5/13/83

LETTER REPORT ON PROBLEMS ASSOCIATED WITH THE DOE'S ASSUMPTIONS OF BASALT-WATER REACTIONS

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ABSTRACT

DOE calculations in the BWIP Site Characterization Report predict low oxygen fugacities and high hydrogen overpressures exceeding an atmosphere from basalt-water equilibrium reactions. With present waste package designs, the consequences of these reactions could lead to continuous production of large quantities of hydrogen which could cause waste package degradation and interfere with repository performance before closure.

The DOE in the BWIP Site Characterization Report has claimed that if water is in equilibrium with basalt, the oxygen fugacity will be so low as to greatly reduce corrosion and the hydrogen overpressure will be so high (~2-10 atmospheres) as to possibly inhibit radiolysis. Since the basalt-water reaction will occur over the temperature range from ambient basalt (~50°C) to the surface temperature of the waste package (~250°C) it is possible that the kinetics of the reaction may inhibit the attainment of equilibrium at low temperatures for long times while permitting it at the higher temperatures in short times. In the case where basalt-water reactions tend to equilibrium at the higher temperatures, radiation fields from the waste package may drastically change the reactions, the kinetics and the time to reach equilibrium.

The NRC will not be able to evaluate the models and data on the performance of the waste package and the engineered barrier system unless it has experimental evidence on both the kinetics and the assumed equilibria associated with these reactions. If the DOE is incorrect in assuming low oxygen fugacity and high hydrogen overpressure then important aspects of the basalt waste package design will be affected. More importantly, if the DOE is correct, there is a set of serious potential problems that can interfere with the performance of the waste package and the repository. These problems may also invalidate some of the heat transfer models used in the past to calculate properties of the near field host rock and the engineered barrier system.

If basalt-water reactions at temperatures comparable to the waste package surface tend to equilibrium in relatively short times, then as water drips through the rock adjacent to the waste package large quantities of hydrogen will be generated.

If the equilibrium hydrogen pressure for the basalt-water reaction exceeds one atmosphere as calculated by the DOE, then prior to repository closure, the water in the higher temperature regions of the repository will continuously react with basalt to produce hydrogen. (The quantities would depend upon presently unknown kinetic rates.)

Large quantities of hydrogen mixed with steam and reacting with carbon steel surfaces of the waste packing can introduce serious new canister failure modes.

If some of the hydrogen is produced in the pores of the rock along with the deposition of dissolved salts, the mechanical, chemical and heat transfer properties of the host rock will require reevaluation and testing.

Either the absence or the presence of the proposed basalt-water equilibria leads to important effects in estimating and evaluating repository and waste package performance. It is necessary that the details of the kinetics and the equilibria of basalt-water reactions be determined with and without the presence of gamma radiation over the total range of temperatures from ambient to the maximum. Since the kinetics are surface area dependent and can be catalyzed or inhibited by metals or clays, replicate experiments will also be needed in the presence of the proposed waste package materials.

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5/13/83

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