Imaging serpentinised rocks from the Mid-Atlantic ridge through µ-CT, spectral CT and 2D techniques: towards a better characterisation of alteration reactions

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Serpentinisation involves the hydration of gabbroic and peridotitic rocks through seawater circulation near oceanic ridges, triggering chemical reactions at high temperatures (300–500°C). This process is widespread in slow to ultraslow spreading ridges, significantly influencing oceanic crust in these settings. It leads to the alteration of primary minerals, the precipitation of secondary phases, and the redistribution of chemical elements. However, visualising the three-dimension spatial orientation and penetration of serpentinisation processes within the oceanic crust rocks remains challenging.

To investigate textural features of serpentinisation, such as the alteration of primary phases, the distribution and localisation of secondary phases, and the mapping of vein networks, we conducted a 3D petrological study on serpentinised gabbro and peridotite samples from a hydrothermal field on the mid-Atlantic ridge. Our study utilised X-ray micro-computed tomography (micro-CT), a non-destructive imaging technique, complemented by spectral X-ray micro-computed tomography (sp-CT), using a Tescan UniTOM XL Spectral (DMEX, Pau, France). Both methods allow non-invasive 3D imaging of materials, based on both the material-specific X-ray attenuation coefficient and the density. While micro-CT provided 3D qualitative visualisations of the material chemistry and density, sp-CT enabled semi-quantitative analyses through 2D slice-based examination.

To validate the X-ray imaging workflow and assess its advantages and limitations, we performed Scanning Electron Microscopy (SEM) analysis, including Backscattered Electron (BSE) imaging and Energy-Dispersive Spectroscopy (EDS) pointing and mapping. High-resolution micro-CT and sp-CT revealed sulphur patches bordered by calcite, iron oxide, and carbonate vein networks, as well as chromite alteration in serpentinised peridotites. In the serpentinised gabbronorite, sulphur patches were observed surrounding clinopyroxenes.

This study highlights the potential of combining micro-CT and spectral-CT with traditional chemical 2D quantitative techniques to investigate fluid circulation and mineralisation in rocks. For serpentinites, this approach could offer valuable insights into the location and kinetics of alteration reactions, gas pockets and potential catalyzers for organic compounds formation.

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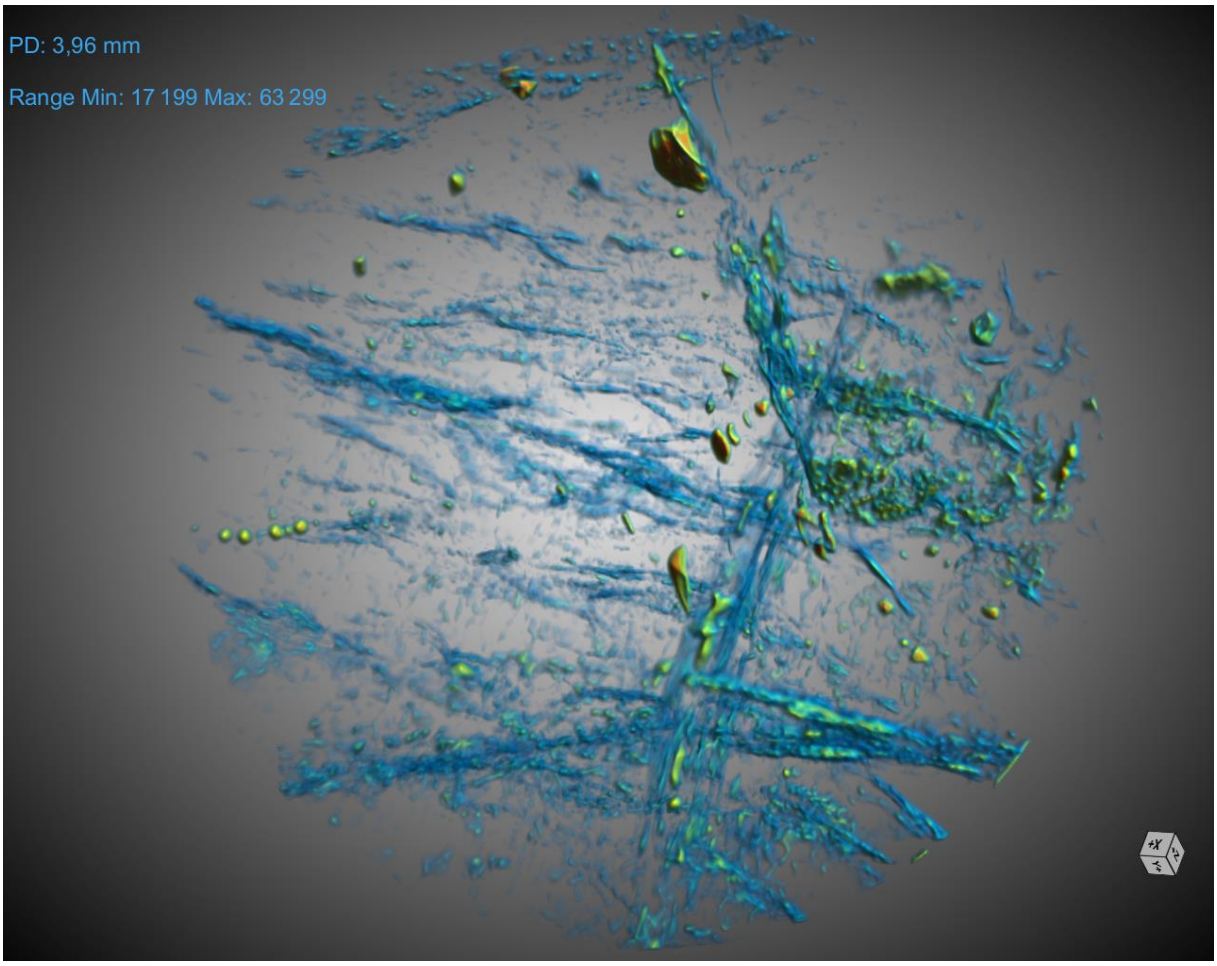

Image : 3D visualisation of vein network and clusters of sulphurs in a serpentinite.