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September 19, 2008
Contract No. NRC–02–07–006
Account No. 14002.01.151
Docket No. 06300001

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Mr. Eugene Peters
Office of Nuclear Material Safety and Safeguards
Division of High-Level Waste Repository Safety
Two White Flint North
11545 Rockville Pike
Mail Stop EBB-2-BO2
Washington, DC 20555

Subject: IM 14002.01.151.802—Final—Simulations of Magma-Waste Package Interactions Using Computational Fluid Dynamics

Dear Mr. Peters:

This letter transmits Intermediate Milestone 20.14002.01.151.802, Final—Simulations of Magma-Waste Package Interactions Using Computational Fluid Dynamics, which incorporates NRC changes as outlined in the attached comment and response table.

If you have any questions, please contact Debashis Basu at (210) 522-8333 or me at (210) 522-5085.

Sincerely,

Philippe Dubreuilh, Ph.D.
Manager, Geology & Geophysics

PD/slo
Attachment
cc:

NRC		CNWRA/GED	
L. Kokajko	M. Shah	W. Patrick (letter only)	CNWRA Dirs/EMs (letter only)
B. Meehan	B. Hill	B. Sagar (letter only)	L. Gutierrez (letter only)
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NRC Comments and CNWRA Responses

Contract No.: NRC-02-07-006   Project No.: 14002.01.151   Deliverable No.: IM 14002.01.151.802

Comment No.	Section/ Page	Para.	NRC Comment	CNWRA Response
1	1.2		Give more detail of other work that has been conducted to simulate movement of magmatic fluids along a drift. Does this work analyze a viable alternative scenario to that provided by Woods et al. 2005?	Added extrusive case (between 4th and 5th paragraphs, Section 1.1): In the case of an extrusive igneous event, DOE models assume only the contents in the waste packages directly intersected by a conduit is released and transported to the surface by ascending magma (Sandia National Laboratories, 2007a,b). Scenarios in which ascending magma jags along a drift, resulting in an offset conduit [e.g., dog-leg scenario presented in Woods, et al. (2002)], are dismissed as unlikely. Also, in Sandia National Laboratories (2007a), they treat magma as a single, incompressible phase, and determine that in the repository, it would be largely stagnant once all drifts are filled. Thus, their models do not include alternative eruption scenarios (e.g., a secondary conduit forms and horizontal flow develops down a drift) which might provide a mechanism to transport the contents of an increased number of waste packages directly to the surface. This work examines possible consequences to the scenario presented by Woods, et al. (2005) (if horizontal flow develops down drift as a result of, for example, a secondary conduit).

Comment No.	Section/ Page	Para.	NRC Comment	CNWRA Response
2	1.1 or 1.2, and /or 3		What are the bounding assumptions that prompted this analysis. These should be discussed more thoroughly. You should carefully describe the parameters and limitations of the simulation runs (e.g. invariant viscosity). In scenarios (i) and (ii), what happens as the magma/lava fills the dike, and its temperature drops? Is magma temperature tied to viscosity in the simulations? Is latent heat considered?	In Section 2.4, added "The magma properties are for a magma with a temperature of 1,450 K [2,150 °F], the tuff properties for a tuff at 300 K [80.33°F], and the Alloy-22 at 300 K [80.33°F]. With one exception (Figure 3-4 depicts the temperature profile ~10 minutes after the drift is filled with magma), magma temperature and viscosity are held constant in these simulations, and latent heat is not considered."
3	2.4 and 3		Why choose 40 Pa-s for viscosity and ~1200°C for temperature? Why not give magma temp in degrees C?	In Section 2.4 on p. 2-4, we say "Properties...were obtained from Detournay, et al. (2003)". These properties are tied to the temperatures used for the magma, tuff, and waste packages, so we kept all the parameters the same. FLUENT requires temperature in Kelvin, so the temperature reported for simulations was in Kelvin, and the English conversion is °F.
4	2.1		Justify why a dike width was chosen that is wider than the drift diameter? I am unsure what dike widths have been selected as most likely, but 8 m is very wide.	In Section 2.1, added: Dike width was chosen based on the mean dike width used in the igneous scenario models included in the total system performance assessment (TSPA) used by the DOE (Sandia National Laboratories, 2007b).

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5	1.2 or 2.1		Spend a few more lines describing the prescribed scenario, for example, that the dike-induced fracture extends across the drift to the surface, and that magma treated in this model is not (?) the leading/first magma to arrive at the drift, otherwise the scenario will be more like that described by Woods et al. (2005) or Darteville and Valentine (2005).	Simulations in this report are based on Phillips and Menand experiments and DOE models [see Sandia National Laboratories, 2007 (AMR: Dike/Drift Interactions, MDL–MGR–GS–000005, Rev.02) Section 6.3.3.5.6 p.6-57, Section 6.4 p.6-138; might also check out earlier version BSC 2004 (AMR: Dike/Drift Interactions, MDL–MGR–GS–000005, Rev.01); also BSC 2005 (AMR: Magma Dynamics, ANL–MGR–GS–000005, Rev.00)]; this basis is mentioned in Section 1.1. Modified/added to Section 1.2: This summary report documents the important technical aspects and results of computational analyses designed to investigate the flow of magma into a horizontal subsurface tunnel including obstacles after intersection during initial ascent. These models are not designed to simulate the conditions of initial intersection or investigate possible changes to the properties of the leading/first magma to arrive at the drift but rather the conditions after intersection as the drift is effusively invaded and filled with magma.

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6	3.1		Regarding trapping of air in an intruded drift, the report should mention the previous assumptions of Woods et al. (2005) for small permeability of host rock. This work assumes zero permeability – is it that the walls may be essentially impermeable on the time scales considered in this work?	Simulations in Dartevelle and Valentine (2005) and AMR: Magma Dynamics, ANL–MGR–GS–000005, Rev. 00 (BSC 2005) considered the end of the drift as a closed vertical boundary, and the permeability of the host rock was not taken into consideration. In subsequent simulations of effusive flow of magma inside a drift [AMR: Dike/Drift Interactions MDL–MGR–GS–000005, Rev. 02 (Sandia National Laboratoies, 2007)], DOE used FLAC3D. Properties of materials provided in Table 6-28 p.6-235 did not mention any value of the permeability of the host rock; it is likely that the host rock permeability was not considered. Woods, et al. (2005, 2002) also do not consider host rock permeability. Moreover, adopting the permeability into the existing frame of CFD simulations would require a fundamental change in the governing Navier-Stokes equations and modifications of the source terms to accommodate the porosity.
7	1.2	1	define *spanwise* – is this along-drift?	"Preliminary simulations in three-dimensions showed insignificant effect of the *spanwise* dimension on the predicted flow and thermal field. In addition, three-dimensional simulations resulted in a large computational grid" was changed to "Differences in the predicted flow and thermal fields between preliminary simulations using two- and three-dimensions were insignificant, and three-dimensional simulations resulted in a large computational grid". Hence, *spanwise* was removed.
8			Figure captions should be more explicit concerning the significance of the colors and flow vectors.	Modified as suggested.
9	3.1	3	line 12, *decrease* or *fall*, not *extinguish*	Changed to *decrease*.