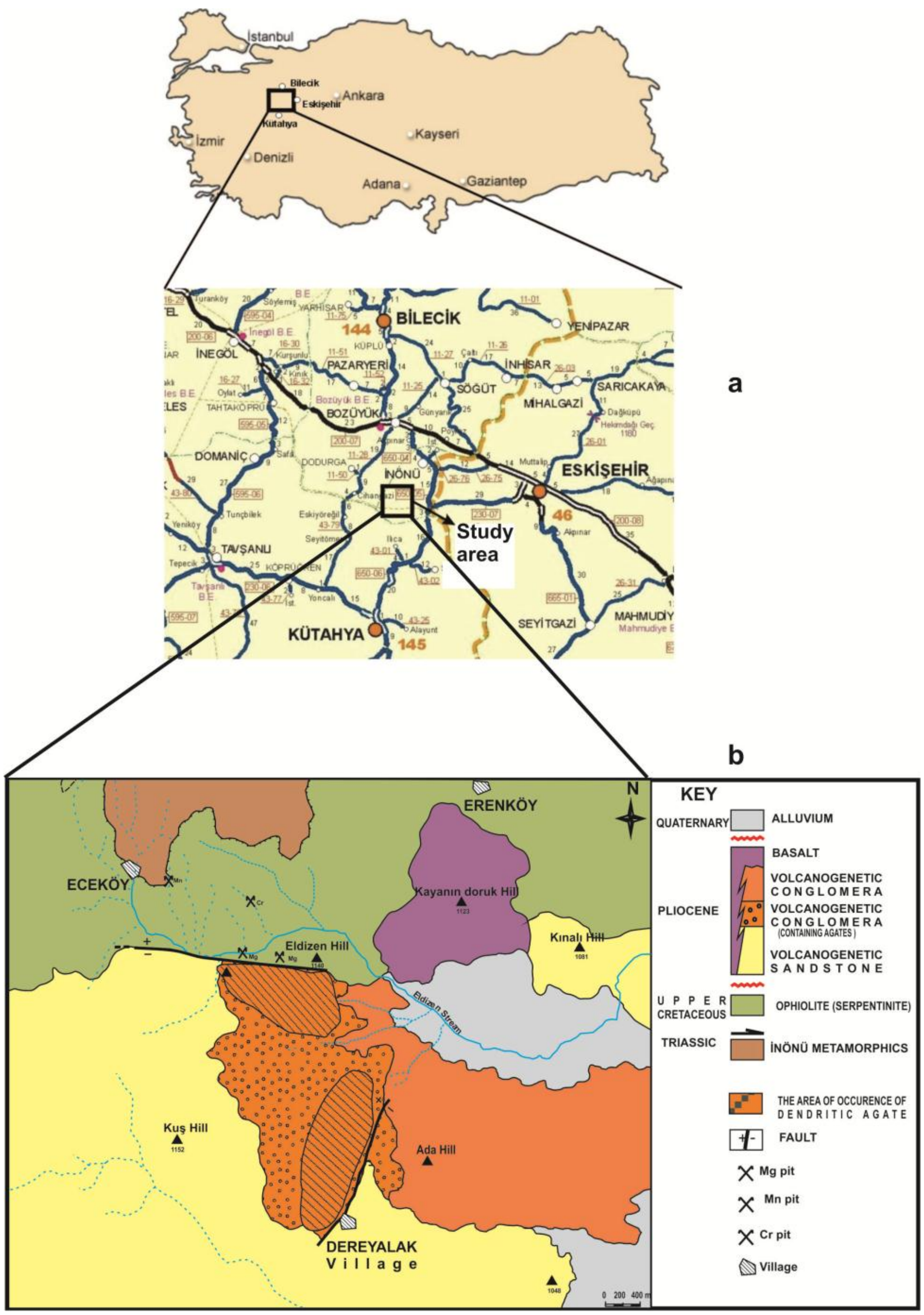

Figure 1. (a) Location map and(b)the geological map of around Dereyalakvillage (modified after Çalık and Arzoğulları, 2014).

3. OCCURRENCE OF THE DEREYALAK DENDRITIC AGATE

The Dereyalak dendritic agate occurs in volcanogenetic conglomerates of Pliocene. Masses of nodular agates varying in size from 5 to 30 cm show an irregular distribution patterns in the host rock (Fig 2). The agate forms in mainly white and black colours and shows a zoned macrostructure (Fig 2) The dendritic agate nodules present near the surface have the more fractured. The intensive mineralization of the agate formation occurs through E-W trending and NW-SE trending faults are situated in the studied area (Çalık and Arzoğulları 2008, 2014)

Figure 2. A close - up of the host rocks of volcanogenic conglomerates, including dendritic agate nodules in mainly white and black colours and show a zoned macrostructure.

Dereyalak dendritic agates might have formed by sepiolite replacement with low-T silica-rich hydrothermal solutions which came most likely along the fracture systems based on the previous studies (Çalık and Arzoğulları 2008, 2009, and 2014).

3.1 Mineralogical and optical properties of the Dereyalak dendritic agate

The Dereyalakdendritic agate has been subdivided into the four zone that are, from centre to rim, the transparent zone, the white zone, the pirolusite zone and the opal zone on the base of the investigation of XRD analyses in the previous studies (Çalık and Arzoğulları 2008, 2009, and 2014). The main mineralogy of agates is cryptocrystalline alpha-quartz (chalcedony), moganite (cryptocrystalline quartzine) and opal - CT and opal - C based on the XRD analysis of the agate. Under the polarizan microscope and SEM images of the Dereyalak dendritic agate show that their internal structure consists of mainly fibrous texture, micron- sized crystalline grains (Fig 3a -b) and spherulite texture. The different textures in the agate also confirm the presence of a zoned macrostructure(Çalık and Arzoğulları 2008, 2009, and 2014)

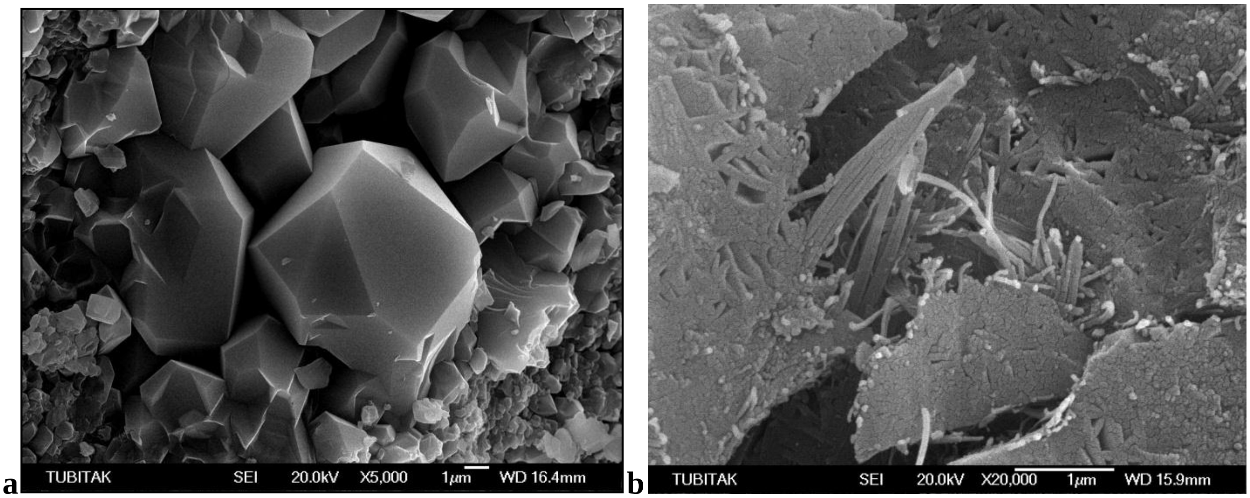

Figure 3. a-Electron microscope image showing the granular texture (X5000 magnification,) from the dendiritic agate b- Electron microscope image showing thefibrous texture (X20000 magnification) from the dendiritic agate (Çalık, Arzoğulları 2008).

4. IMAGING OF SPECTRAL PROPERTIES OF DEREYALAK DENDRITIC AGATE

We used the ASTER AST_L1T data in WGS84 datum and UTM Zone 37N for the targeted area that remains between upper left latitude 39° 45′ 45″N and longitude 29° 56′ 22″E, lower right latitude 39° 41′ 25″N and longitude 30° 04′ 56″E. We extracted the data to process further at 08:51:17 UTC on July 08, 2007.VNIR and SWIR bands were used for the computations with up sampling the images to 15 m from spatial resolution of 15m and 30m, respectively.

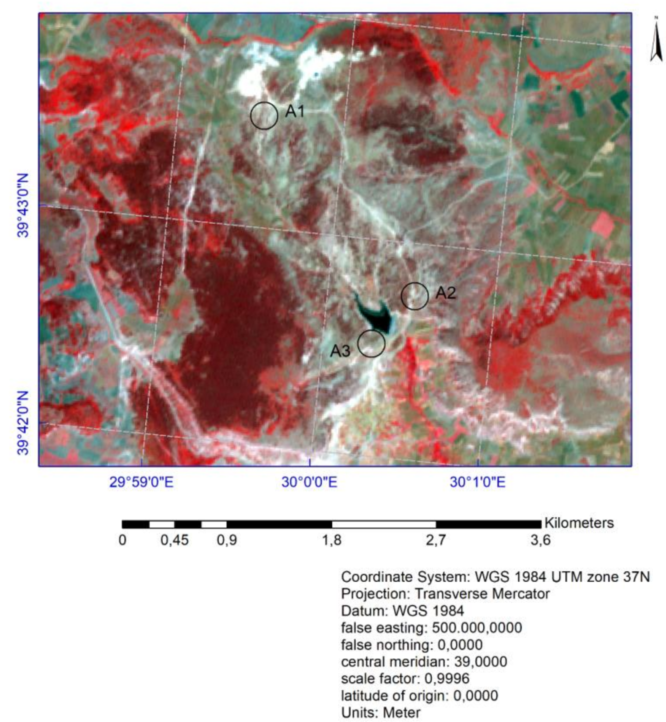

Figure 4. Color composite of Band 3 (red), Band 2 (green) and Band 1 (blue)at 08:51:17 UTC on July 08, 2007

Figure 4 depicts the color composite of Band 3 (red), Band 2 (green) and Band 1 (blue). In this Figure red areas show dense forested areas. There are three regions with agates covering the surface marked as A1, A2 and A3. The main geological feature in these selected regions is conglomerates, housing the dendritic agate nodules with mainly white and black colors. In order to show the conglomerate units that , in turn, gives us an idea about to agates occurrence, two methods, independent component analysis (ICA) and decorrelation stretch methods were applied to VNIR and SWIR bands of ASTER satellite.

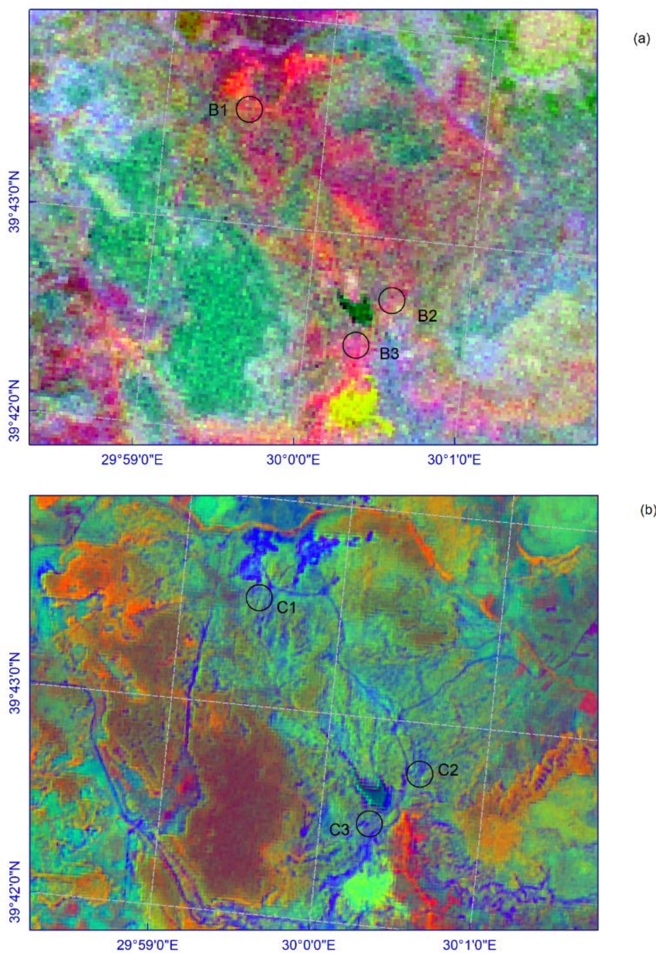

Figure 5**. a.**Color composite of first three bands of ICA output ICA Band 1 (red), ICA Band 2 (green) and ICA Band 3 (blue)**b.** Decorrelation stretch method is applied toband 3 (red),SWIR band 5 (green), and band 1 (blue)

ICA is a multivariate statistical method to find undefined features in a set of random variables. ICA is a non-Gaussian approach to independent source of data. Simply, linear representation of non-Gaussian data can be done with ICA (Hyvärinen and Oja 2000). Decorrelation stretch is an image enhancement method depending on eigenvector problem. This method is working well withGaussian data. The correlation between bands removed by applying rotation of coordinate transformationin order to enhance the image bands (Campell 1996).

ICA method is applied to six SWIR bands resulting in six output bands. In Figure 5a, color composite of first three bands of ICA output that have largest variance is obtained by placing ICABand 3 in red, ICA Band 2 in green and ICA Band 1 in blue. The region with conglomerates, including dendritic agate is given in Figure 5a with a circle in B1, B2 and B3, respectively.In this Figure, the colors can be represented for the forested area with light green areas, for the lake with dark green and for the village with yellow color. The clusters in B1, B2 and B3 can be seen as mixture of pink and purple that is discriminated from around especially in B2 and B3. Agates are accumulated around these regions.

Decorrelation stretch methods is widely used in geological studies. In order to support findings from ICA, decorrelation stretch method is applied toSWIR band 5,band 3, and band 1, respectively. This procedure is followed by obtaining color composite of band 3 (red),SWIR band 5 (green), and band 1 (blue).The region with conglomerates, including dendritic agate is given in Figure 5b with a circle in C1, C2 and C3, respectively. The color inside C1, C2 and C3 light indigo blue. It can be said that this color is mostly caused by conglomerates.

5. CONCLUSION

We present spectral analysis of satellite data that is used to explore spatial distribution of the dendritic agate and opal formations appear as disorderly-random nodules in and over the volcanogenic conglomerates.

Although, SWIR bands have some information about the conglomerates, additional process is necessary. Evaluation of different band combinations from different time range to delineate the outcrop of the conglomerate unit is still ongoing and the results will be presented in due course.

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