Table 1.—Comparison of SiO_2 content, phenocryst mineralogy,[1] inclusions,[1] age, magnetic polarity, and volume of volcanic map units in the Clear Lake volcanic area, California

[Data on map unit symbol queried where uncertain. Empty spaces, absent or no information]

Map unit	Geographic area and name of map unit[2]	SiO_2[3]	PHENOCRYSTS														INCLUSIONS						Age[4]	Mag. polar.	Vol.
			FELDSPAR					PYROXENE																	
			Quartz[4]	K-feldspar	Plagioclase		Biotite	Horn-blende	Ortho-pyroxene	Clino-pyroxene		Olivine (or others)[5]		Clots of phenocrysts[6]		Diabasic-textured matrix[7]		Other felsic[8]		Xeno-crysts[9]				
			mm %	mm %	mm %		mm %	mm %	mm %	mm %		mm %		mm %		mm %		mm %		mm %				
tk	WESTERN AREA Kelsey Tuff Member of Huichica Formation[10]	57.9–59.8	1–2	<1					1–2	2				1	<1	1–2	2			2–5 f	1			C ~36,000 yr		0.15
dlc	Rhyolite of Kelsey Creek	72.2	2–5	10–15	2–5	7–10			2–5	3–5	1–2	1–2												± 0.58–0.02	N	0.47
dch	Rhyolite of Cameo Hump	69.8–71.6	2–7	5	2–7	5			1–2	0.5	1	0.5						10–100	1–2					± 0.58–0.02	N	0.39
ms	Rhyolite of Mills Creek	74.1	2–5	10	2–5	10			0.25–2	3–5								10–100	0.5–2					± 0.60–0.02		0.27
bdb	Basaltic andesite of Bottle Rock	57.9												0.5–1.5	2–3	0.5–1.5	1								0.008
dlv	Rhyolite of Tule Valley	64.8	1–5	1	1–5	1.5			1–5	1.5	0.25													± 0.66–0.02 ± 0.62–0.02	N	0.0029
bs	Olivine basalt north of Sweetwater Creek													1–25	25	10–30				a	5–20					0.0052
	CENTRAL AREA MOUNT KONOCTI																									
ml	Young pyroclastic deposits	58.9–62.9							p			p		p						a,a,ba,b,bbg,bhl, ae,as,f,gv	5–20					0.080
ha	Rhyolite andesite of Anderson Island	56.8							0.5–1.5	1				0.25–3	2–3					gb		1–2 kf,pl 1–2 q	0.5 tr		0.00001
bbf, bbl	Basaltic andesite of Buckingham Peak	56.2–57.7												0.5–1	5										i?	0.012
bh	Basaltic andesite of Horsedrink Bend	57.6							1.5	5				1–2	2							1–2 q	tr			0.029
dwp	Rhyolite of Wright Peak	68.5	1–5	5	1–15	5–10			1–10	5–8	0.5–2	1–2		0.5–2	0.5	0.5–2	0.5			5–10 pl-px+ gdmicr	1–5			± 0.26–0.02		0.26
bahf, bahp	Basaltic andesite of Howard Peak	57.2												0.25–1	2–3	0.25–2	3–5			2–60 a,r	0.5–1	1–5 q	0.5			0.019
bch	Basaltic andesite of Cobb Mountain	56.8												0.25–2	<0.25	0.25–1	<0.25			2–300 a,r	0.5–1	1–2 q	tr			0.016
dmk	Dacite of Mount Konocti	65.4	1–6	2	0.5–6	5			0.5–6	10	0.5–1	tr		0.5–1	1	0.5–1	0.25			0.5–3 pl-px+	tr					0.077
dbr	Dacite of Benson Ridge	66.4–68.6	0.5–6	5–8	0.5–15	5			0.5–10	5–10	0.5–3	0.5–1		0.5–2	0.5	0.5–2	0.5			10–12,000	1–2					0.77
dbh	Dacite of Buddingham Bluffs	66.8	1–3	1–5	1–10	5			1–10	5–7						0.5–2	0.5			5–10 pl-px+ granular	1–5				N	0.5
dhg	Dacite of Henderson	67.5	0.5–5	2	1–10	1			1–6	6–10	0.5–2	0.5		0.5–2	1	0.5–2	0.5			5–20	1–2				N	0.75
dsh	Rhyolite of Soda Bay	68.0–70.2	1–5	5–8	2–50	3			1–10	10–15	0.5–2	0.5–1				0.5–2	0.5–2			1–10	1–2			± 0.43–0.05 ± 0.39–0.04 ± 0.25–0.04	N	0.17
dh	Rhyolite of Horsethief Bay	70.5	1–5	5	3–10	5	3–10	10	0.5–2	2		0.5–2	0.5	0.5–2	0.5					5–500	1–25	50–250 sf	tr		N	1.557
df	Dacite of Fraser Point	64.6	0.5–1	5	0.5–1	2	2–5 f, part clots			0.5–1	tr	0.5–2	2	0.5–2	2											0.77
dbm	Dacite of Bell Mine	64.9	1–3	1–2	2–8	3				0.5–1	tr	0.5	tr													0.11
dlm	Rhyolite north of Elu Flat	67.9	1–10	2	1–10	1			1–10	5	0.5–1	tr	0.25–1	0.2–0.5	0.5–2	0.5–2	0.5									0.41
dkb	Dacite of Konocti Bay	64.7	1–5	5	1–5	5			1–6	5	1–2	tr		1–3	1.5	1–3	1.5							w 1.10 ± 0.02	R	0.04
dsc	Dacite of Shaw Valley	66.4	1–5	2	1–5	1			1–10	5	0.5–1	<0.5	0.5–4	0.5–2	0.5	0.5–2	0.5			3–15	2			w 1.09 ± 0.02 w 1.10 ± 0.02	R	0.37
ea	Crawford andesite	63.1–64.3					0.25–2	10–15				0.25–3	3–5	0.25–3	1	0.15–0.3 ca	<10							w 1.15 ± 0.02 w 1.17 ± 0.02	R	4.1
rsmq, rsmq	Rhyolite north of Sugarloaf	72.9	2–8	5	2–15	5			0.5–1	1				0.25–0.5	tr					3–10	5			w 1.11 ± 0.02 w 1.13 ± 0.02			
dp	Pacific pyroclastic deposit north of Sugarloaf															0.1 f								w 1.11 ± 0.01		0.0078
bwf, bwp	Basaltic andesite of Wardlaw Flow	74.1	1–5	10	2–6	5–7			3–8	5–7	0.5–1.5	2–3								400	tr	0.1–700 b,d, f, pl-px+ mic,dol	<1		w 0.54 ± 0.02		0.707
bwf, bwp	Basaltic andesite of Lower Lake Road	57.6														1	tr	0.5–1	1–2				1–2 q	w 0.44 ± 0.08	N	0.026
bwf, bwp	Basaltic andesite of Shaw Valley	57.0														1–2	1	3–6					2–5 q	1		0.041
bws	Basaltic andesite of Wardlaw Spring Mound Mine	54.0							0.5–2	10						0.5	tr	1	5			b–300 d	tr			0.0008
aws	Andesite west of Shaw Valley	59.7							<0.5	tr						0.5–1	0.5–1					mic				0.0002
rc	Rhyolite of Cole Canyon	70.3	2–5	10	2–5	10			2–5	10	0.5–2	1								5–100	1–2			± 0.54 ± 0.02	ind	0.027
rm	Rhyolite northeast of Mount Olive	74.3	1–5	10–15	2–6	5–7			2–6	5–7	0.5–1.5	3–5										dol?,f				0.013
rmg	Rhyolite of Sugarloaf deposit west of Sulphur Mound Mine	74.7		tr		tr				tr												fl–200 d,dem,dol, mic,sed?,gv,f?					0.0083
rsm	Rhyolite south of Mcinnis Creek	75.9							1–2	1						1	1									0.0006
rmc	Rhyolite north of Mcinnis Creek																									
bmp	Pyroclastic deposits	56.4							1–2	<0.5				0.25	1								1–3 q	w		0.054
bmf	Flow	59.5							1–2	<0.5				0.5–1	tr								1–3 q	w	N	
my	Rhyolite of Red Hill Road Pyroclastic deposits	74.4			1–7	0.5–2			1–7	0.5–2	1–2	0.5–1		1	tr					10–60	0–2			± 0.50–0.02		0.068
mf	Flow	74.3							1–2		0.5–1	0.5		1	tr											
rhc, rhc, rhc	Rhyolite of Thurston Creek	75.1–75.7							1–2		0.5–1	tr		1	tr									± 0.47–0.015 ± 0.51–0.01	N	0.27
dbf	Rhyolite of Sugarloaf	70.8	1–5	5	1–15	5–10			1–10	10–15	0.5–1	0.5	0.25–1	1–2	0.5–2	2				5–50	5–10			± 0.61–0.03 ± 0.64–0.03		0.317
dsm	Dacite of Sugarloaf Mountain deposit west of Sulphur Mound Mine	70.8	2–5	5	2–5	3–5			2–5	5	1	0.5	0.25–0.5	0.5										± 0.60–0.02 ± 0.57–0.02		0.787
dsp	Rhyolite of Spruce Mine	70.8–71.1	2–10	5–10	2–10	5–8			2–10	5–7	1	0.5	0.25–1	0.5										± 0.53–0.03		0.58
	CLEARLAKE HIGHLANDS–THURSTON LAKE AREA																									
rlv	Rhyolite of Borax Lake	76.1																		0.2 cpx-opx-pl-rhyol, tuf	0.5 tr			± 0.91–0.013	N	0.067
dcp	Dacite of Clearlake Park	66.8–64.8							0.5–2	0.25						0.5–2	0.5			ten?			1–2 q	tr		0.027
bac	Basaltic andesite of Arrowhead Road	54.7							0.5–2	tr						0.5–1.5	0.5						0.5–2 q	tr		0.0047
bcc, bcf, bcc	Basaltic andesite of Roundtop Mountain	53.2–55.2							0.5	tr						0.5	5						1–5 q	tr	N	0.10
dcc	Dacite of Cache Creek	67.5	1–4	2	2–20	1			2–20	4	0.5–2	tr		1	0.5	0.5	0.5–2	tr		5	tr			± 0.40–0.04	N	0.12
dw	Dacite of Wheeler Ridge	64.0	1–5	3–5					1–10	5–8			0.5–1	tr	0.25–1	1	0.25–1	1								0.35
dgf	Dacite south of Gifford Flat	64.7	1–3	4	1–3	2			1–3	3				0.5–1	1	0.5–1	1							± 0.44–0.03		0.19
dpf	Dacite of Plum Flat	67.2	1–5	2–3	2–10	7–10			2–10	7–10	1–2	2–3	0.25–1	1–3	1–4	1–2	1–2	1								1.05
dt	Dacite of Thurston Lake	66.2	5	3–5					5–15	7–10			0.5–1	1–3	0.5–1	1–2	1–2	1		1–10	0.25		>10	2–3		1.7
dpl	Dacite of Pinkeye Lake	66.7	2–5	5	2–5	2–3			2–5	2–3				0.25–0.5	0.5	part clots 0.5–2	0.5		2 spc	3				± 0.46–0.03		0.19
dhv	Dacite of Clearlake Highlands	65.6	1–4	3					1–4	3	0.5–3	tr		2	4									± 0.52–0.06		0.12
dgp	Rhyolite of Geysers Pipeline	66.1	2–5	1	2–5	<1			1–10	5–10	0.25–1	0.5–5	<1													0.0277
dnh	Rhyolite north of Bald Mountain	69.3									1–25 f	tr	0.5–4	tr										± 1.2–0.3	R	0.0012
	NORTHEAST AREA																									
bhg, bhg	Basaltic andesite of Hog Hill	57.4–58.8							0.5–3	10				0.5–1	1	0.5–2	3						0.5 q	1		0.33
bcy, bcy	Younger basaltic andesite of Cobb Creek	57.6							0.5–1	2				0.2	1	0.2	1									0.13
bcw	Older basaltic andesite of Cobb Creek	56.7							0.5–1	2				0.5–1.5	0.5	0.5–1.5	0.5									0.0093
bdy, bdy	Basaltic andesite of Rattlesnake Mountain	57.6							1.5	8				0.5–1	1											0.021
ebf, ebf	Andesite of Sulphur Bank	57.7–59.3							0.5–1	0.5–2				1	tr										i	0.052
eag	Andesite of old cinder cone									1										tr						0.00397
	Inclusions of andesite (Holocene)								0.5–1	4				tr	1										N	
bc	Basaltic andesite south of Round Mountain	55.7							0.5–2	0.5				0.5–2	0.5	0.5–3	0.5			3–20 f	1–10					0.021
dcmt, dcmt, bcmt, bcmt	Dacite of Cherk Mountain	65.7							0.5–2	3		1	tr	0.5–2	10										N	0.0095
	Basaltic rocks	50.8–58.0							1–2	6–35				0.25–1	0–5	0.25–1	2–10						1–10 q	tr	mixed R, bas N, or i	0.2
	MOUNT HANNAH AREA																									
dk	Rhyodacite of Seigler Mountain	68.5–69.1	1–5	5	1–10	5	1–10	5	1	1–2	1–3	3	0.25–1	0.5	0.25–1	0.25								± 0.61–0.02	N	0.47
dwc	Dacite of Wildcat Mountain	67.4–68.4	1–3	1			0.5–5	5–10						1–2	1					9–30	~0.5			±0.33 (±0.16)	i	0.093
dch	Older dacite of Cobb Mountain	65.8–68.2	1–3	3–5			1–10	5–10	0.5–1	tr				1–2	5					5–150	1–10				i	0.607
bhr	Basalt of Harrington Flat	49.9–50.9	1–2	1			1–4	5–10						0.5–2	2–3					5–10	tr				i	0.29
adw	Andesite of Putnam Smith Spring	60.9														1–4 cpx-opx	15–20								R	0.12
df	Rhyodacite of Lush Lomond	69.2	1–3	3–5			1–10	10–15	0.5–1	tr				0.25–1	1	0.25–1	1			5–150	1–10			± 0.56 ± 0.03	i	0.58
awf, awf	Andesite of Split Rock Ridge	62.7–63.5					1–6	0.5–2, 0.5–1						1–4	2	1–4 cpx-opx	1					3–10 pc,tf	1	±0.38 (±0.06) ±0.36 (±0.05)	i	0.16
dhc	Rhyodacite of Dinner Circle	66.6–69.7	1–5	2–3			2–4	tr						1–3	1–2									±0.60 (±0.02) ± 0.52 (±0.02)	ind	0.47
dlb	Dacite of Boggs Lake	67.3	1–5	5			1–6	tr						1–2	1									± 0.59 ± 0.06		0.039
ag	Andesite of Agnes Valley	60.3					1–2	29–30 part clots						1–2	1									± 1.00 ± 0.05	R	0.477
agc	Andesite of Gamma Flat	62.6					0.5–2	20						0.5–3	15–20	0.25–0.5 ba	0.25								R	0.35
rhg, rhf	Rhyolite of Bonanza Springs	74.7–77.5					0.5	0.25						0.25	0.25					<pc,f	1–2			± 1.02 ± 0.04	R	1.67

[1]Modal (volume) percent of phenocrysts and inclusions mainly estimated from hand specimen; a few estimated from outcrop or thin section. Horizontal bracket indicates combined percentage of two or more minerals listed. Abbreviations: mm, in millimeters; %, modal percent; p, present; tr, trace.

[2]Units named primarily on the basis of SiO_2 content: basalt less than 53, basaltic andesite 53–59, andesite 59–63.5, dacite 63.5–68, rhyodacite 68–72, and rhyolite more than 72 percent SiO_2. A few units that have a range of SiO_2 content are named for the dominant SiO_2 type. Units are grouped according to petrographic criteria that suggest affinity to rocks of the same petrologic group.

[3]SiO_2 content determined by U.S. Geological Survey rapid-rock methods (Shapiro, 1975) and recalculated to a 100-percent total, volatile-free, and a ratio of ferrous iron adjusted to 0.85. Accuracy for SiO_2 by the rapid-rock method is generally ~1 percent. The chemical variation of samples from three volcanic units near Borax Lake (Rhyolite of Borax Lake (rlv), dacite of Clearlake Park (dcp), basaltic andesite of Arrowhead Road (bar)) suggests that SiO_2 accuracy is better than ±0.5 percent in that series.

[4]Quartz in rhyolite, rhyodacite, and dacite is phenocrystic; quartz in basalt, basaltic andesite, and andesite is probably xenocrystic.

[5]Olivine phenocrysts commonly altered to orange iron-titanium oxide; cn, Ti-magnetite; ilm, ilmenite (titanium oxide); ol, olivine; opx, orthopyroxene; cpx, clinopyroxene; pyr, combined cpx and opx; pl, plagioclase; ol, olivine.

[6]Diabasic-textured mafic inclusions are andesitic in composition (SiO_2, 58.9–62.4 percent) and are mainly composed of elongate plagioclase and clinopyroxene in ensophitic texture. Inclusions are commonly fine grained and rarely exceed 10 centimeters in diameter. Clots are similar to inclusions that have been interpreted as chilled inclusions of basaltic or andesitic melt in felsic volcanic rocks elsewhere (Eichelberger, 1980; Bacon and Metz, 1984; Sliman and others, 1991).

[7]Abbreviations: f, Fraxinian assemblage; gv, Great Valley sequence; sp, serpentinite; c, rhyolite; d, dacite; a, andesite; ba, basaltic andesite; b, basalt; perlogic map unit symbol is given for inclusions known to be from other units of the Clear Lake Volcanics.

[8]Abbreviations: q, quartz; pl, plagioclase; Kf, K-feldspar; cord, cordierite.

[9]Abbreviations: r, Franciscan assemblage; pc, Great Valley sequence; sp, serpentinite; c, rhyolite; d, dacite; a, andesite; ba, basaltic andesite; b, basalt; perlogic map unit symbol is given for inclusions known to be from other units of the Clear Lake Volcanics.

[10]Age is potassium-argon (K/Ar) age in millions of years (Ma) from Donnelly-Nolan and others (1981) unless specified as C, for carbon-14 age, in thousands of years (yr). Analytical error, one standard deviation, is given where known. Ages are whole-rock determinations of the whole rock, a, sanidine; bi, biotite. Parentheses enclose age that does not fit stratigraphic sequence, magnetic polarity, or other ages on the same unit.

[11]Magnetic polarity from Mankinen and others (1978), Mankinen and others (1981), or determined in the field by B.C. Hearn, Jr., using a portable Ruggar magnetometer. Abbreviations: N, normal; R, reversed; i, intermediate; ind, independent.

[12]Volume calculated from estimates of average thickness, existing area of exposure, and estimated area concealed beneath younger deposits. Volume for the early basalts rocks (bss, bmp, bsm) includes their maximum area of exposure south of the map area. Volume queried where average thickness and (or) concealed extent uncertain.

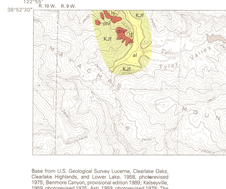
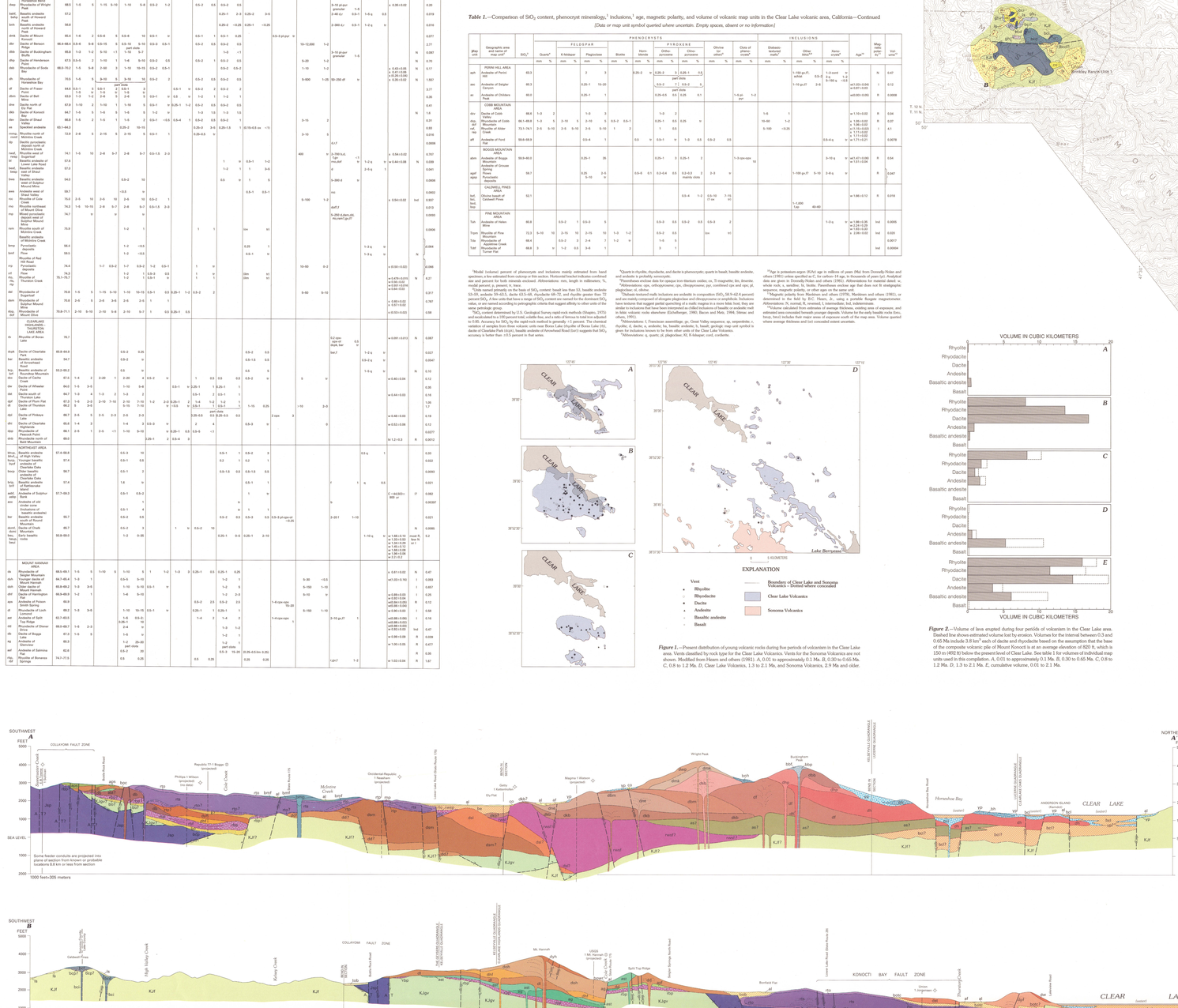
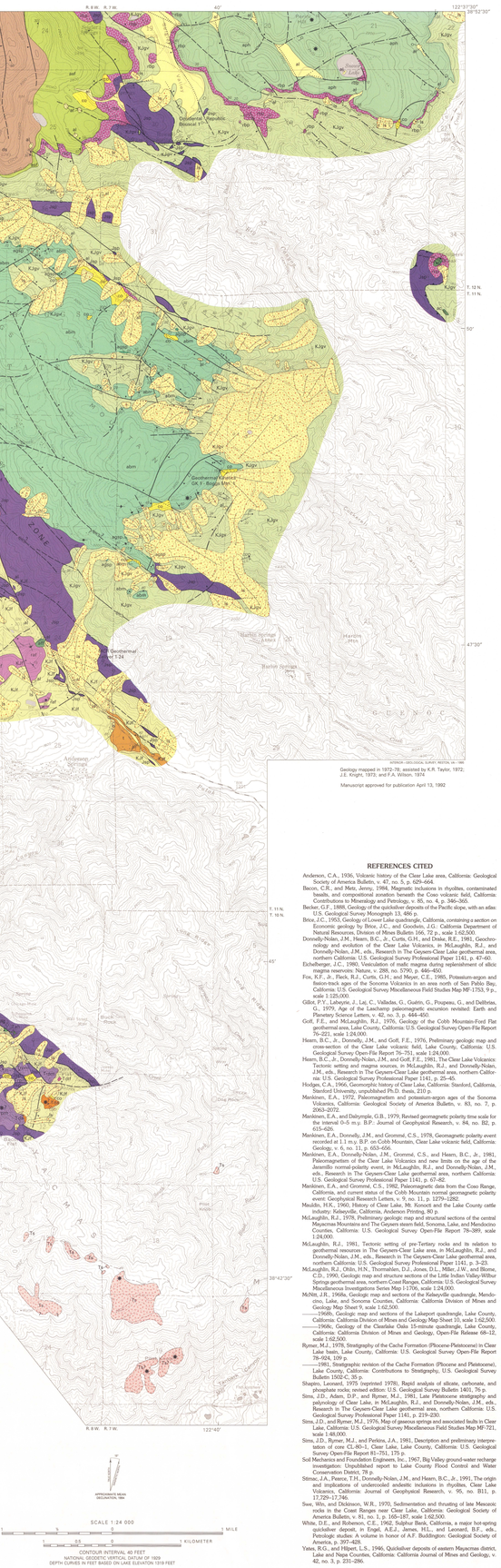


Figure 1.—Present distribution of young volcanic rocks during five periods of volcanism in the Clear Lake area. Vents classified by rock type for the Clear Lake Volcanics. Vents for the Sonoma Volcanics are not shown. Modified from Hearn and others (1981). *A*, 0.01 to approximately 0.1 Ma. *B*, 0.30 to 0.65 Ma. *C*, 0.8 to 1.2 Ma. *D*, Clear Lake Volcanics, 1.3 to 2.1 Ma, and Sonoma Volcanics, 2.9 Ma and older.

Figure 2.—Volume of lava erupted during four periods of volcanism in the Clear Lake area. Dashed line shows estimated volume lost by erosion. Volumes for the interval between 0.3 and 0.65 Ma include 3.8 km^3 each of dacite and rhyodacite based on the assumption that the base of the composite volcanic pile of Mount Konocti is at an average elevation of 820 ft, which is 150 m (492 ft) below the present level of Clear Lake. See table 1 for volumes of individual map units used in this compilation. *A*, 0.01 to approximately 0.1 Ma. *B*, 0.30 to 0.65 Ma. *C*, 0.8 to 1.2 Ma. *D*, 1.3 to 2.1 Ma. *E*, cumulative volume, 0.01 to 2.1 Ma.




Geothermal Wells
Geothermal Steam Pipeline
Geothermal Power Plant
Geothermal Steam Field
Geothermal Area
Clear Lake
Lakeport
Kelseyville
Upper Lake
Lower Lake
Middletown
Cobb Mountain
Mount Hannah
Mount Konocti
Bartlett Springs Fault Zone
Collayomi Fault Zone
Konocti Bay Fault Zone
Mayacmas Mountains
Sonoma Volcanics
Clear Lake Volcanics
Quaternary Sedimentary Deposits
Franciscan Assemblage
Great Valley Sequence
Serpentinite
Geothermal Steam Field GK, I - Burgo Steam Field
Geothermal Steam Field GS - Sulphur Bank
Geothermal Steam Field GF - Geysers
Union Lakeview Fallon State 45-9
Union Kelly Geysers Unit 1
Union NE Geysers 2
Union Lakeview Fallon State 45-9
Union Kelly Geysers Unit 1
Union NE Geysers 2
Geothermal Well 324
Geothermal Well 1
Geothermal Well 2
Geothermal Well 3
Geothermal Well 4
Geothermal Well 5
Geothermal Well 6
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