ICTMS 2022

5th International Conference on Tomography of Materials & Structures
27th June- 1st July 2022, Grenoble, France

IS XCT SUITED TO STUDY FINE-GRAINED ROCKS?

Hugo SAUR[2], Charles AUBOURG[2] and Peter MOONEN[1,2*]

[1] Universite de Pau et Pays de l'Adour, E2S UPPA, CNRS, DMEX, Pau, France

[2] Universite de Pau et Pays de l'Adour, E2S UPPA, CNRS, TOTAL, LFCR, Pau, France

*Speaker : peter.moonen@univ-pau.fr

1. Introduction

Shales are anisotropic fine-grained rocks showing structural heterogeneities over a wide range of scales. The anisotropy at the scale of the rock formation is orders of magnitude larger than a typical sample for X-ray tomography (XCT). At the other end of the spectrum, the microstructure contains many features that are beyond the spatial resolution of a laboratory XCT system. XCT therefore appears to be of limited use in the study of shales. Yet, our study comes to the surprising conclusion that XCT yields valuable insights across all scales.

2. Materials and Methods

We focus on a km-long strain gradient of the Eocene Arro-Fiscal marls formation, which outcrop in the piggyback Jaca basin (Spain). Field observations enabled characterizing the km-scale heterogeneities. Anisotropy of Magnetic Susceptibility (AMS) measurements on 281 samples (10 cm^3 each) collected along the gradient, served to quantify the evolution of the bulk anisotropy of the illite (clay) texture [1]. 10 subsamples (2.5 mm^3 each) were cored from five representative AMS samples for XCT analysis. With a voxel size of 1.2 µm, only the largest quartz and calcite grains can be individually distinguished, representing less than 10% of the total sample volume. Complementary optical microscopy analysis yields insight in the matrix heterogeneity.

3. Results and Conclusion

The XCT data reveal that the orientation of calcite grains is a sensitive marker of the field-scale heterogeneity. At 2 km from a fault, these grains align with the bedding direction and they gradually align with the cleavage plane when approaching the thrust region. This observation matches the field observations and the optical micrographs. The orientation of quartz grains yields similar info, but the signal looks more scattered [2]. It appears their potential to reorient is proportional to their grain size, with large grains remaining aligned with the bedding direction as opposed to smaller ones [3].

Another interesting observation is that 2.5 mm^3 XCT samples are representative for grain-level analysis in terms of grain size, shape and anisotropy: distinct samples from the same region yield almost identical results. However, when taking ensemble averages the results start deviating. This is because the sample size, while representative at grain level, does not cover the larger scale heterogeneity discussed earlier. We forward the hypothesis that the illite orientation, picked up by AMS, is actually an average between the bedding and cleavage orientation [3].

This short summary indicates that the XCT study of a small volume of shales can indeed reveal key characteristics at both larger and smaller scales.

4. Acknowledgements

The authors wish to thank E2S for financial support and TotalEnergies for providing DMEX the XCT system used in this study.

5. References

[1] T. Boiron et al. (10.1016/j.jsg.2020.104130)
[2] H. Saur et al. (10.1016/j.jsg.2019.103905)
[2] H. Saur et al. (10.1029/2021JB022025)

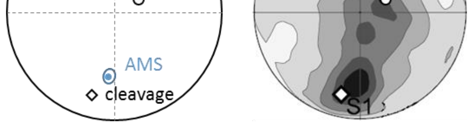

Figure 1. stereoplots showing the orientation and dip seen on site (black markers), recorded by AMS for the clay fabric (blue) and for each grain analysed by XCT (contour plot).