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The Role of Drone Photogrammetry, Remote Sensing and GIS Methods in the Detection of Ore Areas and Their Surroundings

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Abstract: Mining works take place in a laborious and long process. The terrestrial methods used include classical activities that are economically very expensive and do not lead directly to results. The geography studied in mining areas brings with it many difficulties. It requires different methods in order to ensure the sustainability of mining operations and to use time efficiently. This study was carried out in order to contribute to mining research by using the most effective methods of the study conducted for this purpose. The study area was carried out in the Bayat District of Corum, in the western part of the Central Black Sea Region. Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. The study which was applied in a license area where the height difference is high in difficult geographical conditions. In the first stage of the study, the digital elevation model of the region was prepared by taking drone images from different heights in difficult geographical conditions. In the second stage, using the high spectral resolution of the ASTER satellite data, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined with terrain maps created using data from drone and ASTER satellite images. For this purpose, unsupervised classification methods and band ratio techniques were used to extract the potential mineral distribution. The samples obtained from the ground control points taken as field-validated and the results of the regression analysis were evaluated together.

Keywords: Remote sensing, Drone photogrammetry, GIS

Introduction

With the rapid development of technology, the widespread use of Remote Sensing (RS) methods and research is considered an important innovation. Analyzes with infrared and thermal bands of high spectral resolution satellite images play an important role in the investigation of potential mining fields. A small amount of ore resources are used in the world and there are countless potentials waiting to be discovered. RS technology has taken its place in the spectrum of scientific research as a multidisciplinary. Studies with remote sensing methods have begun to leave their mark on the world literature.

Analyzing systems that provide high-resolution images of mining areas are UVA tools. Drone-based mining exploration gains value when combined with remote sensing methods. Drones have quickly become one of the most cost-effective and efficient tools for collecting high-resolution data, aligning between larger-scale, lower-resolution satellite data collection and much more limited traditional terrestrial survey approaches (Hill,2022).

A study conducted in Yankari Park in Nigeria used ASTER and Hyperion satellite data to identify alteration minerals. The algorithms used are based on Linear spectral separation and spectral angle mapping (Abubakar et al., 2017). Instead of the spectral angle mapper used in this study, the spectral correlation mapper, which is the corrected version of these methods, was preferred.

In another study conducted in the Sittampundi Anorthositic complex in South India; For thermal waters, VNIR and SWIR data from nine band high spectral resolution ASTER satellite data were examined. The usability of different multispectral satellite data and mineral ratio images for lithological differentiation has been investigated (Arivazhagan et al., 2017). A similar study was conducted in Oman to investigate the mineral mapping performance of ASTER satellite data in arid regions. ASTER bands for mineral mapping, band ratio literature was reviewed (Rajendran & Nasir, 2018).

In another study to determine the band ratio of hydrothermal alteration minerals, principal component analysis, Crosta technique and spectral angle mapper techniques were applied using ASTER satellite data. Spectroradiometry was used to extract the spectral signatures of the stone samples. (Yalçın et al., 2017). Different RS methods of ASTER bands were investigated to analyze potential mining fields in Çorum province. (Alkan et al., 2017).

Data obtained from satellites or Unmanned Aerial Vehicles (UAVs) makes these hard work equipped in a short time. Unmanned Aerial Vehicles (UAVs) or drones is a proven technology for some of these activities (Wyard, 2022). The diversity of remote sensing methods and high spatial resolution of drone data in the exploration of metallic minerals makes a great contribution to the studies. This study was carried out by combining effective methods to contribute to mineral exploration. For this purpose RS, UVA Drone and GIS processes were jointly used.

Method

Drone Photogrammetry and Remote Sensing

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. The digital elevation model of the region was prepared by taking drone images from different heights in difficult geographical conditions. Using the high spectral resolution of the ASTER, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined using merged data from drone and ASTER images. The samples obtained from the ground control points and the drilling for field-validated.

Study Area

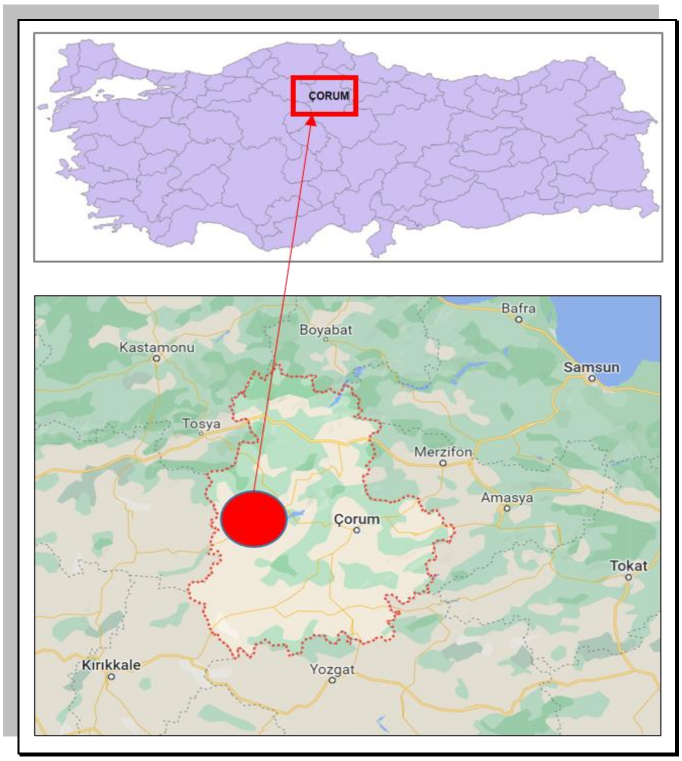

Figure 1. Study area

The study area was carried out in the Bayat district of Corum, in the western part of the Central Black Sea Region. Projection is UTM, Datum WGS 84 and Zone 36 (Figure 1). A continuation of the significant parts of Central Anatolia Region in the Central Black Sea Region; the most part springs in the Yeşilırmak Basin (Gulersoy, 2013). Parallel to the tectonic development of Anatolia, Corum province is located on a large area covered by metamorphic masses, conglomerates, limestones, and sandstones. In this geological formation, the probability of high temperature harboring of metamorphic belts is considered important in terms of investigating potential ore areas (Ongur, 2005). Classical local drilling activities were carried out in geothermal studies in the research area. No study has yet to be related Remote Sensing (RS) and Drone Photogrammetry (DP) adds high-value effects to this work.The study which was applied in a license area where the height difference is high in difficult geographical conditions. GCP, Drilling Check Points (DCP).

Experimental Design and Methods

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. In the first stage of the study, the digital elevation model of the region was prepared by taking drone images from different heights in difficult geographical conditions. In the second stage, using the high spectral resolution of the ASTER satellite data, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined with terrain maps created using data from drone and ASTER satellite images. For this purpose, unsupervised classification methods and band ratio techniques were used to extract the potential mineral distribution. The samples obtained from the ground control points taken as field-validated and the results of the regression analysis were evaluated together.

Ground sampling points were selected by using multi-spectral satellite data to be used in determining potential mineral areas in pre-classification. ASTER satellite multispectral bands are widely used in geological surveys. Separate field studies GPS measurements were carried out to determine the locations of soil classes in 4 different regions in the study area. By evaluating the spectral signatures of the samples by classification analysis, appropriate spectral ranges were determined and new test areas were created for the field study. The new samples analysis were completed by determining their positions with GPS were added to the spectral library inventory. Geometric and radiometric corrections have been applied to satellite data. Atmospheric corrections have been applied to visible, visible-infrared bands of ASTER satellite. The flow chart showing the working steps is shown in Figure 2.

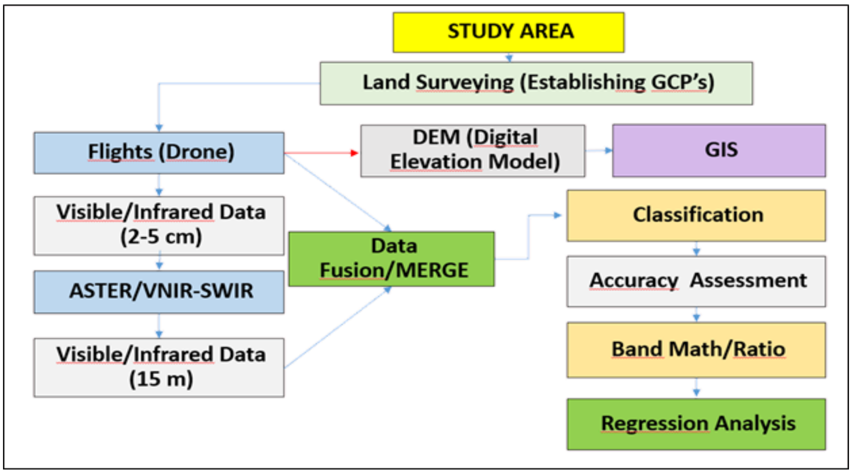

Figure 2. Flow chart

Drone studies were carried out with a two planned flight by determining the ground control points. Due to the difficult geography, the flight altitude was realized as 90 m. The mosaic and DSM images obtained were combined using the data fusion method. In the first stage of the study, mosaic image and DSM image of the region was prepared by processing Pix4d software (Figure 3).

The projection system is described in UTM and northern 36 segments. The location data of these points, Turkey national fixed satellite stations (TUSAGA-ACTIVE), is taken and converted into the national network based on the GPS coordinate system. One of the reasons for working with GPS was to test the positional accuracy of the sampling points on Google Earth, City Surf Globe and Orthophoto maps. Another was to compare the spatial accuracy of the ASTER satellite image with high spatial resolution images. It is aimed to increase the accuracy of image classification due to the ground accuracy of the samples by means of land measurements for sampling purposes (Alkan, 2019).

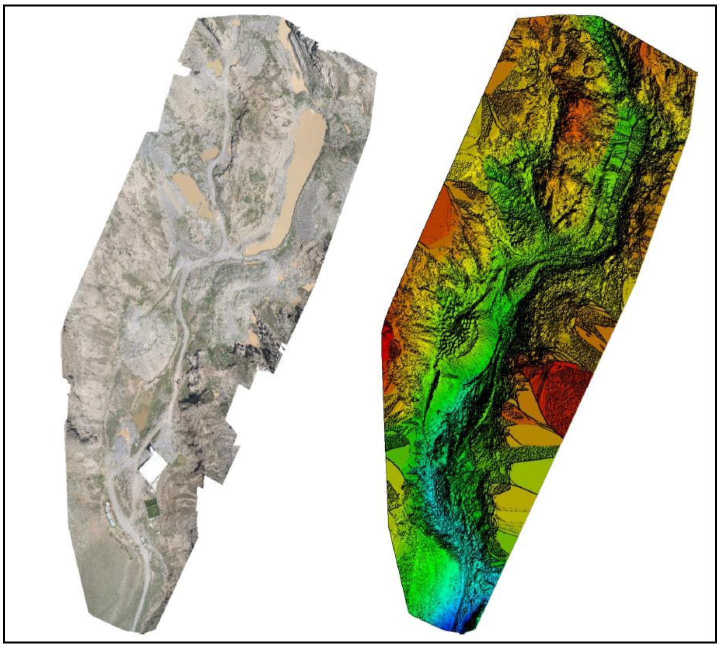

Figure 3. Ortomosaic and DSM images designed by UAV

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area.The digital elevation model of the region was generated by processing of the drone images from different heights in difficult geographical conditions. Using the high spectral resolution of the ASTER, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined using merged data from drone and ASTER images. The samples obtained from the ground control points and the drilling for field-validated.

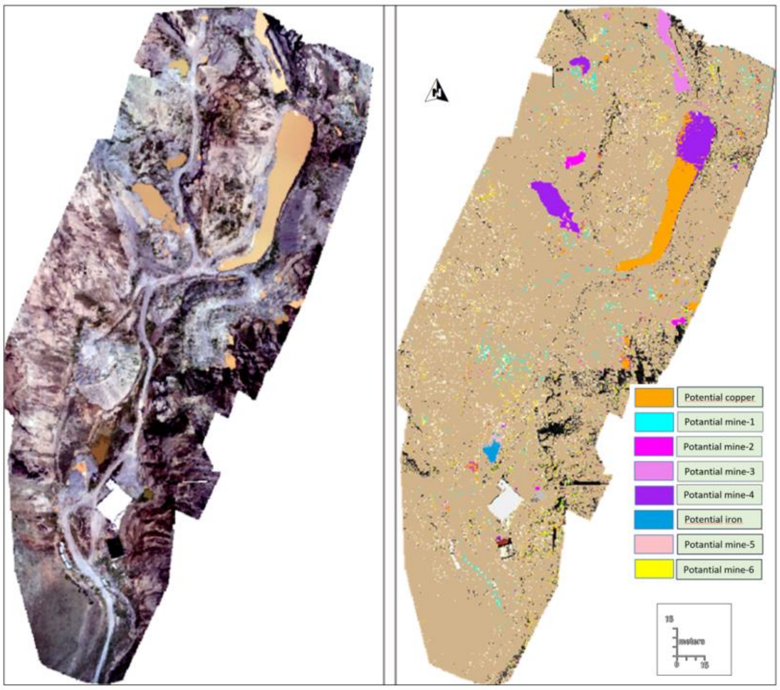

Figure 4. MLC Image

As for the exploration of ore- potential estimated in the study area, obtained by field studies; 55 points measured by GPS formed the sampling points for the classification process. It will be used for this purpose have investigated different algorithms for the selection of classification methods MLC (Maksimum Likelihood) and

SCM (Spectral Correlation Mapper) algorithms.Spectral Correlation Mapping algorithm which are defined as the modified version of SAM (Spectral Angle Mapper) (Figure 4 &5). Via pre-classification process, GPS measurements performed in the field where the mine drilling points with the coordinates of the samples assigned to eight different classes ASTER data in the same projection.

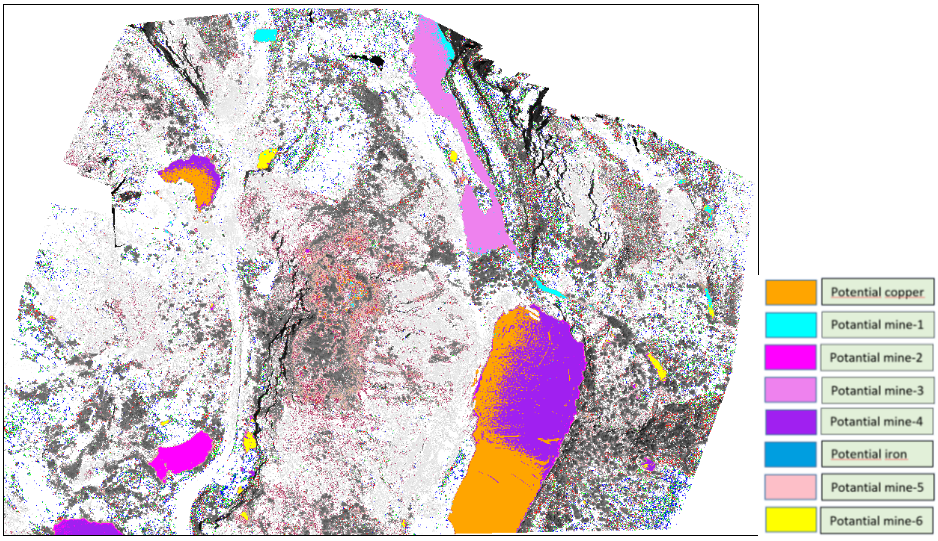

Figure 5 . SCM Image

DEM was generated by processing DSM image to achieve different elevations of the potential minerals for the study area (Figure 6).

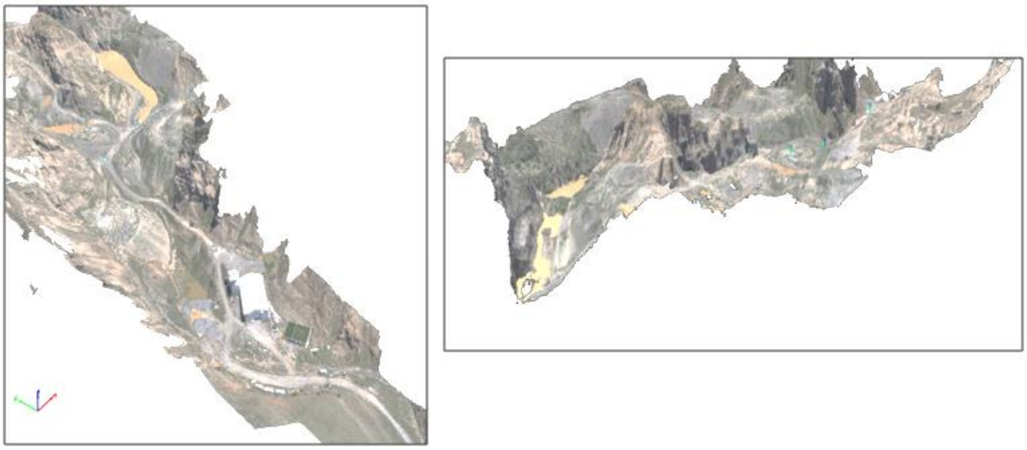

Figure 6 . DEM (Digital elevation model)

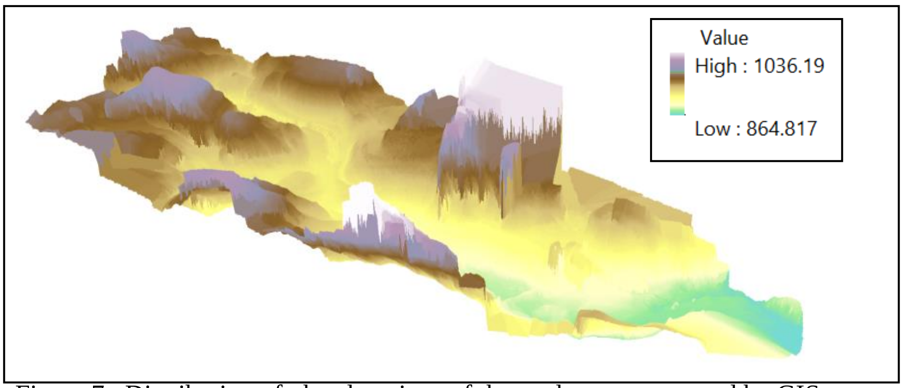

Figure 7 . Distribution of the elevations of the study area generated by GIS

Accuracy analysis results were compared by using two different classification methods (MLC and SCM) for the investigation of potential mineral areas. Accuracy analysis result for MLC 0.91 and SCM 0,94. The overall Kappa statistical values obtained for the eight main classes in the MLC and SCM classifications are shown in

Table 1. Kappa, which mainly calculates the image classification accuracy, was obtained with the following formula.

$$\kappa = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+} * x_{+i}}{N^2 - \sum_{i=1}^{r} x_{i+} * x_{+i}}$$

In the formula, r = number of classes, xii = diagonal elements of error matrix, xi + = sum of rows; x+ i = column total, N = total number of pixels in error matrix.

Table 1. Kappa statistics of the MLC and SCM classifications

Class	Kappa	Class	Kappa
Copper	0.9412	Copper	0.9742
Iron	0.9754	Iron	0.9621
Mine-1	0.8821	Mine-1	0.9158
Mine-2	0.9087	Mine-2	0.8923
Mine-3	0.9147	Mine-3	0.9355
Mine-4	0.8941	Mine-4	0.9290
Mine-5	0.9214	Mine-5	0.8934
Mine-6	0.8946	Mine-6	0.9271

Another analysis that has been studied is on the ASTER thermal 14 band, it was aimed to reveal the mineral areas with high thermal energy in the region. Band 14 of the ASTER satellite which has 5 strong thermal bands, was tested for this study. Ore-dense areas are shown in Figure 8.

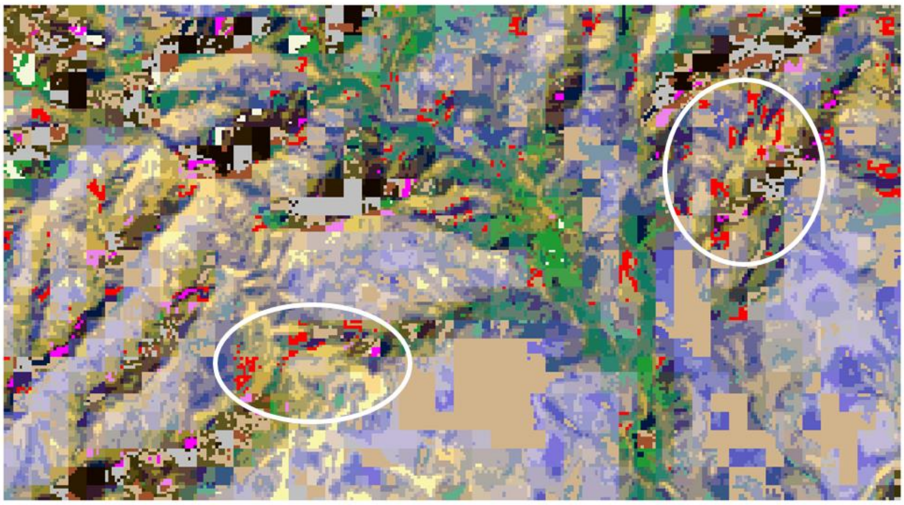

Figure 8 . Mineral presence created by ASTER 14 band performance

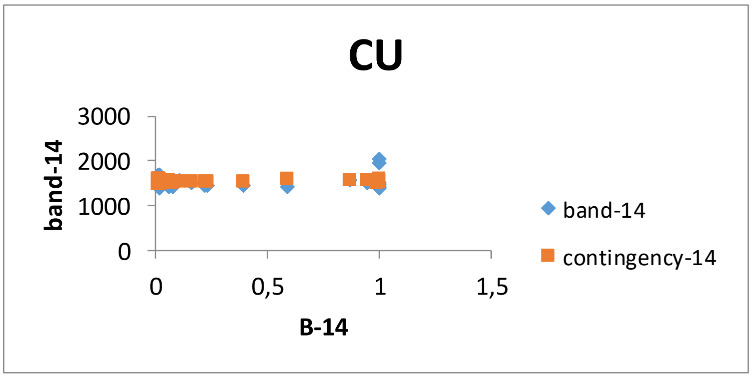

Figure 9 . Performance of the ASTER 14 band for Cu Minerals

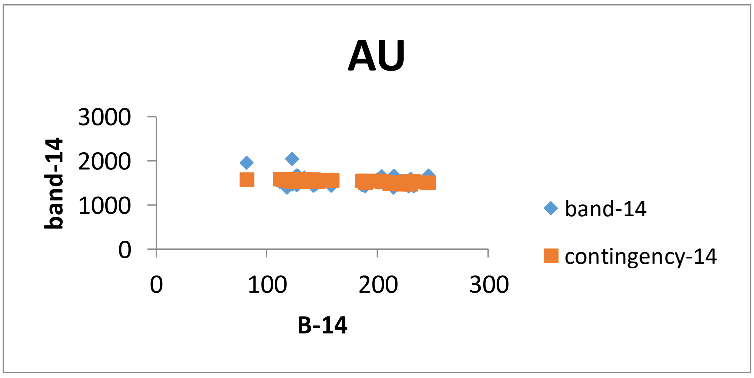

Figure10 . Performance of the ASTER 14 band for Au Minerals

The regression graph of Cu nad Au potential areas is shown in figure 9 and 10.

Results and Discussion

The aim of this study, which was carried out using RS and Drone photogrammetry methods, was to determine the presence of minerals.. For this purpose, the MLC and SCM performances of the classification methods studied were evaluated together and an accuracy of over 90% was obtained. In the regression analysis for the estimated potential areas, 55 points selected from ground-tested test points were used in the classification procedures. The regression analysis and the relation of mineral elements expected to exist in the predicted potential mineral areas were investigated particularly focused on Copper (Cu) and the Gold (Au) surroundings.

In the regression analysis for estimated potential geothermal areas, 24 points selected from the drilling-tested points were used in the classification procedures for the histograms of mineral groups respectively. Drone photogrammetry and remote sensing methods can be used for the mine areas efficiently.-High spatial resolution (UAV:2-5 cm) and high spectral resolution ASTER images effectivly used in data fusion method to explorate minerals.

Conclusion

The use of RS and drone-based photogrammetry methods in the preliminary studies of mining research is great importance in terms of the cost of drilling activities. RS methods which integrate topographic, geological and geomorphological features with the help of satellite images can be used in researches, surface symptoms can be examined and statistics and potential mineral fields can be reached.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

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