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TITLE: NEW MEXICO GEOCHRONOLOGY RESEARCH LABORATORY ZUNI BANDERA VOLCANIC FIELD ROAD LOG

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SUBMITTED TO: 1993 QUATERNARY DATING FIELD CONFERENCE
APRIL 27-28, 1993, GRANTS, NM

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

NEW MEXICO GEOCHRONOLOGY RESEARCH LABORATORY

1993 QUATERNARY DATING FIELD CONFERENCE ZUNI-BANDERA VOLCANIC FIELD

APRIL 27-28, 1993

ROAD LOG

ROAD LOG PREPARED

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PURPOSE

This field conference was designed to assemble a group of Quaternary researchers to examine the possibility of using the Zuni-Bandera volcanic field in western New Mexico as a test area for evaluating and calibrating various Quaternary dating techniques. The Zuni-Bandera volcanic field is comprised of a large number of basaltic lava flows ranging in age from about 700 to 3 ka. Older basalts are present in the Mount Taylor volcanic field to the north. Geologic mapping has been completed for a large portion of the Zuni-Bandera volcanic field and a number of geochronological investigaons have been initiated in the area. While attending this conference, please consider how you might bring your expertise and capabilities to bear on solving the many problems in Quaternary geochronology.

WARNING

Much of the land that we will be crossing for the next two days is owned by the Ramah Navajo, Zuni, Laguna, or Acoma Indian Tribes or is under the jurisdiction of the U. S National Park Service or the Bureau of Land Management. Permits are required from these organizations for sample collection

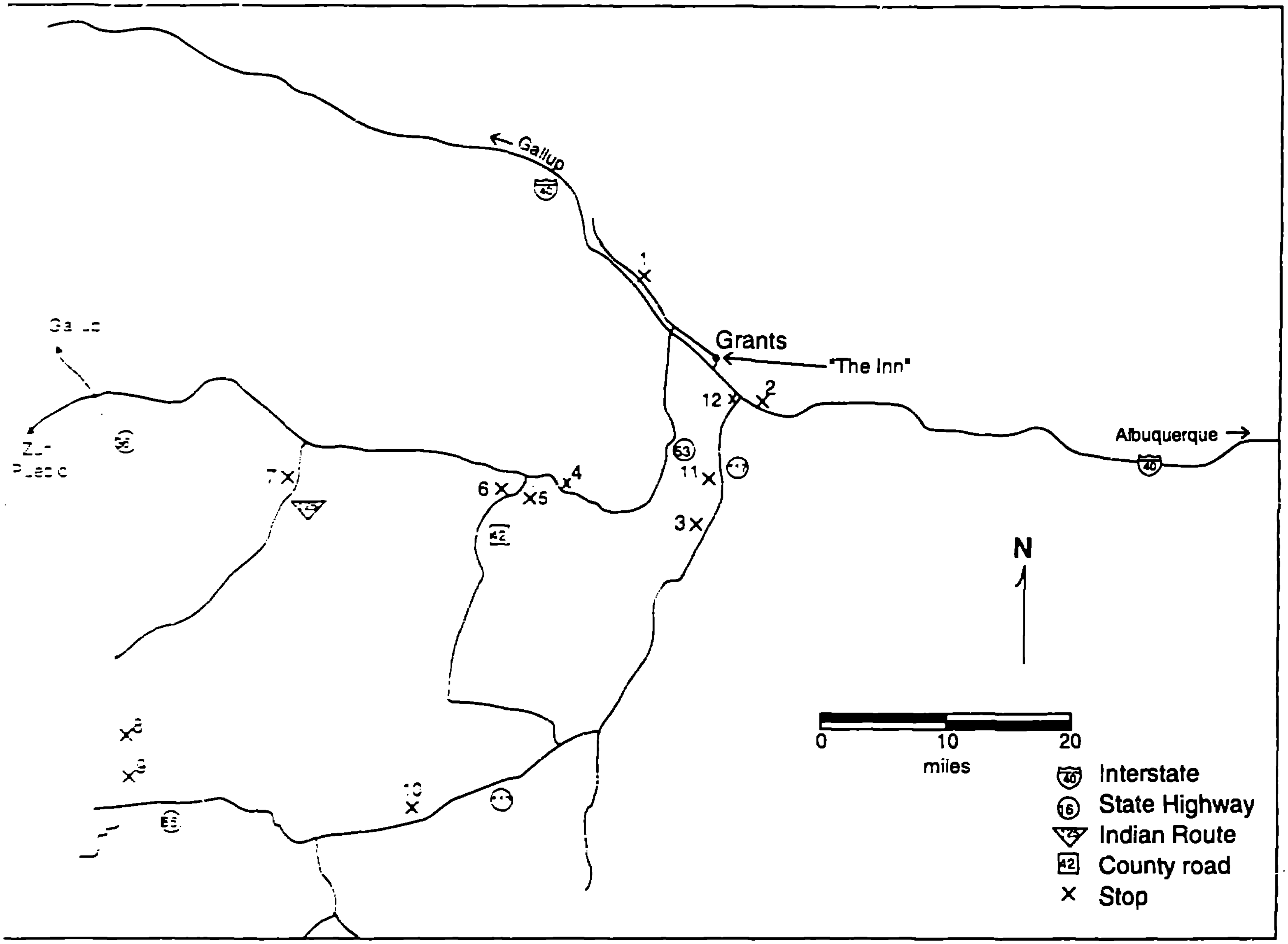

Figure 1. Route Map: Days 1 and 2

ROAD LOG

April 27, 1993

Mileage: 00.0. Best Western Motel "The Inn"- Grants, New Mexico. Turn left from the parking lot at The Inn and proceed west along old Highway 66 through the town of Grants. During the uranium "boom" days, the Grants area was a major producer of uranium. The first discovery of uranium in this region was in 1950 in the Jurassic Todilto Formation. With the decline in the demand for uranium, the economy of this region has suffered and the population of Grants has dropped. Formation of the new El Malpais National Monument is helping the economy by drawing more tourists to the region.

Mileage: 0.9. Note prairie dog town on right hand side of the street. Residents of Grants keep these critters fat and sassy with stale vegetables from the local supermarkets.

Mileage: 1.6. El Malpais National Monument Tourist Center.

Mileage: 2.4. Grants Mining Museum on Iron Avenue. We will meet here tonight for a wine and cheese party.

Mileage: 3.4. Proceed west on NM 122 towards Milan. Black Mesa, on the right hand side of the road, is one of the low mesas that surround Mount Taylor. The basal flow capping the mesa has been dated at 2.57±0.13 Ma (Laughlin et al., in press). Go through the town of Milan. Continue past the intersecton of NM 605 (6.0 mileage) on Highway 122. El Tintero cinder cone is at 2 o'clock. This cone is the source for the Bluewater flow.

Mileage: 12.9. Stop 1: Bluewater Flow
Lat. 35° 15.80 N
Long. 107° 58.23 W

Bluewater Flow

The source of the Bluewater flow is El Tintero cinder cone about 20 km west of Grants. Except where it has been quarried for road metal, El Tintero is well preserved and maintains its original shape. Original surface features are also well preserved on the Bluewater flow except where it is covered by aeolian sands and silts.

The Bluewater flow is a tholeiite, very similar in composition to the Laguna and McCartys flows (Table 1). Most samples of the flow are holocrystalline and microporphyritic with both olivine and plagioclase present as phenocryst phases. The groundmass is dominated by plagioclase and clinopyroxene with minor opaque oxides and perhaps some olivine.

Attempts to date the Bluewater flow have been made using three different methods: conventional K/Ar, U series, and the ^{3}He surface dating technique. All samples used for dating were collected at the same outcrop (Stop 1). Conventional K/Ar dates of 5.69±0.12 and 2.23±0.24 Ma were obtained on two different samples collected by Laughlin and Perry respectively. Based upon the degree of preservation of this flow and its position on the present valley floor, these apparent ages are believed to be anomalously old because of the presence of excess Ar. Sims and Murrell (unpublished data) have obtained a well defined isochron age of 79 ka using the U series method (Figure 2). Poths is dating two samples from this outcrop using the ^{3}He surface dating method. Preliminary dates are 45 and 47 ka (uncertainty in production rates is ± 30%). The application of this technique will be discussed at this first stop. During crushing of olivine, Poths detected large amounts of excess ^{40}Ar in the Bluewater flow. Continue west on NM 122 .

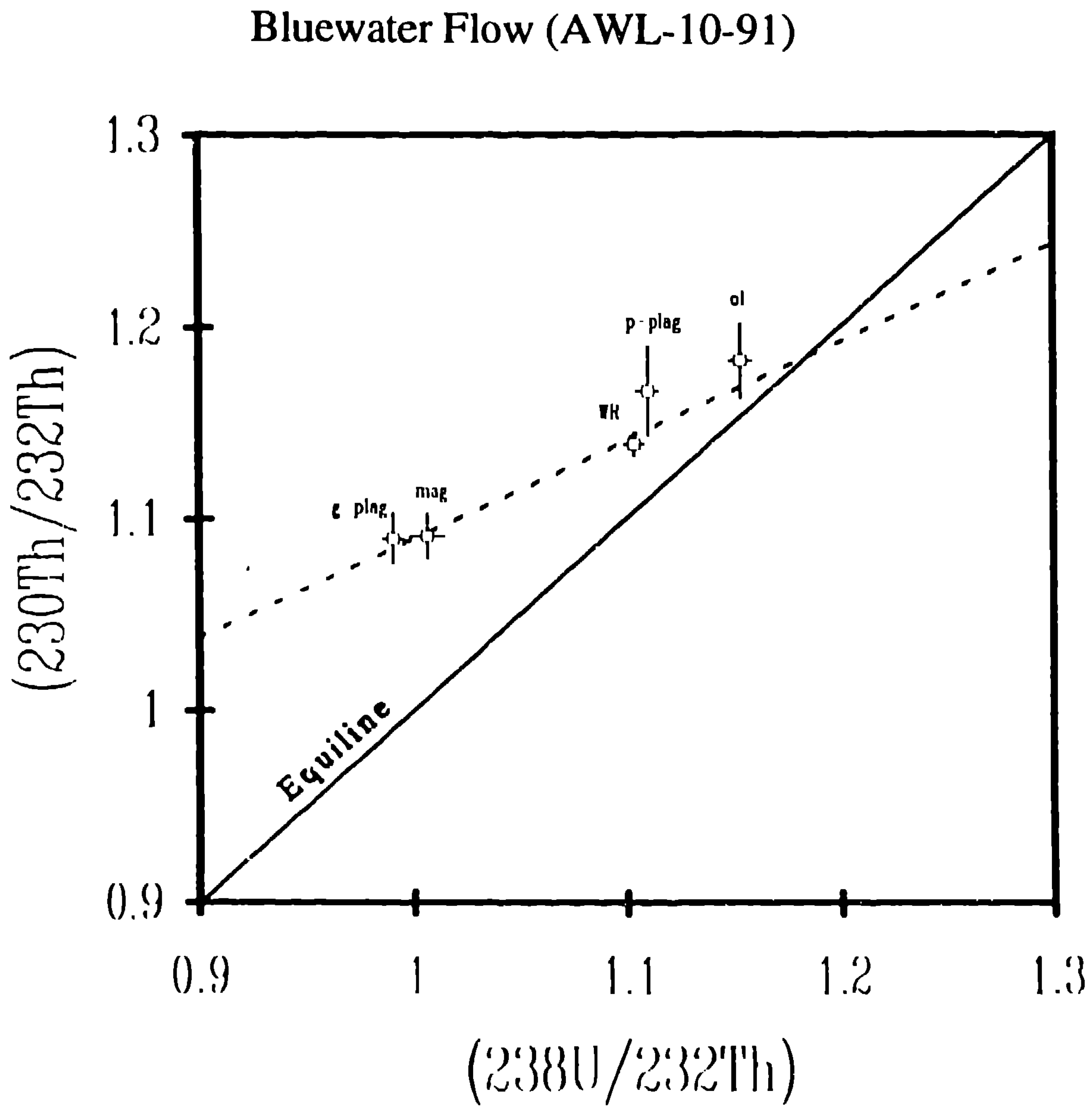

Figure 2. $^{230}Th/^{232}Th$ versus $^{238}U/^{232}Th$ for the Bluewater flow from the Zuni Bandera field on the Jemez Lineament in New Mexico. The isochron, shown by the dashed line gives a 2σ age of 79 ka +40 ka/-30 ka.

Table 1

Representative Chemical Compositions of Dated Basalts

	Bluewater	Laguna	McCartys	Twin Craters	Bandera	Ramah Navajo	Fence Lake	North Plains
SiO_2	51.62	50.23	51.48	48.86	44.47	50.70	50.03	52.06
TiO_2	1.25	1.53	1.41	1.44	3.04	1.17	1.38	1.45
Al_2O_3	15.13	14.50	15.18	14.84	15.22	15.05	14.92	15.72
Fe_2O_3	11.49	1.82	11.87	12.48	4.39	11.66	12.24	10.95
FeO	N.A.	9.27	N.A.	N.A.	8.42	N.A.	N.A.	N.A.
MnO	0.16	0.17	0.16	0.17	0.15	0.16	0.17	0.15
MgO	7.42	9.45	8.29	9.15	9.30	8.34	9.00	6.34
CaO	9.30	8.83	9.11	8.87	8.80	9.57	9.16	9.99
Na_2O	2.60	2.91	2.78	2.81	3.38	2.44	2.74	2.79
K_2O	0.42	0.77	0.69	0.74	1.60	0.36	0.64	0.66
P_2O_5	0.15	0.22	0.19	0.22	0.58	0.14	0.19	0.22
Total	99.54	99.70	101.16	99.58	99.35	99.59	100.47	100.33

Mileage: 13.0. Turn left on access road to Exit 72 on Interstate 40.

Mileage: 13.2. Return to Interstate 40 and proceed east.

Mileage: 23.6. Zuni Canyon flow is on the right. This flow, which originated from Paxton Springs volcano, is an alkaline basalt. Based upon the degree of surface preservation, it is older than the Bandera flows and younger than both the Bluewater and Laguna flows. Although this flow has not been dated, there are several potential sites to look for charcoal beneath the flow within Zuni Canyon. The small hill on the right surrounded by lava is Chinle Formation. It is capped and ringed by travertine deposits of Quaternary age.

Mileage: 26.8. There are high mesa basalts to the north on the southern flank of Mount Taylor; these range in age from 3.7 to 2.9 Ma (Perry et al., 1990, Laughlin et al., in press). We are now traveling across the Laguna flow which has been dated at 50 - 120 ka (Laughlin et al., in press).

Mileage: 30.2. Exit Interstate 40 at the New Mexico 117 interchange towards Quemado (Exit 89). cross over the interstate and proceed east on frontage road (NM 124) to the right. McCartys flow is on the left. Geomorphic features of the McCartys flow were first described by Nicholls (1946) and Carden and Laughlin (1974) described the chemical variations along the length of the flow.

Mileage: 31.4. Stop 2: Laguna Flow.

Lat. 35° 04.53' N
Long. 107° 45.22' W

Laguna Flow

The Laguna flow (Qbc of Maxwell, 1986) is well exposed in the Rio San Jose valley east of Grants. According to Maxwell, it originated from the El Calderon volcano at the southern end of the Zuni Mountains. From its source it flowed northward around the east side of the Zuni Mountains before it turned eastward to flow down the Rio San Jose valley. Within the valley it is overlain in places by the McCartys basalt. Drake et al. (1991) concluded from water well data that it can be traced eastward down the valley beneath alluvium to the vicinity of the Laguna Pueblo where it is again exposed at the surface.

The Laguna flow is an olivine tholeiite (Table 1). It is typically holocrystalline, except locally, where small amounts of glass containing opaque oxides are present. All thin-sections show olivine phenocrysts in a groundmass of plagioclase, clinopyroxene, olivine and opaque oxides. Sample 63, collected where the flow is relatively thick, is characterized by an ophitic texture with plagioclase and clinopyroxene as well as olivine appearing as phenocryst phases.

Several attempts have been made to date the Laguna flow by the conventional K/Ar method (Laughlin et al., 1979, in press, Lipman and Mehnert, 1979) with ambiguous results. Laughlin et al. (1979) reported an apparent age of 1.57±0.26 Ma for a sample collected along Interstate 40 west of the intersection with N.M. Highway 117. Because it was believed that this age was anomalously old, the flow was resampled at two new sites. Laughlin et al. (in press) report ages of 0.054±0.50, 0.110±0.076, and 0.120±0.73 Ma for these samples (sample 63 was analyzed twice)(Table 2). Lipman and Mehnert (1979) reported an apparent age of 0.28±0.25 Ma for this flow.

Return to Interstate 40/NM 117 intersection and proceed south on NM 117.

Table 2

K/Ar Dates on Second Pulse Basalts

Sample ID	Location	Material	K_2O (%)	$^{40}Ar^*$ (10^{-12} m/g)	$^{40}Ar^*$ (%)	Age (Ma)
B-1-74	West of Bandera Crater	Basalt	1.32	0.378	7	0.199±0.042
BR-2-74	Black Rock, Zuni Pueblo	Basalt	0.48	0.483	1	0.70±0.55
153	Black Rock, Zuni Pueblo	Basalt	0.59	0.139	6	0.164±0.035
AWL-2-89	Cerrito Arizona	Basalt	0.98	0.209	1	0.148±0.087
AWL-6-90	East of El Morro	Basalt	0.48	0.076	0.5	0.109±0.044
AWL-10 80	Laguna Flow	Basalt	1.13	0.088	0.2	0.054±0.050
63	Laguna Flow	Basalt	0.84	0.132	1	0.110±0.076
			0.85	0.147	1	0.120±0.073

Mileage: 42.6. Turnoff to Sandstone Bluffs overlook.

Mileage: 44.9. Stop 3: McCartys Flow at "Little Narrows".
Lat. 34° 56.01 N
Long. 107° 50.33' W

McCartys Flow

McCartys flow is the youngest basalt flow within the Zuni-Bandera volcanic field. Its source is a low shield volcano located about 40 km south of the intersection of Interstate Highway 40 and N.M. Highway 117. A small cinder cone about 8 m high sits on top of this broad shield. Although some of the lava flowed southwestward 8 to 9 km, most followed the preexisting drainage and flowed northward about 40 km before turning to flow eastward 10 km down the Rio San Jose valley. The McCartys flow overlies older basalts of the Zuni-Bandera volcanic field and Holocene alluvium.

The McCartys flow is typically a vesicular, porphyritic basalt. Carden and Laughlin (1974) examined chemical and petrographic variations along the length of the flow and reported that within

4 km of the source the basalt is characterized by plagioclase phenocrysts 0.20 to 1.5 cm in length. At greater distances from the source, large plagioclase phenocrysts are absent and olivine phenocrysts are present. Plagioclase is the dominant mineral in samples of McCartys flow.

Prior to the work of Laughlin et al. (unpub), the age of McCartys flow was poorly constrained. Nichols (1946), on the basis of Indian legends and archeological and faunal evidence concluded that the McCartys eruption probably took place after 700 A.D. During the summer of 1992, we were able to collect two charcoal samples from a baked soil beneath the flow at the "Little Narrows" including 1-2 mm diameter burnt roots (Stop 3). Accelerator mass spectrometer radiocarbon dates of 2970±60 and 3010±70 years B.P. were obtained on these samples. Poths is now analysing two samples of the surface of the flow using the ^{3}He method. A preliminary date of 1900±1000 yrs has been obtained on one sample. An uncertainty in the production rate of ±30% may contribute to the discrepancy with the radiocarbon dates.

Leave Stop 3 and return to The Inn in Grants via NM 117 and Interstate 40.

April 28, 1993, 0800

Mileage: 00.0. Best Western Motel "The Inn". Turn right from the parking lot at The Inn and proceed to I-40 west.

Mileage: 3.6. Take Exit 81, turn left on NM Highway 53 (south).

Mileage: 6.3. San Rafael. The town of San Rafael was the site of the first Fort Wingate. The fort was established 1862 and was used in the wars against the Navajo Indians. It was abandoned in 1868 and a new Fort Wingate built near Gallup. Fort Wingate was named after Capt. Benjamin Wingate who died from wounds received from Confederate troops during the battle of Val Verde. Soldiers from the fort used to visit the Ice Cave at Bandera Crater and haul ice back to the fort to chill their martinis.

Mileage: 23.7. Turnoff to El Calderon. This volcano is the source of the Laguna flow that we looked at yesterday at Stop 2. Although we will not stop here on this field trip because of time constraints, it is worth visiting this site to see examples of collapsed lava tubes. For the next several miles, Precambrian granites and gneisses are exposed on the right side of the road. These Precambrian rocks contain numerous veins of fluorite which were extensively mined during World War II.

Mileage: 26.0. Stop 4: Twin Craters Flow.
Lat. 34° 59.51' N
Long. 108° 02.04' W

Twin Craters Flow

Because of the difficulty in separating flows from several different vents, Maxwell (1986) included as one unit, Qbt, flows from the Twin Craters and the Lost Woman and La Tetera (Tetra) vents. He considers these flows as older than the Oso Ridge flows and younger than the El Calderon flows. The Twin Craters flow at this stop is fine-grained and microporphyritic with olivine phenocrysts in a groundmass of plagioclase, clinopyroxene, olivine and opaque oxides. It is tholeiitic in composition (Table 1).

At this stop, the Los Alamos group was able to collect charcoal from the soil beneath the flow and overlying the Precambrian gneiss. This sample yielded a radiocarbon date of 15,800±90 yrs. B.P. No other dates are available for this flow. After looking at the charcoal in the soil, we will climb on top of the outcrop to look at surface features on the flow. The surface features here appear much more degraded than the ca. 10 ka Bandera flow (Stop 5, 6) suggesting that the 15.8 ka age may be in error.

Mileage: 28.8. Turn left on private road to the Ice Caves and Bandera Crater.

Mileage: 29.5. Stop 5: Bandera Crater Trading Post.
Lat. 34° 59.64' N
Long. 108° 05.22' W

Bandera Crater and Flows

The Bandera flows originated from Bandera Crater, a double cinder cone about 150 m high and 1 km in diameter. The eruption of Bandera Crater and its associated flows was the second youngest volcanic event in the ZBVF. Like many other cinder cones in the ZBVF, Bandera Crater is breached to the southwest. A large lava tube, intermittently collapsed, extends about 29 km south from the breach in the crater wall and a commercial ice cave is located in a collapsed portion of the tube near the Candelaria Trading Post. Causey (1971) recognized seven stages in the development of Bandera Crater and its associated flows, culminating in the eruption of the black cinders that cap the cinder cone and blanket the hills to the north. Two small commercial cinder pits have been opened in the cinders covering the hills to the north of NM Highway 53 where the cinder blanket is thickest. A variety of crustal and mantle xenoliths and anorthoclase megacrysts have been found in these cinder pits (Laughlin et al., 1971, 1974; Gallagher, 1973).

The Bandera lavas are nepheline normative, holocrystalline, microporphyritic and vesicular near the surface. Both aa and pahoehoe surfaces are common on the flows. The whole rock chemistry of a representative sample of the Bandera flows is given in Table 1.

Four different dating techniques are being used to date the Bandera flows or to constrain their ages: conventional K/Ar, ^{14}C, ^{3}He, and $^{40}Ar/^{39}Ar$. At the time of preparation of this road log, only the ^{14}C, ^{3}He, and conventional K/Ar results are available. Two K/Ar dates (Laughlin et al., 1979) have been obtained on flows that immediately underlie flows from Bandera Crater. These dates of 0.199±0.042 and 0.148±0.87 Ma (Table 2) provide maximum ages for the Bandera flows. A minimum age for the Bandera activity of 3,166±77yrs BP is provided by a radiocarbon date on a twig enclosed in laminated ice in the Candelaria Ice Cave in the main lava tube from Bandera Crater (Thompson et al., 1991). The significance of this date will be discussed in the field by Julio Betencourt and Dave Love.

In May, 1992 the U.S. National Park Service provided a backhoe to excavate through the cinders on the hillside north of Bandera Crater in an attempt to find charcoal for radiocarbon dating. In the course of two days, ten short backhoe trenches were excavated. The first seven trenches did not penetrate the cinders and it was only when the backhoe was moved about 200 m to the north of the present commercial cinder pit that the trenches encountered soil below the cinders (Figure 3). The sample site is about 1.0 km northeast of the crater rim in the axis of a shallow swale, with an upstream drainage area of about 0.1 km^2. The bottom of the swale is presently unchanneled, accumulating fine-textured loamy soils derived from the adjacent sandstone slopes. The scoria deposit may also have mantled a shallow valley.

The stratigraphy in the charcoal sample site consists of 0.4-1.1 m of fine-textured cumulative soil overlying 0.9-1.2 m of scoria. The scoria deposits include two distinctly different layers; an upper layer, 0.55-0.75 m thick of frothy scoria; and a lower layer, 0.35-0.50 m thick of rounded scoria with abundant lithic fragments. Beneath the scoria deposit are sandstone boulders with intervening pockets of sandy clayey soil, up to about 0.30 m thick. The charcoal samples were collected from within these pockets of soil among the sandstone boulders. Sample Beta-53845 consisted of charcoal within patches of darker soil that possibly represented burnt roots. The charcoal was separated in the laboratory by hand-picking. Sample AA-9075 consisted of small (1-2 mm) fragments of disseminated charcoal in the soil matrix. The charcoal was hand-picked in the field. Sample Beta-53845 yielded a radiocarbon date of 9,170±70 yrs. B.P. and sample AA-9075 gave an age of 9,810±60 yrs. B.P. Because of the possibility of sample contamination by modern rootlets not removed during sample preparation of Beta-53845, we conclude that the date of 9810 yrs B.P. provides the most reliable maximum-limiting age for the eruption of the Bandera cinders.

Two samples of the surface of the Bandera flow were collected for ^{3}He dating. The first sample was collected along the west side of the trail from Bandera Crater to the Ice Cave on the east side of the lava tube (Stop 5). The sample consisted of a slab of the pahoehoe surface of the flow. The second sample was an in place block of aa lava from the west edge of the flow at the foot of Cerro Bandera (Stop 6). Results of the ^{3}He dating, including a preliminary value of 13,500±2000 yrs will be discussed by Poths at this stop

A sample of the Bandera flow from near the vent (Stop 6) has been collected for U series dating and both basalt and anorthoclase megacryst samples have been collected for conventional K/Ar and $^{40}Ar/^{39}Ar$ dating. No results are available as yet on these samples.

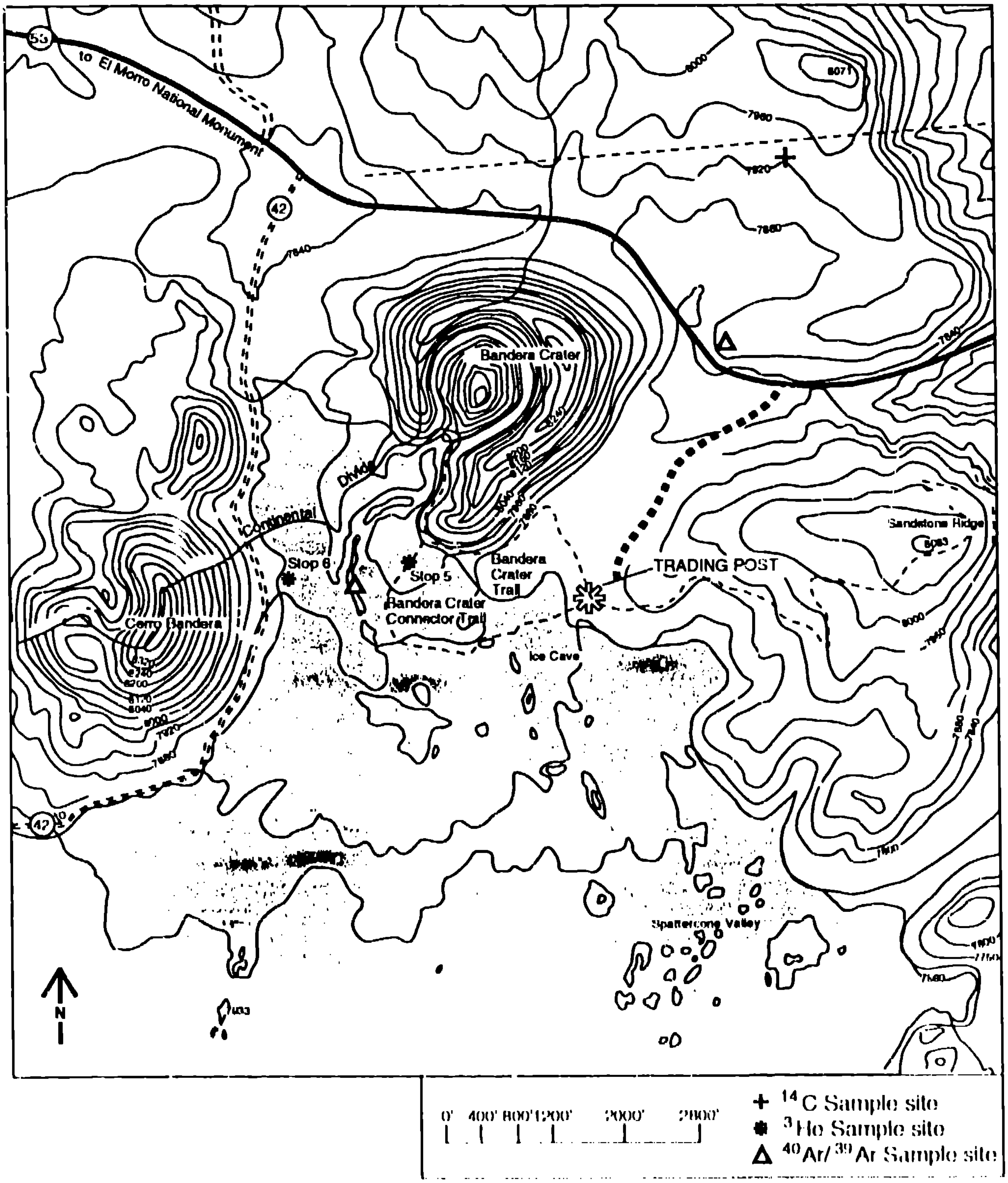

Figure 3. Sampling Sites Near Bandera Crater

Two stops will be made at Bandera Crater. At Stop 5, we will park in the parking lot of Candelaria's Trading Post and walk first to the site where a sample of the pahoehoe surface of the Bandera flow was collected for ^{3}He dating. Because the trenches through the cinders were refilled after sample collection, a stop will not be made at the cinder pit. From here, we will proceed to the Ice Cave where Julio Betencourt and Dave Love will discuss their radiocarbon dates on the laminated ice in the cave.

Mileage: 30.1. Turn left onto Highway 53.

Mileage: 30.7. Continental Divide, Elevation 7882 feet.

Mileage: 31.3. Turn left onto County Road 42. Laughlin et al. (1979) reported a conventional K/Ar date of 0.199±0.042 Ma on basalt (Table 2) from the west side of County Road 42 from approximately this spot. This flow is from the second pulse of volcanic activity recognized in the ZBVF (Laughlin, et al., in press).

Mileage: 32.3. Stop 6: West side of Bandera flow.

Lat. 34° 59.57' N

Long. 108° 05.48' W

Stop 6 is on the west side of the Bandera flow, at the base of Cerro Bandera. At this site, Poths collected her second sample for ^{3}He dating. A short walk across the aa surface of the flow will take us to the main lava tube from Bandera Crater. Samples were collected here for conventional K/Ar and ^{40}Ar/^{39}Ar dating. Results are not yet available for these samples.

Laughlin et al. (in press) report a conventional K/Ar date of 0.148±0.087 Ma on a basalt flow from Cerrito Arizona collected about 4 km southwest of this stop (Table 2). This flow is also from the second pulse of volcanic activity recognized in the ZBVF.

Approximately 8 km south of this stop, a plagioclase phyric basalt, "the Big Plag Basalt" is exposed south of Cerro Rendija. Stratigraphic relations suggest that eruption of this basalt should fall within the second phase (about 0.150 Ma) of volcanic activity. Conventional K/Ar dating, however, yields results of 3.7±0.4 Ma and 5.92±0.14 Ma. A very pure plagioclase separate, enriched in the phenocryst plagioclase component, was prepared to emphasize the effect of excess ^{40}Ar. This sample gave an apparent K/Ar age of 19.5±2.2 Ma (WoldeGabriel and Laughlin, unpubl. data) suggesting a large amount of excess ^{40}Ar. Sims, Laughlin, and WoldeGabriel are now preparing mineral separates to date this flow using the U-series method.

Mileage: 33.4. Return to Highway 53 and continue west.

Mileage: 46.0. A sample of basalt was collected from the pressure ridge at this site. Conventional K/Ar dating gave an age of 0.109±0.044 Ma (Table 2) suggesting that it is correlative with the basalts beneath Bandera Crater and the basalt at Black Rock on the Zuni Pueblo approximately 50 km to the west (Laughlin et al., in press).

Mileage: 48.2. Entrance to El Morro National Monument. Inscription Rock is to the left. Travelers from the days of the Spanish explorer, Onate, in 1605, carved their names on Inscription Rock as they passed through this area. A pool of water at the base of the rock provided relief to the travelers in this typically dry region. This was also a stop on the Indian trail between Zuni and Acoma Pueblos.

Mileage: 51.6. Turn left on Navajo Highway 125.

Mileage: 53.6. ***Stop 7: Ramah Navajo Flow.***
Lat. 35° 01.58' N
Long. 108° 24.51' W

Ramah Navajo

This will be a very brief stop to look at a basalt flow that has given us an extremely anomalous apparent age of 7.65±0.08 Ma. It is a tholeiitic flow (Table 1), holocrystalline and equigranular. It consists of plagioclase, olivine, clinopyroxene, and opaque oxides. About two feet of aeolian sands and silts cover the flow and only the tops of pressure ridges are exposed above the alluvial surface. It is probably coeval with the approximately 0.700 Ma flows of the North Plains (Stop 10) and the Fence Lake flow (Stops 8 and 9). Return to Highway 53.

Mileage: 55.6. Continue west on Highway 53. For the next hour, until we reach Stop 8, we will be passing intermittently through both Ramah Navajo and Zuni Indian lands. Vegetation along the highway is dominantly pinon and juniper.

Mileage: 63.7. Town of Ramah. This is a Morman farming town established in the late 1800's. There are no basalts around Ramah. The lavas flowed west down the valley beyond the hills south of NM 53 and thence into the Rio Pescado and eventually the Zuni River valleys.

Mileage: 75.6. Turn left on NM Highway 36. If you continue west on NM 53 for about 10 km, you would reach the Zuni Pueblo and the Black Rock basalt outcrop dated by Laughlin et al. (in press) at 0.164±0.035 Ma.

Mileage: 102.2. Stop 8: This stop is at the north edge of the Fence Lake flow.
Lat. 34° 44.37 N'
Long. 108° 40.60'

Fence Lake Flow

The Fence Lake flow is one of the oldest and probably the largest basalt flow in the ZBVF. Its vent, which cannot be identified, was probably located somewhere along the present Continental Divide where it is now covered by the Chain of Craters or flows from them. From this general area, lava flowed both to the north and to the west for distances of up to about 100 km. North of the present town of Fence Lake, the lava was apparently confined by a preexisting drainage to a width of two to three kilometers. Twenty to 30 meters of post-flow erosion has left the flow remaining as a prominent ridge. Further west, the lava turned and flowed southwestward into the valley of the Zuni River.

The Fence Lake flow is tholeiitic (Table 1) and is chemically very similar to basalts of the North Plains. Because of differences in flow thickness, there is considerable variability in the petrography of samples from this flow. Most samples are relatively coarse-grained, however, with phenocrysts of olivine, plagioclase, and, in some cases, clinopyroxene in a groundmass of plagioclase, clinopyroxene, and opaque oxides. Where the flow is thick, the texture is commonly subophitic to ophitic.

The Fence Lake flow has been dated by both the conventional K/Ar and $^{40}Ar/^{39}Ar$ methods with mixed results (Table 3). Laughlin et al. (1979) reported a K/Ar date of 1.41±0.29 Ma for a sample collected from the north side of the flow (sample FL-3-74, Stop 8). This date was believed to be anomalously old and another sample was collected from the south side of the flow (AWL-4-90, Stop 9). An unpublished date of 0.184±0.036 Ma was obtained on this sample. Because of the discordancy between these two apparent ages, additional material was collected from the north side of the flow (sample AWL-14-91) and both conventional K/Ar and $^{40}Ar/^{39}Ar$ dates were run on both this sample and on sample AWL-4-90 from the south side of the flow. Results of these analyses are given in Table 3. We conclude that the age of the Fence Lake flow falls between 0.6 and 0.7 Ma.

Table 3

Conventional K/Ar and $^{40}Ar/^{39}Ar$ Dates for the Fence Lake Flow and North Plains Basalts

Sample ID	Location	Material	Mesh Size	K_2O (wt%)	$^{40}Ar^*$ (10^{-12} m/g)	$^{40}Ar^*$ (%)	Age (Ma)†
AWL-5-89	North Plains	Basalt		0.64	0.674	6	0.69±0.13
AWL-1-90	"	Basalt		0.52	0.656	8	0.72±0.10
AWL-3-90	"	Basalt		0.51	0.519	4	0.59±0.09
FL-3-74	Fence Lake	Basalt		0.46	0.9250	6	1.41±0.29
AWL-4-90#	"	Basalt		0.65	0.2060	1	0.18±0.04
AWL-4-90	"	Basalt	-28+40	0.77	0.5044	2	0.46±0.04
AWL-4-90	"	Basalt	-100+140	0.83	0.6925	2	0.58±0.04
AWL-4-90	"	Basalt	-100+140	0.83	0.8226	3	0.69±0.07
AWL-14-91	"	Basalt	-28+40	0.47	0.3357	3	0.53±0.03
AWL-14-91	"	Basalt	-100+140	0.54	0.2507	2	0.23±0.03

Sample ID	Location	Material	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	$^{40}Ar/^{39}Ar$	$^{40}Ar^*$ (%)	J	Age‡ (m.y.)
AWL-4-90	Fence Lake	Basalt	4.07806	0.10856	33.28092	4	0.000277	0.6±0.09
AWL-14-91	"	Basalt	8.52051	0.05782	19.11986	11	0.000278	0.67±0.30

* Radiogenic argon
† Determined from decay constants and isotopic abundance of Steiger and Jager (1977).
# Data from the University of Arizona (sample UAKA 90 051).
‡ McIntosh and Laughlin (unpublished data)

Mileage 105.5. Stop 9: This is the south side of the Fence Lake flow. **New exposures have been cut by the highway while widening the road.**

Mileage: 108.2. Turn left on NM 36/117.

Mileage: 126.5. Turn left on NM 117. Now crossing the North Plains. These plains are covered by 0.600 to 0.700 Ma basalts which, in turn, are covered by aeolian soils. Much of the land in this area is part of the old York Ranch owned by New Mexico Governor Bruce King and his family.

Mileage: 135.5. Stop 10: South of Cerros de los Gatos. **These plugs may have served as vents for some of the North Plains basalts.**

Lat. 34° 37.22 N
Long. 108° 14.72 W

North Plains Basalts

The basalts of the North Plains are tholeiitic and generally similar to the Fence Lake flow in composition (Table 1). These flows have not been adequately mapped and, because of aeolian sand cover, it is difficult to determine how many flows are present in the area. They comprise the southern part of the ZBVF and are overlain in the north by the Hoya de Cibola flows and McCartys flow. Their source vent or vents cannot be located because of probable burial by younger flows from the Chain of Craters and associated cinder cones. In many places these flows are covered by aeolian sands and silts and only the tops of pressure ridges protrude above the alluvium

The North Plains basalts are typically relatively coarse-grained and porphyritic with phenocrysts of both plagioclase and olivine. Groundmass constituents include plagioclase, clinopyroxene, opaque oxides and, in some cases, minor glass and olivine.

Several attempts to date these flows have been made using the conventional K/Ar method (Table 3). Ander et al. (1981) report an age of 3.8 Ma for one of the North Plains basalts but this date appears to be anomalously old. More recent dates fall between 0.593 and 0.724 Ma (Laughlin et al., in press), suggesting that these flows are coeval with the Fence Lake flow.

Mileage: 150.9. Gus Rainey's ranch house is on the left. Gus was a local folk hero, often accused of murder. Gus died in his 90's in the Grants jail while awaiting trial for a double murder. The southern end of McCartys flow is on the left. Cebollita Mesa is the high north-south trending mesa at 12 o'clock. This mesa is about the same elevation as the high mesas around Mount Taylor. It is capped by basalt, approximately 20 meters thick, and the surface is dotted by many maars and at least three shield volcanoes. Cebollita Peak at the south end of the mesa is composed of relatively evolved alkaline basalt (Perry, Laughlin, and Anderson, unpub data). Our brief reconnaissance in 1992 is the only geologic work done on the mesa. It would make an outstanding M.Sc. thesis area. Whole-rock chemical data and a few K/Ar dates should be available by the time of the Field Conference.

Mileage: 165.8. La Ventana Natural Arch straight ahead

Mileage: 173.6. Stop 11: Sandstone Bluffs Overlook

Lat. 34° 58.53' N
Long. 107° 49.03' W

McCartys Overlook

This stop provides an excellent overview of the younger basalts of the El Malpais National Monument. It also provides an ideal setting to discuss possible collaborative geochronology work in the ZBVF.

Mileage: 183.4. Stop 12: McCartys Flow. (Optional)

Lat. 35° 05.16' N
Long. 108° 46.52' W

Time permitting we will stop here to look at surface features on the McCartys flow and to examine relationships between the Laguna and McCartys flows.

This stop concludes the 1993 Quaternary Dating Field Conference. From here you may proceed north on NM 117 to Interstate 40 and then east to Albuquerque. As you drive east on the Interstate, note basalts in the valley east of Laguna Pueblo. These flows are generally believed to be the distal end of the Laguna flow that we examined at Stop 2 and that originated from El Calderon. A detailed geochemical/ geochronological investigation by Reid has been started to test the El Calderon/Laguna flow/ Laguna Pueblo flow correlation.

HASTA LUEGO!

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