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Research Article

IDENTIFICATION OF ALTERED TUFF AND SUPERGENE ZONE AT FERDOWS AREA, IRAN PROSPECTING FOR POLYMETAL USING LANDSAT 8 AND ASTER SATELLITE IMAGES

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ABSTRACT
Application of remote sensing in recent years, the exploration of mineral resources has been developed. Most satellite images applied in mineral exploration have capability to identify areas of alteration. Since a direct correlation between Polymetal alteration and mineralization in the area is the ideal expectation, identifying them with the help of satellite images, which accelerates the exploration and lowering the cost has high significance. There is an extensive alteration zone in the study area. Enhancement methods have been applied to satellite data available for this region to identify alteration zones, including the alteration of the area associated with Polymetal mineralization, the type of alteration is argillic. Therefore, the index of alteration minerals such as kaolinite, illite, montmorillonite, alunite and dickite, have been used to indentify the argillic alteration zone. Chlorite and epidote were minerals used for identification of propylitic alteration.

Keywords: *Remote Sensing, Alteration, Satellite Images, Polymetal Prospecting, Ferdow*

INTRODUCTION
One of the most important applications of satellite imagery processing, is identification of deposits by using layer separation and identification of lithology, alteration zones, represented ore-mineralization processes. Area is divided into structural zones within the longitudes of 58° to 58.5° and latitudes of 34° to 34.5° located around the Ferdows city. Major volcanic units in the area of Polymetal mineralization are tuffs (with acidic and intermediate composition) (Fotovat *et al.,* 2012). Extensive alteration zones in the outcrop area and contact alteration zone with anomalous ground and airborne radiometric data indicate an important role of regional alteration for Polymetal ore-mineralization (Fotovat *et al.,* 2012). Alteration in the study area is due to the influence of hydrothermal fluids associated with hydrothermal and supergene alteration, by alteration of plagioclase in volcanic units to clay minerals.

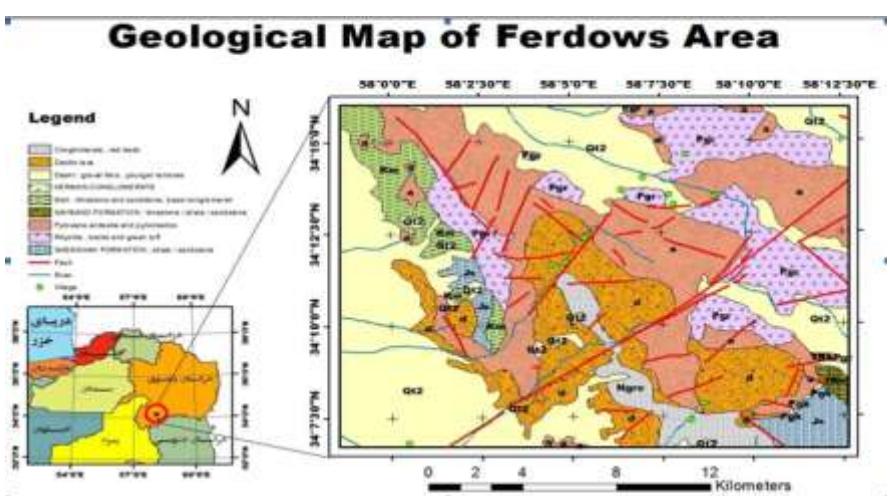

Figure 1: Geological map and geographic location of the study area.

Empirical Study

Because rocks are made up of different minerals and mineral absorption and reflection are different, so the satellite data processing (especially in view beyond the visible spectrum) and some minerals in rocks can tell them (Sabins, 1999; Lillesand *et al.,* 2004). Altered rocks of the spectral differences due to minor differences in the extent of absorption and reflection spectra of their constituent minerals, electromagnetic waves, the most important way to detect the alteration is in the processing of satellite images (Kruse et al, 1993). One of the most common approaches in the processing of satellite imagery is the band ratio method. The method includes dividing the two bands on each other. Band reflectance level of the target is higher, the absorption band for the same purpose, which is higher than the denominator. Application of this method eliminates topographic and shade effects in images and detects brightness ranges, which are used for separating various lithologic units (Rouskov, *et al.*, 2005).

Based on reflection characteristics of various minerals, the graph of the spectral phenomena, we can decide to use or not to use this method. Results of applying band ratios are grey-tone images, which by themselves are not a suitable criterion for detecting target areas, but only define areas with higher possibility for mineralization.

Using false color (RGB), images can be produced to interpret and draw conclusions based on them, is more reliable and practical. In this study, the alteration zone enhancement techniques ratio bands on Landsat-8 and ASTER satellite data were used. It is explained that the recently launched Landsat-8 (February 11, 2013) and no studies have been done using data yet to have much less noise in each band of the spectral data, the power of radiometric resolution is higher, the lower the spectral width of each band and the band number is expected to increase more than the previous series of Landsat sensor applications (*Landsat 8-Fact Sheet, 2013).*In this study, according to the band ratios of Landsat-7's sensor ¬ band than conventional sensors, ASTER, attempting to separate and detect alteration in the area studied. The ratio of band equivalent applied to the alteration of the angelic region as well as enhancement can attribute the band (6/5 in the red band, three quarters of the band Blue and 7/6 in the green band) sensor Landsat-8 is the altered zones can be seen in blue light (Figure 2). PC4 and PC2 principal component analysis as well as the band was applied to the sensor data fusion that the band ratio 7/6 as compared to the band of angelic alteration zone enhancement do well (Figure 3).

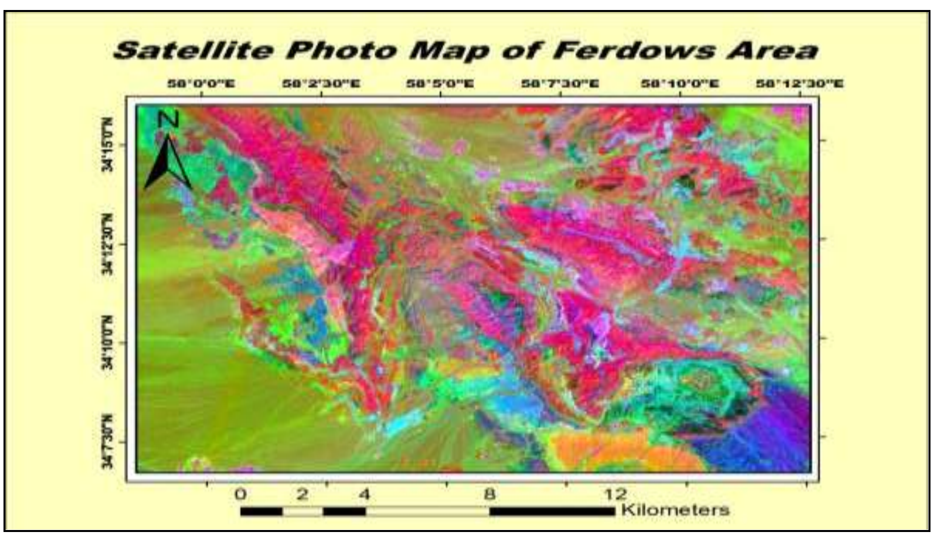

Figure 2: Combined ratios Band (6/5 in the red band, 3/4 in Blue Band and 7/6 in the green band) on Landsat-8 images

Including the identification of argillic alteration band ratios used in the ASTER band ratios can be combined (6/5 in the red band, 6/7 in the blue band and 5/7 in the green band) noted that the light blue

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areas are altered (Figure 4). Also, with the ASTER bands 4, 5, 6 and 7 in the band ratio (B4 + B7) / (B5 + B6) the dispersion of kaolinite and alunite, alteration of kaolinite and argillic as indicated. The zones containing kaolinite and alunite band than the color of light (white) can be seen (Figure 5).

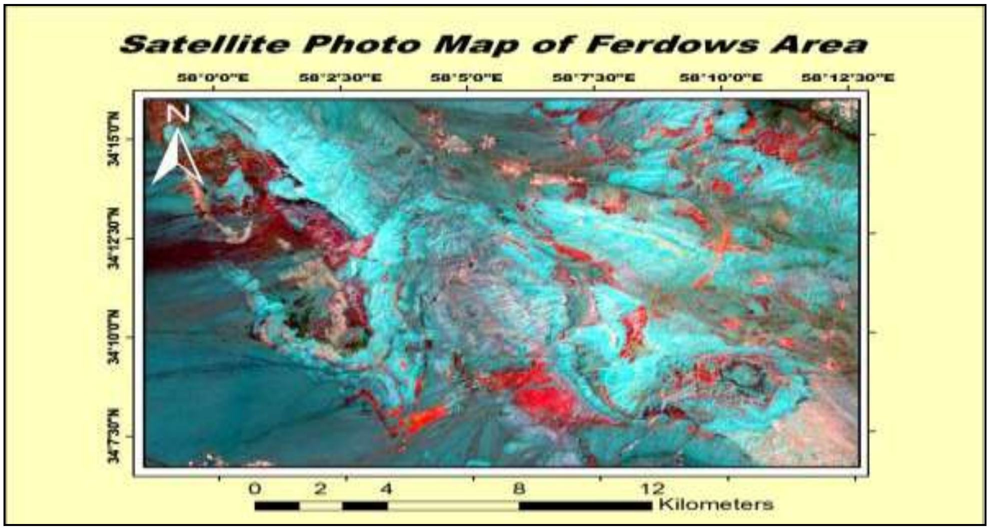

Figure 3: The combination of band ratio 7/6 and PC4 and PC2 principal component analysis on Landsat-8 images

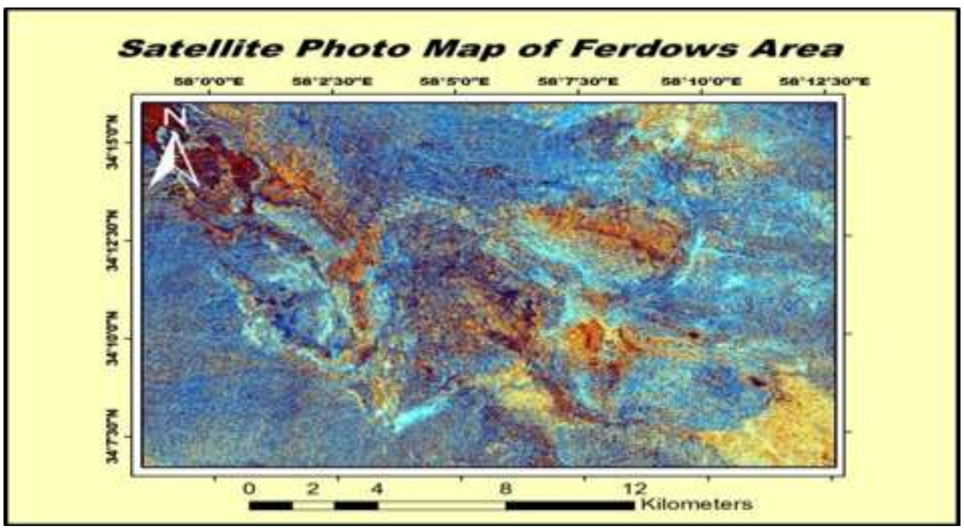

Figure 4: Combined ratios Band (6/5 in the red band, 6/7 in the blue band and 5/7 in the green band) on ASTER images

Using the technique of spectral angle mapping (SAM) on ASTER satellite data was used to detect argillic, kaolinite and alunite alterations. Spectral angle mapping and spectral classification is a method in which the analogy with the spectral angle between the spectra is determined by counting pixels. The spectra as vectors in a space equal to the number of bands are considered. The output of image analysis and image classification rule is the number of end members. Pixels that have smaller angular range seen in the photos rule darker, more sorted with reference variety show. This method of identifying the argillic and kaolinite alteration, distribution of alteration index minerals such as kaolinite, montmorillonite, dickite and spectral angle mapping method was determined by pyrophyllite (Figures 6-9).

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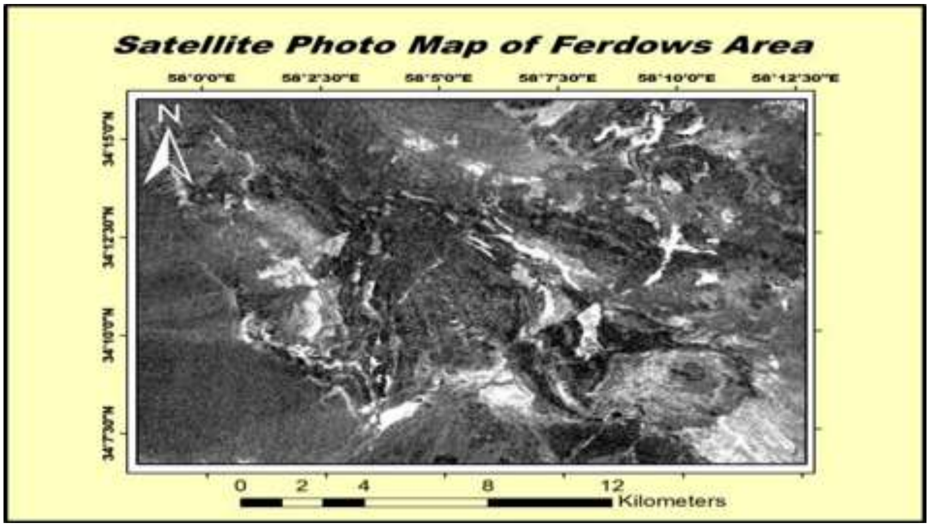

Figure 5: Band ratio (B4 + B7) / (B5 + B6) on ASTER images.

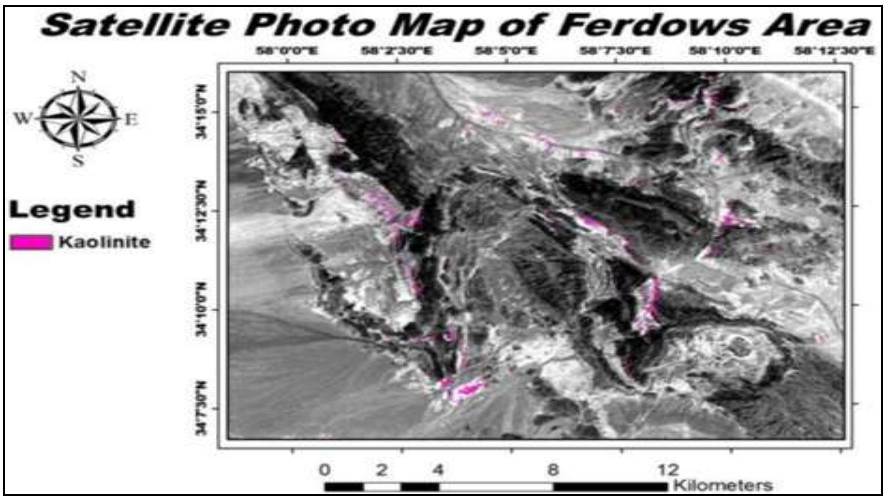

Figure 6: Using SAM to specify alteration, the purple areas observed are kaolinite.

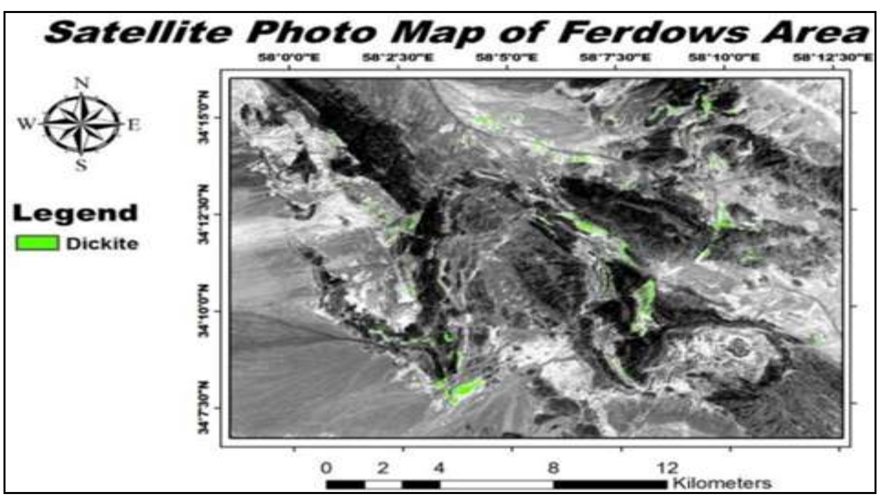

Figure 7: Using SAM to specify alteration, the orange areas observed are montmorillonite.

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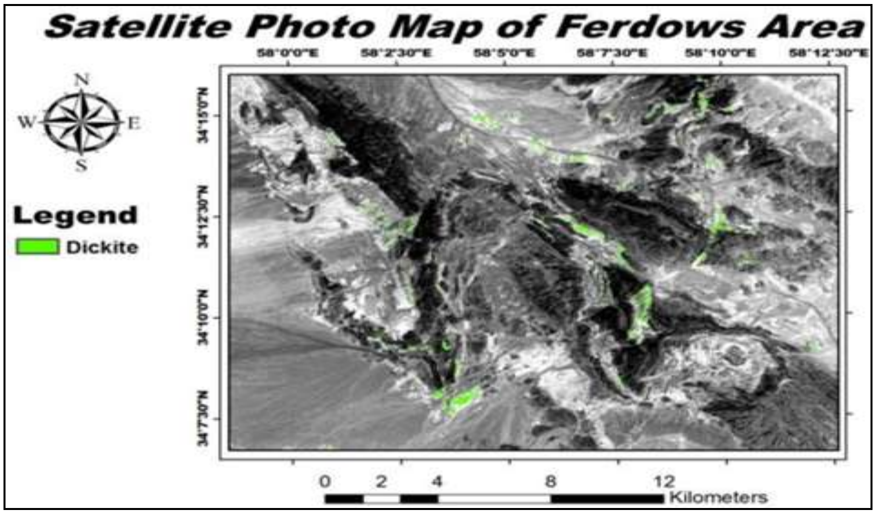

Figure 8: Using SAM to specify alteration, areas with dickite appear in green color.

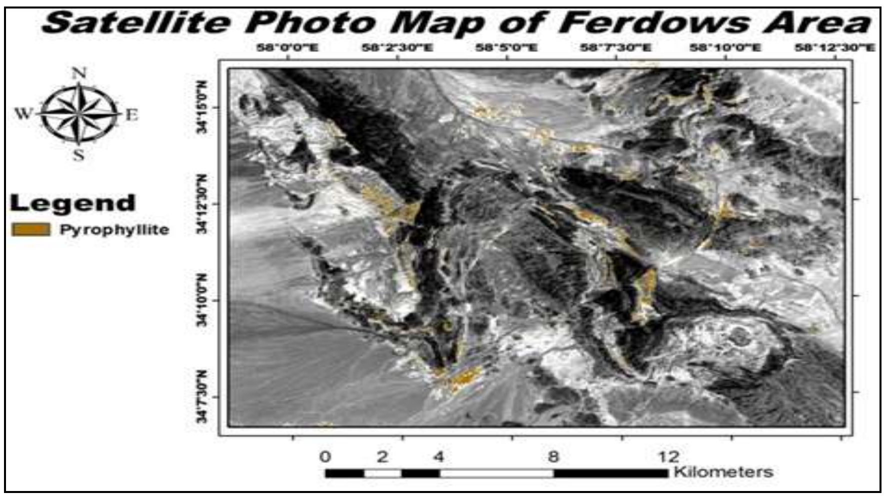

Figure 9: Using SAM to specify alteration areas with pyrophyllite are observed in light brown color.

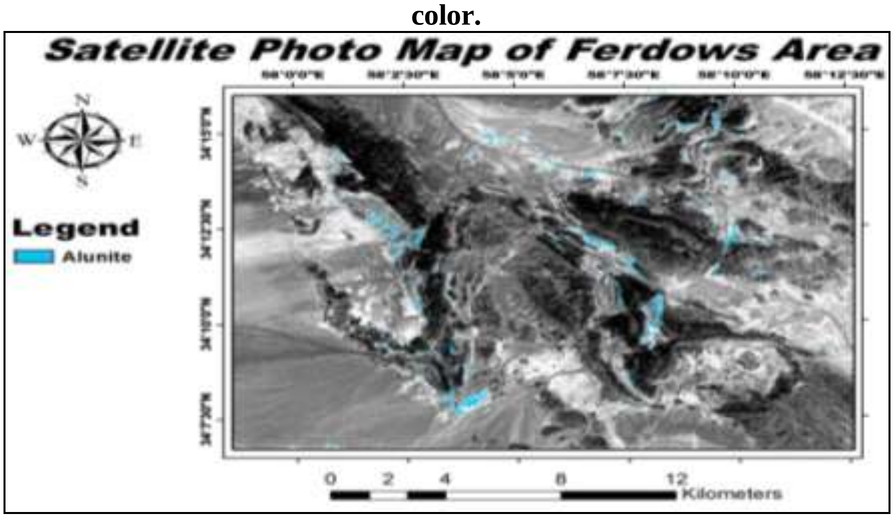

Figure 10: Using SAM to specify alunite alteration, areas with alunite appear as bright blue.

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Also to identify alunite alteration, distribution of the mineral alunite alteration index was determined by using spectral angle mapping (Figure 10).
In order to, identify propylitic alteration, as the next step, distribution of epidote and chlorite minerals in the alteration index was determined by using spectral angle mapping (Figures 11 and 12).

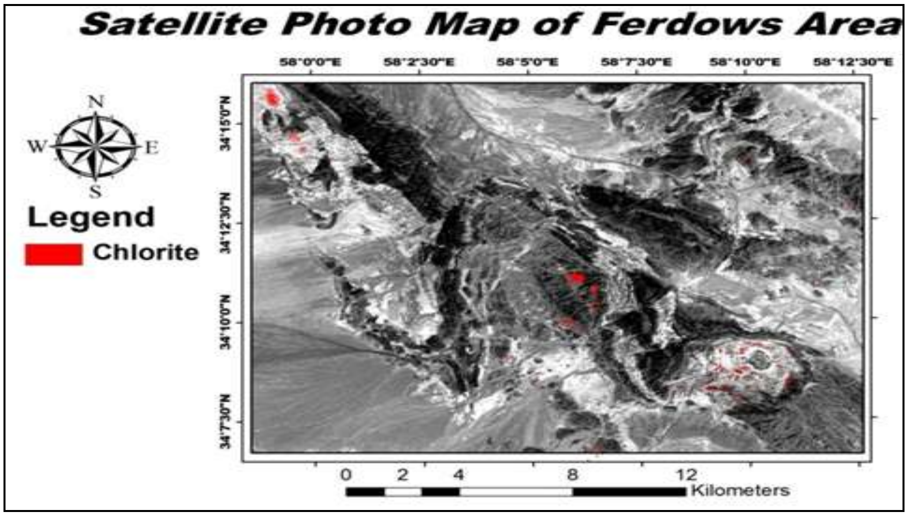

Figure 11: Using SAM to specify propylitic alteration, areas with chlorite can be seen as red.

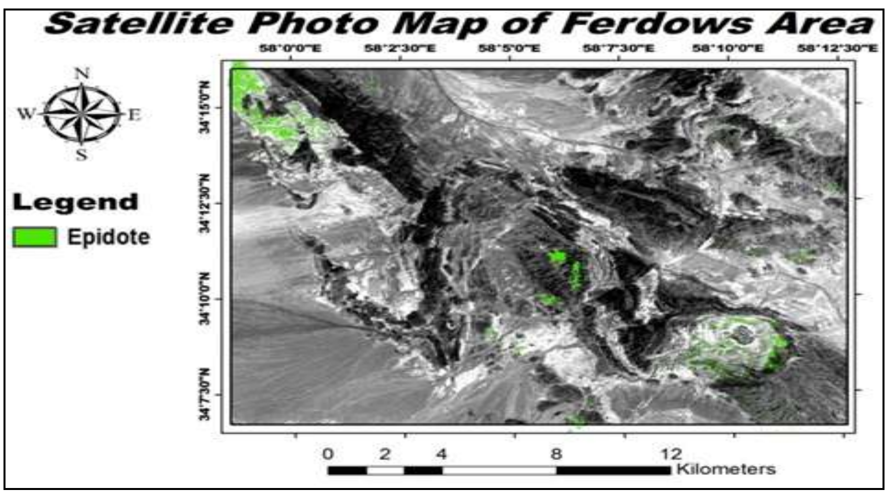

Figure 12: Using SAM to specify propylitic alteration, areas with epidote appear as green.

RESULTS AND DISCUSSION

By using the technique of spectral angle mapping data from ASTER, argillic and propylitic alteration of ore-mineral distribution were extracted. The data showed that the distribution of kaolinite, montmorillonite and dickite for argillic zones, overlap well with those obtained from Landsat-8 images. Also, due to the high accuracy of spectral angle mapping techniques, kaolinite in those tuffs of the area during supergene processes (plagioclase feldspars are converted to clay minerals), which their identification in hand sample is not possible, were also determined. Since the region's richest Polymetal reserves (Anaroon Deposit), which is a supergene mineralization (Magnanimity and Associates, 2013) is identified by its high kaolinite content illustrated by the processed image. Due to the abundance of kaolinite in the volcanic units, this technique can be applied for identification of supergene mineralization zones.

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