Contribution ID: **838** Type: **Oral 20 Minutes**

Multiscale characterisation of and flow simulation in the nano-porous structure of shale matrix: challenges and solutions

Thursday, 17 May 2018 14:56 (15 minutes)

Shale is a fine-grained sedimentary rock. Flow simulation in shale is challenging due to its multiscale porous structure (consisting of nano- to micropores and fractures) and multi-physics gas flow mechanism (including continuum flow, slip flow, transition flow, Knudsen diffusion and surface diffusion) in these pores. The available studies have provided preliminary understandings on the porous structure of shale and flow processes within that; however, the reliability of these models depends on the representativeness of the structures and accuracy of flow models, which are hindered by the difficulties including, but not restricted: (1) FIB-SEM can provide high-resolution images but the field of view is much smaller than the scale of measurable samples in lab; (2) traditional definition of mean free path of gas molecules may be inaccurate when gas adsorption occurs in the nanopores; (3) discrepancies exist regarding the equations describing flow in the single capillary, which is the basis of flow simulation in porous structure; (4) gas-water flow pattern in nanopores is yet well understood; (5) contribution of nano-scale matrix permeability to the productivity is controversial. In this study, the challenges of these issues are analysed with the aids of thorough review of literature and potential solutions, including multiscale image reconstruction, molecular dynamics simulation and pore network modelling, are proposed. This study may give insights into the multiscale flow simulation in the nanoscale porous media and point out the future direction for researchers.

References

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Session Classification: Parallel 11-F

Track Classification: MS 1.23: Challenges in porous media characterization and modelling of multi-phase flow with capillarity