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Photoluminescence of REE^{3+} in minerals and ceramics – A Raman artefact and how to make use of it –

Trivalent rare-earth elements (REE^{3+}) are commonly incorporated as trace elements in a wide range of natural minerals (e.g., zircon, monazite / xenotime, titanite) and synthetic ceramics. Their unique 4f electronic configurations lead to sharp, element-specific photoluminescence (PL) emissions. These emissions are typically narrow due to shielding by outer electron shells, making them highly sensitive to the local crystal field environment. In Raman spectroscopy, the PL of REE^{3+} can appear as an analytical artifact, potentially mimicking or obscuring true Raman bands. In this contribution, applications are presented that turns these "artefacts" into powerful tools: a) hyperspectral PL intensity mappings enables visualization of mineral textures, zoning, and trace-element distributions at micrometer scales [1]; and b) advanced multi-variate spectra data analysis enables to decipher the degree of amorphisation/crystallinity as useful for the structural characterisation of actinide-containing minerals used fo U-Th dating or ceramic-based nuclear waste-forms.

References

[1] Christoph Lenz, Lutz Nasdala, Dominik Talla, Christoph Hauzenberger, Roland Seitz, Uwe Kolitsch; Chemical Geology 415 (2015)
[2] Christoph Lenz, Gordon Thorogood, Robert Aughterson, Mihail Ionescu, Daniel J Gregg, Joel Davis, Gregory R Lumpkin, Frontiers In Chemistry 7 (2019)
[3] Christoph Lenz, Elena Belousova, Gregory R Lumpkin; Minerals 10 (2020)

Figures

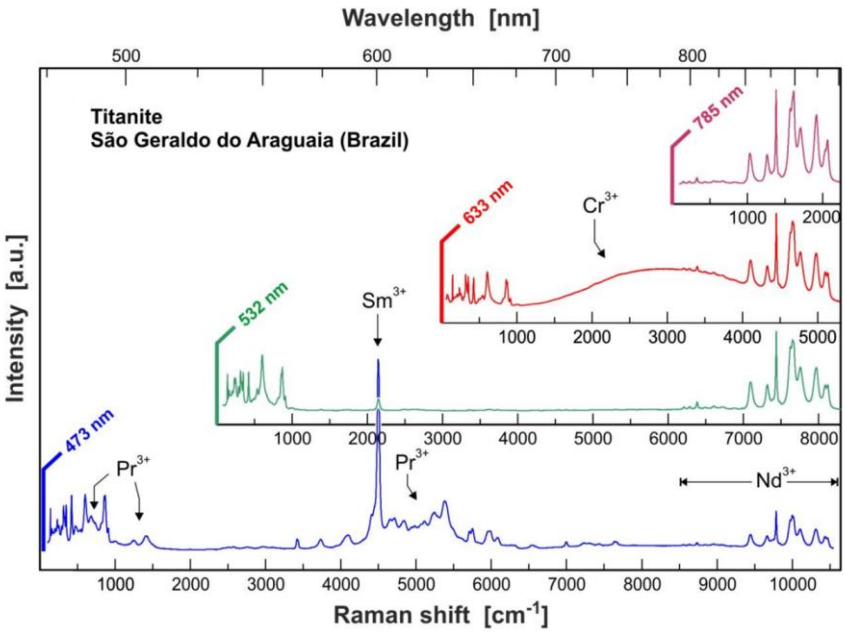

Figure 1: "Raman" spectra of a titanite from São Geraldo do Araguaia (Brazil) obtained using four different laser excitation-wavelengths (473, 532, 633, and 785 nm). Note that, dependent on laser excitation, PL emissions of multiple different trace elements such as Sm^{3+}, Pr^{3+}, Nd^{3+} and Cr^{3+} may appear in or obscure the Raman spectrum (Fig. from [1])