Geophysical Research Abstracts
Vol. 16, EGU2014-11131, 2014
EGU General Assembly 2014

Effective gas permeability of Tight Gas Sandstones as function of capillary pressure – a non-steady state approach

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Single- and two-phase (gas/water) fluid transport in tight sandstones has been studied by conducting series of permeability tests on core plugs of nine tight sandstones of the Southern North Sea. Experiments comprised
1) steady state single-phase gas permeability tests, yielding absolute (Klinkenberg-corrected) permeability coefficients between 1E-17 and 1E-19 m^2,
2) steady state permeability tests with water yielding absolute permeability coefficients from 1E-16 to 1E-19 m^2
3) dynamic gas breakthrough (drainage and imbibition) experiments yielding effective gas permeability coefficients between 1E-17 and 1E-22 m^2.

Petrophysical standard methods (He-pycnometry, Archimedes method, NMR, Hg-injection porosimetry) were used to assess the porosity and characterize the pore structure of the samples.

The key-results are as follows:
- Permeability coefficients decrease with increasing confining pressure (10 to 30 MPa) by less than one order of magnitude.
- Intrinsic permeability coefficients determined with water are always lower than Klinkenberg-corrected gas permeability coefficients.
- Gas permeability coefficients after capillary breakthrough clearly increase with increasing pressure difference, confirming capillary pressure-controlled change in gas saturation. For all samples several repetitive drainage/imbibition cycles were conducted to monitor the dynamic process of water displacement and gas transport. At any given pressure difference, the effective gas permeability is higher during spontaneous imbibition than during drainage.
- For all samples a maximum drainage/desaturation-curve was defined, yielding the maximum effective (apparent) gas permeability as function of the initial pressure difference.
- An exponential relationship was obtained between the intrinsic (water) permeability and maximum effective gas permeability for pressure differences from 1 to 10 MPa.
- A weak relationship exists between the capillary displacement pressure determined from mercury injection porosimetry (MIP) and capillary snap-off pressures determined under in-situ stress conditions on core plugs as well as intrinsic permeability coefficients.