



(RESEARCH ARTICLE)



Produce feldspar mineral map using Spectral Angle Mapper (SAM) technique by hyperspectral image analysis

Mohammed Mejbil Salih ¹, Khalid I. Hassoon ², Mohammed A Almajeed A Alabas ^{3,*} and Samir Saify ³

¹ Geomatics Eng. Division, Civil Engineering Department, University of Technology, Baghdad, Iraq.

² Ministry of Science & Technology, Baghdad, Iraq.

³ Department of Civil, Faculty of Engineering, University of Babylon, Babel, Iraq.

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Abstract

The analysis of the hyperspectral image is an important method used in mineral detection. A map of the Feldspar mineral will produced for the study area, which lies to the west of the holy province of Karbala and limited in image that download from USGS website (type hyperspectral image from EO-1 satellite) , by using Spectral Angle Mapper (SAM) technique in the Erdas software, which is based on calculating the spectral reflection curve of any point on the image and the spectral reflection curve of feldspar mineral that is available in the spectral library of the software. For the purpose of verifying the results of the image analysis, ground truth (field work) was used by collecting 12 soil samples and finding the spectral curve for each sample by the spectral analysis device (ASD) and the result show the match between image and ground, where produced Feldspar mineral map.

Keywords: Hyperspectral Image; Erdas software; SAM; ASD; Image processing

1. Introduction

The Hyperspectral imaging is an emerging modern technique in remote sensing that expands and improves the capability of multispectral image analysis; it takes advantage of hundreds of continuous spectral channels to uncover materials that usually cannot be resolved by the multispectral sensor [1]. The method of mineral investigation requires great field work for the great human effort, long period of time and the seriousness of the work and its problems. To solve these problems, the hyperspectral image analysis will used ,where it will reduce the time of work , reduce the risk work and give primary indicate of mineral distribution. Two types of Feldspar minerals will be investigated in this research.

The advantage of hyperspectral imaging is the ability to characterize the inherent chemical properties of a sample. This is achieved by measuring the spectral response of the sample, i.e., the spectral pixels collected from the sample. Usually, a hyperspectral image contains thousands of spectral pixels. The image files generated are large and multidimensional, which makes visual interpretation difficult at best. Many digital image processing techniques are capable of analyzing multidimensional images. Generally, these are adequate and relevant for hyperspectral image processing. In some specific applications, the design of image analysis algorithms is required for the use of both spectral and image features [2],[3].

Therefore, the aim of this research is investigation of the Feldspar mineral by used remote sensing also to:

* Corresponding author; Mohammed A Almajeed A Alabas
Department of Civil, Faculty of Engineering, University of Babylon, Babel, Iraq.

- Determine the location of the work and available areas of the Feldspar mineral, which greatly facilitate the staff work.
- Reduce effort, cost of the field work, and the factor of time.
- The analysis of hyperspectral images of mineral detectors can be used to enter the field of investment by building plants according to minerals available in the soil.
- And production map of Feldspar mineral to help researcher, investor and the geologist in investigate at the mineral.

2. Study area and methodology

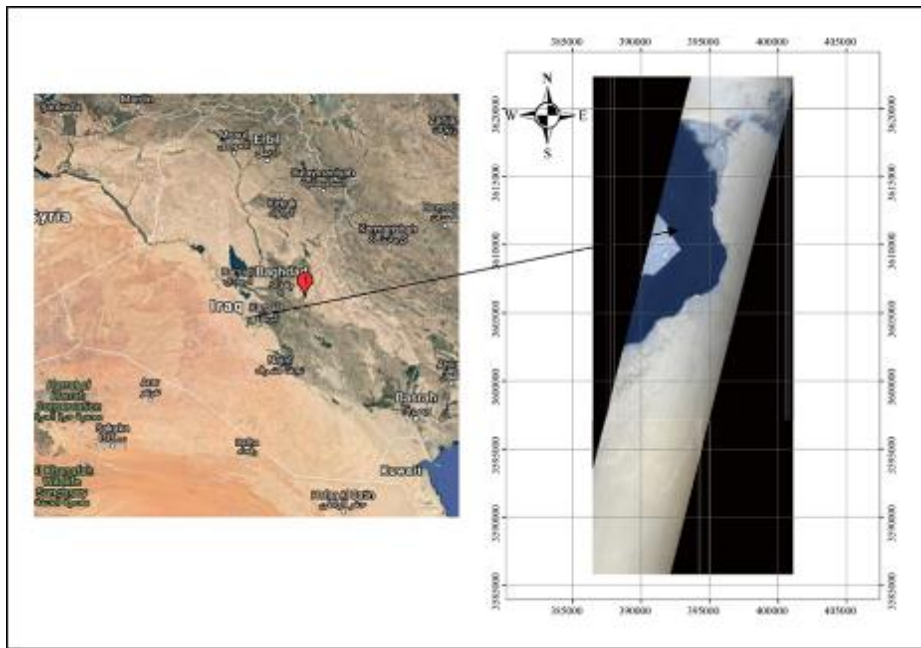


Figure 1 Study area

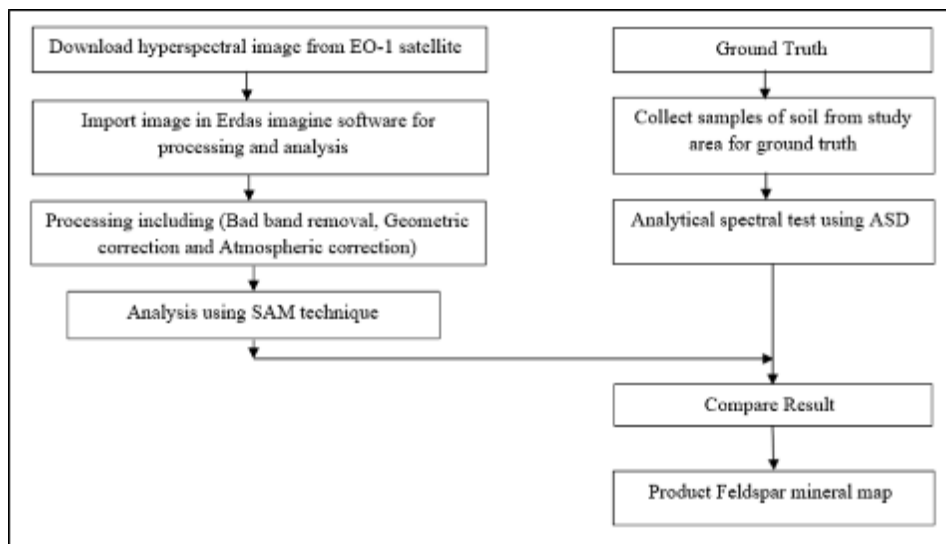


Figure 2 The flow chart of the methodology of the works

The study area is located to the west of the holy city of Karbala, represented by the area that is subtracted from the Hyperspectral image (EO1H1690372006325110PM_1R) produced from Hyperion sensor on EO-1 satellite that is shown in figure (1) [4],[5]. This area is very important because it is located on the main road linking the three provinces of holy Karbala, Al-Anbar and Al-Najaf Al-Ashraf.

Figure 2 shows the flow chart of the methodology of works.

2.1. Image processing

Image processing including geometric correction of image, bad band removal, spatial subset of image and atmospheric correction by use Internal Average Relative Reflectance (IARR) by using the Erdas software. These corrections are very necessary to decrease the error of the analysis of image this image shows in fig (3).

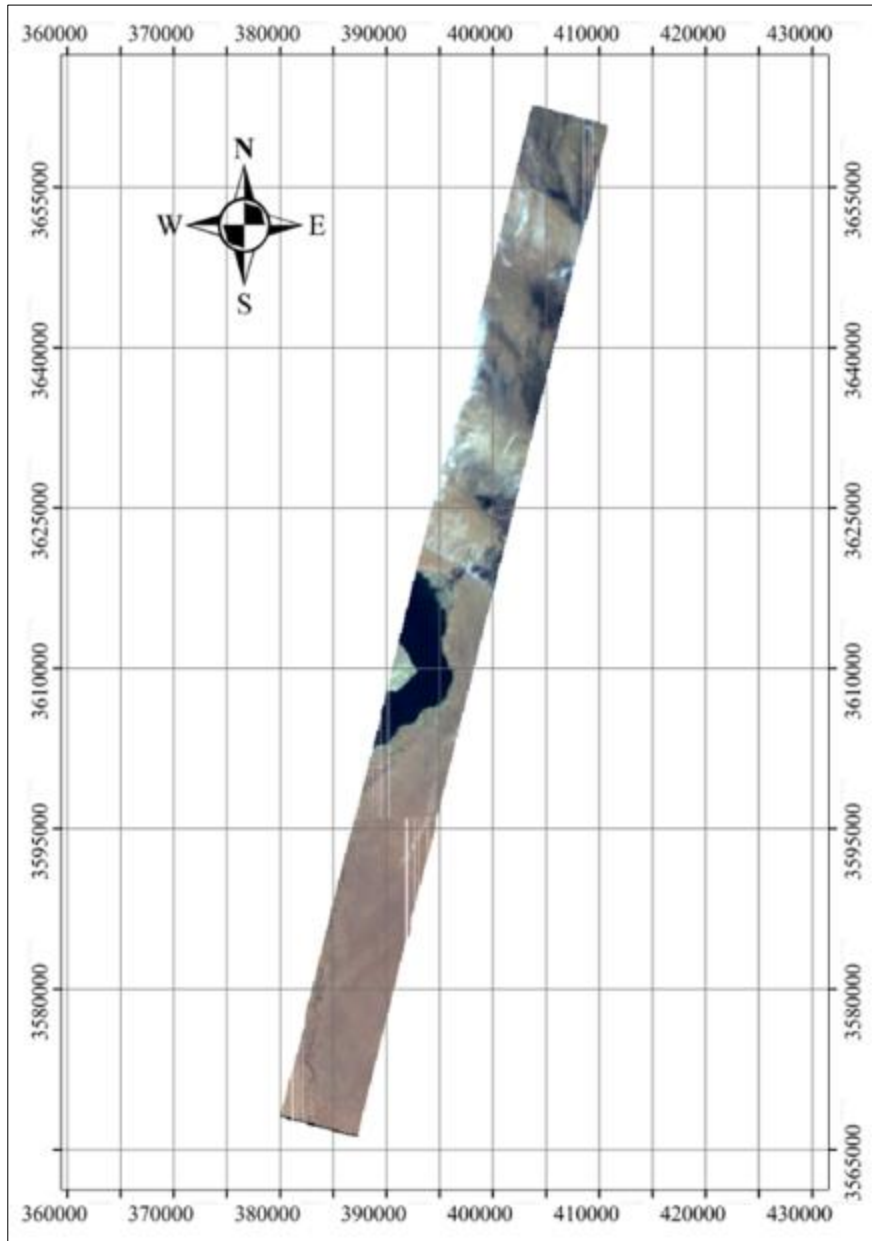


Figure 3 Corrected image

2.2. Image analysis

The SAM technique determines the similarity between unknown spectrum (pixels or bands) in the hyperspectral image and reference spectrum (spectral library) in the software. The value of angle from zero to 90°, where to apply the equation (1) to calculate the angle [1],[6].

$$\text{Cos } \theta = \frac{\sum XY}{\sqrt{\sum X^2 \sum Y^2}} \dots\dots\dots (1)$$

Where θ is the angle formed between the reference spectral and image spectral, X is the image spectral, and Y is the reference spectral (spectral curve of Feldspar from spectral library in Erdas software).

In this analysis the threshold value (the result of cosine law) was used to detect the target in the image equal to 0.95, which means the analysis will show the distribution of any mineral greater or equal 0.95. Therefore, the mineral whose value is closer to one will be selected.

Twelve points were located on image with coordinates listed in table (1) and shown in fig. (4) and used to calculate SAM values. This result shown in table (2) will compare with ASD result to improve the match between image analysis and ground.

Table 1 Coordinates of sites

point	N (m)	E (m)
1	3612469.43	396595.89
2	3611113.91	396633.94
3	3605840.10	394389.01
4	3604057.02	394083.10
5	3601602.61	393196.43
6	3599210.12	392283.75
7	3598498.20	392615.31
8	3597940.82	392896.38
9	3598767.17	390530.72
10	3597428.57	389028.54
11	3603643.78	395304.68
12	3603548.07	396211.30

Table 2 SAM value of mineral in image points

Mineral Type →	An-F	Mic-F
Sites/points ↓		
1	0.9753	0.9712
2	0.963	0.959
3	0.9606	0.9572
4	0.9402	0.9361
5	0.9058	0.9017
6	0.8746	0.8706
7	0.8544	0.8504
8	0.8157	0.8118
9	0.816	0.8121
10	0.9029	0.8988
11	0.9969	0.993
12	0.9969	0.9931

An-F: Anorthite (Feldspar) (NaSi,CaAl)AlSi₂₀8; Mic-F: Microcline (Feldspar) (K,Na)AlSi₃₀8

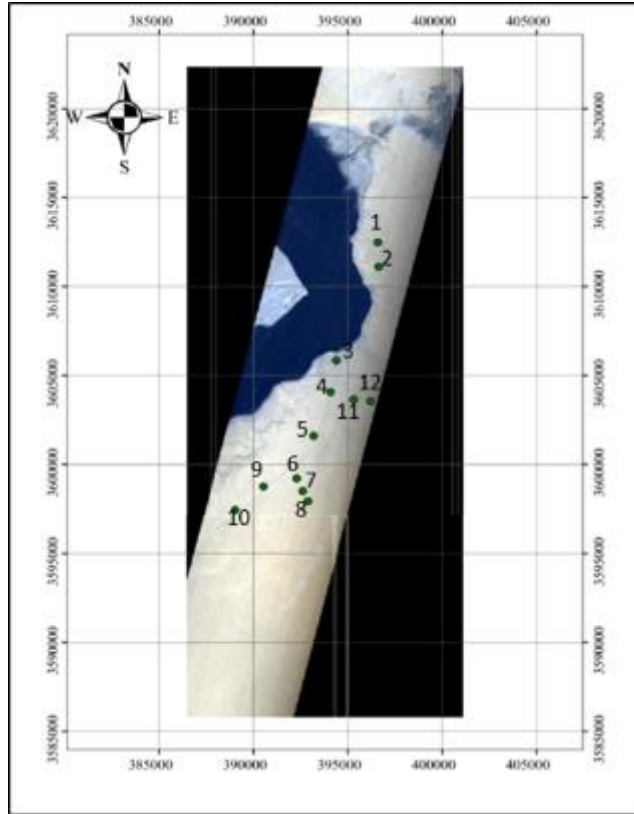


Figure 4 Points on image

2.3. Ground Truth

Table 3 SAM value of a mineral by using ASD test

Mineral Type →	An-F	Mic-F
Sites/points ↓		
1	0.9752	0.9963
2	0.976	0.9967
3	0.9655	0.9921
4	0.9726	0.9953
5	0.9675	0.9933
6	0.9742	0.991
7	0.9749	0.996
8	0.9626	0.9826
9	0.9675	0.9936
10	0.9617	0.9847
11	0.9698	0.9939
12	0.9772	0.9945

For check the result of Erdas software must be done the ground truth, where ground truth including soil samples collection from twelve sites in the study area, and they were tested in laboratory by using analytical spectral test (ASD) [7]. The test was done for the 12 samples where the results showed the spectral reflectance curves of these samples that shown in fig (5). The equation (1) is used to calculate SAM values too, Where X = spectral curve value of ASD result and Y = reference spectral (spectral curve of Feldspar from spectral library in Erdas software) [8]. Table (3) shows the result of SAM values, where these values are near to one that means there are Feldspar mineral

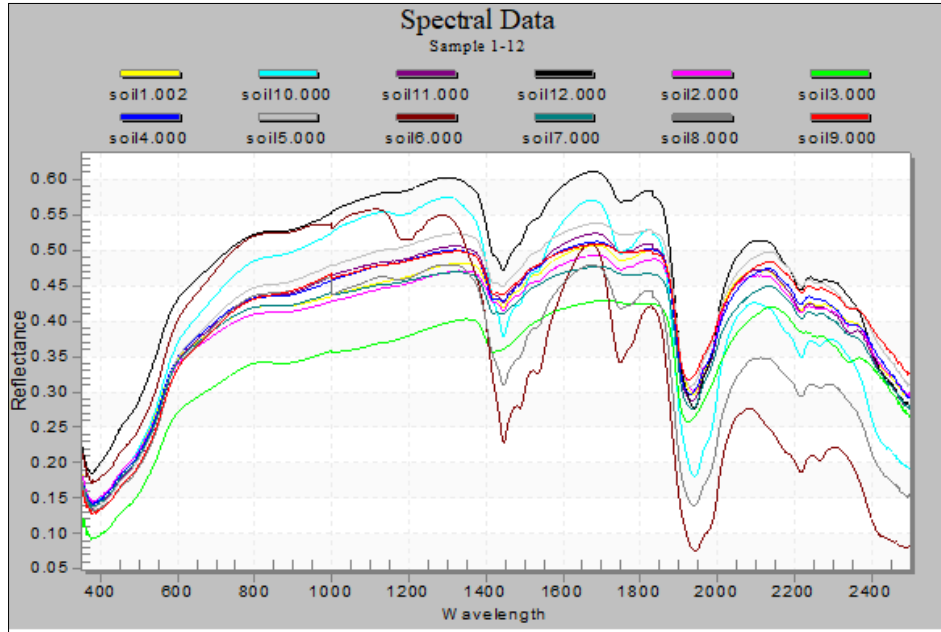


Figure 5 Spectral curves of twelve site by ASD test

3. Results and discussion

Figures (6) and (7) show the match between SAM values of image analysis and ASD test. After conducting the ground truth process, which proved that the results of the hyperspectral image analysis were identical to reality. According to the ground truth result, it possible to use the threshold in Erdas software equal to 0.9 to produce figure (8) that shows the distribution of Feldspar metal Map was produced in the study area by using GIS software [9].

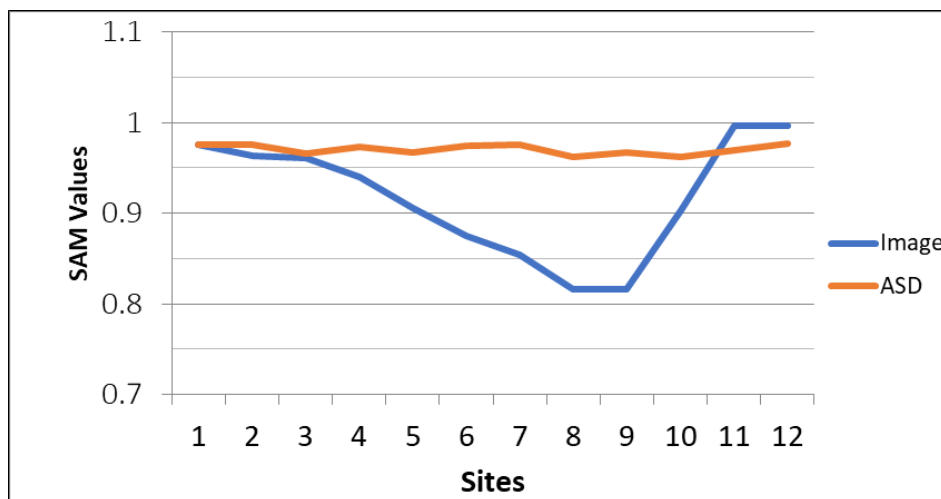


Figure 6 SAM values of Anorthite (Feldspar) (NaSi,CaAl)AlSi₂₀8

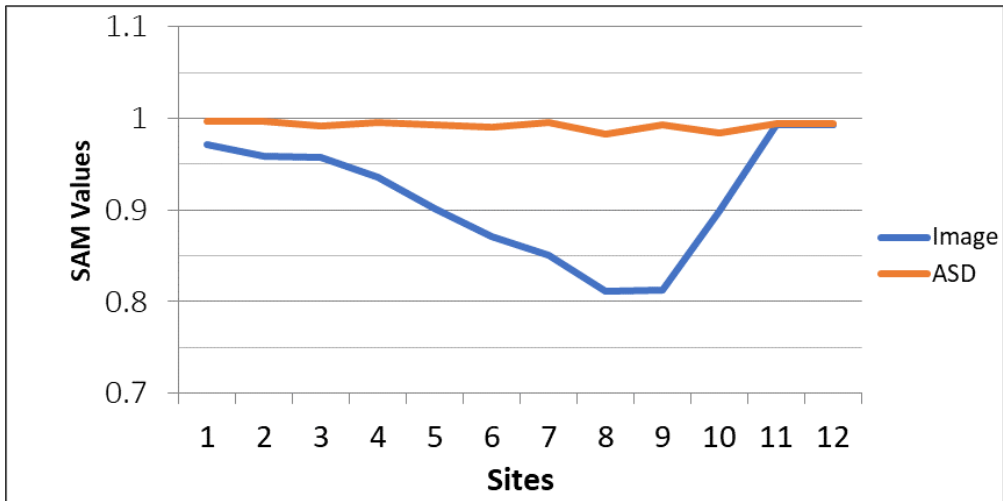


Figure 7 SAM values of Microcline (Feldspar) (K,Na)AlSi₃O₈

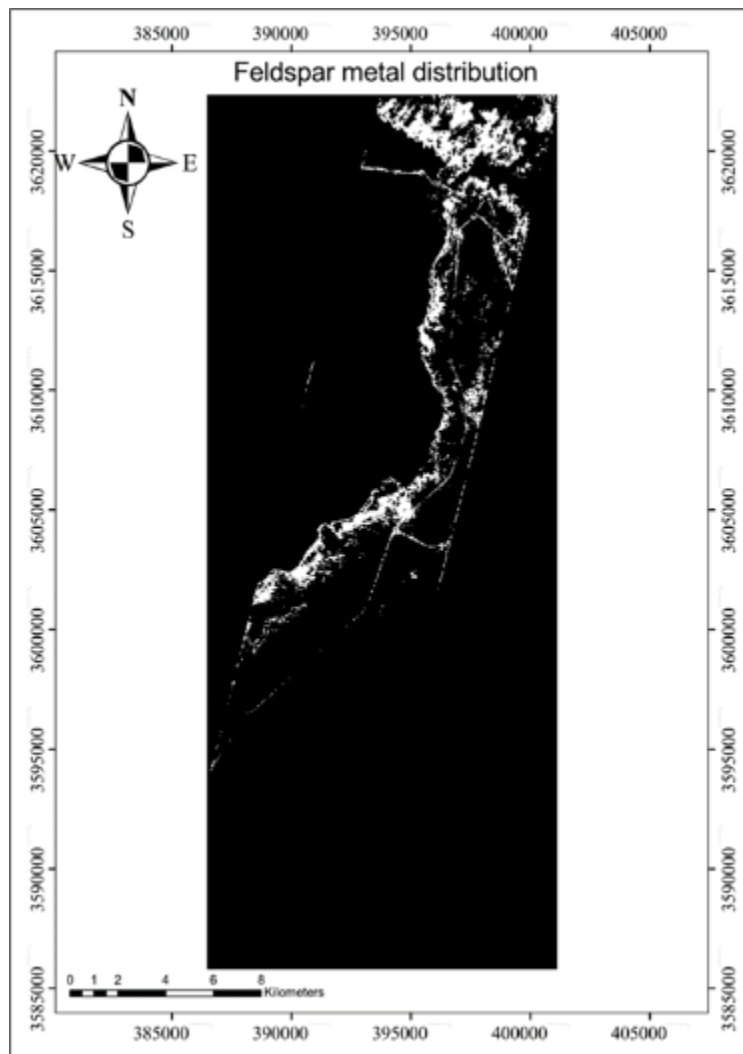


Figure 8 Feldspar Mineral distribution

4. Conclusion

- The use of hyperspectral images contributes significantly to the primary detection of minerals through the production of maps related to the investigation of minerals and their areas of distribution, which can help the competent authorities, researchers and investors in their work, where this use contributes in to reduce the human effort and time period and reduce the risk during the mineral detection process.
 - The use of SAM technique for the production of maps indicating more distribution of mineral in the study area.
 - The results show a large spread of Feldspar, which is used in many industries like the glass, paper, and optics industries.
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Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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