Mine-by experiments and subsurface excavations in claystones

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The term weak rock has been used to identify Argillaceous materials such as Claystones. Claystones have more than 2/3 of their mineral grains smaller than clay-sized fraction (<4µm). Claystones are also referred to as clay-shales, an engineering term that was introduced in the early 1960s to emphasize that these weak rocks were transitional between soil and rock. The ISRM (International Society for Rock Mechanics) classes for weak rock are identified as R0 (Extremely Weak), R1 (Very Weak) and R1 (Weak), with uniaxial compressive strengths ranging from 0.25-1 MPa, 1-5 MPa and 5-25 MPa, respectively. What is not captured in this simple strength-based classification is the changing and complex behaviour of these materials as they transcend from Weak to Extremely Weak.

The behaviour of underground excavations in the weak rock Claystones is often characterized by time-dependent deformations. These deformations are associated with (1) overstressing and strain-weakening, (2) swelling and squeezing and (3) environmental effects. While many tunnels have been excavated in these materials, their successful completion was often achieved after finding solutions to manage the time-dependent behaviour. In most cases our ability to characterize the behaviour of Claystones based on extensive laboratory tests was seldom adequate in forecasting the underground in-situ behaviour. These differences in laboratory and in-situ behaviour are often attributed to complex unloading/loading stress path experienced around the underground excavation compared to the simplified loading/unloading stress path used in laboratory tests. An additional complication is the hydromechanical behaviour of Claystones, which is challenging to capture in laboratory experiments. Consequently, Mine-by experiments are sometimes carried out to establish the characteristics and behaviour of the Claystones around underground excavations. Mine-by type experiments involve installing instrumentation in a volume of rock and excavating a tunnel through the instrumented volume. The results from the instrumentation when combined with the geometry of the tunnel and observations made during excavation typically provide new insights into the behaviour of these complex materials. In order for a Mine-by experiment to be successful it must be carried out with the same care and control that is used in laboratory experiments. This makes successful Mine-by experiments difficult to accomplish and costly to execute.

In this presentation three Mine-by type experiments will be reviewed: (1) An 11-m-diameter test chamber carried out in Western Canada in the Shaftsbury Shales and two Mine-by experiments in the Opalinus Clay, (2) one perpendicular to strike of the bedding and (3) one parallel to the strike of the bedding. The review will focus on the contributions each experiment have made to our understanding of Claystone behaviour and lessons learned. Despite the efforts of the geo-engineering community over the past 50 years, our ability to predict the short-term hydromechanical behaviour of Claystones, remains a challenge.