Addressing the Complexities of Contamination and Remediation in Fractured Rock Aquifers

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Fractured rock and carbonate aquifer offer a degree of geologic complexity that far exceeds that of near surface, unconsolidated, porous media aquifers. The complex distribution and connectivity of fractures, joints, conduits, vugs, and other discontinuities in the rock, coupled with the large range in their hydraulic properties, results in highly convoluted flow paths over distances from meters to kilometers. Fractured rock and carbonate aquifers are also characterized by void space associated with the initial formation of the rock. The rock matrix is not significant in characterizing groundwater flow; however, it does play a significant role in the long-term retention of contaminants and the design, implementation, and success of remediation strategies.

Existing remediation technologies may not be sufficient to achieve management objectives in the complex geology of most fractured rock aquifers. Significant quantities of contaminant mass will continue to be present in the groundwater, even after aggressive remediation technologies have been applied. Efforts need to be directed at minimizing costs and streamlining protocols that recognize the long-term stewardship that will be warranted at these geologically complex sites. Recent advances in understanding physical and chemical processes and characterizing groundwater flow and chemical transport in fractured rock aquifers are leading to defensible site conceptual models that can minimize the number of monitoring locations to achieve long-term monitoring objectives. In addition, innovative methods of monitoring in situ changes in biogeochemical conditions point to further reductions in long-term costs at geologically complex sites of groundwater contamination.