

The Andrew Whitham CASP Fieldwork Award – 2019 Winner

Applicant: TWOMEY, Vincent

Project title: Unravelling the kinematic history of intrusion-induced forced folding associated with emplacement of the Sandfell Laccolith, SE Iceland

Award: £2,000

Specific objectives and deliverables:

Over the past 20 years, the positive and negative impacts of igneous intrusions on petroleum system development have become widely recognised. This is primarily because 3D seismic reflection data has allowed the extent and structure of igneous intrusion networks, and associated host rock deformation, to be imaged and quantified. Numerous studies have shown that intrusions can mature source rocks (e.g. Muirhead et al., 2017), facilitate hydrocarbon migration (e.g. Rateau et al. 2013), form fractured reservoirs (e.g. Schutter, 2003), or create suitable 4-way dip closure traps (i.e. forced folds; e.g. Rodríguez Monreal et al., 2009). However, most previous studies have focused on examining the impact of mafic intrusions on petroleum system development, because the boundaries of these bodies typically have a high acoustic impedance contrast compared to the host sedimentary strata, meaning they are well-imaged in seismic. Yet a recent study has shown felsic intrusions may also be common in sedimentary basins, but their lower densities and seismic velocities, which can be similar to host strata, mean they are not obvious in seismic reflection data and often not interpreted (Watson et al., 2018).

Shallow-level igneous intrusions are commonly accommodated by roof uplift (i.e. forced folding), regardless of their composition. Identifying forced folds, which are attractive exploration targets, in seismic reflection data could thus be a way of discerning felsic intrusions, allowing their distribution to be mapped and aiding de-risking. Furthermore, whilst forced folds have been seismically imaged above mafic saucer-shaped sills (i.e. fold and sill geometries are not equal), field observations of forced folds above felsic intrusions suggests the fold mimics the intrusion shape. Two key problems are that field exposures of felsic intrusions and forced folds do not capture 3D geometries and the duration and rate of folding, which controls intra-fold deformation, is difficult to determine.

This proposal seeks funding to support follow-up fieldwork examining excellent 3D exposures revealing the structure of the silicic, Sandfell Laccolith and an overlying forced fold of host basalt lavas, which I have initially mapped as part of my PhD examining emplacement mechanisms of shallow level igneous intrusions in SE Iceland. Through ongoing geochronology and palaeomagnetic work, I have begun to discern the duration and rate of emplacement of the Sandfell Laccolith. Importantly, emplacement rate can be translated into strain rate, which dictates fracturing and faulting processes within folds. The aim of the proposed fieldwork is to: 1) Quantify the geometrical relationship between the fold and laccolith and; 2) Analyse fracture and fault patterns, relating their formation to emplacement processes.

Key to this work will be collection of structural field measurements and acquisition of drone photogrammetry to build a detailed DEM, from which inaccessible localities can be analysed. With respect to seismic reflection imaging of forced folds above potential felsic intrusions, this work will: 1) Help delineate characteristics of forced folds develop above felsic intrusions, 2) Assess how emplacement rate (i.e. strain rate) impacts sub-seismic fracturing and faulting, providing insight into potential intra-fold deformation within intrusion-induced forced folds, feeding into de-risking of exploration targets and, 3) Produce an interpreted 3D virtual outcrop model that will be freely available and useful for teaching in academia and industry.

Proposed work plan:

The requested budget will fund a 14-day field campaign in July 2019 for myself and a field assistant.

Spring 2019 - Analysis of 2018 Palaeomagnetic samples (Results to aid sampling strategy for 2019).

July 2019- Detailed structural mapping of entire structural aureole of Sandfell Laccolith with aid of MOVE™ software with emphasis on fault and fracture orientations and dips of layered basalt lavas.

- Collect orientated drill core and block samples from deformed host rock for Palaeomagnetic analysis in designated structural transects distributed across the structural aureole.
- Drone photogrammetry to analyse structures in inaccessible areas.

Autumn 2019 - Sample processing and interpretation, merge with structural data. Prepare for peer review journal.

Proposed expenditure, including details of any other sources of funding:

Flights (2x Return flights & baggage; EDI-KEF; www.wowair.co.uk): £450

Car Rental (Ford Focus, 14x days; www.booking.thrifty.is) and Fuel (based on 2018 costs): £1,300

Accommodation (Camping site fees 2 ppl x 14 nights = £20 per night): £280

Total: £2,030

The total requested herein will provide enough to cover all essential expenses for the proposed fieldwork.