

Statement of Work, University of Bristol  
Contract 99035, Modification 12  
CNWRA Project 06002.01.051 (Igneous Activity KTI).  
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December 26, 2002

Future volcanic activity may disrupt the proposed Yucca Mountain radioactive waste repository site during the next 10,000 years. Staff needs to develop quantitative estimates of the health and safety hazards that may result from future igneous activity. In addition, staff needs to evaluate a broad range of models and data proposed by the U.S. Department of Energy to support potential licensing of the repository. A key component of the hazards analysis is understanding how rising basaltic magma may interact with subsurface repository structures, such as tunnels or drifts. Prior work at the University of Bristol focused on laboratory experiments using materials that simulate magma and drifts. These experiments investigated the dynamics of how gas-bearing and gas-free fluids like magmas could suddenly decompress into subsurface openings, which can accelerate and fragment the fluids. This work is directly linked to the development and verification of numerical models that also represent decompressive flow process. The work also involves investigations of the circulation of bubbly magma within a repository due to density variations caused by separation of bubbles.

The emphasis of work in FY2003 will shift from initial flow conditions to the conditions of sustained flow through subsurface structures. Following intersection of the rising magma with the tunnel, a pathway will likely be established to the surface. Magma will then flow through this pathway for days to weeks, impacting the performance of engineered structures located along or near the flow path. Convective circulations may occur in magma-filled structures due to gas exsolution and segregation. A number of different flow regimes may develop, depending on the volume flux of magma through the system, the size of bubbles in the magma, and the geometry of flow system. The flux of magma through the dike may drive a recirculating flow within a drift, which may result in the entire volume of the tunnel being exchanged with the dike. Conversely, there may be stagnant regions where the magma has a long residence time. Vapor bubbles also will exsolve or grow from the magma. If the bubble size is large, the bubble rise speed may be large compared to the flow within a drift, resulting in significant melt-bubble separation in the drift and the formation of a coalesced foam at the drift roof. This process may result in foam collapse, which drives fire-fountain eruptions. Along with the foam collapse, dense degassed magma may drain back into the dike/conduit system and possibly be re-entrained into the ascending magma flow. Time scales for foam collapse and flow recirculation may depend critically on the geometry of the dike-drift intersection and the angle of the tunnel to the dike. Staff need to consider these processes in quantifying the likely range of temperatures, pressures, and flow dynamics of magma along these potential pathways, in order to evaluate the likely impacts on waste containment structures and effects on health and safety. Work in Modification 12 will occur in FY2003 as these tasks:

- 1) Complete the analysis of results from physical analog experiments conducted at CNWRA facilities. Conduct supplemental experiments to constrain pressure-volatile relationships for gum resin-acetone system. Conduct supplemental experiments to evaluate decompression effects in volatile-bearing systems using conditions comparable to FY2002 volatile-absent experiments. Publication of results in a suitable earth science journal.
- 2) Incorporation of experimental results into numerical models, including presentation of integrated results in a report suitable for submission to a scientific journal. This task includes collaboration with consultant Dr. Onno Bokhove at the University of Twente, Netherlands.

3) Use of experimental apparatus constructed during FY2002 at the University of Bristol to evaluate quasi-steady flow conditions for gas-bearing magma flowing through a vertical conduit abutting an open, horizontal tunnel. This task includes collaboration and coordination with consultants at Cambridge University, England, on analysis and modeling. Conduct a systematic series of experiments evaluating two-phase flow dynamics of bubbly fluids. Results are to be presented in the form of reports, journal publications, and presentations at suitable conferences.

4) Provide expert advice as required on volcanology in relation to potential magma-repository interactions, including potential support for NRC-DOE meetings.

The period of performance will be from September 30, 2002 to September 26, 2003.

Documents prepared for presentation at international meetings will be transmitted to the CNWRA no less than 45 days prior to the intended submittal date for the meeting. This time is necessary to complete CNWRA internal review of the documents, and comply with NRC contract requirements for document submittal.