Multi-scale characterization of water flow in submarine hydrothermal systems

Supervisors: Michele Paulatto (m.paulatto@imperial.ac.uk), Sam Krevor, Carl Jacquemyn, Matthew Jackson

Department: Earth Science and Engineering

Aims: To combine laboratory measurements, 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.

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 sea water [1]. 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.

Methods: You will carry out laboratory measurements of elastic and fluid flow properties on rock samples from the survey area and you will compare them to numerical predictions based on microstructural data obtained by 3D X-Ray imagery [2]. Seismic and other geophysical data from the Mid-Atlantic Ridge [1,3,4] will be interpreted to build a numerical 3D representation of the hydrothermal system and its tectonic environment. The constraints from field and laboratory measurements will form the basis for numerical simulations of hydrothermal fluid flow using state of the art numerical models developed for hydrocarbon reservoir modelling [5]. 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.

External collaborators: R. Dunn (Hawaii), J.P. Canales (WHOI), M. Andreani (Lyon)

Multi-disciplinarity: The project will involve the application of imaging and modelling techniques developed for hydrocarbon explorations to new scientific areas. It is developed to take advantage of the widely diverse but complementary expertise available at ESE and sits at the intersection of laboratory rock physics, field geophysics and numerical modelling.

References: