THÉ ERUPTIVE MECHANISM OF THE PERIDOT MESA VENT, SAN CARLOS, ARIZONA

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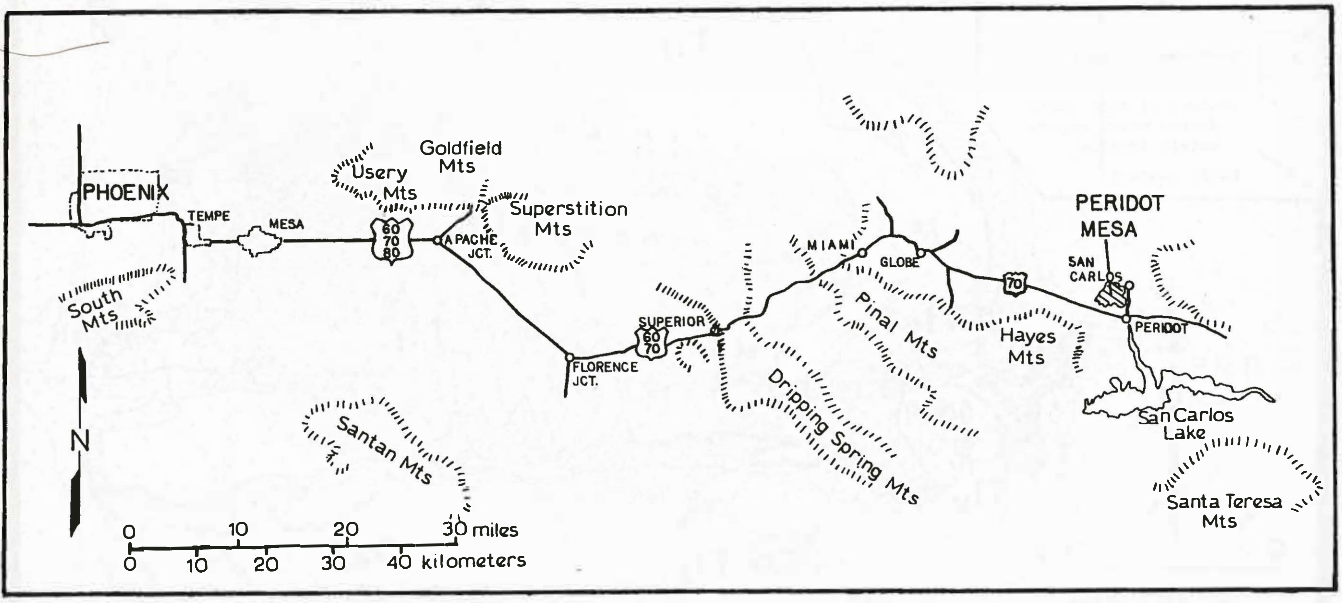

Figure 1. Location map of Peridot Mesa and road log for the field trip.

INTRODUCTION

The Peridot Mesa Vent belongs to the San Carlos volcanic field located in San Carlos Valley and Ash Flat, Arizona (fig. 1). This field has received little attention but Bromfield and Schride (1956) suggest an age of Pliocene or Pleistocene for the lavas which have not been dated radiometrically. The volcanic field is comprised of several diatreme-like vents of which Peridot Mesa is the best studied. The vents erupted tuff rings of pyroclastic surge tephra and flows of lava of entirely a basaltic composition. The flows are generally thin (less than 10 m) and overlie as well as interbed with Tertiary lake beds and Gila-type conglomerate. The lavas are flat-lying and form uplifted plateaus and terraces that have been dissected by erosion. The lavas are widely noted for the abundant four-phased lherzolite nodules that are contained in the flows and bombs around at least several of the vents.

This study is primarily directed at the Peridot Mesa Vent although petrologic data from nearby vents is also examined. Both the physical and the petrologic aspects of the vent are of great interest and will be discussed as two parts in this report.

The author would like to acknowledge M. F. Sheridan for his help in unraveling the eruptive history of the vent, and M. Prinz whose unpublished studies of the nodules have drawn much attention to the locality, and Luween Smith of the Los Alamos Scientific Laboratory for help in drafting.

DESCRIPTION

STRATIGRAPHY

Peridot Mesa is a basalt flow that caps grus and lake beds of Pliocene age. Upon closer inspection the lava flow is found to be of several parts: a lower unit of pyroclastic-surge beds which are overlain by a welded scoria and a massive nodule containing flow that is of coarser texture within the vent (fig. 2). Cinders, bombs, and spatter are abundant near the vent.

The grus, a reddish-tan friable material, is a Tertiary surface and a relative basement high. It has limited exposure and in most areas is overlain by Pliocene lake beds that

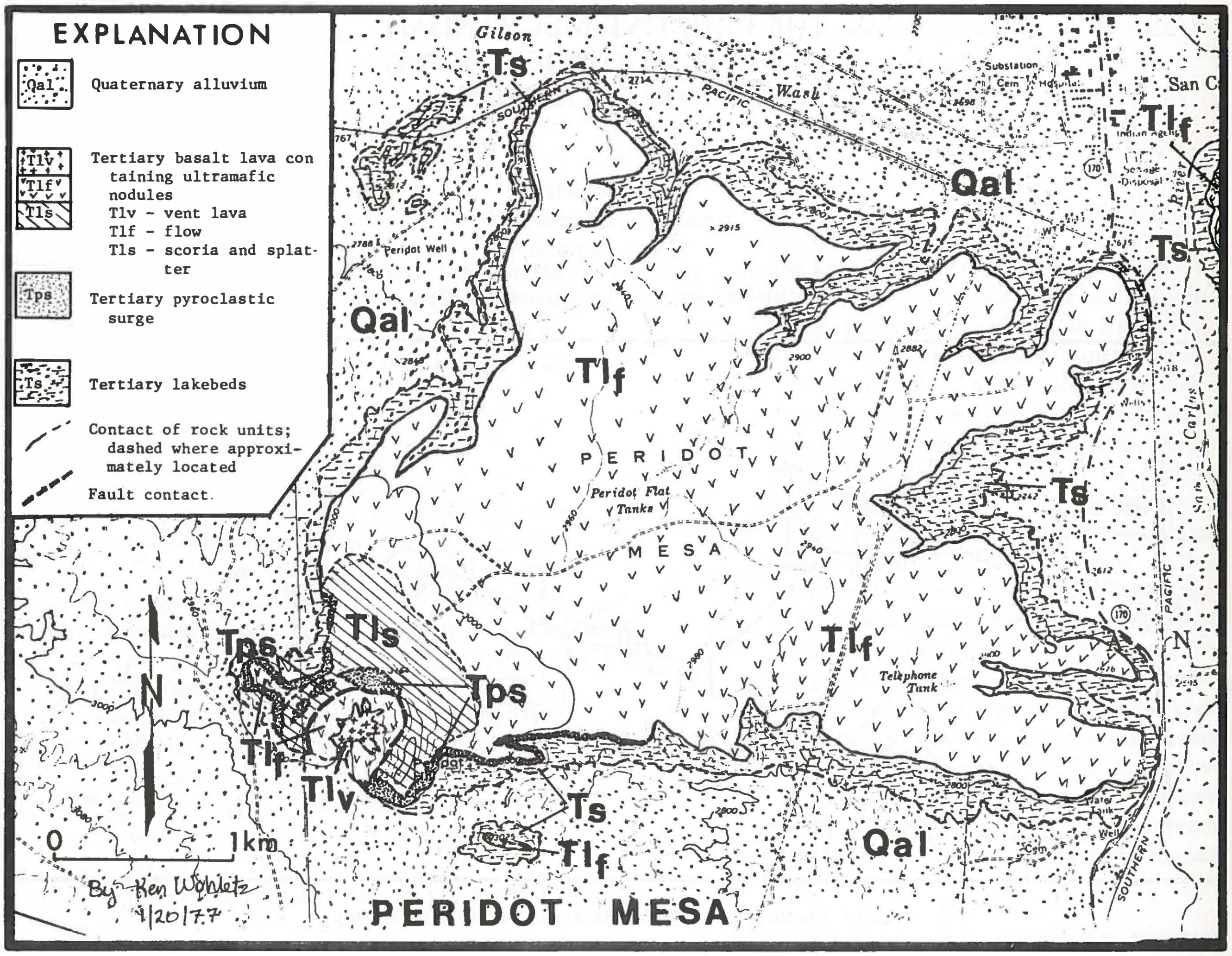

Figure 2. Geologic map of the Peridot Mesa area.

form extensive flat-lying deposits along the Gila and San Carlos rivers. The lake beds are white and are very distinct from interbeds of basalt that exist in the area. The lake beds are normally graded, often cross bedded, and are composed of silts and sands.

The Pyroclastic-surge deposit (Sparks, 1976; Wohletz and Sheridan, in press) is of great importance in understanding the eruptive history of the vent. It overlies the lake beds and grus and is 10 to 15 m thick at the vent decreasing in thickness away from the vent where it pinches out at a distance of 1,200 to 1,500 m. The surge deposit is light tan and is composed of dominantly reworked lake-bed silts and sands with lithic fragments of granite, basalt and peridotite. About 5 to 10 percent of the deposit is accretionary lapilli and palagonite, found mostly near the vent. Surge beds average in thickness from 1 to 5 cm and show three main bed forms: inversely graded planar beds, massive beds, and sandwave beds consisting of dunes, antidunes, ripple-drift laminations, and cross laminations. Sandwave beds are most common near the vent whereas planar beds dominate in distal portions of the deposit. Massive beds are common throughout the deposit.

A thin (less than 1 m) scoriaceous agglutinate (welded scoria) overlies the surge and grades into massive lava above. Caliche has filled vesicles in both the scoria and the lava. The lava flow is just 2 to 3 m thick at its lateral extremities but thickens to 15 to 20 m along its central axis. In its thickened portions near its terminus, columnar jointing is well developed in the upper portions of the flow. Near the vent cinders and air-fall lapilli interbed with the surge and scoria units. The lava within the vent is coarse-grained and apparently occurring as intruded masses and foundered blocks within a breccia matrix. Although the bulk of the nodules occupy a distinct zone within the flow, there is no

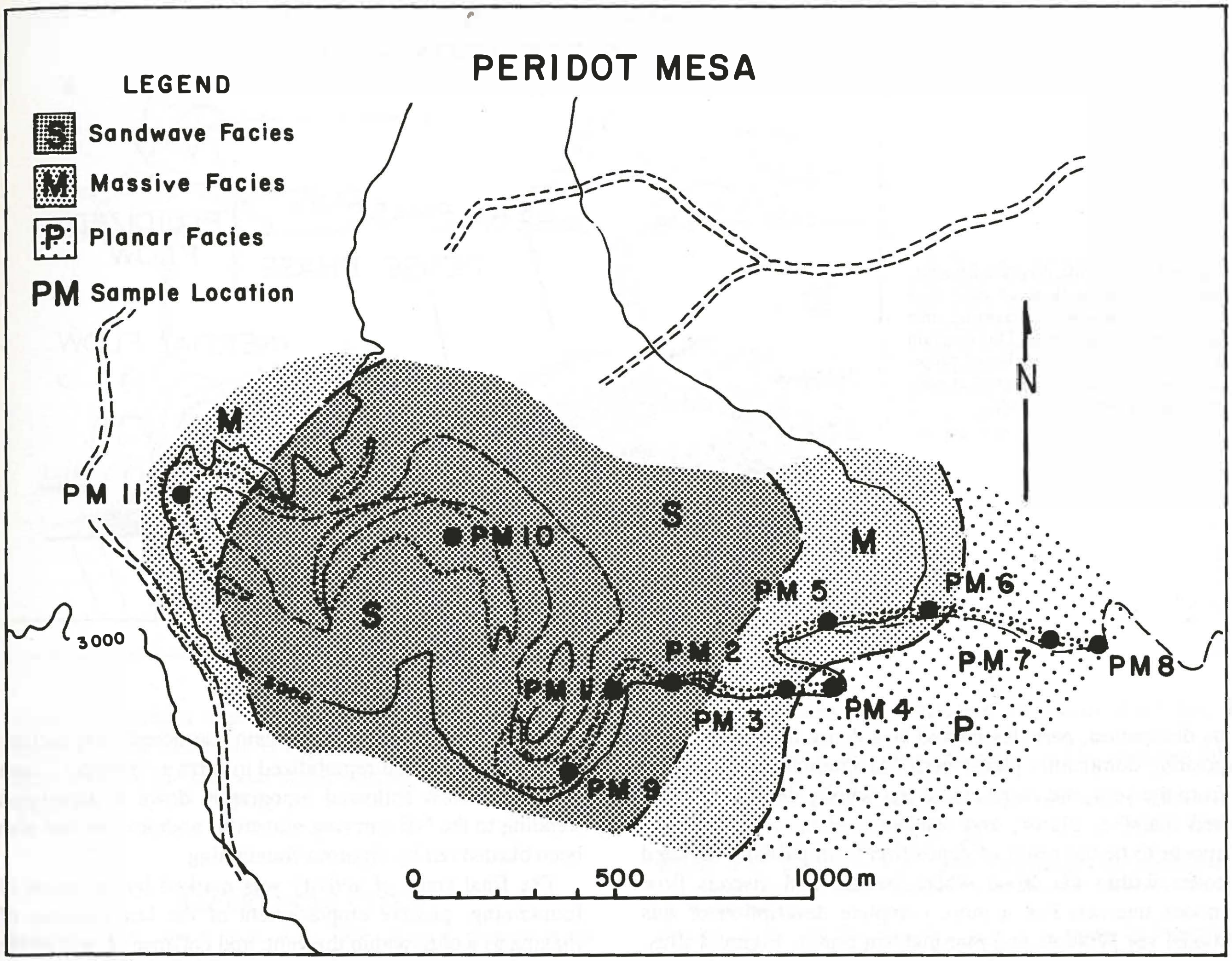

Figure 3. Pyroclastic surge facies map of Peridot Mesa.

evidence that the nodules accumulated at the bottom of the magma reservoir prior to eruption with the result of them being the last extruded materials. On the basis of their overall occurence throughout the lava, the spatter, and to some degree the surge, nodules were probably suspended in the magma.

STRUCTURE

The vent is best described as a diatreme. It is surrounded by a tuff ring made up of surge beds and air-fall lapilli and cinders. The tuff ring is breached on its southeastern side forming a crater of approximately 550 m in diameter. The tuff ring is armored with spatter. A circular fault exists within the tuff ring apparently displacing the inner portion of the vent 5 to 10 m downward. The lava flow is "rootless" in that it begins outside the tuff ring probably having formed from a lava fountain. The flow trends northeast following a paleo-valley.

PYROCLASTIC-SURGE FACIES

The surge deposit shows a bed-form facies distribution (fig. 3) that is discussed by Wohletz and Sheridan (1976; in press). A sandwaves facies is where sandwave and massive beds dominate; a massive facies is where sandwave and planar beds interfinger with massive beds; and a planar facies is where planar and massive beds dominate. The facies distribution was studied by measurement of 11 stratigraphic sections at various distances from the vent. The sections were classified to a facies by a Markov analysis of bed-form transitions (Wohletz and Sheridan, in press). This facies distribution suggests that the surge was erupted as a highly inflated cloud containing a lean mixture of particles and entrapped gases. As it moved away from the vent, particles moving in a viscous mode of transport, saltated along the substrate depositing dominantly sandwave type beds. As the cloud moved farther away from the vent, gases escaped and the cloud deflated until prior to

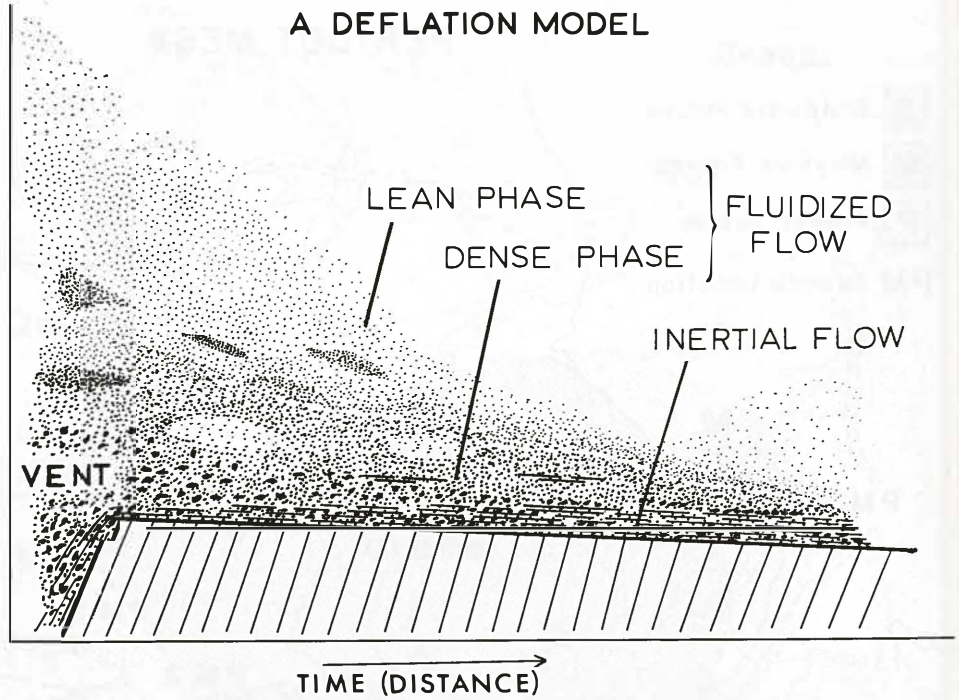

Figure 4. Schematic diagram illustrating the deflation (loss of gas) of a pyroclastic surge with increasing time (distance) from the vent. This diagram is an integration of a number of surge-cloud profiles that likely exist at various stages of surge transport.

its dissipation, particles moved as a dense inertial flow depositing dominantly planar beds. At intermediate distances from the vent, the surge cloud, not wholly deflated, deposited massive, planar, and sandwave beds. Massive beds appear to be the result of deposition from partially deflated zones within the cloud where inertial and viscous flow modes interact. For a more complete description of this model see Wohletz and Sheridan (in press). Figure 4 illustrates the surge model.

ERUPTIVE HISTORY

Eruptive activity began with explosive vent-clearing activity and emplacement of pyroclastic surges. Surges have been shown by Moore (1967) and Waters and Fisher (1971) to be the results of explosive phases of activity. Due to the existence of accretionary lappilli, palagonite, and lake beds, water was likely abundant in the first phases of eruption, producing steam explosions (phreatomagnatic) as it contacted hot magma. Beside expanding steam, CO_2 is a volatile likely to have contributed to the explosive nature of eruption as McGetchin (1968) suggests for mantle-derived magmas in Colorado Plateau diatremes. Pyroclastic explosions forming surges occurred before much magma made its way to the surface as evidenced by materials blasted out of the vent that are dominantly lake-bed material. Surge deposits along with fall deposits formed a tuff ring around the vent.

Following the phreatomagmatic/volatile-fluids eruption stage, less explosive magma was extruded producing a lava fountain. Spatter from the fountain "armored" the earlier-formed tuff ring and remobilized to form a "rootless" lava flow. The flow followed topography down a depression trending to the NE carrying numerous nodules that had also been blasted out by vigorous fountaining.

The final stage of activity was marked by cessation of fountaining, passive emplacement of the last volumes of magma as a plug within the vent, and collapse of vent as the volcanic neck foundered.

CONCLUSIONS

The eruptive sequence at Peridot Mesa casts light on the eruptive mechanism and therefore the composition of some mantle-derived magmas. The explosiveness of the eruptions, the structure of the vent, and the existence of dense ultramafic nodules that were supported or suspended in the lava suggest that the magma was volatile-rich and moved at high velocities to the surface. At some point in time, volatiles (CO_2, H_2O) must have exsolved from the magma and reached the surface prior to the rest of the magma. The eruption scenario at the Peridot Mesa diatreme is likely to be much like that proposed by McGetchin (1968). The sequence of events is illustrated in Figure 5 and is summarized as follows: (A) a crack is propagated to the surface by a supercritical, CO_2-H_2O-rich fluid by hydraulic fracture; (B) the fluid flows through the fracture, blasting away a vent at the surface, producing pyroclastic surges; (C) a Venturi-like vent structure develops allowing magma to flow to the surface at increased velocities and entraining

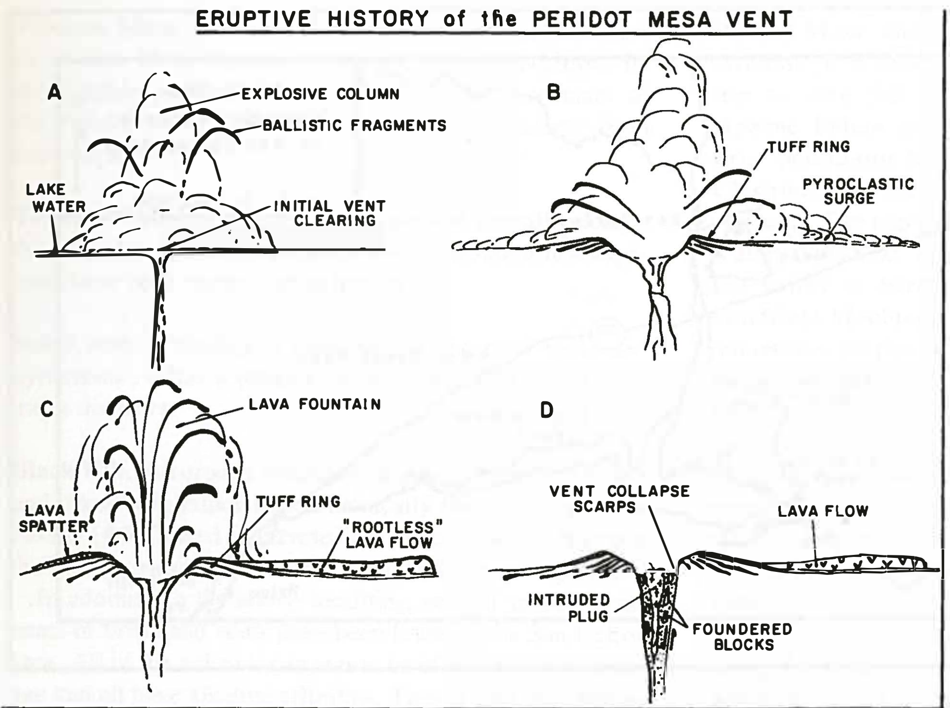

Figure 5. Illustration of four stages of the eruptive history of the Peridot Mesa vent: (A) Explosion of volatiles initiating a vent; (B) pyroclastic-surge stage developing a tuff ring and widening the vent; (C) lava fountaining stage producing a "rootless" lava flow; and (D) collapse of the vent after cessation of lava extrusion.

ultramafic nodules to produce a lave fountain; (D) when the magma in the reservoir is expended, pressure in the vent decreases and the material in the vent neck collapses downward.

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THE SAN CARLOS ALKALINE ROCK ASSOCIATION

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Several volcanic features occur in close proximity to the Peridot Mesa tuff ring and flow (see fig. 1). The features were noted and briefly described in a doctoral dissertion by Marlowe (1961). They are apparently related in time and major-element chemistry. The following paragraphs give a brief description of the features:

Peridot Mesa Basanite. The profusion of ultramafic nodules contained in this lava make it the best known of the volcanics in the area. The published work on the area is concerned mainly with the nodules and megacrysts in the basanite (Mason, 1968; Prinz and Nehru, 1969; Frey and Prinz, 1971). An average of several analyses collected

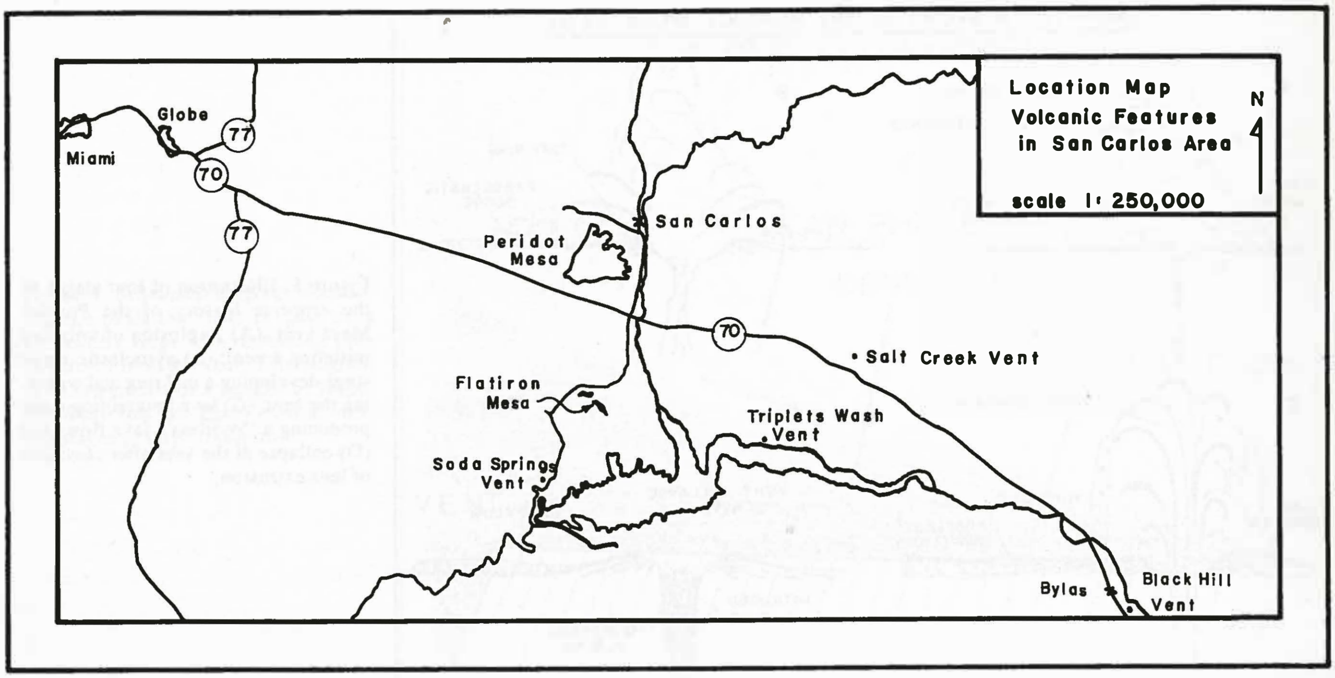

Figure 1. Location map of alkaline volcanics in the San Carlos area.

along the length of the flow is given in Table 1 (column 1). That average is very similar to analyses published by Prinz and Nehru (1969). The composition of the flow is remarkably uniform except for two-fold variations in potassium, rubidium and barium. The cause of the alkali metal variations is unknown; it may be due to alteration but the rocks appear fresh in thin section. Thin sections of the basanite reveal fragments of olivine and pyroxene from the lherzolite nodules, thus the analyses probably show higher Mg/Fe than initially present. Nevertheless, the Mg/Fe ratio in the basanite is easily high enough to be in equilibrium with upper mantle olivine.

The nodules range up to 50 cm in diameter and commonly are 10 cm in diameter. The most abundant type of nodule is spinel lherzolite consisting of olivine, orthopyroxene, spinel, and chromian diopside. Other nodule types include harzburgite, websterite, clinopyroxenite, orthopyroxenite and gabbro. Clinopyroxene-rich bands up to 10 cm thick are present in many of the spinel lherzolite nodules. In addition to the polycrystalline nodules, there are megacrysts of black, vitreous clinopyroxene and spinel, and plagioclase. Fragments of kaersutite up to 2 cm long have been found in the vent area. Geochemical evidence suggests that the polycrystalline nodules are accidental inclusions in the host basanite, but that the megacrysts are probably cognate.

Soda Springs Vent. Described by Cross and Holloway (1974).

A small (~100 meter) tuff ring or eroded plug consisting of mugearite (#2, Table 1) with trachytic texture containing numerous megacrysts of ferro-kaersutite (#3, Table 1) and anorthoclase, (#4, Table 1) and rare titanomagnetite and ferrobiotite. The composition of the megacrysts is consistent with their formation by cotectic crystallization from the host magma. Calculations suggest the mugearite is produced by fractional crystallization of kaersutite from the Peridot Mesa basanite. A K-Ar determination done on an anorthoclase megacryst yields an age of 5.28 ± 0.13 m.y.

Table 1. Chemical Composition of Rocks and Minerals from the San Carlos Area, Arizona. (in weight percent)

Oxide	1	2	3	4	5
SiO_2	46.0	52.3	38.7	62.6	47.0
TiO_2	2.77	2.02	4.56	0.08	2.32
Al_2O_3	15.2	18.2	13.6	21.1	15.2
Fe_2O_3*	13.3	11.1	17.3	0.43	11.6
MgO	8.15	2.76	8.56	n.d.	8.24
CaO	7.68	5.82	10.0	1.60	8.58
Na_2O	4.73	4.54	2.56	7.80	3.48
K_2O	1.89	2.89	1.14	3.50	1.99
P_2O_5	0.90	0.96	n.d.**	n.d.	0.62
Total	100.7	100.6	96.4	97.1	99.0

* Total iron calculated as Fe_2O_3
** n.d. = not determined

1. Average of 7 analyses of the Peridot Mesa basanite.
2. Representative analysis of Soda Springs mugearite.
3. Ferro-kaersutite megacryst from Soda Springs.
4. Anorthoclase megacryst from Soda Springs.
5. Alkali Basalt from Black Hill.

Flatiron Mesa. This is a flow remnant which is identical to Peridot Mesa basanite in texture and composition. Its topographic position would allow it to be a remnant of the Peridot Mesa flow. No ultramafic nodules have been found in it.

Triplets Wash. Apparently the remnant of a small volcano, the lavas here are highly altered and no detailed investigations have been carried out on this area.

Salt Creek. Probably a diatreme, all exposed rocks are pyroclastic. It has a roughly circular outline of about 400-meter diameter.

Black Hill. An eroded volcano consisting of massive flows and dikes with minor tuff. Chemically the lavas are alkali basalts (#5 Table 1), intermediate in composition between the Peridot Mesa basanite and the Soda Springs mugearite.

In addition to the above localities, several smaller remnants of flows and vents have been found in the San Carlos area. All of the volcanics appear to be of roughly equivalent age and all have alkaline affinities. They would thus appear to have a common origin. The abundance of ultramafic nodules whose mineralogy indicates an upper mantle source (Frey and Prinz, 1971), and the Fe/Mg ratio of the basanite would allow it to be in equilibrium with olivine in the mantle. Consequently it would appear that the basanite is the parental magma for the other volcanics, the latter being produced by fractional crystallization of the basanite.

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FIELD GUIDE

Leaders: J. Holloway and K. H. Wohletz

GENERAL STATEMENT

The trip begins at Arizona State University, Tempe, Arizona and is designed to return there at the end of one full day. The purpose of the trip is to examine the volcanic vent and peridotite nodules of great beauty at Peridot Mesa, and other volcanic rocks near San Carlos, Arizona. It is most important for those interested in this trip to note that Peridot Mesa is on the San Carlos Apache Indian reservation and that access is limited. Prior permission for access must be obtained through the Chairman of the San Carlos Council, San Carlos, Arizona. The trip proceeds from Tempe in the Salt River Valley on US 60–70 east towards Apache Junction where the valley is bordered on the north and east by the Goldfield Mountains and Superstition Mountains. These mountains are part of a large silicic volcanic field (Sherian and others, 1970; Sheridan, 1968). From Apache Junction, the field trip proceeds along US 60–70 to Florence Junction along the border of the Basin and Range Province to the west with the transition zone of the Colorado Plateau to the east. From Florence junction, US 60–70 continues to Superior, Miami, and Globe, passing through exposures of the Apache Leap Tuff (Peterson, 1968), and the Schultze Granite, a pluton surrounded by porphyry copper mines. From Globe the trip continues along the Gila River on US 70 to the San Carlos River where the town of San Carlos is located at the foot of Peridot Mesa. In this area there are several diatreme-like vents whose basaltic lavas contain abundant peridotite nodules. Much of the following road log is updated from an earlier log in the Arizona Geological Society Guidebook III (1968).

ROAD LOG

MILES Interval	MILES Total	
0.0	0.0	Leave loading dock at A.S.U. Physical Science Building. Turn right on University Drive, then right on Rural Ave., and then left on Apache (US 60–70) to Apache Junction.
16.4	16.4	East of the Bush Highway three main structural blocks can be seen in the volcanic complex to the northeast. The Goldfield Mountain front to the north is underlain by basement granite. Above the granite is a band of non-welded rhyolite ash-flow tuff, the Geronimo Head Formation of 17 m.y. age, which forms a conspicuous light-colored outcrop. The ash-flow tuff is in turn overlain by a black, glassy dacite lava. The elevation of the Goldfield front is approximately 1,000 m on the west and 800 m on the east; the volcanic sequence thickens to the east.

To the east of the Goldfield Mountains is the Superstition mountain block. This mass of ash-flow tuffs and lavas has an elevation of 1,600 m of which at least 650 m are part of the Superstition volcanic sequence. Whereas the Goldfield volcanics are dipping to the northeast, the ash-flow tuffs and lavas of the Superstition Mountains are horizontal.

Between these two main mountain masses is an area with an elevation of 600–700 m, which is underlain by steeply dipping lavas, ash-flow tuffs, and epiclastic volcanic breccias (lahars). The lahar units suggest volcanotectonic subsidence. The dips of the lahars and the outcrop distribution outline at least two caldera margins.

7.4 23.8 Apache Junction. Continue on US 60–70–80 which curves toward the southeast. For the next 15 miles the highway parallels the trend of the Superstition Mountains, which lie to the east and northeast. This range, the locality of the fabled Lost Dutchman Gold Mine, is composed chiefly of volcanic rocks of Tertiary age: ash flows, air-fall and water-laid tuffs, mud flows and lava flows and plugs that range from rhyolitic to basaltic in composition. Volcanic activity in the Superstitions began 29 m.y. ago with eruptions of dominantly quartz latite lava to form a ring of stratovolcanoes and domes. At 25 m.y. the eruption of vast quantities of ash formed what is now called the Superstition Tuff. During the eruption of ash, caldera collapse occurred, ponding ash to thicknesses over 1,000 m within the caldera. The prominent layered cliffs making up the summit of the Superstition mountains represents the resurgent dome of the caldera composed of the Superstition Tuff (showing at least 9 cooling units) which ponded in the caldera. Parts of the caldera ring domes form the rampart-like cliffs on the northern part of the mountains.

7.2 31.0 Roadcut through a rhyodacite lava, part of a caldera moat-filling dome. Hills on the low lands west of the Superstition Mountains are all silicic lava flows and dikes. The road here parallels the trend of a major Basin and Range fault to the west which displaces basement rock over 1,000 m downward on the western side.

9.3 40.3 Florence Junction. The hills just north of the highway are eastward-tilted blocks of remnants of quartz latitic ash flows.

2.5 42.8 The rugged hills to the north are composed mainly of volcanic rocks of the Superstition Mountain complex. The volcanic rocks overlie tilted and faulted Pinal Schist, granitic rocks, and sedimentary rocks of the Apache Group, all of Precambrian age.

1.4 44.2 To the north (~8 o'clock), glimpses may be caught of a pointed mountain, Weavers Needle, which is a historic landmark used in location of the Lost Dutchman Gold Mine.

0.5 44.7 Dromedary Peak at 2 o'clock. Faulted and sheared remnants of an ash flow resting on Pinal Schist.

1.3 46.0 Pinal Schist in roadcuts.

1.3 47.3 At 12 o'clock is Picketpost Mountain, a prominent landmark of the region.

2.5 49.8 Roadcuts in alkali olivine basalt of probable Tertiary age, very similar to the 30 m.y. basalt that underlies all of the Superstition complex.

For the next several miles, there are excellent views of Picketpost Mountain. At its base are rhyolitic lava flows which are overlain by a thick series of light-colored tuffs that make up most of the steep flanks. The mountain is capped by quartz latite lava flows that emerge from a vent on the eastern flank of the mountain. This lava has been K-Ar dated at 18.0±0.3 m.y. (Damon, et al., 1966).

2.0 51.8 Entrance to Boyce Thompson Arboretum, a center for the study of desert biology and ecology, recently acquired by the University of Arizona. The basin over which we are driving is filled by alluvium and the Gila Conglomerate. At the east boundary of the basin is the Concentrator Fault, trending north to northwest, with its west side down. East of the fault lie eastward-dipping sedimentary rocks of late Precambrian and Paleozoic ages that have been intricately faulted by both north- and east-trending fault systems. Many of the east-trending faults are mineralized, and one of them formed the Magma vein, the location of one of the major copper mines of Arizona. The pre-Tertiary rocks are overlain by the thick sequence of quartz latitic ash flows (dacite) that make up the towering cliffs of Apache Leap. The ash flow has been K-Ar dated at 19.6±0.6 m.y. (Creasey and Kistler, 1962; Damon and Bikerman, 1964).

To the southwest, toward the base of

Picketpost Mountain, several light-colored pits mark areas where high-grade perlite has been mined from the rhyolitic lava flows.

2.6 54.4 Town of Superior. Road forks. Keep to right on main highway. Proceeding to the east out of Superior, the road crosses the Concentrator fault, the east side of which is the uplifted block. The lower parts of the cliffs consist stratigraphically of: The Cambrian Balsa Quartzite resting with sedimentary contact on diabase, the Martin Limestone (Devonian), the Escabrosa Limestone (Mississippian), the Naco Limestone (Pennsylvanian), and the Tertiary Whitetail Conglomerate. Important replacement copper mineralization occurs within the lowermost beds of the Martin and manganese mineralization occurs along faults in the Escabrosa (prominent white cliff former).

2.9 57.3 The upper parts of the cliffs east of Superior are the reddish colored quartz latite ash flows of the Apache Leap Formation. The ash flows overlie the Whitetail Conglomerate and consist of one well-developed cooling unit. For the next six miles the road goes upward through the cooling unit from the non-welded zone through a densely-welded block vitrophyre, a brown to gray densely welded, devitrified zone, and finally through light colored vapor phase zone of partial welding.

6.3 64.1 Near Pinal Ranch at the eastern fault boundary of the ash-flow sheet. For the next several miles, the highway passes through the Tertiary Schultze Granite stock. Much of the copper mining in this area is around the northern contact of the granite with Pinal Schist.

4.7 68.8 At 2 o'clock, Pinal Mountains. The higher part of the range consists of the Pinal Schist and Madera Diorite, the lower rounded hills consist of Schultze Granite. In the next few miles along the canyon of Bloody Tanks Wash, the granite shows spectacular jointing.

4.2 73.0 Enter town of Miami, Arizona. The town is built around the Miami copper mine of the Inspiration Consolidated Copper Company. Many smaller mining companies operate in the area.

6.4 79.4 Enter town of Globe, Arizona.

1.6 81.0 Intersection of Highways US 60 and 70. Keep to the right on US 70. The route now leaves the Pinal Mountains, which were a highland and drainage-divide area through much of late Cenozoic time. The Phoenix basin to the west received sediment from the mountains through most of late Cenozoic time. The route now enters the Safford basin, where nearly continuous deposition continued into early Quaternary time. The deposition was terminated by differential uplift. Because of this uplift and subsequent erosion, about 800 feet of lower Quaternary sedimentary deposits were removed from the area. Remnants of the deposits are exposed on the slopes of mesas and benches, which are predominant in Safford and Duncan basins. The cycle of erosion is continuing in this area at the present time; the gravels exposed in roadcuts here and for several miles to the east are late Pleistocene in age and were deposited in the earlier versions of the present stream channels.

0.06 81.6 At 12 o'clock, Hayes Mountains, altitude 5,300 to 5,700 feet. The lone peak to the north is capped by a basalt flow that is early Quaternary in age. The rugged peaks and slopes to the south are composed of granite of Precambrian age, and the southwestward-dipping rocks on the south skyline are Precambrian and Paleozoic quartzite overlain by Paleozoic limestone.

0.4 82.0 Drainage divide. To the northwest, the streams drain into Pinal Creek, which is tributary to the Salt River. To the southeast the drainage is into the Gila River.

1.2 83.2 On right: State Highway 77 to Tucson.

5.7 88.9 Entering hills and ridges, erosional remnants of sediment probably early Pleistocene in age. These sediments are termed informally the "upper unit of basin fill" and are the uppermost unit of Gilbert's (1875) Gila Conglomerate. Note the characteristic red-brown to brown color, fine-grain size, local calcareous beds and tuff beds, and the even near-parallel bedding. The upper unit of basin fill is well sorted; the bedding, grain size, and good sorting contrast with the lenticular bedding, coarse material, and poorly sorted gravel of middle to late Pleistocene age. Here, the mesas slope northward to Aliso Creek and are gravel-capped terraces of streams tributary to the creek.

1.0 89.9 At 9 o'clock, the low hills to the north are part of the Apache Mountains and are underlain by Precambrian and Paleozoic quartzite.

Near the southeast end are minor outcrops of grayish Paleozoic limestone.

3.5 93.4 Top of divide, approaching Safford basin.

At 10 o'clock to 11 o'clock, the Natanes Plateau is on the skyline. The volcanic rocks on the skyline are andesite to basalt flows of middle Tertiary age. The low platform in the middle foreground is capped by basalt of early Pleistocene age. The altitude of the platform is about 4,000 feet, and it formerly was buried by the upper unit of basin fill (early Pleistocene in age).

At 11 o'clock to 12 o'clock, the Gila Mountains—principally andesite flows and tuffs of middle Tertiary age.

At 3 o'clock, the upper unit of basin fill crops out beneath the flow that caps the northernmost peak of Hayes Mountains. The top of the peak (4,200 feet altitude) corresponds to the approximate top of the upper unit of basin fill in this area.

4.5 97.9 At this point, Peridot Mesa is in view from 9 o'clock to 11 o'clock. The vent tuff ring is the low rounded hill on the west side of the mesa with the lava flow extending out to the northeast. San Carlos Valley in the background consists of Tertiary lake beds and Gila-type conglomerate interbedded with numerous basalt flows.

4.0 101.9 Turn left off US 70 to Peridot, and continue north on State Route 170 towards the town of San Carlos. Just before reaching San Carlos, the road passes along the cliffs that form the terminus of the Peridot Mesa Lava flow. Note the lake beds beneath the flow.

3.8 105.7 San Carlos. From this point make a left turn on a road paralleling the mesa top.

0.5 106.2 Turn left on dirt road ascending to the mesa top. From this point on the trip will be described by your guides; the road is to be used only with proper permission.

4.3 110.5 Return to junction of US 70, but instead of returning to highway, continue south under bridge on road to San Carlos reservoir. For locations and descriptions of the following localities, refer to Appendix.

4.0 114.5 Flatiron Mesa lies directly south of the road. The flow capping the mesa is compositionally identical to the flow at Peridot Mesa.

4.0 118.5 Soda Springs. A small, black outcrop can be seen northwest of the road.

7.0 125.5 Return to junction of US 70.

27.0 152. 5 Black Hill (also called Black Point). Continue east on US 70 past the town of Bylas. Black Hill can be seen to the northeast of the highway. A small dirt road goes past the east side of the vent from the highway.

133.2 285.7 Return trip to Tempe.