USING THE MAGNETIC SIGNATURE OF FORMER HYDROCARBON-RICH ENVIRONMENTS TO TEST FOR THE SUITABILITY OF CARBON SEQUESTRATION: A NUMERICAL APPROACH

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Background

For former hydrocarbon reservoirs to be used for carbon sequestration, we need to understand the ability of the reservoirs to retain the stored CO_2. One way to determine this is to understand the migration history of the hydrocarbons which previously resided in the environment. Understanding the migration paths is challenging. There are several approaches, the standard of which is petroleum systems modelling; however, models need to be tested. One way to test such models is using the magnetic signature of rocks. When hydrocarbons pass through a rock they change the environment, which causes authigenesis of minerals, in particular magnetic minerals, for example, the Natural Magnetism Group at Imperial has shown that iron-rich sulphur minerals are typically associated with biodegradation of oil, and vertical migration of oil with the formation of siderite (iron carbonate) (Badejo et al., 2021; Abdulkarim et al., 2022). The magnetic signature of rocks can be rapidly measured, and the magnetic mineralogy and grain-size determined even when concentrations are as low as 100 ppm.

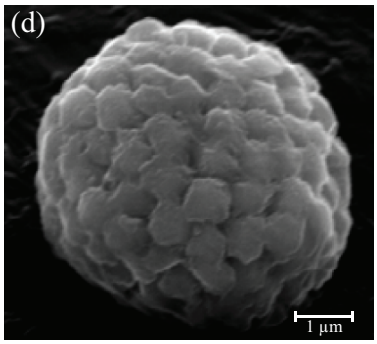

Figure 1. Framboidal iron sulphide. From Emmerton et al., (2012).

Often associated with hydrocarbon-related magnetic minerals are the presence of both iron oxide and/or sulphide framboidal aggregates; framboids are structures formed of symmetric grains that have spontaneously assembled in raspberry shapes (Fig. 1). It is thought that the magnetic signature of these framboids has the potential to be used as a magnetic proxy for studying migration. However, in both the natural and synthetic samples, it has proven difficult to isolate the magnetic signature of these framboids from bulk samples, which contain distributions of other magnetic particles.

Project

The aim of this proposal is to use three-dimensional numerical models (micromagnetic models) to isolate and quantify the magnetic signature of these framboids, to allow us to optimise protocols for their detection. Recently, Edinburgh and Imperial have jointly successfully developed the next generation of micromagnetic code (Ó Conbhui et al., 2018). This code is a step-change from previous models, and allows for the numerical study of much larger magnetic systems, in particular the magnetic response of framboidal aggregates (Valdez-Grijalva et al, 2020).

The student will use the micromagnetic Finite Element Model (FEM) to determine and quantify both the signature of isolated framboids, plus the response of bulk samples containing other magnetic materials. The effect of size will also be investigated: If the magnetic minerals migrate it is expected that they will travel greater or shorter distances according to their size, and since the magnetic properties are highly size dependent, this will be key to understanding migration.

Knowledge of computer programming and/or mathematics/physics would be beneficial.

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