AGE OF CHANGBAISHAN VOLCANO AND TIANCHI LAKE

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The Changbai Mountains in NE China, bordering on Korea, are the sources of three rivers and the location of a famous young volcano. On the top at 2200 m a. s. l. is a vast crater, the Tianchi Lake, with a depth of 373 m and an area of 9.82 km^2, around which many alkaline lava-flows are widely dispersed. It has been suggested that the lavas were formed of magma extruded from the volcanic vent. In sequence, these lavas from bottom upward are: alkali-quartz-trachyte, pantellerite and obsidian, trachytic pumice and pyroclastic lava (Fig. 1), all situated on a large basaltic platform, and form the highest peak of Changbai Mountains, Mount Baitou.

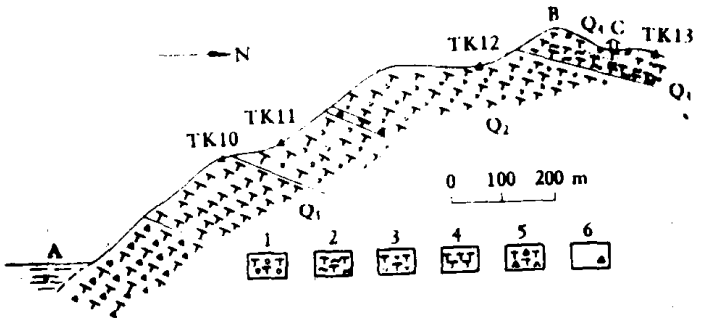

Fig. 1. The section in Mount Tianwenfeng (from Geological Crew of Regional Survey, Jilin Province, 1978). 1—Q_4 trachytic pumice; 2—Q_3 pantellerite and obsidian; 3—Q_2 riebeckite acmite-augite quartz trachyte; 4—Q_2 grayish-green alkali-quartz trachyte; 5—Q_1 trachytic pyroclastic-lava; 6—location of specimens. A—Tianchi Lake, B—Tianwenfeng, C—Meteorological Station.

To study the formation and evolution of the Changbaishan Volcano and Tianchi Lake, investigation in situ has been made and experimental research carried on.

I. Geochronological Dating

1. Samples from the sections of Mount Tianwenfeng (Fig.1), the Changbai Falls (Fig. 2) and along from Fenkou to Meteorological Station in Tianchi were collected and anorthoclases (assumed to be phenocryst) in specimens chosen for K-Ar dating. Potassium was analysed with Zeit-III-flame photometry; argon was extracted in ultra-high-vacuum line (static vacuum $1-3\times10^{-8}$ torr, background 1.3×10^{-8}cc ^{40}Ar STP). Highly pure ^{38}Ar ($^{38}Ar/^{36}Ar > 10^5$, $^{38}Ar/^{40}Ar > 10^4$), made in Switzerland

was used as the trace, prepared by the method of manifold diffusion[1]. Argon isotopes were measured with MM 1200 and ZhH1301 mass spectrometry. The results (Table 1) show that these data are the youngest of K-Ar dating reported in China. The evaluation about the precision and accuracy of the ages are as follows:

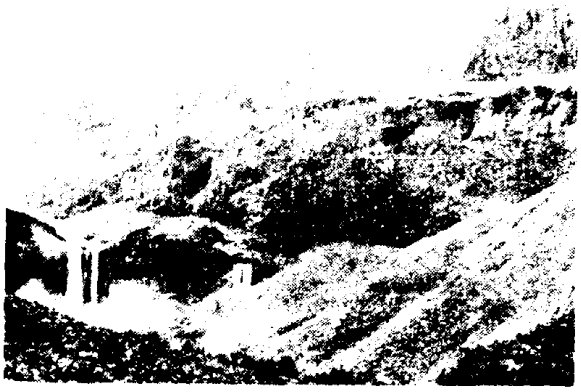

Fig. 2. The section in Changbai Falls, 1—3 show each of the flows and locations of TK01, TK02 and TK03 respectively.

(i) Good parallel measurements were obtained. For example, argon extracted from sample TK12 was divided into two parts, each of which measured by ZhH 1301 mass spectrometry gave ages of 0.0978 ± 0.0024 and 0.101 ± 0.0064 m.y. with an error of 1.6%. The age of TK 12 approximates that of CT6 measured in the laboratory of Australia National University (Table 1). Both samples (TK 12 and CT6) are from the same flow.

(ii) Errors in experiments were low. The analytic error of potassium is less than 1%, that of ^{38}Ar dilution preparation is 0.51%; the percentage of radiogenic argon is mostly more than 20%, resulting from a gentle rise atmospheric argon. According to G. B. Dalrymple[2], the standard deviations of age are less than 5%

Table 1

K-Ar Ages of Alkaline Volcanic Rocks in Changbai Mountains

Location	Sample No.	Weight (g)	K(%)	Spike ($\times 10^{-11}$ moles)	$^{40}Ar_{rad.}/g$ ($\times 10^{-10}$ moles)	$^{40}Ar_{rad.}$ (%)	Ages and Deviation (m.y.)	Mass Spectrometer
Section in Tianwenfeng (Fig. 1)	TK13	15.1253	5.32,5.52,5.24	8.9166	0.08133	11.6	0.0876±0.015	ZhH1301
	CT6-1	2.11966	5.395, 5.382		0.075197	12.9	0.080±0.004	MM 1200
	CT6-2	2.11966	5.395, 5.382		0.085320	14.6	0.091±0.003	(Australian)
	TK12-1	15.9080	5.36, 5.44	8.9590	0.09153	23.2	0.0978±0.0024	ZhH 1301
	TK12-1	15.9080	5.36, 5.44	8.9590	0.09460	24.8	0.101±0.0064	ZhH 1301
	TK11	10.0616	5.48,5.72,5.52	9.3102	0.2700	49.2	0.281±0.045	MM 1200
	TK10	10.0595	5.48,5.76,5.52	9.3092	0.2715	41.0	0.281±0.019	(Chinese) (Chinese)
Fengkou	TK25	9.4490	5.63, 5.64	8.5905	0.2134	23.6	0.219±0.002	(Chinese)
	CT3-1	2.13492	5.085, 5.085		0.22431	38.0	0.254±0.005	(Australian)
	CT3-2	2.13492	5.085, 5.085		0.24315	40.4	0.276±0.004	(Australian)
	TK06	12.0671	5.56, 5.72	8.9377	0.3217	33.5	0.329±0.014	(Chinese)
Section in Changbai Falls (Fig. 2)	TK03	10.3637	5.44, 5.52	8.9547	0.1999	20.1	0.210±0.004	(Chinese)
	TK02	8.09355	5.37, 5.44	8.4900	0.4140	19.8	0.442±0.015	(Chinese)
	TK01-1	6.7405	5.28, 5.28	9.6557	0.5047	29.8	0.551±0.024	(Chinese)
	TK01	6.6016	5.09,5.10,5.12	8.1832	0.5404	24.5	0.611±0.015	(Chinese)

All samples are anorthoclases, decay constants: $\lambda_e = 0.581 \times 10^{-10}$/yr, $\lambda_\beta = 4.962 \times 10^{-10}$/yr, $^{40}K/K = 1.16 \times 10^{-10}$(atom).

for 2/3, and 5—17% for the rest.

(iii) Ages measured by K-Ar method tally with geologic occurrence. For instance, in the section of Changbai Falls there are three flows with the lower flow dated at 0.58 ± 0.02 m.y., the middle one at 0.44 ± 0.02 m.y., and the upper one at 0.21 ± 0.01 m.y. (Fig. 2).

Thus it can be seen that the precision of K-Ar ages is high.

2. The paleomagnetic pole of samples from trachytes, pantellerites and pyroclastic lavas in the mid-upper part of Mount Baitou, measured by Institute of Geology, State Bureau of Seismology, indicates a normal position of paleomagnetic field. It corresponds to Brunhes normal epoch (0.69—0 m.y.) and confirms K-Ar ages.

3. ^{14}C dating of the charcoals in a large number of trachytic pumice and volcanic ash scattering on the periphery of the Tianchi crater gives ^{14}C dating 1050 ± 70 to 1410 ± 80 yr.

II. Formation and Evolution of Changbaishan Volcano and Tianchi Lake

Since the Mid-Miocene there were many stages of eruption of basaltic magma forming a vast platform of basaltic lavas, among which the Junjiashan basalt has an age of 2.60 ± 0.29 m.y. The lavas around the crater is a suite of alkaline valcanic rocks, the oldest of which is dark-gray alkaline quartz-bearing trachyte, located in the lower flow of the section in Changbai Falls. Because the bottom of alkaline volcanic rocks is covered, the beginning of the eruption of trachytic magma may be earlier than 0.58 ± 0.02 m.y. The youngest volcanic eruption is set in 1702 AD (in the local chronicles). There have been many eruptions from the Tianchi crater since the Pleistocene, They may be divided into the Baitoushan episode (the Mid-Upper Pleistocene, 0.58 ± 0.02—0.0876 ± 0.015 m. y. BP) and the Baiyunfeng episode (the Holocene, 1200 yr. BP to present) (Table 2). The three flows of early stage of Baitoushan episode are made of thick trachyte, clearly seen in the section of Changbai Falls (Fig. 2) and the fourth flow has vast lava-sheet of pantellerite and obsidian

Table 2

The Sequence of Volcanic Flows and Episodes of Volcanism in Mount Baitou

Time	Sequence of Volcanic Flows and Episodes of Volcanism	Age	Eruptive Materials	Thickness (m)
Holocene Epoch (Series) Q_4	Baiyunfeng episode (group) — late stage	1597, 1668, 1702AD	gases, ashes	15±30—40
	Baiyunfeng episode (group) — early stage	1050±70—1410±80 yr	pyroclastic lava, trachytic pumice	
Late-Middle Pleistocene Epoch (Series) Q_{2-3}	Baitoushan episode (group) — late stage — 4th flow	0.0876±0.015 m. y.	pantellerite and obsidian	>644
	Baitoushan episode (group) — early stage — 3rd flow	0.0926±0.006—0.219±0.002 m.y.	riebeckite acmite augite quartz trachyte	
	Baitoushan episode (group) — early stage — 2nd flow	0.28±0.02—0.44±0.02 m.y.	alkali-quartz trachyte	
	Baitoushan episode (group) — early stage — 1st flow	0.58±0.02 m.y.	alkaline trachyte	
Late Pliocene Epoch N_2^3	Junjianshan episode	2.60±0.29 m.y.	alkalic olivine-bearing basalt	110±

covering the underlying layer (Fig. 1). Baiyunfeng episode occurred in about 1200 yr BP, erupting first a great number of pumices, then volcanic debris and breccia, and lastly only ashes and gases. The successive sequence can be seen on Mount Baiyunfeng (Fig. 3). It thus indicates that volcanism in the Changbaishan Volcano has been more and more retarding. The Tianchi crater, inheriting the previous volcanic vent of basaltic magma, was unceasingly enlarged and deepened along with accumulation of alkaline lava and formed a "Krakatoa" caldera with the eruption of large pumices and volcanic ashes about 1200 yr BP. Analysis of the water in the

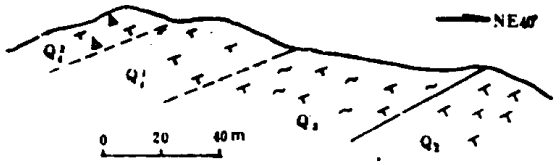

Fig. 3. The section in Mt. Baiyun (from Geological Crew of Regional Survey, Jilin Province, 1974). Q_4^2—pyroclastic lava; Q_4^1—trachytic pumice and ash; Q_3—pantellerite; Q_2—alkali-quartz trachyte.

Tianchi Lake gives $\delta D = -104.4$, $\delta^{18}O = -13.56$ (smow), showing the same character as that of atmosphere water, which might be stored after 1702 AD. The perennial water in the Tianchi crater suggests that the previous volcanic vent has been stopped up, and at present the Changbaishan Volcano is quiescent.

References

[1] 王松山等,测定地质年龄的钾-氩稀释法,地质科学, 1979, 2: 139—150.
[2] Dalrymple, G. B. & A. Lanphere, *Potassium-Argon Dating*, W. H. Freeman and Company, 1969, 105—106.