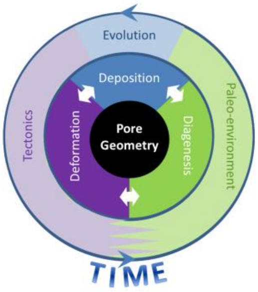
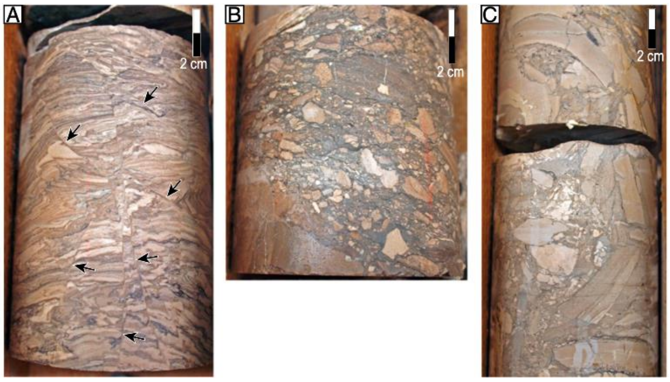


PhD project: Determination of processes governing hypogene dissolution and collapse of carbonate rocks

Supervisors: Prof Cathy Hollis (University of Manchester, Prof Fiona Whitaker (University of Bristol), Dr Hilary Corlett (MacEwan University), Prof Atle Rotevatn (University of Bergen)

The susceptibility of carbonate and evaporite successions to dissolution means that they are prone to collapse. This creates complex zones of brecciation, and in the subsurface, these zones might result in borehole instability, poor core recovery, erratic wireline log responses and possibly high flow rates. They might also be recognised on seismic data as localised, non-stratabound, chaotic responses that are associated with vertical zones of disruption, indicative of fluid escape. Developing a predictive understanding of these features is important for effective development and management of resources, from groundwater aquifers, geothermal and hydrocarbon reservoirs, to subsurface storage of hydrogen and CO_2.



Often, brecciated zones in limestone and evaporites are assumed to form as a result of stratal collapse by near-surface dissolution from surface recharge of meteoric waters [1, 2], *i.e.* they are typically assumed to be the product of groundwater flow. However, dissolution from upward-rising meteoric or formational fluids, for example along faults and fractures, can also occur [3].

Breccias from the upper Stettler and Big Valley Formation, west Canada Sedimentary Basin, formed by dissolution of anhydrite and collapse[4] Copyright (copyright year) National Academy of Sciences

The processes by which this so-called hypogene karst forms are less well understood, and dissolution as a result of cooling and/or mildly acidic groundwater, oxidation of H_2S, fluid mixing and CO_2 ingress have all been invoked [5,6,7,8]. What has yet to be fully achieved is a holistic interpretation of the structural, sedimentological and diagenetic processes that govern the location of collapse features, coupled with process-based understanding of interactions between fluid flow and water-rock interaction to assess rates, patterns and distributions of dissolution under contrasting conditions. This PhD project aims to address these issues by:

- Data review and characterisation of documented collapse features from published case studies based on outcrop, core and seismic studies
- Characterization of subsurface collapse features in core, using subsurface data from two areas in the West Canada Sedimentary Basin (WCSB) within Devonian strata.
- Construction of a series of 1D, 2D and 3D reactive transport models to assess the processes governing cavern formation from rising fluids and the viability of a range of existing conceptual models for a suite of rock types
- Delineation of the structural controls on collapse breccia distribution
- Comparison of model outputs with natural geological systems, and evaluation of critical feedbacks between permeability evolution, fluid flow, rock properties and dissolution.

This project has the potential to deliver new and exciting results that will inform how fluids of variable compositions flow and react within sedimentary basins. It will also have direct application to the improved recovery of oil and gas from mature fields, as well as the safe and secure storage of CO_2 in carbonate and evaporite reservoirs, cap-rock integrity, and water management in geothermal heat production.

Requirements

This project requires an upper second class or first class degree BSc or MEarthSci in geological sciences and/or an MSc at merit level or above in a geological discipline. Students should be numerate, have some knowledge of coding and experience of using models in Earth Sciences as well as be willing to conduct geological description and petrographical analysis. Experience of carbonate sedimentology, diagenesis and structural geology is an advantage.

This is a split-site PhD project between University of Manchester and University of Bristol. The successful applicant will be expected to spend time working on site at both universities, but the lead university will be decided in consultation with the applicant based on their skill sets and personal circumstances. It is expected that periods of data collection will be spent in Canada (Calgary and Edmonton) and visits to Norway to look at subsurface data is also anticipated.

Training

Training will be provided in carbonate diagenesis and geochemistry, geochemical modelling and state of the art reactive transport modelling. The successful candidate will join internationally renowned research teams in carbonate geoscience and fluid and reactive transport modelling at Universities of Bristol and Manchester. It is expected that the successful candidate will be highly numerate and have strong communication skills in order to integrate with co-workers at collaborating universities and to communicate with sponsoring companies.

Funding

This project is supported as part of a Joint Industry Project (PD3) funded by Tullow, Wintershall Dea and Woodside. Funds will cover the student stipend and research fees. Unfortunately, because of the level of funding available, this project cannot be offered to international students.

Further information

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Deadline for applications: 30th November 2020. Please apply online at:

https://www.manchester.ac.uk/study/postgraduate-research/admissions/how-to-apply/

References: [1]Loucks, R., 1999, AAPG Bulletin, 83, 1795 – 1834; [2]Tucker, 1991, J. Geol. Soc., London, 148, 1019-1036; [3]Klimchouk et al., 2017, Hypogene Karst Regions and Caves of the World, Springer, 911pp, 10.1007/978-3-319-53348-3; [4] Galloway et al., 2018, PNAS, 115, doi/10.1073/pnas.1807549115 [5]Poros et al., 2012, Int J Earth Sci, 138. 643-01, 429-452; [6]Barnett et al., 2015; Spec Pub.Geol. Soc. London, 435; [7]Beavington-Penney et al., 2008, Sedimentary Geology, 209, 42-57; [8]Hill, 1990, AAPG Bulletin, 74, 1684-1692