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A new core analysis method based on rate-transient analysis (RTA) theory for measuring porosity and permeability in tight rocks

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Summary

Estimation of matrix permeability is essential for long-term economical evaulation of unconventional oil/gas reservoirs. Currently, a number of laboratory techniques (e.g. pulse-decay permeability, crushed-rock permeability) are available for assesment of gas permeability in tight rocks. These methods operate under different experimental conditions and utilize different physical principals; therfore, test time and results can varry substantially from one technique to another and further between different laboratories. The major challenge associated with these routine laboratory-based tecniques is the inability to represente the gas flow regimes that are encountered during field-scale production. A new laboratory-based technique ("RTAPK") – that is based on rate-transient analysis (RTA) – has been recently developed at University of Calgary for measuring permeability in tight lithotypes with permeabilities within the microdarcy and nanodarcy range, mimicking the field-scale conditions that are encountered during hydrocarbon producion from tight gas and liquid-rich gas reservoir.

Repeated testing on selected core plug samples from the Canadian Montney Formation consistently demonstrate an identical flow regim sequence to what is observed commonly in the field. A transient linear flow period is observed as the gas pressure transient propagates along the core plug, followed by boundary-dominated flow after the pressure transient reaches the end of the core plug. The permeability values estimated using two common RTA methods (slope of a square root of time plot, and distance of investigation (DOI) equation) are in good agreement (±5% for both experiments performed), providing an important redundancy to the analysis procedure. Pore volume is also estimated from the time at the end of linear flow and the slope of the square-root of time plot. Finally, test times for the a core plug sample with an apparent gas permeability of 0.0007 md, after the initiation of the production phase, are on the order of only a few minutes to obtain.

The permeability results using this new method are comparable to those obtained using the pulse-decay permeability technique under similar experimental conditions (confining

and mean pore pressures). There is only a minimal discrepency (±10%) between the permeability values obtained from RTAPK and PDP tests which can be justified in terms of measurement erros and permeability anisotropy.

Routine laboratory techniques for determination of permeability in tight rocks usullay use samples that are not representative of the “in-situ” reservoir rock or cannot fully reproduce fluid flow mechanisms that occur during subsurface production. The new approach presented herein, involves analysis of rate and pressure data from the core test analogously to larger-scale well-test/production data. This approach offers some advantages over conventional pressure-decay and pulse-decay analyses, by better representing conditions in the field and achieving results in a relatively shorter time-frames.