PRELIMINARY ANALYSIS OF THERMAL-INFRARED MULTISPECTRAL SCANNER DATA OF THE IRON HILL, COLORADO CARBONATITE-ALKALIC ROCK COMPLEX

by

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1. GEOLOGIC SETTING

The Iron Hill carbonatite-alkalic igneous rock complex is in the Powderhorn mining district, approximately 40 km south-southwest of Gunnison, Colorado . The complex, which occupies about 30 km², was emplaced in metasedimentary and metavolcanic rocks during the late Precambrian or early Cambrian (Olson and Hedlund, 1981). The main rock types in the complex, from oldest to youngest, are fenite, pyroxenite, uncompahgrite, ijolite, nepheline syenite, and dolomitic carbonatite. The carbonatite is limonitic and forms an elliptically shaped 4km² stock. Calcitic and dolomitic carbonatite dikes are also numerous throughout the complex and in the pre-existing rocks. Pyroxenite is the most widespread rock type within the complex, but pyroxene is extensively altered to biotite, phlogopite, and vermiculite. Fenite, which formed through Na, K-metasomatism of the country rocks (Heinrich, 1980), typically contains more feldspar and less quartz than the equivalent unaltered country rocks. The other alkalic rock types are less widespread and less well exposed. Parts of the complex are covered by Oligocene ash-flow tuff and alluvial, colluvial, and glacial deposits. Sagebrush and grass cover is moderately dense to very dense at low to intermediate elevations; coniferous tree cover is dense at high elevations and on some north-facing slopes at lower elevations.

2. DATA PROCESSING

TIMS data were acquired of the Iron Hill area on July 22, 1990 from a mean altitude above terrain of 4000m. Weather conditions prior to the flight indicated that the ground was dry. Initial data calibration was conducted by assuming a linear relationship between the observed blackbody signals and the band pass fluxes at the hot and cold blackbody temperatures convolved with the spectral responses for the six channels (Palluconi and Meeks, 1985). The coefficients of this linear relationship were then used to convert the observed signals to equivalent fluxes. A generic spectral atmospheric correction for the path radiance, transmission, and downward sky radiance based on MODTRAN (Berk et al., 1989) was then employed.

Several methods have been used for extracting spectral emissivity information from TIMS data (Gillespie et al., 1986; Kahle and Rowan, 1980; Lahren et al., 1988; Watson and Raines, 1989; Watson et al., 1990; Gillespie, 1986; Hook et al., 1990; Kealy and Gabell, 1990). Decorrelation stretches have been commonly used (Gillespie et al., 1986), although they are of limited value because they do not yield interpretable spectral information.

In this study a new algorithm (Watson, 1992a) is used to compute spectral emissivity ratios, independent of any emissivity assumptions. This algorithm has the advantage that any of the possible emissivity ratios can be computed and, thus, a large variety of composite ratio images can be constructed, which permits examination of various geologic hypotheses based on the spectral properties of the surface materials.

Prior to processing the TIMS data, evaluation of laboratory reflectance spectra of field samples identified 13 TIMS ratios that might be useful for distinguishing the main rock types.

Initial analysis of these ratio images resulted in selection of the following images for detailed evaluation: $^2/_1$, $^3/_1$, $^4/_1$, $^5/_1$, $^1/_6$, $^3/_6$, and $^2/_5$. A vegetation mask, which was based on high $^3/_2$ digital numbers, was used to reduce the influence of vegetation on the contrast stretches and, hence, increase lithologic discrimination. The cause of the high digital numbers in vegetated areas in this and the other ratio images is not clear. The ratio images were then spatially filtered to remove scanline noise using a two-dimensional fast-Fourier transformation (Watson, 1992b) and registered to a 1:24,000 topographic map. The registration was accomplished by first using a small set of control points to perform an affine transformation and, then, an inverse distance weighed algorithm (Hummer-Miller, 1990) was employed using over 100 control points.

3. INTERPRETATION AND CONCLUSIONS

Most of the alkalic igneous rocks (pyroxenite, ijolite, and uncompahgrite) are readily distinguished from the silica-saturated rocks (quartzite, granite, and ash-flow tuff)in each of several color-ratio composite images, especially those including the $^2/_1$, $^5/_1$, $^1/_6$, $^3/_6$, and $^3/_1$ ratios. This implied large spectral emissivity contrast is consistent with the markedly different laboratory reflectance spectra of these two rock groups. In general, quartzite, granite, and ash-flow tuff are spatially separable in the color-ratio composite images, but color variations within the alkalic-rock group may reflect the proportions of rock, soil, and vegetation, as well as rock composition differences. Although the carbonatite stock is distinctive from the alkalic rocks, it is difficult to distinguish from some of the other rock types.

Distinction of the carbonatite from tuff and from some granitic areas, and separation of the fenite from granite were only feasible using color-ratio composite images which had had the vegetation mask applied prior to contrast stretching. Several different masked color-ratio composite images were needed to display subtle spectral emissivity difference that are critical for mapping these lithologic variations. Discrimination of the carbonatite is hampered by the location of the weak CO_3 reststrahlen feature between TIMS channels 5 and 6.

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