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Airborne Thermal Infrared Multispectral Scanner Images over
Disseminated Gold Deposits, Osgood Mountains, Humboldt County, Nevada

M. Dennis Krohn
U.S. Geological Survey
Reston, Va. 22092

SUMMARY

The U.S. Geological Survey (U.S.G.S.) acquired airborne Thermal Infrared Multispectral Scanner (TIMS) images over several disseminated gold deposits in northern Nevada in 1983. The aerial surveys were flown to determine whether TIMS data could depict jasperoids (siliceous replacement bodies) associated with the gold deposits. TIMS data were collected over the Pinson and Getchell Mines in the Osgood Mountains, the Carlin, Maggie Creek, Bootstrap and other mines in the Tuscarora Mountains, and the Jerritt Canyon Mine in the Independence Mountains. The Osgood Mountain sites were flown by the National Space Technology Laboratory (N.S.T.L.) on mid-morning of 27 August at an altitude of 9150 m; no cloud cover was present.

The sediment-hosted disseminated gold deposits are a major resource for the production of gold in the United States. Gold is disseminated throughout the host rocks in submicroscopic particles, generally less than 5 micrometers (0.005 mm) in size. The sediment-hosted deposits are thought to be low-temperature replacement-type deposits, in which hydrothermal fluids dissolve carbonate minerals and in their place precipitate quartz and fine-grained gold. Prospecting for the deposits is based on geochemical sampling to detect anomalous concentrations of gold, mercury, arsenic, antimony, tungsten, and thallium. Little or no evidence for alteration is present on the surface in these deposits; hence the deposits are referred to as invisible gold, "no-see-em" gold, or bulk-mineable gold deposits. This lack of obvious surface alteration in the host rocks makes detection of disseminated gold deposits a challenge for remote-sensing technology.

A comparison of five major gold deposits in the western United States (Carlin, Cortez, Getchell, Jerritt Canyon, and Pinson) indicates eight geologic characteristics that may be detectable at the surface by different remote-sensing techniques. These characteristics include: 1) silicification of the host limestones to jasperoids, characterized by the Si-O band near 9.3 micrometers; 2) limestone host rocks, characterized by a relatively flat response between 8 and 12 micrometers, except for a sharp band at 11.5 micrometers; 3) organic matter, which is opaque in the near infrared, but may appear transparent in the thermal infrared; 4) argillic/phyllitic alteration characterized by several vibrational features between 8 and 14 micrometers; 5) intrusive rocks, characterized by a shift in the Si-O fundamental toward longer wavelengths with increasing mafic composition; 6) calc-silicate minerals possibly characterized by different structure of the bands near 10.8 micrometers; 7) hot-spring deposits which are not directly related to the disseminated gold deposits but show spectral characteristics at the surface related to hydrothermal alteration at depth; and 8) structural features

interpreted by photo-interpretation, which have an important effect on localizing the mineralization in the disseminated gold deposits.

TIMS data of the Osgood Mountains showed a high degree of correlation for the 6 spectral bands between 8 to 12 micrometers. Correlation coefficients were 0.99. Interband correlation was removed by the following steps: 1) a principal component (PC) rotation, 2) a histogram normalization, 3) low-pass filtering of the lower PC components, and 4) the inverse PC rotation. The effect of the transformation on the histograms was to greatly exaggerate small differences observed in the original and intermediate PC data. In the image data, TIMS channel 2 (8.6-8.9 micrometers) is displayed as red, channel 3 (9.0-9.4 micrometers) as green, and channel 5 (10.3-11.1 micrometers) as blue.

Silicification is the primary geologic characteristic depicted by TIMS. Six types silica-enriched areas are observed on the TIMS image:

- 1) Primary deposition - Osgood Mountain Quartzite
- 2) Diagenesis - Chertification of limestone
- 3) Quartz-vein emplacement - Metamorphic and structural veins
- 4) Jasperoid formation - Siliceous replacement of limestones
- 5) Geomorphic deposition - Quartz-rich alluvial fans and dune sand
- 6) Cultural artifacts - Mine tailings

Most of these features have distinctive morphologies. The larger features, such as the Osgood Mountain Quartzite and the mine tailings, could be discriminated on the TIMS image. The smaller features, such as the jasperoids and the chertified limestones, could not be adequately discriminated at the 25-m resolution of the flight. Density contrasts among these different forms of silicification may make thermal inertia a useful technique in delineating these silica-enriched units.

The interbedded clastic and carbonate rocks of the Preble Formation, a primary host rock for the disseminated gold deposits in the Osgood Mountains, appear to have silica content intermediate between the quartzites and the purer carbonate rocks. Some units that contain both siliceous shales and chert beds resemble the more siliceous units because of preferential resistance of quartz to weathering. A previously unmapped exposure of Preble Formation in a volcanic area was clearly shown on the TIMS data.

The large intrusive plutons of the Osgood Mountain are readily seen on the TIMS image, but smaller cross-cutting dikes are not resolved. Variations within the image appear to correspond to aplite dikes and quartz veins within the pluton. Calc-silicate alteration adjacent to the intrusive bodies, a former source of tungsten, is also seen in the TIMS image and can be distinguished from the more siliceous alteration associated with the disseminated gold deposits. Two younger basalt flows, mapped as the same unit on the geologic map, can be distinguished on the image. Since X-ray and chemical data of the two flows are similar, differences in surface roughness rather than composition may cause the distinctive colors on the image.

Several linear features are observed on the TIMS data as a combination of geomorphic features and tonal alignments. One linear feature was mapped in the alluvium east of the Getchell Mine. It corresponds to a structure mapped by a recent U.S.G.S. telluric survey that has electrical properties similar to the Getchell fault, the main zone of mineralization at the Getchell mine.

TIMS data seem to be a useful supplement to conventional geochemical exploration for disseminated gold deposits in the western United States. Siliceous outcrops are readily separable in the TIMS image from other types of host rocks. Different forms of silicification are not readily separable, yet, due to limitations of spatial resolution and spectral dynamic range. Features associated with the disseminated gold deposits, such as the large intrusive bodies and fault structures, are also resolvable on TIMS data. Inclusion of high-resolution thermal inertia data would be a useful supplement to the TIMS data.