SURFICIAL MATERIAL MAPPING OF AFGHANISTAN: A TOOL FOR ECONOMIC RECOVERY

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1. INTRODUCTION

Access to modern digital data sets can support and expedite the decision-making processes during the revitalization of the economic sector of Afghanistan. Successful management of natural resources depends upon credible and reliable scientific data and knowledge of resource occurrence and distribution within a country. Public and private sector resource developers require this information to guide planning and investment decisions. In 2004, the USGS signed a letter of agreement with the Islamic Republic of Afghanistan to collect hyperspectral data of the country to aid in this revitalization.

2. BACKGROUND

Imaging spectrometer data are detailed remotely sensed data. By measuring the interactions of sunlight with materials on the Earth's surface, scientists are able to identify reflectance properties related to the composition of surficial minerals and vegetation. Between August 22 and October 2, 2007, USGS scientists conducted a nationwide airborne hyperspectral survey over Afghanistan. The hyperspectral data were collected using NASA's WB-57 aircraft, which was based at Kandahar Airfield. The data (referred to as HyMap) were collected from an altitude of 50,000 feet in 218 flight lines, each line of data consisting of 128 channels in the reflected solar portion of the electromagnetic spectrum (0.4 to 2.5 microns) [1]. The resulting mosaic map of surface materials derived from the HyMap data were resampled to a pixel spacing of 23 meters for analytical use.

This project was a collaborative effort between the U.S. Geological Survey, NASA, and the Office of Secretary of Defense, with support from the Afghanistan Ministry of Mines and USAID. This is the first hyperspectral survey of an entire country and represents the single largest hyperspectral data collection by any agency or organization. The data will aid in assessments of the country's water, mineral, coal, oil, and gas resources, as well as geologic hazards. The synoptic nature of these data makes them ideal for characterizing geographic areas that are remote, difficult to access, and challenging or prohibitive to visit during field work.

3. DATA PROCESSING

The HyMap data were atmospherically corrected using a modified Atmospheric COrection Now Software (ACORN) and ground calibration scheme [2]. The data were processed using an ENVI/IDL (Environment for Visualizing Images/Interactive Data Language)-based software package, called PRISM [3] (Processing Routines in IDL for Spectroscopic Measurements). The surface materials have been identified and grouped into classes. These classes were selected based on several criteria, including the reliability of detection and discrimination of these materials using the HyMap imaging spectrometer, the importance of these materials to studies of the geology, mineral resources [4], and soil composition, the potential occurrence of these materials at the pixels size of the imagery, and the likelihood these materials will occur over areas large enough to be visible at the scale of this map. The MICA (Material Identification and Characterization Algorithm) module of PRISM does not force a pixel to match an entry in the spectral library and employs a threshold on band depth to avoid spectral discriminations when absorption features are very weak. Therefore, some pixels are not classified as containing any of the listed materials. Non-classification can also occur when absorption features are distorted because surface reflectance is poorly calculated or the signal-to-noise ratio of the image data is low. These conditions may arise for pixels on steep, north-facing slopes, when the sun angle is low, and for pixels shadowed by clouds. Minerals occurring abundantly on the surface and minerals in less abundance but with unique spectral features are robustly detected and discriminated by the method. However, minerals with similar spectral features are less well discriminated when mineral abundances

are low and/or the spectral features of vegetation interfere with the mineral signatures.

4. DATA SUMMARY

Afghanistan provided a nearly ideal physical environment for the collection of remotely sensed data. Surficial material maps based on USGS processing and analysis of the HyMap data provide mineralogical and structural details not seen on existing geologic maps. The spectral and spatial resolution of the hyperspectral data reveals details of previously undifferentiated geologic units and serves as a basis for the refinement of existing geologic data and maps. The surficial material maps show centers of alteration and variations in surficial mineralogy that can be related to volcanic activity. The data are being used as a tool to re-evaluate areas of known mineral occurrences. Reevaluation of known areas of previous mining activities with modern geologic data should encourage and accelerate redevelopment and provide incentives for private sector investment. The HyMap data have expanded the understanding of site-specific characteristics by mapping the spatial distribution of hydrothermal alteration minerals, the determining alteration assemblages and zones, and identifying variations in the oxidation state of iron-bearing minerals. The data, when combined with other modern geologic analytical tools such as airborne geophysics, have identified additional centers of probable hydrothermal alteration that warrant future investigations and analyses.

5. REFERENCES

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