NERC Centre for Doctoral Training in Oil & Gas (2017 start)

Project Title: High-resolution imaging of structures beneath active mud volcanoes: reconstructing fluids emission and assessing future hazards

Host institution: University of Aberdeen

Supervisor 1: Dr. Davide Oppo; Supervisor 2: Dr. Luca De Siena

Additional Supervisors: Prof. André Revil (Univ. Savoie Mont-Blanc); Patrice Imbert (Total)

Project description: A clear understanding of processes related with mud volcanoes is fundamental to entirely evaluate their impact on petroleum exploration and exploitation, specifically as potential hazards. There have been large efforts to understand mud volcanoes internal structure by observing outcrop analogues and, more importantly, by using subsurface datasets that consent to characterize their deep features across the overburden. Geophysical techniques until now applied to the study of mud volcanoes provided 1) relatively shallow (less than 60m), high-resolution imagines of the subsurface and 2) deep seismic sections, which are missing of necessary resolution. In this framework, the project will address the problem of improving joint applications of Electrical Resistivity Tomography and seismological techniques to obtain high-resolution images of structures at intermediate depths beneath the Nirano Mud Volcanoes Field (NMVF), Italy. The most important structures governing medium-short term fluids emission activity, therefore influencing the surface evolution, are likely located within the first hundred meters below the surface. We propose to perform a 3D geoelectrical survey to measure self-potential, DC resistivity and induced polarization using a ca. 900m-long-cable array. This setup allows to reach a maximum investigation depth of ca. 180m, which is more than triple respect to previous investigations at NMVF. A new 4D inversion technique allows filtering uncorrelated noise in data over time. This workflow enhances resistivity contrasts between fluid conduits and host sediments, highlighting subtle changes in gas saturation inside the volcano reservoirs and conduits, and allowing a better imaging of preferential flow paths in subsurface.

The joint acquisition and processing of data from active and passive seismic surveys will expand the investigation depth of time-lapse resistive tomography down to 500m. Chaotic seismic phases and intensities provide the deepest insight into the problem of imaging fluid propagation and highly heterogeneous structures. The seismic dataset will be analysed to 1) reconstruct noise directionality, symptomatic of volcano dynamics at different depths, and 2) exploit seismic noise and coda for imaging deep structures via absorption/scattering tomography and interferometry. In the final stage of the project, the 4D joint inversion of seismic and resistivity datasets will provide the best coupled imaging resolution and depth penetration so far available in mud volcanic settings. Since first year, the student will collect geophysical and geological data at NMVF, and will start to acquire competences in processing ERT and seismological data. During the following years, he will progressively gain expertise in 4D processing for both datasets, working at UK and France partner Institutions. At the end of the PhD, the student will also gain the ability to integrate geophysical and geological data during interpretation, a competence increasingly required by academia and industry. The proposed project comprises techniques ideally suited for gas and fluids detection in shallow subsurface of challenging environments, with feasible application to environment-focused studies.

CDT Research theme(s): (c) Exploitation on challenging environments. It fully addresses the request that CDT projects should be sufficiently distinct from existing industry-funded research.

Research context: The student will join the community of University of Aberdeen, which provides strong expertise in Petroleum Geoscience. DO is a geologist who extensively worked on spontaneous focused fluid flows, with emphasis on their significance to petroleum systems definition. LDS is a Geophysicist working on transfer knowledge between academia and industry. AR is Professor of Geophysics and expert on ERT techniques. PI is a geologist who has considerable experience working on natural fluids seepage through multidisciplinary approach.

Research costs: Costs should not exceed £5000 p.a. and include: high-performance workstation (£4000), field work (£2000) and attendance to international conferences (£3000). **Career routes**: The student will gain expertise in coupled Geology and Geophysics, with preferential careers including Oil & Gas Industry, specialist work in Service Company, research in Academia.