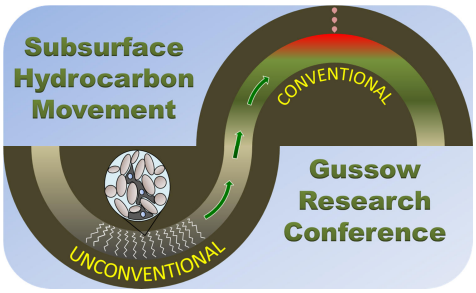

Relationship between the acoustic properties and microstructure of source rocks: insights through an effective medium approach

Hamza Tazi[1,2], Elisabeth Bemer[1], Mathilde Adelinet[1], Luc Dormieux[2], William Sassi[1], Tristan Euzen[3]
1-IFP Energies Nouvelles, 2-Laboratoire Navier, 3-IFP Technologies (Canada)

Summary

Source rocks are now both regarded as essential elements of petroleum systems and hydrocarbon prospects. Successful exploration and production of such unconventional reservoirs implies an understanding of their poromechanical behavior. The large variability of source rocks prevents any straightforward generalization of the observations. In this work, we seek to understand the link between the acoustic properties of source rocks and their microstructure characteristics.

Our study synthetizes literature data on the acoustic and petrophysical properties of the main organic-rich shale formations produced in North America. We added to this database in-house measurements carried out on samples from the Montney formation in the Western Canada Sedimentary Basin. The characterization methods and experimental conditions have been systematically reviewed and classified according to their reliability. Sample porosity has notably been estimated through different approaches: the comparison of the obtained porosity values for our sample set shows that these approaches are not equivalent. Relevant microstructure information such as volumetric mineral content and high-resolution imaging has also been collected for each considered shale formation.

The global dataset indicates that the acoustic velocities and anisotropy level of organic-rich shales are mainly controlled by the clay and organic matter content. Samples richer in clay and organic matter show lower velocities and higher level of anisotropy.

We investigated the role of soft components like clay and organic matter in source rock mechanical behavior through an effective medium approach. Several microstructure models were defined according to the microstructure information provided by the literature and original SEM images of the Montney samples characterized at IFP Energies Nouvelles. The volumetric fractions of the different phases were deduced from XRD analysis and measurements of TOC and porosity. The elastic moduli used for the mineral and organic matter phases have been taken from the literature.

The computed effective elastic properties have been compared to the measured elastic properties of the different source rock formations. Sensitivity analysis has been carried out to identify the most influent parameters in the defined effective medium models.

Keywords: source rock, ultrasonic velocity, effective medium modeling, clay and organic matter, Montney formation