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Investigation of the Applicability of ASTER Satellite Images for Exploration of Barite Mineralization in the Bitlis Region

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Abstract – The purpose of this study is to examine the exploration for barite mineralization by using remote sensing data and field verification work. The mineralization is situated at the sites of Küllüce, Pertük, Haçinan, Kamurangazi, and Işıklı in the Bitlis province. Barite is found in vein, lens, and stratiform forms in the Devonian epimetamorphic rocks and carbonate rocks, and the Permian limestone. Due to presence of the ferrous and clay minerals along the contacts of the barite outcrops, alteration mineral indices were seen as an indicator on the satellite image. The ASTER satellite image is used for discrimination of lithologic contacts, identification of lineaments and mapping of alteration minerals. Alteration minerals (iron oxide and alunite, kaolinite, and illite-smectite-sericite) were used the methods of reflectance spectroscopy and spectral mapping using ASTER imagery by mineral indices of minerals in host rocks. Also, the mapping of calcite, muscovite and dolomite in the host rocks was performed by band ratio indexes. Lineaments and probable faults were revealed using a relief map obtained from the ASTER image and digital elevation model. They show an extension in dominant NE-SW direction with less N-S trending. Based on the interpretation of all data, overlapped by the ArcGIS software, it was determined that probable potential barite areas were compatible with tectonic lines of the field. It has been observed that three different barite outcrops were identified during the fieldwork. This work demonstrates the ability of ASTER image to provide information on barite and host rocks, which is a valuable for mineral exploration.

Keywords – Bitlis, ASTER, alteration minerals, barite exploration, lineament

I. INTRODUCTION

Nowadays, parallel to the developments in satellite technologies, a lot of information can be obtained from the satellite data with less cost and less time and effort. Satellite data are used in many different fields including geological studies. The developments in satellite technologies, in particular, provide high images of spatial, spectral and radiometric resolution. By using these high resolution images, it is possible to obtain more accurate and more information from the satellite data.

High spatial and spectral resolution ASTER satellite images are used extensively in the following subjects: Mineral mapping, exploration of mines, determination of alterations, monitoring of volcanoes, monitoring of water pollution, determination of vegetation and soil types, determination of surface temperature, determination of land use types, determination of damage assessments in result of natural disasters as flood, erosion, fire, and digital elevation model (DEM) production.

From west to east, the Taurids covering the southern part of our country is rich in barite, galena-barite, iron- bearing barite, and lead-zinc (Pb-Zn) minerals. This mineralization zone (barite, galena-barite, iron- bearing barite) from west to east; Şarkikaraağaç (Isparta) and Hüyük (Konya), Alanya and Gazipaşa (Antalya), Anamur (Mersin), Feke (Adana), Attepe (Adana), Adıyaman and Muş-Bitlis regions. In addition, Zn-Pb and Pb-Zn mineralization are found in the Yuları (Alanya-Antalya), Ortakonuş (Anamur-Mersin), Göktepe (Ermenek-Konya), Aladağlar (Niğde) and Kayseri locations [1]. The investigated area is located in a part of the Bitlis Massif in northwest-southeast direction in the Bitlis-Zagros Suture zone in the Eastern Taurus Mountains (Fig. 1).

The geology, tectonics and metamorphism of the region have been investigated in the study area and its vicinity in the past years [2], [3], [4], [5]. There are also detailed investigations on the mineralogy, geochemistry and origin of the barites in the field [6], [7]. In recent years, remote sensing studies on mineral mapping, ore-tectonism relationship and alterations have been conducted in the study area and other regions of Taurids [8].

The aim of this study is to investigate the exploration of barite deposits which are an economic importance by remote sensing data and field verification studies. Mineral mapping, determination of alterations, mineralization-lineament relationships and potential mineralization areas were carried out with the help of ASTER satellite image [9].

II. MATERIALS AND METHOD

In this study, 1/25 000 scale topographic map, 1/100 000 scale geological map of General Directorate of Mineral Research and Exploration, ASTER satellite image and ArcGIS software were used. Terra satellite, which was built by Japan Ministry of Economy, Trade and Industry, was launched from California on 18 December 1999 and placed into orbit. It has 5 different sensors: Aster, Modis, Ceres, MOPITT and Egypt.

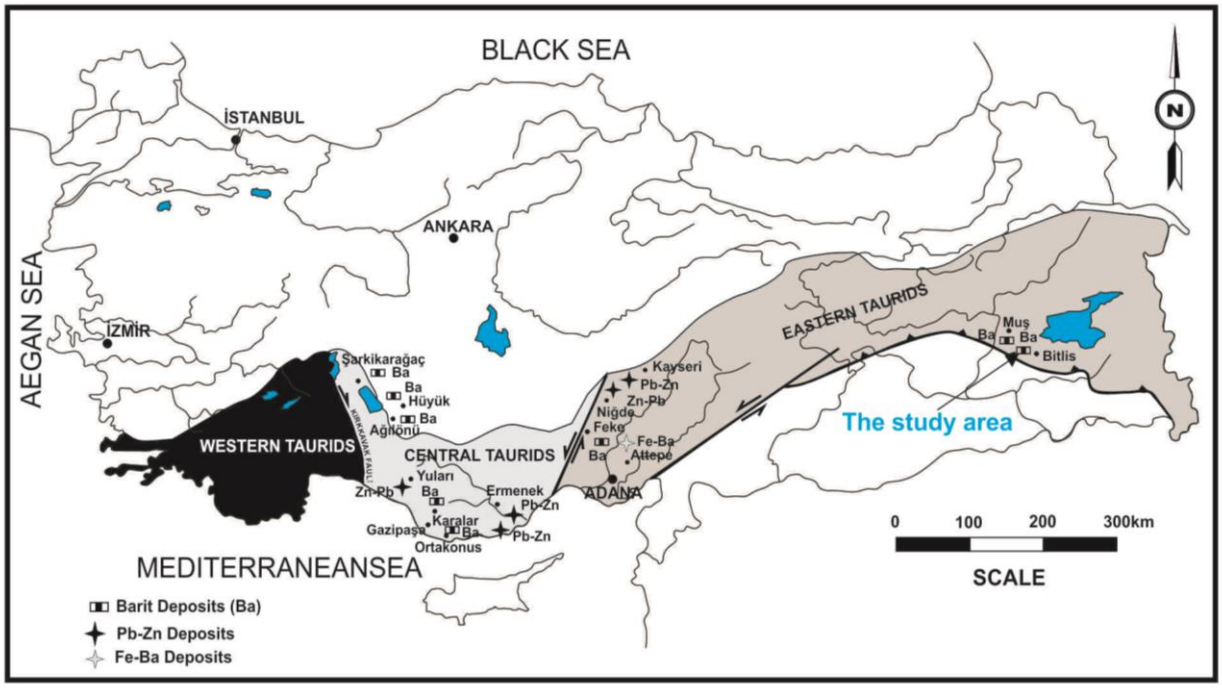


Fig. 1. Location map of barite and lead-barite, lead-zinc, iron- bearing barite mineralizations in the study area and other locations in the Taurus Mountains [1].

Aster Satellite has 14 bands and its spatial resolution is VNIR 15m, SWIR 30m and TIR 90m (Table 1). Terra is a joint Earth observing mission within NASA's ESE (Earth Science Enterprise) program between the United States, Japan, and Canada. The US provided the spacecraft, the launch, and three instruments developed by NASA (CERES, MISR, MODIS). Japan provided ASTER and Canada MOPITT. The Terra spacecraft is considered the flagship of NASA's EOS (Earth Observing Satellite) program. In February 1999, the EOS/AM-1 satellite was renamed by NASA to "Terra". 1) 2) 3) 4) [10].

Table 1. Characteristics of ASTER satellite imagery [10]

Sensor	Band N.	Spectral Interval (μm)	Spatial Resolution (m)	Radiometric Resolution (bit)
VNIR	1 2 3N 3B	0.52-0.60 0.63-0.69 0.78-0.86 0.78-0.86	15	8
SWIR	4 5 6 7 8 9	1.600-1.700 2.145-2.185 2.185-2.225 2.235-2.285 2.295-2.365 2.360-2.430	30	8
TIR	10 11 12 13 14	8.125-8.475 8.475-8.825 8.925-9.275 10.25-10.95 10.95-11.65	90	12

Remote sensing studies were carried out in two main sections.

1) Alteration minerals of the Devonian aged Meydan Formation (chlorite-sericite schist, dolomite, calcschist and limestone) and Permian aged Cırrık limestone (chloritoid schist intercalated crystallized limestone), which are the host rocks of the barite mineralization in the study area, were mapped using ASTER satellite image. In addition, mineral indexes for mapping of these rocks in the study area were utilized [9].

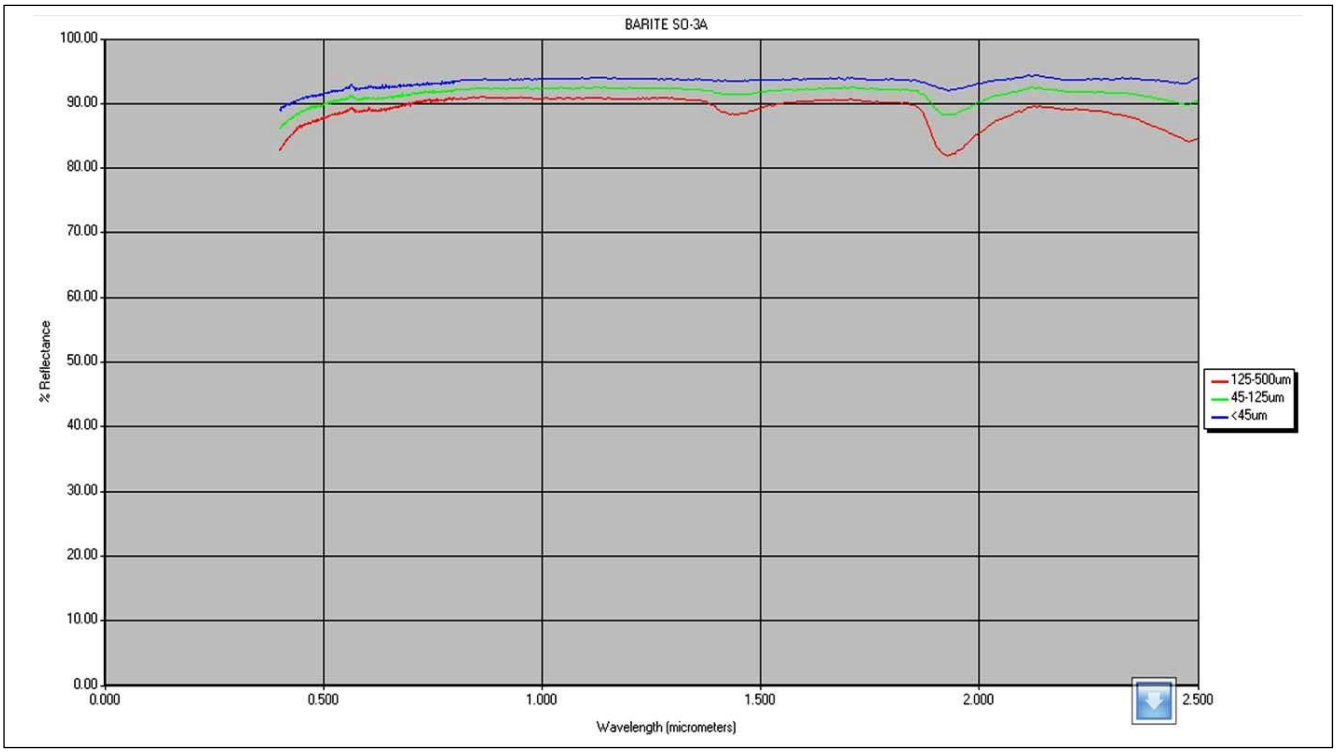
2) Lineaments and faults in the region were determined by using relief map, obtained from satellite images and digital elevation model. In this research, satellite images were enriched with image processing methods to determine geological features [9]. In order to determine the lineaments, the digital elevation model obtained from the ASTER stereo image and the various lineaments filters applied to the ASTER images were used.

Band rationing and imaging spectroscopy (reflectance spectroscopy / spectral mapping) methods were applied to the enriched ASTER satellite image for mapping of barite outcrops in the study area. The barite spectra of the sampling areas on the satellite images were presented in Fig. 2 [11].

III. RESULTS

A. Geology and Mineralogy of Bitlis Barite Mineralization

Barite mineralization is located in Küllüce, Pertük, Haçinan, Kamurangazi and Işıklı sites in the northeast of Bitlis province (Fig. 3). The mineralization is in the forms of vein, lens and stratiform within Devonian aged Meydan Formation containing chlorite-sericite schist, dolomite, calcschist, and limestone and within Permian aged Cırrık limestone including chloritoid schist intercalated crystalline limestone. Due to the presence of ferrous and clayey minerals along the contacts of the barite outcrops in the field, alteration mineral indices have been seen as traces in the satellite image. The mineral paragenesis of the mineralization consists of barite, galena, chalcopyrite, pyrite, malachite, azurite, hematite, limonite, calcite, quartz, muscovite, sericite and chlorite [1], [6], [7], [9].



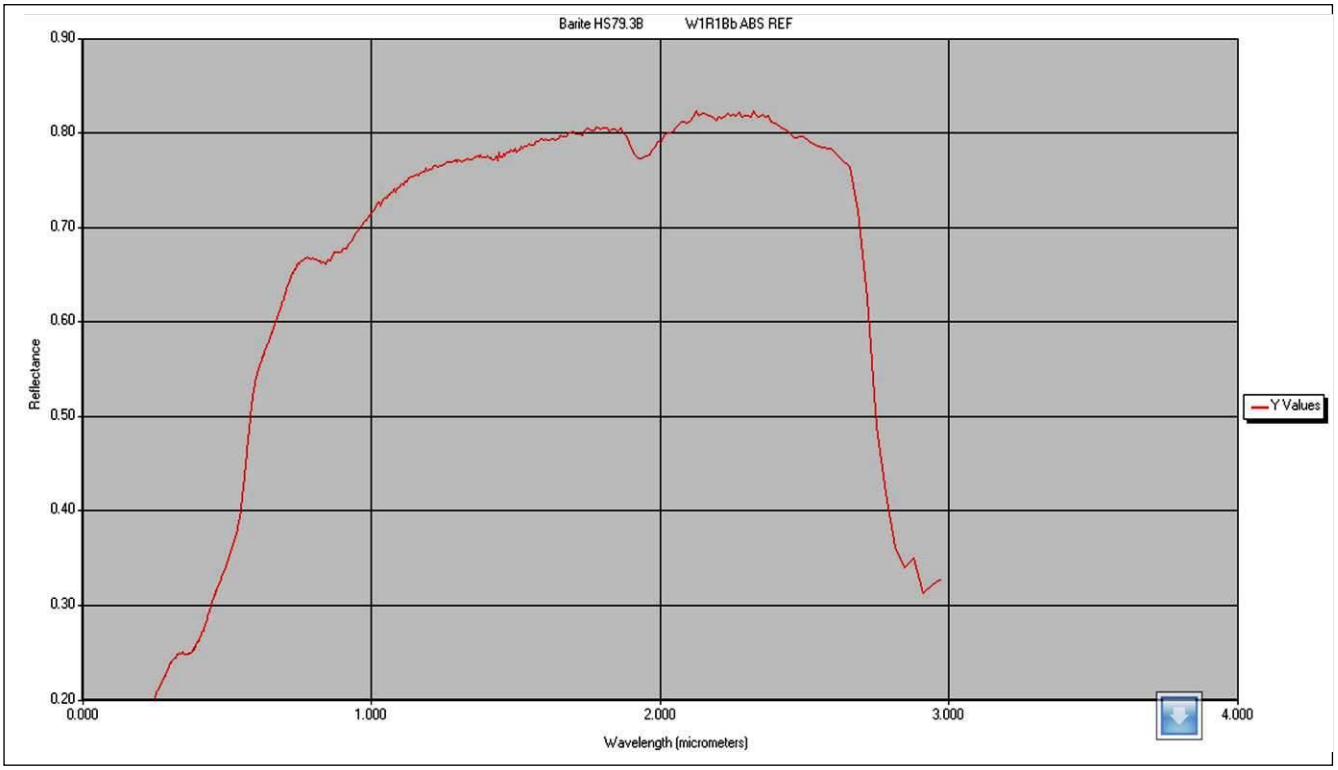


Fig. 2. Reflection graphics in the JPL and USGS spectral library of barite [11].

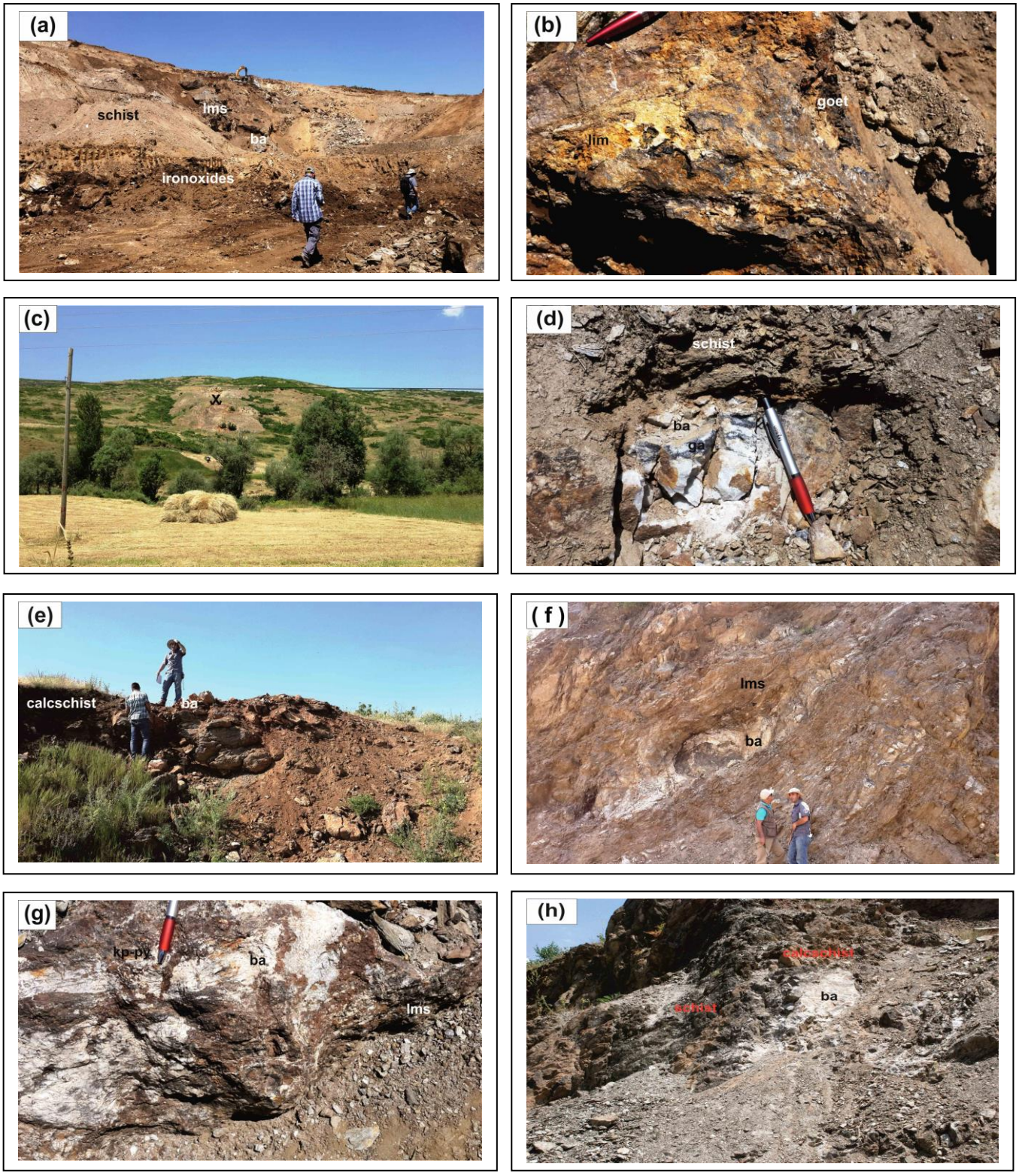


Fig. 3. The field photograps of mineralizations in Küllüce (a-b), Pertük (c-d), e: Kamurangazi (e), Işıklı (f-g-h) locations (lms: limestone, ba: barite, goet: goethite, lim: limonite, kp: chalcopyrite, py: pyrite)

B. Data Preparation

1/25000 scale $K47C_3$ and $K47C_4$ sheets covering the study area were obtained and scanned and transferred to computer environment. These maps were georeferenced in ArcGIS software and coordinated according to UTM ED50 (37.zon) projection system and topographic map mosaic was created. 15m resolution digital elevation model (DEM) was created by using ASTER DEM data belong to the study area and relief map was prepared using the DEM. The relief map was used to determine the lineaments (Fig. 4). In addition, 1/100000 scale geology map prepared by MTA was supplied and digitized in ArcGIS software (Fig. 5) [2].

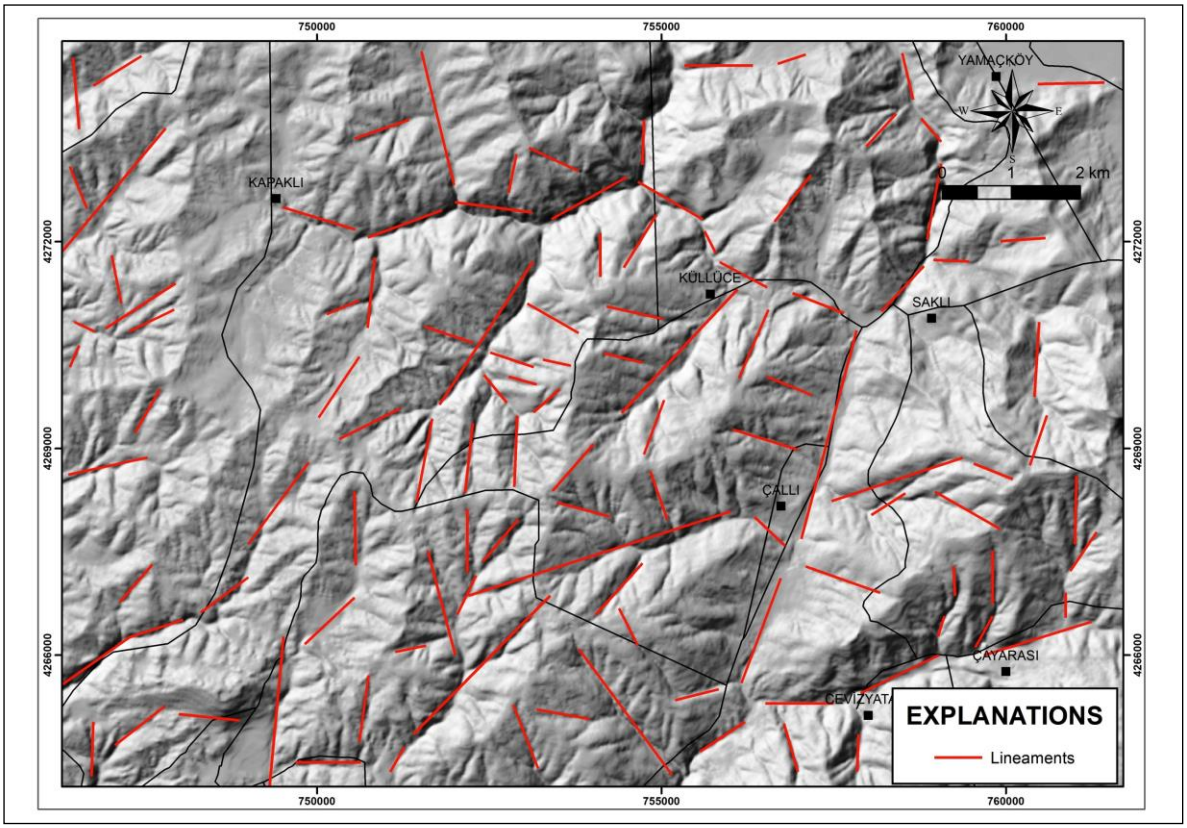


Fig. 4. Lineament map of the study area

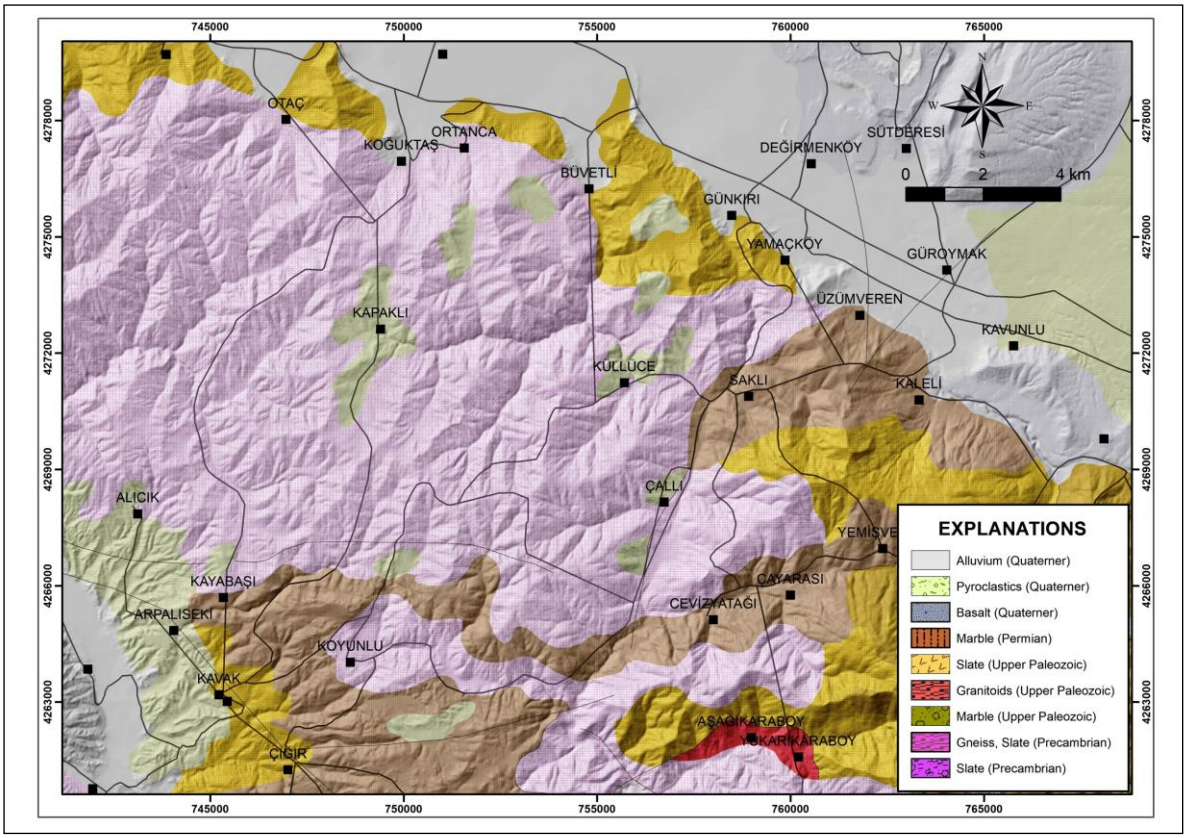


Fig. 5. Geological map of the study area [modified from 2]

ASTER satellite image of the study area was supplied and radiometric correction was performed with FLAASH algorithm on the satellite image. This satellite image was used to distinguish the lithological contacts, to detect the lineaments and faults and to map the alteration minerals.

C. Mapping of alteration minerals

Alteration minerals as alunite, kaolinite, illite-smectite-sericite, and iron-oxide minerals and mineral indices of minerals forming host rocks of barite ore were determined by reflection spectroscopy and spectral mapping methods on ASTER image. In addition, spectral characteristics of the sampling points were evaluated on the satellite images. The alteration minerals were mapped by making geometric, radiometric and atmospheric corrections on ASTER satellite images.

Maps of alunite, kaolinite and illite-smectite-sericite and iron oxide minerals were prepared by reducing the vegetation effect by using various mineral mapping methods (Figs. 6, 7). In addition, some mineral indices have been applied for the host rocks containing barite ore. For this purpose, calcite, muscovite and dolomite minerals were mapped by using 6/8 * 9/8, 7/6 and 6+8/7 band ratio indices (Fig. 8) [9]. According to the mineral maps, alteration minerals are concentrated in three different areas. These sites are along the Serikavisim Ridge, along the Geligarnişan Creek, and the junction point of Avluk Creek and Geligarnişan Creek (Fig. 9).

D. Lineaments determination

In order to determine the lineaments and possible faults in the study area and its surroundings, the relief map obtained from the ASTER satellite image and the digital elevation model were used. Various linearity filters have been applied to ASTER satellite image and lineaments have been brought to the forefront. According to the obtained lineament map, it is determined that the dominant lineament directions in the region extend in the northeast-southwest trending and less in the north-south trending (Fig. 4).

It was observed that the potential sites identified along the Geligarnişan Creek are in compatible with the tectonic lines. All data were overlapped with ArcGIS software to identify three potential barite sites (Fig. 9) and were consistent with tectonic lines.

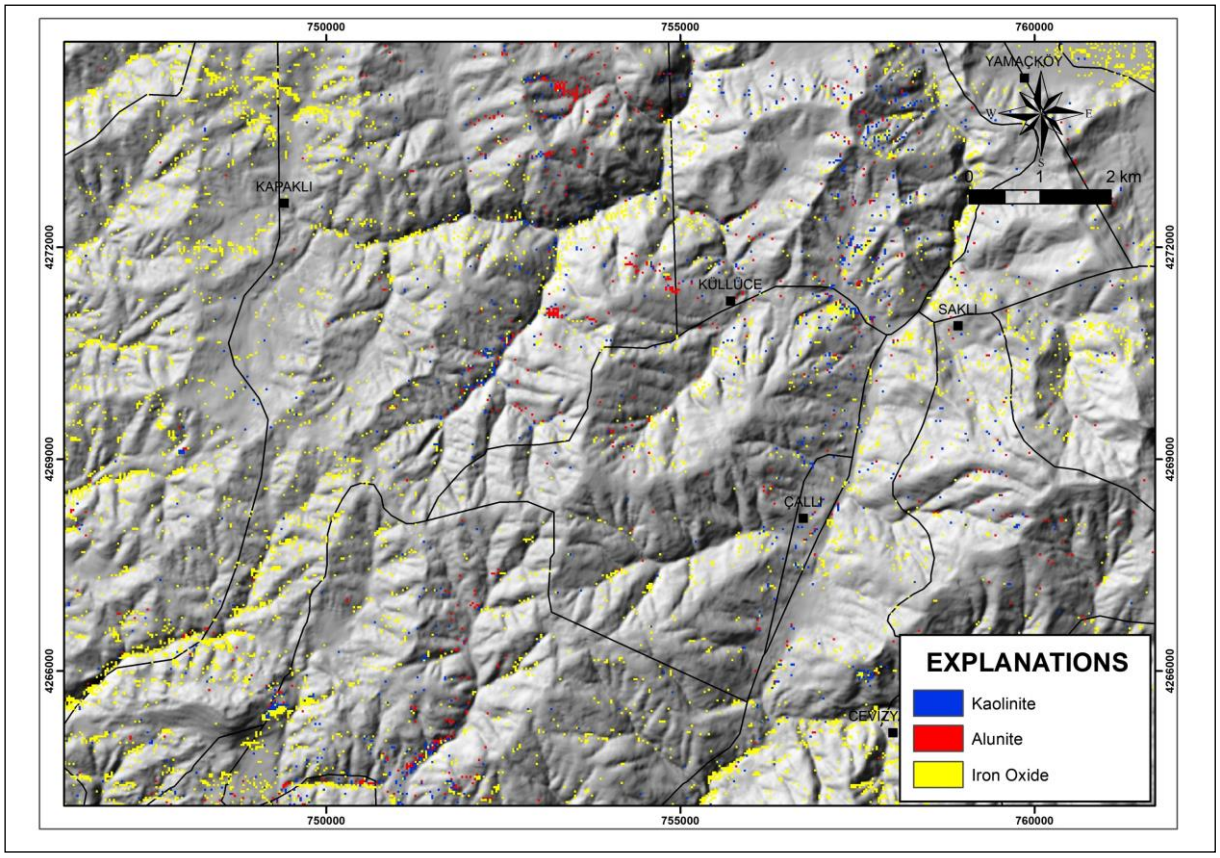


Fig. 6. Map of kaolinite-alunite and iron oxide alteration minerals in the study area

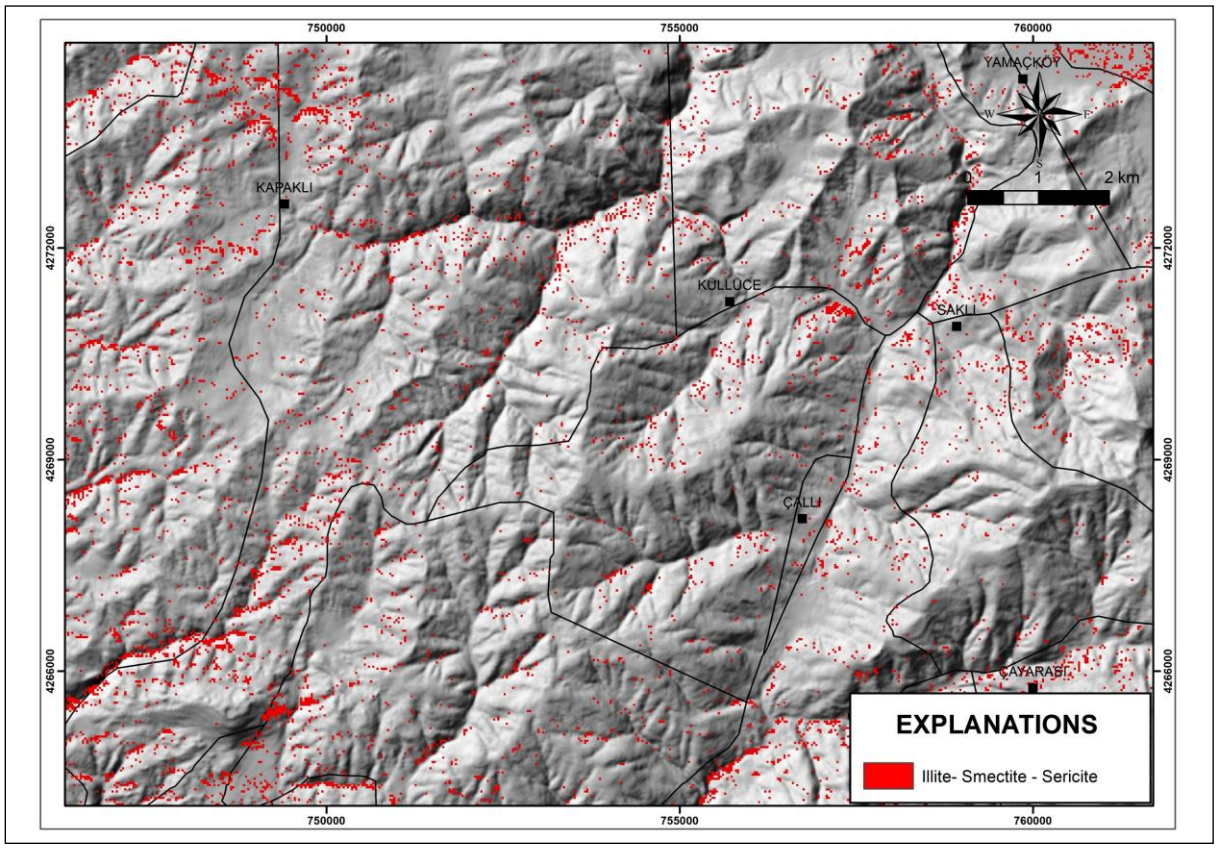


Fig. 7. Map of illite-smectite-sericite alteration minerals in the study area

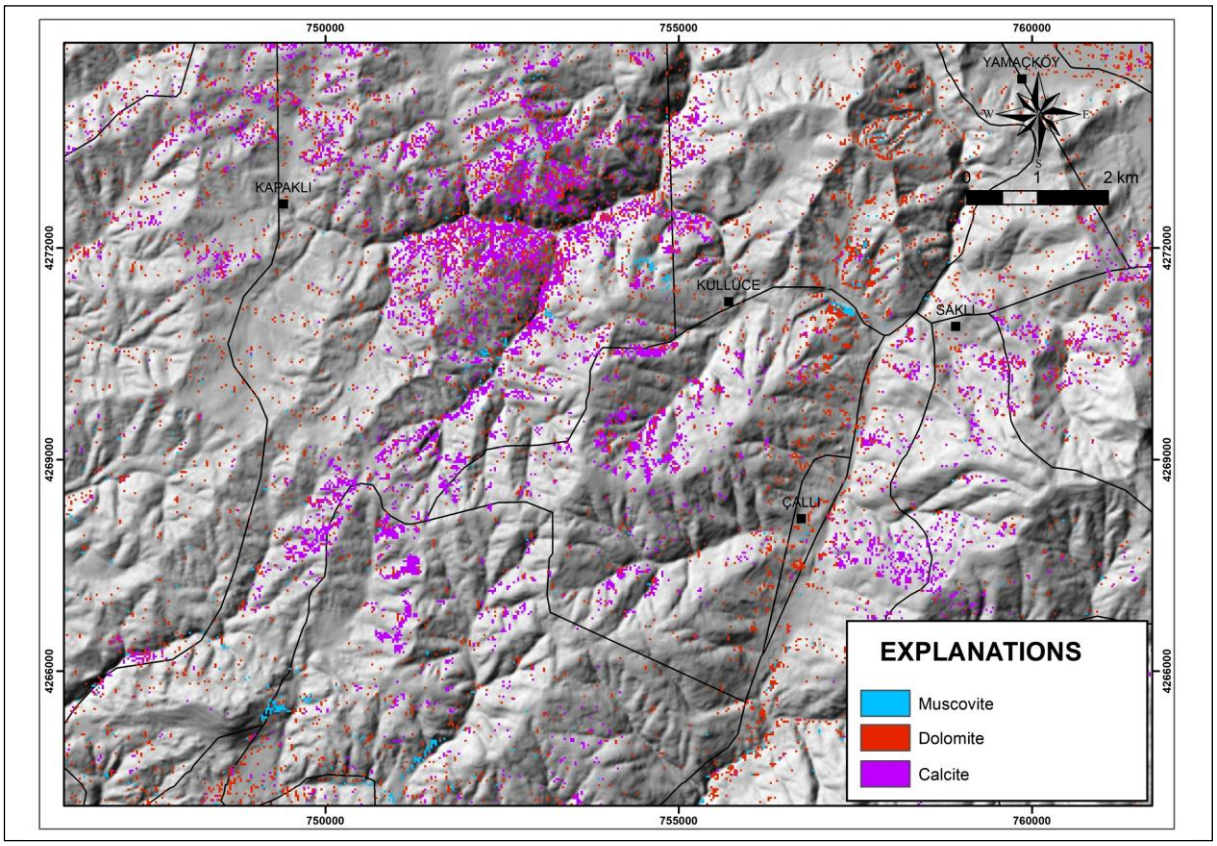


Fig. 8. Map of muscovite-dolomite-calcite minerals in the study area

Fig. 9. Google Earth images of potential mineralization sites identified in the study area (1) Serikavisim Ridge, (2) Geligarnişan Creek, (3) the junction point of Avluk Creek and Geligarnişan Creek

IV. CONCLUSION

This research has yielded the following important results:

- Iron-oxide, alunite, kaolinite and illite-smectite-sericite alteration mineral maps have been made in the study area and potential barite and host rock outcrops have been identified by using alteration areas.
- Band ratio mineral indexes (6/8 * 9/8, 7/6 and 6 8/7) were used for the calcite, dolomite and muscovite minerals, which were composed of the host rocks of the barite mineralization in the study area, and mineral maps were obtained.
- In the result of the assessments, potential barite sites were identified in the Serikavisim Ridge surroundings, the Geligarnişan Creek and the junction point of Avluk Creek and Geligarnişan Creek.
- According to the lineament and fault map, it is determined that the dominant lineament directions in the region extend in NE-SW direction and less in the N-G direction. Particularly, the potential barite site identified along the Geligarnishan Stream was found to be compatible with the tectonic lines.
- As a result, in this study, ASTER satellite imagery can be used to explore the barite mineralization by using host rock minerals, alteration areas and lineaments. It was observed that four barite outcrops were determined during field studies and control of potential sites but three barite outcrops could not be determined by remote sensing methods. The reason for this is thought to be the small size of the barite outcrops and the dense vegetation in the field.

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REFERENCES

[1] O. Cengiz, T. Uysal, and N. Hanilçi, “Bitlis Masifi (Doğu Toroslar, Muş)'ndeki barit yataklarının jeolojisi, mineralojisi, jeokimyasal özellikleri ve oluşumu,” Süleyman Demirel Üniversitesi Bilimsel Araştırma Projesi, Proje No: 01028-m-05, Isparta, 2010.

[2] S. Türkünal, “1:25 000 ölçekli Muş K46-(c1-c4-d2-d3) paftalarının arazilerinin jeolojik raporu,” MTA Raporu No: 4059 (yayınlanmamış), 1969.

[3] A. Boray, “Bitlis dolayının yapısı ve metamorfizması”, Türkiye Jeoloji Kurultayı Bülteni, 18/1, 1975, p. 81-84.

[4] H. Savcı, F. Yöndem, M.C. Göncüoğlu, and N. Turhan, “Bitlis-Mutki dolayının jeotektonik evrimi”, Türkiye Jeoloji Kurultayı 33. Kurultay Bildiri Özleri, 1979, p. 113-114.

[5] M.C. Göncüoğlu and N. Turhan, “Bitlis Metamorfik Kuşağı orta bölümünün temel jeolojisi,” Maden Tetkik ve Arama Genel Müdürlüğü Jeoloji Etütleri Dairesi Raporu, No: 1707, 1985.

[6] O. Cengiz, T. Uysal, and N. Hanilçi, “Isotope (S and Sr) geochemistry and fluid inclusion characteristics of barite deposits in Bitlis Massif, Eastern Turkey,” Sixth International Symposium on Eastern Mediterranean Geology incorporating The Ninth International Conference of Jordanian Geologist Asssociation, Abstracts Volume, 83, 02-05 April 2007, Amman (Jordan).

[7] O. Cengiz, “Bitlis barit yataklarının mineralojik ve jeokimyasal özellikleri,” Doğu Toroslar-Türkiye. 8th Geochemistry Symposium 2-6 May 2018, Antalya, p. 196-197.

[8] Ö. Kayadibi, O. Cengiz, E. Şener, and T. Topçu, “Gölcük ve Keçiborlu (Isparta) bölgeleri arasındaki hidrotermal alterasyon alanlarını ASTER ve Landsat TM/ETM+ uydu görüntüleri ile haritalama,” I. Ulusal Jeolojik Uzaktan Algılama Sempozyumu Bildiriler CD'si, 22-23 Mayıs 2008, Cumhuriyet Üniversitesi Jeoloji Mühendisliği Bölümü, Sivas, p. 59-60.

[9] O. Cengiz and E. Şener, 2015. “AL Madencilik Barit Plastik Sanayi ve Ticari A.Ş.’nin ruhsat sahalarına ait barit yataklarının (Bitlis Masifi) uzaktan algılama metotları ile haritalanması”, SDÜ Yüksek Öğretim Vakfı ve Döner Sermaye İşletmesi, 38, 2015.

[10] 2001, “ASTER User's Guide Part I General (ver 3.1),” pp. 101, March.

[11] A. M. Baldridge, S. J. Hook, C. I. Grove and G. Rivera, “The ASTER Spectral Library Version 2.0,” Remote Sensing of Environment, Vol. 113, p. 711-715, 2009.