Appendix B. Supplementary Material to Support Chapter 2

Tables B1a and B1b list earthquakes of magnitudes between 5 and 6 for the same time periods as text tables 2.1 and 2.2, respectively.

Table B2 shows azimuth and distance from Uwēkahuna and Whitney Vaults to points within Kīlauea Caldera shown in text figure 2.4.

Table B3 contains Whitney tilt data to support text figure 2.3.

Figure B1 plots occurrence of earthquakes designated as "south Hawai‘i" on a timeline that also shows (1) Kīlauea eruptions and intrusions, (2) Mauna Loa eruptions, and (3) Kīlauea earthquake swarms.

Appendix B Table B1 a. Earthquakes M 5-6, 1790-1894

Date begin	Date end	Loc.1	Type2	Comment	References
1/9/1826 11/5/1827 4/12/1829 11/22/1829			EQ EQ EQ EQ	Earthquakes, M 5.3—locations unknown, but possibly beneath Kīlauea	(Klein and Wright, 2000)
10/13/1833	1/29/1838	sf??	EQ	M 5.3, 5.6 (4), 5.9-- classified as “south Hawai‘i”	(Klein and Wright, 2000)
4/7/1839		sf?	EQ	M 5.3—classified as “south Hawai‘i”	(Klein and Wright, 2000)
12/18/1840		sf??	EQ	M 5.6—classified as “south Hawai‘i”	(Klein and Wright, 2000)
9/30/1841 11/9/1842		sf??	EQ	M 5.3—classified as “south Hawai‘i” M 5.3—classified as “south Hawai‘i”	(Klein and Wright, 2000)
9/1/1844	1/8/1856	sf??	EQ	M 5.6, 5.3—17 shocks classified as “south Hawai‘i”	(Klein and Wright, 2000)
10/22/1855		hm	C	Earlier dome collapsed, lava 100 ft down, no activity	(Coan, 1856b)
7/30/1857		sf??	EQ	M 6.1	(Klein and Wright, 2000)
9/9/1857		sf?	EQ	M 5.6	(Klein and Wright, 2000)
4/30/1858	6/1/1860	sf??	EQ	M 5.6—three shocks classified as “south Hawai‘i”	(Klein and Wright, 2000)
3/12/1861		sf??	EQ	M 5.3—classified as “south Hawai‘i”	(Klein and Wright, 2000)
12/30/1861		sf??	EQ	M 5.6	(Klein and Wright, 2000)
5/9/1863		sf??	EQ	M 5.9—classified as “Hawai‘i”	(Klein and Wright, 2000)
11/26/1863		sf??	EQ	M 5.9—classified as “south Hawai‘i”	(Klein and Wright, 2000)
12/11/1865	11/7/1867	sf??	EQ	M 5.3 (2), 5.6- classified as “south Hawai‘i”	(Klein and Wright, 2000)
4/19/1868	5/17/1868	sf??	EQ	M 5.3 (4) aftershocks of the 1868 earthquake classified as “South Hawai‘i”	(Klein and Wright, 2000)
6/10/1868 7/12/1868		sf??	EQ	M 5.3--do.[3] M 5.3--do.	(Klein and Wright, 2000)
7/23/1868		sf??	EQ	M 5.9—do.	(Klein and Wright, 2000)
8/7/1868	11/1/1876	sf??	EQ	M 5.0 (2), M 5.3 (45), M 5.4 (2), M 5.5, M 5.6 (12), M 5.9 (3)—do.	(Klein and Wright, 2000)
11/16/1868		sf?	EQ	M 5.6	(Klein and Wright, 2000)
9/13/1871		sf?		M 5.9	(Klein and Wright, 2000)
8/2/1877 3/16/1879		sf??	EQ	M 5.3 (2)--do.	(Klein and Wright, 2000)
5/15/1879	6/20/1880	sf??	EQ	M 5.3 (4), M 5.6--do.	(Klein and Wright, 2000)
5/21/1882	12/2/1885	sf??	EQ	M 5.0, 5.3 (4), 5.4 (3), 5.6 (2)--do.	(Klein and Wright, 2000)
10/18/1886	7/26/1890	sf??	EQ	M 5.6 (2), 5.9, 5.3 (4), 5.9, 5.4, 5.2—do.	(Klein and Wright, 2000)
10/15/1891	6/16/1894	s??		M 5.3 (4), 5.6 (with aftershocks)--do.	(Klein and Wright, 2000)

[1] Location abbreviations: Kīlauea caldera (kc); Halemaumau crater (hm); East rift zone (erz); Southwest rift zone (swr); seismic southwest rift zone (sswr); Koa‘e fault zone (koae); South flank (sf)
[2] Eruption (E); intrusion (I); Earthquake ≥ M5 (EQ); Earthquake swarm (EQS); Collapse of Kīlauea’s summit (C)
[3] do. = aftershocks of the 1868 earthquake classified as “South Hawai‘i”

Appendix B Table B1. b. Earthquakes M 5-6, 1895-1925

Date begin	Date end	Loc.[1]	Type[2]	Comment	References
3/10/1897	5/6/1897	sf??	EQ	M 5.3 (3)--classified as "south Hawai'i"	(Klein and Wright, 2000)
10/24/1897		sf?	EQ	M 5.3—classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
5/17/1898 9/15/1898 1/4/1899		sf??	EQ	M 5.3--classified as "south Hawai'i" (3 dates)	(Klein and Wright, 2000)
10/31/1899 7/10/1900 10/12/1900		sf??	EQ	M 5.3--classified as "south Hawai'i" (3 dates)	(Klein and Wright, 2000)
9/28/1902		sf?	EQ	M 5.6—classified as "Kīlauea south flank??"	(Klein and Wright, 2000)
5/3/1905	5/7/1905	sf?	EQ	M 6.18 w M 5.3 foreshock and many aftershocks, some as strong as M 5—classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
9/5/1907	9/7/1907	sf?	EQ	M 5.16 with at least 2 aftershocks, one of M 5.3—classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
3/13/1909		kcal	EQ	M 5.35, deep beneath Kīlauea caldera??	(Klein and Wright, 2000)
4/19/1910		sf??	EQ	M 5.3 classified as "Kīlauea?"	(Klein and Wright, 2000)
4/10/1912		sf??	EQ	M 5.3--classified as "south Hawai'i"	(Klein and Wright, 2000)
5/22/1912		sf?	EQ	M 5.9—classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
10/14/1912	10/15/1912	kcal	EQS	Kīlauea caldera 0-5 km?—Halema'uma'u obscured, so not sure how shallow earthquakes relate	(Jaggar, 1947, p. 43-45; Klein and Wright, 2000)
10/25/1913	11/9/1913	ksf	EQ	M 5.81-- Kīlauea south flank, at least 14 aftershocks	(Klein and Wright, 2000)
5/24/1914	6/2/1914	sf?		M 5.22 on 6/1/1914	(Klein and Wright, 2000)
5/26/1915		sf?	EQ	M 5.24 classified as "Kīlauea south flank??"—at least 7 as	(Klein and Wright, 2000)
7/11/1916		sf?	EQ	M 5.04 classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
10/3/1916	10/7/1916	sf??	EQS?	12 events 20-30 km	(Klein and Wright, 2000)
10/8/1916		sf?	EQ	classified as "unknown", but felt generally over south Hawai'i -- Kīlauea south flank?	(Klein and Wright, 2000)
7/29/1917		sf?	EQ	M 5.2 (2) classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
5/21/1918	5/23/1918	kcal	EQ	M 5.14 deep beneath Kīlauea caldera??—2 aftershocks	(Klein and Wright, 2000)
2/25/1919		sf?	EQ	M 5.2 classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
6/18/1919		hm	EQS?/C	ass. with lowering of Halema'uma'u lava lake level?	(Klein and Wright, 2000)
8/26/1919		kcal?	EQ	M 5.00 deep beneath Kīlauea caldera?	(Klein and Wright, 2000)
11/28/1919	12/4/1919	erz	EQS/C/I	> 200 events associated with draining of Halema'uma'u lava lake. Assume middle east rift intrusion with south flank response	(Bevens and others, 1988, v. 2, p. 1059; Klein and Wright, 2000)
10/27/1920		sf?	EQ	M 4.2 classified as "Kīlauea south flank?"	(Klein and Wright, 2000)
5/19/1921		sf?	EQ	M 4.5 felt all island	(Klein and Wright, 2000)
2/21/1922		sf?	EQ	M 5.72 classified as "Kīlauea south flank?"—several aftershocks	(Klein and Wright, 2000)
3/12/1922		kcal	EQ	M 4.63 classified as "deep beneath Kīlauea caldera??"—several aftershocks	(Klein and Wright, 2000)
sf	6/1/1922 6/8/1922	kcal erz sf	EQS	earthquake swarm of 560 events (108 at 0-10 km beneath Kīlauea caldera; 432 beneath east rift zone) associated with 850-foot lowering of lava lake south flank response (67 events)	(Bevens and others, 1988, v. 3, p. 287-290; Klein and Wright, 2000)

[1] Location abbreviations: Kīlauea caldera (kc); Halema'uma'u crater (hm); East rift zone (erz); Southwest rift zone (swr); seismic southwest rift zone (sswr); Koa'e fault zone (koae); South flank (sf)

[2] Eruption (E); intrusion (I); Earthquake ≥ M5 (EQ); Earthquake swarm (EQS); Collapse of Kīlauea's summit (C)

Date begin	Date end	Loc.[1]	Type[2]	Comment	References
7/19/1924	7/30/1924	hm	E	Return of lava to bottom of Halemaʻumaʻu	(Bevens and others, 1988, v. 3, p. 576; Klein and Wright, 2000)

Appendix B table B2. Azimuth and distance to deformation centers[1]

A. Uwēkahuna vault

Location[1]	Azimuth from Uwēkahuna		Distance (km)	Comment
	Inflation	Deflation		
2	287.8	107.8	1.77	northernmost center
1	309.5	129.5	2.49	
9	319	139	3.91	easternmost center
3	323.8	143.8	3.63	
7	331.2	151.2	3.63	
10	334.4	154.4	3.68	southernmost center
6	337.7	157.7	3.63	
8	341.0	161.0	3.03	
4	344.3	164.3	3.11	
5	361.2 (1.2)	181.2	3.08	westernmost center
Halemaʻumaʻu	330.5	150.5	1.42	summit eruption center
Keanakākoʻi	305.7	125.7	3.15	southeast caldera
Puhimau	342.6	121.7	4.76	upper east rift zone
Kōkoʻolau	339.6	125.0	5.46	upper east rift zone

B. Whitney vault

Location[1]	Azimuth from Whitney		Distance (km)	Comment
	Inflation	Deflation		
2	53.7	233.7	2.16	northernmost center
1	34.6	214.6	2.89	
9	13.0	193.0	3.88	easternmost center
3	21.8	201.8	4.05	
7	25.9	205.9	4.39	
10	27.2	207.2	4.57	southernmost center
6	29.4	209.4	4.67	
8	36.9	216.9	4.47	
4	37.5	217.5	4.58	
5	34.80	224.8	5.12	westernmost center
Halemaʻumaʻu	51.7	231.7	3.02	summit eruption center
Keanakākoʻi	11.7	191.7	2.53	southeast caldera
Puhimau	342.6	162.6	3.29	upper east rift zone
Kōkoʻolau	339.6	159.6	4.03	upper east rift zone

[1] Numbers denote deformation centers at Kīlauea's summit shown on fig. 5 of Fiske et. al., 1969

Table B3. Whitney tilt data associated with Halemaumau draining and collapse (Fig. 2.3)

Event[i]	Begin	End	Dh	Eq_N	T_{mag}	T_{az}[ii]	Comment[iii]	Reference(s)[iv]
lava lake	9/12/1915	9/28/1915	-42.3				draining	BTW2, p. 361-362
eq swarm	9/22/1915	9/29/1915		>100			erz intrusion	(Klein and Wright), 2000
tilt change	8/30/1915	9/19/1915			7.43	196	deflation	
lava lake	5/25/1916	6/6/1916	-124.4				draining	BTW2, p. 463-464
eq swarm	6/4/1916	6/11/1916		>200			erz intrusion	(Klein and Wright, 2000); BTW2, p. 465
tilt change							no record	
lava lake	6/6/1916	2/1/1917	206.0				filling	BTW2, p. 465-561
lava lake	2/1/1917	2/23/1918	18.7				filling	BTW2, p. 561-728
tilt change	-	1/19/1918					incomplete record	
tilt change	1/19/1918	2/21/1918			11.64	42.5	inflation	
lava lake	2/23/1918	3/3/1918	"0"				Halemaʻumaʻu overflow	BTW2, p. 733-738
tilt change	2/21/1918	3/26/1918			6.55	161	deflation--mixed[v].	
lava lake	3/3/1918	3/26/1918	2.0				building new levees	BTW2, p738-748
eq swarm	3/26/1918	4/5/1918		41			summit only?	(Klein and Wright, 2000); BTW2, p. 749-755
lava lake	3/26/1918	4/5/1918	-85.3				draining	BTW2, p. 754-755
tilt change	3/24/1918	4/3/1918			2.28	198	minor deflation	
tilt change	4/3/1918	11/8/1918			21.0	124	deflation-mixed	BTW2, p. 757-842
lava lake	4/5/1918	11/8/1918	75.5				filling	
Lava lake	11/81918	11/16/1918	-68.3				draining	BTW2, p. 844-846
eq swarm	11/15/1918	11/17/1918		>79			intrusion?	BTW2, p. 846)
tilt change	11/10/1918	11/17/1918			11.0	358	regional inflation[vi]	
tilt change	10/22/1918	2/1/1919			80.6	355	regional inflation	
lava lake	11/16/1918	2/7/1919	75.8				filling	BTW2, p. 846-885
tilt change	2/1/1919	11/28/1919			7.6	360	regional inflation	
eruption	2/7/1919	11/28/1919	-5.5		5.6	324	"Postal rift" eruption, Kīlauea	BTW2, p. 888-1128
lava lake	11/28/1919	11/30/1919	-187.1				caldera	
eq swarm	11/28/1919	11/30/1919		7			draining	BTW2, p. 1128
tilt change	11/28/1919	11/30/1919			3.34	198	deflation	
tilt change	11/30/1919	12/28/1919			3.91	21	inflation	
lava lake	11/30/1919	12/22/1919	194.2				filling	BTW2, p. 1055-1186
Lava lake	12/22/1919	1/15/1920	-95.4				draining	BTW2, p. 1077-1078
	12/15/1919	7/20/1920					Mauna Iki (sw rift) eruption	BWT2, p. 1074-1186
eq swarm	12/15/1919	12/19/1919		83			no tilt change; shallow swr	(Klein and Wright, 2000); BTW2, p.1074-77
	12/22/1919	2/8/1920		30			intrusion	BTW2, p. 1086)
tilt change	12/28/1919	12/31/1919			1.73	194	south flank response deflation; source 2 response to eruption	
lava lake	1/15/1920	3/18/1921	110.6				filling	BTW2, p. 1093-1129
tilt change	1/26/1920	3/20/1921			7.2	40	inflation	
lava lake	3/18/1921	3/25/1921	-1.3				Halemaʻumaʻu overflow	BTW3, p. 63-75
lava lake	3/25/1921	7/25/1921	-107.6				draining	BTW3, p. 75-152
tilt change	3/20/1921	7/22/1921			3.5	234	deflation—mixed?	
lava lake	7/25/1921	10/1/1921	86.3				filling	BTW3, p. 152-204
tilt change	7/22/1921	10/10/1921			2.4	152	deflation-mixed	
lava lake	10/1/1921	11/20/1921	-95.5				draining	BTW3, p. 204-216
tilt change	10/10/1921	11/20/1921			0.7	104	mixed	

Event[i]	Begin	End	Dh	Eq_N	T_{mag}	T_{az}[ii]	Comment[iii]	Reference(s)[iv]
lava lake	11/20/1921	5/13/1922	104.3				filling	BTW3, p190-220
tilt change	11/20/1921	5/24/1922			5.8	315	inflation--mixed	BTW3, p. 219
Lava lake	5/13/1922	6/6/1922	-251.2				draining	BTW3, p. 277-317
eq swarm	5/15/1922	6/1/1922		>600			kcal ⇒ erz e/I	BTW3, p. 287-290, 302
eruption	5/28/1922	5/30/1922					Eruption/intrusion east rift zone	BTW3, p. 284-285
tilt change	5/24/1922	6/6/1922			15.4	196	deflation	BTW3, p. 290
Lava lake	12/22/1922	1/3/1923	-57.9				draining	BTW3, p. 372-383
eq swarm	12/31/1922	1/4/1923		133			erz intrusion?	BTW3, p. 375, 384-386
tilt change	12/24/1922	12/31/1922			3.45	220	deflation	BTW3, p. 290
lava lake	1/3/1923	7/21/1923	188.0				filling	BTW3, p. 382-441
tilt change	12/31/1922	8/25/1923			7.0	83	mixed	
Lava lake	7/21/1923	8/29/1923	-128.9				draining	BTW3, p. 451-461
eq swarm	8/3/1923	8/6/1923		76			minor lava lake/tilt change	
eq swarm	8/24/1923	8/27/1923		92			East rift intrusion	BTW3, p. 461-462
eruption	8/25/1923	8/26/1923					Eruption/intrusion east rift zone	BTW3, p. 460
tilt change	8/25/1923	8/27/1923			3.04	261	mixed	
lava lake	8/29/1923	2/9/1924	142.4				filling	BTW3, p. 461-508
tilt change	8/27/1923	1/31/1924			14.2	328	inflation--mixed	
Lava lake	2/9/1924	2/21/1924	-76.2				draining	BTW3, p. 506-508
eq swarm	2/13/1924	2/20/1924		21				BTW3, p. 510
tilt change	1/31/1924	2/12/1924			3.15	201	deflation[vii]	BTW3, p. 510
Lava lake	2/21/1924	3/1/1924[viii]	-85.3				draining	BTW3, p. 512
eq swarm	3/7/1924	4/17/1924		85			mid erz intrusion	(Klein and Wright, 2000)
tilt change	2/25/1924	4/28/1924			14.52	196	net deflation[ix]	BTW3, p. 514, 528
Lava lake	4/28/1924[vii]	6/1/1924	-289.6				draining	BTW3, p. 524, 530-560
eq swarm	i	4/29/1924		264			lower erz intrusion	BTW3, p. 515-528
eruption	4/17/1924	5/27/1924					Halemaʻumaʻu—expl. eruption	BTW3, p. 536-560
tilt change	5/10/1924	5/31/1924			63.8	199	Deflation; mixed—due to deep eq	
tilt change	4/28/1924	6/1/1924			1.4	285	on 5/30/1924	(Klein and Wright, 2000)
	5/31/1924							
tilt change	6/1/1924	8/1/1924			11.82	172	regional deflation	
eruption	7/19/1924	7/30/1924					Return of lava Halemaʻumaʻu	BTW3, p. 581-583
tilt change	8/1/1924	9/14/1924			3.42	38	inflation	
tilt change	9/15/1924	12/29/1924			7.80	194	deflation	
total	2/25/1924	12/29/1924			80.45	194		

[i] Headings 1-7 as follows: Event = type of measurement; Begin and End = beginning and ending times; Dh = increase or decrease in height of lava lake surface difference measured in meters; Eq_N = number of earthquakes in swarm; T_{mag} = Whitney tilt magnitude in seconds; tilt azimuth in degrees.

[ii] Azimuths from the Whitney vault that fall within the range of centers defined for the inflation preceding the 1967-68 eruption (Fiske and Kinoshita, 1969)—see Chapter 4 appendix table D3--are highlighted in **bold** type.

[iii] Eruptions and well-documented or suspected intrusions are *italicized*. Inflation/deflation of Kīlauea's shallow reservoir are highlighted **bold**. Other inflation/deflation vectors are explained in subsequent footnotes and text.

[iv] Reference to the weekly and monthly reports of the Hawaiʻian Volcano Observatory (Bevens and others, 1988) are abbreviated as follows: Volume 2 = BTW2; volume 3 = BTW 3.

[v] Deflation or inflation azimuths at variance with the centers defined by Fiske and Kinoshita (1969) can be explained as a vector addition of a regional deflation (see the large 1918-1919 inflation and 1924 deflation) and shallow uplift beneath Halemaʻumaʻu.

[vi] Azimuths between 270 and 360° (inflation) or between 90 and 180° (deflation) lie outside of the range of azimuths to inflation centers. .preceding the 1967-68 eruption (Fiske and Kinoshita, 1969) and are interpreted as a deeper regional inflation. See text for further explanation.

[vii] Followed by inflation between 2/12 and 2/21. Changes in lava lake level are poorly correlated with tilt change in this period.

[viii] No tilt measurement between 3/1/1924 and 4/28/1924.

[ix] During this period an unchanging level of Halemaʻumaʻu lava lake is accompanied by alternating episodes of inflation and deflation. The net tilt change for this period (deflation) is shown.

Figure B1. Graphs showing "south Hawai‘i" earthquakes related to Kīlauea (middle panel) or Mauna Loa (lower panel) activity, 1820–1904. Earthquakes identified in the Klein-Wright catalog (Klein and Wright, 2000) as "south Hawai‘i" are compared to times of Kīlauea and Mauna Loa eruptions and intrusions. Closely spaced events near times of eruption or intrusion are probably associated with that volcano. Earthquakes in blue symbols designated "kl sf" for Kīlauea south flank have a bit more evidence regarding their location than merely "south Hawai‘i," such as better felt reports or association with Kīlauea volcanic events. Most of the events designated "south Hawai‘i" are probably Kīlauea south flank but with insufficient location information. Isolated events of M>4.0 are most likely either south flank or deep magma-supply earthquakes, although the volcano designation is ambiguous.

Appendix Figure B1. "south hawaii" earthquakes related to activity at Mauna Loa and Kilauea