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Elastic properties of source rocks

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Seismic velocity prediction in organic-rich shales remains challenging because the elastic properties of either the organic matter or the individual clay minerals present in shale are not fully understood. Conventional measurements of 'macroscopic' or 'average' properties on core plugs are not sufficient to fully address the degree of property variation within organic-rich rocks. Alternatively, most analyses of organic matter rely on samples that have been isolated by dissolving the rock matrix that may result in different kerogen properties. In addition, the nano-granular nature of this rock makes it difficult to link effective elastic properties to maceral properties, such as elastic moduli, composition, maturity, and quality. We address this issue by use of nano-indentation, coupled with confocal laser-scanning microscopy (CLSM) as a tool for visualization and identification of the organic part within source rocks, and quantifying the nanoscale elastic-property measurements. This study shows a combined application of Scanning Electron Microsopy (SEM), CLSM imaging and nano-indentation data to provide a microstructural basis for analyzing these macroscopically complex and heterogeneous rocks. Organic matter is successfully imaged within the matrix of the source rocks despite inherent lithologic differences of the phases. Nano-indentation measurements showed kerogen within the source rocks of Bazhenov and Lockatong Formations to be softer than the surrounding mineral matrix. In particular, Young's modulus of kerogen varies between 10 and 15 GPa, whereas bulk and shear moduli vary from 5 to 10 GPa and from 4 to 5 GPa, respectively.