OPEN-FILE REPORT 03-113
Sheet 2

Geology of Kanaga Volcano

Kanag a Volcano is a 1,300 m (4,287-foot) high, historically active cone-shaped stratovolcano located on the north end of Kanaga Island in the Andreanof Islands Group of the Aleutian Islands. The volcano is undissected, symmetrical in profile, and is characterized by blocky andesitic lava flows, with well-developed levees and steep flow fronts, that emanate radially from, or near, the 200-m-wide summit crater. The lack of dissection of the cone suggests the entire edifice was constructed in post-glacial Holocene time. Historical eruptions were reported in 1791, 1827, 1829, 1904-1906, and 1993-95 (Miller and others, 1998); questionable eruptions occurred in 1763, 1768, 1786, 1790, and 1933. The upper flanks of the cone are very steep (>30°) and flows moving down these steep flows commonly fragment into breccias and lahars. A non-vegetated lahar, or group of lahars, extends from high on the southeast flank of the cone down to the northeast shore of the intracaldera lake. This lahar deposit was observed in 1999 but does not appear to be present on aerial photos taken in 1974 and is assumed to be part of the 1994-95 eruption.

Most recent eruptions of Kanag a, including the 1994-95 eruption, were primarily effusive in character with a subordinate explosive component. Lava was extruded from, or near, the summit vent and moved down the flank of the cone in some cases reaching the ocean. In 1994, lava flows going down the very steep north and west flanks broke up into incandescent avalanches tumbling over steep truncated sea cliffs into the Bering Sea. A common feature of Kanaga central vent eruptions is the occurrence of widespread ballistics and accompanying craters. Steam and fine ash plumes rose to 7.5 km ASL and drifted a few tens of kilometers downwind. Plumes such as these are unlikely to deposit significant (i.e., sufficiently thick to leave a permanent record) tephras on other islands downwind.

Se veral recent non-vegetated flow fields (labeled Qhlf on the geologic map) are identifiable on the east-northeast, south, southwest, west-southwest, and northwest flanks of the volcano with the latter three fields extending to the ocean. Older lava flows and flow fields (labeled Qholf) are vegetated to varying degrees but retain fresh-appearing surface features such as levees, pressure ridges and steep lobate flow fronts. In the past, lava flows from both units may have broken out from points below but near the summit. Pyroclastic flows and pumiceous debris flows along the southern base of the volcano contain abundant silicic pumice clasts. The source domes for this material appear to have been overridden by andesitic flows that form the present-day Kanaga edifice.

Kanag a Volcano is composed primarily of porphyritic two-pyroxene andesite; phenocrysts are chiefly plagioclase, clinopyroxene, orthopyroxene, and Fe-oxide minerals with traces of olivine and hornblende. The groundmass is usually a pale to light-brown glass with microlites of plagioclase and pyroxene. Kanaga volcanic rocks are medium-K, calcalkaline in character; samples from the present edifice show a relatively narrow compositional range from 51 to 66 percent SiO_2 with an average of 56 percent.

Pumices from the p yroclastic flows, airfalls, and debris flows are more silicic ranging from 63 to 66 percent SiO_2 (dacitic). Multiple dome collapse is the most likely origin for these deposits and, although dacite domes have not been identified at Kanaga, the location and pumice clast size of the pyroclastic deposits suggests their parent domes are buried by still more recent lava flows from the Kanaga cone.

Silicic andesite domes crop out in the southern part of the caldera in and adjacent to the intra-caldera lake. These domes are compositionally different from the silicic pumices and are thought to represent an earlier eruptive phase more closely related to the andesite edifice.

Kanag a Volcano is partly surrounded by, and in fault contact with, overlapping volcanic cones. Coats (1955) and Brophy (1990) consider the oldest of these cones to be exposed along the north coast of the island immediately east of Kanaga Volcano. This composite cone consists chiefly of massive, thick-bedded, altered K-rich andesite lava flows and volcanic breccias. The cone is overlain by over 450 m of basaltic andesite and andesite flows and volcanic breccias that form most of Kanaton Ridge.

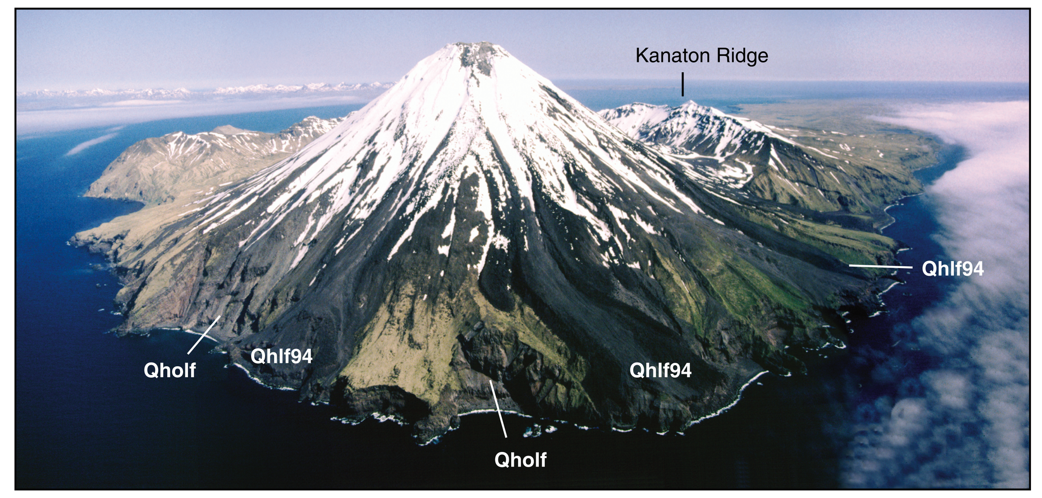
Kanag a Volcano is partly enclosed on its south and east sides by Kanaton Ridge, a prominent scarp-like feature sculpted into the side of a large ancestral basaltic andesite cone named Mt. Kanaton by Coats (1955). This crescent-shaped feature is either the remnant of 1) a typical island-arc collapse caldera-rim now breached to the north, or more likely the 2) the scarp of an avalanche caldera resulting from directed edifice failure to the north and west.

Typical Aleutian arc collapse calderas are surrounded by voluminous pyroclastic flow or tephra deposits representing the catastrophic caldera-forming eruption (Miller and Smith, 1987). Pyroclastic flow deposits are uncommon on Kanaga Island south of Kanaton Ridge and tephra deposits, although abundant, do not seem sufficiently thick or coarse enough to represent a caldera-forming eruption and are absent in some areas where deposition would have been expected. The lack of suitable pyroclastic flanking deposits could also be explained if Kanaton Ridge is a somma-like feature representing an avalanche scarp of northward-directed edifice failure. This failure may or may not have been associated with voluminous explosive volcanic activity and thus could have occurred without leaving voluminous deposits on Kanaga Island itself. These observations could be explained by assuming a Pleistocene age for the formation of Kanaton caldera. Subsequent glaciation could have resulted in the erosion of deposits from the caldera-forming eruption. The thick section of pumice-rich, cross-bedded outwash found in the central part of the island indicates at least some silicic explosive volcanism occurred prior to the Holocene and indeed pumice in the deposit may represent material from a caldera-forming eruption.

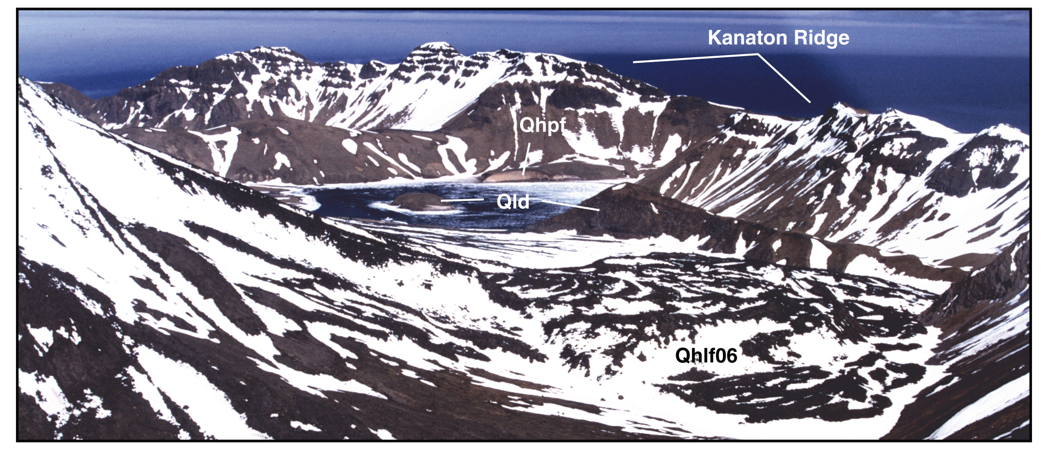
An intracaldera lak e about 1.5 km long occurs in the southeast corner of the caldera at an elevation of about 330 m (1,000 feet) above sea level. A flat-topped lava dome in the center of the lake and a beveled pumice deposit on the southeast shore of the lake are indicative of higher lake levels in the past. A fan-shaped lahar deposit that contains cobble and small boulder size clasts of pumice and lithics extends from the southwest slope of Kanaga volcano to the ocean and may be evidence of catastrophic release of water from the southwest corner of the caldera through the southwest corner of the caldera, possibly associated with a dome eruption during a higher stand of the lake. The lahar is now separated from the caldera by a young (1906) lava flow.

Hot springs are scattered o ver an east-west area of about 100 m x 20 m along the south side of stream about 500 feet above sea level and about 1 km from Weed Bight. Temperatures of up to 92°C were measured in several places but several small (5-10 cm high) geysers were noted in inaccessible locations suggesting higher temperatures; some of these geysers were surrounded by cones of travertine (?) up to 20 cm high and 70 cm wide.

Fumarolic activity. Coats (1955), who climbed the volcano in 1946, reported fumaroles near the summit of the volcano on the southeast, south, and southwest sides and several fumaroles in the bottom of the 60 m deep summit crater. Aerial observations in 1999 indicate much the same situation prevailed. Coats (1955) measured temperatures of 104°C at these fumaroles and also noted the presence of sulfur crusts and a faint odor of hydrogen sulfide. Aerial photographs taken in 1974 suggest a fissure striking NE may extend through the summit vent for a few hundred kilometers on either side of the vent. Photographs of the 1994-1955 eruption indicated a "leaky" summit vent with fumarolic activity spread around the outside of the vent; a particularly vigorous vent was noted down the southeast flank several hundred meters from the summit on strike with the apparent summit fissure.



Kanaga Volcano, July 2000, view is to the southeast. Selected geologic units indicated by map symbols. Photograph by C.J. Nye, Alaska Division of Geological and Geophysical Surveys.



Kanaga Volcano, July 2000, view is to the east across intracaldera lake. Selected geologic units indicated by map symbols. Photograph by C.F. Waythomas, U.S. Geological Survey.

TABLE 1.--CHEMICAL ANALYSES OF LAVA AND PYROCLASTS FROM KANAGA VOLCANO

[Analyses with sample numbers prefixed by 9, 0, or 00 by Geoanalytical Laboratory,Washington State University. All other analyses from Coats, 1952, and Brophy, 1990]

Map unit		Qhlf1994	Qhlf1906	Qhlf1906	Qhlf1906	Qhlf06	Qholf	Qholf	Qholf	Qholf	Qholf	Oholf	Qholf
Lithology	1994 ash	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow
Sample #	Nye 6	0NK07	0M01A	0M09A	C97	C116	KG21	C112	C107	KG22	KG23	KG24	KG25
SiO_2	59.94	56.23	58.14	56.54	55.18	55.62	55.50	57.31	60.14	54.78	58.80	56.85	55.60
Al2O_3	18.52	17.80	17.28	17.70	17.97	16.88	17.87	18.21	16.60	18.49	17.48	18.27	17.90
FeO*	5.11	7.27	6.91	7.29	8.12	8.62	7.18	7.51	6.64	8.05	6.47	7.25	7.45
MgO	2.25	3.94	3.47	3.86	3.95	3.79	5.10	3.07	2.58	4.63	3.32	3.68	4.46
CaO	7.20	8.63	7.75	8.41	9.22	8.65	9.07	7.88	7.24	8.09	7.44	8.33	10.00
Na_2O	4.09	3.41	3.55	3.46	2.61	3.51	3.29	3.65	3.60	3.58	3.54	3.18	2.39
K_2O	1.95	1.53	1.75	1.54	1.50	1.64	1.38	1.65	2.05	1.54	1.82	1.44	1.29
TiO_2	0.63	0.85	0.81	0.85	1.00	0.84	0.79	0.08	0.72	0.65	0.78	0.85	0.70
P_2O_5	0.19	0.18	0.19	0.18	0.27	0.28		0.46	0.25				
MnO	0.12	0.17	0.16	0.17	0.17	0.17	0.15	0.18	0.16	0.19	0.16	0.15	0.16
Cs		2.87	2.52	2.21									
Rb		37.40	42.93	36.60			36.00			36.00	46.00	37.00	33.00
Ba		540.00	603.00	537.00			444.00			482.00	587.00	487.00	381.00
Sr		396.00	396.00	399.00			370.00			379.00	371.00	394.00	335.00
La		10.44	11.80	10.55									
Ce		22.33	24.68	22.43									
Pr		2.98	3.24	3.03									
Nd		13.86	14.82	14.08									
Sm		3.94	4.04	3.93									
Eu		1.18	1.21	1.17									
Gd		4.02	3.98	4.11									
Tb		0.69	0.70	0.68									
Dy		4.35	4.25	4.31									
Ho		0.93	0.91	0.94									
Er		2.60	2.64	2.54									
Tm		0.39	0.38	0.38									
Yb		2.48	2.47	2.51									
Lu		0.41	0.40	0.40									
Y		24.81	24.96	24.35			35.00			32.00	36.00	33.00	30.00
Zr		115.00	131.00	115.00			93.00			105.00	122.00	89.00	98.00
Hf		3.25	3.49	3.26									
Nb		2.42	2.70	2.41									
Ta		0.18	0.19	0.17									
Pb		9.28	8.93	7.72									
Th		3.71	4.41	3.51									
U		1.53	1.78	1.49									
Ga		20.00	19.00	18.00									
Cu		76.00	55.00	66.00									
Zn		71.00	67.00	67.00									
V		212.00	196.00	219.00			211.00			232.00	190.00	220.00	186.00
Sc		27.00	24.40	26.00			29.00			26.00	21.00	24.00	30.00
Cr		28.00	20.00	20.00									
Ni		10.00	6.00	6.00									

Map unit	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf	Qholf
Lithology	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	pumice	pumice	pumice	pumice	pumice	pumice
Sample #	0NK04	00CW241d	0NK02B1	0NK02L1	0NK02L2	0NK02P1	0NK09	0M09B	0M09C	0M10	00NK01P1	00CW08-1	00CW241b
SiO_2	56.07	56.45	55.56	58.44	56.37	56.16	56.45	55.76	57.89	58.62	56.81	57.67	57.15
Al2O_3	17.55	18.01	17.86	17.23	17.70	17.73	17.98	18.10	17.44	17.42	17.76	17.56	17.77
FeO*	7.63	7.18	7.19	6.91	7.29	7.45	7.34	7.33	7.01	6.75	7.19	7.17	7.18
MgO	4.00	3.83	4.12	3.40	4.03	4.02	3.75	4.08	3.58	3.31	3.80	3.34	3.67
CaO	8.62	8.54	8.87	7.60	9.62	8.67	8.52	8.78	7.72	7.45	8.40	7.78	8.19
Na_2O	3.39	3.38	3.29	3.58	3.36	3.36	3.41	3.35	3.54	3.62	3.38	3.58	3.37
K_2O	1.51	1.46	1.46	1.72	1.47	1.44	1.42	1.44	1.66	1.73	1.52	1.72	1.53
TiO_2	0.88	0.80	0.86	0.77	0.82	0.82	0.76	0.82	0.79	0.76	0.80	0.79	0.79
P_2O_5	0.18	0.18	0.17	0.19	0.18	0.18	0.20	0.17	0.19	0.19	0.19	0.22	0.18
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.16	0.17	0.16	0.17	0.17	0.17
Cs	2.77	2.16	2.83	3.25	2.86	2.87	1.79	2.088	2.501	2.676	2.883	2.543	2.289
Rb	35.52	36.23	36.34	43.35	37.22	37.05	36.72	34.702	40.655	43.377	37.57	43.296	38.017
Ba	527.00	522.00	518.00	608.00	529.00	524.00	564.00	504	583	615	537	636	548
Sr	398.00	402.00	403.00	391.00	397.00	406.00	424.00	394	383	381	400	431	411
La	10.26	10.18	10.03	11.76	10.29	10.28	10.67	9.902	11.283	12.005	10.5	12.674	10.696
Ce	21.90	21.81	21.52	24.84	22.17	21.95	22.37	21.193	23.847	25.067	22.449	26.771	22.759
Pr	2.92	2.93	2.89	3.28	2.95	2.94	2.95	2.855	3.184	3.31	3.008	3.541	3.036
Nd	13.60	13.59	13.47	15.00	13.66	13.74	13.43	13.151	14.414	15.155	13.886	16.023	14.226
Sm	3.80	3.76	3.75	4.06	3.86	3.82	3.73	3.82	4.037	4.145	3.89	4.268	3.842
Eu	1.18	1.13	1.15	1.20	1.16	1.16	1.18	1.142	1.174	1.207	1.154	1.277	1.202
Gd	3.97	3.83	3.95	4.08	3.94	3.95	3.68	3.944	4.028	4.258	3.914	4.193	3.941
Tb	0.68	0.67	0.68	0.70	0.68	0.67	0.62	0.657	0.687	0.692	0.676	0.714	0.696
Dy	4.27	4.23	4.33	4.39	4.28	4.28	3.94	4.272	4.387	4.316	4.276	4.415	4.341
Ho	0.91	0.90	0.90	0.94	0.90	0.90	0.84	0.877	0.908	0.924	0.881	0.916	0.912
Er	2.56	2.56	2.49	2.70	2.55	2.52	2.36	2.532	2.577	2.631	2.503	2.61	2.592
Tm	0.38	0.37	0.38	0.40	0.38	0.38	0.35	0.373	0.386	0.395	0.383	0.391	0.39
Yb	2.38	2.43	2.42	2.56	2.48	2.46	2.23	2.394	2.555	2.531	2.461	2.539	2.504
Lu	0.39	0.40	0.39	0.41	0.40	0.39	0.37	0.389	0.409	0.421	0.404	0.419	0.41
Y	23.70	24.24	24.62	25.74	24.61	24.52	22.27	24.045	24.718	25.329	24.394	25.313	24.924
Zr	114.00	107.00	109.00	131.00	114.00	110.00	105.00	106	123	127	117	128	111
Hf	3.15	3.17	3.12	3.55	3.18	3.13	2.87	3.12	3.52	3.61	3.22	3.6	3.3
Nb	2.31	2.31	2.31	2.71	2.35	2.31	2.33	2.27	2.56	2.73	2.38	2.75	2.43
Ta	0.17	0.16	0.17	0.19	0.16	0.17	0.16	0.17	0.19	0.19	0.17	0.19	0.18
Pb	8.83	8.86	8.96	10.17	9.52	9.44	8.60	7.62	9.3	9.45	9.73	8.97	8.8
Th	3.55	3.68	3.56	4.29	3.69	3.61	3.97	3.33	4	4.28	3.72	4.49	3.88
U	1.45	1.51	1.44	1.77	1.50	1.47	1.64	1.37	1.66	1.77	1.51	1.82	1.59
Ga	19.00	17.00	18.00	18.00	21.00	20.00	18.00	20	18	19	17	19	19
Cu	79.00	123.00	71.00	63.00	69.00	45.00	48.00	95	49	85	68	74	77
Zn	71.00	105.00	75.00	72.00	75.00	75.00	72.00	80	72	87	72	77	92
V	237.00	207.00	233.00	186.00	214.00	208.00	204.00	230	195	181	195	203	200
Sc	25.80	26.80	28.60	23.80	27.20	27.00	24.40	26.6	22.2	21.4	25.7	21.7	26
Cr	24.00	26.00	33.00	21.00	30.00	26.00	22.00	24	23	12	28	11	19
Ni	9.00	12.00	12.00	7.00	10.00	12.00	12.00	11	9	6	8	4	9

Map unit	Qholf	Qhld	Qhld	Qhld	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv
Lithology	pumice	andesite	andesite	andesite	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow
Sample #	00CW241c	0NK03	0NK05	0NK06	00CW24-3	C135	C127	C124	KG18	0M01C	0NK08	00CW20-1
SiO_2	59.05	60.43	57.57	54.47	58.80	51.72	53.65	60.49	58.48	60.09	57.36	59.53
Al2O_3	17.51	17.39	17.88	17.56	17.68	18.66	17.68	16.84	17.87	16.96	17.46	17.67
FeO*	6.52	6.20	7.10	7.50	6.61	9.11	8.13	6.54	7.42	6.39	7.06	6.69
MgO	3.25	2.87	3.70	5.18	3.12	4.61	5.51	3.12	3.13	3.00	3.60	2.68
CaO	7.28	6.89	8.07	9.69	7.57	9.15	8.39	6.31	7.11	6.82	8.21	6.52
Na_2O	3.49	3.67	3.35	3.13	3.55	3.67	3.38	3.62	3.49	3.71	3.62	3.80
K_2O	1.75	1.54	1.28	1.35	1.66	1.85	1.71	2.05	1.84	1.92	1.55	2.06
TiO_2	0.78	0.64	0.69	0.81	0.67	0.72	0.68	0.48	0.64	0.74	0.77	0.66
P_2O_5	0.20	0.21	0.20	0.16	0.18	0.32	0.42	0.38		0.19	0.20	0.23
MnO	0.17	0.18	0.18	0.16	0.16	0.18	0.18	0.16	0.16	0.16	0.17	0.15
Cs	2.593	3.186	2.69	2.571	0.989					2.848	2.837	2.201
Rb	42.537	39.872	33.218	32.139	44.472				23	47.59	38.646	52.093
Ba	606	601	503	467	649				608	657	586	783
Sr	389	412	386	382	414					385	456	493
La	11.72	11.267	10.084	9.077	11.375					12.602	11.683	15.459
Ce	24.688	23.592	20.979	19.548	22.993					26.428	24.215	29.143
Pr	3.28	3.045	2.812	2.6	2.907					3.447	3.14	4.093
Nd	14.981	13.631	12.837	12.291	12.836					15.525	14.269	18.263
Sm	4.017	3.571	3.527	3.489	3.277					4.084	3.834	4.589
Eu	1.181	1.136	1.166	1.067	1.066					1.209	1.176	1.299
Gd	3.886	3.491	3.571	3.635	3.146					4.059	3.779	4.308
Tb	0.686	0.601	0.611	0.6	0.523					0.69	0.627	0.705
Dy	4.351	3.776	3.838	3.868	3.332					4.338	3.916	4.375
Ho	0.925	0.822	0.826	0.829	0.726					0.941	0.84	0.931
Er	2.626	2.319	2.336	2.3	2.004					2.665	2.36	2.591
Tm	0.386	0.35	0.357	0.35	0.305					0.403	0.352	0.393
Yb	2.54	2.308	2.254	2.141	2.027					2.635	2.234	2.554
Lu	0.417	0.38	0.376	0.358	0.326					0.432	0.369	0.427
Y	24.536	22.157	21.936	21.977	19.4					26.005	22.378	25.64
Zr	124	120	101	105	107				113	143	113	127
Hf	3.51	3.18	2.81	2.82	2.95					3.82	3.16	3.72
Nb	2.61	2.49	2.11	2.11	2.44					2.93	2.47	2.89
Ta	0.19	0.18	0.15	0.15	0.19					0.22	0.18	0.21
Pb	9.93	10.38	7.59	8.33	8.39					9.98	8.62	10.69
Th	4.37	4.18	3.36	3.16	5.14					4.91	3.93	5.81
U	1.79	1.71	1.38	1.31	2.06					2	1.61	2.44
Ga	20	19	16	17	18					19	20	20
Cu	67	27	37	62	36					59	43	42
Zn	80	77	78	66	66					76	69	74
V	179	143	168	224	173					176	211	162
Sc	21.6	17.8	21.8	33.5	21.5					21.6	21.7	15.1
Cr	16	15	32	107	19					9	22	14
Ni	7	5	9	30	6					5	9	7

Map unit	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv
Lithology	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow
Sample #	9M120	KG32	KG31	KG19	KG12	KG18	KG17	KG16	KG15	KG14	KG13	KG36	KG35	KG34	KG33
SiO_2	58.49	57.54	56.85	57.62	58.33	58.83	59.14	58.02	58.49	57.47	60.07	58.03	57.25	59.64	59.59
Al2O_3	17.78	18.56	18.56	18.30	18.22	17.98	17.88	18.22	17.94	17.99	18.31	18.02	18.47	17.89	18.06
FeO*	6.43	6.92	7.15	6.84	6.70	6.75	6.68	6.69	6.72	7.17	6.52	6.75	7.24	6.05	6.22
MgO	3.35	3.42	3.38	3.33	3.09	3.15	2.86	3.11	3.05	3.21	2.92	3.21	3.16	2.69	2.81
CaO	7.77	7.45	7.56	7.59	6.92	7.15	6.88	7.50	7.07	7.62	6.83	7.21	7.61	6.64	6.30
Na_2O	3.56	3.87	3.95	3.70	4.02	3.51	3.47	3.59	3.66	3.74	3.98	3.81	3.64	3.99	3.98
K_2O	1.62	1.83	1.84	1.79	1.90	1.85	2.27	2.00	2.24	1.98	2.36	2.10	1.85	2.30	2.22
TiO_2	0.67	0.73	0.53	0.68	0.67	0.64	0.68	0.69	0.68	0.66	0.71	0.70	0.62	0.66	0.65
P_2O_5	0.17														
MnO	0.17	0.16	0.17	0.14	0.16	0.16	0.14	0.16	0.15	0.17	0.14	0.16	0.16	0.14	0.16
Cs	1.101														
Rb	41.593	44	40	42	44	46	56	37	53	50	61	57	42	58	51
Ba	651	586	355	686	709	608	736	651	754	708	750	760	690	864	797
Sr	447	424	424	491	484	459	469	494	471	498	420	463	499	463	445
La	9.983														
Ce	20.187														
Pr	2.579														
Nd	11.54														
Sm	3.045														
Eu	1.01														
Gd	2.999														
Tb	0.504														
Dy	3.336														
Ho	0.683														
Er	1.966														
Tm	0.299														
Yb	1.967														
Lu	0.319														
Y	18.505	35	22	33	35	36	35	35	35	34	35	35	35	34	33
Zr	98	107	110	102	117	113	117	101	122	113	147	114	101	134	144
Hf	2.82														
Nb	2.31														
Ta	0.17														
Pb	5.75														
Th	4.13														
U	1.72														
Ga	18														
Cu	30														
Zn	61														
V	200														
Sc	23.2														
Cr	26														
Ni	6														

Map unit	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	TQkv	Qhla	Qhla	Qhpf	Qhpf	Qhpf	Qhtc
Lithology	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	lava flow	pumice	pumice	pumice	pumice	pumice	pumice
Sample #	KG38	KG39	KG40	KG41	KG42	KG43	KG45	9M22	00CW241e	0M01B	0M08A	00CW083	00CW14-2	C130
SiO_2	57.57	58.24	56.63	57.96	59.15	60.28	61.68	57.83	65.65	63.63	66.36	66.21	66.30	63.92
Al2O_3	18.6	18.46	18.50	18.33	17.9	17.84	18.56	18.33	16.62	16.87	16.65	16.63	16.53	16.85
FeO*	6.73	6.40	7.21	6.72	6.64	6.03	4.70	6.67	4.26	4.93	3.91	3.96	4.09	5.03
MgO	3.02	2.81	3.23	2.89	2.90	2.86	1.83	2.74	1.60	2.08	1.51	1.55	1.43	2.51
CaO	7.01	6.91	7.66	7.40	6.88	5.78	6.15	7.11	5.03	5.62	4.81	4.85	4.90	4.92
Na_2O	3.78	3.85	3.64	3.57	3.77	3.90	3.85	3.78	4.18	3.88	4.12	4.15	4.10	3.90
K_2O	2.60	2.60	2.25	2.26	2.21	2.49	2.47	2.41	1.91	2.15	1.90	1.91	1.91	1.69
TiO_2	0.71	0.67	0.71	0.70	0.71	0.67	0.64	0.72	0.45	0.52	0.43	0.43	0.43	0.69
P_2O_5								0.24	0.16	0.19	0.16	0.16	0.16	0.32
MnO	0.16	0.16	0.16	0.16	0.17	0.15	0.11	0.17	0.14	0.15	0.15	0.15	0.15	0.17
Cs								1.654	1.816	1.953	3.011	3.039	3.048	
Rb	68	66	61	633	56	56	61	64.748	51.937	60.669	49.696	50.704	50.476	
Ba	756	758	675	752	672	708	728	785	734	861	721	718	721	
Sr	427	427	451	431	379	367	411	459	393	420	364	382	375	
La								15.719	13.068	13.778	13.465	13.681	13.368	
Ce								33.245	25.494	27.054	26.155	26.885	26.226	
Pr								4.327	3.13	3.25	3.193	3.251	3.168	
Nd								19.421	13.086	13.84	13.414	13.705	13.495	
Sm								4.934	3.183	3.351	3.161	3.211	3.242	
Eu								1.347	1.008	1.034	0.93	0.998	0.956	
Gd								4.56	2.96	3.054	2.923	3.014	2.963	
Tb								0.741	0.506	0.508	0.493	0.52	0.502	
Dy								4.727	3.192	3.158	3.171	3.293	3.22	
Ho								0.999	0.683	0.678	0.658	0.699	0.678	
Er								2.848	1.967	1.929	1.898	2.053	1.983	
Tm								0.417	0.311	0.294	0.314	0.327	0.31	
Yb								2.794	2.119	1.979	2.13	2.128	2.125	
Lu								0.44	0.365	0.331	0.36	0.37	0.365	
Y	39	37	36	39	34	39	62	26.725	19.133	18.856	18.502	19.44	19.253	
Zr	173	178	153	176	143	155	159	150	137	133	147	140	144	
Hf								4.66	3.75	3.55	3.79	3.87	3.76	
Nb								3.87	2.82	2.94	2.74	2.79	2.77	
Ta								0.28	0.21	0.22	0.22	0.22	0.22	
Pb								10.59	8.16	7.07	9.56	10.15	10.05	
Th								7.32	5.35	6.75	5.11	5.3	5.34	
U								3.07	2.15	2.68	2.07	2.19	2.15	
Ga								20	17	19	18	17	17	
Cu								51	13	54	27	9	40	
Zn								76	57	65	71	64	79	
V								171	87	103	74	69	76	
Sc								17.2	9.9	12.9	7.5	8.5	8.7	
Cr								9	2	8	1	1	1	
Ni								7	3	4	2	2	2	

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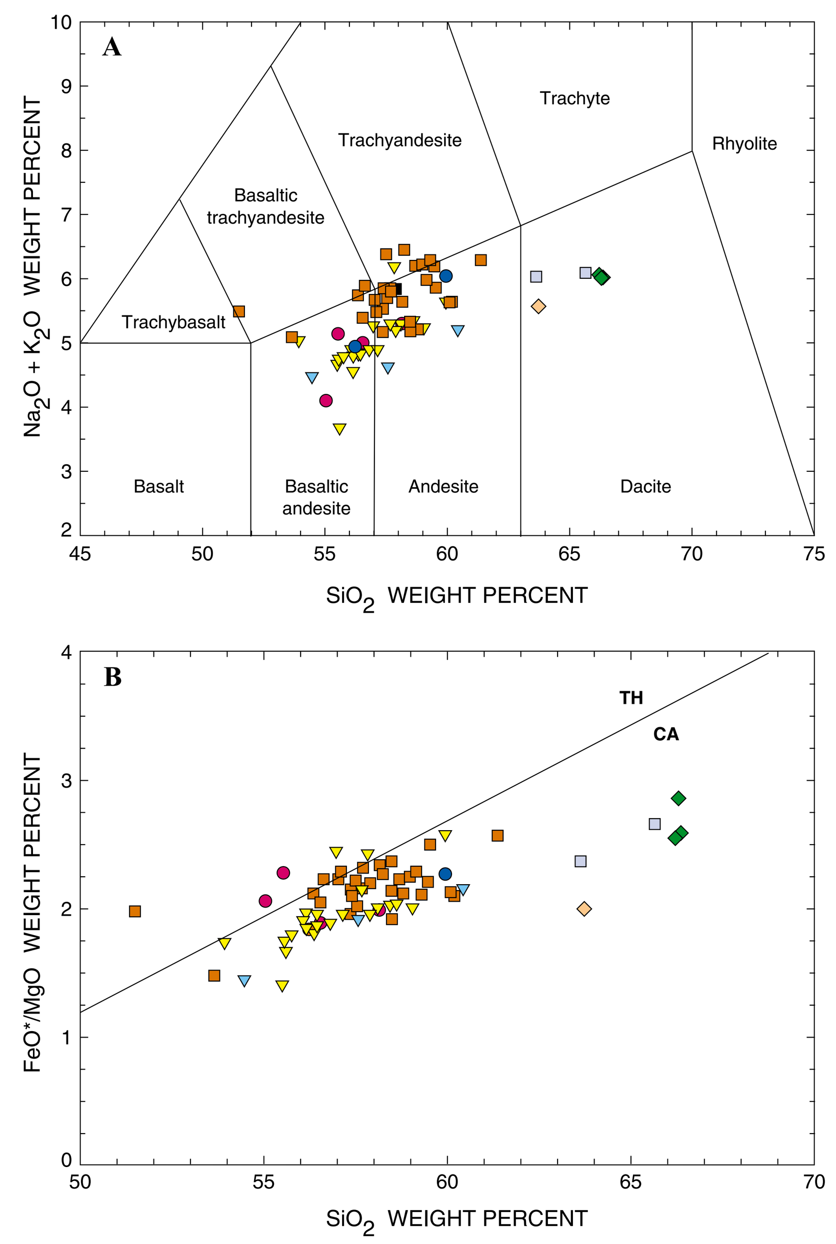

Variation diagrams for Kanaga volcanic center rocks. Complete major and minor element data included in Table 1. (A) Total alkali-silica diagram. Discriminant lines from LeBas and others (1986). (B) FeO*/MgO-silica diagram. Tholeiite-calkalkaline discriminant line from Miyashiro (1974).