XENOLITHS IN VOLCANIC ROCKS FROM MAUNA KEA VOLCANO, HAWAII

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OPEN-FILE REPORT 82-201

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

INTRODUCTION

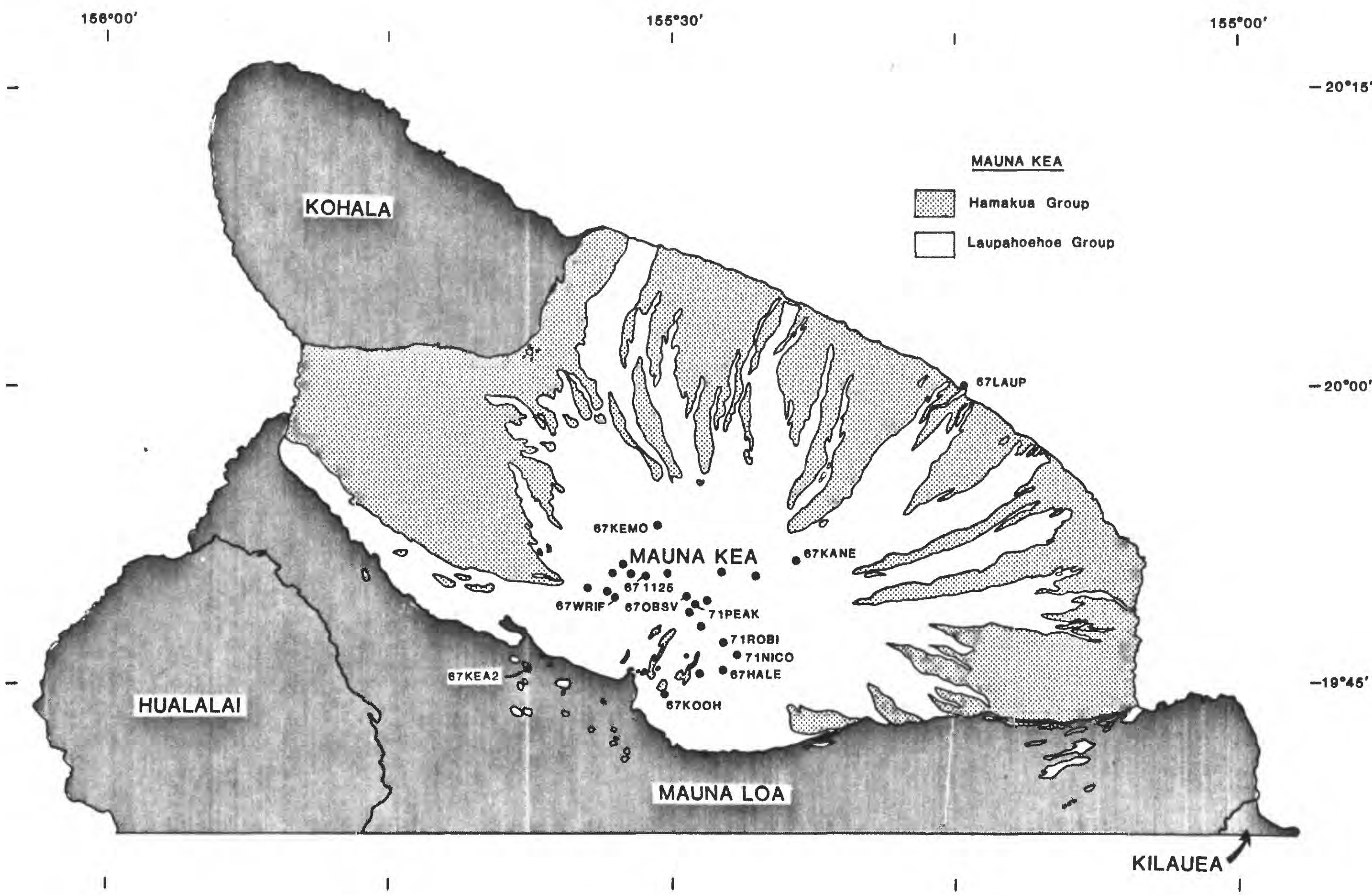
Mauna Kea volcano consists of the older Hamakua and the younger Laupahoehoe Groups of Porter (1979a & b). The Hamakua Group can be subdivided into a lower unit of olivine basalt and rare picritic basalt and an upper unit of olivine basalt, ankaramite, and andesite (hawaiite and mugearite) (Stearns and Macdonald, 1946). The lower unit represents the tholeiitic shield while the upper unit consists of alkalic lavas. The Hamakua Group is overlain by and separated from the younger Laupahoehoe Group of Porter (1979), by a 4 to 15 foot section of Pahala ash (Stearns and Macdonald, 1946). Porter (1979a & b) presented a detailed account of the Quaternary stratigraphy and chronology of the cinder cones, domes, tuff cones, and flows of basalt and andesite, that comprise the uppermost Hamakua and Laupahoehoe Group rocks. A great number of the cinder and ash cones contain scarce to abundant coarse grained xenoliths. Macdonald (1949) described several of the xenolith localities, whereas this report describes many more.

During the late 1960s and early 1970s, E. D. Jackson and his coworkers undertook a study of Hawaiian xenoliths. A part of this study was done on Mauna Kea volcano where xenolith counts were done at 12 locations. At locations where xenoliths were numerous, either 50, 100, or 200 xenoliths were measured, described, and their modal mineralogy estimated. Every 10th xenolith and other xenoliths of special interest were collected. The xenoliths were identified as being cumulate rocks, metamorphic (mantle) rocks, or veins. The descriptive details, as well as a subset of the rocks and their thin sections are in the Jackson collection at the U.S. National Museum. The interested reader should contact the curator of the Department of Mineral Science for more information.

SAMPLE LOCALITIES

The general sample locations are shown in Figure 1. The 67HALE count is from a cinder cone due west of Hale Pohaku. The xenoliths occur as cored bombs, fragments, and blocks in cinder of andesitic composition. The first 100 counts are from the south slope of the cone and the second 100 counts are from the west slope where both the blocks and inclusions are larger. The 67KOOH count is from Koohi cone, a Hamakua series cone. The cone is soil covered, but a gravel pit on the south edge exposes bombs, cinder and light-colored blocks. There are an unusually large number of cored bombs. The 67OBSV count is from the Mauna Kea summit cinder cone. The 67KANE count is from the west saddle of Puu Kanakaaleonui cinder cone. The 67KEMO count is from a roadcut on the north side of Puu Kemole, a cinder cone with a small flow at the north edge. The cinder cone is covered by 30 to 60 cm of soil, but contains bombs as large as 75 cm across and blocks of dense hawaiite containing inclusions as large as 45 cm across. The flow on the north side contains fairly abundant xenoliths as large as 8 cm. The 67-1125 count is from the northwest side of the central cone on an unnamed cinder cone with a summit elevation of 11253 ft. on the west rift of Mauna Kea. The cone has bombs as large as 2 m across and a few light-colored broken blocks, although none appear to be exotic. The 67WRIF count is from a cinder cone on the lower branch of the road up the west rift of Mauna Kea. The surface has a lag gravel of bombs with ash underneath. The bombs are as large as 90 cm across and occur with a few dense blocks which are not exotic. The 67KEA2 count is

Figure 1. Locations of the Mauna Kea xenolith counts on a map of the northern half of the island of Hawaii. The designated counts are listed in Table 1 with size and structural data.



from Puu Kea #2 on the Pohakuloa firing range. The hill is very weathered, but has a little lag gravel on the surface containing rare dunite xenoliths and bombs; blocks are quite rare and are not exotic. Most of the counted xenoliths are from excavated pits on the east edge of the hill. The 67LAUP count is from an ankaramite flow located at the second road turn of the old road northwest of Laupahoehoe stream. The 40-foot section appears to be a single flow with irregular contacts. The xenoliths are more abundant near the base of the flow. The 71ROBI count is from cone 12040 between Keanakakoi and Puu Keonehehee. The xenoliths are loose in the tuff, in bombs, or in light-colored blocks. Those in the blocks were not included in the count. The host tuff is probably mugearite in composition. The 71PEAK count is from a tuff cone at the top of the road down from the University of Hawaii Observatory platform. The host tuff is probably mugearite in composition. The 71NICO count is from the east slope and north rim of Puu Keonehehee. The tuff cone is black hawaiite and the xenoliths are present in dense blocks rather than loose in the tuff. Five 15-20 foot thick flows are exposed in the inner crater wall; only the lowest contains xenoliths. The counted xenoliths could be from this flow.

THE XENOLITHS

Size and structural data for the xenolith counts are given in Table 1. The vast majority of the xenoliths are angular to subangular and most are fairly small, being measured in tens of mm. A significant percentage are foliated while only a few have compositional layering. Grain size layering was not seen in any xenoliths. Most of the counted xenoliths are cumulate gabbro rich in clinopyroxene and generally containing olivine as well. The modes of the xenoliths from each locality are shown in Figures 2a to 2l on an unfolded olivine-clinopyroxene-plagioclase-chromite tetrahedral diagram. Counts 67HALE, 67KOOH, 671125, 67WRIF, 67KEA2, and 71ROBI also have abundant metamorphic dunite xenoliths.

Only three xenoliths have been analyzed and the results are listed in Table 2. Microprobe mineral analyses of the three analyzed xenoliths are given in Table 3. The microprobe data was reduced using program C-92-2 (Beeson, 1967). Table 4 gives the laboratory density and field modes of selected xenoliths.

DISCUSSION

Xenoliths were not found at all examined cones, nor were there always enough xenoliths present to count. Table 5 lists additional cones examined and a brief description of the localities.

It is noteworthy that the different types of xenoliths are not randomly distributed over the mountain. In particular, abundant 2-olivine dunite xenoliths and olivine-rich cumulate rocks are restricted to cones to the south and west of the summit. The cones to the north and east apparently do not contain 2-olivine dunite xenoliths. Porter (1972) proposed that a buried summit caldera exists to the southwest of the summit area and the presence of 2-olivine dunite and olivine-rich cumulate rocks could be related to the presence of this inferred buried caldera. However, we note that the caldera inferred by Porter (1972) is much smaller than the area where cones containing dunite xenoliths occur.

TABLE 1. Shape, size and structure of xenoliths from Mauna Kea

Count Identi-fication	Area of Count (sq.ft)	Number Counts	Angularity*			Percent Comp. Layering	Percent Foliated	Percent Veins	Arith. Mean Diameter (mm) Xeno	Median Diameter		1st Quartile		3rd Quartile		Mean Diameter of Dunite (mm)
			%A	%S	%R					(mm)	-ø	(mm)	-ø	(mm)	-ø	
67-HALE	10,000	191	42	42	16	9	21	<1	31.5	22.6	4.50	10.9	3.45	39.4	5.30	33.4
67-KOOH	12,000	100	28	55	17	2	26	7	41.8	30.3	4.92	19.0	4.25	46.9	5.55	42.3
67-OBSV		133	46	35	19	6	44	<1	59.2	44.6	5.48	21.1	4.40	73.5	6.20	-
67-KANE	35,000	101	77	18	5	1	9	2	20.2	12.1	3.60	6.6	2.72	21.1	4.40	-
67-KEMO	12,600	100	45	47	8	3	25	2	49.3	36.8	5.20	23.4	4.55	53.8	5.75	-
67-1125	1,500	92	29	58	13	2	11	7	29.1	16.0	4.00	11.3	3.50	32.0	5.00	29.4
67-WRIF	9,000	100	42	46	12	2	26	1	25.8	13.5	3.75	9.2	3.20	28.8	4.85	25.8
67-KEA2	$25x10^6$	100	30	29	41	3	5	10	37.0	26.9	4.75	15.5	3.95	46.9	5.55	34.9
67-LAUP	400	98	58	31	11	0	9	0	13.4	10.2	3.35	6.7	2.75	13.5	3.75	-
71-PEAK	10,000	100	37	42	21	1	13	0	58.6	46.9	5.55	28.8	4.85	61.4	5.84	-
71-NICO	4,250	50	45	43	12	2	14	0	15.7	7.1	2.82	5.5	2.45	16.0	4.00	-
71-ROBI	10,000	100	87	13	0	0	15	0	11.5	8.9	3.15	6.1	2.60	11.3	3.50	7.5

*A = angular; S = subangular; R = rounded
None of the counted xenoliths have size layering.

Figure 2. Field estimated modal mineral abundance data for individual xenoliths from each count listed in Table 1. Points with a single xenolith are designated as ● ; those with two xenoliths as ● ; those with more than two xenoliths by ● and an adjacent number.

Fig. 2a.

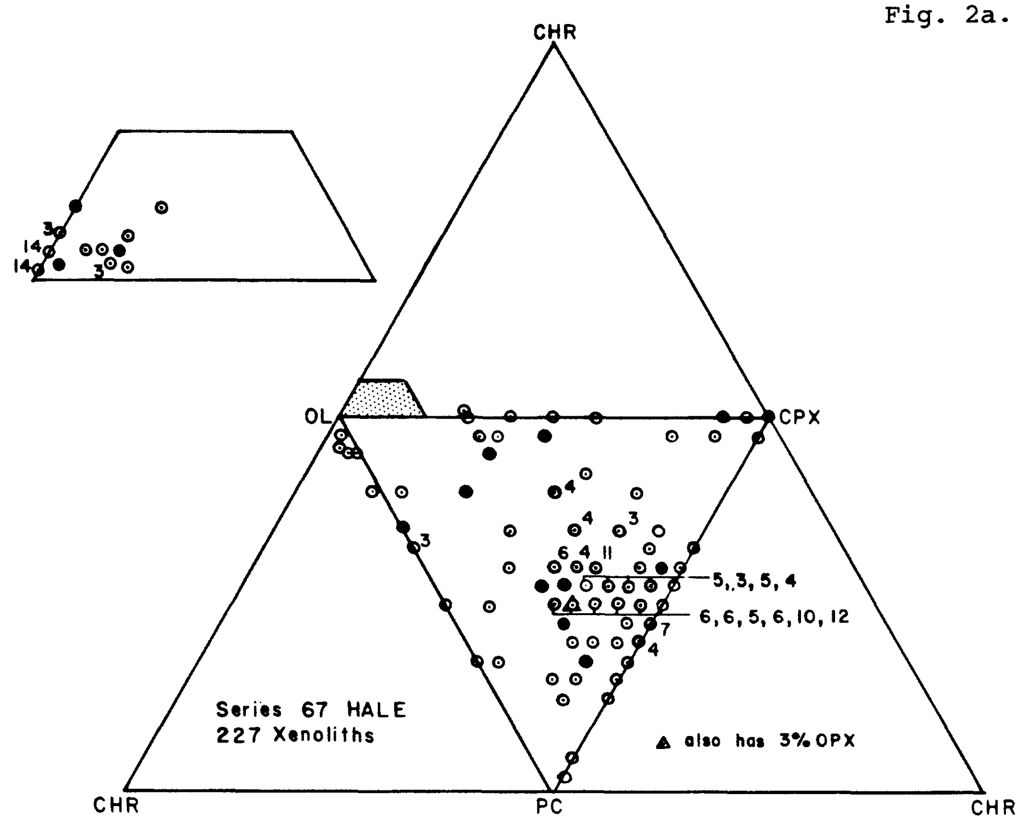

CHR
OL
CPX
CHR
PC
CHR
5, 3, 5, 4
6, 6, 5, 6, 10, 12
Series 67 HALE
227 Xenoliths
▲ also has 3% OPX

Fig. 2b.

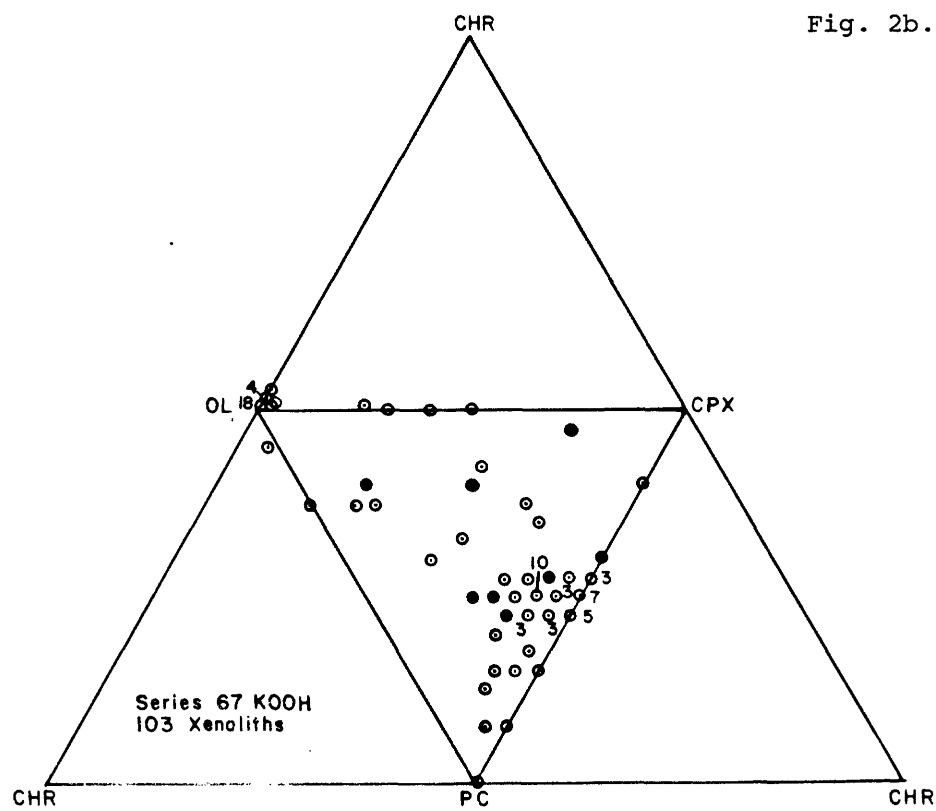

CHR
OL
CPX
CHR
PC
CHR
Series 67 KOOH
103 Xenoliths

Fig. 2c.

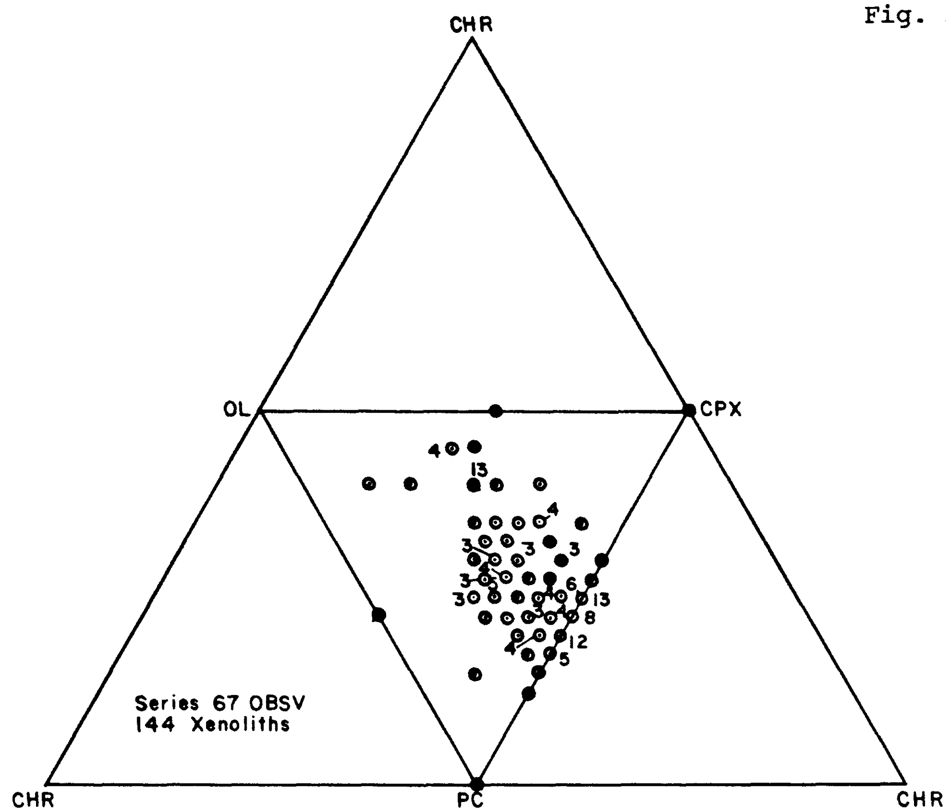

CHR
OL
CPX
CHR
PC
CHR
Series 67 OBSV
144 Xenoliths

Fig. 2d.

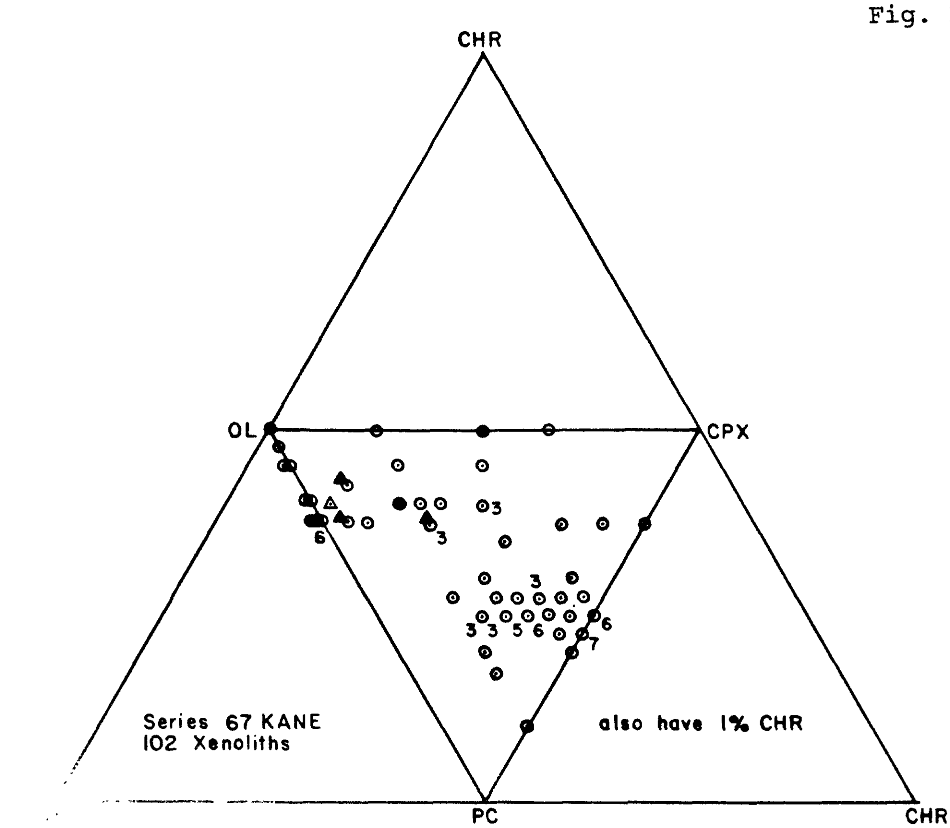

CHR
OL
CPX
CHR
PC
CHR
Series 67 KANE
102 Xenoliths
also have 1% CHR

Fig. 2e.

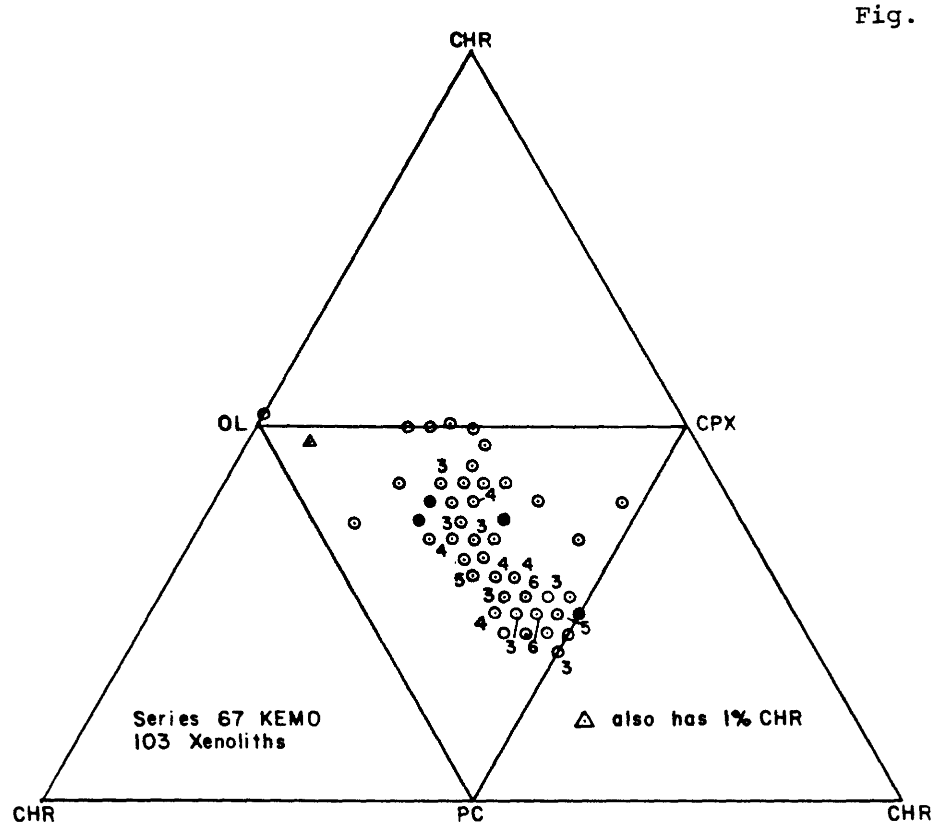

CHR
OL
CPX
Series 67 KEMO
103 Xenoliths
also has 1% CHR
CHR
PC
CHR

Fig. 2f.

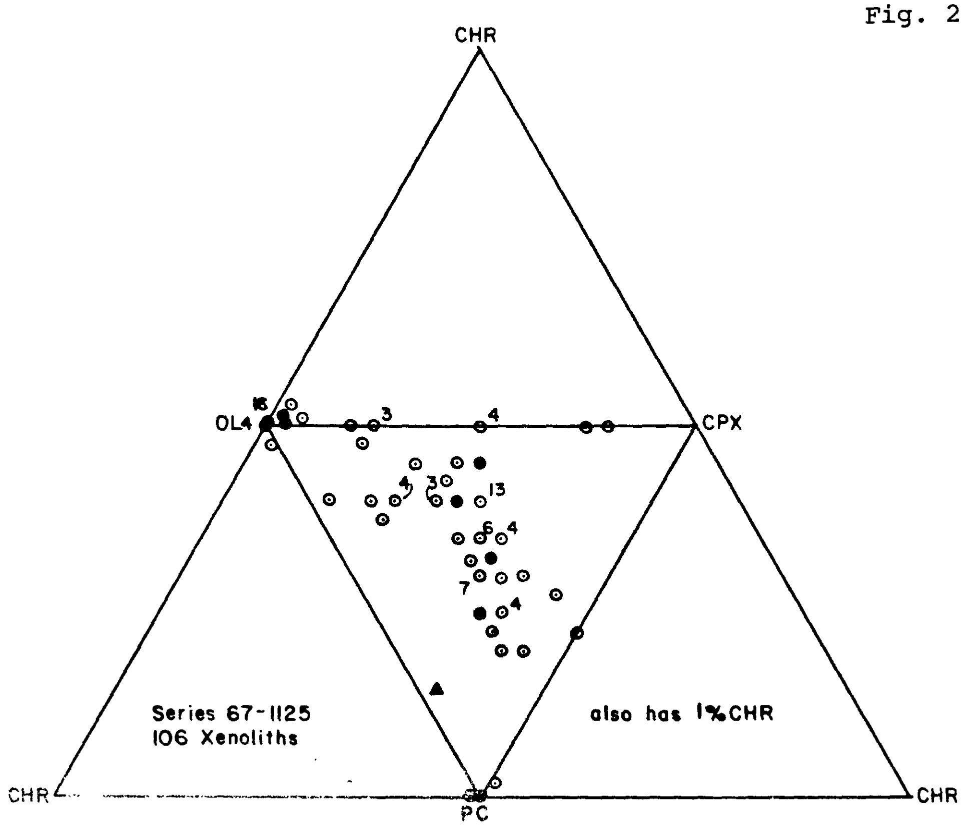

CHR
OL
CPX
Series 67-1125
106 Xenoliths
also has 1% CHR
CHR
PC
CHR

Fig. 2g.

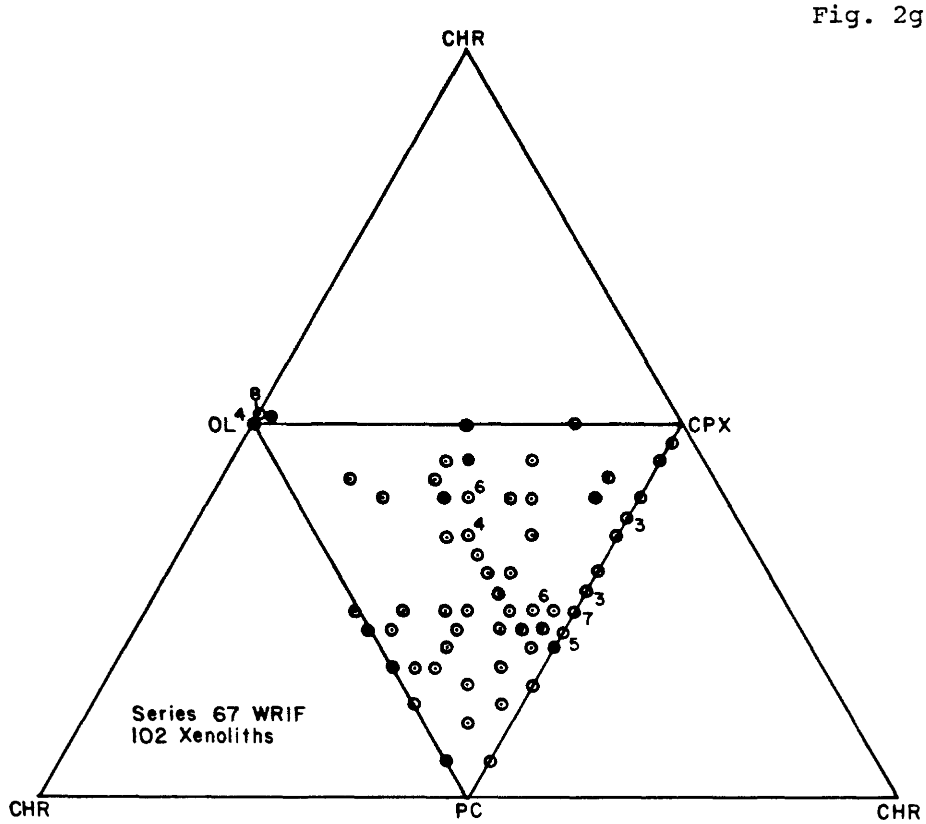

CHR
OL
CPX
Series 67 WRIF
102 Xenoliths
CHR
PC
CHR

Fig. 2h.

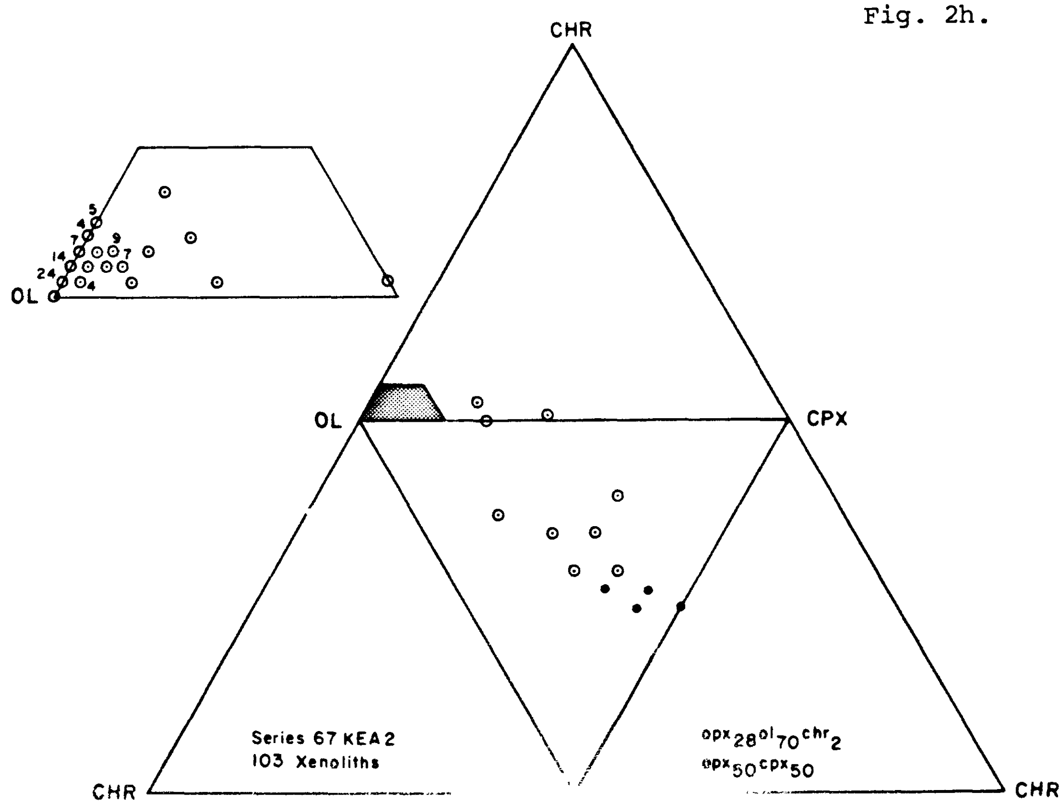

CHR
OL
OL
CPX
Series 67 KEA 2
103 Xenoliths
opx28ol70chr2
opx50cpx50
CHR
CHR

Fig. 2i.

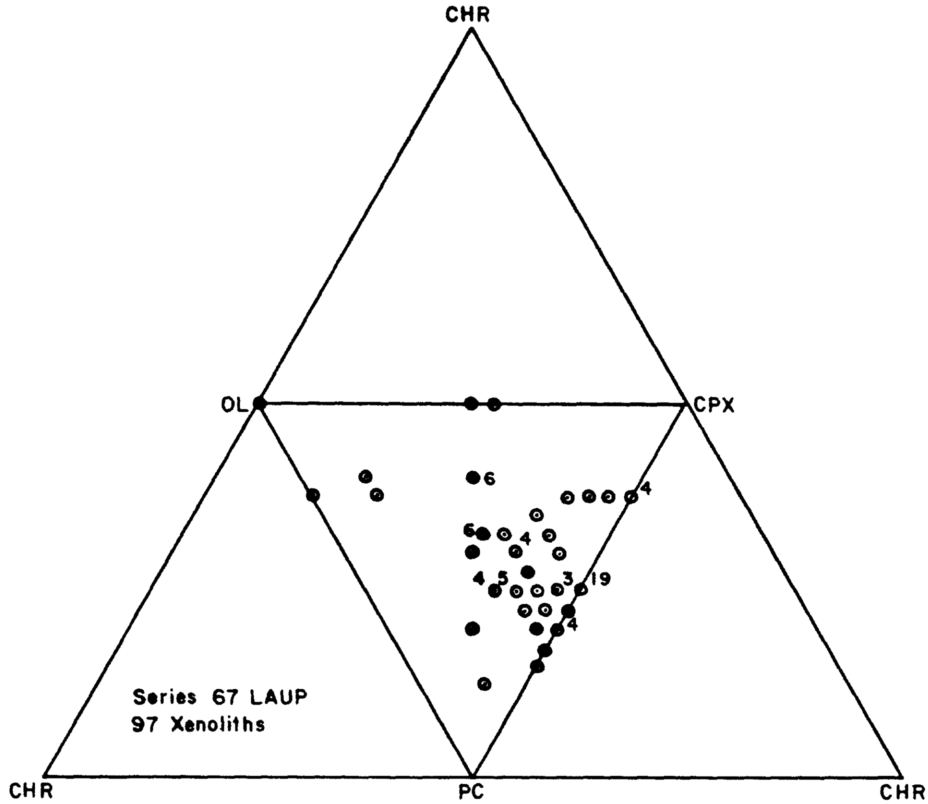

CHR
OL
CPX
6
6
4
4
5
3
19
4
4
Series 67 LAUP
97 Xenoliths
CHR
PC
CHR

Fig. 2j.

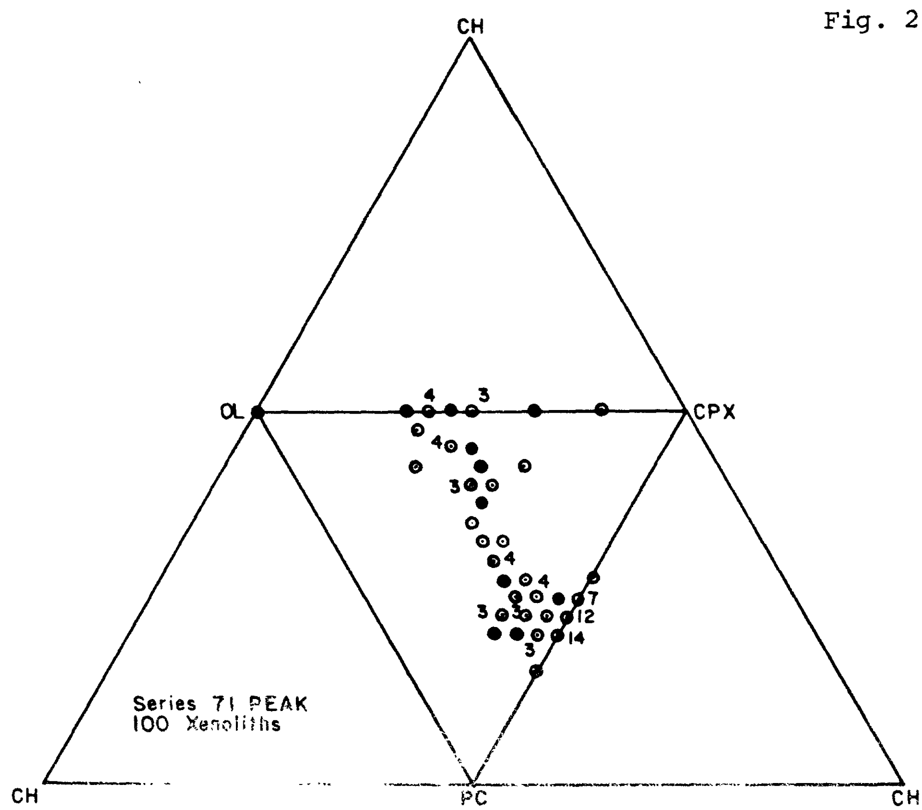

CH
OL
CPX
4
3
4
3
4
4
7
3
12
14
3
Series 71 PEAK
100 Xenoliths
CH
PC
CH

Fig. 2k.

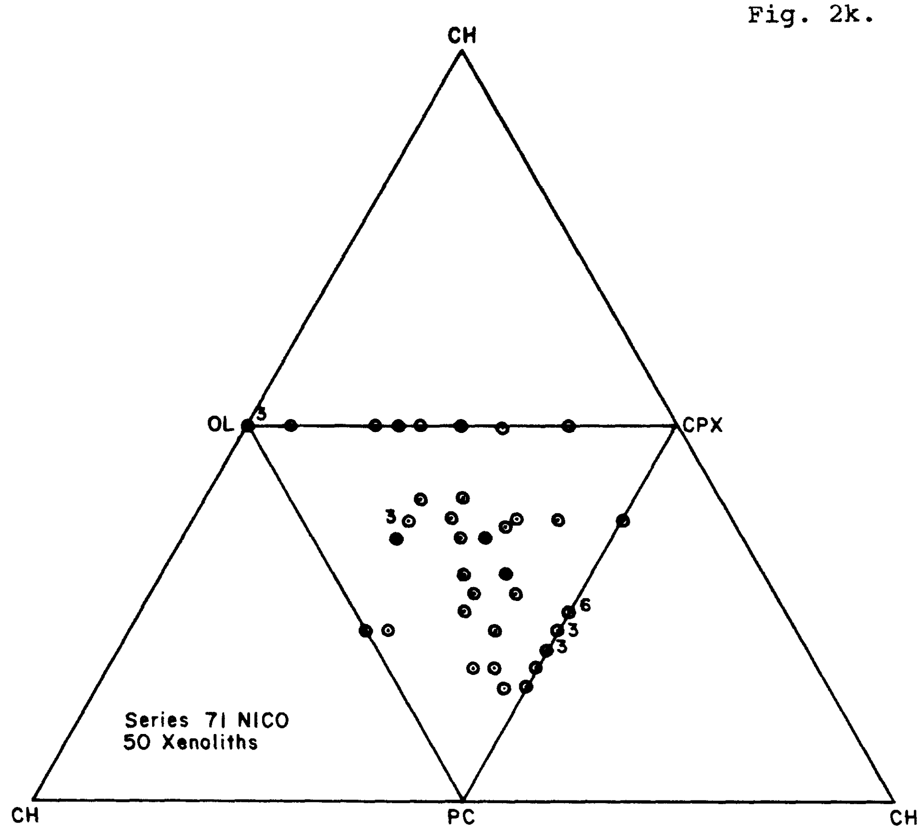

CH
OL
CPX
3
3
6
3
3
Series 71 NICO
50 Xenoliths
CH
PC
CH

Fig. 2l.

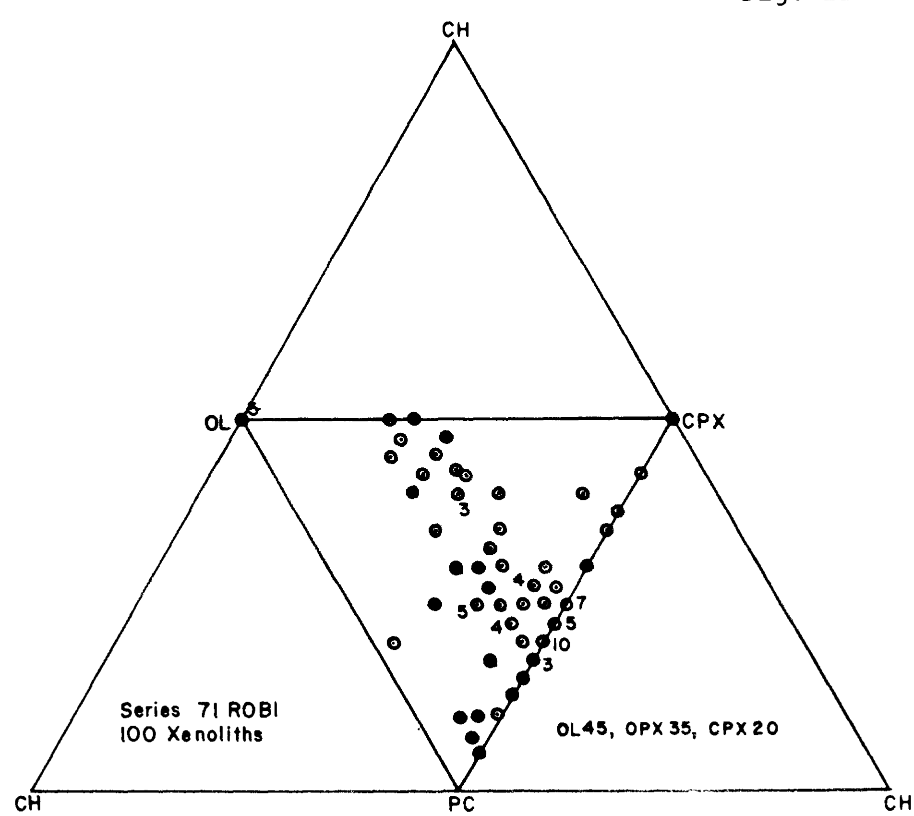

CH
OL
CPX
3
4
7
5
5
4
10
3
Series 71 ROBI
100 Xenoliths
OL45, OPX 35, CPX 20
CH
PC
CH

TABLE 2. Major element chemistry of xenoliths from Mauna Kea*

	67-1125-2 2px gabbro	67-KOOH-50 ol gabbro	67-KEA2-54 gabbro
SiO_2	51.23	49.47	49.81
Al_2O_3	16.98	11.86	16.29
Fe_2O_3	2.67	2.68	1.43
FeO	4.68	7.89	5.76
MgO	8.22	14.06	9.48
CaO	11.95	10.64	12.62
Na_2O	2.51	1.32	2.24
K_2O	.14	.08	.03
H_2O^+	.08	.12	.18
H_2O^-	.03	.08	.07
NiO	.02	.05	.03
Cr_2O_3	.05	.15	.11
TiO_2	1.29	1.40	1.77
P_2O_5	.03	.02	.11
MnO	.13	.16	.12
CO_2	.01	.02	.01
Total S	.00	.00	.00
Subtotal	100.02	100.00	100.06
Less O	.00	.00	.00
Total	100.02	100.00	100.06
		Field Modes	
Ol	-	10	tr
CPX	25	40	50
OPX	25	tr	tr
PC	50	50	50

* Analysts: Major element wet chemical analyses by E. Engleman; Cr_2O_3 determined colorimetrically, and NiO by atomic absorption spectrophotometry by R. L. Rahill.

TABLE 3. Microprobe Mineral Compositions in Mauna Kea Xenoliths

	Clinopyroxene					Orthopyroxene					
	67KEA2-54		67KOOH-50	67-1125-2		67KEA2-54			67KOOH-50		67-1125-2
	cpx-1	cpx-2	cpx-1	cpx-2	cpx-3	opx-1	opx-2	opx-3	opx-1	opx-2	opx-1
SiO_2	52.40	52.19	51.65	51.76	51.80	53.43	53.24	53.26	53.83	53.26	53.22
Al_2O_3	2.40	2.24	2.67	2.11	2.14	1.02	1.29	1.23	1.23	1.41	1.11
FeO*	6.50	6.37	6.29	9.14	8.93	16.56	17.90	16.71	15.75	17.46	18.02
MgO	15.44	14.88	14.68	14.97	14.66	27.70	26.88	27.17	28.20	27.15	25.73
CaO	22.12	22.57	21.98	21.83	21.01	.64	.70	.80	.77	.79	1.17
Na_2O	.37	.33	.35	.33	.33	-	-	-	-	-	-
MnO	.19	.17	.18	.21	.22	.38	.40	.40	.32	.36	.39
TiO_2	.62	.72	.87	.65	.72	-	-	-	-	-	-
Cr_2O_3	.15	.17	.20	.12	.08	-	-	-	-	-	-
Total	100.19	99.63	98.87	101.10	99.88	99.73	100.41	99.58	100.10	100.41	99.63

	Plagioclase				
	67KEA2-54	67KOOH-50	67-1125-2		
	pc-1	pc-1	pc-1	pc-2	pc-3
SiO_2	51.63	51.17	52.96	53.37	52.27
Al_2O_3	30.48	30.58	29.32	29.40	29.95
Fe_2O_3	.45	.41	.57	.62	.59
CaO	12.55	13.13	11.81	11.46	12.67
Na_2O	4.50	4.23	4.71	4.81	4.26
K_2O	.04	.15	.20	.21	.17
Total	99.65	99.66	99.57	99.86	99.90

	Olivine	
	67KEA2-54	67KOOH-50
	ol-1	ol-1
SiO_2	36.39	36.93
FeO	26.47	25.26
MgO	34.71	36.70
NiO	.21	.25
MnO	.30	.31
CaO	.13	.07
Total	98.21	99.52

TABLE 4. Field modes and density of selected samples*

	Ol	Ol"	OP	CP	PC	Ch	ρ.		Ol	Ol"	OP	CP	PC	Ch	ρ.
63MK-1A	95		5				3.09	67KEMO-10	20			35	45		2.90
-1B	30		2	18	50		3.00	-11		85		10	4	1	3.27
-1G							3.16	-13	40			30	30		3.04
-2	20		60		20		3.18	-17	65			35			3.15
-3			80		20		3.34	-20	35			60	5		3.23
-5			80		20		3.34	-23	25			35	40		2.84
-6			10	40	45	5	2.98	-29	10			40	50		2.89
-8	20		80				3.28	-30	20			40	40		3.18
-10	100						3.29	-34	45			35	20		3.13
-11	5		15		65	15	2.95	-40	10			60	30		3.10
-13							3.04	-50	15			40	45		3.10
-14							2.75	-55A	35			50	15		3.21
67-KAN-5							2.82	-55B	50			35	15		3.21
67-MCI-3							2.93	-59ABC	20/5/30			40/50/30	40/45/40		2.98
67-108-2							2.47	-60	30			35	35		2.94
-3							2.86	-61	35			35	30		3.13
-5							3.00	-62	5			45	50		3.00
-6							2.93	-76	10			45	45		2.84
66-MK-2							3.21	-79	50			25	25		3.15
-3							3.35	-80				50	50		2.92
67-KANE-31	10			40	50		2.88	-95	5			45	50		2.87
-50	65			25	10		3.21	65-1125-2			25	25	50		2.94
-67	70			5	25		3.19	-4	25			4	70	1	2.80
-71	50			25	24	1	2.98	-10	40			40	20		3.23
-76	35			20	45		2.85	-70A	45			35	20		3.07
-80	35			20	45		3.26	-90	60	39				1	3.35
-88	21			25	42		2.97	-100	20			25	55		2.77
-90	20			30	50		3.18	67-WRIF-10	45			45	10		3.21
-92	50			25	25		3.25	-20	50	50					3.30
-97	15			40	45		2.73	-40	45			35	20		3.11
-100	5			45	50		2.83	-70	30			35	35		2.86
67-KEMO-2	25			55	20		3.26	-79				50	50		2.86
-3	50	42				3	3.28	-90	40			40	20		3.27
-6	30			30	40		2.93	67-KEA2-1			50	50			3.31
-7	60			40			3.05	-9	10			45	45		2.75

TABLE 4 . (Cont.)

	Ol	Ol"	OP	CP	PC	Ch	ρ.
67-KEA2-20	20			40	40		2.85
-26	10			45	45		3.01
-30	50	45		3	2		3.32
-33		90		6	4		3.26
-35	10			40	50		2.96
-37A	95			4		1	3.29
-37B	55			43		2	3.29
-43	96					4	3.20
-51	20			35	45		2.99
-52A	60	30		9		1	3.33
-52B	60	39				1	3.33
-52C	60	20		19		1	3.33
-53A	75	15		3		7	3.32
-53B	50	20		25		5	3.32
-54				50	50		2.91
-62		98				2	3.35
-70	30			30	40		3.16
-86	10			40	50		3.18
67-HALE-10	98			1		1	3.22
-17	50	44		4		2	3.27
-26A	5			45	50		2.84
-26B	10			45	45		2.84
-30	25			25	50		3.03
-40A				40	60		2.98
-40B	5			50	45		2.98
-50A	20			40	40		3.05
-50B	45			20	35		3.05
-59		95		4		1	3.06
-60A				50	50		2.95
-60B				40	60		2.95
-70	25			35	40		3.00
-100	10			30	60		2.91
-109A	30			30	40		2.95
-109B	25			25	50		2.95
-110	30			30	40		3.16

	Ol	Ol"	OP	CP	PC	Ch	ρ.
67-HALE-111	92				4	4	3.30
-116	95			3		2	3.12
-120	30			40	30		2.98
-121A	5			45	50		2.80
-121B	10			40	50		2.80
-130	10			85	5		2.76
-140	15			40	45		2.92
-150A	20			40	40		3.37
-150B	50			50			3.37
-154	20			25	55		2.86
-168	5			50	45		3.00
-171	45			40	15		3.26
-174A	10			60	30		2.87
-174B	30			5	65		2.87
-180A	80	18				2	3.33
-180B	50	5		40	4	1	3.33
-187A	60			35	5		2.93
-187B	5			35	60		2.93
-193A	5			45	50		2.85
-193B				5	95		2.85
67-KOOH-8	25			70	5		3.02
-30	10			40	50		2.92
-40	50	49				1	3.20
-55	20	79				1	3.24
-58	20			30	50		2.95
-60				55	45		3.07
-66	10			70	20		3.13
-69	25			50	25		2.84
-70	50	25		24		1	3.10
-77	5			45	50		2.95
-80A	5			50	45		2.67
-80B				15	85		2.67
-80C	5			25	70		2.67
67-OBSV-2	25			45	30		2.85
-8A	25			55	20		3.12

TABLE 4. (Cont.)

	Ol	Ol"	OP	CP	PC	Ch	ρ.
67-OBSV-8B	25			30	45		3.11
-10	20			35	45		2.90
-11	5			40	55		2.81
-13A	20			25	55		2.98
-13B	40			40	20		3.07
-19	5			35	60		2.82
-20	10			50	40		2.89
-25	15			50	35		2.87
-26	35			45	20		3.07
-30	35			35	30		2.99
-32	25			50	25		2.98
-42				50	50		3.03
-50	30			30	40		2.95
-51				50	50		2.83
-52				50	50		2.69
-53	5			45	50		3.29
-59A				35	65		2.81
-59B	20			40	40		2.81
-60	40			40	20		3.12
-68A	10			40	50		3.04
-68B				50	50		3.04
-70	5			40	55		2.72
-74A	15			50	35		3.13
-74B	15			15	70		3.08
-80				45	55		3.06
-90				55	45		3.05
-93	10			60	30		3.16
-110	20			40	40		2.91
-112	25			35	40		3.03
-117	20			55	25		2.98
-120	5			35	60		2.85
-121A	20			50	30		2.93
-121B	45			45	10		2.97
-121C	20			50	30		2.93
-126	25			25	50		2.92
67-OBSV-129	20			35	45		3.02
-130	20			40	40		3.01

* Ol = deformed olivine; Ol" = recrystallized olivine; OP = orthopyroxene; CP = clinopyroxene; PC = plagioclase; Ch = chromite. Density is in gm/cm^3

Table 5 . List of all Locations Examined for Xenoliths

Quadrangle	Latitude (19°)	Longitude (155°)	Elevation (ft)	Xenoliths present	Sample ID	Location Name
MAKAHALAU	52.92'	31.83'	7800	yes	67KEMO	Kemole
UMIKOA	53.72'	24.65'	8520	no	67PUK-1	Pau Kea
	54.48'	29.48'	7600	rare	67LUA 1-3	Kaluamakani
	54.36'	29.78'	7400	no	67LUA-4	Kaluamakani
KEAMUKU	46.20'	37.55'	5640	yes	67KEA-2	Puu Kea
AHUMOA	49.97'	30.08'	12800	yes		
	50.42'	31.26'	11050	yes	67-1125	
	50.11'	31.62'	11080	yes		
	50.30'	31.76'	10880	yes		
	50.65'	32.10'	10240	in flow		
	50.18'	32.11'	10700	yes	67-108	
	50.31'	32.50'	10600	yes	67MCD 1-4	
	50.53'	32.72'	10320	yes		
	50.58'	32.86'	10260	in flow		
	50.68'	33.28'	9720	yes		
	50.72'	33.59'	9240	no	67PUK 1-2	
	50.73'	33.82'	9020	no	67AHA-1	Puu Nanaha
	49.74'	34.12'	8830	yes		
	49.60'	34.13'	9000	no		
	49.53'	33.27'	9760	no	67-9928-1	
	49.59'	33.02'	10000	yes		
	49.38'	32.89'	10040	yes	67WRIF	
	45.71'	31.30'	7154	no		
	48.73'	36.84'	7042	no		Puu Ahumoa
	45.04'	35.82'	6082	no		
MAUNA KEA	51.30'	26.33'	12075	no		
	51.54'	23.70'	9480	yes	67-KANE	Puu Kanakoleonui
	52.02'	23.13'	9160	no	67HOL	Puu Holei
	50.73'	25.86'	12414	rare		Puu Makanaka
	50.74'	26.82'	12610	no		
	50.26'	26.88'	12679	no		
	50.63'	27.52'	12600	no		
	50.56'	27.50'	12520	in flow		
	50.34'	27.80'	13154	no		
	49.65'	29.69'	13186	no		
	49.46'	29.06'	13600	yes	67OBSV	Puu Poliahu
	49.42'	28.25'	13796	yes	71PEAK	
	49.62'	27.90'	13080	rare		
	49.01'	28.66'	13280	yes		
	48.83'	29.86'	13060	in flow		Waiau
	48.28'	28.26'	12420	in flow		Keanakakoi (quarry)
	47.70'	27.74'	12080	rare	71ROBI	
	49.34'	23.30'	9096	no		Puu Kaiwiiwi
	47.12'	27.51'	11400	yes	71NICO	
	47.24'	27.14'	11606	no		Puu Keonehehee
	45.59'	28.23'	9400	yes		Puu Haiwahine
	45.92'	27.88'	9668	yes	67HALE	To west of Hale Pohaku
	45.41'	27.69'	9394	yes		Puu Kalepeamon
	45.61'	26.98'	9003	no		
	45.14'	27.30'	8996	no		
	47.82'	24.63'	10080	no		
	45.02'	25.33'	8819	no		
PUU AKALA	45.22'	22.00'	6860	no		
PUU OO	44.84'	27.56'	8470	no		
	44.46'	28.10'	8170	no		
	43.40'	27.46'	7612	no		
	43.82'	27.12'	7884	no		Hookomo
	43.92'	23.78'	6918	no		Puu Oo
	43.27'	26.50'	7200	no		
	43.46'	26.13'	7320	no		
	43.65'	25.88'	7656	no		Loaloa
	43.14'	29.25'	6973	no		
	42.88'	29.32'	6973	no		
	42.48'	29.40'	7017	no		
	42.20'	29.45'	6916	no		
	42.90'	29.93'	7091	no		Omaokoili
PUU KOLI	44.65'	35.93'	5800	yes		
	44.20'	33.64'	6246	no		
	44.71'	30.45'	6800	yes	67KOOH	Puu Koohi
	42.71'	32.92'	6515	no		
	(20°)	(155°)				
KUKUIHAELE	05.65'	32.98'	1470	yes		
PAPAALOA				yes	67LAUP	Laupahoehoe point

Note:
Underlined sample identifications have had counts done; see Table 1. Others indicate single to several samples collected. All samples are in the Jackson collection at the National Museum.

Although many of the host lavas and tuffs have not been analyzed, there is an apparent correlation between the host rock type (alkalic basalt, hawaiite, mugearite) and the xenolith assemblage present with olivine-rich cumulate and 2-olivine dunite xenoliths more abundant in the more mafic lavas. This suggests that many of the xenoliths are cognate wall-rock from the crystallizing magma chamber from which the host lavas erupted. However, the presence of rare orthopyroxene-bearing cumulate xenoliths at several of the cones indicates that at least some of the cumulates formed by crystallization of a tholeiitic magma. These could be cumulate rocks crystallized from the earlier tholeiitic shield building Hamakua Group magmas or fragments of oceanic crustal layer 3. The 2-olivine dunite xenoliths are similar to those from many other localities in Hawaii. They may represent deformed olivine cumulates crystallized from the tholeiitic shield-building lavas as proposed by Sen and Presnall (1980) for the Koolau shield on Oahu. If these rocks are crystal cumulates from a tholeiitic magma chamber, the buried caldera may have been considerably larger than inferred by Porter (1972).

ACKNOWLEDGMENTS

Rick Murnane and Walt Friesen compiled most of the data in this report from E. D. Jackson's field notes.

REFERENCES

Beeson, M. H., 1967, A computer program for processing electron microprobe data, U.S.G.S. Open-file Report.

Macdonald, G. A., 1949, Petrography of the island of Hawaii, U.S. Geol. Surv. Prof. paper, 214 D, p. 51-93.

Porter, S. C., 1972, Buried caldera of Mauna Kea Volcano, Hawaii, Science, 175, p. 1458-1460.

Porter, S. C., 1979a, Quaternary stratigraphy and chronology of Mauna Kea, Hawaii: A 380,000 year record of mid-Pacific volcanism and ice-cap glaciation: Summary, Geol. Soc. Am. Bull., Part I, 90, p. 609-611.

Porter, S. C., 1979b, Geologic map of Mauna Kea Volcano, Hawaii, Geol. Soc. Am. Map and Chart Series, MC-30.

Sen, G., and Presnall, D. C., 1980, Dunite nodules of the Koolau shield, Hawaii: Crystal cumulates from a tholeiitic magma chamber, Geol. Soc. Am. Abstracts with Programs, 12 (7), p. 519.

Stearns, H. T., and Macdonald, G. A., 1946, The geology and ground-water resources of the island of Hawaii, Hawaiian Division of Hydrography Bull. 9, 363 pp.