High resolution 3D imaging of an oceanic core complex: interaction of magma, water and faults on the mid-Atlantic ridge

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Aims: To use high-resolution imaging coupled with other geophysical methods to better understand slow-spreading oceanic ridges in the Atlantic. The project will include determining the geometry of detachment faults that penetrate the oceanic crust, assessing the role of these faults in the transport of fluids to the mantle, and investigating magma supply.

Background: At mid-ocean ridges, tectonic plates are pulled apart and the Earth's mantle slowly rises and is partially molten, producing magma that forms new crust, the outer low-density layer of the Earth. The structure and composition of the crust is controlled by the balance between magmatism, faulting and water circulation [1]. Sea water penetrating cracks and fractures drives metamorphism and returns to the oceans at hydrothermal vent sites. These deep-sea vent systems are a major gateway for exchange of chemicals and heat between the solid Earth and the Oceans and have implications for the long-term evolution of our planet and its climate.

Methods: You will apply Full Waveform Inversion (FWI) [2] to map detachment faults and obtain high-resolution images of seismic velocity, [3,4]. The resulting high-resolution models of the physical properties of the subsurface will be interpreted using rock physics tools and will provide constraints on the geometry of fluid pathways, magma bodies and faults.

Student profile: We are looking for geologists, geophysicists, physicists, computer scientists, applied mathematicians, and others with a numerical background and an interest in imaging the Earth. Some previous experience with active source seismic data and/or numerical modelling would be an advantage. The student will work in a vibrant research environment, have opportunities to undertake internships with industrial sponsors (should they wish to do so), and travel abroad to attend international meetings and visit collaborators.

Multi-disciplinarity: This project applies techniques borrowed from exploration seismology and materials science to advance our understanding hydrothermal circulation and accretion of new crust.

Critical skills: The research will involve software development and data analysis using local and national HPC resources and will help the student develop highly sought-after skills including software development, numeracy, data management and machine learning.

References:

[1] Paulatto, M. et al. (2015), Heterogeneous and asymmetric crustal accretion: new constraints from multi-beam bathymetry and potential field data, *G-cubed*, doi: 10.1002/2015GC005743.

[2] Morgan J. et al. (2016), Next-generation seismic experiments – II: wide-angle, multi-azimuth, 3-D, full-waveform inversion of sparse field data, *GJI*, *204*(2), 1342–1363, doi: 10.1093/gji/ggv513.

[3] Dunn, R. A. et al. (2018), Three-dimensional seismic structure of the Mid-Atlantic Ridge: An investigation of tectonic, magmatic, and hydrothermal processes in the Rainbow Area, *JGR*, 122, 9580-9602.

[4] Canales, J. P. et al. (2017), Seismic imaging of magma sills beneath an ultramafic-hosted hydrothermal system, *Geology*, *45*(5), 451-454.