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An automated Raman system for in-situ identification of minerals in underground locations of salt rock

We present a Raman system for automatic and rapid in-situ identification of minerals in salt rock contours. The system was developed in the context of long-term safe disposal of radioactive waste in deep geological formations (salt rock). Emplacement areas have to be sealed with suitable geotechnical barriers (shaft and drift seals), positioned in the intact rock (Halite, NaCl) to prevent or minimize possible solution flow. Hence, detecting inhomogeneities is important as they can become preferred flow paths if they consist of easily soluble minor components (e.g., veins or nests of potash salts). However, existing mineral identification methods, relying on point-to-point surface laboratory analysis of, e.g., drilled samples, are time-consuming and costly. Raman spectroscopy conveniently distinguishes stable Halite regions (not Raman-active) from other salt minerals (hydrates, sulfates, etc.). In the presented system, spectra acquisition combines shifted excitation Raman difference spectroscopy (SERDS) and dual excitation wavelengths (a SERDS laser tunable near 785 nm and a red laser at 671 nm), while pre-processing uses a trained U-Net deep-learning model to obtain a background- and quasi-noise-free Raman spectrum of the sample [1]. A newly developed reverse search-based identification method qualitatively identifies the pre-processed sample spectrum by matching the intensity, number, position, and width of peaks in the reference spectra of the mineral database against those in the pre-processed sample spectrum. The Raman system uses a 3D camera for mapping the measurement region and a robot arm for accurate positioning (Figure 1). The system was successfully tested at an underground salt rock site. This work is funded through the project 02E12143 by the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN).

References

- [1] Gokuladas D, Sohr J, Braeuer AS, Freyer D. A Raman Measurement and Pre-Processing Method for the Fast In Situ Identification of Minerals. *Minerals*. 2025; 15(12):1316. <https://doi.org/10.3390/min15121316>

Figures

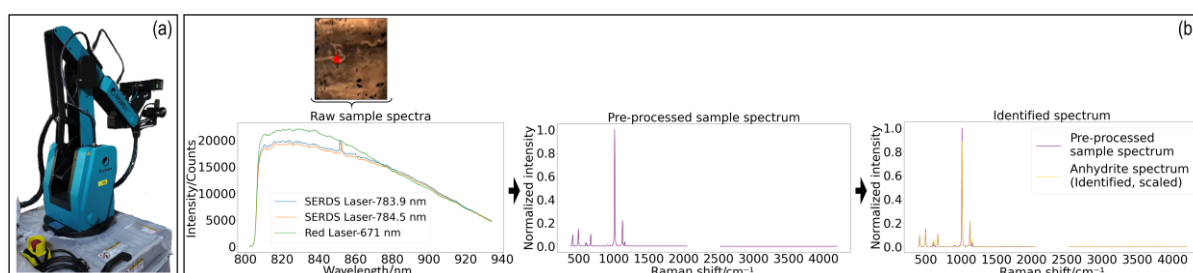


Figure 1: (a) The automated Raman system used for in-situ mineral identification and (b) Pre-processing and identification of Raman spectra from a salt rock sample containing anhydrite bands.