JUL 17 1989

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MEMORANDUM FOR: Ronald L. Ballard, Branch Chief
Geosciences and Systems Performance Branch
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FROM: Keith I. McConnell
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SUBJECT: TRIP REPORT FOR THE MAY 1 - 5, 1989, VOLCANISM FIELD CONFERENCE IN SOUTHERN NEVADA

Purpose of Trip:

In its review of the SCP, the Division of High-Level Waste Management (DHLWM) staff has identified volcanism as a significant concern with respect to the ability of the proposed waste repository at Yucca Mountain to isolate waste. The purpose of this trip was for DHLWM staff to review field evidence regarding basaltic volcanism in the geologic setting at Yucca Mountain.

Agenda:

Attachment 1 contains a tentative agenda for the volcanism field conference developed prior to the trip. The actual trip closely followed the tentative agenda except for days 3 and 4. Both the Reveille Range and Lunar Crater were visited on day 3, while day 4 involved visits to Ubehebe crater and the basaltic cone at Shoreline Butte, both in Death Valley.

Participants:

Attachment 2 contains a list of the participants attending various parts of the field conference. Organizations represented included:

DOE-Los Alamos National Laboratories
DOE Headquarters, OCRWM
State of Nevada, Nuclear Waste Project Office
Clark County, NV government
USNRC, DHLWM
University of New Mexico
DOE Yucca Mountain Project Office
University of Nevada, Las Vegas
DOE-Roy F. Weston, Inc.

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General Observations by DHLWM Staff Resulting from Field Conference:

1) Several stops on this trip included basalts in topographically high areas (e.g., Sleeping Butte, Day 2, Stop 3; Reveille Range, Day 3, Stop 1). Therefore, the fact that Quaternary cones near Yucca are in topographically low areas may only be coincidental and not an indication that topography is a controlling mechanism there.

2) DOE and State of Nevada investigators agreed that structure is undoubtedly a controlling factor of volcanism in the geologic setting at Yucca Mountain. However, there was no concensus among investigators on the questions of at what level in the earth's crust structure prevails and to what extent structure might be involved in controlling future eruptive sites. These factors do not appear to be ascertainable with existing data.

3) DOE's comparison of the age of the cone at Lathrop Wells using both geomorphologic methods and the K-Ar radiometric age determination method (see Stop 1, Day 2) has shown the K-Ar method to be unreliable for assessing the age of young basaltic volcanic rocks in the Yucca Mountain area.

4) A potential problem appears to exist in the integration of efforts between geologists working on tectonic processes (apparently USGS geologists) and geologists working on the surficial expression of volcanism (i.e., Los Alamos geologists). Discussions on the field trip suggested that DOE geologists investigating basaltic volcanism were working independently of USGS geologists working on tectonic models. Although DOE investigators appear to be aware of and attempting to address this potential problem, calculations of the rate and timing of volcanism near Yucca are currently being developed independent of concepts about the underlying tectonic processes responsible for the initiation of volcanism.

5) State of Nevada investigators demonstrated that the use of geochemical trends to determine the stage of a volcanic cycle appears to be an immature and not completely refined methodology. Multiple interpretations are possible for chemical trends derived from basaltic centers. Therefore, judgements made using geochemical trend analysis should, at this stage of site characterization, be considered preliminary and the possibility of other reasonable conceptual models exists.

6) The Lunar Crater area seems to be an excellent candidate for a natural analog study of Quaternary basaltic activity primarily because the Lunar Crater volcanic field was/is a very active volcanic field (containing at least 110 Quaternary volcanic centers) and, as a result, provides an excellent opportunity to study the process of basaltic volcanism in great detail. In addition, the Lunar Crater volcanic field appears to be in the same "belt" or "zone" (i.e., Death Valley - Pancake) of volcanism as Quaternary basalts in Crater Flat suggesting that processes active in the Lunar Crater area may be similar to processes responsible for basaltic volcanism near Yucca Mountain. Discussions with DOE investigators indicated that work would be performed during site characterization in the Cima volcanic field which lies outside the Death Valley

- Pancake Range volcanic belt but that Lunar Crater was not being considered as a possible natural analog.

Detailed Observations from Field Conference:

Sunday, April 30, 1989: A 30 minute organizational meeting was held in Paul Prestholt's office at 7:00 pm. Participants included representatives from those agencies listed on page 1. This meeting dealt only with items such as where and when to meet the next day.

Attachment 3 is a map that denotes where the various day's trips were taken with respect to the Yucca Mountain site.

Monday, May 1, 1989 - Boulder Dam - Fortification Hills: Field trip participants met initially to discuss the arrangements for the day's trip. An attendence list (Attachment 2) was started at this preliminary meeting and three informal ground rules for the trip were suggested by NRC staff.

1) Field trip presentations should be limited to published information;

2) the field trip should not be a review of the SCP;

3) Consideration should be given to the well-being of field trip participants in accessing field trip stops because of the temperature during this time of year.

The purpose of this day's trip was to overview the Late Tertiary volcanic history of the southeastern Nevada area. Field trip leaders for this day's stops were investigators from the University of Nevada, Las Vegas (i.e., Eugene Smith, Dan Feuerbach, and Terry Naumann).

Stop 1. Overlook at Lake Mead, NV: At this stop a discussion of the applicability of the volcanic features in the Fortification Hills area to Yucca Mountain was held between state investigators and geologists from Los Alamos. The Los Alamos position was that Fortification Hill, Lunar Crater and Reveille Range were not analogs to Crater Flat because the magma flux in these areas was so much higher in comparison to that in Crater Flat. Another point was that the Fortification Hills area was in a different tectonic setting than Yucca Mountain and direct application of data on the magnitude and recurrence of volcanism derived in the Fortification Hills was not appropriate. However, the NRC staff agree with State of Nevada geologists that the overall results of the studies in the Fortification Hills related to the processes of basaltic volcanism, particularly structural and topographic control, might be of importance to understanding processes at Yucca Mountain.

Stop 2. Lava Cascade, AZ: The next area visited was at Lava Cascade to examine the apparent lack of topographic control on volcanism. In this area, the vent is at the summit of the range and, apparently, topography did not play a significant role in the location of a volcanic event.

Stop 3. Fortification Hills - Kingman Wash, AZ: The next stop was in the Kingman Wash-Fortification Hills area where vents for lava flows are associated with north-trending faults. Basaltic dikes associated with the lava flows are up to 2 meters in thickness at this locality and apparently are unrelated to exposed structures.

Stop 4. West End Wash - Callville Mesa, NV: The final stop of the day was at West End Wash-Callville Mesa where there is good evidence for a hydrovolcanic event with characteristic well-bedded volcaniclastic rocks containing matrix-supported angular blocks. In this area, the volcanic cone is on the hangingwall of normal faults and there appears to be no structural control (i.e., near surface). In addition, basaltic volcanism took place over a period of two million years in this area.

Tuesday, May 2, 1989 - Lathrop Wells, Crater Flat, Sleeping Buttes:

The purpose of this day's trip was to observe recently derived evidence on the age of the Lathrop Wells cone, Red and Black cones in Crater Flat, and cones at Sleeping Butte. Field trip leaders included Bruce Crowe (LANL), Steve Wells (UNM), Les McFadden (UNM), Eugene Smith (UNLV), and Daniel Feuerbach (UNLV).

Prior to beginning this day's stops, Bruce Crowe (LANL) made an informal presentation on Late Tertiary and Quaternary volcanism in the Nevada Test site area. Specific points made were:

1) The NTS area contains an approximately 10 million year old bimodal suite of volcanic rocks. Basalts included with this group are basaltic dikes in Yucca Wash and Solitario Canyon.

2) An initial period of basaltic volcanism occurred approximately 6.5 - 9 Ma. These basalts occur to the north of the Walker Lane trend. One group of basalts of this age group (i.e., those at Piute Ridge) has an associated laccolith intrusive.

3) Following a 3.5 to 6 m.y. period of quiescence, basaltic volcanism apparently stepped (migrated) southwest to the northwest-trending Crater Flat - Sleeping Buttes trend. The basalts at Buckboard Mesa are a complicating factor to this southwest step because they lie well north of basalts of similar age.

4) With respect to Lathrop Wells cone, the last event in the cycle was the cone building event. The whole complex of lavas and cinder cone could be less than 50,000 years old. The cone formed in the Holocene Epoch.

Stop 1. Lathrop Wells cone: At this stop Steve Wells (University of New Mexico) gave a presentation on geomorphological investigations at Lathrop Wells and the comparison with cones in the Cima volcanic field in California. Specifically, geomorphic comparisons between Lathrop Wells cone and A-cone in the Cima volcanic field in California appeared to contradict existing interpretations of the age of the Lathrop Wells cone (i.e., 270,000 years) that were based on K-Ar isotopic age dates from a volcanic "bomb."

The strength of the geomorphic data finally resulted in realization that the previously published age of the Lathrop Wells cone was inaccurate and that the cone quite possibly could have formed in the Holocene. The geomorphic analysis relied on lines of evidence such as the development of intermittent stream channels on the slopes of the cone, the angle of the cone slope, and on the development of an "apron" at the base of the cone.

The Lathrop Wells cone area is the site of at least 6 eruptive events in the Quaternary including a hydrovolcanic eruption that formed pyroclastic surge deposits (Crowe and others, 1988). Early speculation by Los Alamos geologists had suggested that the time between eruptions exceeded 100,000 years, but is now believed to be "a few tens of thousand years" (Crowe and others, 1988). The youngest volcanic event at Lathrop Wells could be as young as mid-Holocene (i.e., approx. 6,000 years) (Wells and others, 1988).

Los Alamos geologists now speculate that the volcanic ashes in the Windy Wash fault trenches may be related to the Lathrop Wells cone. In addition, there are ashes from multiple events in the trench. If this speculation is accurate, then coupling of volcanic and faulting events in the Holocene at the Yucca Mountain site is a reasonable concept. This leads to the NRC concern that ashes found in trench 14, exposing the Bow Ridge fault zone, may also be related to the Lathrop Wells cone suggesting that this fault may have also had Holocene movement.

DOE investigators indicated that the eruptions at Lathrop Wells cone did not appear to be controlled by structures evidenced at the surface. The investigators did state that structural control of basaltic volcanism, including that at Lathrop Wells, is probably a contributing factor at deeper levels in the crust.

Stop 2. Crater Flat: Apparently one part of Black cone in Crater Flat has a slope of 27 degrees. This slope steepness suggests that, because of similar relationships observed at Lathrop Wells cone, the 1.1 million year K-Ar age for the most recent episode of volcanism at Black cone may be inaccurate, providing ages that may be too old.

Daniel Feuerbach (University of Nevada, Las Vegas) presented evidence for multiple eruptions of Red cone and suggested that most flows are unrelated to the cone.

Stop 3. Sleeping Butte cones: Sleeping Butte cone is present on the Nellis Bombing Range approximately 40 miles northwest of Lathrop Wells cone. Sleeping Butte cone is estimated to have an age of approximately 280,000 years and was described as being compositionally similar to the basalt at Lathrop Wells by LANL investigators. There is evidence for multiple eruptive events at this cone. Also present in this area is a second cone termed Hidden cone. Hidden cone appears to be very young morphologically (possibly as young as Lathrop Wells) and occurs on a mesa, again suggesting that topography is not necessarily a factor controlling where basalts erupt. Bruce Crowe connects the cones at Sleeping Butte with the Lathrop Wells cone in a northwest-trending zone of Late Quaternary volcanism. There appears to be little evidence to support this northwest-trending zone as opposed to zones trending in other directions.

Wednesday, May 3, 1989 - Reveille Range and Lunar Crater

The purpose of visiting the Reveille Range was to observe evidence for topographic control of volcanism and evidence that the geochemical processes involved in volcanic cycles is not as simple as Los Alamos investigators have indicated. This part of the day's stops were led by Terry Naumann and Gene Smith of the University of Nevada, Las Vegas.

Stop 1. Reveille Range: In the Reveille Range we observed 3-5 million year old basalts that had erupted in a range, again suggesting that topography is not necessarily a controlling mechanism for basalt intrusion or eruption. NRC staff specifically asked the assembled group of investigators whether topography is a controlling mechanism for basalt eruptions in the Basin and Range. The consensus was that the relationship depends on the volcanic field being studied. However, it is apparent from relationships observed on this trip that topography cannot be considered at this time to be a controlling mechanism in basaltic volcanism.

UNLV investigators have indicated that they observe a nepheline-hypersthene normative to nepheline normative transition in each of the three basaltic volcanism cycles in the Reveille Range. LANL investigators indicate that the Lunar Crater field may be an extension of the Reveille Range field and that there is an overall general nepheline-hypersthene normative to nepheline normative transition in the cycle, with the most nepheline normative rocks being the Quaternary basalts in the Lunar Crater field. This relationship is totally dependent on correlating basalts in the Reveille Range and Lunar Crater fields, something that has not been systematically done.

Stop 2. Lunar Crater volcanic field: The last part of the day was spent in a visit to the Lunar Crater Volcanic field. Frank Perry of the University of New Mexico led this part of the trip. LANL/UNM investigators have not done any significant work in the Lunar Crater field since 1981, and the results of their mapping prior to 1981 are not yet published. LANL investigators indicated that Ken Foland from Ohio State University and some of his students were now heavily involved in the Lunar Crater field but that most of the work performed by Ohio State workers was unpublished.

The Lunar Crater field is 20 km northeast of the Reveille Range field and contains basalts that range in age from 3-4 Ma to Holocene. Crowe and others (1986) indicate that there are at least 110 Quaternary basaltic centers in the Lunar Crater field, the youngest being Black Rock crater that appears to be geomorphically very young (i.e., younger than Lathrop Wells cone). Only reconnaissance work has been done in this area by the geomorphologists at UNM, so no specific conclusions about the ages of the cones or comparisons with Lathrop Wells cone were made.

Thursday, May 4, 1989 - Ubehebe Crater and Cone at Shoreline Butte:

The purpose of this day's trip was to observe eruption features characteristic of Quaternary volcanic cones and the disruption of a cone by strike-slip faulting.

Stop 1. Ubehebe Crater, CA: Ubehebe Crater is a maar volcano in Death Valley and has a K-Ar age of 1 Ma on scoria, however, Bruce Crowe, based on geomorphologic arguments, believes that 1 m.y. is too old and that Ubehebe crater could be very young. Indian Legends have it that smoke (i.e., vented gas) was observed along one part of the cone rim of Little Hebe crater suggesting that volcanic activity could have occurred in historical times. The cinder cone at Ubehebe is overprinted by a hydrovolcanic explosion ash. DOE-LANL investigators indicated that the groundwater table at the time of the ash eruption must have been near the present base of the crater.

Although Ubehebe Crater is outside of the Death Valley - Pancake Range belt of volcanism, it represents another young basaltic cone in the geologic setting of Yucca Mountain.

Stop 2. Cone at Shoreline Butte, CA: The basalt of Shoreline Butte occurs in the central Death Valley area south of Furnace Creek ranch. A small cone occurs in the center of the valley and has been bisected and offset by a right-angle strike-slip fault. There is a K-Ar age of .69 m.y. for this cone, but LANL workers indicate that the geomorphology suggests that this age is incorrect and that the cone is significantly younger than .69 m.y. Discussions at this stop included speculation that the cone may have been partially buried by sediments deposited in Lake Manley. The COCORP regional seismic reflection line formed the basis for the conclusion that a magma body existed at 15 km near this cone.

Friday, May 5, 1989 - Cima Volcanic Field, CA:

The purpose of this day's trip was to visit the Cima volcanic field to examine evidence for the ages of volcanic cones in that field. UNM investigators have developed a geomorphologic and soils related age determination methodology that is supported by K-Ar age determinations. The results of the analyses in the Cima field are being used to reassess the ages of basaltic cones in the vicinity of Yucca Mountain.

The Cima Volcanic field is near Baker, California. The Cima field has 40 vents and 60 flows. Ages range from 7-8 Ma to less than 20,000 yrs. UNM investigators have performed detailed soil surveys in this area and have developed a soil stratigraphy from which they believe they can assign ages. In addition, using cone slope morphology and the development of intermittent streams on the slopes, the UNM investigators have developed an age classification scheme tied to relatively reliable K-Ar ages. It was this scheme that was used as a basis for reassessing the age of the Lathrop Wells cone.

The youngest cone in the Cima field is believed to be A-cone. A-cone is believed to less than 20,000 years old based on the above described age classification schemes. As at Lathrop Wells, there is evidence for multiple eruptive events. UNM investigators plan to perform additional work in the area during site characterization.

Recommendations:

1) Invite Ken Foland (Ohio State University) to the NRC to discuss his recent work in Lunar Crater.

2) Meet with DOE to clarify and discuss concerns on the integration of work related to volcanism and the use of natural analogs.

3) Unresolved items in this trip report should be included and tracked in the tectonics open-item tracking system.

References Cited:

1. Crowe, B., Harrington, C., McFadden , L., Perry, F., Wells, S., Turrin, B., Champion, D., 1988, Preliminary geologic map of the Lathrop Wells volcanic center: Los Alamos National Laboratory, LA-UR-88-4155, 7 p.

2. Crowe, B.M., Wohletz, K.H., Vaniman, D.T., Gladney, E., and Bower, N., 1986, Status of volcanic hazard studies for the Nevada Nuclear Waste storage investigations: Los Alamos National Laboratory, LA-9325-MS, Vol. II, 101 p.

3. Wells, S.G., McFadden, L.D., Renault, C., 1988, A geomorphic assessment of Quaternary Volcanism in the Yucca Mountain area, Nevada Test Site, Southern Nevada: Geological Society of America Cordilleran Section, v. 20, no. 3, p.242.

Keith I. McConnell

John S. Trapp

Charlotte E. Abrams

Attachments: As stated

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QUATERNARY VOLCANISM FIELD CONFERENCE
May 1 - 5, 1989

Volcanism has been identified as a significant concern with respect to proposed waste repository at Yucca Mountain and may develop into a licensing issue. In light of the concern about volcanism in the geologic setting at Yucca Mountain a review of the currently available and newly developed field evidence is planned in this field conference. The two main objectives of this conference on Quaternary Volcanism are: 1) assess the evidence for the nature and magnitude of Quaternary volcanism in the geologic setting of Yucca Mountain, and 2) evaluate the available data in areas of structural control, topographic control, accuracy of age determinations, polycyclic nature of volcanic events, and natural analog studies.

SUNDAY, APRIL 30, 1989

Preliminary meeting in Paul Prestholt's office at 7:00 p.m.

Location: Spend night at Best Western Lighthouse Inn, Boulder City, NV.

MONDAY, MAY 1, 1989: FORTIFICATION HILL AREA (Depart Paul Prestholt's office 7:00am)

Purpose: To observe evidence developed by state investigators about the nature of Quaternary volcanism in this area and its relation to that observed in the Yucca Mountain area. To include:

- evidence for or against structural control,
- evidence for or against the fact that future eruptions may occur at or near sites of past eruptions,
- evidence for the length and nature of volcanic eruptions,
- evidence for or against topographic control of volcanism.

Location: Spend night Best Western Lighthouse Inn, Boulder City, NV.

TUESDAY, MAY 2, 1989: LATHROP WELLS CONE, RED AND BLACK CONES, SLEEPING BUTTES
Depart Paul Prestholt's Office 7:00 a.m.

Purpose: To observe evidence developed by DOE and state investigators on the nature of Quaternary volcanism in the vicinty of Yucca Mountain (YM). To include:

- evidence for structural control of volcanism,
- evidence for the age of most recent volcanism,

° evidence of the length of volcanic cycles,

° evidence for the waning of volcanism in the YM area.

Location: Spend night at Stationhouse Motel, Tonapah, NV.

WEDENSDAY, MAY 3, 1989: REVIELLE RANGE VOLCANIC FIELD

Purpose: To observe areas that might serve as possible natural analogs for volcanic processes active in the vicinity of YM. To include:

° evidence for the chemical signature of the termination of volcanic cycles,

° evidence for the length of volcanic events,

° evidence for or against structural control of volcanic events,

° evidence for or against topographic control of volcanism,

° evidence for processes underlying Quaternary volcanism.

Location: Spend night at Stationhouse Motel, Tonapah, NV.

THURSDAY MAY 4, 1989: LUNAR CRATER (Travel To Las Vegas)

Purpose: To observe areas that might serve as possible natural analogs to investigate volcanic processes active in the vicinity of YM. To include:

° evidence for the chemical signature of the termination of volcanic cycles,

° evidence for the length of volcanic events,

Location: Spend night at Ramada, St. Tropez, Las Vegas.

FRIDAY, MAY 5, 1989: CIMA VOLCANIC FIELD

Purpose: To observe evidence for the geomorphic comparisons between the Cima volcanic field and the Quaternary cones in Crater Flat. To include:

° evidence for geomorphic age determinations on Holocene basaltic cones,

° basis for SCP related comparisons of cone degradation rates between the Cima and Crater Flat fields,

° evidence for underlying processes responsible for volcanism,

° evidence, if any, for structural control of volcanism.

Location: Spend night at Ramada, St. Tropez, Las Vegas.

ttachment (2)

NAME	REPRESENTING	TEL. #
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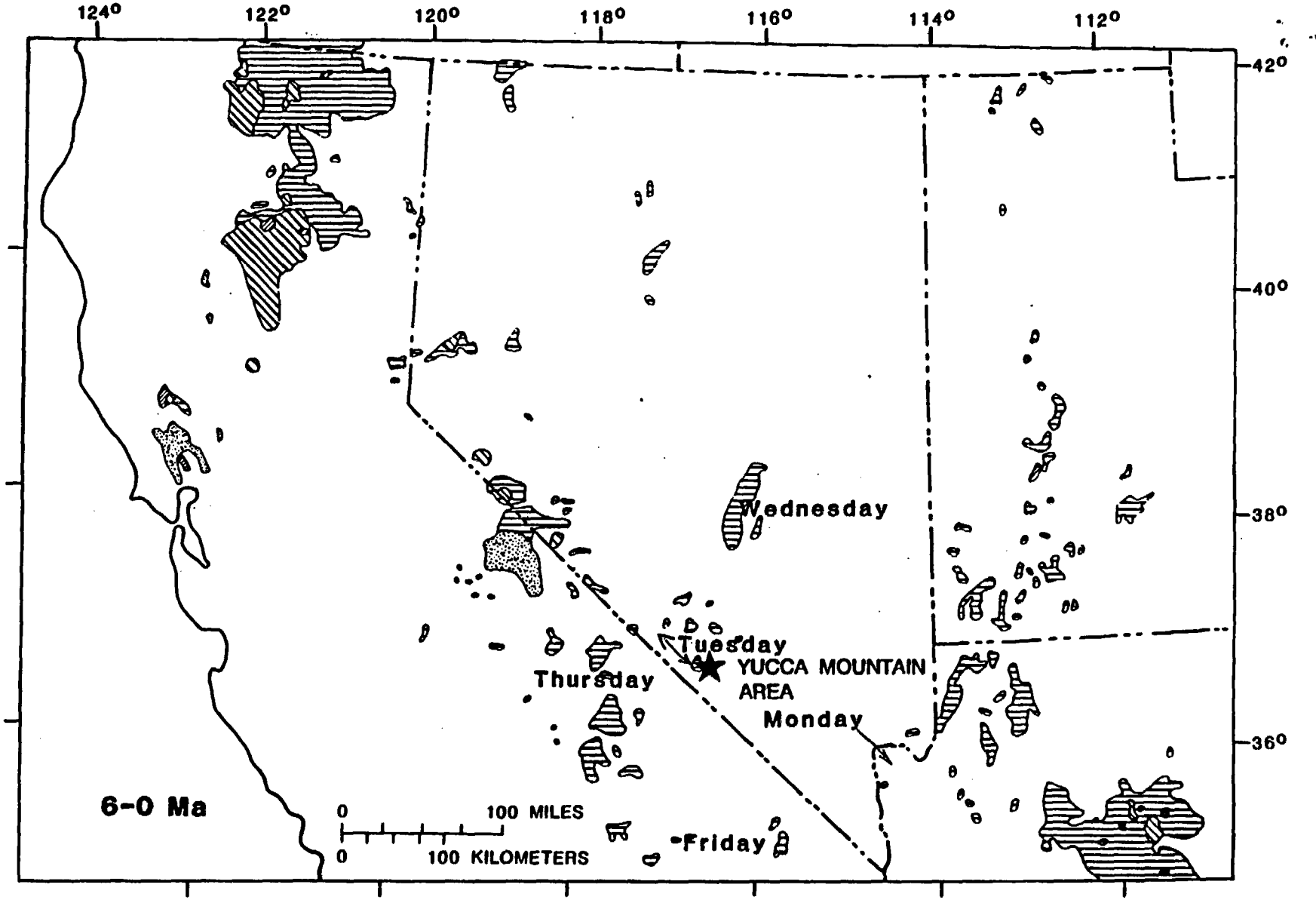

Figure 1-28d. Distribution of the Cenozoic volcanic rocks in the southern Great Basin. Time periods shown are 43-34 Ma (map a), 34-17 Ma (map b), 17-6 Ma (map c), and 6-0 Ma (map d). Ma = million years ago. Modified from Stewart et al. (1977).