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Use of portable X-ray diffraction analysis in mineral exploration

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X-ray powder diffraction (XRD) is a well-established tool in the Earth Sciences, as it allows for the identification and quantification of mineral assemblages and can also be used to determine the crystallinity of a given mineral phase.

Traditionally, XRD devices have largely been restricted to laboratories due to the capital costs, environmental requirements and significant sample preparation. Recent advances in XRD sample holders and X-ray sources have allowed for the development of portable XRD (pXRD) devices where the sample preparation is simpler and does not require regular calibrations by a technical expert. This technology was initially developed by NASA for the Mars Science Laboratory Curiosity Rover to perform mineralogical analysis of the Martian surface.

pXRD instruments require 15 mg of sample at a grainsize < 150 μm, allowing for the mineralogical assessment of either bulk or selective samples (e.g. vein material, individual crystals, etc). The instruments utilise a piezo-harmonic Vibrating Sample Holder (VSH) which vibrates the crystallites in all orientations without macroscopic movement of the sample holder, helping to alleviate the issue of preferred orientation (a problem inherent in conventional XRD instruments) as well as providing particle statistics equivalent to those obtained on a conventional instrument at a grain-size of 3 μm. pXRD utilises a transmission geometry with the X-ray source and detector fixed, preventing the need for ongoing calibrations or servicing (as is required for the goniometers of lab-based instruments). Using a charge coupled detector (CCD) pXRD instruments simultaneously measure XRD and qualitative X-ray fluorescence (for the elements Cl – Pb).

Due to its portability, robustness, minimal sample preparation, relatively fast collection times, and excellent correlation with laboratory-based XRD devices, the pXRD has been shown to be of great use for rapid acquisition of quantitative mineralogical data by the exploration geologist, allowing for more informed and faster decisions during mapping and drilling programs. Quantitative mineralogy provided by pXRD can also be fed into future geometallurgical models.

This study provides examples where pXRD has been applied to exploration of hydrothermal and heavy mineral sands deposits. The case-studies for hydrothermal deposits illustrate the importance of quantitative mineralogy and crystallinity in vectoring towards mineralisation in fine-grained highly altered rocks. The case study for heavy mineral sands illustrates the ease of use with no sample preparation required.