

# Remote Sensing Hydrothermal Alteration Zones in the Marysvale Volcanic Field, Tushar Mountains, UT; an Intercomparison of Landsat 8 and ASTER Imagery.

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## Abstract

Understanding available resources is crucial for enhancing energy security, environmental sustainability, and economic growth. Traditional geologic mapping is characterized by time-intensive and high-cost fieldwork, but through multispectral and hyperspectral remotely sensed imagery it is possible to instantly map extensive areas using unique properties of minerals in the reflected spectral signature of the electromagnetic spectrum. This study explores an intercomparison of mineral mapping using Landsat 8, and ASTER in the Marysvale Volcanic Field, Utah. The satellites were chosen due to their varying number of spectral channels, spectral ranges, and spatial resolutions, allowing for a cross-analysis of their strengths, weaknesses, and overall capabilities. All analysis was conducted through open-source applications to promote accessibility in future research and reproducibility. Developing accurate and accessible mineral mapping tools may be the next step in strengthening our knowledge of resource availability, without the need for rigorous traditional mapping methods.

## Background

The Marysvale volcanic field in Utah is one of the largest volcanic fields in the western United States, known for its uranium and alunite deposits. The igneous rocks found here were intruded ~32-20 million years ago, due to the subduction of the Farallon plate. The area continues to have episodic volcanism due to the extension of the Basin and Range.

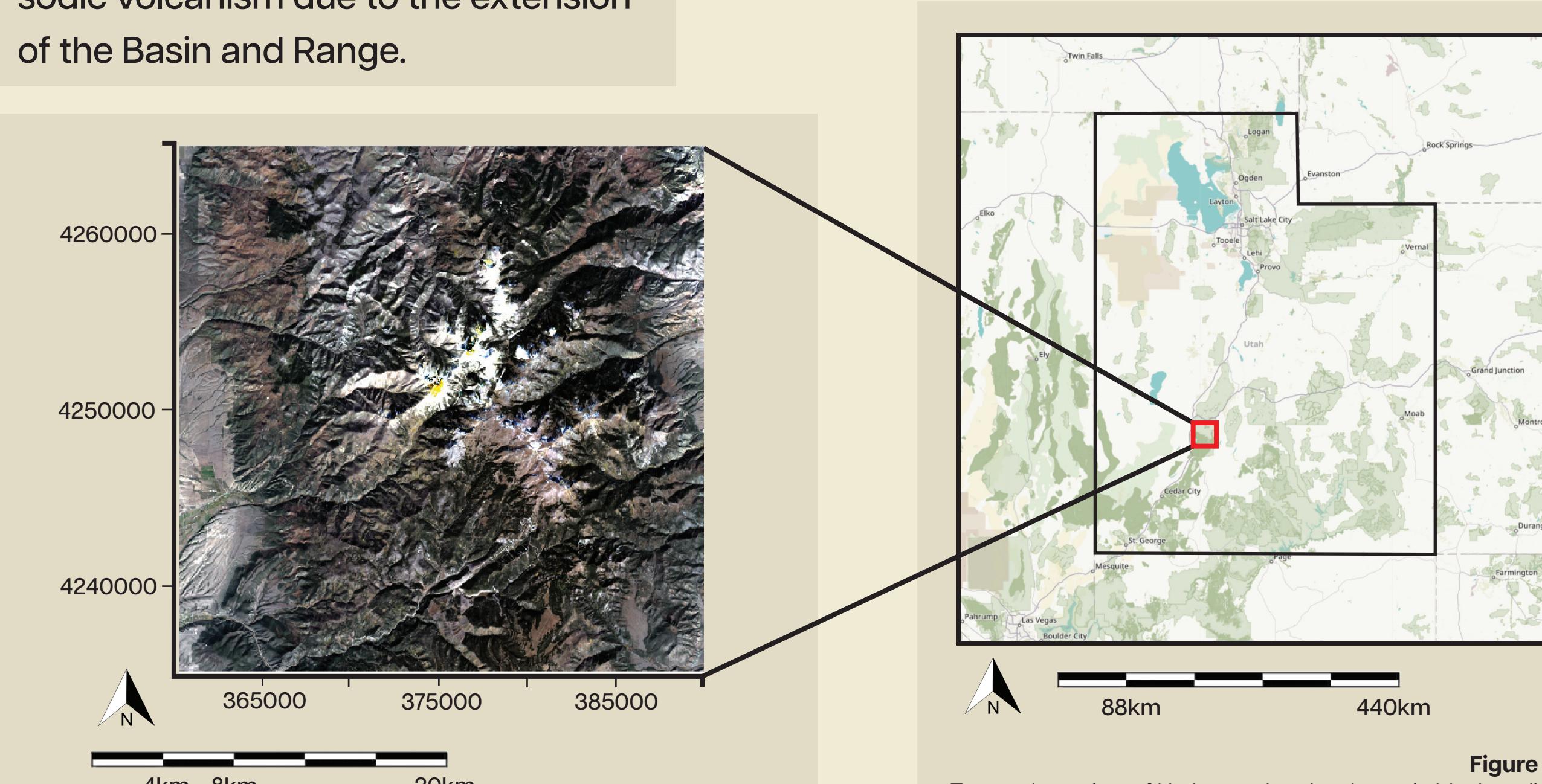


Figure 1a  
RGB map of research extent using Landsat 8 imagery.  
RGB created using Bands 4, 3, 2 respectively.  
UTM zone 12N projection in WGS84.  
Scales represent Easting (x-axis) and Northing (y-axis) in meters.

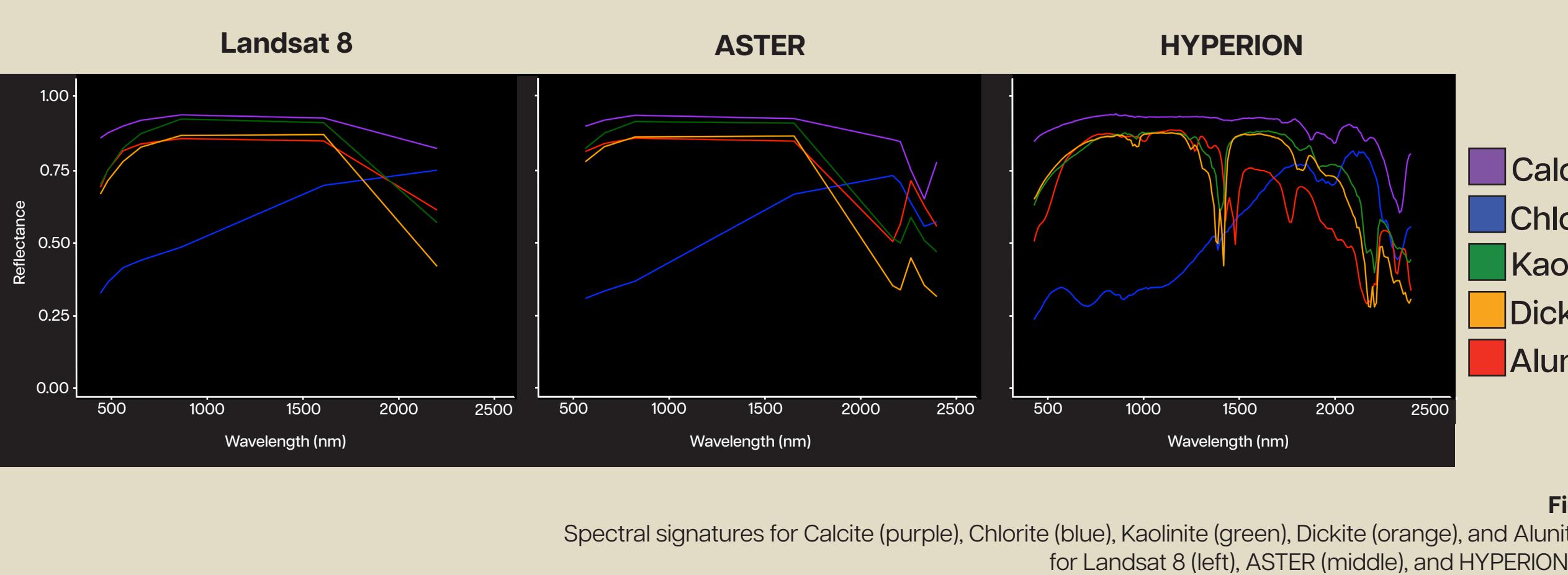


Figure 2  
Spectral signatures for Calcite (purple), Chlorite (blue), Kaolinite (green), Dickite (orange), and Alunite (red) for Landsat 8 (left), ASTER (middle), and HYPERION (right). Plotted using the USGS Spectral Library. Wavelength represented in nanometers on the x-axis and reflectance on the y-axis.

## Landsat

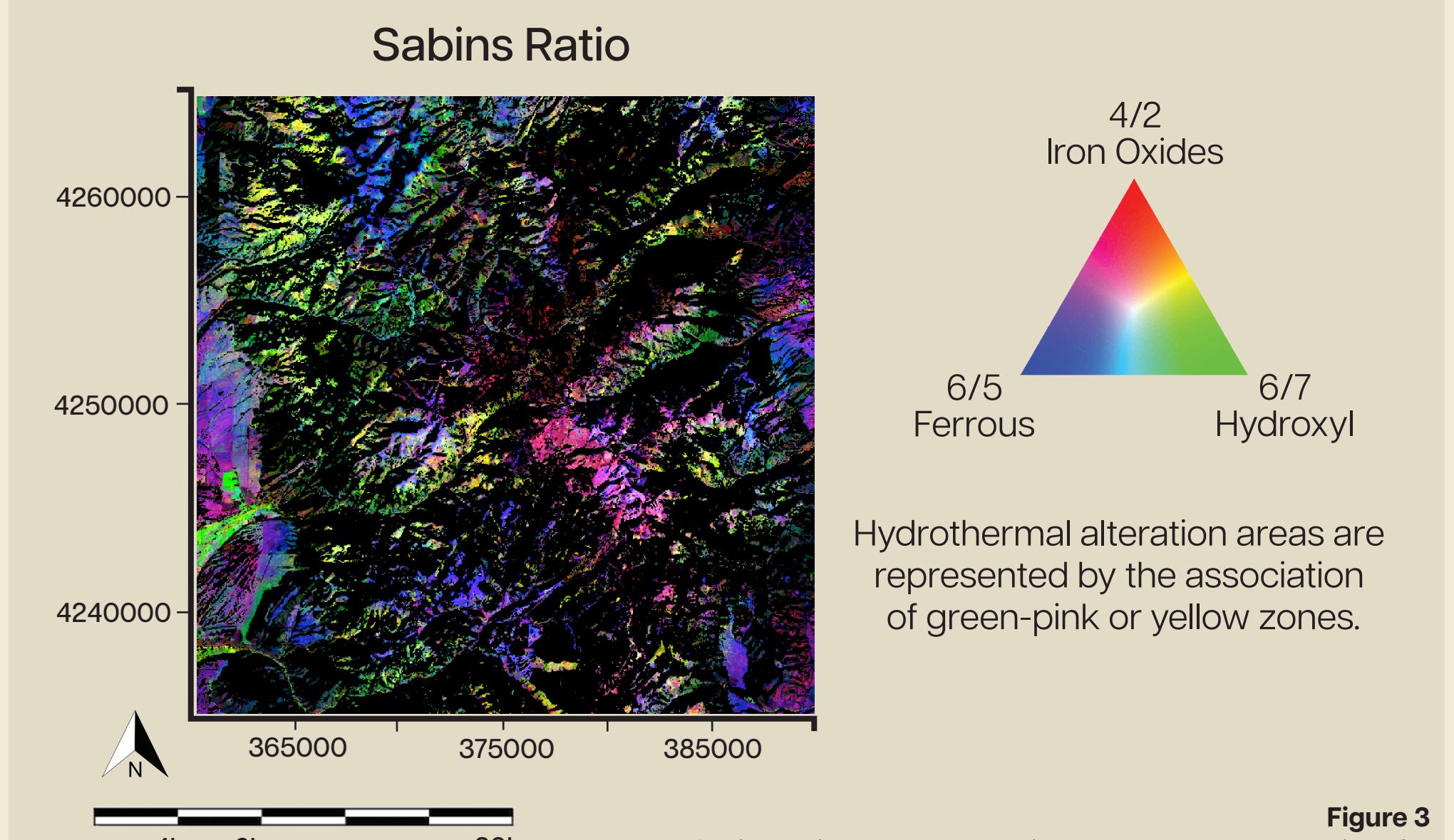
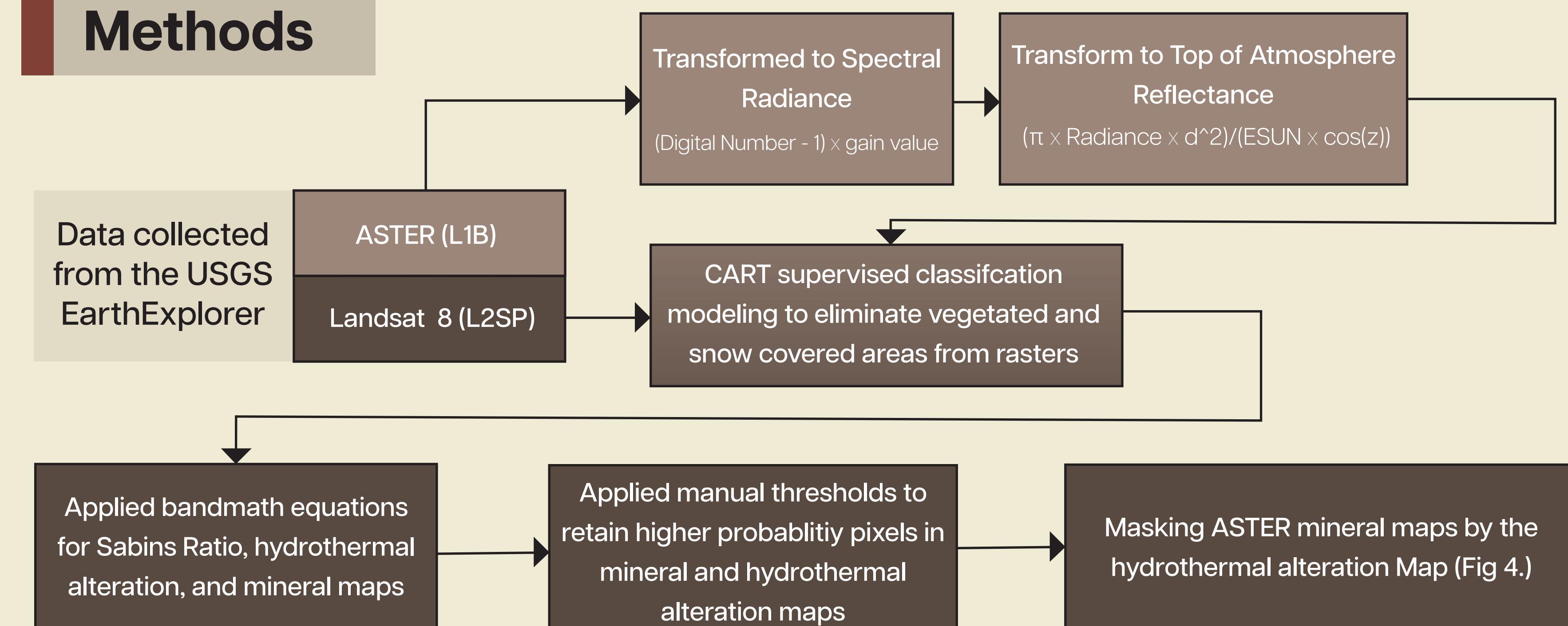


Figure 3  
Sabins Ratio map created using three bandmath equations for Landsat 8 imagery. Red indicates Iron Oxide minerals, green indicates Hydroxyl minerals, and blue indicates Ferrous minerals. Black pixels represent removed areas of snow or vegetation.

## Methods



d = Earth Sun Distance in Astronomical Units  
ESUN = Mean Solar Exoatmospheric Irradiance of Each Band  
z = Solar Zenith Angle

Gain value found in metadata

Collection ID for Landsat image: LC09\_L2SP\_038033\_20231019\_20231020\_02\_T1  
Collection ID for ASTER image: AST\_L1B\_00310012005182513\_20231130134446\_13225

## ASTER

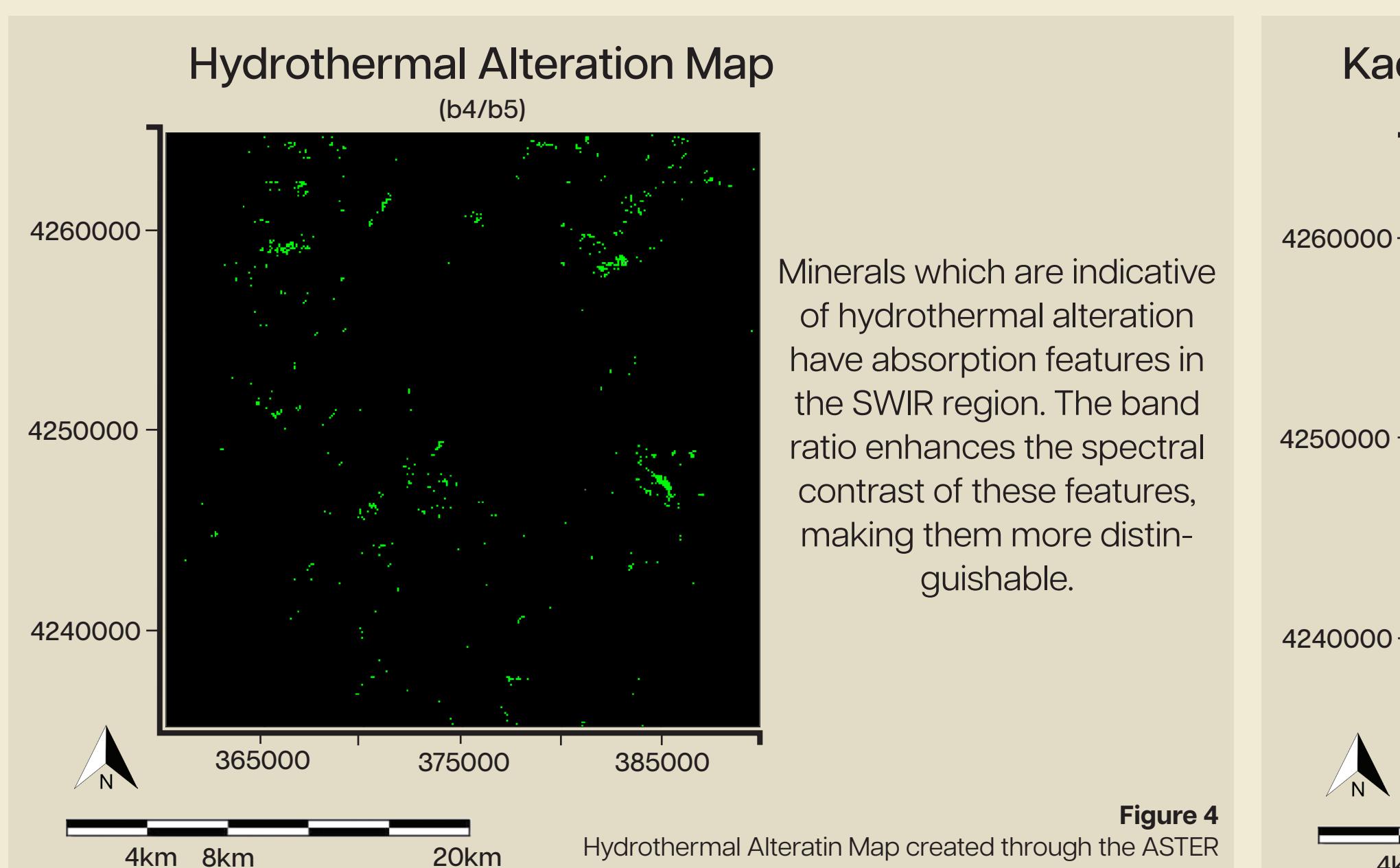


Figure 4  
Hydrothermal Alteration Map (b4/b5) created through the ASTER band ratio 4/5. CART modeling used to remove vegetation and snow cover. Manual threshold applied to remove noise and low probability pixels.

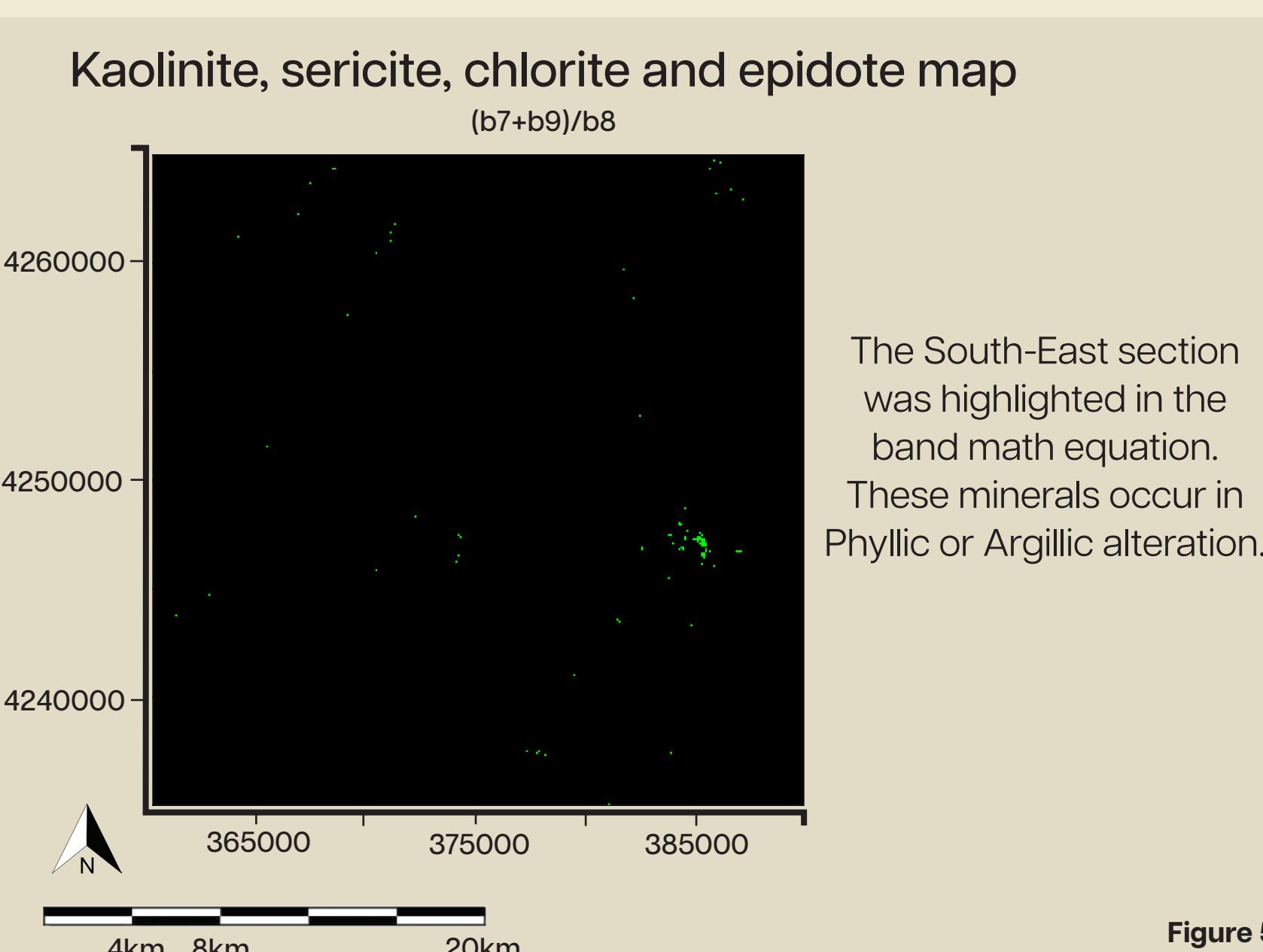


Figure 5  
Kaolinite, sericite, chlorite, and epidote map (b7+b9)/b8 Masked by the Hydrothermal Alteration Map (Figure 4).

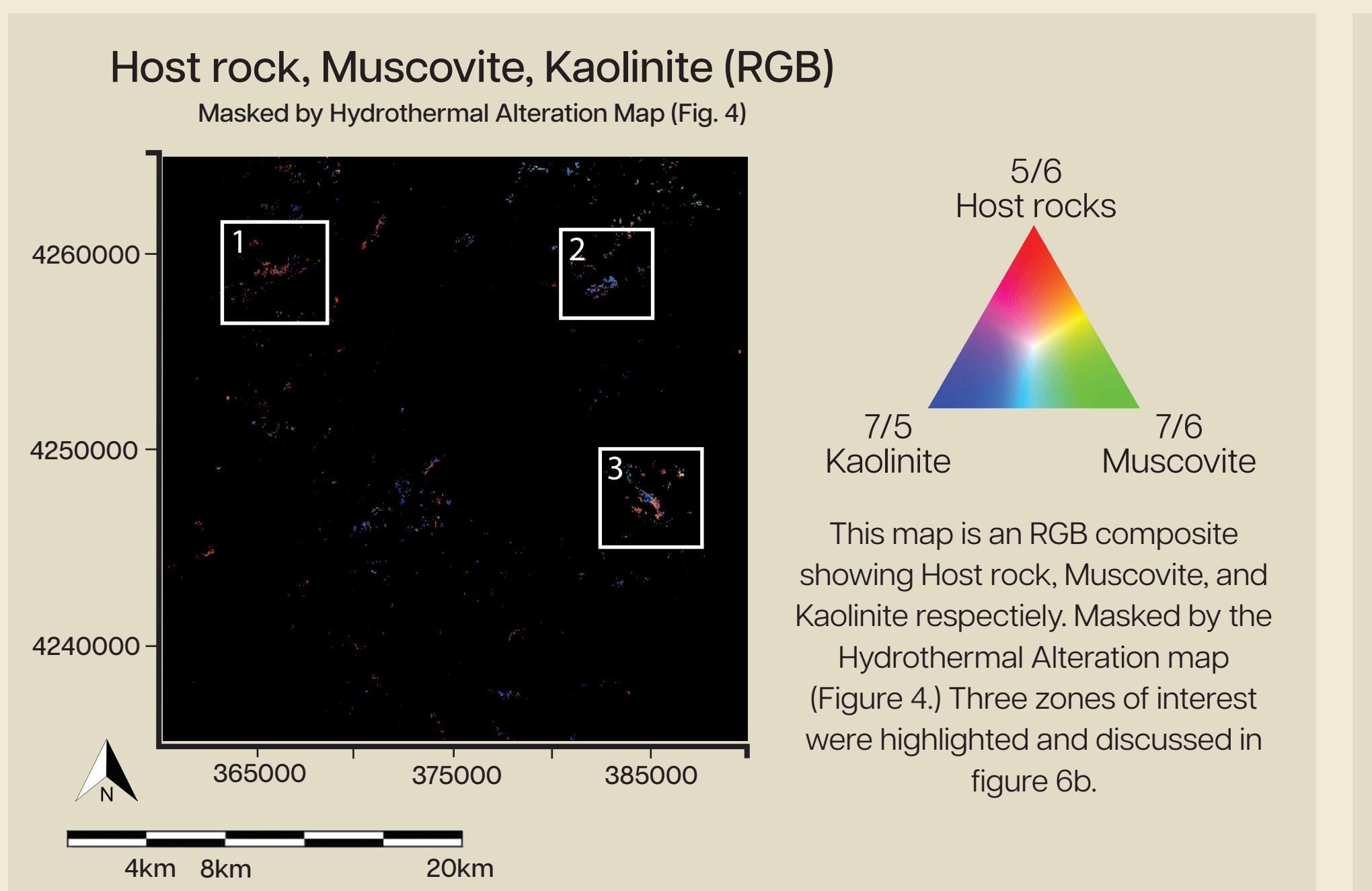


Figure 6a  
Host rock, Muscovite, Kaolinite (RGB) Masked by Hydrothermal Alteration Map (Fig. 4).  
This map is an RGB composite showing Host rock, Muscovite, and Kaolinite respectively. Masked by the Hydrothermal Alteration map (Figure 4). Three zones of interest were highlighted and discussed in figure 6b.

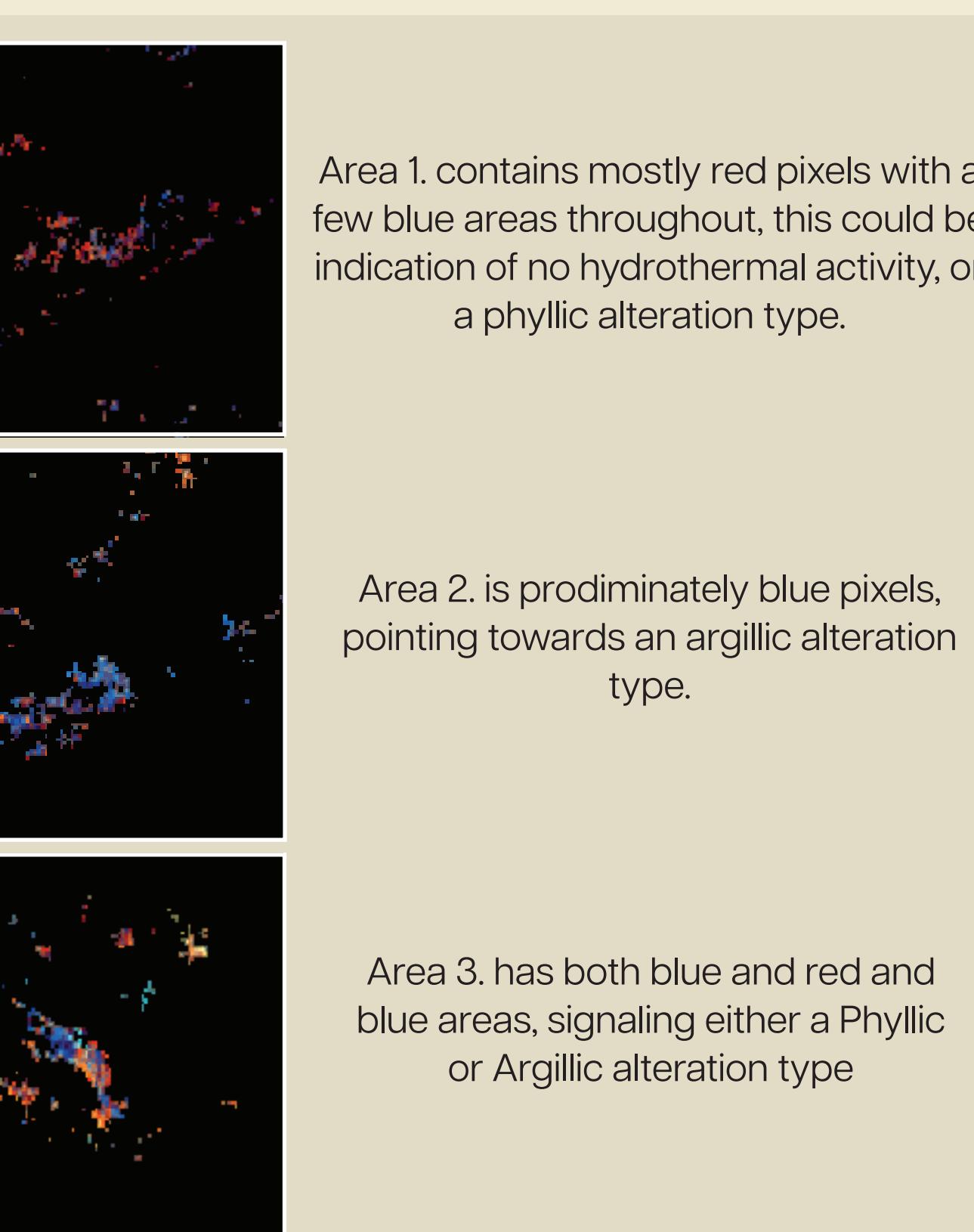
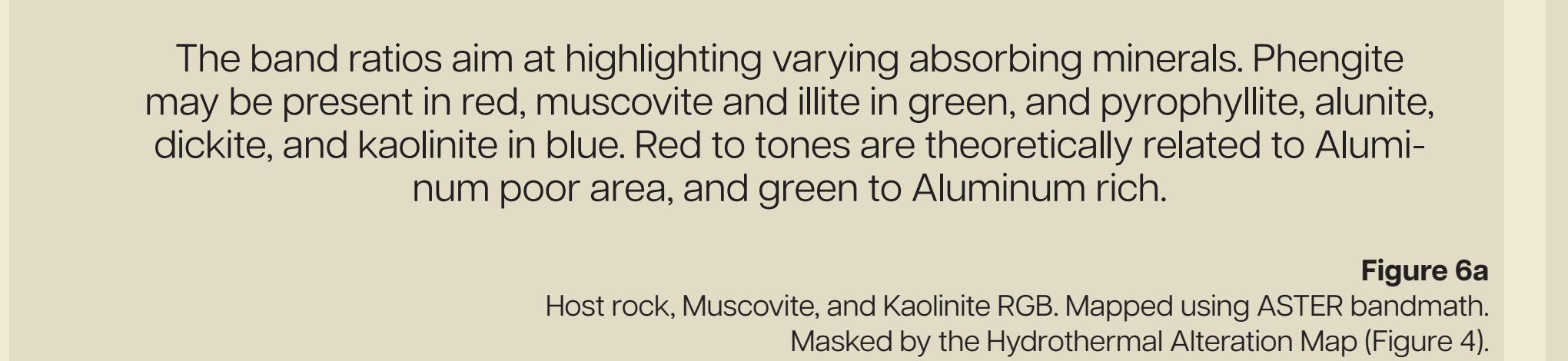


Figure 6b  
Zoomed in zones of interest from Figure 6a. Three areas of interest highlighting potential hydrothermal activity and color indicative of alteration type.

## Conclusion

The results of this study indicate that both Landsat 8 and ASTER imagery can provide valuable insights into hydrothermal alteration zones and their potential mineral assemblages. Landsat 8 is more limited in its application for mineral analysis due to the amount of spectral bands in the shortwave infrared and nearwave infrared; where minerals show their most diagnostic features. Landsat 8 did provide a similar delineation of large-scale alteration features and provided an overview of the distribution of alteration zones across the study area. However, ASTER, with its additional spectral bands, allowed for deeper delineation between minerals associated with hydrothermal alteration, contributing to a more in-depth identification of alteration types. This finer level of detail is particularly valuable for understanding the geological processes and mineralogical composition of the Marysvale volcanics.

Continued research implementing AVIRIS imagery and field validations will allow for mineral basis delineations, leading to a more accurate alteration zone type classification. AVIRIS being a hyperspectral sensor, allows for much more detail in mineral mapping, as well as finer area analysis due to the higher spatial resolution. Performing principle component analysis with AVIRIS can highlight specific spectral characteristics associated with minerals in a quick and efficient way.

## Citations

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