AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

LA-SUB--94-109

RECEIVED
AUG 19 1994
OSTI

**1992-93 Results of Geomorphological and Field Studies
Volcanic Studies Program
Yucca Mountain Project**

Stephen G. Wells

submitted to

**Dr. Frank V. Perry
EES-13, Los Alamos National Laboratory**

October, 1993

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

1. Investigations in the Cima Volcanic Field

I completed the field mapping and stratigraphic studies of the Black Tank volcanic center, which represents the southwestern most eruptive center in the Cima volcanic field of California. The results of this mapping effort are given in Figure 1 that is based upon an enlarged color, vertical aerial photograph (BLM-C-MOOO 22-48-SGW). Contacts between volcanic units and geomorphic features were field checked, incorporating data from eight trenches (BTVC-T1 to T9A,B-92; see Fig. 1) as well as several exposures along Black Tank Wash. Within each of the eight trenches, logs were measured and stratigraphic sections were described such as those in Figure 2a, b.

These data indicate that three, temporally separate volcanic eruptions occurred at the Black Tank center. Figure 3 illustrates the general landscape-stratigraphic position of each unit. The field evidence for significant time breaks between each stratigraphic unit is the presence of soil- and pavement-bounded unconformities. These unconformities can be recognized by the stone pavements, consisting of one-clast thick layer of volcanic bombs with their associated underlying soils developed in an eolian matrix. The clasts on the stone pavements have been slightly varnished, and typically stones have carbonate rinds that formed at the paleo-land surface. Such features indicate that the underlying stratigraphic unit was subaerially exposed for a period of time to allow stone pavement development and soil formation. Estimates of the time required to form such features on alluvial fan surfaces in the Mojave Desert of California are on the order of greater than 2,000 to 4,000 years.

At the Black Tank volcanic center, the following chronostratigraphic sequence has been established. Each stratigraphic unit is labeled as Quaternary volcanic, or Qv, with 1 through 3 indicating age from oldest to youngest. Within each chronostratigraphic unit, volcanic facies are indicated by l = lava, s = scoria, d = dike, and ca = cone apron (eroded cone slope material).

a. Unit Qv1

The oldest chronostratigraphic unit consists of highly degraded scoria/agglutinate vent deposits, as well as eroded dike and lava flow units. The major part of the vent that exhibits relief is associated with the more resistant agglutinate deposits and a long curvilinear dike that trends southwest. The scoria deposits of the vent have been deeply eroded, truncated and buried by overlying cone apron sediments as well as volcanic rocks from younger vents at the Black Tank center. Natural stream exposures on the west side of the vent illustrate these stratigraphic relations. Extremely well-developed soil profiles occur on the cone apron deposits of unit Qv1 and can be traced laterally and stratigraphically beneath the fall sheet deposits of unit Qv2.

No radiometric dates have been determined for unit Qv1; however, morphological and pedogenic comparisons with K-Ar dated vents and flows in the Cima field suggest that the vent is at least greater than 700 ka. Such age estimates are consistent with the fact that Qv1 lava flows are stratigraphically below the 400-500 ka flows of the "E" flows.

b. Unit Qv2

This chronostratigraphic unit consists of a weakly developed scoria vent that developed along the northern flank of the high-relief agglutinate rocks of unit Qv1. The crest of the Qv2 vent is mantled with large (up to one meter in intermediate diameter) volcanic bombs and appears to be partially breached on the southern flank. The most volumetrically extensive eruptive rocks of unit Qv2 are the scoria fall sheets (Qv2s; Figs. 1 and 2) which mantle older Qv1 deposits and lava flows which have been correlated with vent "B" in the Cima volcanic field. These deposits are thickest near the vent (> 2 m locally) and thin rapidly to the south and west. The scoria fall deposits are typically eroded by deeply incised gullies on the northern, southeastern, and western regions. Small patches of the scoria to the south of the Qv1 vent suggest a more extensive tephra sheet that has been stripped by sheetwash, rilling and gullying. In the northern part of the Black Tank vent, these fall sheet deposits typically bury stone pavements and related well-developed soils of much older volcanic units. This suggests a relatively long hiatus in volcanic activity between Qv1 and Qv2 sequences. The northern extent of the fall deposits has been eroded by Black Tank Wash, and thus total volume estimates are limited by such surficial processes. Along the eroded northern flank of unit Qv2s is an exposure of the only known basaltic flow (unit Qv2l; Figs. 1 and 2) associated with Qv2 eruptive sequence. This thin (< 1-2 m) flow lies stratigraphically within the fall sheet deposits and can be traced laterally to the east where the flow is correlative with a buried volcanic bomb layer.

The surface unit Qv2s in the vicinity of trenches BTVC-T4-92, BTVC-T6-92, and BTVC-T7-92 is mantled with dense volcanic bombs that form a stable stone pavement mantling the underlying fall deposits. The moderately developed soils have formed in eolian matrix within the fall deposits underlying the pavement and have been described by Dr. L. D. McFadden. Pedogenic carbonate within the soils formed on unit Qv2s have been sampled and ^{14}C dated by Dr. R. G. Amundson of UC-Berkeley (see annual report by L.D. McFadden). The stone pavement and underlying soil of unit Qv2s can be traced laterally beneath the scoria cone deposits of unit Qv3 (Fig. 3)

Radiometric dates on unit Qv2 have been determined by Dr. C. Olinger of Los Alamos National Lab during a study associated with a NSF research grant of Dr. S.G. Wells. The cosmogenic ^3He dates on a bomb from the crest of the Qv2 vent (see dark box in Fig. 1) yields an average age of 22 ± 8 ka, which is consistent with the degree of soil development and the preliminary ^{14}C dates on soil development of approximately 10-12 ka.

c. Unit Qv3

The youngest and volumetrically largest eruptive sequence at Black Tank is represented by the scoria deposits and flows of unit Qv3. This eruption produced the relatively pristine, breached scoria cone and aa-to-blocky lava flows that filled the ancestral Black Tank Wash, diverting to the north toward the F cone vent (Fig. 1). The scoria cone has well-developed garlands on the

northern and southern flanks in areas where rilling has been relatively minor (Fig. 1). The trenches clearly demonstrate that the cone deposits of unit Qv3 rest stratigraphically above the unit Qv2 and are separated by a soil/stone pavement bounded unconformity (Fig. 2).

The scoria cone has been breached at least twice by lava flows (Qv3la and Qv3lb) which probably occurred during the same eruptive sequence. No field evidence has been found which demonstrates a significant hiatus in time between these two flows. Rather, two large levees of scoria cone debris occur near the breach site on the western side of the cone (Fig. 1); these levees apparently formed as the lava breached the cone and drained westerly down the ancestral Black Tank wash. The presence of a cone flank between these two levees suggests no significant break in eruptive activity. The lava flow of unit Qv3la are mantled with and incorporate large volumes of glassy scoria bombs and reddish rafted cone agglutinate. Inset below and within this flow is the Qv3lb flow that is darker blocky flow with large blocks of rafted cone material. Pressure ridges and troughs are common on blow flow units (Fig. 1).

Flow unit Qv3la displaced Black Tank Wash to the north and against the scoria cone, lava flows, and cone apron deposits of the "F" (or Rainy Day) vent. Qv3la flow then buried a stone pavement and associated soil formed on the deposits of the "F" vent. Thermoluminescence (TL) dating conducted by Dr. S. Forman on the buried and heated buried soils of the F vent yield ages of heating by the overlying Qv3la flow of approximately 8-10 ka. These dates are consistent with the cosmogenic ^3He age of 22 ± 8 ka for the older Qv2s unit and the time required to form a stone pavement and associated soil profile.

d. Conclusions and Regional Geologic Relations

The data presented above demonstrate that the Black Tank volcanic center, which has been used as an analog for studies at Lathrop Wells volcanic center in Nevada, is polycyclic in origin. Hiatuses between eruptive sequences range from a few thousand years to several hundred thousand years.

Preliminary radiometric ages provided by cosmogenic ^3He and TL methodologies are consistent between themselves as well as with the stratigraphy and geomorphology at the volcanic center. In addition recent studies of the paleomagnetism at this center by Dr. J. Geissman support the field relations and ages determined at Black Tank center.

Results of these studies are also consistent with regional geologic relations indicated by field mapping by S. G. Wells, published individual (non-weighted) K-Ar dates of Mr. B. Turrin (U.S.G.S.), and cosmogenic ^3He dates of Dr. C. Olinger on flows from the "I" and "H" vents in the Cima volcanic field. These relations are summarized in a preliminary stratigraphic column of Figure 4.

2. Investigations at Lathrop Wells Volcanic Center

I completed the preliminary mapping of the surficial geology of the Lathrop Wells volcanic center and surrounding areas (Fig. 5). The primary purpose of this mapping is to show the geologic context of Lathrop Wells

volcanic center with respect to the sequence of surficial deposits and landforms that surround, underlie, and overlie the volcanic units mapped by B. Crowe and others. Three major types of surficial deposits and features have been mapped: (a) those associated with volcanic landform development and subsequent modification, (b) those associated with wind (eolian) erosion and deposition, and (c) those associated with fluvial and colluvial processes. A detailed listing of these surficial geologic units and their spatial distribution is shown in Figure 5.

Several initial observations can be made regarding the results of this mapping.

(a) Garland development is primarily limited to the northern and western flanks of the main scoria cone, whereas, weakly developed rills on the scoria cone occur near the top on the southwestern and eastern flanks of the cone.

(b) Large scale eolian landforms (i.e., transverse dunes, coppice dunes, and eolian wind streaks) occur primarily on Q3 lava flows; older lava flows are mantled by units Qv_{sf} (scoria falls) and Q_{esm} (eolian sand mantles).

(c) The pyroclastic surge deposits (Q_{vps}) have been extensively modified by erosional and depositional processes and are interbedded with alluvial units.

(d) The volcanic sequence at Lathrop Wells appears to have the following landscape-stratigraphic relations with alluvial fan and stream deposits:

- all volcanic units are inset below and possibly older than alluvial fan unit Q_{fo};
- scoria fall sheets are interbedded with and underlie (?) unit Q_{f1}; and
- younger alluvial units (Q_{f2}, Q_{fy}, and Q_{al}) are inset into or overlie the youngest volcanic units.

The significance of these observations relates to the models of landscape evolution which have been developed for desert basins of the western U.S. Such models illustrate that the time-transgressive change from Pleistocene-dominated climatic regimes to those of the Holocene yield significant changes in the vegetation and consequently the response of alluvial systems. Specifically, this time of transition is marked by destabilization of hillslopes with vegetation reduction, movement of sediment from hillslopes into streams, and the deposition of alluvial fan units. It is hypothesized that alluvial unit Q_{f1} may be the late Pleistocene-early Holocene alluvial fan deposits which have been recognized so widely in this region. If so, the scoria fall sheet and pyroclastic surge deposits, which are interbedded and stratigraphically beneath unit Q_{f1}, should date to a "latest" Pleistocene time (i.e., < 30 ka) and not to a "late-middle" Pleistocene time (>70 ka but < 140 ka).

In conjunction with the surficial geologic studies at Lathrop Wells, I initiated a study of the landscape-stratigraphic relations of tephra derived from this volcanic center. Preliminary studies of exposures shown to us by Dr. J. Whitney of the U.S.G.S. provided critical supporting evidence for polycyclic eruptions at Lathrop Wells. The stratigraphy illustrated in cross section LWVC-93-E1 (the "northern exposure" site; see Fig. 6) demonstrates the presence of two tephra units that significantly differ in age. The differences in age are reflected in the amount of calcium carbonate cementation and the relations of the units to the local landscape and stratigraphy. The older cemented scoria shows clast

displacement by calcium carbonate plasma, and at the northern exposure site the tephra is within the channel bottom and lies below an alluvial fan unit with a moderately well developed soil. The younger scoria is uncemented, lies stratigraphically above the cemented scoria, is concordant with the slopes of the present landscape, and is overlain by an alluvial fan deposit with a weakly developed soil profile. Slump blocks of the younger scoria's pyroclastic surge facies occurs in an inset fill within the channel (Fig. 6). These field relations suggest a significant difference between the age of these two tephra.

3. 1993-94 Goals and Plans

a) Investigations in Crater Flat Volcanic Field & Sleeping Butte Centers:

- initiate surficial geologic maps of individual volcanic centers and surrounding areas with an emphasis on cone apron sequences and relations to alluvial fan units; and
- analysis of morphological parameter of volcanic features and their relation to the mapped surficial geology.

b) Investigations at Lathrop Wells Volcanic Center:

- completion of surficial geologic mapping, and
- continue landscape-stratigraphic studies of tephra/alluvial fan relations.

c) Publications:

- write and submit a paper on the Late Quaternary Geology and Paleomagnetism of Black Tank Volcanic Center, Cima Volcanic Field, CA" to GSA Bulletin in conjunction with J. Geissman and L. McFadden; and
- assist in writing a summary paper on polycyclic volcanism/Lathrop Wells story.

Log of Trench BTVC-T6-92

Figure 2a

Generalized Stratigraphy of Trench BTVC-T6-92

- Land surface - average slope of 12° , varies from 10° - 15°
- Unit c - Accretionary cone apron with scoria derived from scoria cone (Qv3s) and eolian fines forming matrix in voids; weakly developed surface soil

[bounding pavement/soil unconformity]

- Unit b - 0.3 thick layer of dense bombs with eolian sand matrix; basal contact slopes approximately 8° away from scoria cone (Qv3s); stone line is buried pavement as indicated by varnish on buried bombs, pedogenic calcium carbonate rinds on clasts, and a weakly developed soil below pavement and underlying soil exposed in trench BTVC-T4-92; unit is upper part of unit Qv2s
- Unit a - 1.5 m of scoria and bombs with weak planar parallel stratification, dipping $> 10^{\circ}$ away from unit Qv3s cone center, eolian matrix decreases with depth; unit Qv2s

Schematic Cross Section, Black Tank Volcanic Center Cima Volcanic Field, California

Figure 4

SURFICIAL GEOLOGIC MAP OF LATHROP WELLS VOLCANIC CENTER

EXPLANATION

Quaternary

Volcanic Landforms/Deposits:

- Qvsg - Scoria cone with well developed garlands on cone slopes
- Qvsc - Scoria cone with little garland development on cone slopes
- Qvps - Pyroclastic surge deposits, deeply rilled or interbedded with alluvial fan deposits

Eolian Landforms/Deposits:

- Qess - Eolian sand sheet, stabilized
- Qesc - Eolian sand sheet and coppice dunes, unstabilized
- Qed - Eolian dune, transverse to barchanoid morphologies
- Qesm - Eolian sand mantled by scoria
- Qesr - Eolian sand ramps
- Qe/c - Eolian sand mantled and intermixed with colluvium

Alluvial Landforms/Deposits:

- Qal - Active alluvial channels
- Qfy - Small active alluvial fans on hillslopes
- Qfo - Older alluvial fans, deeply dissected channels with fan surfaces characterized by stone pavements, and well developed soils
- Qf1 - Intermediate alluvial fans, moderately dissected channels with fan surfaces characterized by stone pavements
- Qf2 - Young alluvial fans on valley floor with deposition bar & swale topography preserved and weak to little soil development

Tertiary

- Tmu - Miocene volcanic rocks undifferentiated

Other Features

- _____ (blue lines) = incised rills ranging from a few centimeters to meters in depth
- _____ (purple lines) = volcanic crater rim
- _____ (bold lines) = scarp, eroded or original flow boundaries
- _____ (orange lines) = wind streaks or aligned coppice dunes

Figure 5, legend

Cross Section at LWVC-93-E1
"Northern Exposure"

Figure 6

The University of New Mexico

Department of Earth and Planetary Sciences
Northrop Hall
Albuquerque, NM 87131-1116 U.S.A.
Telephone (505) 277-4204
FAX (505) 277-8843

28 September, 1993

**Dr. Frank V. Perry
EES-13, M.S. J521
Los Alamos National Laboratory
Los Alamos, NM 87545**

Dear Frank:

This communication, in response to your electronic mail message of 24 September, 1993, summarizes paleomagnetic and rock magnetic investigations as part of the Volcanism Studies Program of the Yucca Mountain Site Characterization Project. To date, these efforts have concentrated on three study areas—Lathrop Wells, southern part of the Cima Volcanic field, and Paiute Ridge, eastern Nevada. In particular, John Geissman has been responsible for obtaining, compiling, and interpreting the data from Lathrop Wells and the Cima field; Ms. Cathy Ratcliff (MS candidate in the Department) has studied the Paiute Ridge intrusions and host rocks for her MS research.

Samples from a total of 27 sites were collected for paleomagnetic study from the southern part of the Cima Volcanic field during a trip in May, 1991. Sampling focussed on the Black Tank center, the I cone, and flows exposed west of the termination of the Black Tank lavas. Flows from the I cone all give magnetizations that are well-grouped on the site level (table attached) and consistently of northward declination and very shallow (about 20°) positive inclination. These data are distinct from other volcanic features in the field, and are interpreted to indicate that the I cone erupted at a time different from other features. Flows exposed west of the terminus of the Black Tank flows all give moderate (about 35°) positive inclination, northward declination magnetizations. These flows do not appear to be correlable with either the I cone or F cone flows. The F cone flow forming the prominent falls in Black Tank wash gives a magnetization of about 43° inclination. Overall, paleomagnetic data from the Black Tank center itself can be interpreted to suggest that this center formed by multiple events spread over considerable (definitely more than a few hundred years) time. The relatively young, prominent flows from the center give inclinations of about 30°. One of the flows exposed in Black Tank Wash on the north side of the cone gives a steep (about 63°) positive inclination. The dike exposed on the southwest flank of the center gives a magnetization with an inclination of 47°. One of the (poorly exposed) flows exposed south of and buried by the prominent young flows gives a magnetization with inclination of about 43°. Although the results are not associated with high precision, bombs from the two cones of the Black Tank center give magnetizations that are consistent with their emplacement during the relatively young events associated with the center.

Samples from a total of 23 sites were collected for paleomagnetic study from the Lathrop Wells volcanic center. To a first order, the sampling scheme was not intended to duplicate a massive effort carried out by previous workers. Five sites were occupied in Q16; three of which gave interpretable data. The inclination of this flow is about 53°. Five sites were occupied in

F.V. Perry
28 September, 1993
page two

Q15; four of which gave interpretable data. Excluding the shallow inclination data from one of the sites (LW8), this flow also has an inclination of about 53° . Four sites were occupied in the "buried" flow northeast of the main cone. Two sites are in surface exposures, now determined to be out of place". The other two (LW 11 and LW 12) are in the trench subsequently dug. The data from the two sites are conflicting; greater faith is placed in the data from site LW11, indicating an inclination for this flow of about 47° . Only one site was occupied in Q13 (LW19). The magnetization is very well determined and the inclination is essentially identical to those of Q15 and Q16. Site LW20 was the single site in Q14 and gives a magnetization that is also similar to other eruptive events. Sites LW 16 and LW18 were occupied in small eruptive features south of the main cone. These also give very well-defined results that are not statistically distinguishable from the main lava flows. Sites LW 13 and LW 14 were occupied in small scoria mounds to the northeast of the main cone. Overall, the data from these features are well-grouped and consistent with all other data from the center. Site LW14 is in a dike immediately north of the scoria mound sampled at site LW14. Although the inclination of the dike is steeper than that of the adjacent scoria mound, the precision of the determinations is such that the data are not statistically distinguishable at a high level of confidence. Site LW was in Q16 rubble. Many of the blocks sampled give a well-grouped magnetization of an odd, eastward and moderate positive inclination. The data are difficult to interpret. Site 23 is in poorly agglutinated scoria exposed in the main quarry. The data from these scoria clasts are random at a high level of confidence, suggesting that scoria clasts in the deposit came to rest at a relatively cold temperature. Overall, the paleomagnetic data from Lathrop Wells demonstrate that (1) none of the eruptive events are associated with a highly unusual or even unusual geomagnetic field and (2) the data can not be used to demonstrate that the Lathrop Wells volcanic center originated during a total of two, count em two, eruptive events closely spaced in time.

At Paiute Ridge, east of Yucca Flat, numerous shallow level alkaline mafic intrusions cross-cut Miocene ash-flow tuffs and lower Paleozoic carbonate strata. In 1991, Bruce Crowe suggested that these rocks be studied for paleomagnetic purposes in an attempt to evaluate the duration/episodicity of shallow-level mafic magma emplacement. Cathy Ratcliff has been studying these rocks for her MS thesis at UNM. A total of 57 sites, consisting of 7 to 57 samples per site, have been collected during the course of three sampling excursions. The truly remarkable observation from the Paiute Ridge intrusions and remagnetized host rocks is that these rocks were intruded during what is interpreted to be a complete reversal of the geomagnetic field. The transitional morphology is exceptionally well-defined by the overall Paiute Ridge data set, although it is not possible to determine an actual sequence for the emplacement record. The transitional path of Virtual Geomagnetic Poles is confined to western Pacific longitudes, consistent with data sets principally from younger reversals. The longitudinal confinement has been interpreted by some investigators to indicate coupling between lithosphere plate interaction and processes at the core-mantle boundary (D" layer). With respect to the emplacement history of the the Paiute Ridge magmas, it is likely that the development of the entire sub-volcanic complex occurred over less than 5000 years, possibly over a much shorter time period.

We attach appropriate tables of paleomagnetic data and relevant diagrams for each of these studies. The tables give, among other things, the site mean direction of magnetization (declination and inclination) for each of the accepted sampling sites, and several statistical

F.V. Perry
28 September, 1993
page three

parameters associated with the mean determination, the most salient of which are the α_{95} value (semi-angle of the cone of confidence at the 95 percent probability level about the mean direction; ideally small) and k , the estimate of Fisher's precision parameter of the population of sample directions for the site; ideally large). The projections of directional data are equal area projections; filled symbols refer to lower hemisphere projections; open symbols to upper hemisphere projections.

In terms of planned/proposed publications of these data sets, we anticipate the following:

- 1) Short, Science-type paper on the Paiute Ridge field transition. Authors: Ratcliff, Geissman, Perry, Crowe, Zeitler
- 2) Longer, JGR-style paper on the Paiute Ridge data. Authors: Ratcliff, Geissman, Perry and Crowe?
- 3) MS thesis. Author: Ratcliff!!!
- 4) GSA-Bulletin type paper on the Black Tank center, Cima volcanic field. Authors: Wells, ..., Geissman, ...? (would plan to include data from the I cone and flows to the west of the Black Tank center).
- 5) Mega-Paper on Lathrop Wells. Authors:Geissman, Ratcliff.....

I take this opportunity to briefly describe work intended over the next year. First, before data from either Cima or Lathrop Wells can be published, some rock magnetic studies must be undertaken on representative samples from the majority of the materials studied. Most of these studies can be done in the UNM Laboratory; some require special facilities which we do not have. I am on sabbatical for the Spring, 1994, academic term and plan to visit the Institute of Rock Magnetism at the University of Minnesota. There, I will run appropriate rock magnetic tests on some of the Lathrop Wells, Cima, and also Paiute Ridge materials, if my colleagues approve. I am happy to work on issue-specific problems in the Crater Flat and/or Sleeping Butte areas. The project on the Solitario (sp?) Canyon dike as it relates to interpretation of magnetic anomaly data is definitely a good one. We will need both remanence and adequate rock magnetic (particularly susceptibility) data from a good suite of samples from the dike and, if exposed, the host rocks. As I mentioned to you earlier, beginning in January, 1994, it might be best to have a student involved in the "project" on an hourly basis, rather than a research assistantship.

Please contact us if you have any questions concerning the attached.

F.V. Perry
28 September, 1993
page four

Sincerely yours,

A handwritten signature in black ink, appearing to read 'J. Geissman', with a long horizontal flourish extending to the right.

John Wm. Geissman
Professor of Earth and Planetary Sciences

A handwritten signature in black ink, appearing to read 'Cathy Ratcliff', with a long horizontal flourish extending to the right.

Cathy D. Ratcliff
MS Graduate Student

Attachments

xc: B. Crowe
S.G. Wells
L.D. McFadden
YMP file

Cima Volcanic Field Paleomagnetic Data

SITE	ERUPTIVE FEATURE	n/N/No	Decl.	Incl.	a95	k	a951-3	a951-2	VGP Lat.	VGP Long.
CMP1	F Cone flow?	8/8/08	4.8	42.9	1.9	872.2	1.3	1.8	78.9	41.3
CMP2	A Cone flow	9/9/09	13.2	27.5	2.5	435.9	1.6	2.5	66.1	31.1
CMP3	A cone flow, middle	10/10/10	7.7	27.5	3.5	194.7	2.1	3.7	68.2	43.8
CMP4	A Cone, AA flow	10/10/10	1	29.2	7.3	44.8	1.4	8.7	70.3	61.4
CMP5	A cone flow, middle	11/11/11	10.8	24.3	3.3	182.2	2.3	3.5	65.4	38.2
CMP6	A cone, bombs	9/9/09	7.9	34.7	10.7	23.9	6.4	10.9	72.4	38.9
CMP7	A cone bombs									
CMP8	I cone, phh channel	11/11/11	7.9	22.6	4.1	126.9	2.3	4.5	65.4	45.3
CMP9	I cone, levee	10/10/10	359.2	21.3	3.3	212.8	2.1	3.5	65.7	66.1
CMP10	I cone, lava channel	8/8/08	11.1	17.9	3.2	308.4	1.8	3.3	62.1	40.4
CMP11	I cone, older flow	10/10/12	12.7	19.2	6.7	51.9	2.6	7.7	62.1	36.6
CMP12	I cone older flow	10/10/10	10	21.6	3.5	191.7	1.6	3.9	64.3	41
CMP13	Black Tank Wash, A	12/12/15	10.8	31.2	2.9	213.9	2.3	2.9	69.2	33.8
CMP14	Black Tank Wash, A	9/9/09	11.9	28.3	2.5	407.5	1.5	2.6	67.2	33.3
CMP15	Black Tank Wash, A	11/11/11	330	77.4	8.6	29	4	9.8	54.6	-136.3
CMP16	Black Tank Wash, A	10/10/12	333.1	62.7	3.9	155.4	2.7	3.9	67.6	-174.4
CMP17	A Cone bombs	16	3.3	35	4.7	61.8	2.7	5.7	73.3	44.7
CMP18	A cone bombs	12/12/12	10.9	32.5	7.1	38.4	3.3	8.2	69.9	32.6
CMP19	West of A flow terminus	11/11/12	357.8	34.8	4.8	89.8	3.7	4.7	73.8	71.8
CMP20	West of A flow Terminus	12/12/12	4.7	34.5	3.7	137.3	1.5	4.4	73.2	48.6
CMP21	West of A flow terminus	9/9/09	15.4	34.4	5	105.3	2.9	5.3	68.7	20.4
CMP22	West of A flow terminus	10/10/10	0.5	35.4	4.7	107.2	1.6	5.3	74.3	62.5
CMP23	A Cone dike	9/9/09	358.5	47.2	5.5	88.6	4.6	4.8	83	75.3
CMP24	A cone flow	7/7/07	8.6	29.9	5.8	109.7	2.4	6.1	69.3	40.4
CMP25	A cone flow	7/7/07	6.7	30.8	3.2	359.1	1.6	3.3	70.4	44.7
CMP26	Buried Flow, A cone	6/6/06	206.9	6.8	10.4	42.6	5.3	10.1	-43.8	-154.5
CMP27	Buried Flow, A cone	11/11/13	355.9	43.3	2.97	237.6	1.8	3.2	79.3	84.7

Cima Volcanic Field Paleomagnetic Data

Comments
Combned Line and plane data fails
Combined line\plane: 347.2, 75.9, 5.2, 7.7
Combined line\plane: 5.8,34.8, 4.2,5.3

Cima Volcanic Field Data

Cima Volcanic Field Data

Cima Volcanic Field Data

■ Axial Geocentric Dipole Field
■ Present Day Field

Cima Volcanic Field Data

Cima Volcanic Field Data

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

Site [Sample]	Rock Type, ID	NRM Intensity	n/N/No	Decl.	Incl.	a95	k	a951-3	a951-2	k1-3
LW1	Flow, QI6		9/9/09	2.7	53.5	5.4	93.2	2.3	6	-201.9
LW2	Flow, QI6		9/9/09	13.8	53.3	3.5	210.9	2.2	3.6	-216.4
LW3	Flow, QI6, out of place									
LW4	Flow, QI6, out of place									
LW5	Flow, QI5		8/8/11	18.5	53.6	7.1	62.3	4.4	7	-63.2
LW6	Flow, QI5, out of place									
LW7	Flow, QI5		10/10/12	346.3	53.8	5.3	83.8	3.6	5.4	-75.9
LW8	Flow, QI5		6/6/08	358.3	45.3	5.5	147.9	3.6	4.9	-127.9
LW9	Buried Flow, QI		10/10/10	350.8	42.1	7.5	42.9	2.8	6.7	-131.5
LW10	Buried Flow, QI		7/7/10	17.1	52.2	6.6	85.2	2.6	7.1	-211.4
LW11	Flow, trench		11/11/16	11.2	46.9	2.4	359.2	1.6	2.6	-370.5
LW12	Flow, trench		9/9/13	6.8	54.6	5.1	102.3	2.1	5.8	-247.5
LW13	Scoria Mound			Spec.Decl.	Spec.Incl	MAD	Circle	Circle	MAD	
A				29.1	45.6	3.8				
B				22.4	55.4	3.7				
C				6.4	61.1	1.9				
D				323.2	64.5	7.1				
E				7	54.9	6.4				
F				6.3	55.3	3.3				
G				24.3	49.9	2.8				
H				303.7	51.2	2.2				
I				352.3	56	5.3				
J				6.2	49.2	4.8				
K										
L				353.1	57.4	1.3				
M				9	61.3	8.4				
N				8	59.1	6.5				
O										
P				5.1	58.4	6				
total	Scoria Mound		12/12/12	2.8	57.7	6.8	34.8	2.2	8.3	-147.1
LW14	Scoria Mound			Spec.Decl.	Spec. Decl.	MAD	Circle	Circle	MAD	
A				356.6	42.1	1.4				
B										
C				11.2	39.4	5.5				
D				353.6	46.8	2.5				
E				277.8	-6.7	11.7				

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

E				2.6	36.6	4.8				
F										
G				355.7	45.5	2.7				
H										
I										
J				5	55.1	3.3				
K				4.1	55.7	2.5				
L				9.5	49.8	4.1				
M										
N				2	52.4	1.3				
O										
P										
Q										
R				354.6	33.5	2.5				
S				10	54.4	0.8				
total			11/11/11	2	46.7	5.1	81.8	2.9	5.6	-108.4
LW15	Flow, Dike		10/10/10	2.2	52.2	3.1	364.9	2.3	2.8	-254.3
LW16	Flow,		10/10/10	3.6	52.2	1.2	935	0.9	1.3	-675.8
LW17	Flow,		10/10/10	355	52	3.8	128.6	2	4.4	-197.7
LW18	Flow,		10/10/10	6.8	53.7	4.1	142.1	2.6	5.8	-239
LW19	Flow,		10/10/10	6.3	52.5	2.9	307.7	1.7	3.1	-372.8
LW20	Flow		10/10/10	352.9	53.6	5.2	215.5	2	5	-474.9
LW21	Q16, Rubble			Spec. Decl	Spec. Incl.	MAD	Circle	Circle	MAD	
A				343.6	39.5	4.2				
B				74	34.9	3.8	326.6	20.7	14.9	
C				95.5	61.5	4.6				
D				87.5	57.9	2.3				
E				75	54.8	4.1				
F				95.2	59.2	3.1				
G				101.2	59.4	5.6				
H				204	30	4.4				
I										
J				112	25.4	4.8				
K										
L				121	27.7	7.5	220.7	19.3	7.4	
M				77.1	35.2	8.5				
N										

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

O				103	60	10.2				
P				92.9	60.1	8.2				
total			10/10/14	93.9	48.9	11.4	18.9	8.3	11.3	-16.2
LW22	Flow,		10/10/10	2.8	53.6	1.8	937.9	1	1.9	-1192.3
LW23	Main Cone			Spec. Decl	Spec. Incl.	MAD	Circle	Circle	MAD	
A				342.8	53.2	6.78	134.5	-66.7	15.3	
B				128.1	-23.5	3.4	193.3	39.9	19.3	
C				15.1	13.2	4.7	94.1	-30.1	21.2	
D				113.7	-16.9	2.7				
E										
F				120.1	4.9	2.1	208	-20.5	14.6	
G				384.4	1.9	2.5				
H				204.3	-45.2	2.3	350	-33.5	8.7	
I				7.7	-56.7	7.2	64.6	-14.8	3.1	
J							169.4	76.6	18	
K				223	23.6	4.3				
L										
M				194	-5	4.1				
N										
O				19	59.2	1.1	173.2	-9.5	9	
P				16.4	-47.2	3.8	284.6	-2.8	1.8	
Q				92.3	12.3		16.3	-48.9	3.8	
R										
S										
T				348.4	51.8	4.6	348.8	-48.6	15.4	
U										
V										
W				192.5	55.7	4.4	316	18.8	12.5	
X										
Y				179.1	14	4.1	89.6	-12.1	4.3	
Z				16.4	63.9	8.5				
AA				13.7	19.6	4.9	125.8	48.3	13.2	
BB										
CC										
DD				9.5	50.8	3.8	146.6	29	8	
total				26.1	58.2	36.9	1.6	19.9	20.8	-2.6

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

[illegible]

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

[illegible]

Lathrop Wells Paleomagnetic Data, 1991-1992 Sampling

[illegible]

Lathrop Wells, Paleomagnetic Sampling Sites

Lathrop Wells Paleomagnetic Data

Lathrop Wells Paleomagnetic Data

Total Data

Axial Geocentric
Dipole Field

Present Day Field

Lathrop Wells Paleomagnetic Data

Lathrop Wells Paleomagnetic Data

Lathrop Wells Demagnetization Diagrams Lava Flows

PAIUTE RIDGE PALEOMAGNETIC STUDY

C. RATCLIFF

PURPOSE

Use paleomagnetic data to determine if this is a monogenetic or polycyclic volcanic center.

RESULTS

Data from 36 sites in intrusive, extrusive, and host rocks are interpreted to show that the Paiute Ridge volcanic/sub-volcanic center recorded a reversal of the geomagnetic field.

INTERPRETATION

The Paiute Ridge intrusions were emplaced and cooled through remanence blocking temperatures (450°C-600°C) in less than about 5,000 years, based on best estimates of the duration of transitional fields. That is, Paiute Ridge is a monogenetic center.

PROGRESS REPORT

1. Additional field excursion to look for cross-cutting relationships (plus photographs?)
2. Thesis defense in early November
3. Presentation at AGU meeting in December 1993
4. Manuscript in preparation to be submitted to "Science"
5. $^{40}\text{Ar}/^{39}\text{Ar}$ age determinations from 3 samples

PAIUTE RIDGE PALEOMAGNETIC STUDY -- HIGHLIGHTS

-- Paiute Ridge is located in the Halfpint Range of southern Nevada, on the eastern part of the Nevada Test Site.

--The area consists of a network of shallowly emplaced mafic dikes, sills, and lopoliths, which intrude mid-Miocene ash-flow tuffs and Paleozoic carbonate strata. Local lava flows indicate that surface eruptions accompanied magma emplacement. The mafic rocks are approximately 8.5 m.y. old.

--Samples were collected from 57 sites in intrusive and extrusive mafic rocks (including syenite pods), and host rocks. Results from 36 sites are presented.

--Nearly all site means are $>40^\circ$ from the time-averaged late Miocene expected direction; these are considered to be transitional directions.

--Four sites show significant changes in remanence direction with sample position (relative to contacts); this is consistent with the idea that there are rapid directional changes during field transitions.

--The plot of virtual geomagnetic poles (VGPs) is confined to west Pacific longitudes, very similar to transitional VGP paths reported from other localities. The persistence of this pattern may reflect inherent characteristics of the geodynamo.

--Paleomagnetic and rock magnetic data preclude the possibility that the unexpected directions are the result of rock magnetic behavior or vertical axis rotation and/or tilting:

- demagnetization behavior
- positive contact tests
- TRM acquisition experiments

--Based on best estimates of the duration of transitional fields, we conclude that the Paiute Ridge intrusions were emplaced and cooled, at least through remanence blocking temperatures, in less than about 5000 years.

Intrusive Basaltic Rocks	Basalt Flows	Syenite Pods
Tertiary Volcanics, Undifferentiated	Paleozoic Rocks, Undifferentiated	Alluvium
Site Locations	Fault, dashed where approximate	

- (a) Equal area projection of site means for intrusive rocks
 (b) Equal area projection of site means for remagnetized host rocks
 (c) Equal area projection of virtual geomagnetic poles

PAIUTE RIDGE SITE MEANS

SITE		D	I	$\alpha 95$	k	N/Nt	Description
I	5	209.4	-36.3	10.2	44.1	6/9	chilled margin
N	4	246.2	-9.2	10.54	41.34	6/11	sill interior
T	7	246.5	-12.4	12.24	40.03	5/9	sill interior
R	8	310.3	48.6	4.49	132.66	9/9	dike
U	14	260.4	29.5	10.07	36.87	7/10	conduit
S	19	267.6	-33.3	8.96	39.19	8/10	radial dike
I	20	244.9	-50.4	11.14	30.34	7/10	radial dike
V	21	296.2	-22.7	4.82	133.07	8/9	dike
E	28	302.6	29.4	4.3	144.62	9/10	dike
	29a	283.5	38.1	9.42	51.57	6/9	dike
R	29b	307	28.1	17.21	52.36	3/3	fused tuff xenolith
O	32	240.6	14.8	6.18	45.93	13/14	upper contact
C	37	228	8	3.93	199.3	8/11	dike
K	39	258.9	20.9	10.02	45.65	6/8	dike
S	44	245.6	-30.3	9.81	28.5	8/9	lopolith interior
	51	288.2	31.4	4.81	90.9	11/11	lopolith interior
&	55	231.3	1.8	6.09	83.7	8/9	lopolith interior
L	30	270.3	10.2	3.64	232.53	8/8	syenite pod
A	31	246.2	-2	6.72	81.68	7/10	syenite pod
V	40	262.2	6.9	7.03	91.89	6/7	syenite pod
A							
S	48	300	35.8	3.26	220.89	10/10	flow 1
	49	298.7	29.5	2.89	318.73	9/9	flow 2
	50	293.9	26.9	3.69	172.2	10/11	flow 3 (lava lake?)

[illegible]

PAIUTE RIDGE SITE MEANS

SITE	D	I	$\alpha 95$	k	N/Nt	Description
5	209.4	-36.3	10.2	44.1	6/9	chilled margin of 10 m thick sill
4	246.2	-9.2	10.54	41.34	6/11	sill interior
7	246.5	-12.4	12.24	40.03	5/9	sill interior
8	310.3	48.6	4.49	132.66	9/9	N-S trending dike near confluence with sill
14	260.4	29.5	10.07	36.87	7/10	conduit interior
19	267.6	-33.3	8.96	39.19	8/10	NE-trending radial dike emanating from conduit plug
20	244.9	-50.4	11.14	30.34	7/10	E-trending radial dike emanating from conduit plug
21	296.2	-22.7	4.82	133.07	8/9	N-S trending dike, near southern end
28	302.6	29.4	4.3	144.62	9/10	N-S trending dike, near northern terminus
29a	283.5	38.1	9.42	51.57	6/9	N-S trending dike, near northern terminus
29b	307	28.1	17.21	52.36	3/3	fused tuff xenolith in dike at site 29
32	240.6	14.8	6.18	45.93	13/14	upper contact of Paiute Ridge lopolith
37	228	8	3.93	199.3	8/11	NW-trending dike emanating from Paiute Ridge lopolith
39	258.9	20.9	10.02	45.65	6/8	NW-trending dike emanating from Paiute Ridge lopolith
44	245.6	-30.3	9.81	28.5	8/9	interior of Paiute Ridge lopolith
51	288.2	31.4	4.81	90.9	11/11	Interior of Paiute Ridge lopolith
55	231.3	1.8	6.09	83.7	8/9	interior of Paiute Ridge lopolith
30	270.3	10.2	3.64	232.53	8/8	syenite pod
31	246.2	-2	6.72	81.68	7/10	syenite pod
40	262.2	6.9	7.03	91.89	6/7	syenite pod
48	300	35.8	3.26	220.89	10/10	basal lava flow
49	298.7	29.5	2.89	318.73	9/9	flow 2
50	293.9	26.9	3.69	172.2	10/11	upper flow or lava lake

PAIUTE RIDGE SITE MEANS

SITE	D	I	α_{95}	k	N/Nt	Description
6	260.5	25	6.67	82.98	7/11	baked tuff <3.0m below site 5
9	297.4	32.1	8.35	122.06	4/4	fused tuff <0.5m from radial dike
22	289.6	25.9	9.73	62.81	5/8	fused tuff <0.5cm from dike at site 21
23	297.9	23	5.67	83.37	9/10	fused tuff <1.0m from N-S trending dike
33	259.4	8.2	3.71	223.54	8/10	baked tuff ~10.0m above contact with Paiute Ridge lopolith
41a	262.9	22.4	6.42	205.75	4/6	limestone ~70.0m below contact with Paiute Ridge lopolith
41b	286.3	40.5	1.6	819.58	11/13	baked & fused tuff within 30.0m of lower contact of lopolith
45	226.7	-6.8	3.72	137.09	12/12	fused tuff at upper contact of PR lopolith
52	284.3	32.6	4.91	87.6	11/13	fused tuff <4.0m from upper contact with PR lopolith
*54	322.2	52.5	6.27	115.29	6/8	Ammonia Tanks tuff ~30.0m from intrusions
*56	175.3	-50.1	2.42	357.22	11/15	Rainier Mesa tuff ~1.0km from intrusions

*tilt-corrected site means for non-remagnetized ash-flow tuffs

● = Declination □ = Inclination
 For sites 4, 28, 31: 1 div.=0.1 A/m
 For site 6: 1 div.=0.01 A/m

SITE 53 - Upper contact of large, central lopolith

SITE 25 - E to W traverse across a 10m thick lopolith

- Lower Contact Rocks (max. distance below contact is about 1.0m)
- Upper Contact Rocks (max. distance above contact is 2.0m)
- Lopolith Interior (number indicates distance from lower contact)

October 12, 1993

To: Frank Perry

From: Les McFadden

Sub.: Contract Activities, 1992-93

Contract activities involving field soil studies in the YMP volcanism studies are summarized below:

- **Field Work**

Four field trips to the Lathrop Wells/Crater Flat field area occurred during 1992-93. Accomplishments include:

1. Discovery of soil stratigraphic evidence for a sequence of tephra, probably derived from the Lathrop Wells Cinder Cone, clearly separated by a period of time required to form the intervening soils.
2. Discovery of a very young tephra that exhibits only very incipient soil development, consistent with younger, Holocene eruption.
3. Formal description of quarry sequence, sampling for soil laboratory analysis, thermoluminescence analysis.
4. First formal trip to Crater Flat area.

- **Laboratory Analyses**

1. Submittal new suite of samples to InterMountain Laboratory following formal procedures.
2. Received thin sections of pavement, soils recently from LANL thin-section laboratory. Examination of thin section materials will supplement ongoing field and conventional laboratory analyses of the soils.
3. Received results of extractive Si, Al, and Mn chemistry for a Crater Flat profile. Generally, results consistent with previous results indicating minimal chemical alteration of the tephra and translocation of incorporated components from dust.
4. Received first analyses of ^{14}C -carbon content and isotopic C and O content of pedogenic carbonate in the Black Tank Cone ephra. Results (ages range from approximately 10,500 to 2,500 yrs BP) compatible with pre-existing ^3He , and TL ages, and inconsistent with K/AR ages of Turrin (USGS). Success of Silver Lake Beach Ridge dating effort reported last

ear indicates future efforts to ^{14}C date pedogenic carbonate from Lathrop Wells soils may be justified.

- University of New Mexico QA audit
Post-Audit report was favorable.

DATE

FILMED

9/9/94

END