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WATER IN THE HOLE! DEVELOPMENT OF SHAFT GROUTING METHODS TO SEAL DEVONIAN LIMESTONE AND SANDSTONE AQUIFERS IN THE FIRST SHAFT OF THE DETROIT SALT MINE (1906–1907)

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Abstract

Pioneering water-sealing work in the first shaft of the Detroit salt mine during 1906 and 1907 led to the development of cementitious grouting techniques that remain in use today. Grouting methods were developed to overcome dangerous inflows of hydrogen-sulfide-laden water. Initial efforts to sink a shaft began in 1898, but work did not start in earnest until December 1904 because of problematic water under artesian pressure documented by test wells near the top of bedrock. To obtain a successful seal at the top of bedrock required modified shaft-sinking techniques, but deeper, water-bearing zones in Devonian carbonate and sandstone formations required different strategies. Laboratory experimentation using a beer keg and limestone cuttings from drill-holes demonstrated the efficacy of grouting off the carbonate aquifers using cement. Application of injection methods based on the laboratory experiment led to successfully sealing a prolific conglomeratic aquifer in the Lucas Dolomite at a depth of 155–169 feet (ft) (47–52 meters [m]) by February 1906. The technical approach, patented in 1907, involved grout injection into cased holes drilled at angles outward from the shaft bottom. This fan pattern of grout holes is still commonly used today in grouting of fractured bedrock aquifers in mine shafts and declines.

As may be expected, simple cement injections could not stop the inflows from the underlying Sylvania Sandstone because the particle size of cement is too large to penetrate intragranular pore space in the permeable sandstone. A modified approach was employed that involved closely spaced drill-holes into the sandstone at depths between 420–430 ft (128–131 m). The drill-holes were first blasted to create fracture porosity, then the holes were cased down to the target zone and grouted to create a “cofferdam” that held back most of the flow from the sandstone formation. A modified shaft liner was then installed to seal off the remaining water. Grouting of intragranular pore space in sandstones remains a challenge today. Even with modern chemical grouts that contain no suspended particles and exhibit much lower viscosities than cement, sealing off porous sandstone remains difficult.

Key words: Detroit, Detroit Salt Company, grout, Bradt, water, shaft