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Fractured-Rock Aquifers
Understanding an Increasingly Important Source of Water

Fractured-rock aquifers in the United States provide water for domestic use, locations for isolating hazardous and toxic waste, and sites for foundations and infrastructure.

Ground water is one of the Nation's most important natural resources. It provides drinking water to communities, supports industry and agriculture, and sustains streams and wetlands. A long record of contributions exists in understanding ground-water movement in sand and gravel aquifers; historically, these aquifers were easily accessible and the first to be investigated. With increased demand for water, communities are looking to fractured-rock aquifers, where water moves through fractures in the rock. Fractures, however, may not always convey or store large quantities of water. Understanding ground-water flow through fractured-rock aquifers is an area of ground-water research that will have increasing importance to our Nation over the coming years.

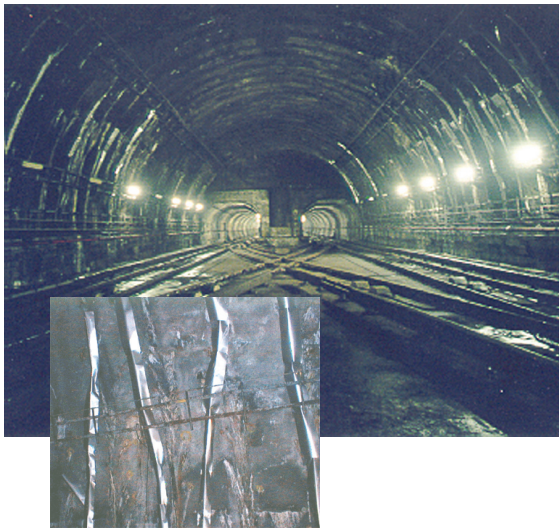
Fractures form complex paths for fluid movement in fractured-rock aquifers. Mapping rock types and fractures, where the rock is exposed, enables scientists to link fracture orientation, the interconnectivity of fractures, and fracture length with the availability of water.

Many areas of the United States rely on fractured-rock aquifers for water supply. In addition, areas experiencing population growth in the Northeast, Southeast, and mountainous regions of the West are likely to rely heavily on water supplies from fractured-rock aquifers. Finding water for thirsty communities, however, is not the only societal issue requiring an understanding of ground-water flow in fractured rock. Land-use practices affect water quality in fractured-rock aquifers, particularly where ground water flows rapidly through fractures. Fractured rock aquifers also are viewed as potential repositories for radioactive and other types of waste, where it is desirable for the ground water to be inaccessible or move at a very slow rate.

Complexity of Fractured Rock

Understanding how water flows—or doesn't flow—through fractured rock is a crucial factor in decisions made by ground-water resource managers and geological and structural engineers. Fractures may transmit large quantities of water; in other areas, they may be nearly impervious. Because of the complex distribution of fractures in almost every type of rock, no single method can unambiguously map fractures and their capacity for fluid movement. U.S. Geological Survey (USGS) scientists synthesize research from the fields of geology, geophysics, hydrology, and geochemistry to develop methods of identifying subsurface fractures and their role in the movement of ground water and chemical constituents.

The Washington Metropolitan Area Transit Authority (WMATA) is currently using metal pans on the walls (inset) of subway tunnels as a temporary means of diverting water leakage. The excessive leakage in tunnels is damaging electrical conduits and other infrastructure. Building foundations, large structures such as dams, and infrastructure for transportation, water supply and other utilities frequently are built in fractured rock. With an understanding of how water moves through fractures, geologic and structural engineers can design cost-effective ways of diverting water from such structures.



U.S. Department of the Interior
U.S. Geological Survey

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Low-level radioactive waste is buried in unconsolidated sediments overlying a fractured dolomite aquifer near Argonne, Illinois. Throughout the United States, low-level radioactive waste, landfills, septic tank effluent, and other potential sources of ground-water contamination are frequently close to fractured-rock aquifers.

USGS Research in Fractured Rock

The ability to characterize and understand ground-water flow conditions in a cost-effective manner is needed to ensure sound decisions in ground-water management. For example, a manager that needs to provide a water supply must answer a series of questions. Where do fractures produce enough water for a production well? Where is the ground water recharged and what land use activities affect its quality? Are the availability and quality of the water supply sustainable? Similar questions also arise in characterizing sites of contaminated ground water and assessing fractured-rock aquifers as potential repositories for various types of waste.

The USGS conducts research to develop field techniques and interpretive methods for characterizing fluid movement and chemical migration in fractured-rock aquifers to answer such questions. USGS research focuses on characterizing ground-water flow in fractured-rock aquifers over distances from meters to kilometers. Research is conducted at well-instrumented field research sites, such as the Mirror Lake watershed in central New Hampshire, or on actual field problems with resource managers and regulators. Ground-water resource managers and geological and structural engineers are now applying the results of this research in fractured-rock aquifers throughout the United States.

— A. M. Shapiro

The USGS publishes the results of its research in technical articles and other publications, and conducts seminars, workshops, and training classes. Numerous Federal and State agencies that work cooperatively with the USGS have attended USGS demonstrations of techniques used to characterize ground-water flow in fractured-rock aquifers.

With the experience in characterizing ground-water flow in fractured-rock aquifers, the USGS is now addressing other issues of societal importance in fractured-rock aquifers, which include processes affecting bacterial activity, and the transport of colloids and pathogens.

For More Information

More information on characterizing ground-water flow and chemical transport in fractured-rock aquifers can be found at the following web sites:

USGS, National Research Program, Transport Phenomena in Fractured Rock: *http://water.usgs.gov/nrp/proj.bib/shapiro.html*

USGS, National Research Program, Hydrology of Fractured Rocks: *http://water.usgs.gov/nrp/proj.bib/hsieh.html*

Fluid Flow and Solute Transport in Fractured Rock, Mirror Lake, New Hampshire: *http://toxics.usgs.gov/sites/mirror_page.html*

Natural Attenuation of Chlorinated Solvents in Fractured Rocks, Naval Air Warfare Center Research Site, Trenton, New Jersey: *http://toxics.usgs.gov/nawc_page.html*

USGS, Ground-Water Resources Program: *http://water.usgs.gov/ogw/GWRP.html*

USGS, Toxic Substances Hydrology Program: *http://toxics.usgs.gov*

USGS, Office of Ground Water, Branch of Geophysics: *http://water.usgs.gov/ogw/bgas*

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