ULTRAHIGH RESOLUTION 3D IMAGING AND CHARACTERISATION OF NANOSCALE PORE STRUCTURE IN SHALES AND ITS CONTROL ON GAS TRANSPORT

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INTRODUCTION

Shale gas is the fastest growing energy sector globally. The imaging and quantification of size, geometry and distribution of the pores and minerals in shales is highly challenging due to their extremely fine grain size. Nano X-ray computed tomography (Nano-CT) combined with focused ion Beam-Scanning Electron Microscopy (FIB-SEM) are used to resolve this problem and give us information in 3D from multiple scales in the shale gas extending down to resolutions of 50 nm.

AIM

To understand the relationship between fluid transport and pore microstructure in gas shales. Specific objectives include:

➢ To undertake different measurements using FIB-SEM and Nano-CT and combine these imaging data to examine how the variability of the pore network architecture of shales at different scales affects the physical properties and unconventional reservoir quality.

➢ To characterise the petrophysical properties on a small rock shale sample (25 µm) on the same location that was used for the Nano-CT and FIB-SEM measurements to judge whatever the same place can represent the whole shale sample.

SCIENTIFIC QUESTIONS

• How is the hydrocarbon stored in gas shale within the same area measurement by Nano-CT and FIB-SEM?

• How does the microstructural distribution of porosity and kerogen in gas shale within the same site compare when applied by different measurements that can control the gas transport sample?

• How can gas shale microstructure be modified for the optimization of gas production?

METHODS

Nano-CT is used on the nano-level scale. Thousands of projections are taken as the sample is rotated through 360° and a series of 2D radiographs are then reconstructed into 3D images to reveal the internal structure of shale.

FIB-SEM is a destructive technique which uses an electron beam to progressively mill or remove material from the face of the sample between high resolution imaging of the exposed surface.

CONCLUSIONS

• FIB-SEM and Nano-CT can be applied in tandem for the quantification of the fine scale pore network architecture characterisation because they interrogate different scales.

• In each case, different shale components can be distinguished.

• The 2D/3D microstructural properties on shale change from sample to sample, for different scales and using different experimental measurements.

FUTURE WORK

Work is currently being carried out on improvements in the following areas:

• The flow, quantification, type and distribution of kerogen.

• The size distribution and connectivity of pores as a function of scale, distinguishing between key finely connected porosity and larger unconnected porosity.

• The balance between sample representativity and resolution.

• Permeability simulation based on empirical modelling, upscaling and the use of machine learning methods.

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