Interpretation of hydraulic responses to borehole drilling and flow logging as planning tools for hydraulic tests

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SKB (Swedish Nuclear Fuel and Waste Management Company) is conducting site investigations and monitoring in Forsmark in mid-eastern Sweden, as part of preparations for an extension of the existing final repository (SFR) for short-lived radioactive waste (SKB 2013). As part of the site investigations, boreholes are drilled and used to establish physical and hydraulic properties of the bedrock volume in which the extension will be constructed. Geophysical investigations are typically used as guidelines to determine borehole placements and orientations, while hydraulic borehole tests are used to assess the hydraulic connectivity and properties of the fracture network of the bedrock.

This study describes SKB's approach for hydraulic monitoring during borehole drilling as a tool for planning of subsequent hydraulic tests. Two recent boreholes (KFR90 and -91) were drilled horizontally from the existing SFR construction tunnel, at 100 m depth below the sea level and with lengths of 450 and 340 m, respectively. The boreholes were drilled roughly perpendicular to each other, with the aim to intersect previously modelled deformation zones of relevance for the site understanding. Borehole KFR91 was drilled first, followed by temporary installation of a pressure sensor in the borehole for continuous monitoring during drilling of the second borehole (KFR90). Pressure in KFR90 was monitored during daily pauses in active drilling, through a temporary pressure sensor mounted at the borehead.

Pressure monitoring in KFR91 showed almost no hydraulic response to the drilling of KFR90, despite both boreholes intersecting deformation zones that should provide hydraulic connectivity between them. This lack of identifiable hydraulic interference response could be due to several reasons, but one main drawback is probably the sparse instrumentation used in KFR91 (a single pressure sensor) and the length of the borehole (340 m) that damped potential local pressure changes associated to daily cycles of borehole drilling and closing of KFR90.

However, other boreholes in the SFR bedrock volume, sectioned by packers and instrumented with pressure sensors for continuous pressure monitoring, demonstrated hydraulic responses to the KFR90 and -91 drilling activities, suggesting hydraulic connectivity across the fracture network. For instance, pressure responses within one borehole (KFR105) indicate a strong hydraulic coupling with borehole KFR90. Moreover, although less clear, one borehole section (KFR27:2) demonstrate pressure variations that are consistent with impacts from drilling. However, responses were unclear in some other boreholes (KFR102A, KFR102B, and KFR104) that intersect deformation zones that should be hydraulically connected to borehole KFR90.

Difference flow-logging (PFL method) tests are planned in both KFR90 and -91. These tests will provide detailed information on hydraulic transmissivity along each borehole. The results of the PFL tests and associated hydraulic responses will be used to define a plan for placement of borehole packers and for execution of upcoming interference tests. The interference tests will use packed-off sections of borehole KFR90 as sinks, and aim to assess hydraulic connections across the fracture network of the SFR extension volume. An integrated analysis of all tests and hydraulic responses related to KFR90 and -91 will be used to plan placements of permanent borehole packers and installation of pressure sensors, for continuous pressure monitoring of the boreholes prior to and during the SFR extension.

References

SKB, 2013: Site description of the SFR at Forsmark at completion of the site investigation phase. SDM-PSU Forsmark. SKB TR-11-04, Svensk Kärnbränslehantering AB.