NERC DOCTORAL TRAINING

UK Oil and Gas Collaborative Doctoral Training Centre (2017 start)

Project Title: Unlocking Natural Catalysis in Subsurface Oil Recovery.

Host institution: University of Birmingham (UoB)

Supervisor 1: Professor Joe Wood

Supervisor 2: Dr Sean Rigby, Nottingham; Prof. Lynne Macaskie, Birmingham.

Project description: Subsurface oil recovery could present a future opportunity to recover additional oil from partially spent reservoirs in the North Sea (e.g. The Steam Oil Company) in addition to heavy deposits in other parts of the World (e.g. Venezuela) We propose to study subsurface recovery using in-situ combustion combined with catalytic upgrading, by utilising the clay minerals occurring naturally in these geological formations, 'unlocking' their potential as catalysts. These include deposits such as oxides of iron and vanadium. Producing these resources effectively and with minimal environmental impact requires innovative science and technology. We seek to utilise chemical and biochemical methods of releasing and transforming these species to make active catalyst particles which will be applied down-hole in the reservoir to aid the recovery of oil and greatly reduce the environmental impact associated with alternative techniques such as mining and steam injection. For example, Fe-based catalysts could have high potential 'in the well' as they can function in steam reforming in the combustion step, in sulphide removal and hydrocarbon hydrogenation. E.g. Bacteria can be used to produce magnetite (Fe_3O_4) which can be 'doped' with additional metals. We propose to apply and adapt previously developed upstream engineering techniques including Toe-to-Heel Air Injection (THAI) and catalytic upgrading process in-situ (CAPRI). These are based upon in-situ combustion in a horizontal well incorporating thermal upgrading. We also seek to utilise these natural catalysts to decrease the coke deposition and deactivation associated with refinery type catalysts, which can otherwise greatly limit the process lifetime and to decrease the environmental impact of the process by using naturally occurring metals. Specific aims are to:

- Produce oil with increased API gravity and lowered viscosity from partially upgraded heavy oil.
- Reduce the need for additional surface upgrading at the refinery and thus energy use.
- Utilise particles as catalysts such as iron oxide, representative of metals naturally occurring in the geological formation as models for fines from past natural formation damage/erosion of an iron rich mineralogy which can augment upstream upgrading and reduce the requirement for refining.The THAI-CAPRI process is a novel oil recovery method. Operating the well with dispersed nanoparticulate catalysts brings new challenges of how to convey the catalyst in to the mobile oil zone (Rigby), as well as understanding the fate of such nano-materials in the environment. The student will participate in a comprehensive training programme and will be comfortable working at the interface between Geoscience and Engineering.

Research theme: The THAI CAPRI process is directly used for effective production of unconventional hydrocarbons (heavy oil, Canada) with lower sulphur & CO_2, which avoids the use of energy for steam and production of contaminated water associated with alternative techniques.

Research context: Existing PhD students have been working on the THAI-CAPRI process, but this project has a wide scope so that each can investigate a particular area (e.g. type of catalyst). This approach offers opportunities for team work and collaboration.

Research costs: Rigs and equipment are already in place from previous projects.

Career routes: The student will have a broad range of career options upon graduating, including further academic career or working in the catalysis or oil and gas industries. The students will be highly marketable to major oil companies such as BP and more specialised heavy oil extraction companies, Petrobank. A recent PhD graduate has taken up a lectureship Petroleum Engineering.