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Research Paper

Processing of ASTER Satellite Images Using the Fractal Concentration-Area Method

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Abstract: The Zafarghand area is located as a porphyry Cu deposit in the northeast of Isfahan and the southeast of Ardestan, which is a part of the Iran-Central structural zone; More precisely, it is located in the Urmia-Dokhtar volcanic belt. In the porphyry Cu deposits exploration, identifying and determining the alteration zones is of special importance. The aim of the present study is to identify and highlight the alteration zones of Zafarghand area, with the help of fractal geometry in the processing of ASTER sensor satellite images. Accordingly, considering the raster nature and digital form of satellite images, the digital number values of each pixel from the image matrices were considered as samples in a systematic network. Finally, the algorithm of the Concentration-Area (C-A) fractal model was implemented as an efficient method for determining anomaly samples in the set of digital number (DN) values of ASTER satellite image pixels. The alteration zones identified with the help of the aforementioned technique based on their expansion in the region represent the very effective performance of this method. So that, especially in the case of phyllic and propylitic alterations, there is a very high correspondence between the results of satellite image processing and the spread of alterations in field studies. The non-identification of potassic and argillic alterations in the obtained results is also directly related to their limited expansion in the study area. Finally, it could be acknowledged that the application of the fractal C-A method (considering its structural nature) in decision-making has been successful and has proven to be very effective in determining the alteration zones in the Zafarghand area.

Keywords: Fractal geometry, C-A model, Image processing, ASTER, Zafarghand.

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INTRODUCTION

Fractal geometry is widely used to estimate thresholds and effectively separate the geochemical anomaly from the background. By analyzing the variation in their fractal dimension, anomalous patterns could be identified and distinguished. In areas where there are no anomalies in a specific geochemical variable, and only the background is present, the distributions diagram for that variable will show minimal fluctuations. Consequently, the fractal dimension will be close to 2. However, when the variable surpasses the normal range and enters the realm of anomalies, the appearance of high peaks in its variability causes an increase in the fractal dimension, proportional to the intensity of the anomaly. This allows for the differentiation between background and anomalous values by comparing the fractal dimensions of the two populations. Several studies have examined various algorithms and methods for calculating the fractal dimension. These include variogram analysis, the N-S (Number-Size) model, the C-A (Concentration-Area) model, the C-V (Concentration-Volume) model, the C-P (Concentration-Perimeter) model, the C-N (Concentration-Number) model, and the fractal model of power spectrum-area.

Given the importance of The Zafarghand exploration area, this research focuses on processing satellite images from the ASTER sensor in order to identify surface geochemical alterations in this area. Therefore, the C-A fractal model is utilized for satellite image processing, which is recognized as an effective method in separating geochemical anomalies from the background and as an effective method in decision making.

CASE STUDY

The Zafarghand copper exploration area is located in the southeastern Ardestan, in central Iran, about 110 kilometers northeast of Isfahan. The deposit is situated in the west of Zafarghand, as part of the 1:100,000 Ardestan geological sheet, ranging from 52°23'55"E to 52°26'30"E longitude and 33°10'30"N to 33°11'52"N latitude [1]. To access the area, one can use the Ardestan-Naeen Road in the eastern part, the Ardestan-Isfahan Road in the central section, the Zafarghand-Zefreh Road in the southern part, and the Ardestan-Natanz Road in the northern part of the region. The studied deposit is located at the western margin of the Central Iran structural zone and on the central part of the Urmia-Dokhtar Magmatic Arc (UDMA), which, similar to other porphyry copper deposits in Iran and worldwide, has a magmatic origin [1].

MATERIALS AND METHODS

In line with the main objective of this study and for highlighting various geological anomalies and important indicator minerals in the assessment of mineral potential in the study area, ASTER satellite images will be utilized. The ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) sensor is mounted on the Terra satellite and was launched into space in 1999.

Cheng et al. (1994) proposed the C-A fractal model, which could be used to identify the geochemical anomalies from geological background [2]. The C-A method is based upon a very simple empirical set of equations, which may be used to define the geochemical background and anomalies.

After performing the necessary preprocessing on the satellite images of the ASTER and data preparation, the C-A model algorithm is applied to the brightness values of each pixel, considering their coordinates and area. Finally, for enhancing the desired features, the Band Ratio (BR) method will be employed. Figure 1 illustrates the steps of this study in the form of a flowchart.

Finally, according to the accuracy observed in the obtained results, a final alteration map of Zafarghand area regarding propylitic, phyllic, and argillic alterations was prepared, which could be seen in Figure 2.

CONCLUSION

In this study, the application of the concentration-area fractal model as a structural approach for separating anomalous values from the background was employed to process satellite images (ASTER sensor imagery) and highlight the alterations of porphyry copper in the Zafarghand exploration zone in the northeast of Isfahan province. Considering the raster and digital nature of satellite images, and consequently, the existence of a regular matrix of DN values for each image, the C-A fractal model encounters a dataset similar to systematic data (similar to geochemical data). The results showed that based on the structural nature of the C-A fractal model to separate anomalous values, using this method is very effective in processing raster-based satellite images. So that in the obtained results, it was observed that, due to the decision based on

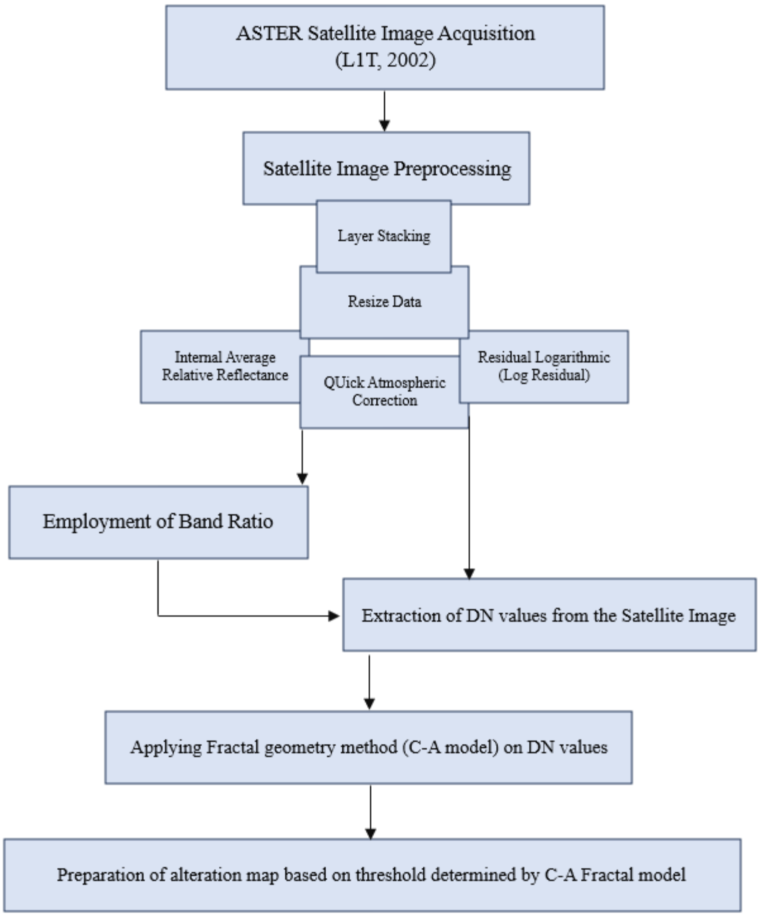

Figure 1. The flowchart of various stages and the process of the task execution

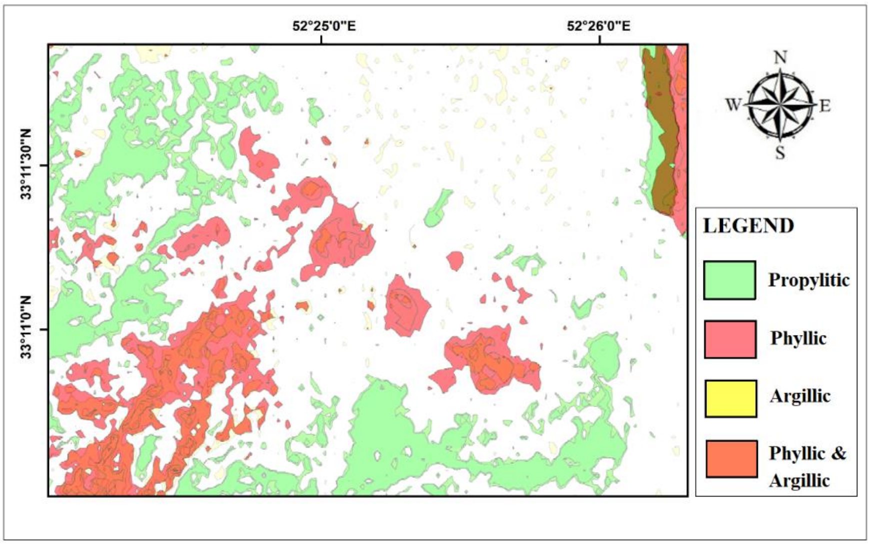

Figure 2. The alteration map of the promising areas using by the C-A fractal model in the ASTER image processing

the structural nature of this method, the DN values determined by the C-A fractal model in the matrix set of images have a good spatial correlation with each other. It was also observed that the results of the band ratio highlighting method based on the C-A fractal model in the matrix set of images show good agreement with the propylitic and phyllic alterations in the studied area.

REFERENCES

[1] Alaminia, A., Bagheri, H., and Salehi, M. (2017). *"Geochemical and geophysical investigations, and fluid inclusion studies in the exploration area of Zafarghand (Northeast Isfahan, Iran)"*. Journal of Economic Geology, 9(2): 295-312. (In Persian)

[2] Cheng, Q., Agterberg, F. P., and Ballantyne, S. B. (1994). *"The separation of geochemical anomalies from background by fractal methods"*. Journal of Geochemical Exploration, 51: 109- 130.