TESTING HYPERSPECTRAL DATA FOR GEOBOTANICAL ANOMALY MAPPING, DIXIE VALLEY, NEVADA, GEOTHERMAL AREA

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KEY WORDS

remote sensing, GIS, hyperspectral, geobotany, soil geochemistry, biogeochemistry, Dixie Valley, vegetal-spectral

PROJECT BACKGROUND AND STATUS

A number of studies are currently being undertaken for the characterization of the Dixie Valley, Nevada, hydrothermal convection system. This project consists of one individual component of the above, and an effort to synthesize data from other studies. These two components include:

- Characterization of vegetal-spectral anomalies potentially associated with faults located in northern Dixie Valley.

- The synthesis of data, both from existing sources and those being currently collected, into a comprehensive Geographic Information System (GIS) database for interpretation, modeling, and archiving purposes.

Nash and Wright (1996), and Nash (1995), found that spectral-vegetal anomalies were present at three study sites located over hydrothermal convection systems in Nevada. The vegetal-spectral anomalies are closely associated with biogeochemical anomalies, and often associated with soil-geochemical anomalies. This preliminary work indicated that high-spectral resolution (hyperspectral) data could be useful in geothermal exploration, however the work was done at the ground-level with a hand-held spectrometer. Therefore, to utilize this tool in a cost effective manner over larger areas, airborne hyperspectral imagery needs to be tested. Dixie Valley was chosen for this experiment as the area is well-characterized geologically, and advanced visible and infrared imaging spectrometer (AVIRIS) hyperspectral data had already been acquired through DOE funding for use in a USGS study.

Initial work on this project began during July, 1996. At that time field work was undertaken to collect vegetal-spectral and soil-spectral samples, and vegetation samples for biogeochemical analysis. Thus far, black greasewood (*Sarcobatus vermiculatus)* has been the focus in the vegetation analyses. Vegetation spectra are being collected at a 10 nm sampling interval across the visible and near infrared region, with soil spectra being collected at a 2 nm sampling interval across the short-wave infrared region.

Data collection transects, established by Hinkle (1995), and Hinkle and Erdman (1995) for soil gas, soil-geochemical, and biogeochemical work, are being used again for this study. Data analyses results from this study are being correlated with the results from the above previous studies. The data collected in the field effort will be used for ground-truth purposes for the interpretation of the airborne AVIRIS hyperspectral imagery. It is anticipated the AVIRIS data interpretation will begin during January, 1997, with follow-up field work to begin during May, 1997.

A GIS database has been initiated with the following data:

a. Soil gas data (Hinkle, 1995)
b. Soil-geochemical data (Hinkle and Erdman, 1995)
c. Faults

d. Biogeochemical data
e. Landsat Thematic Mapper imagery
f. Roads
g. Township and range.

An effort is now underway to collect all pertinent data related to the Dixie Valley hydrothermal system. All data collected in this effort will be added to the GIS. It is anticipated that the two-dimensional GIS will be augmented with three-dimensional data.

PROJECT OBJECTIVES

Technical Objectives

- Determine if geobotanical anomalies exist over the Dixie Valley hydrothermal convection system through the examination of vegetal-spectral data collected using a field spectrometer.

- Determine if correlations exist among vegetal-spectral, soil-spectral, soil-geochemical, and biogeochemical anomalies.

- Test AVIRIS hyperspectral data for geobotanical anomaly detection.

- Build a Dixie Valley geothermal GIS database to provide faster and better access to data for hydrothermal convection system characterization.

Expected Outcomes

- Generation of vegetal-spectral anomaly maps.

- Generation of soil-spectral anomaly maps.

- Generation of maps showing correlations among vegetal-spectral, soil-spectral, soil-geochemical, biogeochemical, soil-gas, and faults.

- Generation of Dixie Valley geothermal GIS database.

APPROACH

The approach for this project can be broken into three significant components. These include field work, data interpretation, and GIS database generation. Field work was initiated at the beginning of the project to begin characterization of spectral-vegetal anomalies and to correlate them with soil-geochemical, soil-gas, biogeochemical, and soil-spectral anomalies, and faults. The spectral data collected in this effort will also be useful as ground truth in AVIRIS data interpretation. Field work continued for ground truth purposes relating to final AVIRIS data interpretation.

Data interpretation has currently included the analyses of vegetal-spectral data generated in the field, and correlations of these data with biogeochemical data and soil-geochemical data. These analyses have included the use of visual-graphical and multivariate statistical methods including cluster analysis.

Data interpretation will begin on the AVIRIS data during February, 1997. AVIRIS processing will include atmospheric correction, georeferencing, and spectral unmixing. Spectral unmixing will be done to separate the components of mixed pixels. For the area of interest, virtually every pixel will consist of a mix of soil, rock, leaves, and stems. The vegetation and soil will be separated and unmixed to show spatial changes in their respective apparent reflectance curves. The unmixed data will then be analyzed to determine subtle changes from normal end-members.

GIS database generation will involve the input of all data relating to the Dixie Valley hydrothermal convection system into a georeferenced geographic form with linked tabular attribute data. This will initially be in a two-dimensional format with the latter addition of three-dimensional data.

RESEARCH RESULTS

Field work was started late into the season. Vegetation data collection was limited due to the dormancy of some species. For instance, leaves on little greasewood (*Sarcobatus baileyi*) were partially to wholly desiccated. As little greasewood was the most abundant shrub on the alluvial fans, data collection was limited to the valley floor where there was a relative abundance of black greasewood that were still actively photosynthesizing.

Initial analyses of black greasewood spectral data showed a clear variance of the lateral position of the red-edge (transition between the red visible and near infrared) through blue shifting. This was interpreted by finding the position, in nm, of the point-of-inflection (POI) of the red-edge. Figure 1 shows a graphical representation of normalized red-edge point-of-inflection data in comparison with a composite graph of soil-geochemical data derived from Hinkle and Erdman (1995). The soil-geochemical graph was created from the summation and normalization of Ag, As, Ca, Cd, Cu, Hg, H^+, Li, Mo, Pb, Sb, Sr, and Zn concentration values, which have been shown to be associated with the hydrothermal convection system. Soil-geochemical data is shown by a dashed line where high values indicate an anomaly. The POI values are shown by a ball-and-line pattern with blue shifts indicated by low values.

Four of the five lowest values on the POI graph fall within the soil-geochemical anomaly. The fifth, and lowest, POI value is an outlier that was probably generated from spectra acquired from a shrub that had partially gone into dormancy. The loss of chlorophyll in this case would cause an extreme value to occur. It should also be noted that no high POI values fall within the soil-geochemical anomaly. Breaks in the POI line indicate areas along the transect where no vegetation was available for spectral analysis. Similar correlations occur between the vegetal-spectral and biogeochemical data.

The results of this project thus far are encouraging. If vegetal spectral anomalies can be detected and correlated with other ground truth data from the AVIRIS data, then strong evidence will exist that this tool can be successfully used in geothermal exploration. The use of hyperspectral data analysis for geobotanical anomalies associated with hydrothermal convection systems would be especially useful in heavily vegetated areas, such as rain forests.

FUTURE PLANS

Future plans include (1) processing and interpretation of AVIRIS hyperspectral data for vegetal-spectral and soil-spectral anomaly interpretation, (2) field work consisting of biogeochemical sampling and field spectroscopy, and (3) continuation of the GIS database generation.

INDUSTRY INTEREST AND TECHNOLOGY TRANSFER

Organization	Type and Extent of Interest
Oxbow Geothermal	General exploration interest
Transpacific Geothermal	

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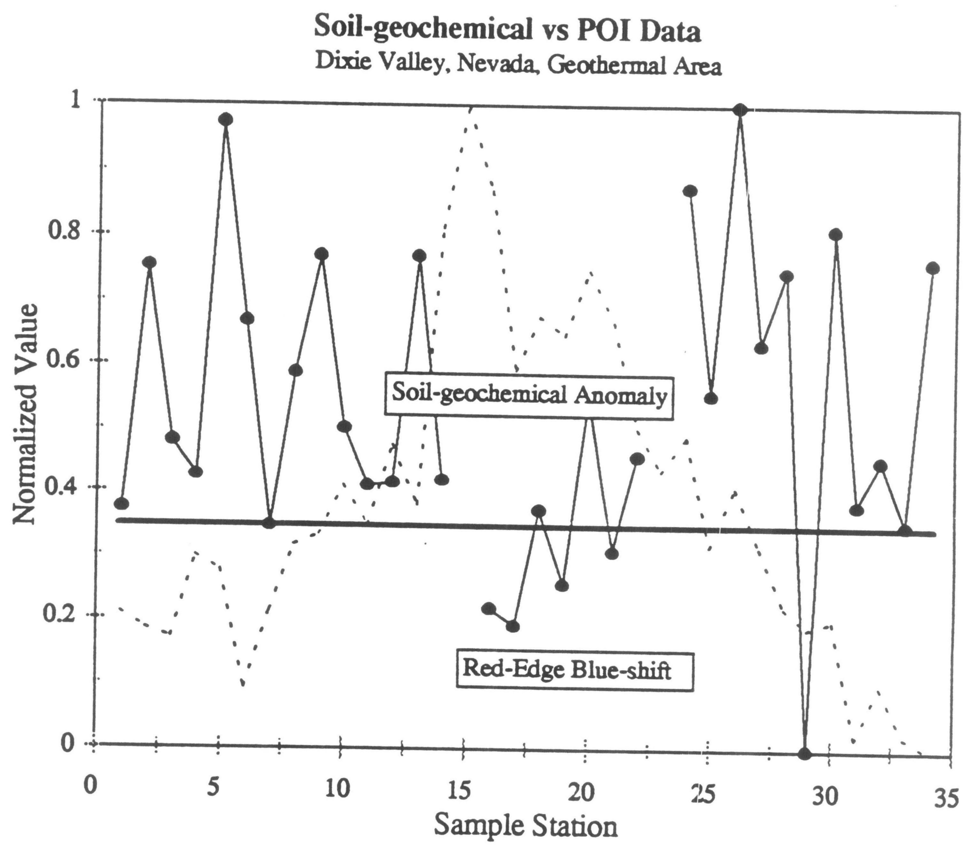

Figure 1. Correlation between POI and soil-geochemical values.