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Uranium detection in phosphate rocks by laboratory spectroscopy, toward the remote sensing of non-traditional uranium deposits

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In 1989, Ilani and Strull observed secondary uranium mineralizations leaching out of the Senonian phosphorites and the thermally metamorphosed phosphorite deposits of the Hatrurim formation in the northeastern Negev Desert in Israel (Ilani and Strull, 1989). These uranium enriched deposits are thought to have developed via the arrival of uranium (and other trace metal) bearing hydrothermal fluids after thermal alteration of extensive phosphorite deposits in the region. This led to uranium substitution and subsequent accumulation in the local phosphate minerals (e.g., hydroxy-apatite). Uranium-enriched phosphate deposits are considered "non-traditional" uranium ores, which have garnered increasing interest both from the human health and national security perspectives.

This work aims to understand the effect of uranium uptake on the reflectance spectra of relevant local rocks and minerals; with the goal toward quantifying uranium detection via reflectance spectroscopy remote sensing. The methodology is a combined field and laboratory approach to generate results that can then be used to train remote sensing algorithms.

The results for 70 samples collected near Arad, Israel are presented. The samples were collected, characterized by laboratory XRD and XRF, and their reflectance spectra between 350 – 2500 nm were measured using an ASD spectrometer. The samples had an average uranium concentration of 1400 ppm. In the field, it is clear that the uranium leaches to the surface in secondary efflorescent minerals (Fig. 1). This also strongly affects the reflectance spectroscopy of the surface of the collected samples. In addition to collecting spectra of uranium-bearing and comparable background material, we have also separated and purified uranium-bearing effloresccent minerals, carnotite in particular (Fig. 2). The pure spectra of these minerals can be used for direct uranium deposit identification. Pure uranium-bearing mineral spectra are also absent from most reflectance spectral libraries.

We present a summary of our results thus far: both efforts to unmix field and mixed laboratory reflectance spectra, as well as our efforts to purify uranium-bearing efflorescent salts and measure a corresponding pure reflectance spectrum. We provide implications for the use of these results to remotely detect uranium in non-traditional ore deposits and other possible surface uranium enriched sites (e.g., mines).

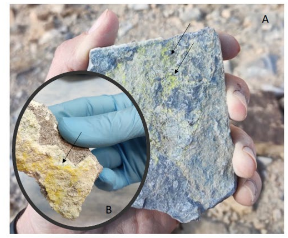

Figure 1. Characteristic examples of collected samples in the field (A) and laboratory (B) with secondary U-bearing mineral crusts (black arrows).

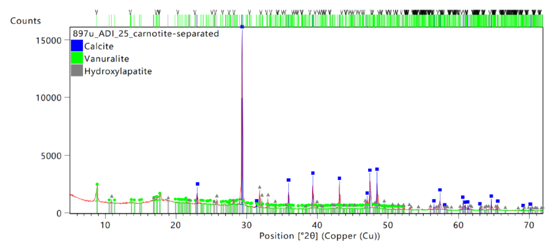

Figure 2. X-ray diffractogram of one sample of purified vanuralite (carnotite family mineral), coevolved with calcite.