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

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A Thesis Submitted to
Computer Science Department, Faculty of Computer and Information sciences, Ain Shams University
for the Degree of Doctor of Philosophy in
Computer and Information Sciences.

2019

# ACKNOWLEDGMENTS

First and for most I thank “**Allah**” for enabling me to attain new knowledge and experience through this work.

I dedicate this work to the memory of my dear father.

I wish to express my sincere appreciation to **Prof. Dr Taha Elarif**; Faculty of Computer and Information sciences, Ain Shams University; for his generous suggestions and valuable advice.

I have the greatest pleasure to express my deepest thanks, my sincere gratitude and appreciation to. **Dr Mohamed Aly Zaky El Zalaky, Dr Reda Ahmed El-Arafy** and **Dr Mahmoud Elsaid Hegazy** - Nuclear Materials Authority, for their keen supervision, continuous guidance, encouragement, support and fruitful suggestion, guidance and directions and remarkable effort also for high spirit to fulfill the best presentation of this work.

My deep gratitude to **my colleagues at work** for their cooperation and their help in conducting this work.

I would like to express my sincere gratitude to **Prof. Dr Mamdouh A.G. Hassan** my scientific spiritual father who unfortunately passed away a few months before the official Ph.D. dissertation. Prof. Dr Mamdouh believed in me like nobody else and gave me endless support. On the academic level, he taught me the fundamentals of conducting scientific research. Under his supervision, I learned how to define a research problem, find a solution to it, and finally publish the results. On a personal level, he inspired me by his hardworking and passionate attitude.

Last but not least, my gratitude and appreciation are due to **my family**, I am very grateful to **my husband, my daughter,** and **my son** for their understanding, and supporting. I give my deepest thanks to **my mother** and **my brother** for their continuous encouraging, worthless trust and endless support.

# 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 applyied 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