LINKING ELASTIC PROPERTIES OF ROCKS TO THEIR MICROSTRUCTURE BY USING NANOINDENTATION AND SEM-EDS

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ABSTRACT

Characterizing the elastic properties of rocks is a key parameter in reservoir engineering. However, these natural materials exhibit a wide variety of microstructures, even if they belong to the same facies, leading to a significant dispersion of their elastic properties. The evolution of the Young's modulus of seven carbonate rocks as a function of their global porosity shows that porosity is not the only factor controlling the elastic properties. The purpose of this study is to understand which microstructural parameters impact the rock elastic properties.

A full procedure has been developed to combine nanoindentation measurements with Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS), in order to identify the volume fraction and elastic properties of the mineral phases of each rock. After performing nanoindentation grids on the samples, SEM-EDS analyses were carried out in ex-situ conditions. A specific method was needed to identify the locations of the shallow imprints in the microscope, so that a mineral phase can be attributed to each indentation test (Figure 1). EDS mapping of the whole surface of the samples was also performed to get a statistically representative characterization of the mineralogical composition, and Mercury Intrusion Porosimetry tests were carried out to assess the pore size distribution and evaluate the volume fractions of the porosity families.

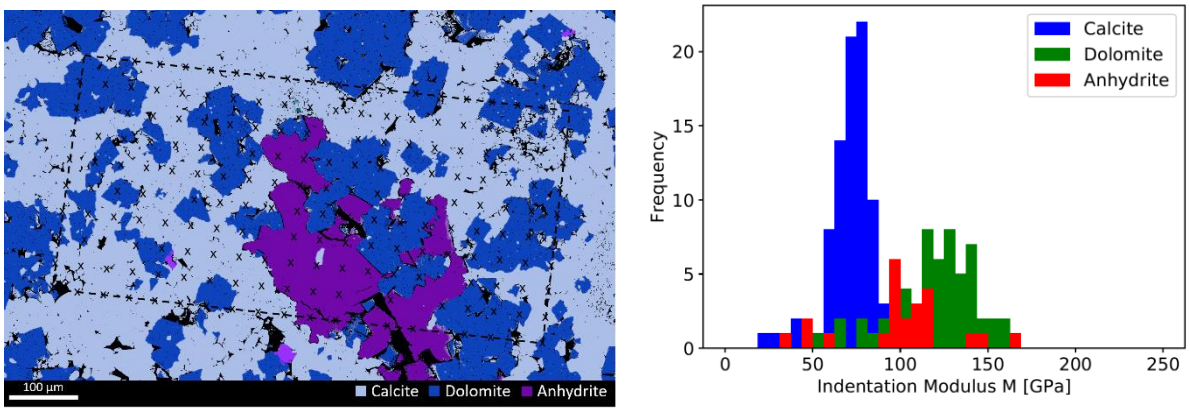

Figure 1. (left) Example of a SEM-EDS map over which an indentation grid is superimposed. The contour of the grid is marked here with dashed lines. (right) Histogram of the indentation modulus of the identified phases.

The homogenization technique was then used to predict the macroscopic Young's moduli, which were finally compared with the values obtained from triaxial experiments. We find that the mineral composition of the carbonate rocks is a key parameter contributing to their elastic properties. While capturing the overall trend, the homogenization scheme overestimates the measured Young's modulus. A discussion on the effect of other microstructural features is conducted to explain this overestimation.

KEYWORDS

Carbonate Rocks, Nanoindentation, SEM-EDS Analyses, Elastic Properties, Homogenization.