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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: DOE/LANL site visit to Lathrop Wells volcano, Nevada. 20-5702-441.

DATE/PLACE: April 3, 1995. Lathrop Wells volcano, Nevada.

AUTHORS: Brittain E. Hill, Charles B. Connor.

PERSONS PRESENT: B.E. Hill, C.B. Connor (CNWRA); J. Trapp, S. McDuffie, C. Glenn (NRC); P. Lipman, P. Delaney (USGS); S. Self (U. HI); B. Crowe, K. Kinnegan, F. Perry, G. Valentine (LANL); J. Nesbit, C. Einberg, T. Bjerstedt, S. Nelson, T. Crump, J. Weston, S. Wells, L. McFadden (DOE/Contractors); C. Johnson, D. Tillson, G. Yogodzinski, E. Tiesenhausen, J. Perry (Nevada/Counties); W. Melson (NWTRB); K. Roggensack, S. Williams (ASU).

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BACKGROUND:

The CNWRA conducted an expert-panel review of ongoing volcanism research on October 3-7, 1994. Part of this review entailed a 2 day field trip to some of the Quaternary and Pliocene volcanic centers in the Yucca Mountain Region (YMR). The details of this review are contained in Hill (1995). Although the scope of this review was to examine CNWRA volcanism research, the expert-panel members raised questions about some of the volcanological interpretations presented in publications by Los Alamos National Laboratory (LANL) and State of Nevada researchers. These questions were based on the panel-member's visit to the YMR volcanoes and their individual and collective experience in basaltic volcanism, and reconciling their observations with published interpretations of some YMR volcanic features. Prior to publication of the review results (Hill, 1995), Bruce Crowe and Frank Perry of LANL sent a letter to the 5 review-panel members objecting to comments regarding the LANL volcanism program and their desire to lead a field trip to Lathrop Wells volcano to present unpublished data and outcrop interpretations first-hand to the panel members (Crowe and Perry, 1995). The field trip was conducted on April 2-3 1995, as an open meeting for applicants and licensees. Additional information regarding this trip is presented by Trapp (1995).

SUMMARY OF FIELD TRIP:

Participants met on the evening of April 2, 1995, at DOE offices in the Las Vegas Bank of America building, to listen to presentations by LANL staff and contractors on research conducted at Lathrop Wells volcano. Copies of the handout for these presentations are attached as Appendix A. Much of the information presented was a summary of published work or material presented in the Crowe et al. (1995) status report. Most discussions of these data were postponed until the next day's field visit to Lathrop Wells volcano.

The agenda for the field trip is attached as Appendix B. The field trip followed the agenda closely, with an additional stop added at the end of the day to examine reworked deposits of Lathrop Wells scoria. Drs. Lipman, Delaney and Self provided written summaries of their observations and interpretations of this field trip, which are attached as Appendix C.

Stop 1: Discussion of Holocene volcanic deposits (Qs4a), which have been removed by quarrying immediately south of the main cone. Several photos of these deposits were shown, none of which clearly documented the nature and extent of the tephra units interpreted as Holocene pyroclastic deposits by Crowe et al. (1995). Most participants agreed that an infiltrated soil with Holocene thermoluminescence dates was developed on fall deposits that underlie the Holocene deposit, but that the characteristics of the Qs4a deposits were unclear. Hill attempted to focus discussions on the photos and samples he had of these deposits, but the group decided to move onto the next outcrops in order to examine field evidence instead.

Stop 2. Agglutinated deposits draped by Qs2 fall. Here, agglutinated beds of scoria with some minor rheomorphic characteristics are about 3 m thick and high, and dipping roughly 60° SE. Deposits are interpreted to represent a vent deposit. Surrounding fall deposit has been removed by quarrying, but might have come within about 1 m of the top of the agglutinate. Orientation of the outcrop may have been disturbed by quarrying. The lack of symmetry makes it difficult for this to be a vent. Self and Lipman stated they thought this was nothing more than a cone-wall remnant from an earlier phase of the eruption rafted outwards on the lavas. The composition of this outcrop is the same as the underlying lavas.

Fall deposits immediately south of this outcrop are all highly oxidized yet lack aerodynamic forms or agglutination. Instead, the scoria are angular and fragmented, indicating sufficient time during transport to cool before deposition. Pervasive oxidation present in these deposits is likely a function of landing on a hot lava flow rather than a primary fallout characteristic. Such oxidation is pervasive on lower parts of falls resting on lavas at Lathrop Wells, yet no oxidation is observed on falls resting on older surfaces.

Stop 3. Fall deposit 1.9 m thick, on the northern side of a small hill of Paintbrush Tuff. Upper section of the fall is heavily eroded. Infiltration of eolian sediments is obvious in the upper 0.1-0.3 m, with some laterally irregular development of carbonate beds at the base of the infiltration zone. Scoria throughout the section commonly have carbonate beards on their undersides and limonitic tops, indicating alteration from meteoric water. There is very obvious bioturbation throughout the upper 1 m of the deposit, with numerous root casts and roots. Multiple graded beds are apparent, and the basement contact is exposed. McFadden described the soil development here, indicating that the upper vesicular A horizon may only have developed in the Holocene. Wells concluded that if the age of this deposit was 100 ka, then there should be more soil development. Crowe stated they had no plans to do granulometry on the deposits unless they felt it was important for consequence studies. Crowe has measured the 10 largest clasts in the fall deposits around the main cone, and they increase in size towards the cone.

Stop 4. Ql1d flow/vent relationships. Vesicular basaltic breccia exposed along road-cuts at the southwest margin of the older lavas. All CNWRA/NRC participants agreed that this exposure simply represents a flow-front breccia, not a lava overriding a vent as interpreted by LANL researchers. Scattered bombs on the flow top may have been transported on the lava, or ballistically from the vent. The flow breccias have variable amounts oxidation, a lack of fines, abundant blocks of vesicular basalt, lack agglutination, and have gradational contacts with the lavas, all of which are characteristic of flow-front breccias.

Stop 5. Western basal sector of the main cone. Coarse angular alluvial deposits overlie the eroded fall deposits at this location, whereas the flanks of the main cone are not apparently modified by alluvial

processes except for minor rilling on the south flank. LANL researchers stressed compositional differences between the scoria fall and main cone, and obvious differences in geomorphic modification. They maintain that similar degrees of dissection should exist on similar age features, regardless of deposit type. Neither proponents or opponents of this interpretation could prove their points convincingly, although the interpretation that the main cone formed without creating a distributed fall sheet (cf. Crowe et al., 1995, p. 2-15) is a unique interpretation for these types of volcanoes. Obvious differences in the degree of eolian infiltration may influence erosive processes between the cone and fall deposits, as will the presence of established bedrock drainages above the fall deposit. Gravity-induced small scale slumping may be the dominant geomorphic process on the cone, whereas alluvial processes would be dominant on the fall deposit. Sources of testable ambiguity include the influence of eolian infiltration on slope stabilization, comparisons with other cinder cones of similar age and genesis (e.g., cones at Cima are more agglutinated, which affects erosion significantly), and overall preservation and weathering of the fall sheet.

Stop 6. Finely-bedded scoria deposits. Features of the deposits that LANL researchers cite as indicative of a surge origin for the bedded deposits are the dominance of thin planar to low-angle cross bedded forms, variations in the degree of sorting, interbedding with thin fallout deposits, and presence of poorly vesiculated, sideromelaine-rich clasts. Alternative interpretations to these deposits focused on eolian reworking. The degree of sorting and bed forms were interpreted as eolian, not surge. The unusual abundance of quartz clasts also was cited as indicating an eolian origin. These interpretations could not be resolved in the field.

Stop 7. Trench exposure of Qs1 lavas. A stratigraphically older lava flow with a moderately preserved flow-top breccia has been trenched back to an overlying lava. The older lava is thought to be significantly older than an overlying 1-m-thick fall deposit, as there is reportedly more carbonate deposited in the lava than in the fall. This fall deposit is no longer exposed in the trench walls, which have collapsed. However, according to McFadden, there are no eolian or sedimentary beds between the lava and overlying fall, and carbonate beards are moderately developed on the scoria in the fall. An alternative interpretation is that the differences in carbonate deposition are due to permeability differences between the scoria and lava. Stagnation in fractures on the lava allows for more carbonate deposition, whereas little stagnation occurs in the more permeable fall.

The overlying (younger) flow is thought to rest upon a scoria vent. Again, the absence of agglutination, large clast size, variable oxidation, overall morphology of the clasts (blocky and vesicular) and gradational contacts indicates that this is a basal flow breccia near the front of the lava flow, not a scoria vent. As expected, the composition of the breccia matches the lava. Although it is no longer exposed, apparently about 5-7 m of scoriaceous breccia occurs between these lavas. LANL workers believe that these lavas (i.e., Ql1) all originated a short (< 100 m) ways from their present exposures, and each flow lobe essentially represents the local eruption of a very small volume of lava. The influence of pre-existing topography on lava damming and breakouts has not been determined but apparently is being considered.

Stop 8. Scoria mounds at eastern base of the main cone. Reported dike cutting a mound appears to be a push-up or ramp structure from the underlying lava flow. Bombs on the scoria mound may be apparently abundant due to the eolian removal of fines; all upper mound surfaces are modified and highly infiltrated. Numerous large bombs on the mound surfaces have been drilled for paleomagnetic analysis, even though they are loose and overlie infiltrated surfaces. A consistent magnetic orientation has been observed for sampled ejecta exposed in trenches on several mounds, which leads the LANL researchers

to conclude that these mounds are vents. However, rafted pieces of earlier cone phases may also remain above the magnetic blocking temperature during transport, especially when covered rapidly by unconsolidated scoria. Arguments against rafting continuously focused on differences in composition between the scoria and exposed surfaces on the main cone, a semi-linear alignment of the scoria mounds, compositional similarity with the lavas, and other (no longer exposed) evidence such as dikes, radial dips to scoria, and abundance of agglutinate. None of these observations are inconsistent with a rafting origin. Possible solutions to this controversy include conducting paleomagnetic studies at obviously rafted deposits such as Sunset Crater, Arizona, and determining if the Lathrop Wells scoria mounds rest upon lavas or upon bedrock.

Stop 9. Main cone summit. Little discussion of the exposures here; all participants agreed that there has been significant infilling of the cone crater and channel development on the inner crater walls. The irregular distribution of bombs in the inner crater walls can be attributed to infiltration or deflation of surrounding deposits. Many of the cosmogenic exposure dates were collected on the north rim area, at both the summit shoulder and the northern cone flank up to 20 m below the summit. LANL researchers maintained that while none of the outcrops visited at Lathrop Wells proved that this volcano was reactivated and erupted at least 4 discrete times, the "entire picture" held together for polygenetic volcanism. There was much disagreement about that observation.

Stop 10. Reworked remnants of the Holocene tephra (Qs4b). Loose coarse ash in several declivities on top of the older southern lavas (Ql1a). Deposit rests upon variably oxidized and vesiculated basalt. All of the tephra looks like scoria in hand sample, and all of it has been moderately reworked. Valentine concluded that the unit originated from hydrovolcanic eruptions, based on presence of sideromelane and quench fragments. There was no explanation on how a hydrovolcanic eruption would only disrupt scoria beds and not the underlying lavas or bed-rock ignimbrites; other interpreted hydrovolcanic beds at the main cone have up to 20% ignimbrite clasts. No ready explanation on where the vent for this deposit was, except that it must have been destroyed by quarrying since it has never been seen. Perry maintains that the Qs4 glass is fresh therefore compositional variations are magmatic and not the result of surficial weathering. Perry hasn't analyzed oxidized and nonoxidized components of Qs4b, nor investigated how surficial weathering may have affected geochemistry of 1-5mm diameter clasts. Similar problems may be present with the basaltic ash in Trench 8, which Perry stated looks like Lathrop Wells but is consistently depleted in rare earth elements. The Trench 8 ash also looks fresh, yet the geochemical variations are difficult to explain as a magmatic process if this is a Lathrop Wells deposit.

IMPRESSIONS AND CONCLUSIONS:

Information presented on this trip clearly shows there are significant amounts of data on Lathrop Wells that have not been presented in LANL or DOE literature. These data include documentation of the missing Qs4 deposits, trench logs for shallow and deep trenches, results of petrographic analyses, and abundant geochemical analyses. The arguments for polycyclic eruptions are based on 3 main points, which have alternate interpretations:

- Geochemical variations show a regular trend from oldest to youngest deposits, which cannot be produced through simple crystal fractionation or crustal contamination. However, basaltic eruptions may be zoned through other differentiation processes, such as the mixing of 2 compositionally similar magmas or differential melting. That magma compositions would be so similar after a tens of thousands of years hiatus implies a regularity in petrogenesis that is rarely observed.

- Volcanic fall deposits rest upon a buried soil that is Holocene in age. The arguments for a primary volcanic origin of these falls are equivocal and have not been presented in detail. The degree of rounding, sorting, and bedding in these deposits may indicate local reworking of late-stage cone deposits, rather than a Holocene eruption.

- The main cone appears geomorphically unmodified, whereas the fall deposits are relatively eroded and thus represent differences in age. There are 2 main problems with this hypothesis: (i) fall deposits associated with cone formation are absent; LANL researchers interpret this to mean that no dispersed fall deposits occurred during cone formation, rather than these deposits being eroded away. However, simple erosion of this fall would indicate that temporally equivalent deposits may have greatly different erosional histories, controlled by different physical characteristics of the deposits; and (ii) geomorphic comparisons are based on analogy with volcanoes at Cima, California. These volcanoes are more highly agglutinated and have significantly finer eolian deposits than Lathrop Wells, both factors which may significantly affect cone-slope stability.

PENDING ACTIONS: Review of published and unpublished LANL/DOE data on Lathrop Wells is an ongoing technical assistance task for the NRC.

RECOMMENDATIONS:

Alternate interpretations to those of LANL researchers are clearly viable for Lathrop Wells. These interpretations indicate that no significant hiatuses occurred during the eruption of Lathrop Wells, which occurred about 120 ka. Physical volcanological and geochemical studies at historically active volcanoes provide accurate data to compare with interpretations at Lathrop Wells. Data collected to date at such volcanoes do not support many critical LANL interpretations at Lathrop Wells. CNWRA research should focus on collecting independent physical volcanological data for Lathrop Wells and conducting detailed studies on eruption dynamics and physical volcanology at appropriate historically active volcanoes. Appendices are with original copy. The author will supply upon request.

PROBLEMS ENCOUNTERED: None significant.

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