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Geological Review of Department of Energy Proposed Sites in Minnesota for High-Level Radioactive Waste Disposal

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Introduction

The Department of Energy (DOE) proposed three potentially acceptable sites for high-level radioactive waste disposal in Minnesota. These sites were chosen on the basis of the nature of the exposed or near surface crystalline rock bodies they contain. However, the accuracy of the data used by the DOE in choosing these sites is variable, from excellent to poor.

Geology

The Mississippi-Mille Lacs Site (NC-10) is thought to be composed of granites and gneisses. Only one to five percent of the site has exposed bedrock. The glacial overburden is more than 200 feet thick in some areas. Therefore, bedrock interpretation has been obtained mainly through indirect geophysical data. The area is also a groundwater aquifer and can yield up to 500 gallon per minute. The major discharge zones are the Mississippi and Rum Rivers.

The Red River Valley Site #1 (NC-7) is thought to be composed of granite. Because no bedrock exposures exist within 65 miles of the site, the location and dimensions of the granite have been interpreted by geophysical data. The glacial overburden ranges from 200 to more than 300 feet thick. The area is a groundwater aquifer and surface drainge is to Canada.

A third proposed site is the Red River Valley Site #2 (NC-6). Like NC-7, there are no bedrock exposures within the site. It is covered with 300 to 500 feet of glacial overburden, and is also a groundwater aquifer for agriculture and domestic purposes. Drainage from this site is to Canada.

The potential disposal sites were chosen on the basis of the exposed or near surface crystalline rock bodies they contain. Yet, the sites chosen in Minnesota have very little to no exposed rock. Also, the accuracy of the Minnesota geological maps used to make the choices is highly variable with poor accuracy in areas of unexposed bedrock.

Faulting and shearing may also be a problem in the bedrock at these sites. The two Red River Valley sites are thought to be located on Archean greenstone-granite. (We can not be certain there is granite at these locations and if present, the lateral extent and thickness may not be sufficient to meet DOE guidelines.) There are modern analogues to the greenstone belts in current island arcs, such as the Aleutions and the West Indies, which have similar size, chemistry, and rock types. Accreted island arcs would suggest a large aamount of faulting and shearing in the bedrock, which would provide groundwater pathways in the crystalline rock.

The granites in the Mississippi-Mille Lacs Site are associated with the Penokean Orogeny of 1800 million years ago. There are no mapped faults in the area; however, interpretation of faults is difficult in granite, especially with limited outcrop. Simpson and Schmid (1) and Segall and Pollard (2) discuss the structures developed within fault zones in granites. These include broken feldspars, augen structures, c-and s-surfaces, and wedge- and rhomb-shaped cavities in faulted granites. All of these structures can be found in the granites of the Mississippi-Mille Lacs Site. In addition, the enhanced erosion along fault zones causes these areas to appear as troughs or gullies in the field. Hence, the exposed rock would be the least sheared rock, and it is visibly fractured and sheared. Thus, the unexposed rock would be expected to be equally or more severely fractured and sheared.

Conclusion

Little, poor, or no data on the underlying bedrock is available for the Minnesota sites chosen by the DOE. In NC-7 and NC-6, the thickness, lateral extent, and even the existence of the granite can not be certain. In NC-10, there is faulting and shearing, which provide pathways for radionuclide release to the accessible environment.

References

1. Simpson, C., and Schmid, S. 1983. An Evaluation of Criteria To Deduce the Sense of Movement in Sheared Rocks. *Geol. Soc. of Amer. Bull.* 94:1281-1288.
2. Segall, P., and Pollard, D. 1983. Nucleation and Growth of Strike Slip Faults in Granite. *J. of Geophy. Res.* 88: 555-568.