Introduction

Demonstrating the effectiveness of hyperspectral sensors to explore for geothermal resources will be critical to our nation’s energy security plans. Discovering new geothermal resources will contribute to established renewable energy capacity and lower our dependence upon fuels that contribute to green house gas emissions. The use of hyperspectral data and derived imagery products is currently helping exploration managers gain greater efficiencies and drilling success. However, more work is needed as geologists continue to learn about hyperspectral imaging and, conversely, as data processors begin to understand how to apply certain target minerals, mineral assemblages, and temperature data to deliver meaningful hyperspectral data products.

Hyperspectral Sensors & Data Cubes

Multispectral sensors such as those on Landsat 7 or ASTER collect data over a few relative broad wavelength bands. By contrast, hyperspectral sensors can simultaneously collect image data across hundreds of narrow, adjacent spectral bands. Depending upon the degree of resolution, hyperspectral sensors can be installed on a variety of platforms including: hand portable, truck mounted, airborne or satellite platforms. A diagram showing the reflective and emissive spectral ranges across the very near infrared (VNIR), short wave infrared (SWIR), mid wave infrared (MWIR) and long wave infrared (LWIR) is shown in Figure 1, below:

Geothermal Exploration Tools

The exploration phase of geothermal energy strives to answer “where to drill”. Introducing an airborne hyperspectral survey early during the exploration process can help define and narrow the Area of Interest (AOI) and reduce the level of investment needed for later exploration phase surveys.

Hyperspectral Identification of Geothermal Mineral Deposits

A few example minerals that can indicate the presence of a hydrothermal system are listed below. Each of the five minerals has distinctive signatures (see Figure 3) and these can be mapped as mineral assemblage maps (see Figure 4).

- **Cinnabar (HgS)** – Cinnabar sometimes called “cinnabarite”, is a name applied to mercury sulfide, the common ore of mercury. Generally cinnabar occurs as a vein-filling mineral associated with recent volcanic activity and alkaline hot springs.
- **Tufa and Travertine (CaCO₃)** – Geothermal springs sometimes produce similar, less porous carbonate deposits known as travertine. Mono Lake, California, is famous for its Tufa columns – a form of travertine where CaCO₃ is precipitated when carbonate rich source waters emerges into alkaline soda lakes.
- **Opal – SiO₂·H₂O** – a hydrated silicic that usually includes 3-10% water content.
- **Chalcedony – SiO₂** chemically identical to quartz, but has a cryptocrystalline structure.
- **Quartz – SiO₂** – second most abundant mineral in the earth’s continental crust, comprised of a continuous framework of SiO₂ tetrahedra.

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