CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Field studies of basaltic volcanoes around Sleeping Butte, Nevada, and the eastern part of the Nevada Test Site. 20-5704-124

DATE/PLACE: September 9-16, 1994. Yucca Mountain Region, Nevada

AUTHORS: Brittain E. Hill and Charles B. Connor

PERSONS PRESENT: CNWRA: B.E. Hill, C.B. Connor, S. Lynton; Smithsonian Institution: James P. Luhr.

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BACKGROUND:

Field investigations are being conducted on basaltic volcanoes of the Yucca Mountain Region (YMR) to develop an independent capability to evaluate models of basaltic igneous activity proposed for this area by the DOE, State of Nevada, and other research groups. Current efforts are directed at collecting samples for detailed geochemical, mineralogical, and petrographical analyses at the CNWRA and Smithsonian Institution. These data will be used to explore alternative hypotheses to those currently proposed for the YMR and evaluate the effect of these hypotheses on models of repository performance. Previous work in August 1993 focused on sampling the Quaternary and Pliocene volcanoes of Crater Flat, Buckboard Mesa on the Nevada Test Site (NTS), and the Lathrop Wells volcano.

SUMMARY OF ACTIVITIES:

Hidden Cone is located on the southern part of the Nellis Air Force Range (NAFR) about 45 km northwest of the candidate repository site at Yucca Mountain. Hidden Cone and Little Black Peak represent the two 0.3 Ma volcanoes that form the Sleeping Butte volcanic center (Figure 1). Crowe and Perry (1991) have proposed that Hidden Cone is polycyclic, with significantly younger scoria-fall deposits mantling the older cone and lava flows. Although Crowe and Perry (1991) appeal to an erosional unconformity between older agglutinated fall deposits and younger scoria-fall in the summit area of Hidden Cone, this unconformity was not observed. The absence of significant cone rilling through channeled erosion also is interpreted to represent mantling of the older, rilled cone by younger deposits, as is the lack of a basal cone debris-apron (Crowe and Perry, 1991). The absence of rilling can be explained by a lack of channelized flow on the highly unconsolidated cone deposits. Minor down-slope movement of unconsolidated cinder deposits may occur through gravitationally induced sliding, although this effect may be minor for deposits emplaced at a stable angle of repose. The northern flank of Hidden Cone contains numerous shallow (<0.5 m deep and about 2-3 m wide) depressions that likely represent small slumps of the upper scoria deposit. Relatively recent but minor sliding of the upper cone deposits also may create the apparent erosional unconformity exposed at the northern base of the cone (Crowe and Perry, 1991). The dike-fed lava flow on the northern flank of Hidden Cone likely represents eruption on a primary topographic surface and does not require removal of cinder deposits that are thought to have channeled the flow (Crowe and Perry, 1991). These types of flows are common on the flanks of historically active basaltic volcanoes. In essence, much of the evidence cited by Crowe and Perry (1991) for polycyclic volcanism at Hidden Cone can be interpreted as the products of a single eruption and very minor amounts of erosion or mass wasting.

Two hours were spent exploring the Miocene(?)-aged vents located approximately 1 km NE of Hidden Cone. The first of these vents consists of a roughly NE-trending dike, surrounded by some spatter and abundant bombs. The dike and vent geometries are interesting because they are consistent with a NNE-trend defined by the Quaternary Hidden Cone - Little Black Peak cinder cones. A second, larger vent is located approximately 250 m ENE of the first. This vent forms a small topographic high and also is roughly along the Sleeping Butte trend. Numerous outwardly dipping strata of slightly welded to indurated bombs, scoria and spatter are found around this vent. Several small dikes cut these strata. These dikes trend NE, in a direction consistent with the Sleeping Butte alignment. Both of these vents overlie Miocene lava flows in the area that outcrop north and west of Hidden Cone. The relationship of these vents to the Sleeping Butte alignment is interesting in that it suggests that this alignment may be long-lived (i.e., cinder cones have erupted along the alignment intermittently over a long period of time). Similar alignments are found in several other volcanic fields, including the San Francisco Volcanic Field in Arizona. The occurrence of long-lived alignments strengthens the hypothesis that structural control plays an important part in the development of these features. Confirmation of the idea that some vent alignments in the Yucca Mountain region form and remain active over periods several million years would have a strong impact on our understanding of patterns of volcanic activity in the region, and likely would impact volcanism probability models. Mapping of these vents and their relationship to Hidden Cone and Little Black Peak would greatly assist our interpretation of the Sleeping Butte alignment.

Dikes, sills, and lavas of the Nye Canyon basalts east of the NTS on the NAFR (Figure 1) were examined. These units represent the eruption of at least three volcanic centers at about 6.8 ± 0.2 Ma (Crowe et al., 1983). The basalt of Nye Canyon contains about 10 percent phenocrysts of olivine, plagioclase, and clinopyroxene, with minor amounts of amphibole and plagioclase megacrysts (<1 cm). Dikes range in width from 1 to >10 m and commonly are around 5 m wide.

Basaltic lavas and dikes of Scarp Canyon on the eastern border of the NTS (Figure 1) were emplaced at 8.7 ± 0.3 Ma (Crowe et al., 1983). Dikes are generally 1-2 m wide with about 10 percent vesicles and 10 percent phenocrysts of olivine, plagioclase, and clinopyroxene, with minor amounts of plagioclase megacrysts (<1 cm). Lavas are blocky flows that range from 1-3 m thick, are highly eroded, and have the same mineralogy as the dikes. This volcanic center may represent eruption of a single vent and lava flow, with subsequent disruption by faulting and erosion.

Basaltic sills, dikes, and minor lava flows were emplaced at 8.5 ± 0.3 Ma in the Paiute Ridge area (Crowe et al., 1983). Dikes are generally 3-10 m wide with about 10 percent vesicles and 10 percent phenocrysts of olivine, plagioclase, and clinopyroxene, with minor amounts of plagioclase megacrysts (<1 cm). The mineralogy and hand-sample characteristics of the Paiute Ridge dikes are very similar to dikes at Scarp Canyon (Figure 1) and likely represent a contemporaneous pulse of magmatism at about 8.5 Ma. Poorly welded ignimbrites develop secondary welding within about 1 m of the dikes, which increases in intensity towards the dike-ignimbrite contact and locally results in a dense, black vitrophyre. Sills in the northern part of the Paiute Ridge center extend in thickness to about 15 m. These sills are generally diabasic, but can range to relatively coarser-grained syenite. Late-stage magmatic segregates of coarse plagioclase and amphibole (to 1 cm) are injected along fractures in the upper parts of the sill. Wall-rock alteration is restricted to secondary welding on the lower contacts of the sill and extends to several meters below the sill. Wall rock above the sill also has secondary welding, which extends for 15-20 m inward. Where the sill is thickest, the vitrified roof-rock has undergone subsequent alteration; the normally black vitrophyre is an opaque grey and contains some clays, and the secondary fiamme are altered to clays and weather readily from the surrounding rock. These features likely are the result of deuteric alteration from degassing of the sill after emplacement.

OTHER ACTIVITIES:

One day was spent planning the field trip for the peer-review meeting. Participants will visit the Lathrop Wells volcano for half a day, spend a full day examining the Quaternary and Pliocene volcanoes of Crater Flat, and half a day at the Fortification Hill dike complex near Hoover Dam, Arizona. Topics of discussion include evidence for polycyclic eruptions, pyroclastic deposits as indicators of eruption energetics, and the morphology of subvolcanic features in the shallow (0-300 m) subsurface.

Ground magnetic data also were collected in two areas of Crater Flat in order to determine the effectiveness of this method for identifying shallow intrusive structures near the Crater Flat alignment. The basic problem is that the cinder cones and their associated lava flows likely produce large enough magnetic anomalies to obscure the comparatively small anomalies associated with dikes, especially on aeromagnetic maps. Ground magnetic surveys may be useful in identifying dikes, as long as the dikes are shallow compared to the map distance to lava flows.

The first survey was done on the approximately E-W road between Red Cone and Black Cone. Magnetic readings were collected every 5 m over a distance of 1.1 km. Data were drift corrected by reoccupying a base station at 30 minute intervals. Significant drift was observed during one interval and stations were resurveyed to reduce the effects of this drift. The results of the survey showed a gradient that is identical to the one seen on aeromagnetic maps. There was no evidence of a shallow dike between the two cones based on the single traverse.

Ground magnetic data also were collected between the two Little Cones. 581 stations were occupied on 8 traverse lines. Most lines are 400 ft long and trend 142° magnetic. Large amplitude (generally greater than 1,000 nT), short wavelength magnetic anomalies were identified between the two cones. However, the orientation and distribution of anomalies clearly indicates that at shallow levels dikes strike roughly N-S and are not continuous between the two cinder cones. The dikes identified intersect NE Little Cone and extend at least 350 ft south of the summit of NE Little Cone on a N-S trend. This dike orientation is consistent with mapped structural trends (faults and dikes) elsewhere in Crater Flat. Furthermore, a N-S structural control is consistent with the breaching of SW Little Cone, which occurred on the S side of that cinder cone.

IMPRESSIONS AND CONCLUSIONS:

The evidence for polycyclic volcanism at Hidden Cone is not apparent. This volcano likely represents a single eruptive event with several stages of cone formation and lava flow in a short period of time. Geomorphic processes that modify cinder cone morphologies are not restricted to channelized flow. Gravitationally induced slumping and sliding of surficial deposits at an angle of repose also may create apparent unconformities without producing large talus ramps at the base of the cone.
Miocene(?) volcanoes near Hidden Cone occur along the same apparent structural trend as the Quaternary Sleeping Butte volcanoes, suggesting that some crustal structures in the YMR may control volcano locations for millions of years. Miocene basalts of the eastern NTS have similar mineralogies and likely represent the same basic petrogenesis. Subvolcanic structures at these eruptive centers are well exposed to at least 100 m below the paleosurface. Numerous *en-echelon* dikes commonly occur around each

eruptive center. Direct interactions between wall rock and magma can extend for kilometers away from the surface vent. This distance must be better constrained and its impact on probability models evaluated in detail. Shallow dikes in subsurface can be mapped successfully using ground-magnetic surveys. These low-cost surveys are critical to evaluating models for shallow subsurface volcanic structures in the YMR.

PENDING ACTIONS: None.

RECOMMENDATIONS:

Field and laboratory studies on basaltic rocks of the NTS by the CNWRA should continue. This research is critical to evaluating the DOE license application with regards to Quaternary igneous activity in the YMR, and for exploring and evaluating alternative hypotheses for the consequences of igneous activity on repository performance. Ground magnetic surveys provide simple and cost-effective investigations on the extent and magnitude of shallow subsurface igneous features. Additional ground magnetic mapping on Little Cones is recommended to determine if (i) the mapped N-S trending anomalies extend N of NE Little Cone, (ii) similar magnetic anomalies can be identified associated with SW Little Cone, and (iii) to map the buried edge of the lava flow from SW Little cone. Based on our preliminary survey, a very detailed magnetic map could be constructed in 7 - 9 days of field work in good weather.

PROBLEMS ENCOUNTERED:

Planned studies at Little Black Peak and Thirsty Mesa on the NAFR were terminated due to a lack of communication between several NAFR security groups, which resulted in insufficient authorization to conduct research in these areas. A request to visit these areas was submitted to the NRC in late June 1994, and was passed along to Science Applications International Corporation (SAIC) via the DOE Yucca Mountain Project Office. Apparent authorization for this visit was obtained by SAIC from NAFR personnel and FAXed to the CNWRA prior to the trip. However, this was not an "official" authorization, as the NAFR contact did not transmit this request through proper channels and did not issue an official visit authorization form. CNWRA personnel were met in the field by NAFR security, who were completely unaware of the visit. Several phone calls from the NAFR security office were necessary to establish our identities and try to identify the cause of the security breakdown. Follow-up calls to SAIC revealed that their security contact at the NAFR was the source of the problem. Requests for future visits to the NAFR should be made at least one month in advance, using the attached forms, and coordinated through Lt. Col. Ed Tullman, USAF/DOE Liaison Officer, (702) 295-1147. If the planned trip crosses the NTS, DOE also must be notified.

REFERENCES:

Crowe, B., and F. Perry. 1991. *Preliminary geologic map of the Sleeping Butte Volcanic Centers*. Los Alamos National Laboratory Report LA-12101-MS. Los Alamos, NM: Los Alamos National Laboratory.

Crowe, B.M., D.T. Vaniman, and W.J. Carr. 1983. *Status of Volcanic Hazard Studies for the Nevada Nuclear Waste Storage Investigations*. Los Alamos National Laboratory Report LA-9325-MS. Los Alamos, NM: Los Alamos National Laboratory.

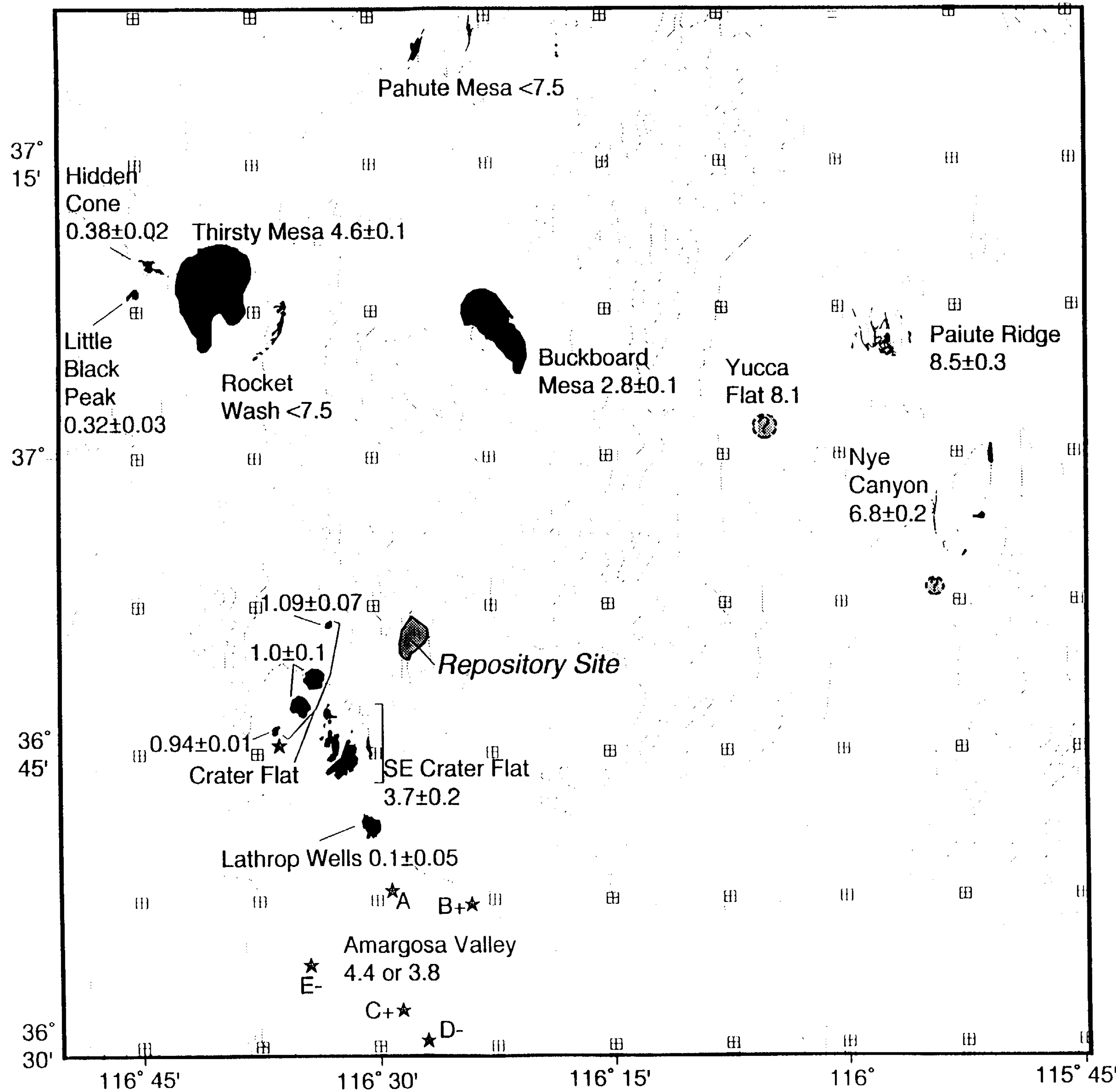

Figure 1
Yucca Mountain
Post-Caldera Basalt

Compiled from Byers et al. (1966), Ekren et al. (1966), Carr & Quinlivan (1966), Noble et al. (1967), Tschanz & Pampeyan (1970), Cornwall (1972), Kane & Bracken (1983), Crowe et al. (1983, 1986), Carr (1984), Crowe (1990), Frizzell & Shulters (1990), Sawyer et al. (1990), Turrin (1992), Champion (1992), Langenheim et al. (1993), Faulds et al. (1994), Perry (1994), Heizler et al. (1994).

Ages in Ma

★ Aeromagnetic anomalies that represent buried (B & D) and inferred basaltic volcanic centers.

200 m Contour Interval

Contours from 3-arc-second Digital Elevation Data, by Brent Henderson, SwRI.

YMBASALT.AI

Mode of Transportation:

Entry / Exit Location:

Dates of Visit: FROM: TO:

Areas to be Visited: Check all that apply

Range Control Center:	Ranges:				Tonopah Area 10	WTC Communications Sites:
Building 200	61	64N	71N	74C	Tonopah EC East	
Red Forces	62	64S	71S	75W	Tonopah EC West	Other:
Black Jack	63	65S	74A	75E	Tonopah Cactus EC	
			74B	76	Tolicha Peak ECR	
					Tolicha Peak EC South	

Purpose of Visit In Detail:

Naturalization Information: Required for all naturalized citizens needing access to Tolicha Peak / Tonopah Ranges

Naturalization Number:

Place of Naturalization and Date:

Typed Name, Grade and Title of Requesting Official:

Duty Phone:

Date:

Coordination:

554 RANS Security Manager	Indian Springs (USAF/LORAL)
554 RANS CC/CD	BLDG 201 Security Manager
BLDG 200 Security	Department of Energy
554 RANS/RST (All Tonopah and Tolicha Peak coordination)	Other
Call to confirm receipt	Other
Range 63	Other

APPROVED FOR ACCESS

Approved for access with escort listed below:

DISAPPROVED

Typed Name, Grade and Title of Approval Authority:

Signature:

Date:

Remarks:

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8013

PRINCIPAL PURPOSE: For positive identificaiton for entry into United States Air Force restricted and controlled areas.

ROUTINE USES: None

DISCLOSURE IS VOLUNTARY: Furnishing this information is voluntary. If you do not give the required information, you will not be allowed entry into these areas.

NAFB Form 0-74, Mar 93 (Back)

554TH RANGE SQUADRON FACILITIES VISIT REQUEST/AUTHORIZATION

This form is subject to the Privacy Act of 1974 (see reverse)

FROM: (Name and Phone Number)	Organization:
TO: 554TH Range Squadron 3770 Duffer Dr. Nellis AFB, NV. 89191-7001 Commercial Phone (702) 652-3606 DSN 682-3606 FAX 682-3808	Name of your Range Squadron Point Of Contact

NAME: LAST, First, M.I.	RANK	Job Title	SSAN	Clearance	Organization	Tolicha Peak / Tonopah Ranges Only		
						Citizenship	Date Of Birth	Place of Birth

SIGNATURES:

Nov 11, 1994

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Research Scientist

Date

11/11/94

Charles B. Connor
Senior Research Scientist

Date

11/11/94

H. Lawrence McKague
Manager, Geologic Setting

Date

11/11/94

Budhi Sagar
Technical Director

Date