Micro-nano-CT imaging in shale structure analysis

Yanfei Wang

Key Laboratory of Petroleum Resources Research, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, 100029, P. R. China.
E-mail: yfwang@mail.iggcas.ac.cn

Abstract

With the development of nonconventional oil and gas exploration, microscopic analysis of mineral distributions in shale receives much more attention in recent years. Unlike traditional computerized tomography (CT) technique in medical science, the source we used is the synchrotron radiation (SR). This energy is strong enough for emitting monochromatic X rays which will be used for the study of morphology, microstructure, transport properties and fracturing of shale. Traditional methods such as optical and scanning electron microscopy (SEM) are common tools for providing valuable information of microstructures; however, those surface observations are often inadequate in obtaining detailed 3D information of the sample, such as compositional distribution inside the shale. Moreover, samples of shale are usually damaged during serial sectioning. Therefore two scientific issues rose: one is how to generate high level reconstructed image data using SR-CT, another is how to use these CT image data to analyzing compositional microstructures. We study sparse regularization methods for reconstruction of image using SR-CT data. In addition, we develop a neural network image segmentation technology based on multi-energy CT image data in order to obtain the 3D structural characteristics and spatial distribution of shale. The new technology can be used to establish the relationship between the organic matter species and the inorganic mineral composition, so as to obtain the micro- and nano-pore features, as well as to provide technical support for the assessment of reserves of the shale gas resource and for the exploration.

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