NOTICE CONCERNING COPYRIGHT RESTRICTIONS

DOE-CFE Geothermal Agreement

THE JOINT TESTING OF REMOTE SENSING TECHNIQUES AND EQUIPMENT FOR USE IN GEOTHERMAL EXPLORATION

Gregory D. Nash - UURI
German R. Ramirez Silva - CFE

PROGRESS REPORT for 1994

Introduction

This project was born out of talks at the second technical meeting. At that time is was decided that remote sensing techniques may prove to be useful to the CFE in geothermal exploration. To this extent, it was concluded that the best interest of CFE would be served through a two phase approach. The first was to test standard remote sensing techniques with low resolution spectral data (Thematic Mapper) to determine its usefulness in geothermal exploration on targets, specified by the CFE, in Mexico. The second was to organize an introductory hands-on training session to demonstrate state-of-the-art digital image and GIS processing equipment to CFE personnel. This would include an introduction to the use and processing of high resolution spectral data.

Planned Scope of Project for 1994

The scope of the project for 1994 was to:

1. Acquire Thematic Mapper (TM) data covering the area of interest.
2. Download the TM data for processing.
3. Process the TM data for hydrothermal alteration mapping.
    - 3a. Do vegetation masking for enhanced color ratio composite (CRC) production.
    - 3b. Do water masking for enhanced color ratio composite (CRC) production.
    - 3c. Create a CRC image.
    - 3d. Create a feature oriented principal component (FPCS) image.
4. Develop hydrothermal alteration maps from the above via GIS techniques.

Results to date

Two Thematic Mapper images were purchased by the CFE covering targets of interest located approximately between Puerto Vallarta and Guadalajara, including the Ceboruco volcanic area. This data was map oriented to a Transverse Mercator projection by EOSAT. Further processing of this data is being at the UURI geomatics laboratory.

The TM data has been down-loaded into UURI's digital image processing and GIS system. The data has been further processed in the following ways:

1. The data was vegetation masked. This was done by creating a normalized difference vegetation index (NDVI). The NDVI image was then classified to a GIS file by brightness values using cluster analysis. The classified data was examined to determine the range of brightness values representing vegetation. These values were then reset to 0, with non vegetation values being reset to 1.

2. The data was masked for water. This was done by creating a reverse vegetation index (RVI), which highlights water. The RVI image was then classified to a GIS file by brightness values using cluster analysis. The classified data was examined to determine the range of brightness values representing water. These values were reset to 0, with non water values being reset to 1.

3. The vegetation and water masks were then combined and used to mask out the unwanted values on the TM data by multiplication of the two data sets.

4. The masked TM data was then ratioed producing a CRC of 5/7, 3/1, and 5/4. These ratios create an image where relatively bright reds indicate OH^- and water bearing minerals, and calcite; where relatively bright greens indicate ferric iron bearing rock; and where relatively bright blue values indicate ferrous iron or limonitic rock. The combination of these various components results in colors that would be expected from basic color theory for additive colors. White and yellow often indicate hydrothermal alteration.

5. The unmasked TM data was processed using the FPCS method. This also produces a hydrothermal map which can be compared to the CRC map for validation purposes. The CRC and FPCS images can also often be processed using GIS techniques to create a more accurate hydrothermal map.

Plans for 1995

Plans for 1995 include finalizing the hydrothermal alteration maps, lineament mapping, and the visit from CFE personnel for equipment demonstrations and introductory hands-on training. The hydrothermal alteration maps will be processed using GIS techniques for refinement and improved accuracy. This data will be correlated with lineament maps and regional geologic trends, as interpreted from the TM data, to determine which areas are, and have been, most structurally conducive to thermal fluid flow. If budgetary constraints allow, it is suggested that this data be field checked in selected areas. It is also anticipate that CFE employees will visit UURI's geomatics center for demonstration and evaluation of digital image and GIS processing equipment and software, as well as hands-on training.