



Image Analysis of Remotely Sensed Data for Discriminating Fertile Granites in Egypt

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ABSTRACT

In the recent years, the younger granites in Egypt attracted a great of interest, due to their association with uranium anomalous and its economically important. Nuclear Materials Authority (NMA) considered the granitic rocks as one of the most important sources of uranium deposits so it conducted exploration programs to search for uranium mineralizations in Egyptian Deserts. These programs led to the discovery of radioactive anomalies and uranium mineralizations in the Northern, Central and Southern Eastern Desert of Egypt, besides Sinai.

The aim of this study is to discriminate uraniferous granite and determine the common characteristic as well as the spectral features of these granites as a template to aid the recognition of radioactive mineralization in the similar granites of Egypt. Therefore, an applicable model was designed and implemented to facilitate the manipulation of satellite image data, to support a flexible implementation of methods used to discriminate the desired granite. Moreover, this model can be applied in other areas to successfully expect the location of the other uraniferous granites in the Egyptian Deserts.

The study relied on 1) Satellite digital images of the visible near-infrared (VNIR) and shortwave infrared (SWIR) ASTER level L1B data, and 2) Airborne data of the Uranium (eU), Thorium (eTh), Potassium (^{40}K) and Total Count (TC) as text files.

This study aimed to integrate the ASTER imagery and airborne gamma-ray spectrometry data and manipulate these data for providing uraniferous granitic patterns using image processing techniques; and to explore the radioactive materials in granite. It also aimed to analyze these patterns to produce accurate potential maps for the fertile granites using GIS techniques in the Central Eastern Desert, Egypt.

The appropriate atmospheric correction method in this study is the Internal Average Relative Reflectance (IARR) which provides the most closely match spectra.

For better recognizing spectral signature anomalies, Minimum Noise Fraction (MNF) transformation has been applied to figure out which bands comprehend the coherent images, therefore eliminating noise from the multispectral data through calculating the eigenvalues of the image. It is found that to remove noise with eigenvalues' value will be close to two.

Several tools and techniques have been applied on the available data for the purpose of mapping mineralization and/or alteration zones such as false color composites (FCC), band ratio (BR), principal component analysis (PCA), decorrelation stretch, spectral angle mapper (SAM) and matched filtering (MF).

The images of the study areas were categorized using the Iterative Self-Organizing Data Analysis Technique (ISODATA) unsupervised image classification method. Different small areas were chosen to represent training samples of the region of interest in

the study areas. Then, the characteristics for these samples were studied and were consequently manipulated using GIS techniques to predict potential map of the fertile Granite.

The study recommended the usage of remote sensing techniques in studying land use which is considered to be as one of the less costly and higher spatial, spectral, temporal and radiometric resolutions in studying areas.

ABBREVIATIONS

ASD	Analytical Spectral Devices
ASTER	The Advanced Spaceborne Thermal Emission And Reflection Radiometer
ASTL1B	Aster Level L1b
BIL	Band-Interleaved-By-Line
BIP	Band-Interleaved-By-Pixel
BR	Band Ratio
BSQ	Band Sequential
CC	Correlation Coefficient
CED	Central Eastern Desert
CEM	Constrained Energy Minimization
CNT	Color Normalization Transformation
Corr	Correlation Coefficient
Cov	Covariance
dB	Decibels
DN	Digital Number
DOS	Dark Object Subtraction
DS	Decorrelation Stretch
EAN	Equal Area Normalization
ED	Eastern Desert
ELM	Empirical Line Method
EM	Electromagnetic
EMS	Electromagnetic Spectrum
EROS	Earth Resources Observation And Science
ETM+	Enhanced Thematic Mapper Plus
FCC	False Color Composites
FFC	Flat Field Calibration
FFT	Fast Fourier Transform
FLAASH	Fast Line-Of-Sight Atmospheric Analysis Of Hypercubes
FPCS	Feature-Oriented Principal Component Selection
GIS	Geographic Information System
GSD	Ground Sample Distance

GUI	Graphical User Interface
IARR	Internal Average Relative Reflectance
ICA	Independent Component Analysis
IDL	Interactive Data Language
IQM	Image Quality Measure
ISODATA	Iterative Self-Organizing Data Analysis Technique
JSS	Japan Space Systems
LIDAR	Light Detection And Ranging
LPDAAC	Land Processes Distributed Active Archive Center
LR	Log Residuals
LSU	Linear Spectral Unmixing
MAE	Mean Absolute Error
METI	Japan's Ministry Of Economy, Trade And Industry
MF	Matched Filtering
MLC	Maximum/Minimum Likelihood Classifier
MNF	Minimum Noise Fraction
MS	Multispectral
MSE	Mean Square Error
MTMF	Mixture Tuned Matched Filtering
NMA	Nuclear Materials Authority
OIF	Optimum Index Factor
PCA	Principal Component Analysis
Pow	Power
PPI	Pixel Purity Index
PSNR	Peak Signal-To-Noise Ratio
QUAC	Quick Atmospheric Correction
RGB	Red, Green And Blue
ROI	Region Of Interest
RS	Radiance At Sensor
RWT	Redundant Wavelet Transform
SAM	Spectral Angle Mapper
SAR	Synthetic Aperture Radar
SFF	Spectral Feature Fitting

SID	Spectral Information Divergence
SNR	Signal-To-Noise Ratio
SSIM	Structural Similarity Index Method
Std	Standard Deviation
SWIR	Short-Wave Infrared
TIR	Thermal Infrared
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VNIR	Visible Near-Infrared
WGS	World Geodetic System
XRD	X-Ray Diffraction

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CHAPTER 1

INTRODUCTION

An image is an easy and reliable medium for transfer of remote sensing information. It can convey position-related, size-related and other related information among different objects. In the context of our write-up here, images have been considered from a broader perspective, including those which a human eye cannot see.

Identifying materials by spectral measurements usually requires extensive field work, specialized skills and experience, sampling, chemical and mineralogical analysis. This is impractical when the goal is to identify materials or map materials over large areas. While airborne and spaceborne sensors have enabled to rapidly image large swaths of the earth, the large amount of data they produce makes it necessary to have algorithms that can process this data automatically. Therefore, our discussion focus on the analysis of remotely sensed images in its digital form representation (as numbers). Taking an example of brightness, simple mathematical tools (like addition, subtraction, multiplication, division) and up to some extent, even statistical tools, can be used to represent a new image of the same scene. But if the image is presented only as a photograph, no numerical manipulation can be done to it. Traditional methods of minerals exploration might be difficult to use due to highly earth complex topography, while the advantage of mapping by satellite imagery for its features application can be done by the imagery.

Remote sensing has been used in mineral exploration since the launch of the Landsat satellites (cooperative project between NASA and the U.S. Geological Survey) which have been orbiting the earth since 1972; and The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is launched in 1999; which is a cooperative effort developed by NASA and Japan's Ministry of Economy, Trade and Industry (METI). Remote sensing data has mainly used for identification of alteration zones and lithological mapping.

This study employs the use of satellite imagery and Airborne data. The imagery was chosen based on the spectral and spatial parameters. Therefore, ASTER data were used in this study.

ASTER data was used for geological mapping since it provides widespread spectral range and high spatial resolution for visible infrared bands. The current study aims to put forward an understanding of how to use data from remote sensing, more specifically ASTER images for geological mapping of the fertile granites plutons at the Eastern Desert (ED) of Egypt.

The Earth's surface reflects the solar radiation to satellite sensors which modify it by its interaction with the atmosphere. The objective of applying an atmospheric correction is to define apparent true surface reflectance values and to retrieve physical parameters of the Earth's surface, including surface reflectance, by getting rid of solar illumination and