Thesis proposal

Petrophysical characterization of deformation bands in reservoir rocks: towards a quantification of processes

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PhD location: Université de Pau et des Pays de l'Adour, Heriot-Watt University (Edinburgh, Scotland).

Rationale and objectives of the thesis:

Geological reservoirs, with their capacity to store resources and gas, are essential elements of the energy transition. It should therefore be possible to predict the petrophysical characteristics of these rocks over the long term, including how they are modified during deformation phases.

Deformation bands are the main mesostructures accommodating early deformation in reservoir, porous and/or poorly indurated rocks that fill foreland basins. At first order, their typology can be related to the nature and magnitude of the mechanical load. Nevertheless, many other parameters may be involved in the formation of deformation bands: the size and morphology of the grains in their initial state, the distribution of porosity in the matrix, the supply of fluids and their chemical reactivity, the existence of pre-existing weakness planes.

This thesis project aims to : (1) characterise parameters such as porosity, permeability, grain size and arrangement and textural changes due to deformation conditions, for each typology encountered in nature; and (2) evaluate the effect of pre-existing deformation bands on the mechanical response of the rock. The expectations from this work are to provide an extensive database to quantify the impact of deformation bands on the structural integrity of rocks. In addition, these data will allow to better constrain fluid migrations allowing a phenomenological explanation of this very common process in porous rocks.

Figure. On the left, southern limb of the anticline bordering the Boixols fault thrust (South on the right of the picture). On the right, Upper Cretaceous Aren formation, with the N-S and E-W deformation bands (East to the right of the picture).

The work will focus on material coming two complementary sites: the Boixols overlap area (Tremp basin) and the Cotiella thrust area (Armena Valley), both located in the southern foreland of the Pyrenees. A number of studies have focused on the Boixols area, tentatively relating deformation bands pattern to large-scale deformation history. Yet the petrophysical properties of the bands, along with their condition of formation, remain largely unknown and non-characterised up to now, which makes this region an ideal study site. These sites also provide access to two types of host rock lithologies: Cotiella cement-limestone calcarenites and Boixols sandstones. During the course of the thesis, 4 components will be developed: a first component of (micro)structural characterisation of the terrain, a second component of characterisation of the grain distribution by 3D XR CT, a third component on the reconstruction of the temperature conditions and the deformation sequence by isotopic approaches, and a fourth component dedicated to the dynamic mechanical study of these deformation bands on samples whose grain distribution has been previously characterised by tomography, accompanied by a numerical modelling of fluid flow at the core-scale. The first three parts will be mainly carried out at the host university (UPPA, Pau, France), and the last part will require a stay at Heriot-Watt University (Edinburgh, Scotland).

Host laboratory:

PAU is located 3h30 away from the two study sites where the target rocks are exposed in excellent conditions. The student will be a member of the Geological Reservoir Characterization (CRG) team. This team (12 permanent researchers, 12 PhD students, 12 post-docs) is interested in geological reservoirs through 3 prisms: geological; petrophysics, and geophysics. This team is integrated in the laboratory of Complex Fluids and their Reservoirs, with analytical platforms very interesting for the student, in geomechanics of porous media and in X-ray microtomography (DMEX). In addition, the IPREM laboratory houses a wide variety of instruments for geochemical measurements at the ppb scale. All this equipment allows the student to develop his or her skills in a work of high scientific quality.

Scientific skills required:

- ✓ Strong knowledge of structural geology and/or rock mechanics
- ✓ Programming skills to effectively use image analysis and numerical modelling tools
- ✓ Good bibliographic and writing integration skills.

How to apply:

Please send your applications by email to one of the PhD supervisors by the **15th of July 2020**. Applications should contain:

- ✓ A cv in English;
- ✓ A cover letter in English;
- ✓ Master's transcripts and rankings;
- ✓ A pdf copy of the MSc thesis (if available);
- ✓ Two letters of recommendation. Referees contact details are also accepted (optional but recommended).