Mapping Hydrothermal Alteration Using Wavelength Mapping and Band Ratios: Insights from EMIT Hyperspectral Data over the Haib Porphyry System, Namibia

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Introduction

- **BACKGROUND → White micas** display distinctive spectral signatures, particularly in the **Al-OH absorption feature**, offering valuable **insights** into **alteration processes** and **fluid compositions** in **hydrothermal systems**. Previous studies (e.g., Laukamp & Lau, 2015; Meyer et al., 2022; Portela et al., 2021; van Ruitenbeek et al., 2005) demonstrated the potential of hyperspectral imaging for characterizing white micas and interpreting geological phenomena.

- **WHAT** we used → **EMIT hyperspectral satellite sensor**

- **WHERE →** in the **Haib region** in southern Namibia, known for its porphyry system

- **WHY →** to investigate **hydrothermally altered rocks** and associated **geological patterns**

- **WHICH METHODS → wavelength mapping** to detect the shift in the Al-OH feature of white mica and **band ratios** techniques to identify mineralogical variations.

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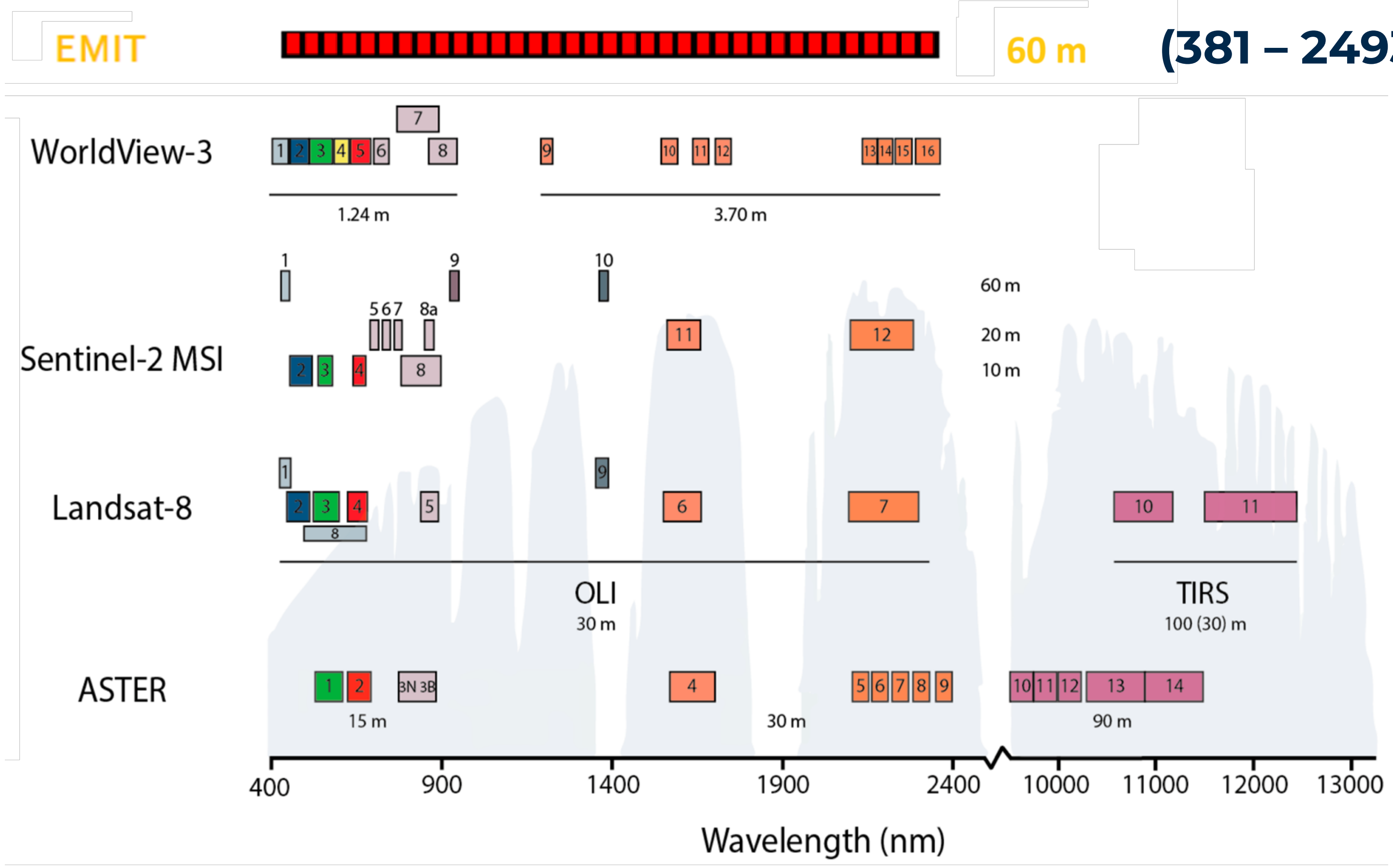
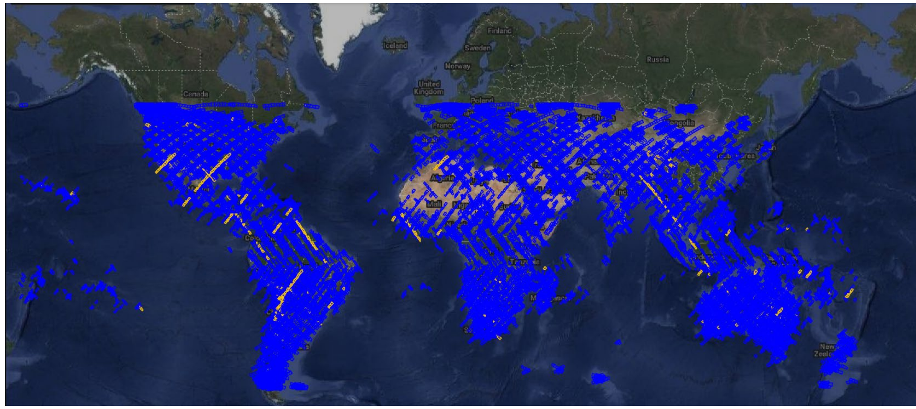
Hyperspectral spaceborne sensor EMIT (Earth Surface Mineral Dust Source Investigation)

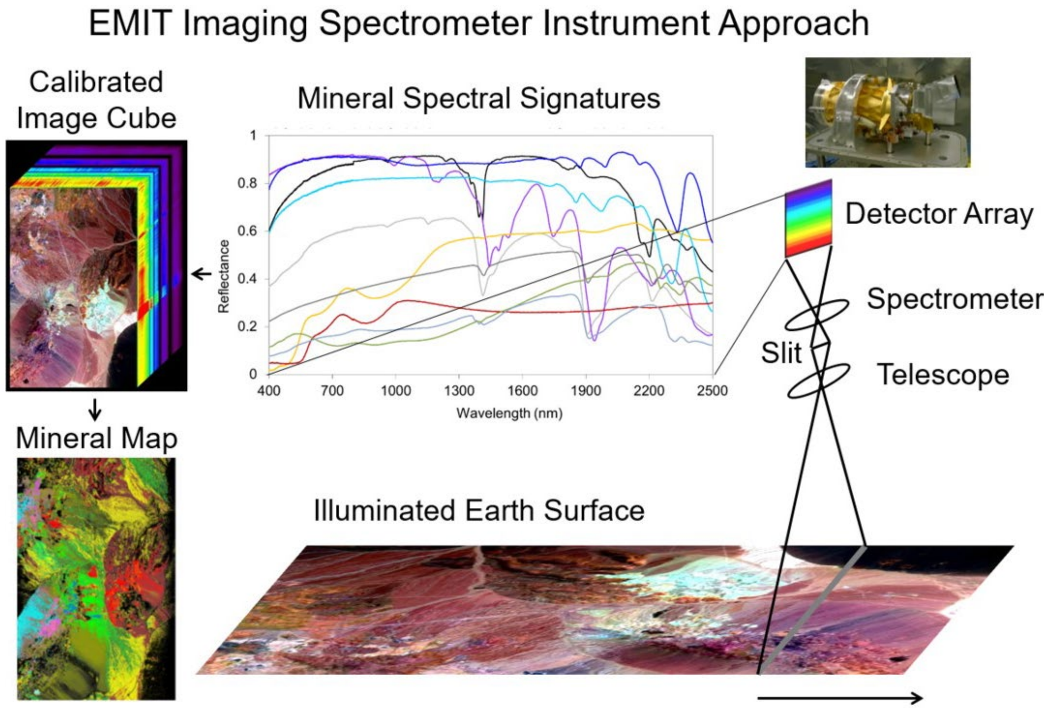


(381 – 2493 nm)

(Modified after Cardoso-Fernandes et al., 2020)



(NASA website - https://earth.jpl.nasa.gov/emit/)



(Green et al., 2020)

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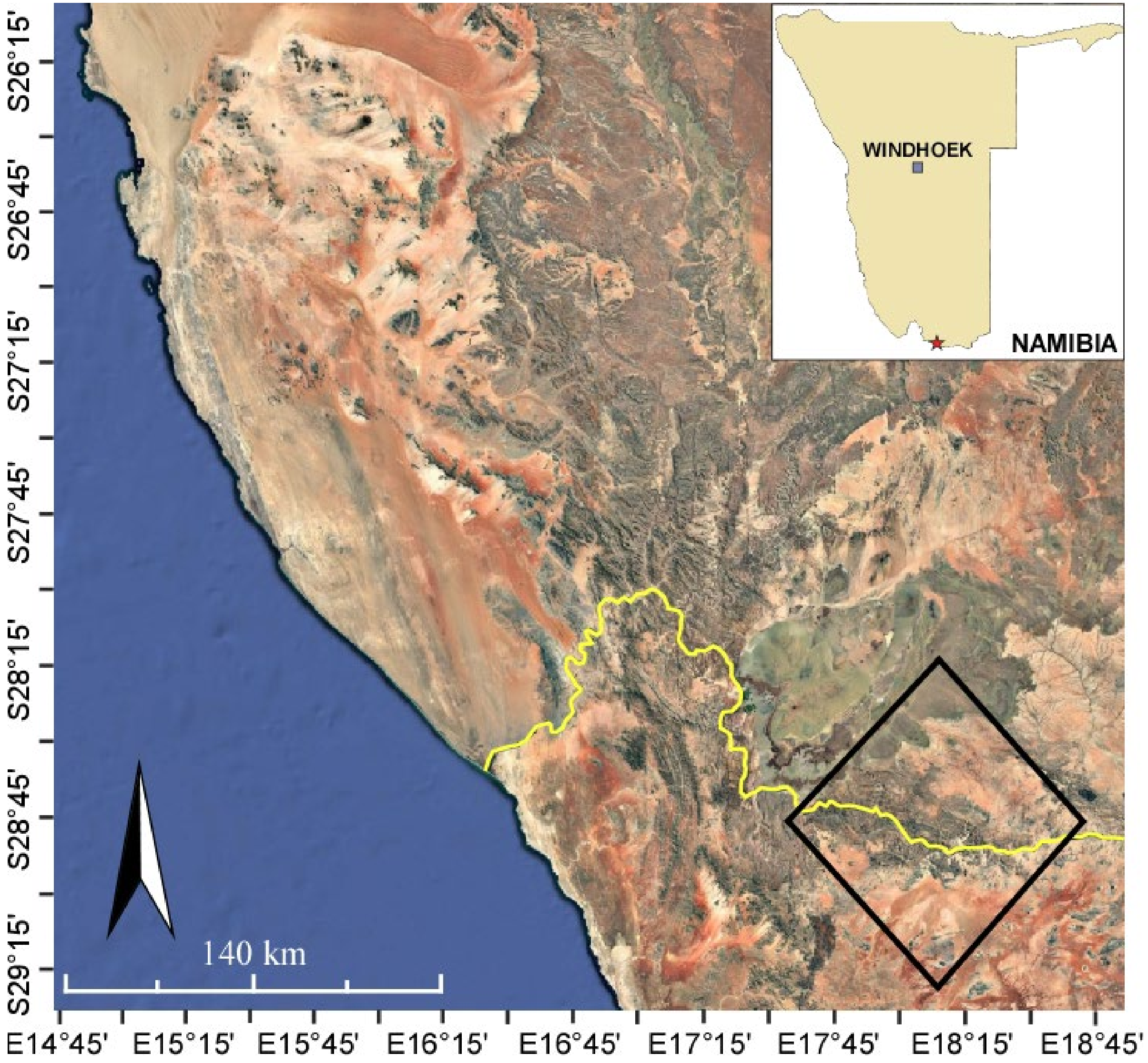
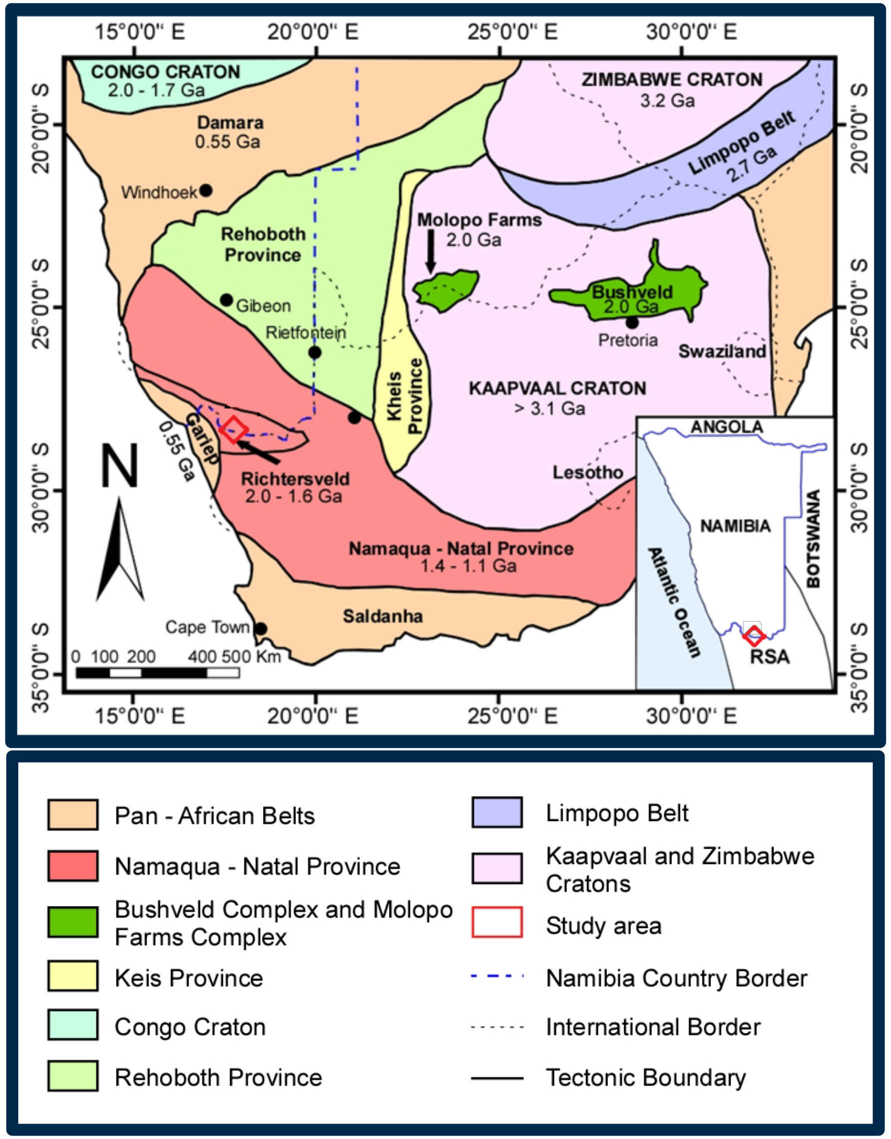
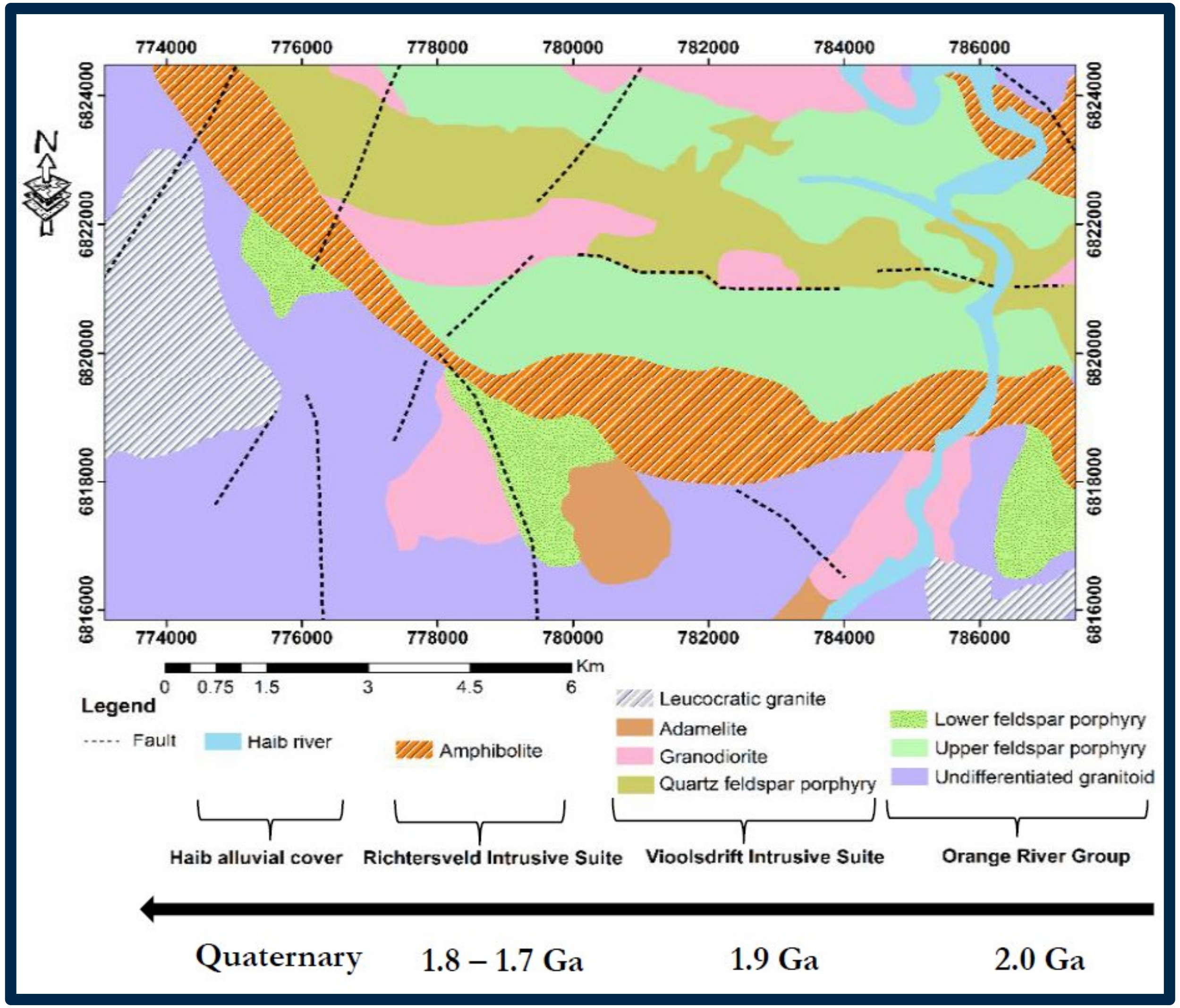
Case study – Geological Setting





(Modified after Schijndel, 2013)

Case study – Geological Setting



(Chinkaka, 2019)

The **Haib** region is characterized by Proterozoic rock units related to the **Orange River Orogeny** (**2.0** to **1.7 billion years ago**).
From oldest to youngest, can be distinguished:

- the **Orange River Group:** mainly calc-alkaline volcanic rocks;
- the **Vioolsdrift Intrusive Suite;**
- the **Richtersveld Intrusive Suite;**
- More recent **Quaternary deposits.**

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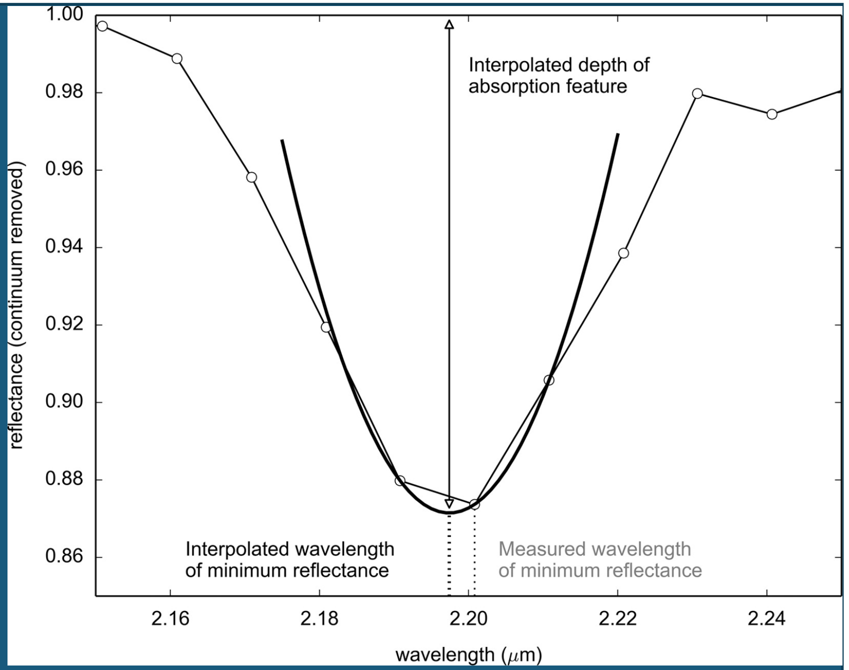
Methods: Minimum Wavelength Mapper

- tool included in the Hyperspectral Python (HypPy) software suite (Bakker et al., 2024)
- It consists of two steps:

1

The continuum of the pixel spectrum is removed, and the deepest absorption features are extracted with a parabolic fit through three adjacent spectral bands.



(van Ruitenbeek et al., 2014)

Output - **two bands** containing:

a) the interpolated **wavelength position** of the minimum reflectance;
b) the interpolated **depth** of the absorption feature (Hecker et al., 2019).

2

The information extracted with the step 1 are merged together.

Output – colour-coded map, where:

The **hue** = different absorption feature wavelegths;

The **intensity** = variation in the feature depth (Hecker et al., 2019).

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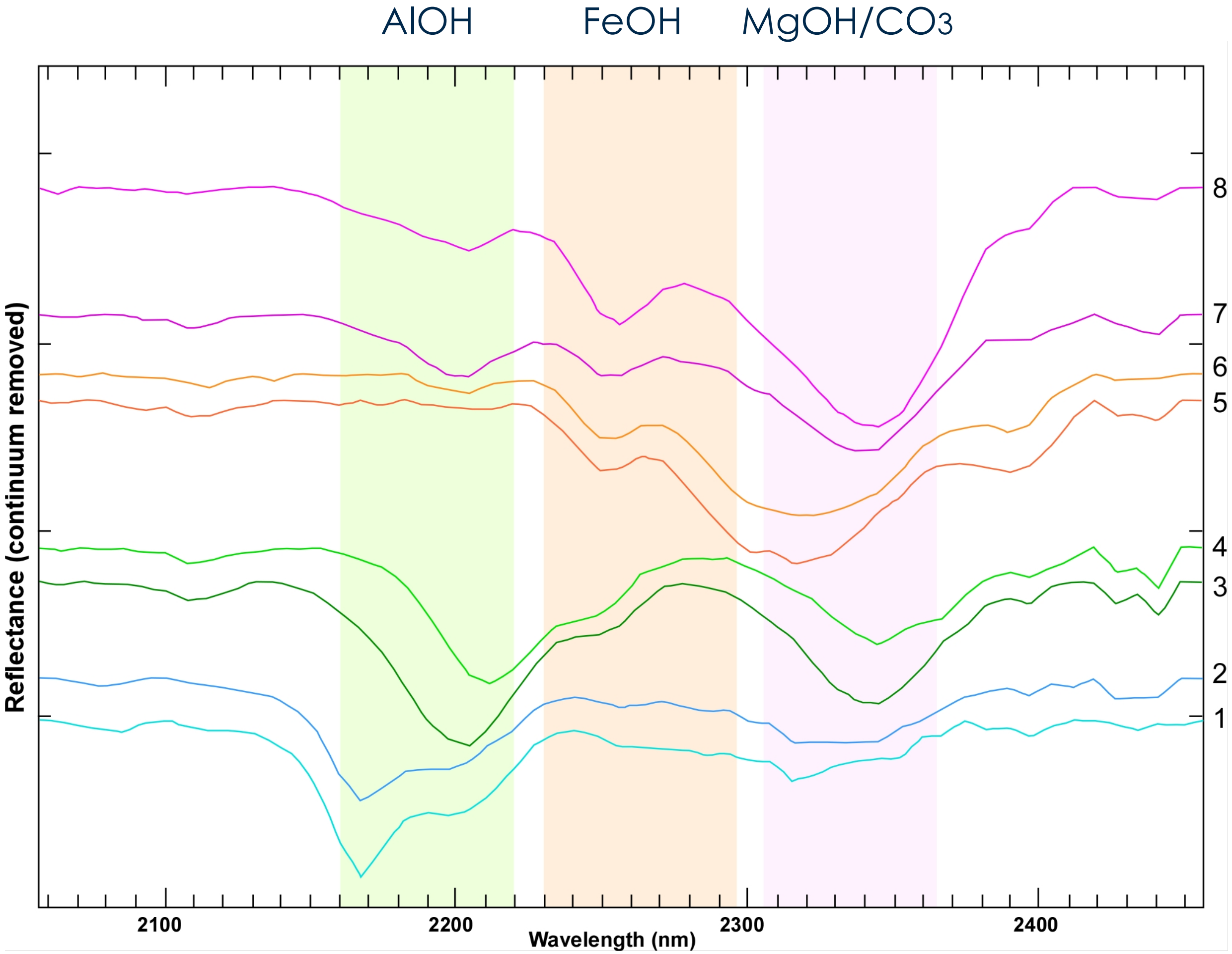
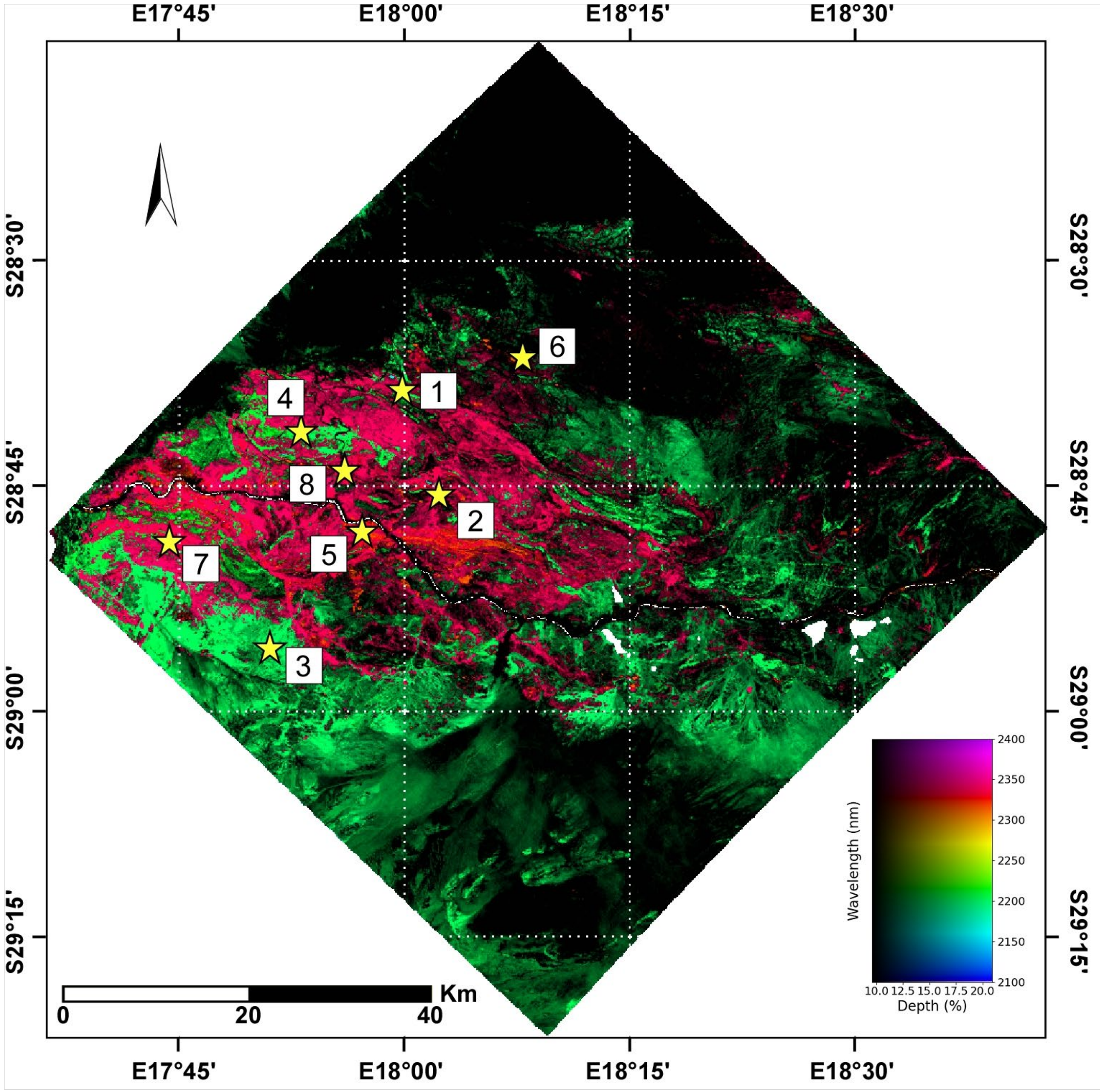
Wavelength Map
2100 – 2400 nm





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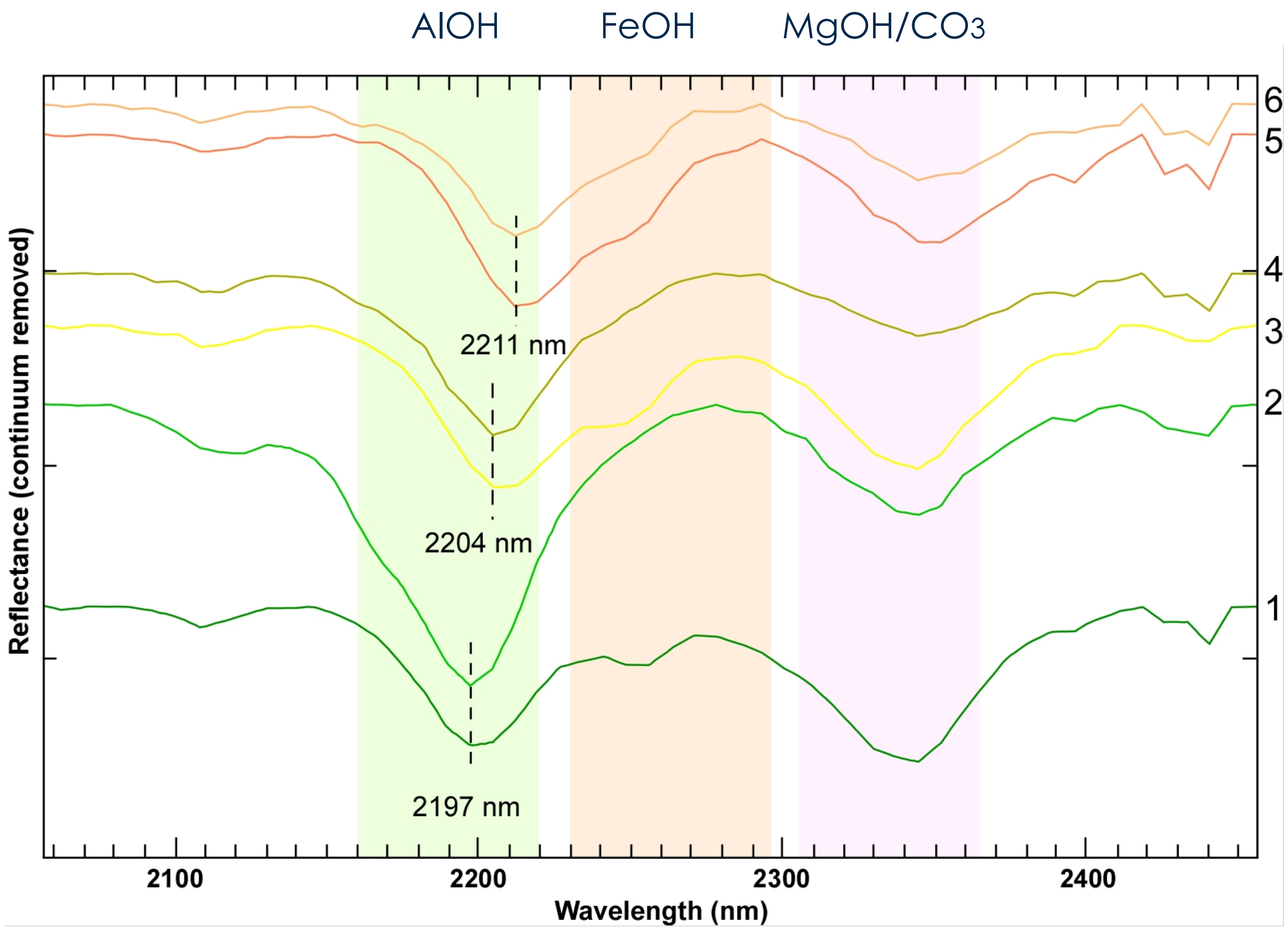
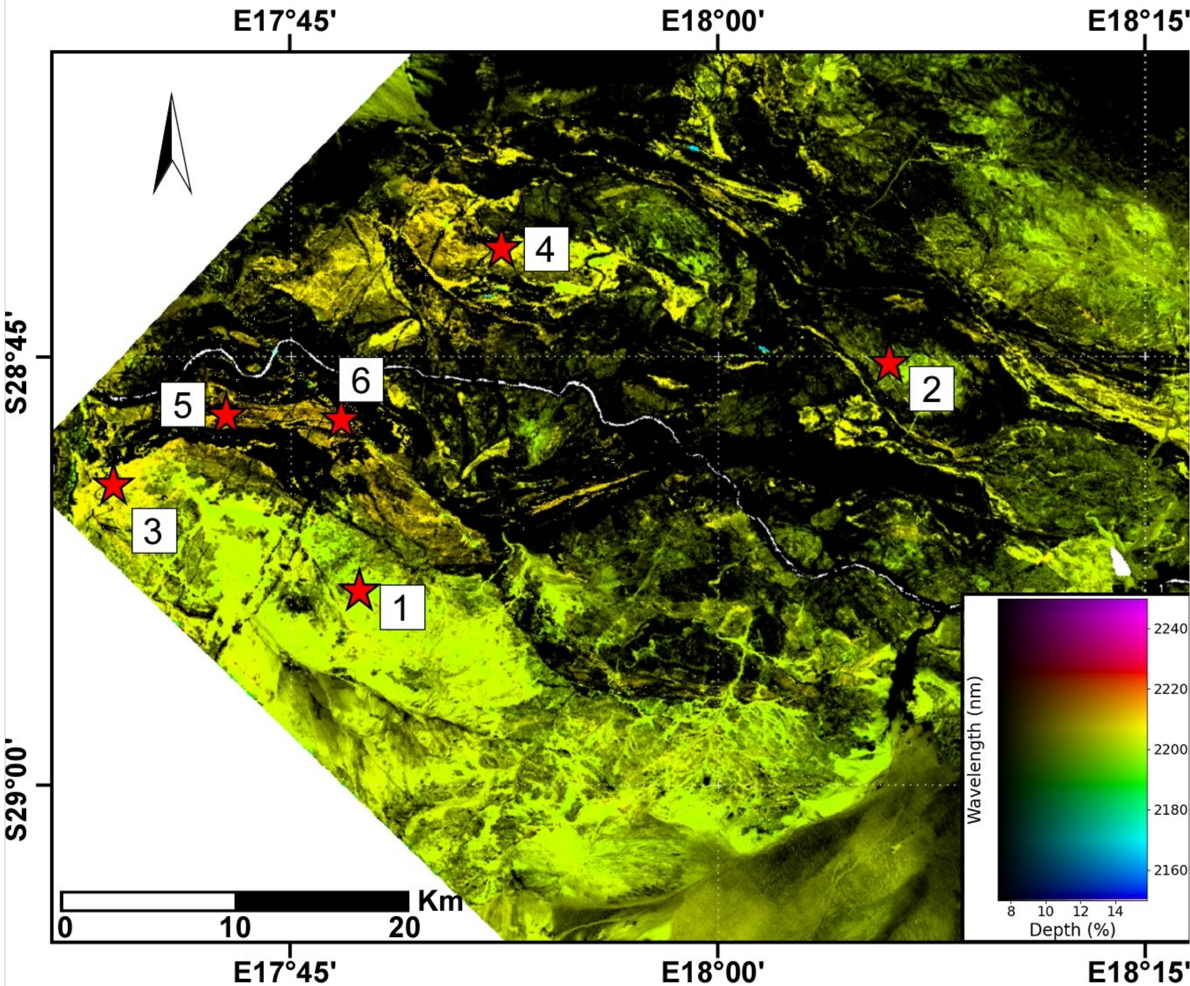
Wavelength mapping and white mica





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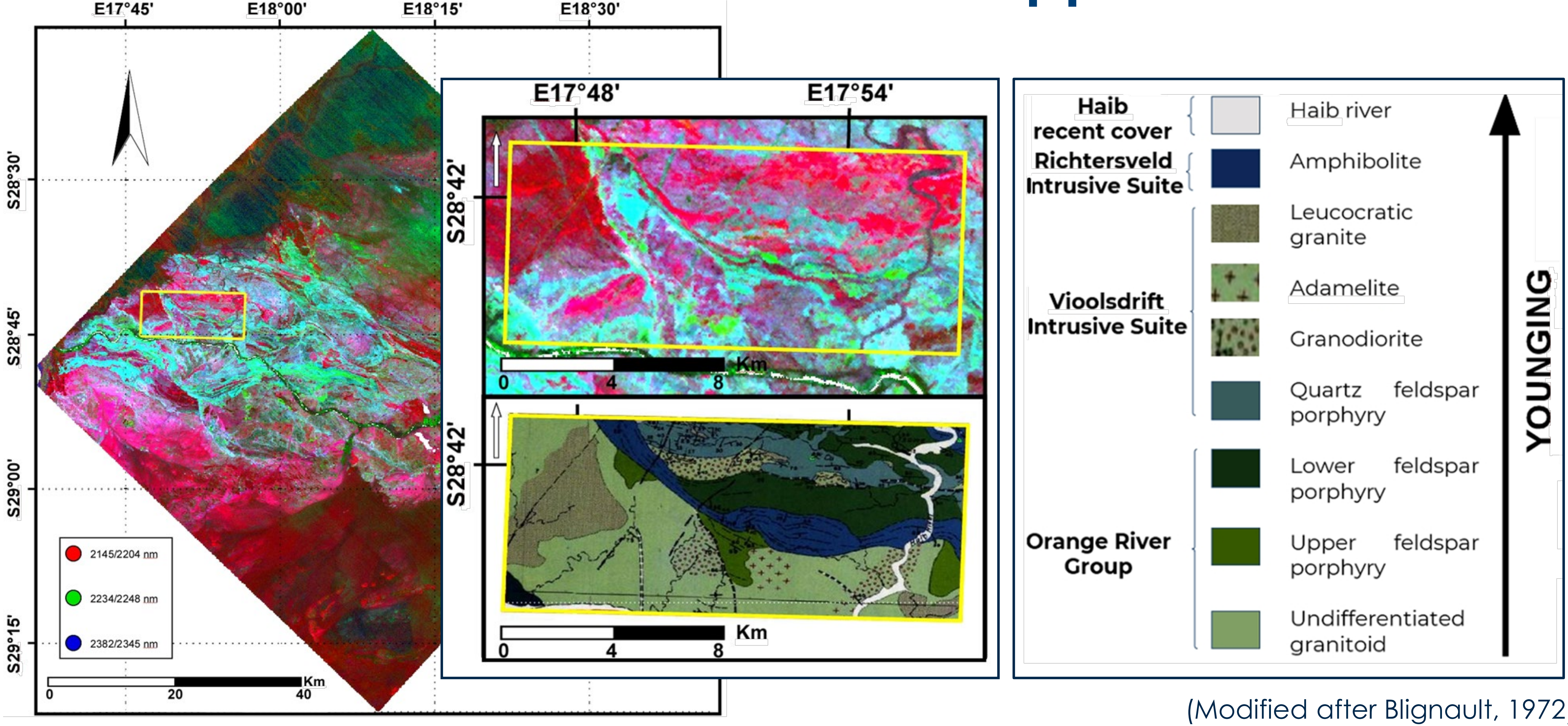
Band Ratio: method and application



(Modified after Blignault, 1972)

Conclusions

- **EMIT** Hyperspectral Satellite sensor is able to detect subtle **Al-OH shifts around 2200 nm** in **white mica;**
- **EMIT** enabled identification of **mineralogical variations** over the Haib area with **60 m spatial resolution;**
- this study demonstrates the **effectiveness of hyperspectral data** for **detailed geological mapping;**
- this study is a solid foundation for future investigations into **fluid compositions**, **mineral distributions**, and **alteration patterns** within **porphyry systems** and other **hydrothermally altered environments**.

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References

Bakker, W., Van Ruitenbeek, F., Van Der Werff, H., Hecker, C., Dijkstra, A., Van Der Meer, F., 2024. Hyperspectral Python: HypPy. Algorithms 17, 337. https://doi.org/10.3390/a17080337

Blignault, H.J., 1972. Geological Map of Haib area.

Cardoso-Fernandes, J., Teodoro, A.C., Lima, A., Perrotta, M., Roda-Robles, E., 2020. Detecting Lithium (Li) Mineralizations from Space: Current Research and Future Perspectives. Applied Sciences 10, 1785. https://doi.org/10.3390/app10051785

Chinkaka, E., 2019. Integrating Worldview-3, Aster and aeromagnetic data for lineament structural intepretation and tectonic evolution of the Haib Area, Nambia. MS thesis.

Green, R.O., Mahowald, N., Ung, C., Thompson, D.R., Bator, L., Bennet, M., Bernas, M., Blackway, N., Bradley, C., Cha, J., Clark, P., Clark, R., Cloud, D., Diaz, E., Ben Dor, E., Duren, R., Eastwood, M., Ehlmann, B.L., Fuentes, L., Ginoux, P., Gross, J., He, Y., Kalashnikova, O., Kert, W., Keymeulen, D., Klimesh, M., Ku, D., Kwong-Fu, H., Liggett, E., Li, L., Lundeen, S., Makowski, M.D., Mazer, A., Miller, R., Mouroulis, P., Oaida, B., Okin, G.S., Ortega, A., Oyake, A., Nguyen, H., Pace, T., Painter, T.H., Pempejian, J., Garcia-Pando, C.P., Pham, T., Phillips, B., Pollock, R., Purcell, R., Realmuto, V., Schoolcraft, J., Sen, A., Shin, S., Shaw, L., Soriano, M., Swayze, G., Thingvold, E., Vaid, A., Zan, J., 2020. The Earth Surface Mineral Dust Source Investigation: An Earth Science Imaging Spectroscopy Mission, in: 2020 IEEE Aerospace Conference. Presented at the 2020 IEEE Aerospace Conference, IEEE, Big Sky, MT, USA, pp. 1–15. https://doi.org/10.1109/AERO47225.2020.9172731

Hecker, C., Van Ruitenbeek, F.J.A., Bakker, W.H., Fagbohun, B.J., Riley, D., Van Der Werff, H.M.A., Van Der Meer, F.D., 2019. Mapping the wavelength position of mineral features in hyperspectral thermal infrared data. International Journal of Applied Earth Observation and Geoinformation 79, 133–140. https://doi.org/10.1016/j.jag.2019.02.013

Laukamp, C., Lau, I.C., Wang, R., 2015. Tracing exchange vectors in hydrothermal systems using SWIR and TIR infrared active functional groups. Presented at the ACOVS11/ASC5, Sydney, Australia, pp. 135–136.

Meyer, J.M., Kokaly, R.F., Holley, E., 2022. Hyperspectral remote sensing of white mica: A review of imaging and point-based spectrometer studies for mineral resources, with spectrometer design considerations. Remote Sensing of Environment 275, 113000. https://doi.org/10.1016/j.rse.2022.113000

Portela, B., Sepp, M.D., Van Ruitenbeek, F.J.A., Hecker, C., Dilles, J.H., 2021. Using hyperspectral imagery for identification of pyrophyllite-muscovite intergrowths and alunite in the shallow epithermal environment of the Yerington porphyry copper district. Ore Geology Reviews 131, 104012. https://doi.org/10.1016/j.oregeorev.2021.104012

Van Ruitenbeek, F.J.A., Cudahy, T., Hale, M., Van Der Meer, F.D., 2005. Tracing fluid pathways in fossil hydrothermal systems with near-infrared spectroscopy. Geol 33, 597. https://doi.org/10.1130/G21375.1

Van Schijndel, V., 2013. Precambrian crustal evolution of the Rehoboth Province, Southern Africa. Department of Earth Sciences, University of Gothenburg, Göteborg.

Yang, K., Huntington, J.F., Gemmell, J.B., Scott, K.M., 2011. Variations in composition and abundance of white mica in the hydrothermal alteration system at Hellyer, Tasmania, as revealed by infrared reflectance spectroscopy. Journal of Geochemical Exploration 108, 143–156. https://doi.org/10.1016/j.gexplo.2011.01.001

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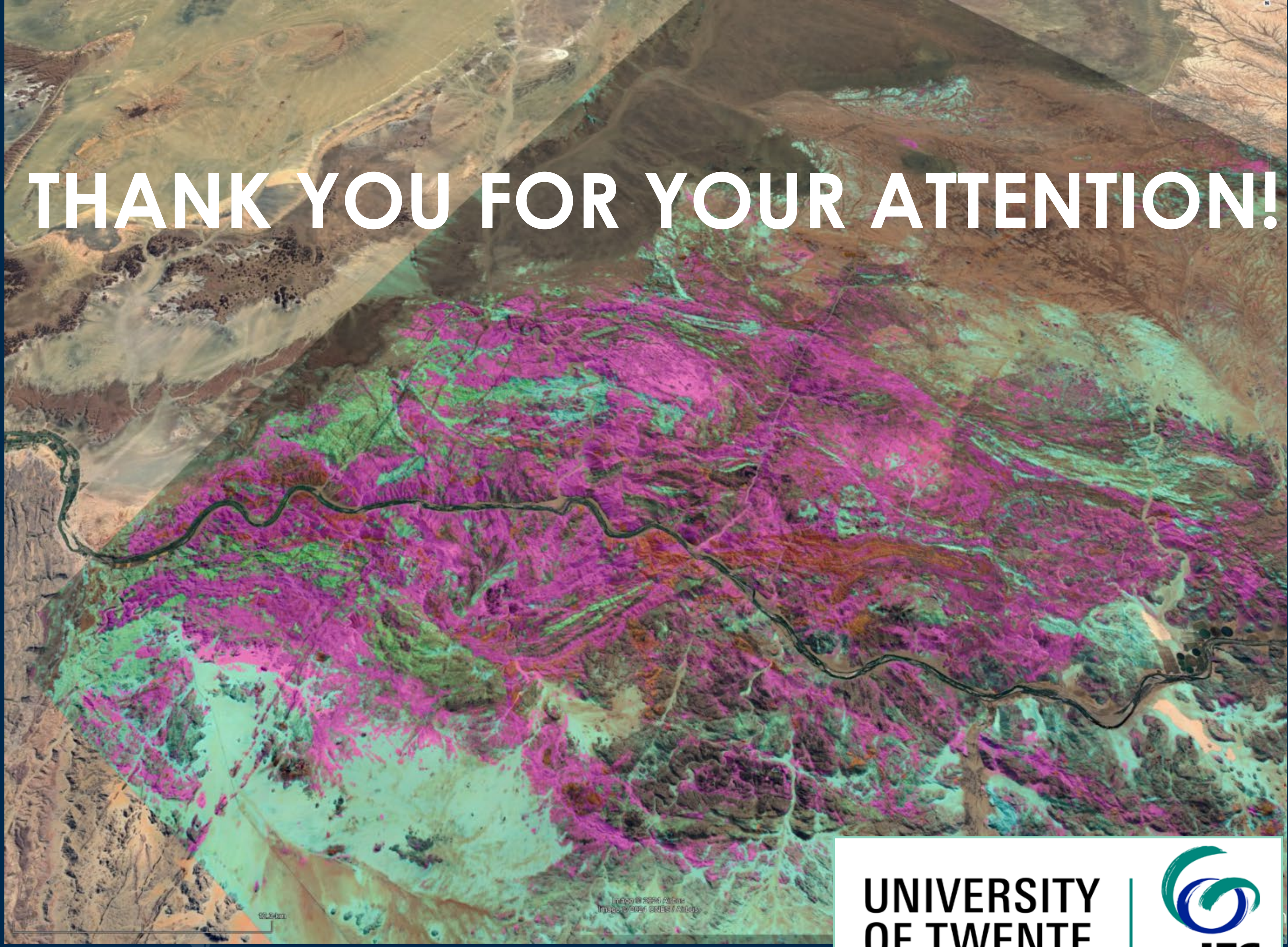

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