Storing hydrogen in rocks?!

Introduction

My name is Cath Cripps, and I'm a geologist who has worked at the British Geological Survey (BGS) for 14 years. I have numerous roles and duties that I perform as a survey geologist, and no two days are the same! Generally, my work involves studying sedimentary rocks and mapping their occurrence in the surface and subsurface, and this principally involves describing, mapping and 3D modelling of them.

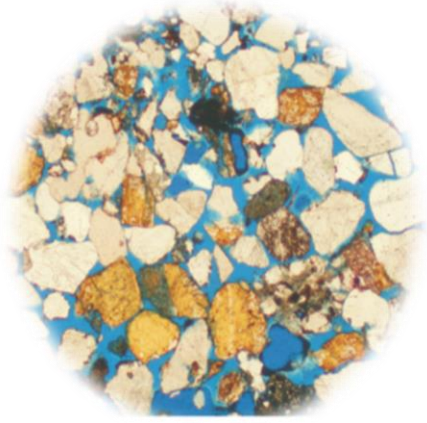
Investigating Chalk Group strata in the field

One project I am currently working on as a specialist sedimentary geologist, is for the Industrial Decarbonisation Research and Innovation Centre ('IDRIC' for short). IDRIC is funded by UK Research and Innovation (UKRI), with collaborations including stakeholders from across industry, academia and government. IDRIC's principal aim is looking into how we can move towards a future without conventional fossil fuels ('decarbonisation'), especially for industry. This sector are large consumers of energy / emitters of CO_2 as part of their industrial processes and operations are often concentrated in clusters in particular areas of the UK, including the Black Country, Grangemouth, Humberside, Merseyside, Southampton, South Wales and Teesside (see https://idric.org/stakeholders/).

One rapidly growing area of development is in using hydrogen as an energy carrier and fuel source. However, one of the challenges is understanding the potential for the storage of large volumes of hydrogen to support the decarbonisation of these industrial clusters. Of course, hydrogen can be stored above ground, but space for this is limited around the industrial clusters and can be expensive.

Sedimentary rocks as storage media in the UK

Sedimentary rocks (rocks that are derived from the erosion and transportation of pre-existing rocks, such as sandstones, or the accumulation of material by biogenic or chemical processes) can hold volumes of fluid much like a giant sponge. Our research involves testing what would happen if we used sedimentary rocks in the UK to store hydrogen near to UK industrial clusters. Sandstones are composed of small mineral grains (generally quartz) that are packed closely together, but leaving small spaces between the individual grains. This gives space for the hydrogen to occupy (this physical attribute is termed porosity).



Section through sandstone with pore space dyed blue

In addition, hydrogen can move between grains or along fractures in the rock (and this physical attribute is termed permeability). When these parameters combine to allow large volumes of hydrogen to be stored in, and move through the rock, it means that the sandstone can accommodate a large amount of fluid, such as hydrogen that can be injected and retrieved from the rock. For the UK, this could mean that sandstones are potentially favourable rocks for underground hydrogen storage, in many locations beneath the country.

IDRIC research into sandstones and sample selection

As part of IDRIC directed research, I was tasked with selecting samples of sandstone with which to test in laboratories both hosted at BGS, the novel micro-CT facility at University of Manchester, and coreflood capability at Heriot-Watt University.

Laboratory capability at the British Geological Survey allows rock samples to be exposed to hydrogen at 50 degrees Celsius and 150 bars of pressure- conditions approaching those where hydrogen could be stored underground

There is currently little research into how hydrogen behaves and interacts with sandstones that could potentially be used to store it. Our project looked at and tested two types of sandstone that occur in the UK. These are sandstone from the Chester Formation, Sherwood

Sandstone Group (Triassic in age- approximately 230 – 260 Million years old) and sandstone from the Lower Greensand Group (Lower Cretaceous- approximately 100 – 126 Million years old). We have developed a series of experiments to investigate whether hydrogen would react with these sandstones or affect the composition of the stored gas. Both of these sandstones are known to be able to hold vast amounts of fluid, however, research concluded that there were no major changes when exposed to hydrogen at elevated temperatures and pressures. Phase 2 directed research has tried to find more weird and wonderful sandstones to see if there are any changes associated with hydrogen, so with this criteria in mind, I selected sandstones from the Carboniferous, the Lower Jurassic and some additional Lower Greensand. I selected samples that might contain more obscure minerals such as pyrite that may have the potential to react with hydrogen and affect how the rock may store / release hydrogen, either through geochemical or microbial changes in the rock, albeit at a micro scale. Our sandstone samples were taken from sedimentary core that is held in the National Geological Data Repository, which holds over 500km of continuous core! Currently, the samples I selected are being experimented on in six different laboratories, more on that later…