Earth Sciences

A study of how fluid moves through rock

At the Exploratory Studies Facility at Yucca Mountain, workers have excavated a series of four test alcoves on the right side of the tunnel. Here, scientists will try to understand how air, water, and other gases move through layers of rock within Yucca Mountain.

The tests conducted within these alcoves will help researchers determine whether Yucca Mountain is a suitable site for disposal of high-level radioactive waste. Understanding how water or gases behave in the natural environment within Yucca Mountain is crucial to this task. For example, one of the components of spent nuclear fuel is radioactive carbon dioxide ($^{14}CO_2$). Scientists need to understand how this gas and other fluids travel naturally through the layers of thick volcanic rock at Yucca Mountain.

Determining important geologic features

During excavation of the alcoves, scientists carefully mapped fractures, joints, and other geologic features. Using special cameras, technicians recorded detailed, three-dimensional pictures of each alcove. Scientists use these to find the best places within the alcove to conduct specific tests.

Measurements of permeability will be the primary testing conducted in each alcove. Permeability is a measure of the degree that gas (categorized as a fluid or liquid) can move through rock. It depends on the size and extent of fractures within the rock, the amount and size of pore space between the grains or crystals of the rock, and the connectivity of the fracture system. Eventually, scientists hope their studies will produce a detailed picture of how gases and liquids could move through the mountain.

How do scientists measure fluid moving through rock?

Scientists are interested in where gases and liquids flow and at what rate of speed. Generally, fluids travel through dense rock exceptionally slowly, a few inches over hundreds, and even thousands, of years. But where fractures exist, fluids may move much more quickly. Of interest then are how liquids and gases get from one point to another. How do they move through fractures? Do they move at different rates through rock layers? What happens at the intersections of such layers? By injecting a constant flow of pressurized air into specific areas, scientists will be able to gain answers to these questions.

To reach this goal, to date, workers dry-drilled a total of seven boreholes within the alcoves and removed the rock core produced. They must be especially careful when choosing where to drill their boreholes to insure realistic results.

Specially designed plugs will be placed inside each borehole at different levels so that segments can be kept isolated for testing. These plugs will not only keep the segments isolated, but will also help monitor the direction of the flow of gas within the borehole. Tracer gas will be injected into one borehole. The presence of gas—when detected by special instruments and sensors within the other two boreholes—will yield important information about the mountain's permeability.

Other tests also will be conducted in each alcove. Scientists will collect rock samples to study their mineral content, and to learn more about their origin and composition. Rocks can reveal much about the geologic past. For example, a careful analysis will show how old a sample is, what pressures and temperatures shaped it, and even establish what the material was like that formed the rock. Finally, scientists will look for layers and traces of calcite-silica deposits in the alcoves and in their analyses of rock samples. This will provide them with information about how old the deposits are and how they were deposited by water moving through the layers of rock.

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

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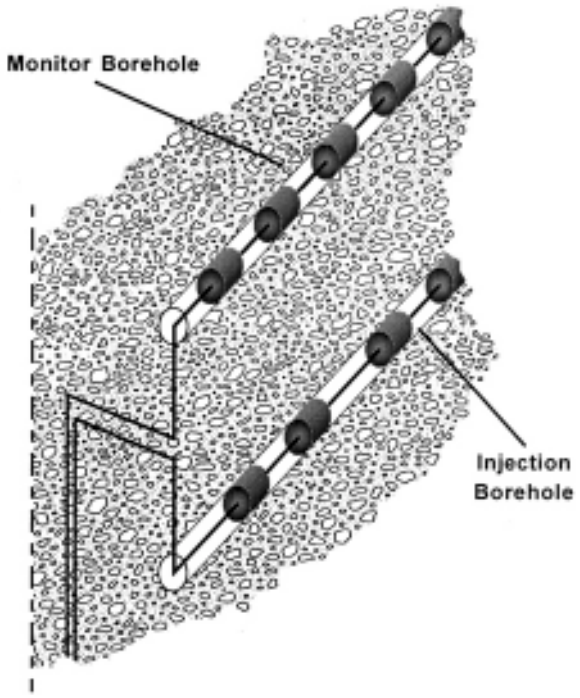
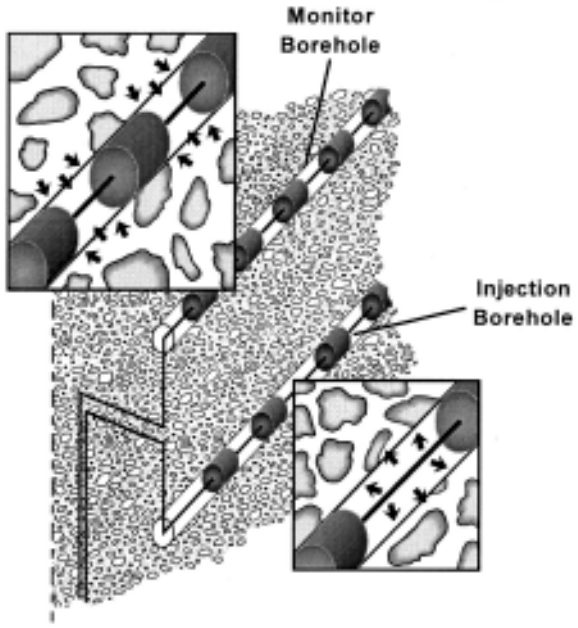
DOE/YMP-0006
June 2000



This illustration shows a normal view of the fluid testing conducted in an alcove. The background rock is visible along with the instrumented boreholes. The monitor borehole, one of three used to monitor the way gas or fluid travel through rock pores and/or fractures, holds “balloon packers” that isolate up to 12 areas. The injection borehole contains balloon packers that isolate the injection area, preventing gas from leaking elsewhere in the borehole.



In this expanded view of the fluid testing, arrows illustrate how pressurized gas travels from the injection borehole through the pores and/or fractures of the rock. The gas is detected by sensors in the monitoring borehole.