Department of Earth Science and Engineering, Imperial College London and Department of Earth Sciences, Natural History Museum

PhD Project 2020

Development of UV-fluorescence Spectroscopy as a Tool for Mineral Exploration

AIM To define and understand spectral fingerprints of minerals that can be used to discriminate between hydrothermal ore deposit environments and to vector within individual systems.

BACKGROUND Many minerals and organic materials fluoresce (emit light) under UV illumination and the fluorescence colour and intensity are a function of the activating frequency and the presence of trace element or molecular activators in the sample structure. In mineralogy, quantitative spectral determinations and the identification of activator elements are surprisingly scarce. The aim of this project is to define spectral fingerprints of alteration minerals that can be used to discriminate between hydrothermal ore deposit environments, distinguish mineralized from barren systems and potentially to vector within individual systems.

Logging drillcore at the giant Resolution porphyry Cu-Mo deposit, Arizona, USA

OBJECTIVES The project will focus on the acquisition of 3D UV-fluorescence spectra (emission intensity as a function of activation and emission wavelengths) of key alteration minerals and the development of Machine Learning algorithms to classify them. Samples will be sourced from the ore and mineralogy collections at the Natural History Museum (NHM) and from a field study site where selected minerals can be collected from a 3D framework around a well-constrained ore system. In tandem, the minerals will be analysed using several techniques including electron microprobe and laser ablation-inductively coupled plasma-mass spectrometry in order to identify trace element activators. The student will also help to develop a workflow for routine acquisition of spectra and digital archiving of data on museum collections samples. Ultimately, we aim to develop a practical tool that can be simply applied in a core-shack environment in mineral exploration, in order to enhance the efficiency of mapping and interpreting hydrothermal systems. This could potentially provide a much quicker and cost-effective solution to current targeting methods that rely on time-consuming chemical analysis of mineral samples. An enhanced understanding of mineral chemical variation in hydrothermal minerals will feed into our overarching research goal to decrease the risk and environmental footprint of mineral exploration that seeks to discover the metals needed for the low carbon energy transition.

METHODS An initial literature review of UV-fluorescence properties of relevant alteration minerals will be used to identify key minerals for further investigation. The NHM Rocks and Minerals database will then be interrogated to locate suitable specimens for reference measurements. A suitable field area will be identified, likely to be in collaboration with an industry partner, to act as an orientation study with spatially constrained sampling. Fieldwork will involve extensive mapping of the alteration domains and sampling.

Samples will be analysed using 3D UV-fluorescence (UV-F) scanning using a brand new fluorescence spectrometer located in the Imaging and Analysis Centre at the NHM. The same areas analysed by UV-F will then be imaged using optical hot-cathode cathodoluminescence, scanning electron microscopy backscattered electron and cathodoluminescence imaging, and analysed by electron microprobe and laser ablation ICP-MS for major, minor and trace elements. Spectral peaks corresponding to specific activators will be identified and spectra quantified in terms of absolute trace element abundances and trace element ratios. Data analytics, including machine learning approaches, will be applied to characterise complex 3D spectral datasets in relation to alteration mineral origin and/or spatial position classifications.

Zunyite in pyrophyllite and euhedral quartz, Big Bertha Extension, Dome Rock Mountains, La Paz County, Az (high sulphidation gold prospect). Hand specimen and sample under UV light showing pink zunyite fluorescence. John Betts Fine Minerals.

WIDER IMPLICATIONS The research will provide new insights into the controls of UV activated fluorescence and potentially also photoluminescence in alteration minerals and will provide a thorough test of the applicability of such spectra for mineral exploration applications.

STUDENT PROFILE We are looking for a well-qualified and highly motivated Earth Sciences/Geology graduate who wishes to carry out a cutting edge PhD in economic geology/geochemistry/ spectroscopy and gain experience in a range of mineralogical and geochemical analytical methods. Excellence in geochemistry and mineralogy are essential; experience of microanalytical techniques and statistical data evaluation are desirable. A desire for involvement with the Imperial Student Chapter of the Society of Economic Geologists and outreach activities will be beneficial.

TRAINING The successful student will join the London Centre for Ore Deposits and Exploration (LODE) research group in the attractive environment of South Kensington, London, that includes researchers from Imperial College London and the NHM. The student will be based full time at the Museum and have the opportunity to work in the state-of-the-art analytical suite. The student will receive training in field mapping, core logging and sampling, laboratory best practice, UV-fluorescence/ photoluminescence spectroscopy, cathodoluminescence, SEM techniques, laser ablation ICP-MS instrumentation and analysis, data reduction and analytics. Attendance and presentation of results at major UK and international conferences will be supported in the research programme. All postgraduates in the Department of Earth Science and Engineering have access to workshops organised by the Graduate School of Engineering and Physical Science which include: personal organisation and effectiveness; thesis writing and completing the PhD; technical writing; teamwork; professional issues in science; research ethics; and presentation skills. There are also optional courses in career planning, IT skills, media and entrepreneurship. Attendance at regular seminars on ore geology, geochemistry and the wider Earth Sciences is compulsory.

FUNDING Funding for the project will be via a successful application by the student to the NERC SSCP DTP or other scholarships programme at Imperial College London. Applications for additional support for conference and workshop attendance will be made to the Society of Economic Geologists student grant program.

FURTHER INFORMATION If you are interested in the project and would like to have further details please contact Jamie Wilkinson at j.wilkinson@nhm.ac.uk

http://www3.imperial.ac.uk/people/j.wilkinson
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