

VOLCANIC ZONE OF THE KURILE ISLANDS

G. S. GORSHKOV

Laboratory of Volcanology, Academy of Sciences of the USSR, USSR.

The volcanic zone of the Kurile Islands was until recent one of the least studied volcanic zones of the Globe. The first information on some volcanoes was brought to Moscow by Cossack Kozyrevsky in 1713. A thorough description of several volcanoes was compiled in 1769 by I. Cherny. These data were published in German by P.S. Pallas in 1783 and have become widely known. After the transfer of the islands to Japan special volcanological investigations were conducted by J. Milne in 1878 and 1885. All further summaries repeated the data obtained by I. Cherny and J. Milne. The latter author reports 52 volcanoes from the Kurile Islands, of which 17 are active.

Japanese scientists (Tanakadate, etc.) published new data in European languages but only for the Taketomi crater, an adventive crater of the Alaid Volcano, which originated in 1934. Our own investigations started in 1946 and were continued in 1951-1954. These investigations embrace, to a certain extent, all the islands of the archipelago, and permitted to get a general idea of nearly all active and of several extinct volcanoes of the Kurile Island arc. At least 89 volcanoes, including 39 active ones, were found.

The Kurile arc, like some other island arcs, is a double one. The outer arc forms the Small Kurile Ridge, the greater part of which is hidden under the ocean waters forming a submarine ridge, called the Paleokuriles in 1947 by the author, and thoroughly investigated by the Institute of Oceanology of the USSR Academy of Sciences in 1950-1951, with the expeditionary ship "Vityaz". The internal arc forms the Big Kurile Ridge, the place of concentration of recent volcanic activity.

The islands of the outer arc are composed of Cretaceous and Lower Tertiary sedimentary and volcano-sedimentary rocks with intrusions of gabbro-diorites.

The foundation of the internal arc is composed of sedimento-volcanogeneous rocks and intrusions of leucocratic plagiogranites and granodiorites of Upper Tertiary.

The map shows the location of active and extinct volcanoes. The numbers of the volcanoes are corresponding to those in table I. First of all,

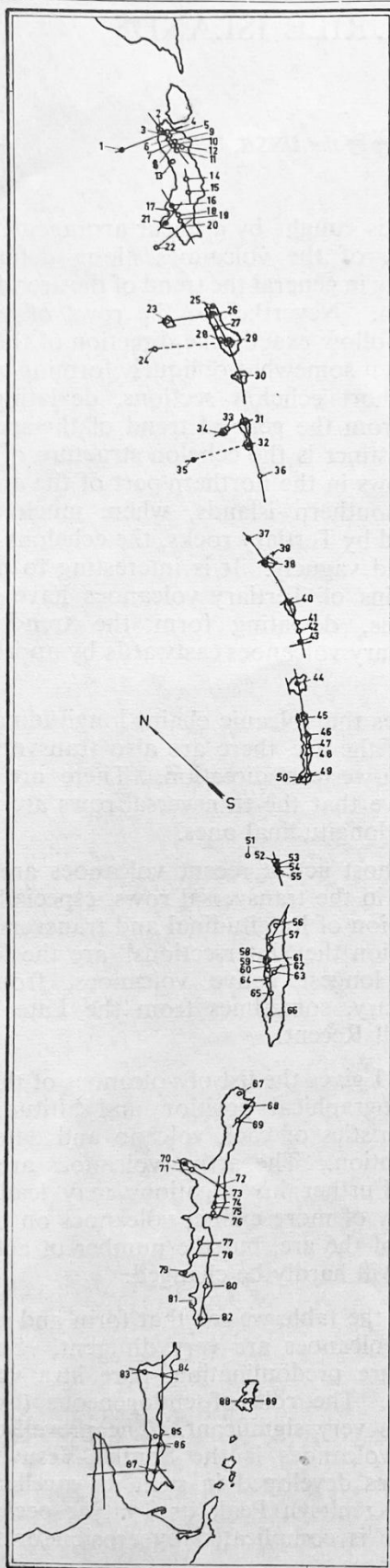
the eye is caught by a linear arrangement of the majority of the volcanoes along definite lines following in general the trend of the arc with, a NE direction. Nevertheless, the rows of volcanoes do not follow exactly the direction of the arc but intersect it somewhat obliquely forming comparatively short echelon sections, deviating northwards from the general trend of the arc. Especially distinct is the echelon structure of the volcanic rows in the northern part of the arc; in the larger southern islands, where much space is occupied by Tertiary rocks, the echelons are only expressed vaguely. It is interesting to note that the chains of Tertiary volcanoes have different directions, deviating from the trend of the Quaternary volcanoes eastwards by approximately 20°.

Besides the volcanic chains longitudinal to the trend of the arc, there are also transversal rows in north-western direction. There are reasons to believe that the transversal rows are younger than the longitudinal ones.

The most active recent volcanoes are usually situated in the transversal rows, especially at the intersection of longitudinal and transversal rows. In addition the "intersections" are the locations of the longest active volcanoes, from Early Quaternary, sometimes from the Late Tertiary epoch till Recent.

Table I gives the list of volcanoes of the Kurile Arc, geographical position and altitude, short characteristics of each volcano and date of the last eruption. The active volcanoes are underlined. Further investigations may lead to the discovery of more extinct volcanoes on the large islands of the arc, but the number of active volcanoes will hardly be changed.

From the table we see that form and structure of the volcanoes are very different. Stratovolcanoes are predominating, pure lava volcanoes are rare. The role of endogeneous (extrusive) domes is very significant. The prevailing form of the volcanoes is the Somma-Vesuvius-type, sometimes developed in such an excellent form as the Krenitsyn Peak or Tyatya; occasionally this type is complicated by erosion or tectonic disturbances.



Ideal single cones (Alaid, Prevost Peak, etc.) and well-developed calderas (Karpinsky, Lvinaya Past, etc) occur frequently. Caldera-walls are usually incomplete. Many active volcanoes have crater lakes (Ebeko, Pallas, etc).

The type of the latest eruptions is rather different. The prevailing type is Volcanian (Ebeko, Cherny, etc.), or Strombolian (Alaid, Chikurachki, Nemo Peak, etc.). Also violent eruptions of the Plinian type (Severgin, Raikoke, etc.) occur. Outpourings of extensive lava flows occur less frequently (Goryashchaya Sopka in 1881, Snow, Menshoy Brat in the Medvezhi Caldera). Widely spread are upheavals of endogeneous domes (Sinarka in 1878, Goryashchaya Sopka in 1883, etc.). Very often destructive incandescent avalanches come down along the slopes of volcanoes (Sinarka, Sarychev Peak, etc.).

Three big eruptions occurred since 1945: the Sarychev Peak erupted on Matua Is. in 1946, the eruption was characterized by strong incandescent avalanches the deposition of which changed the contours of the coastal line. In 1952 Krenitsyn Peak, the central cone of the big Caldera Tao-Rusyr on Onkotan Is., became active; at first a lateral explosive crater originated, then at the foot of the cone—a submarine one was formed in which an endogeneous dome developed. In 1957 an eruption took place in the crater lake of Zavaritsky Caldera on Simushir Is., which resulted in considerable changes of the contours of the northern part of the lake.

The petrographical and chemical composition of recent lavas is rather different. The dominant part of it belongs to pyroxenic andesites with rhombic and monoclinal pyroxene. Biotitic andesites can be encountered on Fuss Peak. Many volcanoes, especially those with pumiceous pyroclastics, produce acid hornblende andesites which are often transformed into dacites. Among lavas and slags frequently occur andesite-basalts and even basalts. Table II gives a few analyses of recent lavas.

The geological history of the Kurile arc before the Upper Mesozoic is not known. The Lower Cretaceous was accompanied by folding movements with intensive volcanic activity. The Upper Cretaceous was characterized by sea transgression and decrease of volcanism. In Late Mesozoic and Early Cenozoic orogenic movements, accompanied by basic intrusions took place, at the same time the Little Kurile arc was completed. In the Tertiary the area of the Big Kurile arc was a region of shoal water and intensive submarine and subareal volcanic activity. Between Miocene

and Pliocene folding and intrusions of granite occurred, followed by a general upheaval and intensive erosion. During the Late Tertiary volcanism renewed its activity and continued till recent times. In the Quaternary upheaval and depression of land formed a number of submarine and subareal terraces. At present the region of the Big Kurile Ridge is lifted up, while the Little Kurile Ridge—is submerging.

At the beginning of the glacial period all modern calderas and sommas of complex volcanoes were formed. Two stages of congelation with weak volcanic activity during the interglacial were known on the northern islands. In post-glacial, and partly in interglacial time, modern central cones of the complex volcanoes and some simple volcanoes (Alaid, Fuss Peak, tentatively also Chirinkotan) originated. The Recent volcanic activity is but a weak remainder of that during the early part of the Quaternary.

Table 1
List of Volcanoes
on the Kurile Islands¹

Name of volcano	Geographic position	Height
ALAID IS.		
1. <i>Alaid</i>	50°51'5 155°34'	2339
	Isolated cone with adventive cones. Top eruption-1894, lateral-1934.	
PARAMUSHIR IS.		
2. <i>Vetrovoy</i>	50°43' 156°03'	1088
	Much destroyed, pre-glacial.	
3. <i>Ebeko (Jo Ruko)</i>	50°41' 156°01'	1138
	The pre-glacial somma destroyed, central cone with 3 craters, in one of which there is a warm lake. Eruptions in 1934/35.	
4. <i>Neozhidanny. (Fusikei)</i>	50°40'8 156°01'7	1066
	Post-glacial cone with lava-flows.	
5. <i>Slag cone.</i>	50°40'5 156°01'3	900
	The same.	
6. <i>Nasedkin.</i>	50°39' 156°00'	1152
	Pre-glacial, destroyed.	
7. <i>Bogdanovich.</i>	50°37' 155°59'5	1056
	Maar with a fresh lake.	
8. <i>Kozyrevsky.</i>	50°36' 156°00'	1161
	Post-glacial cone with lava bocca.	
9. <i>Krashennnikov.</i>	50°36' 156°00'5	950
	Post-glacial cone with a large lava-flow.	

Name of volcano	Geographic position	Height
10. <i>Bilibin</i>	50°33'5 155°58'	1080
	The same.	
11. <i>Vernadsky. (Taise)</i>	50°33' 155°57'5	1184
	Destroyed volcano with traces of post-glacial activity.	
12. <i>Levashov. (Mitsuga)</i>	50°31' 156°04'	857
	Pre-glacial, partly destroyed.	
13. <i>Fersman. (Aragava)</i>	50°30'5 155°50'	1052
	Pre-glacial cone in a caldera.	
14. <i>Arseniev. (Takahiza)</i>	50°23' 155°48'	894
	Tertiary caldera-volcano, destroyed.	
15. <i>Levinson-Lessing. (Komaga)</i>	50°17' 155°41'5	818
	Tertiary, much destroyed.	
16. <i>Chikurachki</i>	50°19'5 155°27'5	1817
	Post-glacial cone, on the edge of an ancient volcano. Erupted in 1853/59.	
17. <i>Tatarinov. (Oruka)</i>	50°18'5 155°26'5	1593
	Pre-glacial caldera-volcano. Explosions in the post-glacial time. Solfatara activity.	
18. <i>Lomonosov. (Kamuri)</i>	50°15' 155°26'	1682
	Complex volcano with post-glacial flows and domes.	
19. <i>Arkhangelsky.</i>	50°13' 155°25'	1463
	Destroyed, pre-glacial.	
20. <i>Karpinsky. (Hakuen)</i>	50°09' 155°22'	1377
	Pre-glacial caldera, with post-glacial effusion and explosions. Solfatara activity.	
21. <i>Fuss Peak.</i>	50°16' 155°15'	1772
	Single cone. Erupted in 1854.	
SHIRINKA IS.		
22. <i>Shirinka.</i>	50°12' 154°59'	748
	Isolated strato-volcano.	
MAKANRUSHI IS.		
23. <i>Makanrushi.</i>	49°47' 154°26'	1169
	Destroyed caldera-volcano.	
AVOS ROCK		
24. <i>Avos.</i>	49°43' 154°06'5	34
	Top of the ancient submarine volcano.	
ONEKOTAN IS.		

¹ Active Volcanoes are italicized; notes refer to last eruption; height in meters.

<i>Name of volcano</i>	<i>Geographic position</i>	<i>Height</i>	<i>Name of volcano</i>	<i>Geographic position</i>	<i>Height</i>
25. <i>Asyrmintar</i> .	49°36' 154°54'	570	RASSHUA IS.		
	Single strato-volcano. Erupted in 1938.		40. <i>Rasshua</i> .	47°46' 153°01'	956
26. <i>Nemo Peak</i> .	49°34' 154°48'5	1019	Destroyed somma with 4 cones. Erupted in 1846.		
	Central cone in a large destroyed caldera Amka-Usy. Erupted in 1906.		SREDNY STRAIT		
27. <i>Shestakov</i> .	49°28'5 154°44'	708	41. <i>Karlic</i> . (Dwarf)	47°39' 152°57'	1
	(Encio) Ancient destroyed massive.		Summit of a submarine volcano.		
28. <i>Kryzhanovsky</i> .	49°25' 154°42'	551	SREDNY ISLETS		
	Ancient caldera-volcano.		42. <i>Sredny</i> .	47°35' 152°52'	27
29. <i>Krenitsyn Peak</i> .	49°21'5 154°42'5	1325	Summit of an ancient submarine volcano.		
	Central cone in the form of an island in the caldera lake of the Tao-Rusyr Caldera. Erupted in 1952.		USHISHIR ISLES		
KHARIMKOTAN IS.					
30. <i>Severgin</i> .	49°07' 154°31'	1145	43. <i>Ushishir</i> .	47°31' 152°49'	401
	Low cone plugged up by the dome in a destroyed E somma. Erupted in 1933.		Somma divided into two small isles, a crater bay with residues of the central cone and domes-in a caldera. Phreatic eruption in 1884. Solfataras.		
SHIASHKOTAN IS.					
31. <i>Sinarka</i> .	48°52'5 154°10'5	934	KETOY IS.		
	The somma destroyed by sector trough faults. A dome in the crater of the central cone. Erupted in 1878.		44. <i>Pallace Peak</i> .	47°21' 152°28'5	993
32. <i>Kuntomintar</i> .	48°45'5 154°01'	828	Excentric cone with a hot lake in the crater on the edge of the Ketoy Caldera (1172 m). Erupted in 1924.		
	Semi-caldera with a small central cone. Erupted in 1872.		SIMUSHIR IS.		
ECARMA IS.					
33. <i>Eastern Ecarma</i> .	48°57' 153°58'	796	45. <i>Uratman</i> .	47°07'5 152°14'	679
	Destroyed volcano.		Partly destroyed cone in a caldera occupied by a crater bay down to 266 m in depth.		
34. <i>Ecarma</i> .	48°57' 153°56'5	1171	46. <i>Prevost Peak</i> .	47°01' 152°07'	1361
	Single strato-volcano. Erupted in the 1760-ies.		Isolated cone, Erupted early in the XIX century.		
CHIRINKOTAN IS.					
35. <i>Chirinkotan</i> .	48°59' 153°29'	742	47. <i>Ikanmikot</i> .	46°58' 152°04'	645
	Post-glacial caldera-volcano. Erupted in the 1880-ies.		Destroyed cone.		
LOVUSHKI ROCKS					
36. <i>Stone Lovushki</i> .	48°32' 153°51'	42	48. <i>Zavaritsky</i> .	46°55'5 151°57'	625
	Top of an ancient submarine volcano.		(Midori-Ko) Two inside caldera-volcanoes. In the inner caldera a lake with slag cone and two domes. Erupted in 1957.		
RAIKOKE IS.					
37. <i>Raikoke</i> .	48°15' 153°15'	551	49. <i>Milne</i> .	46°49' 151°47'	1539
	Single cone. Erupted in 1924.		Somma destroyed from SE, the central cone plugged up with a dome.		
MATUA IS.					
38. <i>Sarychey Peak</i> .	48°05'5 153°12'	1498	50. <i>Goryashchaya Sopka</i> .	46°50' 151°45'	890
	Central cone with destroyed somma. Erupted in 1946.		(Glowing Mountain) Strongly destroyed somma, the central cone crater plugged up with a dome; large lava-flows. Erupted in 1944.		
39. <i>Submarine</i> .	48°05' 153°20'		BROUGHTON IS.		
	Two submarine eruptions in 1924.		51. <i>Broughton</i> .	46°43' 150°44'	800
			Destroyed stratovolcano.		

<i>Name of volcano</i>	<i>Geographic position</i>	<i>Height</i>	<i>Name of volcano</i>	<i>Geographic position</i>	<i>Height</i>
BLACK BROTHERS ISLES					
52. Chirpoi. (Daiho)	46°32' 150°52'5	691	68. Medvezhiy.	45°23' 148°48'	1125
	Destroyed double strato-volcano.			Partly destroyed somma. Three central cones: Kudryavy (988), erupted in 1883; Menshoi Brat (563 m) violent lava-flows.	
53. Cherny (Io-san)	46°31'5 150°52'5	624	69. Caldera.	45°21' 148°47'	854
	Single cone with adventive craterlets. Erupted in 1857.			Ancient, nearly completely closed.	
54. Snow.	46°31' 150°52'5	400	70. Chirip.	45°23' 147°55'	1564
	Single lava cone with abundant lava-flows. Erupted in 1879.			Single cone on the ancient caldera edge. Erupted in 1860.	
55. Chirpoev Brat.	46°28' 150°48'5	752	71. Bogdan Khmelnitsky	45°20' 147°55'	1589
	Much destroyed somma with a central cone. Fumarolic activity in the XVIII century.			Partly destroyed strato-volcano.	
URUP IS.					
56. Desantny. (Daisanto)	46°11' 150°23'	866	72. Baransky. (Jiusu)	45°06' 148°02'	1126
	Tertiary volcanic massive.			Single cone with a lava plug in the crater. Erupted in 1951.	
57. Antipin. (Zurigane)	46°09' 150°14'	1222	73. Tebenkov. (Kotamoi)	45°01' 047°55'	1212
	Cone destroyed from the south.			Extinct central cone, with a large explosive crater Machekha with fumarolic activity on the somma slope.	
58. Trezubets. (Trident)	46°04' 150°07'	1018	74. Ivan Grozny. (Sio)	45°00'5 147°52'	1158
	Somma destroyed in N (1222 m.). The central cone a dome with an explosive crater. Erupted in 1845/46.			Very complex volcano, much destroyed somma. At the summit of the central cone three domes. In the atrio endogeneous and exogeneous domes. Solfataras.	
59. Berg.	46°04' 150°05'	900	75. Motonopuri.	44°59'5 147°50'	953
	Somma in N destroyed (1108). The central cone a dome with small flows. Erupted in 1951/52.			Ancient strato-volcano.	
60. Caldera.	46°04' 150°03'	1100	76. Rebunshiri.	44°58'5 147°48'	782
	Ancient caldera with NW destruction.			Ancient strato-volcano.	
61. Kolokol. (Bell)	46°03' 150°03'5	1326	77. Burevestnik. (Onneto)	44°52'5 147°27'5	1427
	Single cone with a destroyed crater. Erupted in 1894(?).			Ancient destroyed volcano.	
62. Borzov.	46°03' 150°03'	1120	78. Stokap.	44°50' 147°20'	1566
	Destroyed single cone.			Ancient strato-volcano with traces of post-glacial activity.	
63. Kavraisky.	45°57'5 150°03'5	842	79. Atsonupugri.	24°49'5 147°07'5	1205
	Tertiary cone.			Isolated cone with residues of somma on its slope. Erupted in 1932.	
64. Tri Sestry. (Three Sisters)	45°55'5 149°54'	999	80. Urbich.	44°38' 147°12'	907
	Much destroyed volcano with traces of recent fumarolic activity.			Ancient caldera-volcano with a lake.	
65. Rudakov. (Daiba)	45°52' 149°49'	543	81. Lvinaya Past. (Moikesi)	44°37' 147°00'	403
	Single cone with a freshwater lake.			Ancient caldera-volcano with a bay down to 460 m in depth.	
66. Ivao.	54°44' 149°40'	1426	82. Berutarube.	44°28' 146°56'	1222
	Complex volcano with a lake in the destroyed crater. Post-glacial lava flows.			Destroyed shield volcano with post-glacial flows. Solfataras.	
ITURUP IS.					
67. Kamui.	45°31' 148°49'	1323			
	Ancient caldera-volcano, destroyed from NE.				

Name of volcano	Geographic position	Height	No.	Description
KUNASHIR IS.				
83. Rurui.	44°27' 146°08'	1486	No. 1	Andesite-basalt, Volc. Alaid, Crater Taketomi, eruption 1934. Coll. Tanakadate, anal. Jap. Geol. Survey.
	Single strato-volcano with a destroyed crater.		No. 2	Andesite-basalt, Volc. Tiatia, eruption 1812? Coll. Zhelubovsky.
84. Tyatya.	44°21' 146°15'	1822	No. 3	Andesite-basalt, Peak Sarychev, eruption 1946, Coll. Gorshkov, anal. Tovarova.
	Somma with well-preserved fine caldera. A small central cone with lava flows into the caldera mouth. Erupted in 1812.		No. 4	Biotite-andesite, Peak Fuss, coll. Gorshkov, anal. Posnikova.
85. Otdelny.	44°02' 145°46'5	476	No. 5	Andesite, bread-crust bomb, Volc. Ebeko, eruption 1935. Coll. Gorshkov, anal. Tovarova.
	Destroyed volcano.		No. 6	Andesite, Peak Krenitsyn, ash, eruption 1952. Coll. Piip, anal. Tovarova.
86. Mendeleev. (Rausu)	43°59' 145°42'	890	No. 7	Dacite, dome, volc. Mendeleev, coll. Gorshkov, anal. Tovarova.
	Somma and central cone partly destroyed. A dome in the crater, destroyed lateral craterlets on the slopes. Erupted in 1880.			
87. Golovnin. (Tomari)	43°53' 145°32'	547		
	Caldera-volcano with a deep freshwater lake. Two domes and explosive craters in the caldera, a hot lake in one crater. Erupted in the XIX cent.			
SHIKOTAN IS.				
88. Notoro.	43°46'5 146°41'	358		
	Ancient destroyed cone.			
89. Tomari.	43°46' 146°44'	356		
	Ancient destroyed cone.			

Table 2.
Chemical Analysis of Lavas of the Kurile Volcanoes.

Samples	1	2	3	4	5	6	7
SiO ₂	50.29	51.75	53.33	54.80	58.07	61.91	65.30
TiO ₂	1.28	1.20	0.95	0.73	0.68	0.75	1.22
Al ₂ O ₃	18.96	17.20	18.60	18.84	17.21	16.89	15.84
Fe ₂ O ₃	3.44	3.95	4.21	5.79	3.61	3.14	3.08
FeO	6.75	7.58	4.63	2.30	4.23	3.89	2.40
MnO	0.33	0.22	0.18	0.16	0.16	0.21	0.14
MgO	4.14	4.02	4.00	3.70	3.04	2.20	1.70
CaO	10.25	10.32	9.34	8.60	7.41	5.96	5.12
Na ₂ O	2.85	2.12	3.38	2.67	3.19	3.21	3.70
K ₂ O	1.25	0.96	1.09	2.22	2.02	1.01	1.65
H ₂ O	0.20	—	0.21	0.10	0.10	0.32	0.13
H ₂ O	0.09	0.51	—	0.30	0.28	0.62	0.11
P ₂ O ₅	0.40	0.50	n.d.	0.05	0.02	n.d.	0.09
S	0.02	n.d.	n.d.	0.06	0.05	n.d.	n.d.
Total	100.25	100.33	99.92	100.32	100.07	99.75	100.48

REFERENCES

Gorshkov, G.S., Catalogue of the active volcanoes of the World, Part VII Kurile Islands. Int. Volc. Ass. Napoli (in press).

Kuno, H., 1935, Petrology of Alaid volcano. *Jap. Journ. Geol. Geogr.* 12 : (3-4), Tokyo.

Milne, J., 1886, The volcanoes of Japan. *Trans. Seism. Soc. Japan*, 9, (2), Yokohama.

Tatarinov, M., 1783, Neue Beschreibung der Kurilischen Inseln. Neue Nordische Beiträge, Bd. 4. SPb.