Integration of Remotely-Sensed Geobotanical and Structural Methods for Hydrocarbon Exploration in West-Central West Virginia

**Annual Report
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This report covers the first of the two years covered in the DOE grant to investigate structural and geobotanical features of hydrocarbon reservoirs in western West Virginia. The reader is referred to the three previous Quarterly reports for greater detail on tasks originally described in those reports. The progress of the project will be discussed with reference to the tasks identified for the project

Year 1.

Task 1. Obtain and process Thematic Mapper satellite imagery for initial vegetation types, properties and substrate.

The following satellite imagery has been purchased either directly by this grant, or indirectly through matching money provided by the State of West Virginia through the National Research Center for Coal and Energy (NRCCE):

Scene	Quality	Comments
April 10 1984	Some clouds, but they are mostly out of area of interest	
April 19 1987	Bad lines, but they are out of the area of interest	Lineament analysis, also useful for coniferous vs. deciduous vegetation discrimination
September 20 1985	Some thin cloud, affects short-wave bands more severely	Spectral anomaly associated with Volcano and Lewis County test sites
October 18 1995	<ol style="list-style-type: none"> 1. Some thin cloud, mostly over area to the West of area of interest, affects short wave bands more severely 2. Lewis County test site not imaged - will be replaced by data from adjacent path 	Useful for vegetation discrimination because of fall coloration of leaves

As noted above, the Lewis County test site was not imaged on the October 18 scene. This is apparently due to drift in the satellite orbit. Fortunately, I have been able to obtain data from the adjacent path, to compensate for this. The image was collected on October 29, 1989. This data has been georeferenced and has already been incorporated in the image library of the project.

Task 2. Imagery will be referenced to topographic map projections and analyzed using enhancement software and integrated with digitized geologic maps for correlation purposes.

The images have been georeferenced to a UTM projection, using USGS 1:24,000 7.5' topographic maps. All transformations have been carried out to an accuracy estimated to be better than 1 pixel. The coregistration of the image data sets facilitates comparisons between dates and the integration of the multi-temporal data. The images have been enhanced to produce standard simulated and false color image-maps of the area.

The bedrock geology has been digitized from the West Virginia Geological Survey's Geologic Map of West Virginia, 1:250,000 map (1968). (See attached map for example of overlay of map and geology). In addition, subsurface geology has been digitized. For the Volcano area, the structural contours on the base of the Huron Member of the Ohio Shale have been digitized (See attached map).

It is apparent from comparing the satellite imagery and the digitized geology that there is little influence of geological strata on the overlying vegetation. This is not particularly surprising, as the Permian and Pennsylvanian rocks in this area are fairly similar, comprising interbedded sandstones, shales and minor limestones. The fact that the substrate does not vary greatly is useful, as it effectively reduces the complexity of the problem - the necessity to stratify by rock type would have greatly added to the difficulties in interpreting patterns.

Task 3. Several enhancement techniques will be applied to the data to sharpen the imagery and define the response of the vegetation in the spectral bands and compute transformations into bands to maximize the identification of vegetation of interest.

Linear features in the April 19 image were enhanced through application of a 3 by 3 high pass filter. The original data was then added back to the filtered imagery, which were combined in the proportions of 0.8 and 0.2, respectively. The images were printed at a scale of 1 : 60,000.

The vegetation analysis was carried out using the spring and fall imagery. The spring imagery was acquired just prior to leaf-out, and provides excellent discrimination between evergreen and deciduous vegetation. The fall image (October 18, 1995) shows clear patterns of forest with dominant yellow and green fall colors. Consequently image classification has focused on the following six cover classes: Maple - Beech forest, Oak-hickory forest, Evergreen forest, Pasture, City/Road/Bare earth and Water. Automatic classification of this imagery, however, has been hampered by the dissected topography of the area. A large proportion of the image is comprised of areas that are in topographic shadows, and consequently have a different spectral response.

One way of suppressing this problem is a hyperspectral direction cosine normalization, in which the value of each band for each pixel is divided by the sum of the squares of the

values in all the bands for that pixel. The effect of illumination variations tends to be concentrated in the sum of the squares term, and the ratio tends to suppress that influence on the spectral response. For this data set an added complexity was caused by the previously mentioned high clouds. This necessitate a subtraction of a large, constant value from each band prior to the ratio. Unfortunately the cloud was not uniformly distributed throughout the scene, and thus the fact that a constant was used will distort the calculated spectral shapes somewhat. Furthermore, it was found that the signal was simply so low in the shadowed that the ratio imagery was extremely noisy. A vegetation map was produced using this data, but refinements are currently being pursued which will only use the hyperspectral direction cosine corrected data in the shadowed regions.

Task 4. Lineament analysis will be done by two independent researchers on the produced data sets. The results will be compared to gas well production in the study area and field sample analysis for hydrocarbons across the study area.

Lineament analysis was carried out by two independent observers (Warner and Donaldson), and only lineaments observed by both analysts were transferred to the final map. Field checking has shown that the lineaments that parallel the Burning Springs Anticline coincide with the sharp change in dip on the flanks of the fold. Although this does not necessarily imply any connection with fractures, it does lend support to a structural interpretation for at least some lineaments.

Comparison of the lineament interpretation to field soil gas measurements has been delayed by an unusually bad winter and wet spring. It is anticipated that as soon as the soils dries sufficiently to allow gas collection at the recommended four foot depth, the survey will be carried out. Furthermore, the comparison to gas production has also been delayed pending the acquisition of production data for the wells in the area.

Future work

Summer activities will focus on spectral reflectance collection and field gas sampling. In addition, a high priority will be to complete the comparison between the lineaments and gas production in the area.

The Digital elevation data for the area has been purchased, and is currently being mosaiced. One aspect of this data which will be investigated will be to compare the value of the topographic information for lineament interpretation. I am also keen to see to what degree the lineaments identified on the imagery can be also identified on the shaded relief images.

Equipment Purchases.

The Tektronix printer has been purchased, and has been central in developing hard-copy prints of the images, needed for field work and lineament interpretations. Approval has

been given by the Department of Energy to purchase the SUN workstation, however, we are still waiting on the University to process this paper work, so that we can place the order for the workstation.

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