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INFLUENCE OF DRILLING TECHNIQUE ON A BOREHOLE GEOPHYSICAL DATASET— A CASE STUDY IN NEW BRUNSWICK

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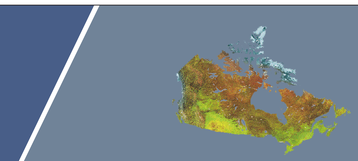

Project Summary

Over the past eight years, the Geological Survey of Canada (GSC) in collaboration with different partners has been investigating potential upward fluid migration pathways from deep shale and tight sandstone gas reservoirs to shallow aquifers in regions of eastern Canada (Raynaud et al., 2016, Rivard et al., 2017, Rivard et al., 2018). As part of the bedrock aquifer studies underway in Sussex, New Brunswick, the GSC drilled, geophysically logged, and hydrogeologically tested 14 bedrock observation wells (50 to 130 m in depth).

The study area is located within a sedimentary sub-basin of the Upper Devonian to Permian Maritimes Basin. The shallow observation wells intersect the bedrock units of the Mabou Group which consist of interbedded fine to coarse-grained, fluvial to continental, clastic units including conglomerate, sandstone, siltstone and mudstone (St. Peter and Johnson, 2009). Rapid and irregular lateral facies changes are the norm in these deposits and lateral persistence of marker beds across the study area was not observed (Crow et al., 2017).

Boreholes were advanced using a combination of hammer and diamond drilling techniques. In four locations, hammer and diamond drilled boreholes were co-located 4 m to 6 m apart, providing a unique opportunity to assess how drilling methods influence a downhole geophysical dataset in this geological setting. The suite of logs included fluid temperature/conductivity, heat pulse flow meter, optical and acoustic televiewers, acoustic caliper, video camera, gamma-gamma density, guard resistivity, full waveform sonic, and spectral gamma. This poster presents some comparisons of the logs collected in the side-by-side boreholes.

Differences between the datasets raise questions on the ultimate benefits and drawbacks of interpreting geomechanical (e.g. moduli) and hydrogeological (e.g transmissivity) parameters for critical projects in wells with different wall roughness conditions. While drilling hammered boreholes is less expensive and time consuming than coring holes, are there potential trade-offs with data quality? Leveraging the placement of adjacent boreholes, this question is examined in the context of a terrestrial, clastic sedimentary bedrock setting. This work is developing knowledge to support design choices for future GSC groundwater studies.

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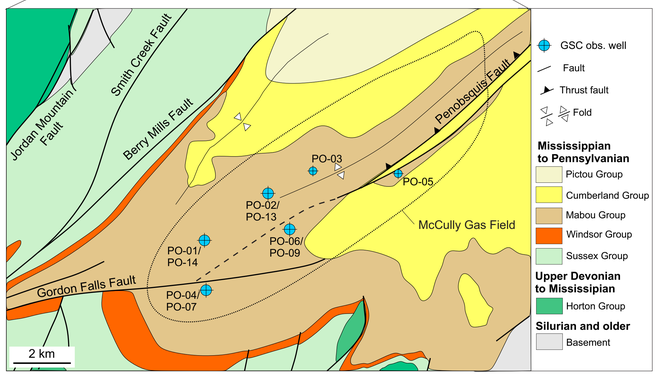
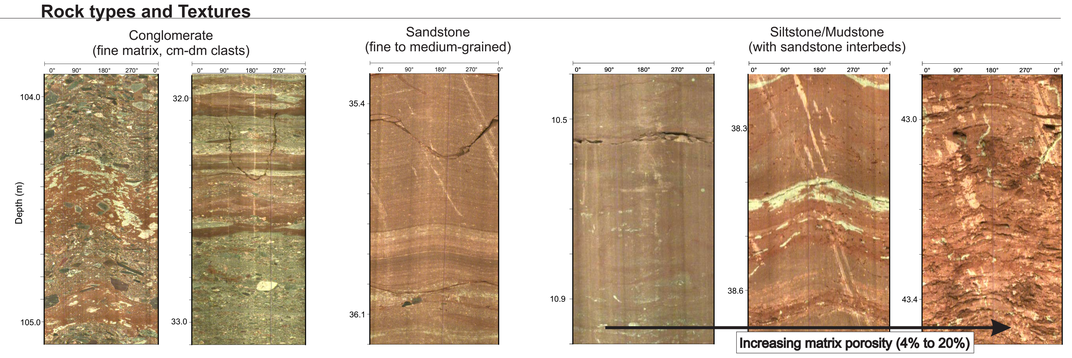


Mabou Group at Outcrop Scale

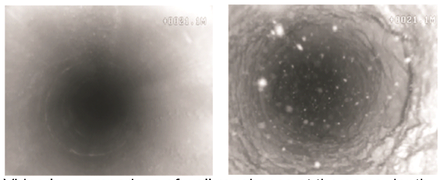
Core and Downhole Imaging Scale

Rock types and Textures

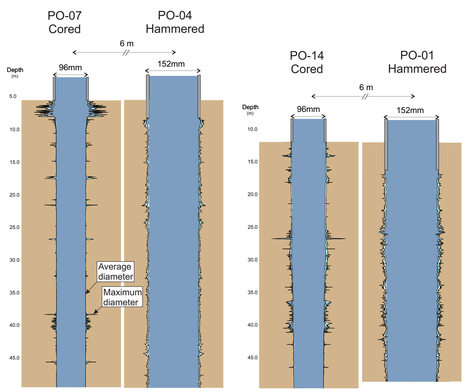


Geophysical Logs in Side-by-side Wells

Borehole Wall Roughness



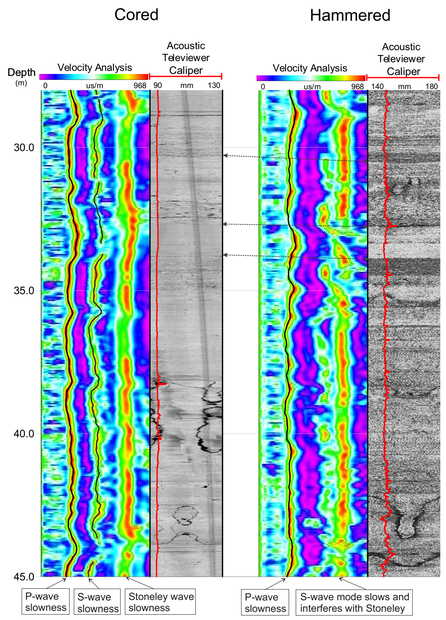
Video log comparison of wall roughness at the same depth from hammer drilling (left) and diamond drilling (right) in boreholes spaced 6 m apart (PO-07, PO-04).



Caliper logs show hammered holes have a rough wall surface along the entire length, while cored boreholes have a smoother surface. Cored holes, however, have fractures extending further into the borehole wall, likely through flushing of circulating fluids.

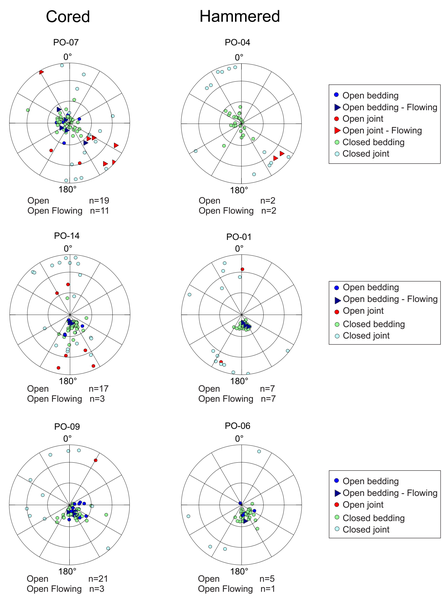
Sonic Velocities

Evaluation of full waveform sonic logs indicated P-wave slowness is, on average, 5% higher in the hammered boreholes than cored, while the S-wave slowness is significantly higher and often appeared to merge with the Stoneley mode.



Structural Analyses

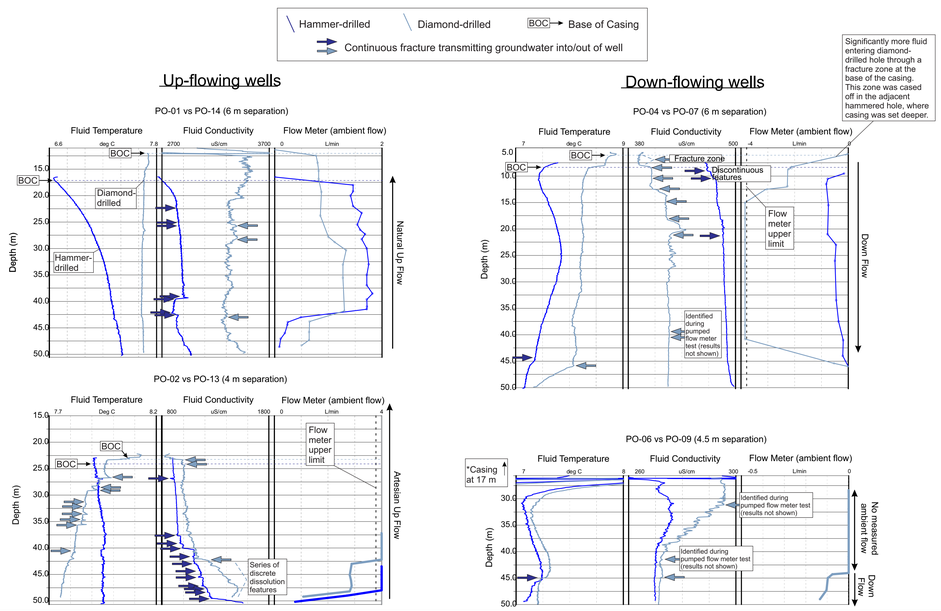
Stereonets from televiewer analyses show the same key trends between borehole pairs, but cored boreholes show a greater variety of structural orientations from finer features which can be identified in a smoother wall. The cored wells have more open features and, in general, more features interpreted as flowing. Circulation of water during diamond drilling likely opened up many of the discontinuities.



Fluid Logs

Fluid logs were helpful in identifying the depths of continuous fractures transmitting fluid into the wells for sampling and model development. Comparison of these logs in co-located wells did not always reveal fluid anomalies at common depths. Discontinuous features in porous zones, often the result of matrix dissolution, also created fluid anomalies without an associated continuous fracture trace around the borehole wall.

Flow meter data revealed that natural vertical fluid movement, present in wells at all four sites, could be flowing at different rates in each well depending on the features intersected by the boreholes. In borehole pair PO-04 & PO-07, the casing was set deeper into the rock in the hammered hole, and showed a very different flow profile than was measured in the adjacent cored borehole.



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