CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Collection of Spectral and Water Content Data in Support of the IKONOS Satellite Image (20.01402.861)

DATE/PLACE: September 16–20, 2000 in Southern Nevada

AUTHORS: R. Fedors and D. Farrell

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PERSONS PRESENT:

David Farrell and Randy Fedors of the Center for Nuclear Waste Regulatory Analyses (CNWRA) and David Groeneveld (consultant) collected spectral profiles (incoming and outgoing near-infrared and visible light) and water content data on Jet Ridge, Crater Flat, and Amargosa Desert in southern Nevada September 17–19, 2000.

BACKGROUND AND PURPOSE OF TRIP:

This field work and the associated interpretation of satellite images are being used to confirm the U.S. Department of Energy's (DOE) data, modeling, and assumptions of selected aspects of unsaturated and saturated zone subissues currently being considered for issue closure. Remotely sensed imagery, ground-based information, and an integrated information system can be used to support a wide range of topics that are important for the Nuclear Regulatory Commission's (NRC) review of the Yucca Mountain (YM) as a high-level waste repository. Delineation of features on the recently purchased high resolution (1 m^2 pixel) IKONOS satellite image of the YM area will aid in the analysis of hydrogeologic features, geologic structures, and biosphere conditions present at the time the image was taken. The IKONOS satellite image and subsequent delineated features can also be used as a base map for interpreting the multitude of low resolution images taken from other satellites where there is a mixture of cover types in any one pixel. Temporal changes of geomorphology, soils, seep areas, farming practices, and natural vegetation can then be gleaned from lower resolution satellite imagery (e.g. 30 m by 30 m pixel of Landsat) taken over the past 30 years. The field data and satellite imagery will be organized into a geographic information system that related studies can use.

The focus of the field work was to collect spectral profiles and associated water contents reflective of different land cover types. Spectral data collected on the ground will be used to create a catalogue of spectral profiles associated with soils, pavements, bedrock, and vegetation to be used to assist in the interpretation of the IKONOS satellite image of the YM area. The satellite image was scheduled to be taken during the 2nd or 3rd week of September 2000. Obtaining the ground-based spectral profiles at approximately the same time as the satellite image will remove complicating factors associated with temporal variations in reflectance of soils and vegetation caused by fluctuations in soil water conditions. Concurrent measurements of incoming radiation will address sun angle and atmospheric variations. Analysis of spectral profiles collected at future times can use these initial catalogue entries as control points.

SUMMARY OF ACTIVITIES:

Spectral profile and soil water content data were collected in Crater Flat, Jet Ridge, Amargosa Desert, and Amargosa Farms for use in the interpretation of the IKONOS satellite image. Incoming solar radiation, or insolation, that is not reflected is either adsorbed or transmitted. Different materials reflect, adsorb, or transmit selected portions of the spectrum to differing degrees. A key assumption in the interpretation of remote imagery is that different cover types are spectrally separable.

Spectral profiles of cover types were obtained in the field using upward- and downward-facing probes connected by fiber optic cables to a portable Ocean Optics spectrometer. An upward-facing irradiance probe (cosine corrected) was used to collect the incoming visible and near-infrared profiles. A downward-facing collimating lense set to 6°-span angle was used to collect outgoing, or reflectance, profiles. The spectral range of the spectrometer is 360 to 900 nm wavelengths. The IKONOS satellite image collects multispectral data in 4 bands (blue, green, red, and near-infrared) as described in table 1 and collects panchromatic information as grayscaled data using the entire 400 to 900-nm wavelength range. Adjacent to locations where spectral data were obtained, water content was measured using a HydroSense domain reflectometer (TDR) probe. Soil samples were collected at selected sites where the TDR measurements were made so that laboratory analysis could be used to confirm the water content estimates.

Table 1. Spectral bands of the IKONOS satellite

Band	IKONOS Wavelength (nm) Range
Blue	450–520
Green	530–610
Red	630–720
Near-Infrared	770–880

Climatic Conditions

One of the technical specifications for the IKONOS satellite image is that the image is taken on a day with < 20 percent cloud cover. Given the climatic conditions of YM, it was expected that < 5 percent cloud cover would be easily attained. The weather conditions during this field work were conducive for the successful collection of a satellite image. The first 2 days were cloudless with light breezes and maximum daytime temperatures in the range 100° to 105°F. There were thin, sparse clouds on the 3rd day (September 19, 2000) with lower maximum temperatures. There was a slight haze likely caused by smoke from regional fires that reduced visibility slightly in the 5 to 10-mi range. There was no indication of rain in the forecast nor in the days immediately preceding the field survey. The occurrence of rain could drastically alter the reflectance of the ground surface. Local townfolk in Beatty, NV remembered a rain event during the last few days of August when asked about the signs of recent flooding in the motel parking lot. The Las Vegas airport registered 0.46 inches of rain August 29th and lesser amounts August 30–31. No precipitation was recorded during the month of September in Las Vegas. The Yucca Mountain Project (YMP) meteorological station data was not yet available, but may be released in preliminary form pending DOE approval of a NRC/CNWRA request. Since 1998 and 1999 data have not yet been released by YMP, it was anticipated that the August 2000 data may not be available in final form for a long time.

Water Content

Water content profiles and stream channel observations suggested that a rain event occurred sometime over the previous few weeks. As expected because of the focusing mechanism of runoff, the water contents generally appeared to be greater in the channels than in the sheet deposits between channels in Amargosa Desert and Crater Flat. The low water content near the ground surface in channels increased significantly in the 10 to 20-cm depth range, below which the water content appeared to decline with depth. The effect of evapotranspiration clearly reduced the near-surface water contents to extremely low values since the last rain event. Measured water content estimates ranged from 1 to 12 percent, though all of the near-surface estimates were in the range of 1 to 4 percent. These water content values are based on the developed regression relationship between the HydroSense readings and laboratory measurements of gravimetric water content.

Water content of the near-surface materials is important because the spectral profiles change drastically with changes in water content. Because of the high transmittance in the blue-green region and high absorption in the near-infrared region of the spectrum for water, a wet soil reflects less than a dry soil. Thus, the total amount of water in the soil affects the spectral profile. The grain size also affects the reflectance of the soil. For example, nearly dry coarse-grained (gravels) sediments have a lower reflectivity than fine-grained (silt/clay) sediments. When nearly saturated, however, coarse sand alluvial sediments have a greater reflectivity as compared to fine-grained sediments. The difference in reflectivity between wet and dry sediments is greater in the near-infrared range rather than the visible range.

Spectral Profiles

The ground-based measurements of spectral reflectance profiles contain the complete profile from 365 to 900 nm at a data resolution of 1100 points. The IKONOS satellite image contains data at 4 discrete bands (see table 1). When the satellite image becomes available, the high data resolution from the ground-based spectral profiles will be aggregated into the 4 discrete bands associated with the IKONOS image. In this report, only the ground-based measurements are discussed.

Spectral data can be collected at different scales. To utilize the satellite image, two scales were deemed to be important for data collection. First, spectral data were collected to represent a mixture of all features in an area. The IKONOS satellite image contains panchromatic data at 1-m pixel resolution and multispectral data at 4-m pixel resolution. Even at this fine resolution, some of the pixels in the satellite image would be mixtures of different cover types (though not nearly as much mixing as seen in, for example, 30-m, 78-m, or 1-km pixel sizes of other satellite imagery). Transects of profiles taken from 2–3 m above the ground were completed so that all the profiles within a transect could be averaged to obtain a representative profile for the terrain. Profiles from eleven transects were obtained by collecting spectral profiles at 1-m intervals along a 100-m line of mixed shrubs, grasses, boulders, bedrock, and soil.

The second scale of spectral data obtained was that of profiles of specific types of desert pavements, alluvial channels, colluvial deposits, bedrock outcrops, and vegetation. The measurements were taken at 1–2 m above the ground cover. For vegetation, this would be considered relevant to canopy cover, not spectra at the leaf level. Canopy and leaf scale spectra would lead to different profiles because of transmission and reflectance changes when there are a bunch of leaves, and because of less than 100 percent leaf coverage of the ground below the plant. Multiple spectral profiles of these features were obtained at each location so that a representative profile could be obtained, thus avoiding the bias of an individual reading at a particular site.

An example of the spectral profiles is included in figure 1. The insolation profiles vary throughout the day and can be used to normalize the reflectance profiles. The insolation profiles also vary slightly with location because of reflectance from surrounding elevated terrain.

A reflectance factor can be calculated by normalizing the profile reflected from a cover type to the insolation. This removes the effects caused by temporal (sun angle and changing atmospheric conditions) and spatial (reflectance from elevated surrounding terrain) variations in the insolation. Figure 2 illustrates the differences between two different desert pavements and between two different plants. The older terrace contains a stronger eolian component in the sediments at the surface than the younger terrace, though the difference in the spectral profiles may also be caused by different source material. More work would be needed to identify the subtle differences in the terraces causing the different reflectance profiles. For comparison, the profiles of creosote and alfalfa are also plotted on figure 2. Alfalfa more strongly absorbs and transmits the visible portion of the electromagnetic spectrum and more strongly reflects the near-infrared portion as compared to creosote.

Spectral profiles of alfalfa (figure 2) and sudan grass in irrigated fields of Amargosa Farms were collected. In addition, vegetation in the Amargosa Farms area was quickly mapped by visual observation from public roads. This will be useful for identification and interpretation of the satellite image. Vegetation in center pivot and flooded irrigation fields were identified, or noted as abandoned or plowed under. The abandoned fields were identified by the presence of desert grasses and shrubs, of which bursage and creosote were the most common.

CONCLUSIONS:

The field work successfully collected data that will be used to interpret satellite imagery at YM.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

Collection of additional profiles directly over the proposed repository and the surrounding areas of YM are pending DOE approval of the workplan sent September 13, 2000. The first formal DOE response to the workplan (J.R. Dyer, 10/17/00) suggested that approval might be forthcoming pending the receipt of additional information and the agreement to conditions on the field work. The items necessary for the NRC/CNWRA work to proceed will be discussed in a teleconference call during the week of October 23–27, 2000. The items include a hazards analysis, a medical needs analysis, a statement of expected emissions or effluents, a statement of proposed access routes and possible disturbance to surface areas, the need for coordination with the Test Coordination Office, and the agreement to hold daily pre-work meetings to discuss safety and environmental considerations.

RECOMMENDATIONS:

To assist interpretations of satellite imagery for temporal changes over the past 30 yr, spectral profiles need to be collected after precipitation events to determine the relationship of water content with reflectivity for different soils. Additional cover types should be identified for collection of spectral reflectance data based on discussions with collaborating Key Technical Issue groups.

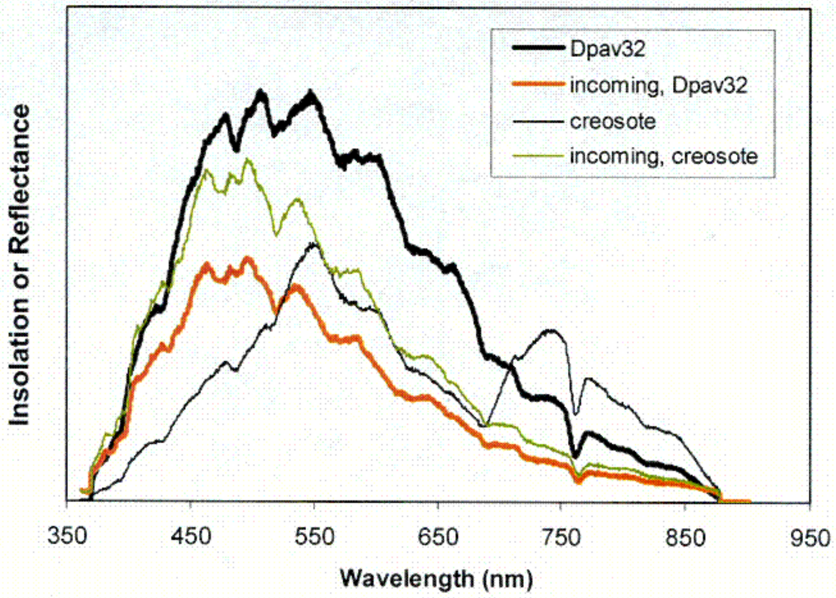

Figure 1. Spectral profiles of insolation (incoming) and reflectance of desert pavement (Dpav32) and creosote. Note the strong reflectance of creosote in the green and near-infrared regions.

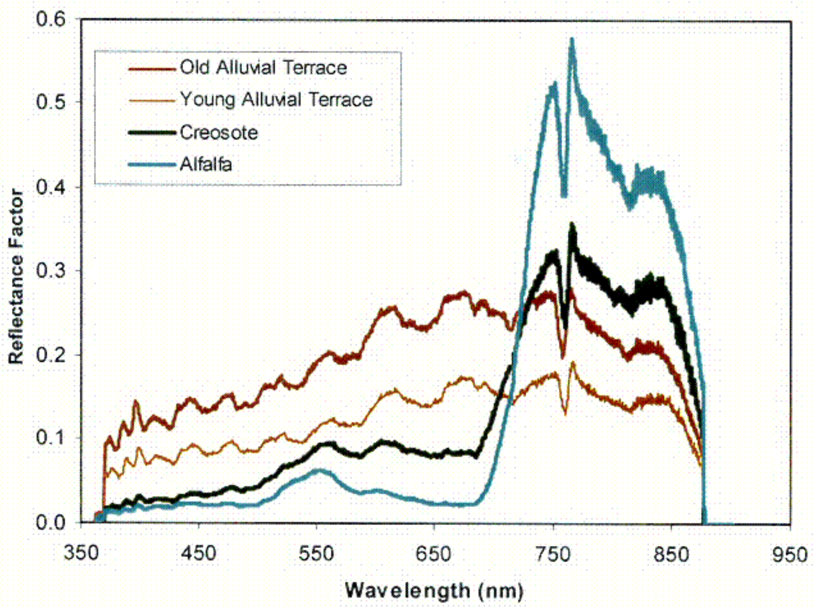

Figure 2. Reflectance factor profiles of young terrace deposits in Fortymile Wash, old terrace deposits in Crater Flat, a creosote bush, and alfalfa in an irrigated field

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SIGNATURES:

Randy Fedors
Geohydrology and Geochemistry

10/19/00
Date

David Farrell
Performance Assessment

10/19/00
Date

CONCURRENCE:

English C. Pearcy
Manager, Geohydrology and Geochemistry

10/20/2000
Date

Budhi Sagar
Technical Director

10/24/2000
Date