**Project Title**: From geo-resources to energy storage: how do underground lithologies respond to thermo-mechanical coupling?

**Ref:** IAP2-21-360

**Closing Date:** January 7, 2022 5:00pm (UK time)

**Supervisors**:
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**Description:**
On our quest to decarbonise our energy resources, underground heat energy storage is a key player. However, the impact of frequent **cyclic thermo-mechanical (TM) stress changes** over prolonged periods remains poorly understood and may threatened the longevity of the systems. This project will aim to fill the gap by performing **laboratory and numerical experiments** under relevant cyclic TM loading conditions to investigate the stability of targeted lithologies in such systems.
To address the energy transition challenges, new subsurface solutions focus either on new resources exploitation (geothermal) or storage (radioactive waste, heat and/or gas – underground gas storage, compressed-air energy storage, H, $CO_2$). All these applications have in common to induce new, shallow, periodic, local thermo-mechanical stress changes. Recent works on TM effects (from room temperature to ca. 100ºC) on porous rocks have demonstrated:
– a peak strength reduction with increasing thermal loading in intact samples, whilst samples with initial discontinuities first displayed an increase in peak shear strength at 50oC before showing similar reduction as intact samples at 100ºC (Woodman, 2020);
– a substantial pore pressure accumulation with thermal loading, with fluid thermal expansion being substantially greater than mineralogical thermal expansion (Garitte et al., 2017);
– a non-valid use of uniform failure and friction criteria, which could lead to an erroneous estimation of the subsurface stress state (Arhens et al., 2021).
Moreover, series of cyclic mechanical loading tests performed at relevant underground gas storage conditions, have shown a complex impact of the material microstructure on the mechanical properties and material response at different scales of observation (Martin Clave et al., 2021). For instance, local microcracking in some minerals (inelastic deformation) appeared to be accommodating further elasticity at the macroscopic scale instead.
The scope of this PhD project is to use **different scale observations to model and predict** the stability of targeted lithologies in underground complex systems when those are subjected to cyclic TM stress changes over prolonged periods. This research work seeks to understand **how grain scale deformation can contribute to the global response of the underground systems and how this response can be controlled to reduce any accompanied induced hazards**. An innovative methodology, combining laboratory and numerical experiments, will be applied to extend the understanding of the thermo-sensitive brittle deformation processes in porous rocks. The data will provide information to support field scale operational

conditions involving periodic TM stress changes as well as shed light on potential for cascading shallow geohazards.
Objectives
O1: Examine the relationship between microstructural deformation and TM stresses.
O2: Collect, analyse and model TM data together.
O3: Transfer and improve existing DEM code from UDEC to open source and undertake grain size sensitivity analysis.
O4: Provide relevant data to inform on risks associated to TM stresses in underground geological storage conditions

More details: https://www.iapetus2.ac.uk/studentships/from-geo-resources-to-energy-storage-how-do-underground-lithologies-respond-to-thermo-mechanical-coupling/

**Eligibility**: APETUS2 is looking for candidates with a first or 2:1 undergraduate degree or have relevant comparable experience – we welcome applications from those with non-traditional routes to PhD study. Eligibility is under UKRI Terms and Conditions, which means that UK and International candidates may apply. For International Students, UKRI only pay the equivalent of home fees.
Those eligible for a home award must:

- Be a UK National (meeting residency requirements), or
- Have settled status, or
- Have pre-settled status (meeting residency requirements), or
- Have indefinite leave to remain or enter

If you are uncertain, please see this link for further information

For more info on the eligibility: https://www.iapetus2.ac.uk/studentships/

**Financial support:** IAPETUS2's postgraduate studentships are tenable for up to 3.5 years and covers: A tax-free maintenance grant set at the UK Research Council's national rate, which in 2021/22 is £15,609 and full payment of their tuition fees at the Home rate.

For more info on the financial support: https://www.iapetus2.ac.uk/studentships/

**Application process:** In the first instance the application process involves completing **both** the application form **and** the EDI form below by **7th January 2022 at 5pm**. If you are shortlisted, you will be contacted by 17th January 2022 and invited to put in a full application to the university where the PhD is based by 8th February 2022.

For more info on the application process: https://www.iapetus2.ac.uk/how-to-apply/

**Have you already contacted the supervisory team about the project?**

Applicants who are engaged in early discussions about the project with the supervisors are more likely to be successful in their application. We therefore encourage you to contact your potential supervisors and ask any questions you may have about the project and IAPETUS2.