EXPLORING THE COMPLEMENTARITY OF SWIR AND TIR FOR AIRBORNE HYPERSPECTRAL MINERAL MAPPING

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1. INTRODUCTION

The ore deposit formation is usually accompanied by hydrothermal alteration of the host rock through which ore bearing fluids circulate. The chemical reactions between these circulating fluids and the host rock result in the formation of new mineral assemblages as the reaction attempts to attain equilibrium. Spectral remote sensing is an effective method for identification of hydrothermal alteration assemblages and has been adopted by geologists in mineral exploration due to its capability to cover large areas when compared with other conventional mapping techniques [1]. Shortwave infrared (SWIR) hyperspectral remote sensing has been used in mineralogical mapping extensively, however, the use of hyperspectral thermal infrared (TIR) remote sensing has been limited. Notable mineralogical mapping with TIR hyperspectral has involved the use of SEBASS dataset (e.g.,[2-4]).

The SWIR wavelength range can help identify mineral groups, like hydrated minerals, carbonates and sulfates, while others may be more clearly separable in the TIR wavelength range. With the recent progress in TIR hyperspectral remote sensing it becomes imperative to determine how minerals mapped with TIR can be linked to minerals mapped using SWIR for better understanding of the distribution of alteration minerals and alteration types.

This research examines which minerals can be identified by SWIR and TIR airborne hyperspectral data, and how information from both wavelength ranges can be combined into effective mineral maps that help the geoscientists on the ground. We use the Yerington district as a test area for two reasons: a) excellent exposure of different alteration systems and zones in one area and b) ongoing economic interests in the area. We determine spatial distribution and patterns of alteration minerals using SWIR and TIR airborne data, relate mineralogy to lithology and alteration, and compare mineral distribution pattern interpreted from SWIR and TIR data to distribution pattern derived from ground samples analysis and "traditional" alteration mapping.

2. THE YERINGTON DISTRICT

The Yerington batholith is a three stage, Jurassic intrusion of quartz monzodiorite to granite composition [5]. It was emplaced into Triassic to early Jurassic sediments and volcano-sedimentary rocks. The first phase (and possibly second phase) of the batholith intrusion caused the formation of garnet-pyroxene hornfels and pyroxene-plagioclase endoskarn at the contact with the sedimentary host rocks. The emplacement of the third intrusion phase also created a granitic porphyry dike swarms that cuts upwards through the system and are closely associated with porphyry copper deposits in the area. Towards the top of the original system, epithermal alteration with associated gold mineralization is present. The following mineral alteration zones can be distinguished in the area due to the many lithologies and alteration systems that are present: phyllic, potassic, sodic-calcic, advanced argillic, propylitic-actilinolite and skarn alteration. Additionally, post-alteration faulting with block rotation expose a 6 km vertical profile (including alteration zones of different paleo-depth) at today's surface [6], making the area highly suitable for mapping a large number of infrared active minerals.

3. METHODS

3.1. Airborne data

The airborne data for this study consists of large numbers of SEBASS and ProSpecTIR scenes. The Spatially Enhanced Broadband Array Spectrograph System (SEBASS) is a hyperspectral thermal infrared push-broom imaging system with two detector arrays covering the atmospheric windows between 2.0 and 5.2 µm (mid-wave infrared; MWIR) as well as 7.8 and 13.5 µm (thermal infrared or long-wave infrared; LWIR). For the work we present here, we focus on the LWIR data. The ProspecTIR-VS sensor is based on a SPECIM EAGLE and HAWK sensor combination (AISA) and is owned and operated by SpecTIR LLC. ProspecTIR acquires data from 0.4 – 2.4 µm, but for this work we focus on the 2.1-2.4 µm range.

3.2. Wavelength Mapping

Wavelength mapping is a method which quickly identifies patterns of dominating minerals in hyperspectral data by highlighting the wavelength of minimum reflectance (emissivity minimum in TIR data). A three point interpolation of the depth and position of the absorption feature is used (Fig 1). The interpolated depth and position information are fused into one image, where the color is an indication of the dominating "absorption" wavelength position and the intensity a measure of the feature's depth [7].

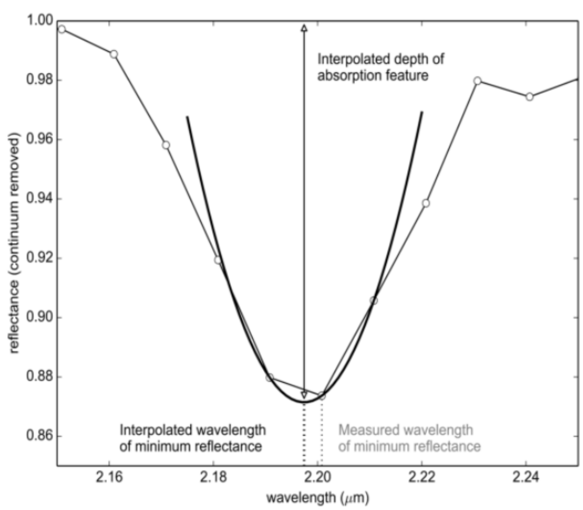

Figure 1: Interpolation method for determining the wavelength position of minimum reflectance of an absorption feature by fitting a parabola through three data points in the immediate vicinity of maximum absorption feature and applying continuum removal.

4. RESULTS

As an illustration of preliminary results, the skarn system is shown in Figure 2. It shows the dominating mineralogy in the SWIR (Fig 2 left) and the TIR (Fig. 2 right). The SWIR imagery very clearly differentiates areas with Al-hydroxyl minerals (e.g. sericite) in green hues from those dominated by Mg-Fe-hydroxyl (e.g. epidote, chlorite) in orange and red. However, an area of gypsum (blue box) and carbonate (magenta boxes) are not (or very difficult) to differentiate in the SWIR from the groups mentioned earlier. The TIR shows clear detection of areas with quartz (cyan), feldspars (green), carbonate (magenta), two types of garnets (orange and red) and gypsum (blue). The SWIR also differentiates readily between different compositions of carbonates (orange and red colors within magenta box) and of sericite (different shades of green from NW to SE). Future work focuses on the link between the airborne results, ground spectra and existing alteration maps based on ground information. This should lead to a knowledge-based expert classification system for different minerals and alteration zones based on SWIR and TIR ground and airborne spectroscopy, and an interpretation of the SWIR and TIR mineral assemblages throughout the Yerington alteration system.

5. ACKNOWLWEDGEMENTS

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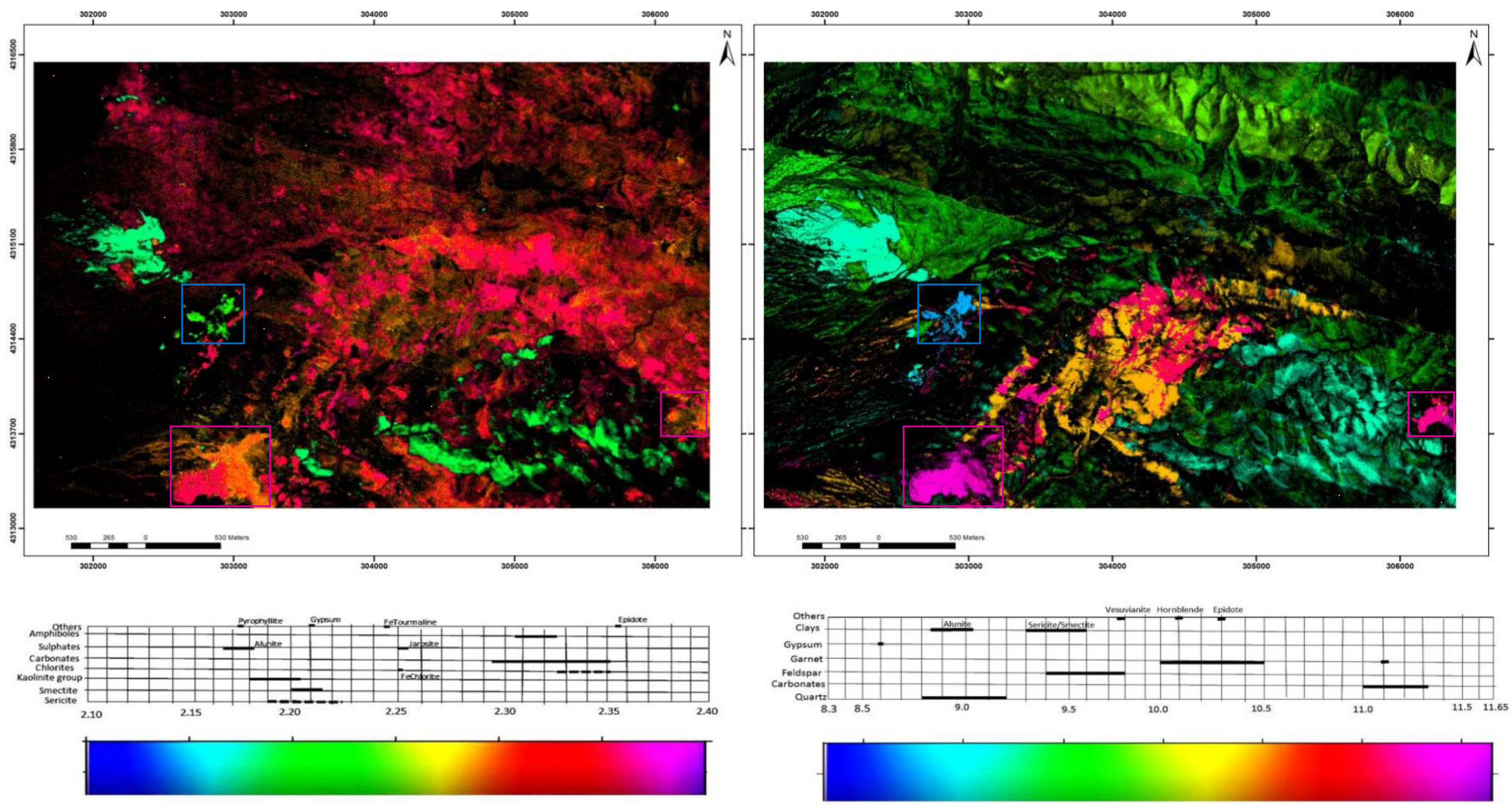

Figure 2: Wavelength mapping of the skarn subarea using ProspecTIR-VS data at 2.1-2.4µm (left) and SEBASS data at 8.3-11.65µm (right). The graphs below indicate positions of spectral features of infrared active minerals and are the key to interpret the colours in the figures above. Mineral distributions and marker boxes discussed in the text.