Several causes have been proposed for deep brines: water-rock interaction (leaching), infiltration of cryogenic brines from large-scale freezing of seawater, and dissolution of evaporites (where present). The cause and age for specific occurrences may be inferred from their composition (e.g., [7]) or they may be undetermined. The simple existence of concentrated chloride brines in the crystalline basement is a general indicator of great age, especially when no evaporites are present in the geologic setting.

The presence of ancient, saline water in the basement suggests that waste isolation in deep boreholes may not depend critically on borehole seals above the waste disposal interval. Within the borehole and the disturbed rock zone (DRZ) within a few feet of the borehole, the permeability will be low and the potential radionuclide pathway will be long, limiting the rate of diffusion-dominated transport to the biosphere above. During the thermal period (a few decades to hundreds of years, depending on waste type) there is the possibility for thermally driven buoyant convection, which seals could help to mitigate. After cooling, with fluid of similar composition in the borehole and formation reestablishing density stratification, the upward hydraulic gradient is likely to be very small or nonexistent regardless of the seals. Radionuclide transport under such conditions would be diffusion-dominated and limited to long pathways and low permeability.

The DBFT will evaluate methods for sampling and testing in the characterization borehole to determine groundwater provenance and apparent age at the test site. The capability for safe handling and emplacement of waste in deep boreholes will be demonstrated, and borehole sealing materials and technologies will be evaluated.

Deep Borehole Field Test

Previous Investigations

The National Academy of Sciences [1] identified deep injection as a promising method for disposal of liquid radioactive or mixed wastes. This was followed in the 1960s by a campaign of injection of cementitious waste slurries into shale, near Oak Ridge, Tenn. The Oak Ridge disposal site was shallower (about 300 m) than proposed for deep boreholes. It was discontinued in the 1980s but continues to be monitored [8].

A number of disposal options for radioactive waste were investigated in the 1980s in the U.S., including deep borehole disposal of commercial spent nuclear fuel [2]. That study was the first to propose a means for emplacing strings of waste packages, threaded together, using a drill rig (drill-string emplacement). Later studies evaluated drill-string emplacement for the Swedish waste program [9]. R&D programs for deep borehole disposal have been ongoing for several years in the U.S. and the United Kingdom [10, 11]. Technical leadership for the DBFT is provided by Sandia National Laboratories for the DOE and builds on Sandia's DBD R&D activities started in 2009 [12].

There have been hundreds of deep-injection wells for wastewater and liquid hazardous waste in the U.S., licensed by the EPA [5]. Approximately 500 to 600 wells have been put into service, with depths from 3,000 to 12,000 feet. The injection intervals are typically separated from underground sources of groundwater by multiple low-permeability confining units. Injection wells have double

Table 1. Summary of selected deep scientific drilling projects conducted internationally

Site	Location	Years	Depth [km]	Diam * [in]	Purpose
Kola SG-3	NW USSR	1970-1992	12.2	8 1/2	Geologic Exploration + Tech. Development
Fenton Hill	New Mexico	1975-1987	4.6	9 7/8	Enhanced Geothermal
Urach-3	SW Germany	1978-1992	4.4	5 1/2	Enhanced Geothermal
Gravberg	Sweden	1986-1987	6.6	6 1/2	Gas Wildcat
Cajon Pass	5 California	1987-1988	3.5	6 1/2	Geologic Exploration
KTB	SE Germany	1987-1994	9.1	6 1/2	Geologic Exploration + Tech. Development
Soultz-sous-Forets GPK	NE France	1995-2003	5.3	9 5/8	Enhanced Geothermal
SAFOD	Central California	2002-2007	4(3)#	8 3/4	Geology Exploration
Basel-1	Switzerland	2006	5	8 1/2	Enhanced Geothermal

* borehole diameter at total depth
#true vertical depth