2022_45_ESE_Paulatto: Multi-scale characterization of water flow in submarine hydrothermal systems

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Background: Black smokers are high-temperature submarine hydrothermal vent systems commonly found near mid-ocean ridges, where new oceanic lithosphere is created by the interaction of magma from the mantle, faulting and chemical interaction with seawater. Water penetrates the young lithosphere, is heated up and picks up chemicals, before returning to the seabed. This project aims to understand the interaction of water with faults (particularly detachment faults) and magma and investigate the conditions under which long-lived black smoker systems develop.

Why is this important? Black smokers are sites of great interest because they represent a major gateway for chemical exchange between the solid Earth and the ocean system. They are associated with high-grade mineral deposits, rich in precious metals and rare earth elements and host unique biological communities that may be analogues for early life ecosystems.

Aims: To combine numerical modelling and geophysical observations to understand the deep structure of submarine hydrothermal systems, their role in the global geochemical cycle, and the creation and hydration of oceanic crust and lithosphere. 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.

Methods: You will apply Full Waveform Inversion (FWI) to map detachment faults and obtain high-resolution images of the roots of a hydrothermal system on the Mid-Atlantic Ridge. 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. These models will be interpreted to build a numerical 3D representation of the hydrothermal system and its tectonic environment and will form the basis for numerical simulations of hydrothermal fluid flow using state of the art numerical models developed for hydrocarbon reservoir modelling. The modelling will help understand the controls on the location and properties of submarine hydrothermal vents in relation to tectonic and magmatic structures and estimate heat and chemical fluxes between the solid Earth and the oceans.

Student profile: We are looking for geologists, geophysicists, physicists, computer scientists, applied mathematicians, and others with a numerical background and an interest in exploring the Earth. Previous experience with active source seismic data or numerical modelling would be an advantage. The student will work in a vibrant research environment, with opportunities to interact with industry partners and international collaborators.

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