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PRELIMINARY STUDY OF KELSO DUNES USING AVIRIS, TM, AND AIRSAR

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1. INTRODUCTION

Remote sensing of sand dunes helps in the understanding of aeolian process and provides important information about the regional geologic history, environmental change, and desertification. Remotely sensed data combined with field studies are valuable in studying dune morphology (Breed et al., 1979), regional aeolian dynamics (Mainguet, 1984), and aeolian depositional history (Blount and Lancaster, 1990). In particular, active and inactive sands of the Kelso Dunes have been studied using Landsat TM (Paisley et al., 1991) and AIRSAR (Lancaster et al., 1992). In this report, we describe the use of AVIRIS data to study the Kelso Dunes and to compare the AVIRIS information with that from TM and AIRSAR.

2. STUDY SITE AND DATA

The Kelso Dunes, Mojave Desert, California, cover about 100 km^2 and range in elevation between 500 m to 900 m. The area of active dunes includes three large linear ridges (up to 170 m high) superimposed by 5-10 m high crescentic and reversing dunes and surrounded by 3-15 m high stabilized transverse and linear dunes (Paisley et al., 1991; Lancaster et al., 1992). Under present conditions, the prevailing westerly winds are counter-balanced by strong orographically controlled winds from the north, east, and south (Smith, 1984). This wind pattern accounts for the position of the dunes and the observation that there is little net change in dune location, even though there is active sand movement (Sharp, 1966). Smith (1967) suggested that the dunes formed under more arid conditions with stronger winds, and have since been modified due to climatic changes. The vegetation cover is less than 5% on the active dunes and 10-15% on the stabilized dunes (Lancaster et al., 1992).

3. METHODS

AVIRIS data (PG02031) used in this study were flown on May 21, 1994. The AVIRIS image data were radiometrically calibrated and were reduced to "scaled surface reflectances" using an atmospheric and solar model, ATREM (Gao and Goetz, 1993). The AVIRIS data were then compared with a Landsat composite image (Paisley et al., 1991) and AIRSAR data collected during the Mojave Field Experiment campaign (Arvidson et al., 1991).

A color composite AVIRIS image is used in this preliminary study. The bands were selected using a laboratory spectra plot of major minerals from the dune area so that the spectra are most separated at these bands (Figure. 1). Point counting of field samples show that most of the Kelso sands are composed of 29-49% quartz, 22-39% plagioclase, 18-29% K-feldspar, 5-15% other minerals including dark minerals. Some sites have highly concentrated magnetite (28%; Paisley et al., 1991). Finally, band #10, #89, and #184, centered at 0.46029 µm, 1.2028 µm, and 2.1073 µm respectively, were assigned red, green, and blue in the image analyzed.

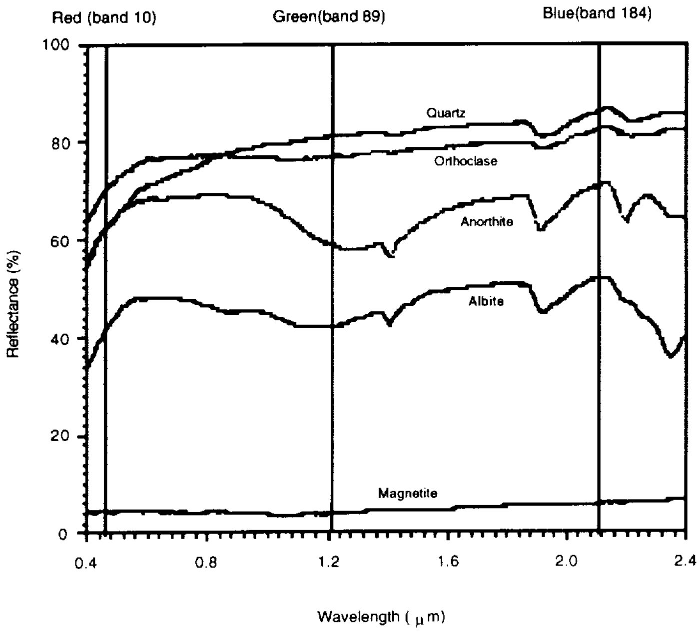

Figure 1. Band selection based on laboratory Spectra from SPAM spectral library (Mazer et al., 1988).

4. RESULTS

The composite AVIRIS image shows more color variation than the corresponding TM scene. The image shows not only the active and inactive units seen on TM and AIRSAR, but also an interesting feature which is not observed: the area to the west of Kelso Dunes is reddish in color and fades away toward the dunes. The same color can be traced to Granite Mountain, which is to the south of Kelso Dunes, through Devils Playground Wash. It has the same signature that is scattered on the large and small ridge of active dunes. This reddish color is on the north and south sides of the ridges which excludes the possibility of solar shadow affects. This signature is not observed on the more vegetated, stabilized dunes, thus excluding the possibility of vegetation. We suggest that certain mineral grains were eroded from rocks in the Granite Mountain, carried by the wash to the area west of Kelso Dunes, and transported to the active dunes by the prevailing westerly winds.

The widespread nature of the reddish color on active dunes on the image can be accounted for by major mineral components, i.e. quartz, plagioclase, K-feldspar, magnetite. The reason for a pixel to appear red is that the DN of the pixel at red band is higher than the DNs at green and blue bands. From the field sample point-counts and laboratory spectra plot, they may be plagioclase, K-feldspar, and/or magnetite. The reason for K-feldspar is that K-feldspar may have higher reflectance at 0.46029 μm, the red band, than other minerals. The reason for plagioclase or magnetite is that their reflectances at 0.46029 μm are closer to that of quartz and K-feldspar than at the other two bands. When the red band is stretched to compose with the other two bands, the red color appears for a pixel with high plagioclase or magnetite concentration. Yeend et al. (1984) noted the presence of areas rich in magnetite derived from local mountains. However, we cannot exclude other possibilities at this point. Further field work and use of mixing model analysis of AVIRIS data may confirm the hypothesis and narrow the possible minerals causing the reddish color.

5. CONCLUSIONS

In this study, AVIRIS data show promising results for analyzing sand dunes. AVIRIS provides higher spatial resolution and more spectral information than TM data. Future field work and unmixing analysis of AVIRIS data may lead to better explanations of material distributions around Kelso Dunes.

When comparing the AVIRIS, TM, and AIRSAR data, we find that AVIRIS data provide more information on mineralogy of the dunes and, thus, on the transport routes. The AIRSAR data provide information on the roughness of the dunes and on the vegetation. The TM data are useful mainly in obtaining a regional view.

6. REFERENCES

Arvidson R.E., S.B. Petroy, J.J. Plaut et al., 1991, "Mojave Remote Sensing Field Experiment", *EOS 72*, pp. 175.

Blount, G., and N. Lancaster, 1990, "Development of the Gran Desierto Sand Sea", *Geology 18,* pp.8183-8204.

Breed, C. S., Grolier, M. J., and J. F. McCauley, 1979, "Morphology and distribution of common 'sand' dunes on Mars: comparison with the Earth", *J. Geophys. Res. 84*, pp.8183-8204.

Breed, C. S., Grolier, M. J., and J. F. McCauley, 1979, "Morphology and distribution of common 'sand' dunes on Mars: comparison with the Earth", *J. Geophys. Res. 84*, pp.8183-8204.

Gao, B-C, K. B. Heidebrecht and A. F. H. Goetz, 1993, "Derivation of Scaled Surface Reflectances from AVIRIS data", *Remote Sensing of Environment*, Vol. 44, No. 2, pp. 165-178.

Lancater, N., L. R. Gaddis, and Ronald Greeley, 1992, "New Airborne Imaging Radar Observations of Sand Dunes: Kelso Dunes, California", *Remote Sens. Environ. 39*, pp.233-238.

Mazer, A.S., A. Martin, M. Lee, and J.E. Solomon, 1988, "Image processing software for imaging spectrometry data analysis," *Remote Sensing of Environ., 24*, 201-210.

Paisley, E. C. I., N. Lancater, L. R. Gaddis, and Ronald Greeley, 1991, "Discrimination of Active and Inactive Sand from Remote Sensing: Kelso Dunes, Mojave Desert, California", *Remote Sens. Environ. 37*, pp.153-166.

Sharp, R. P., 1966, "Kelso Dunes, Mojave Desert, California", *Geol. Soc. Am. Bull. 77*, pp.1045-1074.

Smith H. T. U., 1967, "Past versus present wind action in the Mojave Desert Region, California", In *U.S. Air Force Cambridge Research Laboratories Publication AFCRL-67-0683*, New Bedford, MA, 34pp.

Smith R. S. U., 1984, "Eolian geomorphology of the Devils Playground, Kelso Dunes and Silurian Valley, California", In *Surficial Geology of the Eastern Mojave Desert, California Field Trip 14* (J. c. Dohrenwend, Ed.), Geological Society of American, pp.162-174.

Yeend, W., J.C. Dohrenwend, R.S.U. Smith, R. Goldfarb, R.W. Simpson Jr., and S.R. Munts, 1984, "Mineral resources and mineral resource potential of Kelso Dunes Wilderness Study Area (CDCA-250), San Bernadino County, California", Washington, D. C., U.S. Geological Survey, Open-File Report 84-647.