

Permeability Analysis in Horseshoe Canyon Coals using Open-Hole and Cased-Hole Logs

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Abstract

The Horseshoe Canyon coals of the Late Cretaceous Edmonton Group in Alberta, Canada have proven to be a unique, regionally underpressured "dry coal" gas system. The coals are encountered at shallow depths, typically 200m to 650m, are completed using fluid-free N₂ fracs, and are being exploited in a fairway extending from Edmonton to Calgary and south, approximately 11,000 mi² in areal extent.

EOG Resources Canada is actively pursuing the Horseshoe Canyon coals in the Twining area to the NE of Calgary, where the company has approximately 52,000 net hectares (130,000 net acres) of CBM rights. In 2004, EOG drilled 63 gross CBM wells, inclusive of two CBM Demonstration Blocks, and drilled 166 gross CBM wells in 2005, with a similar number slated for 2006. Typical well density in the Twining area is four wells per section, and EOG anticipates that an average well will recover 0.3 Bcf (1.2 Bcf/sct).

EOG's technical analysis of Horseshoe Canyon coal potential initially focused on stratigraphy, coal thickness and gas content, and on establishing that the coals could produce gas in commercial quantities in the Twining area. Subsequent efforts were focused on identifying permeability in these coals using open-hole logs. It was important to determine which seams would actually contribute gas during production, and thus to optimize a completion strategy prior to extensive development drilling. This was done by utilizing an invasion profile calculated from the induction log, a source of data widely available from the 1970's onward, expressing it as a ratio curve and overlaying it on the gamma ray curve, which is reflective of ash content in the coals. The Resistivity Ratio method of distinguishing permeable from non-permeable seams has been well supported by spinner surveys of producing wells, providing a means to selectively complete only the effectively permeable seams in CBM wells.

Subsequently, during development drilling, a second method of identifying permeability in the Horseshoe Canyon coals, using cased-hole GR-Sonic-Neutron logs, was developed. This log suite is now commonly run by most CBM operators in preference to a more costly open-hole logging suite. It was observed that coals determined from spinner surveys and open-hole logs to be permeable also tended to have higher delta-T readings than tight seams. It may be shown that gamma ray values correlate well with both delta-T and bulk density values for the coals, with lower GR readings corresponding to higher delta-T's and lower bulk densities. Since bulk density cannot be measured in a cased-hole environment (only relative density), delta-T may be considered a proxy for bulk density, and when it is plotted against GR, a trend relating to the deliverability of

individual seams may be seen. A possible reason for the deliverability observation is the likelihood that lower GR (lower ash) and higher delta-T (lower bulk density) seams in the Horseshoe Canyon will have a higher vitrinite content, and better cleating. The GR-delta-T plot is thus an indirect means of gauging permeability in the coals. It is also a graphical representation of the cased-hole visual log analysis technique, in which the sonic curve is opposed to and overlain on the GR curve.

Most of the CBM wells drilled by Industry in 2005 were evaluated using cased-hole logs only, and it is likely that 2006 will follow suit. EOG estimates that completion cost savings of \$15,000-\$20,000/well (~7%) have been realized by using the GR-delta-T Method on the cased-hole logs, followed by selective completion of the coals, based on this permeability criterion.

A case study from a Demonstration Block will be shown, comparing production rates from a control group of wells completed in all coal seams with those from a second group of wells, completed in only 50% of the seams, as dictated by the Resistivity Ratio Method of permeability analysis. The study illustrates that production rates are not compromised by performing only selective completions in these coal seams, whether based on open-hole log analysis or, by extension, cased-hole log analysis.