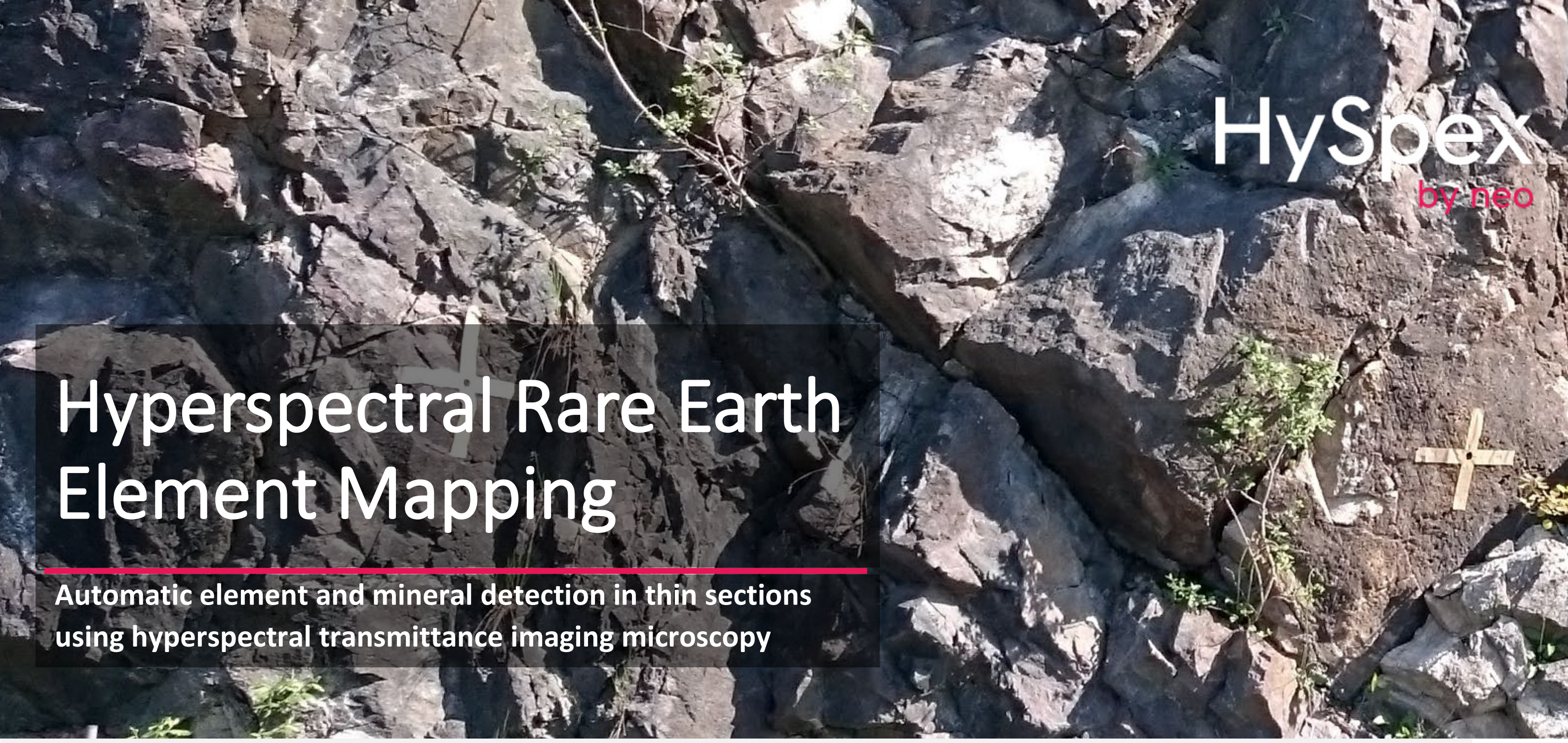


Hyperspectral Rare Earth Element Mapping

Automatic element and mineral detection in thin sections using hyperspectral transmittance imaging microscopy

With the advance on net-zero energy technologies, the worldwide demand for Rare Earth Element (REE), e.g., Neodymium (Nd), is predicted to grow. The predicted increase of on- and off-shore wind turbine installations projects a growth in REE metal demand of about 250% to reach the 2-degree scenario through 2050[1]. More efficient detection and classification methods for these REE-metals will be crucial for future exploration and mining. Hyperspectral imaging is already successful to detect REE minerals and elements in outcrops, rock samples, and drill cores using reflectance measurements and allows for the assessment of previously unexplored deposits.[2,3,4] The analysis of thin sections plays a crucial role in outcrop characterization but is traditionally achieved using crossed polarized light (XPL), scanning electron microscopy (SEM), electron microprobes (EMP), and point spectrometers (Figure 1).

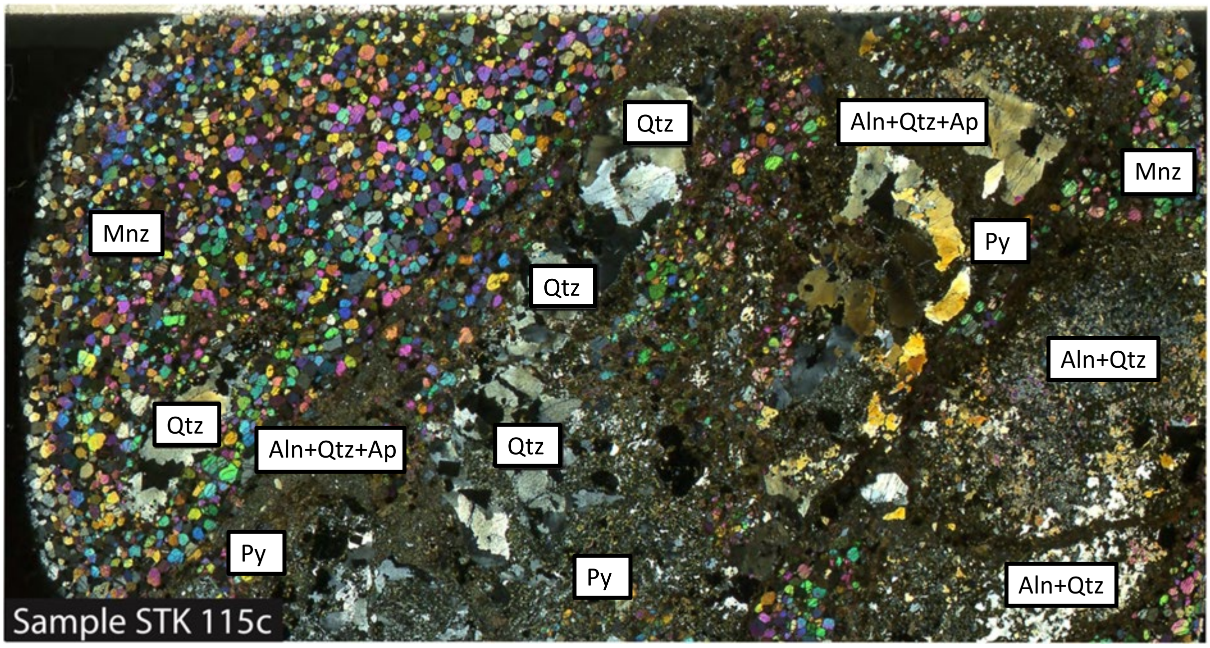


Figure 1. Thin section under cross polarized light (XPL) (Mnz: monazite, Qtz: quartz, Aln: allanite, Ap: apatite, Py: pyrite). The monazites show strong birefringence (interference colors). Image courtesy: Dr. Uwe Altenberger.[5]

Hyperspectral transmittance imaging microscopy of complete thin sections (HyperTIM) is a novel method for the automated detection of REE minerals.[5] HyperTIM uses a HySpex system of the classic series, the VNIR-1600, and a specifically designed sample holder, scanning setup, and microscopic lens. In this example, the method is used on a rock thin section from Steenkampskraal (South Africa), which is analyzed for the REE-bearing mineral monazite ($(Ce,Nd,La)PO_4$), dominated by Nd. Transmittance measurements with the HySpex VNIR camera and a classification algorithm are used to identify and map Nd-bearing monazites in the thin section (Figure 2).

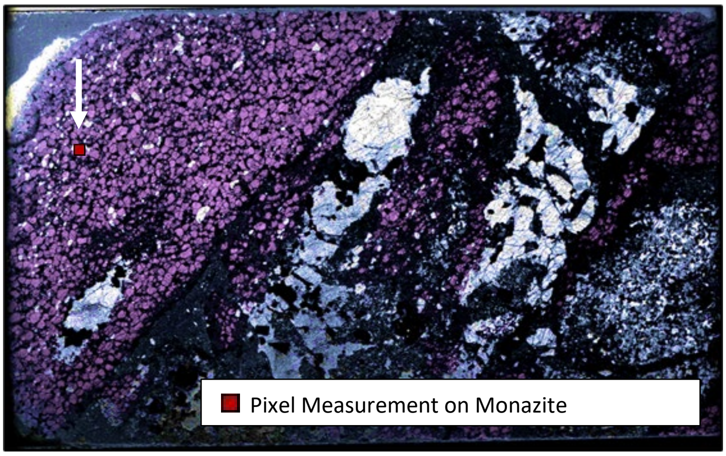


Figure 2a.
False color hyperspectral transmittance image of the thin section. The monazite is highlight by the first Nd absorption feature.[5]

R: Left Shoulder: 563.91 nm,
G: Absorption Max.: 578.46 nm,
B: Right Shoulder: 618.46 nm
as indicated in Figure 2b.

Figure 2b.
Comparison between the measured spectral signatures of a 3x3 Pixel area on a monazite (red) and a measured monazite from the USGS Spectral Library (blue).[6] The three main absorption features of Nd are highlighted, and the left shoulder (LS), the absorption maximum (AM) and the right shoulder (RS) of the first feature are indicated.[5]

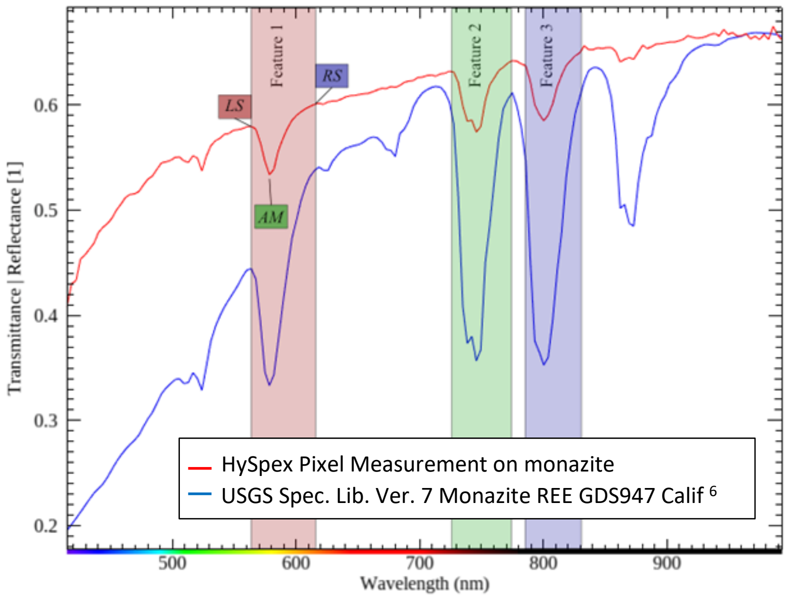
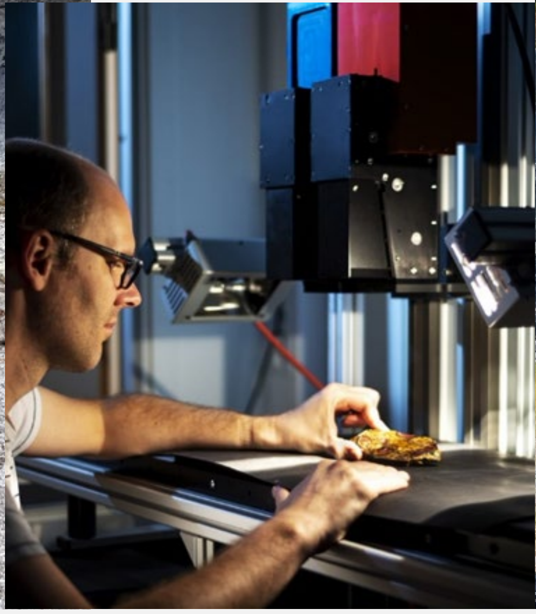


Figure 2c.
Red pixels are classified as monazite (Nd). The other pixels are displayed according to their true color information RGB (R: 640.27 nm, G: 549.36 nm B: 458.44 nm).[5]



The hyperspectral data in this project was acquired using VNIR and SWIR cameras from the HySpex Classic series. The VNIR-1800 camera covers the 400 – 1000 nm range while the SWIR-384 operates in the 930 – 2500 nm range. The cameras have a spectral resolution of 3.3 and 5.5 nm, respectively.

The cameras are designed to operate in both the laboratory and the field, preserving the spectral fidelity needed for scientific and industrial applications thanks to their low-value optical aberrations, thermal stability and custom lenses for a variety of working distances. The portable field system utilizes a battery-based, rugged data acquisition unit to power and control the cameras as well as the necessary moving stages.

The data analysis and development of HyperTIM was performed within the Rare Earth Element Mapping project REEMAP at the German Research Centre for Geosciences GFZ Potsdam.

This example shows the potential of hyperspectral imaging as a tool for applications in the mining industry. It allows for a precise identification of minerals and materials anywhere from exploration and mining to processing and manufacturing. HySpex offers a varied selection of turn-key solutions for scientific and industrial applications. Contact us to discuss your application and requirements with our specialists.

Contact:

hyspex@neo.no

www.hyspex.com

1. World Bank Group, EGPS, The growing role of minerals and metals for a low carbon future, June 2017
2. Turner, D., Rivard, B., and Groat, L.: Rare earth element ore grade estimation of mineralized drill core from hyperspectral imaging spectroscopy, in: 2014 IEEE Geoscience and Remote Sensing Symposium, 4612–4615, 2014a.
3. Koerting, F., Herrmann, S., Boesche, N. K., Mielke, C., Koellner, N., and Altenberger, U.: Technical Report: Mineral reflectance spectra and chemistry of 29 rare-earth minerals and rare-earth oxide powders including niobium- and tantalum-oxid powder, V. 2.0 GFZ Data Services, https://doi.org/10.5880/GFZ.1.4.2019.004, 2019a.
4. Boesche, N. K., Rogass, C., Mielke, C., Herrmann, S., Körting, F., Papenfuß, A., Lubitz, C., Brell, M., Tonn, S., and Altenberger, U.: Hyperspectral Rare Earth Element Mapping of Three Outcrops at the Fen Complex, Norway: Calcitic, Dolomitic, and Ankeritic Carbonatites, chap. 16, in: Rare Earths Industry – Technological, Economic, and Environmental Impli- cations, Elsevier Inc., 235–265, https://doi.org/10.1016/B978-0- 12-802328-0.00016-4, 2016.
5. Daempfling, H., Mielke, C., Koellner, N., Rogass, C., Altenberger, U., Harlov, D. and Knoper, M.: Automatic element and mineral detection in thin sections using hyperspectral transmittance imaging spectroscopy (HypertTIM), in prep.
6. Kokaly, R. F., Clark, R. N., Swayze, G. A., Livo, K. E., Hoefen, T. M., Pearson, N. C., Wise, R. A., Benzel, W. M., Lowers, H. A., Driscoll, R. L., & Klein, A. J. (2017). *USGS Spectral Library Version 7*. https://pubs.er.usgs.gov/publication/ds1035

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