Fracture Characterization at a Bedrock Bioremediation Site in New Hampshire

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Video, optical, acoustic, borehole radar and drilling parameters methods have augmented, and often supplanted, the identification of natural fractures obtained from standard core logging in a series of six boreholes in southeastern New Hampshire. The study site is located at Pease International Tradeport, formerly Pease AFB, where TCE contamination, resulting from degreasing operations during equipment maintenance, are present at different concentrations within the fractured bedrock profile. The boreholes, 150 mm in diameter and approximately 60 m deep, were drilled to develop protocols for bioremediation. All but one borehole were drilled using a triple core barrel (with a Lexan inner barrel) while one borehole was drilled using a tricone button bit.

Southeastern New Hampshire is underlain by Silurian and older metasedimentary rocks that are variably metamorphosed, tightly folded and faulted, and intruded by Paleozoic and Mesozoic igneous rocks. Underlying the bioremediation study site (Great Bay area) are biotite grade calcareous metasandstones and metashales of the Kittery and Eliot formations, both much intruded by Jurassic(?) diabase dikes. Boreholes for this study intersect the Kittery Formation and at least one cross-cutting dike. Fracture patterns in video, optical and acoustic televiewer logs help identify one to three steeply dipping fracture sets (both sealed and unsealed, one commonly parallel to bedding), one generally shallow dipping to subhorizontal fracture set, bedding characteristics (including changing facing directions and offsets that identify folds and minor fault offsets) and intrusive contacts.

Three to five features (fractures?) are recognized as clear reflectors from omni-directional borehole radar and appear to correspond well to some subset of moderate to steeply dipping bedrock fractures and/or contacts, usually within a one meter error. The character of those specific fractures is unclear from the radar record largely because of uncertainties of propagation velocity of the radar pulses and other physical properties of the fractures themselves.

Drilling parameters were recorded by using a computerized system which monitors a series of sensors installed on the drill rig. The drilling parameter recorder (DPR) measured the advance rate, downthrust pressure, rod torque, rotation rate, water inflow and outflow, water pressure, depth and time for all boreholes. These measurements helped improve the quality and efficiency of the drilling process and reduced the amount of fluid being introduced and lost into the aquifer. The variations in parameters as well as the use of compound parameters (combination of individual parameters into expressions of energy or empirical indices) improved our ability to locate fractures and changes in stratigraphy.

Comparisons of DPR data, geophysical logs, and radar were made for each available borehole. Lithologic logs and geophysical logs differ by the very nature of the measurements or observations; geophysical logs scan features found on the borehole wall while lithologic logs analyze the physical core specimens. The DPR does not have the ability to describe rock types but it can distinguish qualitatively and quantitatively between geologic features and units. The DPR profiles agreed well in terms of fracture locations and stratigraphic changes with the geophysical and lithologic logs. For both coring and non-coring holes, it also became apparent that bit wear significantly affected the drilling parameters. However, current drilling parameter interpretation methods do not properly take into account bit wear. It was also observed that for destructive borehole advance, fracture zones are more readily identified using penetration rate and torque as indicators when thrust and rotation are held constant during drilling. The use of the DPR when drilling in bedrock aquifers was immensely useful to the driller in delivering high quality cores with minimal water usage and, improving daily productivity.

The results of this investigation will be used to develop protocols for drilling and use of geophysical methods and DPR for future sites and other geological conditions. These protocols will provide in situ characterization rapidly and more cost effectively, thus limiting the need for expensive field measurements and coring during rock investigations.

Biographical Sketches

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