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May 26, 1995

MEMORANDUM TO: Mysore Nataraja, Acting Section Leader
Geosciences/Geotechnical Engineering Section
ENGB/DWM/NMSS

FROM: Stephen McDuffie, Geologist
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SUBJECT: TRIP REPORT FOR APRIL 24-26, 1995, FIELD TRIP FOR DOE'S VOLCANIC HAZARDS EXPERT PANEL TO LATHROP WELLS AND SLEEPING BUTTE VOLCANOES

On April 24-26, 1995, I participated as an observer in a field trip for the members of an expert panel of volcanologists assembled by DOE. This panel, part of an expert elicitation project on probabilistic volcanic hazard assessment, has previously held two meetings and one field trip, which also had NRC staff in attendance. The purpose of this trip was to better familiarize the experts with the field relationships of the youngest and most controversial volcanoes in the Yucca Mountain area--the Sleeping Butte cones and Lathrop Wells.

The trip convened with an evening meeting on April 24 at the Yucca Mountain Science Center in Beatty, Nevada. This meeting provided an opportunity for Bruce Crowe of the Los Alamos National Laboratory (LANL), a member of the expert panel and one of the principal investigators in DOE's volcanism program, to present his interpretations of the eruption history of Lathrop Wells. This presentation was similar to the one Crowe delivered on April 2, 1995, prior to another site visit to Lathrop Wells (see Trapp/McDuffie trip report). However, Crowe did try to highlight the differences between his interpretations and those of the CNWRA expert panel (Delaney, Lipman, Self), which were discussed during the visit on April 3. Crowe indicated that in disruption probability and risk calculations, both the single and multiple eruption models for Lathrop Wells will be carried forward. Following Crowe were three other speakers: Frank Perry (LANL) on Lathrop Wells geochemistry and geochronology; Steve Wells (University of California-Riverside) on geomorphology studies; and Les McFadden (University of New Mexico) on soil development. These three presentations were fairly similar to those given at the meeting on April 2.

April 25 was devoted exclusively to the Lathrop Wells visit. Most of the stops were the same as the trip on April 3. The first stop, near the east edge of the quarry, was devoted to discussion of the Qs4 eruptive unit, which is no longer exposed at this location due to quarry operations. With regard to the Th and Rb enrichment in Qs4 versus the other units, Wendell Duffield (USGS) suggested Perry consider the possibility of contamination by high-

silica rhyolites found in the area, rather than assume that Qs4 represents a chemically distinct eruption from Lathrop Wells. Perry replied that he tried extensively to model the chemical variations by contamination, but was unable to. He indicated that he could further investigate the possibility of high-Th, high-Rb rocks contaminating the Lathrop Wells magma. George Walker (University of Hawaii) expressed concern that unit Qs4 contains a mixture of red and black (oxidized and nonoxidized) scoria clasts. Perry agreed that this feature is enigmatic, leading him to believe that Qs4 was deposited by a relatively recent hydrovolcanic eruptive phase.

Adjacent to the former Qs4 exposure is one of the Qs1 scoria mounds which Crowe believes to be a former vent. This particular mound was trenched at one time, but has been reworked by bulldozing. Crowe stated that the former trench revealed radially dipping scoria layers, supporting his position that the mound was a rooted vent. The three trenches in Lathrop Wells scoria mounds which demonstrate radial dips have all been backfilled, so NRC staff plan to review photographs of these trenches during in-field verification activities. Finally at this stop, Mel Kuntz (USGS) mentioned the unorthodox nature of Crowe's interpretation that two distinct orientations of dikes (NNW and WNW) fed the scoria mounds around the cone. Normally, a single dike orientation is found at such cinder cones. Crowe responded that it is unusual, but a similar situation has been documented at Red Cone in Crater Flat.

The next stop looked at the Qs2 fall sheet near the southern extent of the Lathrop Wells area. McFadden discussed the soil developed on top of this exposure. Walker mentioned that this scoria overlying sand is nonoxidized, whereas everywhere scoria overlies lava it is oxidized. This suggests the lava was still hot when the scoria was deposited and argues against multiple eruption events at Lathrop Wells. Crowe responded that he believes he has observed nonoxidized scoria overlying lava, but it was in a trench no longer exposed. Photographs of such a relationship are another item to pursue during in-field verification.

After this discussion, the group walked over to the southern location where eolian reworked Qs4 has been identified. Perry first identified this material as Qs4 based on the small grain size, the mixture of red and black clasts, and the clast density.

The next stop was the Qlld lava flow SW of the quarry. On the previous visit, there was disagreement whether this exposure represents an aa lava flow overriding itself to make a clinker base, or a lava flow overriding scoria. A thin, reddish bed of airfall discovered during this visit lends credence to Crowe's interpretation that a lava flow is overriding scoria.

On the west side of the cone, Wells led a discussion about the geomorphic features of the volcano and its deposits. Regarding the garlands visible on the cone in aerial photos, Wells suggested that they are primary volcanic features, not a result of later down-slope creep. Based on his geomorphic interpretation, Wells estimates the main Lathrop Wells cone age at about 30 ka; he can not envision it being as old as 60 ka.

North of the cone, the group discussed what Crowe calls the older, beveled surface which projects beneath the cone. Kuntz and Duffield took issue with the interpretation that the beveled surface must be significantly older than the cone. Near this spot are the well-sorted, fine-grained surge deposits Crowe mapped as Qs2. Walker provided an alternative interpretation that these beds are a dune remnant.

The next stop was about 2 km north of the cone, where the LANL researchers had dug two small trenches the previous day. Exposed in the trenches is a scoria layer 10-20 cm thick, which Crowe suspects is part of the Qs2 fall sheet. There was little volcanologic information to be gained from this stop; Perry used the trenches to demonstrate the complex erosional and depositional history of the area.

The group proceeded to the large trench NE of the cone which cuts through Qll lavas. Surge deposits from unit 2 are said to have draped the topography here, and the inferred hiatus between chronostratigraphic units 1 and 2 in this trench is based solely on calcium carbonate pedogenesis in unit 1. The unit 2 surge deposits are no longer clearly visible in the trench, so photographs of this trench will be requested from DOE.

The next location visited was the controversial dike cutting a scoria mound north of the cone. Crowe sees this exposure as evidence that the adjacent scoria mound is a rooted vent, while Walker proposed, after examination, that the feature is an extrusion feature from the top of an aa flow. In response to Crowe's statement that the scoria mound has radial dips and uniform paleomagnetic direction, Walker said such features can reasonably be found in a rafted scoria mound.

The final stop of the day was the summit crater, where the LANL staff had recently excavated a small trench. Abundant sand is found among the scoria clasts even 2 meters below the surface, demonstrating the high eolian influx. Duane Champion (USGS) suggested that Crowe and Perry search for the Qs4 unit in the trench wall in the future, as Qs4 should have been preserved within the relatively sheltered summit crater. In assessing the overall stratigraphy of Lathrop Wells, Crowe admitted that the LANL work has difficulty showing conclusively that there were long breaks in time between units 1 and 2 and units 2 and 3, but the geomorphic relationships on the north side of the cone are good evidence for a gap between episodes 1 and 3. Crowe seems to see the geomorphic evidence as offering the best support for multiple eruptions at Lathrop Wells, but believes the case is strengthened by considering all evidence as a whole (geomorphology, geochronology, geochemistry, field relationships). During final discussions, Crowe suggested that an unnamed cinder cone near Mt. Lassen might serve as an analog to demonstrate the feasibility of polygenetic volcanism in such cones. The cone supposedly erupted between 12 ka and 20 ka, then again reportedly in the 1850s. Steve Nelson (Woodward-Clyde Federal Services) also mentioned Tabernacle Peak in Utah as another possible example of a polygenetic cinder cone.

April 26 was spent in the area of Sleeping Butte on the Nellis Air Force Range. The trip was led my Scott Minor (USGS), who has done considerable mapping in this area. Bob Fleck, a USGS geochronologist, provided additional information for the trip participants. The first gathering was at a stop along U.S. Highway 95 which afforded a fine view of Little Black Peak (LBP) (the southwestern of the Sleeping Butte pair) and Thirsty Mountain. Minor led a discussion of the structural history of the area, which lies within the Walker Lane zone of dexteral simple shear.

After checking in at the Nellis guard house, we proceeded to the summit of Thirsty Mountain. This low mountain is a shield volcano of trachy andesite which erupted approximately 4.6 Ma. Minor mapped the feeder dikes to Thirsty Mountain with a northwest trend, however Crowe feels they have more of a north-south orientation. Champion's paleomagnetic data suggest that the entire Thirsty Mountain sequence erupted over a period of just decades to hundreds of years.

The group proceeded to Hidden Cone (HC), the northeastern of the Sleeping Butte pair, where we walked around for a couple hours. Minor discussed the presence of a significant north-south trending normal fault which projects beneath HC. This, plus the fact that the lava vented high on the flank of Sleeping Butte, strongly suggests that the vent location is structurally controlled. Radiometric dates for the Sleeping Butte cones fall largely between 300 and 400 ka, though LBP has two dates number 200 ka and HC has one date over 400 ka. Crowe addressed the topic of rilling on LBP and HC. LBP appears to have rills somewhat better developed than HC; he feels that LBP's rills are appropriate for a cone about 350 ka. Crowe believes that HC is geomorphically young compared to LBP and had perhaps two episodes of eruption. He sees an apron around the base with well-developed soils, but a cone surface which is much younger than this apron. He hypothesized a Late Pleistocene tephra eruption which mantled HC to cover any preexisting rills. Britt Hill (CNWRA) suggested that carbonate deposits in the apron indicate discharge of water which has filtered through the cone, hence, the development of soil may have been accelerated in this area. After hiking part way up the cone to observe a boca erupted from the flank, several in the group walked around to the north side to observe a lava flow. Crowe originally mapped this flow as originating from Miocene vents to the northeast, but Fleck's radiometric date and Champion's paleomagnetic data indicate HC as its source. Upon seeing that Champion's paleomagnetic data show a slight difference between some HC samples, Crowe became more convinced of his own interpretation of two separate events at HC. Nonetheless, many remained skeptical of this theory.

The last stop of the day was a brief look at the base of LBP. Minor pointed out that this cone, just over a mile from HC, has no obvious structural control on its location. Along with having rills more developed than HC, LBP has a lower slope angle.

Once the experts provide their elicitations later this year, it should become clear how they each interpret the histories of these cones. Undoubtedly, there will be differences of opinion among the panelists. If there are any questions regarding this report, I can be reached at 415-6684.

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