



## Hydrocarbon Exploration Project Synopsis (Heavy Vegetation)

SpecTIR performed a fracture system structural analysis and applied a wide variety of digital image processing techniques to the airborne SpecTIR (ProspecTIR V-S sensor) data acquired over the client's area of interest in the south-central U.S.. SpecTIR also examined Landsat Enhanced Thematic Mapper (ETM+) and ASTER satellite data as well as color infrared air photos and a 10 meter DEM (Digital Elevation Model) over the area. The goal of the project was to detect spectral differences related to the presence of producible hydrocarbons in the subsurface and to develop methods for using the hyperspectral differences and the surface fracture analysis to explore for additional hydrocarbon accumulations in the area. Using this methodology, we have identified 51 exploration target areas we believe have a very high potential for hydrocarbon occurrence.

Most of the production in the fields examined was from the fractured xxxx Chert, which is structurally trapped in east-west trending faulted anticlines. Production rates and quantities vary greatly from well to well and appear to be related to the amount of fracturing in the chert. The project is based on the premise that almost all hydrocarbon reservoirs leak to some degree, and that the leaking hydrocarbons will be detectable in the near surface environment either directly as soil gas anomalies, or as changes in the composition of surficial rocks and soil, or as variations in the tree type or vigor of the vegetation communities over these areas of micro-seepage. The mineralogical changes that hydrocarbons produce in rocks and soils are fairly well understood and relatively consistent over a range of environments. The changes that hydrocarbons produce in vegetation communities are less well understood and highly variable from one environment to another. However, the work of Barrett N. Rock (formerly at the Jet Propulsion Laboratory and now at the University of New Hampshire; see Lang, et al., 1985) and his research associates has documented that there is a strong correlation between botanical properties and tree root structure (tap root versus lateral root structure) and a tree's ability to grow in hydrocarbon enriched soils. We used these findings and the SpecTIR hyperspectral data to identify and map the tree types and tree communities that are tolerant to hydrocarbon micro-seepage.

In Phase 1 of this study we examined the area in and adjacent to the localized gas fields. This was the first step in attempting to establish a relationship between the presence of economically producible hydrocarbons, surface fracture systems, and surface hyperspectral response. It appeared that several of the most highly productive wells lie on or close to north-south and north-northeast-trending fractures visible in the hyperspectral, satellite, and air photo images. In the context of geologic and well information that we had assembled and that the client had provided there were several image processing algorithms and enhancements of the SpecTIR hyperspectral data that appeared very useful. However, the image processing resulted in products that were multicolored, very complex, and provided too much detailed information that was difficult to understand. There were spectral differences between productive areas and areas outside of production and the highly productive wells in these

fields appeared to have similar discernable spectral signatures within vegetated areas that were different from the lower yield wells but we could not say that these signatures were unique, or that they were associated with a specific tree type or tree community, or that they could be extended to other locations in the area of interest.

To resolve these ambiguities, we performed field work at 37 sample sites scattered throughout the study area. Each of the sites was measured by establishing plots within unique vegetation classes. At each plot, the following measurements were performed:

1. GPS point data was collected at the plot center using Garmin E-Trex handheld units &, when available, a Trimble GPS unit.
2. A species map & description of the canopy (11.3 m radius plot) was made using the SpecTIR data,
3. Percentage Tree Canopy Closure was obtained along N/S and E/W transects using a tubular densiometer.
4. Photographs were taken of the canopy in N, S, E, W directions (magnetic).
5. Notes were taken regarding any additional unique features of the plot.

Using the results of this field work, extensive additional image processing was undertaken and a supervised image classification was performed to extract areas of hydrocarbon tolerant tree types. Hydrocarbon tolerant trees, for the purpose of this study, are defined as those species that have lateral root systems and other botanical properties associated with their root systems. The hydrocarbon tolerant tree types were combined into hydrocarbon tolerant tree communities and these tree communities were displayed as red pixels on a 10m, shaded relief DEM. A surface fracture system analysis was also performed using 1:50,000 scale, pan-sharpened (15m), 7,4,2 (R,G,B), Landsat ETM+ imagery, a 1:50,000 scale mosaic of the color-infrared air photos, and the 10 m DEM of the area. The integration and analysis of all of this additional work culminated in the selection of the 51 high potential exploration areas.

The exploration target areas were selected by overlaying the fracture system analysis on the shaded relief classification image and selecting areas where either fracture systems of multiple orientations or fracture systems of the more likely "open-standing" north-trending orientation coincided with areas of tree communities tolerant to hydrocarbon microseepage. This resulted in the selection of 51 exploration target areas where both conditions existed. The target areas are quite large but the areas where the fracture systems intersect are more likely to be highly fractured and these specific locations, in any given exploration target area, should be evaluated first.