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Magnetic Modeling of Buried Basalt Near the Potential Repository at Yucca Mountain, Nevada, Constrained by New Paleomagnetic, Rock Magnetic, and Petrographic Studies

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Probability estimates for igneous disruption of the potential repository at Yucca Mountain, Nevada, are affected by uncertainties in the number and age of basaltic volcanoes possibly buried in the area. To reduce these uncertainties, the U.S. Department of Energy (DOE) sponsored studies, including a high-resolution aeromagnetic survey of the Yucca Mountain region, to identify potential sites of buried basaltic intrusions and their characteristics. The survey was conducted using a helicopter with an average sensor elevation of 40–50 m [131–164 ft] above terrain. Based on the resulting anomaly map, a subset of seven anomalies (A, G, I, JF5, JF6, O, and Q) was identified for additional testing. These seven anomaly sites were cored to determine whether buried basalt was the source of the anomalies. Basalt was encountered in four of the seven boreholes—A, G, JF5, and Q. Basalt samples from these four boreholes were collected for additional analyses, including radiometric age determinations and mineral identification.

This paper reports petrographic, paleomagnetic, and geophysical modeling results from an independent review of the DOE aeromagnetic data and analysis of core samples. Experiments included measurements of: (i) natural remanent magnetization; (ii) alternating field demagnetization and thermal demagnetization to isolate the inclination of the characteristic remanent magnetization; (iii) room-temperature bulk susceptibility; (iv) temperature dependence of low-field susceptibility to 700 °C [1,292 °F]; and (v) hysteresis and coercivity. The paleomagnetic measurements characterized the magnetic properties of the samples and were used as input for the models. The modeling approach included development of two-dimensional forward models along optimally oriented profiles for each of the four magnetic anomalies. Magnetic source bodies were developed as geologically reasonable polygons with known or inferred magnetic properties for each forward model. Geometry of the source polygons was derived from a combination of known subsurface geologic conditions from the boreholes, extrapolation of nearby geologic structures to the subsurface, analogs to similar features in the region, and general geologic principles. Forward modeling consisted of trial and error alteration of the polygons (both properties and geometries) until the models produced a magnetic response curve that closely matched the observed magnetic profile. Care was taken to preserve aspects of the subsurface geometries that were known (e.g., depth to the top of the body based on borehole information) or were likely (e.g., projection of a nearby fault to the subsurface) and to only alter aspects of the source geometry or magnetic parameters that were uncertain (e.g., lateral dimensions of the body in the subsurface or average remanent magnetization intensity). Results from our geophysical modeling indicate that the profiles of anomalies G, JF5, and Q in the Yucca Mountain region can be modeled as two-dimensional bodies of relatively thin (10–140 m [33–459 ft]) basaltic rock. The study of Anomaly A coupled with observations from the core and from thin sections suggests that this anomaly is best modeled as a relatively thick (>500 m [1640 ft]) basaltic rock suggestive of a sill.