Appendix H. Supplementary Material to Support Chapter 8

Tables H1–H3 contain accumulated earthquake counts and moment for all regions plotted in figures 8.11 and 8.12.

Table H4a gives volumes of the three magma batches erupted at Halema‘uma‘u in 1952, 1961, and 1967-68 that are identified in eruptions between 1952 and the beginning of the Mauna Ulu eruption in May 1969. Table H4b gives additional volumes inferred for intrusions over the same period of time. See text for interpretations using these quantities.

Figure H1 shows the location of edm and Global Positioning System (GPS) stations used in constructing figures 8.8 and 8.9.

Appendix table H1. Accumulated counts and moment release from 1/1/1950 to 11/29/1975

Stage	Region[i]	cum cts	Cts/yr	Cum mom	Mom/yr	Acc adj mom[ii]	Comment
pre-1952	**ms1**	53	21.30	1.489	0.599		Period of inflation from March 5 1950 to the beginning of the 1952
1/1/1950	**ms2.3**	7	2.82	7.469	3.005		Halemaʻumaʻu eruption on June 27, 1952
6/27/1952	**ms4.5**	21	8.45	361.24	145.31		
908 days	**ms5gln**	1	0.4	0.0281	0.0113		40-60 km deep earthquakes north of Kīlauea caldera; precursors to the
2.486 years	**er1**	0	0	0	0		1959 eruption in Kīlauea Iki 11/14/-12/20/1959
	er2.3	36	14.5	13.673	5.500		
	er4.5	8	3.22	2.333	0.938		
	koae	27	10.9	10.4143	4.1892		Koaʻe crisis of December 8-12/1950; deep magma supply earthquakes
	sf1	1	0.4	0.2214	0.0891		and shallow events associated with cracking across the Koaʻe fault
	sf2.3	73	29.4	1193.919	480.26		zone
	sf4	7	2.82	95.7915	38.533		Offshore south flank crisis affecting all regions with many earthquakes recorded on Oahu
1952-1961	**ms1**	743	85.8	34.343	3.965		Period from the beginning of the 1952 Halemaʻumaʻu eruption to the
6/27/1952	**ms2.3**	118	13.6	13.688	1.580		beginning of the 1961 Halemaʻumaʻu eruptions
2/24/1961	**ms4.5**	153	17.7	155.892	17.996		
3164 days	**ms5gln**	378	43.6	39.662	4.579		Buildup to eruption in Kīlauea Iki on November 14, 1959
8.663 years	**er1**	147	17.0	20.495	2.366		Buildup to eruption on lower east rift zone on February 28, 1955
	er2.3	88	10.2	35.965	4.152		
	er4.5	55	6.35	4.389	0.507		
	koae	29	3.35	3.564	0.412		
	sf1	40	4.62	6.225	0.719		
	sf2.3	160	18.5	760.457	87.787		M 6.2, 6.6 earthquakes on March 30, 1954
	sf4	8	0.92	0.979	0.113		
1961-1967	**ms1**	59	8.81	3.074	0.459		Period from the beginning of the 1961 Halemaʻumaʻu eruptions to the
2/24/1961	**ms2.3**	51	7.62	3.673	0.549		beginning of the 1967-68 Halemaʻumaʻu eruption
11/5/1967	**ms4.5**	717	107.0	56.137	8.386		Beginning in 1960 20-35 km deep earthquake swarms beneath Kīlauea
2445 days	**ms5gln**	0	0	0	0		caldera supplant the 40-60 km deep earthquakes north of the caldera
6.694 years	**er1**	24	3.59	0.922	0.138		
	er2.3	117	17.5	9.988	1.492		
	er4.5	56	8.37	1.369	0.205		
	koae	256	38.2	6.900	1.031		
	sf1	63	9.41	5.273	0.788		
	sf2.3	1383	207.0	98.653	14.738		
	sf4	50	7.47	3.331	0.498		

Appendix table 8.1 cont. Accumulated counts and moment release from 1/1/1950 to 11/29/1975

Stage	**Region**[i]	cum cts	cts/yr	cum mom	mom/yr	cum adj mom[ii]	Comment
1967-1969	**ms1**	193	125.0	3.086	1.991		1967-68 Halemaʻumaʻu eruption and the buildup to the east rift Mauna Ulu eruption
11/5/1967	**ms2.3**	84	54.2	2.751	1.775		
5/24/1969	**ms4.5**	233	150.0	10.902	7.035		
566 days	**ms5gln**	0	0	0	0		
1.550 years	**er1**	4	2.58	0.0377	0.0243		
	er2.3	230	148.0	1.320	0.852		
	er4.5	55	35.5	0.5956	0.3844		
	koae	24	15.5	0.631	0.407		
	sf1	14	9.03	0.257	0.166		
	sf2.3	1058	683	26.230	16.927		
	sf4	13	8.39	0.178	0.115		
1969-1974	**ms1**	1454	287.0	6.700	1.324		Mauna Ulu eruption
5/24/1969	**ms2.3**	802	159.0	4.826	0.954		
6/15/1974	**ms4.5**	1272	251.0	55.343	10.938		
1848 days	**ms5gln**	0	0	0	0		
5.060 years	**er1**	38	7.51	0.589	0.116		
	er2.3	1776	351.0	8.999	1.779		
	er4.5	1228	243	6.358	1.257		
	koae	360	71.2	6.392	1.263		
	sf1	47	9.29	0.676	0.134		
	sf2.3	7031	1390	135.256	26.733		
	sf4	654	129	33.835	6.687		
Pre-1975 eq	**ms1**	273	187	3.104	2.131		End of Mauna Ulu eruption to the M 7.2 south flank earthquake
6/15/1974	**ms2.3**	185	127	3.408	2.340		
11/29/1975	**ms4.5**	273	187	25.994	10.981		
532days	**ms5gln**	0	0	0	0		
1.457 years	**er1**	1	0.69	0.0067	0.0046		
	er2.3	516	354	2.675	1.837		
	er4.5	933	641	11.831	8.123		
	koae	19	13	0.562	0.386		
	sf1	4	2.75	0.05	0.0343		
	sf2.3	2085	1431	124.090	85.195		
	sf4	827	568	75.386	51.757		

[i] Regions shown in chapter 1, figure 1.3

[ii] Moment of earthquakes of M≥6.0 is counted as "0" and shown on plots with a symbol (↑) accompanied by date, magnitude and true moment

Appendix table H2. Accumulated counts and moment release from 1/1/1976 to 1/1/1982[1]

Stage	Region[2]	cum cts	Cts/yr	Cum mom	Mom/yr	Acc adj mom[3]	Comment
1976-1982 short-period seiimicity	**ms1**	393	65.50	11.26	1.88		No earthquakes exceed M 6.0 in any region during this period
	ms2.3	63	10.50	1.37	0.23		
	ms4.5	337	56.17	6.02	1.00		
	ms5gln	0	0	0	0		
	er1	146	24.33	1.700	0.28		
	er2.3	2518	419.67	53.63	8.94		
	er4.5	1647	274.50	34.29	5.72		
	koae	199	33.17	12.44	2.07		
	sf1	293	48.83	6.21	1.04		
	sf2.3	9904	1650.6	447.38	74.56		
	sf4.5	600	100.00	6.06	1.01		
1976-1982 long-period seismicity	**lpms1**	335	55.83	2.77	0.46		
	lpms2.3	50	8.33	0.54	0.09		
	lpms4.5	69	11.50	0.80	0.13		

[11] Counts and moment in all regions include continuing aftershocks associated with the M 7.2 earthquake of 11/29/1975
[2] Regions shown in appendix figure
[3] Moment of earthquakes of M ≥ 6.0 is counted as "0" and shown on plots with a symbol (↑) accompanied by date, magnitude and true moment

Appendix table H3a. Accumulated short-period counts and moment release for the Pu‘u ‘Ō‘o-Kupaianaha eruption

Stage	Region[i]	cum cts	Cts/yr	Cum mom	Mom/yr	Comment
pre-1983	**ms1**	222	204.76	4.0042	3.6932	
1/1/1982	**ms2.3**	16	14.76	0.974	0.0899	
2/1//1983	**ms4.5**	106	97.77	9.4114	8.6805	
396 days	**msnp**	1	0.92	0.0146	0.0135	
1.084 years	**er1**	14	12.91	0.0583	0.0538	
	er2.3	1202	1108.7	8.5729	7.9072	
	er4	670	617.97	9.4014	8.6714	
	er5	0	0	0	0	
	er4.5	670	617.97	9.4014	8.6713	
	koae	35	32.28	1.2856	1.1858	
	sf1	23	21.21	0.1086	0.1002	
	sf2.3	2636	2431.3	38.6581	35.6563	
	sf4	317	292.38	2.2003	2.0295	
Stage IA	**ms1**	160	46.27	0.8994	0.2601	
2/1/1983	**ms2.3**	75	21.69	1.6677	0.4823	
7/18/1986	**ms4.5**	149	43.09	10.2827	2.9737	
1263 days	**msnp**	177	51.18	2.1586	0.6243	High count from earthquakes triggered by the 11/16/1983 Ka‘ōiki earthquake
3.458 years	**er1**	21	6.07	0.1581	0.0457	
	er2.3	34	9.83	0.1470	0.0425	
	er4	6	1.74	0.0139	0.0040	
	er5	138	39.91	0.8542	0.2470	High count from earthquakes triggered by the 11/16/1983 Ka‘ōiki earthquake
	er4.5	6	1.74	0.8681	0.2510	Calculated without triggered earthquakes
	koae	10	2.89	0.2063	0.0597	
	sf1	50	14.46	0.4272	0.1236	
	sf2.3	3507	1014.2	133.4378	38.5996	Dominated by earthquakes on 3/20/1983 (M 4.9) and 9/9/1983 (M 5.7)
	sf4	142	40.07	1.0154	0.2937	
Stage IB	**ms1**	501	94.37	3.0731	0.5789	
7/18/1986	**ms2.3**	78	14.69	1.0273	0.1935	
11/8/1991	**ms4.5**	299	56.32	9.3593	1.7630	
1939 days	**msnp**	230	43.33	2.4952	0.4700	
5.309 years	**er1**	69	13.00	0.4150	0.0782	
	er2.3	374	70.45	1.9064	0.3591	
	er4	0	0	0	0	
	er5	65	12.24	0.2490	0.0469	Probably continuing effects of Ka‘ōiki earthquake
	er4.5	65	12.24	0.2490	0.0469	Probably continuing effects of Ka‘ōiki earthquake
	koae	21	3.96	0.1479	0.0279	
	sf1	78	14.69	0.6671	0.1257	
	sf2.3	3691	695.27	365.40	68.8300	Dominated by M 6.2 earthquake on June 25, 1989
	sf4	69	13.00	0.5976	0.1107	

Appendix table 8.3a cont.

Stage	**Region**[i]	cum cts	cts/yr	cum mom	mom/yr	Comment
Stage IIA	**ms1**	483	93.79	4.1961	0.8148	
11/8/1991	**ms2.3**	69	13.40	0.4773	0.0927	
1/1/1997	**ms4.5**	342	66.41	33.3721	6.4802	Dominated by M 5.2 earthquake on February 1, 1994
1881 days	**msnp**	268	52.04	3.7726	0.7326	
5.150 years	**er1**	49	9.51	0.2160	0.0419	
	er2.3	555	107.77	2.7631	0.5365	
	er4	3	0.58	0.0030	0.0006	
	er5	31	6.02	0.0992	0.0193	
	er4.5	34	6.60	0.1022	0.0198	
	koae	46	8.93	1.5474	0.3005	
	sf1	35	6.800	0.5078	0.0986	
	sf2.3	2168	420.98	36.509	7.0893	
	sf4	32	6.21	.0963	0.0187	
Stage IIB	**ms1**	804	116.30	16.4008	2.3724	
1/1/1997	**ms2.3**	219	31.68	1.1227	0.1624	
12/1/2003	**ms4.5**	812	117.46	18.1447	2.6258	
2525 days	**msnp**	389	56.27	14.7828	2.1384	
6.913 years	**er1**	114	16.49	2.2650	0.3276	
	er2.3	489	70.74	4.1389	0.5987	
	er4	16	2.31	0.0710	0.0103	
	er5	78	11.28	0.3074	0.0465	
	er4.5	94	13.60	0.3785	0.0548	
	koae	125	18.08	0.5333	0.0771	
	sf1	71	10.27	1.0831	0.1567	
	sf2.3	3796	549.10	86.0533	12.5926	
	sf4	93	13.45	0.6252	0.0904	
Stage IIIA	**ms1**	302	87.27	1.1262	0.3254	
12/1/2003	**ms2.3**	87	25.14	0.4026	0.1163	
5/18/2007	**ms4.5**	668	193.03	7.5018	2.1677	
1264 days	**msnp**	508	146.79	2.1303	0.6156	
3.461years	**er1**	65	18.78	0.5059	0.1462	
	er2.3	1382	399.35	5.9478	1.7187	
	er4	696	201.12	2.3368	0.6753	
	er5	34	9.82	0.0599	0.0173	
	er4.5	730	210.92	2.3968	0.6925	
	koae	19	5.49	0.0254	0.0073	
	sf1	92	26.58	0.5784	0.1671	
	sf2.3	2986	862.85	24.1275	6.9720	
	sf4	157	45.37	0.3303	0.0954	

Appendix table 8.3a cont.

Stage	**Region**[i]	cum cts	cts/yr	cum mom	mom/yr	Comment
Stage IIIB	**ms1**	114	136.07	0.3346	0.3993	
5/18/2007	**ms2.3**	25	29.84	0.0928	0.1108	
3/19/2008	**ms4.5**	150	179.04	1.9009	2.2690	
306 days	**msnp**	46	54.89	0.1203	0.1436	
0.838 years	**er1**	6	7.16	0.0609	0.0727	
	er2.3	508	606.36	12.3767	14.7732	
	er4	70	83.55	0.3627	0.4329	
	er5	8	9.55	0.0098	0.0116	
	er4.5	78	93.08	0.3725	0.4445	
	koae	16	19.10	0.0578	0.0690	
	sf1	7	8.36	0.0442	0.0527	
	sf2.3	958	1143.5	42.4646	50.6869	
	sf4	16	19.09	0.0778	0.0929	

Appendix table 8.3b. Accumulated long-period counts and moment release for Pu‘u ‘Ō‘o-Kupaianaha eruption

Stage	Region[i]	cum cts	Cts/yr	Cum mom	Mom/yr	Comment
pre-1983	**lpms1**	0	0	0	0	
1/1/1982	**lpms2**	5	4.61	0.0287	0.0265	
2/1//1983	**lpms3**	1	0.92	0.0065	0.0060	
396 days	**lpms2.3**	6	5.53	0.0352	0.0325	
1.084 years	**lpms4.5**	7	6.46	0.0170	0.0425	
Stage IA	**lpms1**	35	10.12	0.1154	0.0334	
2/1/1983	**lpms2**	101	29.21	0.3801	0.1099	
7/18/1986	**lpms3**	66	19.09	0.2946	0.0852	
1263 days	**lpms2.3**	167	48.29	0.6747	0.1951	
3.458 years	**lpms4.5**	35	10.12	0.2191	0.0634	
Stage IB	**lpms1**	422	79.49	2.3469	0.4421	
7/18/1986	**lpms2**	1900	357.90	15.4470	2.9098	
11/8/1991	**lpms3**	2296	432.50	21.8393	4.1139	
1939 days	**lpms2.3**	4196	790.40	37.2863	7.0237	
5.309 years	**lpms4.5**	103	19.40	1.2769	0.2405	
Stage IIA	**lpms1**	250	48.54	0.8941	0.1736	
11/8/1991	**lpms2**	342	66.41	1.1611	0.2255	
1/1/1997	**lpms3**	1446	280.78	4.9944	0.9698	
1881 days	**lpms2.3**	1788	347.19	6.1555	1.1953	
5.150 years	**lpms4.5**	42	8.16	0.4309	0.0837	
Stage IIB	**lpms1**	2751	397.94	13.1825	1.9069	
1/1/1997	**lpms2**	1396	201.94	15.0146	2.1719	
12/1/2003	**lpms3**	1193	172.57	15.0221	2.1730	
2525 days	**lpms2.3**	2589	374.51	30.0367	4.3449	
6.913 years	**lpms4.5**	44	6.36	0.2085	0.0302	
Stage IIIA	**lpms1**	21	6.07	0.059	0.0153	
12/1/2003	**lpms2**	261	75.42	1.0458	0.3022	
5/18/2007	**lpms3**	185	53.46	0.8311	0.2478	
1264 days	**lpms2.3**	446	128.88	1.8769	0.5500	
3.461years	**lpms4.5**	28	8.09	0.2228	0.0644	
Stage IIIB	**lpms1**	82	97.88	0.4217	0.5033	
5/18/2007	**lpms2**	0	0	0	0	
3/19/2008	**lpms3**	0	0	0	0	
306 days	**lpms2.3**	0	0	0	0	Need explanation for dramatic decrease in long-period counts
0.838 years	**lpms4.5**	11	13.13	0.1105	0.1319	

[i] Regions shown in figure 1.3

Appendix table H4. Volumes of magma batches entering Kīlauea plumbing

a. Magma erupted in homogeneous summit eruption or mixed in hybrid eruptions

Magma name	date begin	date end	V (km^3)	Comment	Reference[1]
1952	6/27/1952	11/9/1952	.0870	Halemaʻumaʻu eruption	4
	3/20/1955	5/26/1965	.0333	Latter part of 1955 eruption; mixing percentage 41.9	9, 1
	1/26/1960	1/29/1960	.0035	Middle part of 1960 eruption; mixing percentage35.7	9, 2
Total			.1335		
1954	5/31/1954	6/3/1954	.0050	Kīlauea caldera eruption	8
	11/14/1959	11/21/1959	.0042	1959 eruption episode 1: mixing percentage 45.5	5; 3
	11/22/1959	12/20/1959	.0027	1959 eruption episodes 2-17: mixing percentage 13.2	5, 3
Total			.0119		
1961	3/5/1955	3/6/1955	.0418	Kalalua intrusion--calculated as parent for 1977 eruption	9,
	1/30/1960	2/4/1960	.0086	middle part of 1960 eruption; mixing percentage 58.2	5, 2
	2/24/1961	7/17/1961	.0103	Halemaʻumaʻu eruptions (3)	6
	9/22/1961	9/25/1961	.0390	East rift eruption: assume 1961 and 1967 transferred in equal volume	6, 15
	12/7/1962	12/9/1962	.0049	12/1962 East rift eruption	14, 15
	8/21/1963	8/23/1963	.0022	8/1963 East rift eruption	10, 15
	10/5/1963	10/6/1963	.0155	10/1963 east rift eruption	11, 15
	3/5/1965	3/15/1965	.0033	3/1965 east rift eruption	12, 15
	12/24/1965	12/25/1965	.0036	12/1965 east rift eruption	13, 15
Total			.1292		
1967-68	2/12/1960	2/18/1960	.0043	later part of 1960 eruption: mixing percentage 24.8	5, 2
	9/22/1961	9/25/1961	.0390	East rift eruption: assume 1961 and 1967 transferred in equal volume	6, 15
	12/7/1962	12/9/1962	.0064	12/1962 East rift eruption	14, 15
	8/21/1963	8/23/1963	.0016	8/1963 East rift eruption	10, 15
	10/5/1963	10/6/1963	.0250	10/1963 east rift eruption	11, 15
	3/5/1965	3/15/1965	.0381	3/1965 east rift eruption	12, 15
	12/24/1965	12/25/1965	.0177	12/1965 east rift eruption	13, 15
	11/5/1967	7/14/1968	.0744	Halemaʻumaʻu eruption	7
	8/22/1968	8/28/1968	.0024	8/1968 east rift eruption	16, 18
	10/7/1968	10/22/1968	.0234	10/1968 east rift eruption	16, 18
	2/22/1969	2/28/1969	.0061	2/1969 east rift eruption	17, 18
Total			.2384		
Grand total			.5130	Total amount of unfractionated magma identified; add .01 km^3/year for rift dilation during spreading; lifetime of magma batches ~ 10 years	

[1] 1. (Helz and Wright, 1992); 2. (Wright and Helz, 1996); 3. (Wright, 1973); 4. (Macdonald, 1952); 5. (Richter and others, 1970); 6. (Richter and others, 1964); 7. (Kinoshita and others, 1969); 8. (Macdonald and Eaton, 1954); 9. (Macdonald and Eaton, 1964); 10. (Peck and Kinoshita, 1976); 11. (Moore and Koyanagi, 1969); 12. (Wright and others, 1968); 13. (Fiske and Koyanagi, 1968); 14. (Moore and Krivoy, 1964); 15. (Wright and Fiske, 1971); 16. (Jackson and others, 1975); 17. (Swanson and others, 1976); 18. (Wright and others, 1975)

b. Additional magma transfer to east rift zone: Deflation volumes not associated with eruption[i]

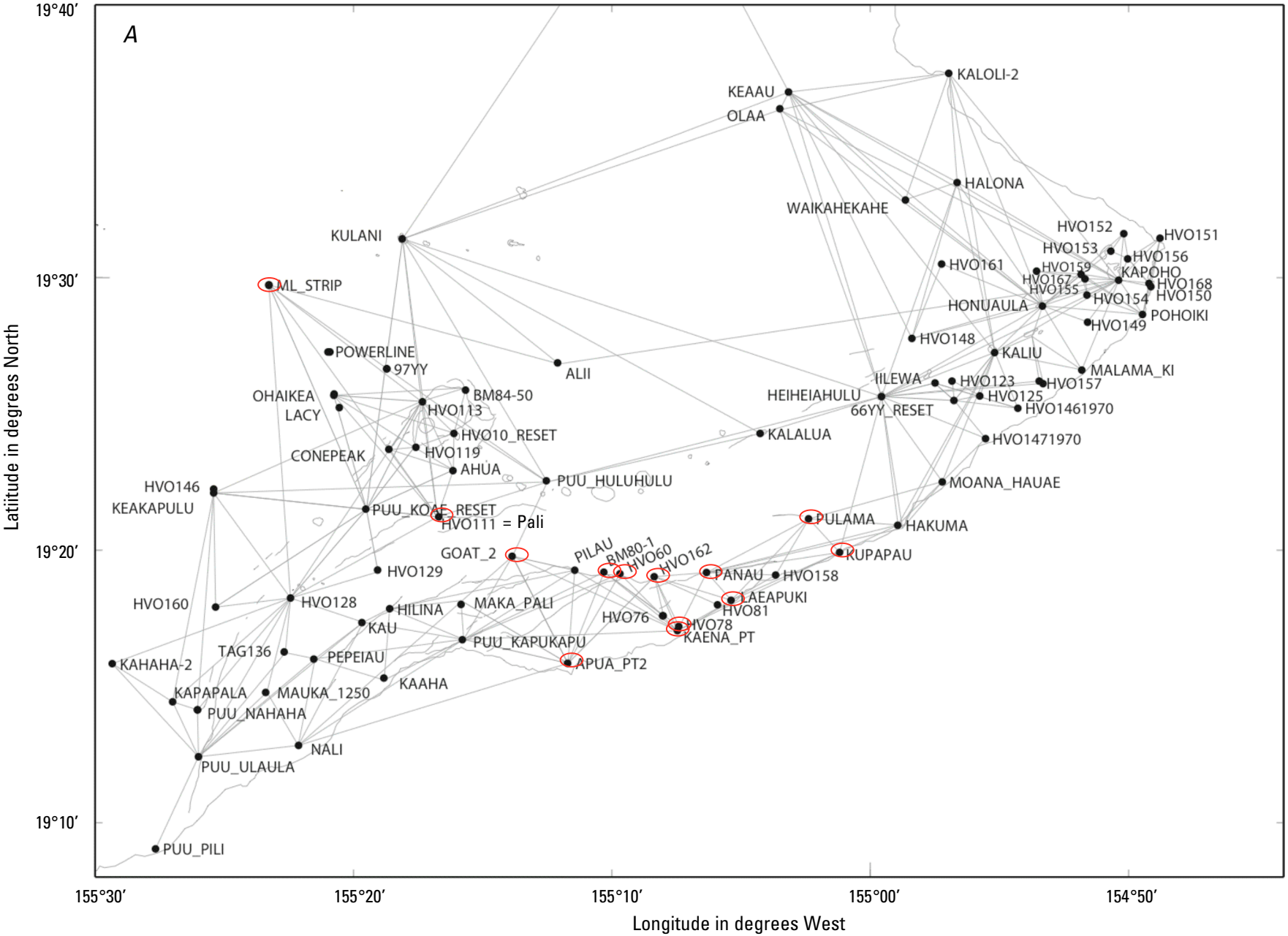
date begin	date end	V (km^3)	Comment
9/15/1950	12/8/1950	.0088	Assumed to be magma batch of 1952 chemistry
12/8/1950	12/16/1950	.0507	do.
Subtotal		.0595	Minimum volume1952 magma intruded into the rift zone.
6/26/1952	10/2/1952	.0323	Assumed to be magma batch of 1961 chemistry
3/10/1954	3/24/1954	.0082	do
12/13/1954	1/17/1955	.0114	do
2/19/1955	12/29/1955	.1494	do
8/31/1959	11/14/1959	.0011	do
Subtotal		.2024	Volume of 1961 magma intruded into the east rift zone
11/15/1959	11/23/1959	.0213	Assumed to be magma batch of 1967-68 chemistry[ii]
12/23/1959	1/17/1960	.0103	do
1/17/1960	10/21/1960	.1405	do
9/21/1961	9/30/1961	.0779	do
10/28/1961	11/4/1961	.0046	do
12/6/1962	12/9/1962	.0092	do
5/8/1963	5/12/1963	.0157	do
6/28/1963	7/2/1963	.0085	do
8/21/1963	8/22/1963	.0036	do
10/4/1963	10/10/1963	.0362	do
11/11/1964	12/1/1964	.0022	do
3/5/1965	3/9/1965	.0395	do
12/23/1965	12/29/1965	.0213	do
10/1/1966	10/7/1966	.0044	do
8/9/1967	8/18/1967	.0038	do
Subtotal		.399	Maximum additional volume of 1967-68 chemistry. May include a percentage of 1961 chemistry
Total		.6609	

[i] Volumes calculated from deflation

[ii] Latest time that magma can enter east rift zone for mixing with the latter part of the 1960 eruption

Figure H1. Maps showing locations of stations shown in text figures 8.9 and 8.10. *A*, Stations in the Hawaiian Volcano Observatory edm network. Stations used in the plots in this report are circled in red. *B*, Stations in the Hawaiian Volcano Observatory Global Positioning System (GPS) network. Stations used in the plots in this report are circled in red.

Appendix figure H1 a. Kilauea south flank edm network



Appendix figure H1 b. Kilauea south flank GPS network