CHARACTERISTICS OF BASALTS IN LANCANG VOLCANIC ROCK BELT AND THEIR TECTONIC SETTING①

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ABSTRACT For mineral composition, chemical composition, rare earth elements of basalt, etc, the characteristics of petrology and geochemistry of alkali-olivine basalt, olivine basalt and trachy basalt in Lancang volcanic belt was expounded in detail, and the basalt in the belt which belongs to alkali basalt of potassic series was pointed out. On the basis of above-mentioned study, the tectonic setting, in which the basalt occurred, had been discussed.

Key words basalt petrology geochemistry rift

1 SURVEY OF GEOLOGY

Lancang volcanic belt lies in the southwestern part of Yunnan Province, P. R. China and from north to south, through Changlin, Lancang, Menglian, Manxin, extends southward as far as Burma. Strata outcropped are sandshale of south section group of Devonian system, volcanic rocks which mainly consist of basalt of Yiliu group of Lower Carbonikerous, carbonate rock of Permian system and Middle-Upper Carboniferous. The outcrop length is about more than 200 km, and width of 1~3 km. On both sides of the belt, there are two rough parallel normal faults[1].

The lithologic character of Lancang volcanics' belt consists of lava and pyroclastic rock, the later is composed of tuff, volcanic breccia and a small quantities of agglomerate; the former predominantly basalt, and has only an extremely small quantities of trachyte and limburgite. According to 1/200 000 Menglian-sized regional survey data and determination of Rb-Sr isotopic age, the period of that volcanic rock is late Lower Carboniferous, its strata are geared to Yiliu group of Lower Carboniferous[2-4].

At present, many of Au, Ag, Cu, Pb, Zn, polymetal ore deposits related to that volcanic rock were discovered; among them, Laochang, Lancang Ag, Pb, Zn mineral deposit is a large-superlarge scale one.

2 PETROLOGIC CHARACTERISTICS OF BASALTOID

In the district, basalt is the most developed volcanic rock which amounts to about more than 90% of total one, it has an evident character that the composition of An of plagioclase contained shows diversity; in plagioclase, An is low, generally only 20%~30%, high up to more than 70%; most plagioclases suffered sericitization and chloritization at varying degrees, fresh plagioclase is rare; dark minerals include olivine, titan-augite and magnetite[5, 6].

According to the characteristics of mineral composition, texture and structure, and by thinking of chemical composition and the calculated CIPW standard mineral composition of rock, basalts in the district may be further divided into the following classes.

(1) Alkaline olivine basalt

It is the basalt that dispersed most broadly over the district, and its outcropping amounts to about 50% of total area of basalt series; it distributed over the whole aforesaid ones, and has

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often been found, especially at Bajiaolin near Lancang seat, at Xiaozhai, Laomianzhai, Luokao in the central part of survey area, and Hui'e, Manxin in the southern part. That rock mostly assumes colors as tile-like grey, grey-black, dark green and etc, with porphyritic texture; most of matrices are intergranular and intersertal texture; its phenocrysts consist of olivine, titanium-bearing augite and plagioclase. The majority of plagioclase phenocrysts show subhedral-euhedral plate-like, the maximum one is 5mm × 2mm, common 2mm × 0.5mm, a few of ones are microphenocrysts; all of them generally have polysynthetic twin, An= 56% ~ 65% through determination of Fedorov stage[7]. The secondary variation of plagioclase is very widespread, it mainly shows sericitization with varying degrees. Olivine phenocrysts appear euhedral and granular, the maximum one is 6 mm × 3 mm, common 2 mm × 0.6 mm, fissility developing; and they have been suffered serpentization universally, partly altered with the formation of iddingsites. Pyroxene phenocrysts always appear short-prismatic, the majority of them have first order orange interference color, an individual one is probably up to second order blue.

The pyroxenes in alkaline olivine basalt of the district contain titanium widespreadly, the maximum is up to 30%; the content of MgO is higher than that of Emeishan basalt, while the content of FeO is lower than that of Emeishan basalt; these contents of the district are all corresponding to those of alkaline olivine basalt in Hawaii[8].

According to summing up mineral optical character and chemical composition the pyroxene of alkaline olivine basalt in the district belongs to titanium-bearing augite.

The matrices of alkaline olivine basalt mainly consist of microplagioclase, oliveine, titanium-bearing augite, titaniferous magetite etc. The composition of microplagioclases varies very largely; the An of them generally is 20% ~ 40%, the minimum is lower than 10%; they appear as subhedral thin strip-like, usually being possessed of albite twin and the majority of them altered with the formation of sericite. The characteristics of matrices of pyroxene and olivine are the same as their phenocrysts except smaller size (< 0.5 mm). The titaniferous magnetite (including leucoxene) appears mostly scattered and cloudy.

(2) Olivine basalt

In the district, olivine basalt belongs to a relatively broadly distributive basalt and makes up about 30% of the total basalt.

This rock mostly appears greenish grey, grayish black, etc, has porphyritic texture, and extreme minority of it is adiagnostic texture without phenocryst (usually compact in field). The mineral composition of olivine basalt is similar to alkaline olivine basalt, but the content of olivine is obviously lower than that of the later, only 2.5%; the content of titaniferous augite is higher than that of the later, up to 15% ~ 20%; the sizes of phenocryst are bigger than 2 mm.

Secondary alteration of the rock is strong, in which plagioclases are mostly altered into sericite.

The difference between an olivine basalt and an alkaline olivine basalt in the field is like that on the specimen, olivine phenocrysts can be seen obviously by the naked eye because the later contains olivine relatively more; but on the specimen of the former, only phenocrysts of plagioclase and pyroxene can be seen, while olivine is very difficult to be found.

(3) Trachy basalt (Oligoclase basalt)

Trachy basalt is only limited to Laochang and Akabo regions in the district, and its lithologic feature is as follows: grey-greyish black color, porphyritic texture; matrix appears trachylike texture, mineral compositions mainly consist of augite and plagioclase. The largest characteristic of this class of rock shows that, the An of microplagioclase contained by matrixes on the low side; through determination of various methods such as electric probe, Fedorov stage and optical microscope, the aforesaid An is about 20%; the mineral belongs to oligoclase; hence the rock is called oligoclase basalt besides. In its matrix, oligoclases present slender tablet microcrystals commonly around the phenocrysts of plagioclase and pyroxene, showing parallel and directional arrangement.

It is worthy of pointing out that there

spread considerably abundant fragments and breccias of trachy basalt in upper strata of C_{2j} at Laochang, they are principal component of agglomerate and volcanic breccia of some mountains, but the outcrop of original stratified trachy basalt is not found. This case is similar to that in Akabo region. However, it remains to be certified that the trachy basalt was relatively early volcanic lava and it became components of agglomerates or breccias during the course of late stage volcanic eruption.

(4) Amygdaloidal basalt

It may include any one of three kinds of the above-mentioned basalts, its supreme characteristic is of quite a number of amygdaloids, of which the mass fraction is up to 35%, commonly 20%. Amygdaloids always appear round, ellipsoidal, some do irregularly extentionlike, too, and show flow line structure; the big head of the amygdaloid is the direction of magmatic flow. Amygdaloids vary in size, and in every extrusion, generally, the bottom is small and the top is large; the least one is only 0.5mm, commonly 2 mm × 4 mm, the maximum more than 1 cm. The amygdaloids mostly consist of quartz, calcite, chlorite and feldspar, and present concentricity-like arrangement, in which the outer circle consists of quartz and feldspar, the inner circle consists of chlorite and calcite; there are also a few amygdaloids wholely calcite. Owing to long period's weathering and leaching effect, the amygdaloids of amygdaloidal basalt on the ground were much weathered, washed away and formed many cavities in them.

3 CHARACTERISTICS OF ROCK CHEMISTRY AND GEOCHEMISTRY OF THE BASALT

3.1 Rock chemistry

For stating and discussing the characteristic of rock chemical composition conveniently, the result of chemical analyses of basalt is listed in the district (see Table 1).

From Table 1, it may be made out as follows:

(1) Contents of SiO_2, TiO_2 and (K_2O + NaO_2)

The SiO_2 of basalt in the district ranges from 43% to 51% (not containing amygdaloidal basalt, the same below), the average is 47.8%; the content of TiO_2 evidently higher than any other kinds of basalt, this is consistent with Ti-rich character in the district; the average of (K_2O + Na_2O) is about 5% lower than that of China's basalt.

(2) Alkalinity of basalt

Scholars had different opinions more or less on the plan of dividing alkalinity of basalt[7-8]. Rittman (1957) divided it with composite index $\delta = (K_2O + Na_2O)^2/(SiO_2 - 43)$: $\delta < 3.3$ is calcium alkaline basalt, $\delta = 3.3$ alkaline basalt, $\delta = 3.3 \sim 6.5$ weak alkaline basalt, $\delta > 6.5$ strong alkaline basalt; according to the standard, basalts in the district wholely belong to alkaline basalt and strong alkaline basalt.

Wright (1969) determined the alkali of rock in the light of relationship between SiO_2 and

Table 1 The petrochemical components of basalts

Rock	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	δ	*A.R*
Alkaline-olivine basalt	48.34	2.71	15.84	4.61	6.08	0.22	8.95	6.85	2.33	2.20	3.84	1.53
Alkaline-olivine basalt	51.06	3.05	18.05	10.75	1.23	0.12	1.84	4.00	4.43	3.35	7.51	2.10
Alkaline-olivine basalt	44.82	2.86	15.42	8.08	4.82	0.15	7.88	9.32	3.41	2.53	> 9	1.50
Alkaline-olivine basalt	49.00	1.83	13.32	2.37	5.32	0.11	7.64	13.49	3.83	1.82	5.5	1.35
Alkaline-olivine basalt	50.50	3.03	17.17	5.81	5.25	0.26	4.47	4.73	4.82	2.08	6.35	1.92
Olivine basalt	47.14	2.00	14.41	7.02	5.40	0.09	8.13	11.34	0.49	2.80	3.61	1.34
Olivine basalt	47.18	3.22	15.14	5.92	7.43	0.24	6.36	8.08	2.83	2.66	7.21	1.02
Trachy basalt	43.08	5.00	15.93	8.06	5.74	0.16	4.29	5.64	4.32	1.20	> 9	1.48
Trachy basalt	50.48	1.88	20.64	17.62	1.32	0.25	4.30	0.44	1.25	0.06	0.23	1.13

alkalinity. The content of SiO_2 of basalt in the district and alkalinity calculated are projected on the figure Wright designed, and then most projecting points fall in the region of alkaline basalt (Fig. 1).

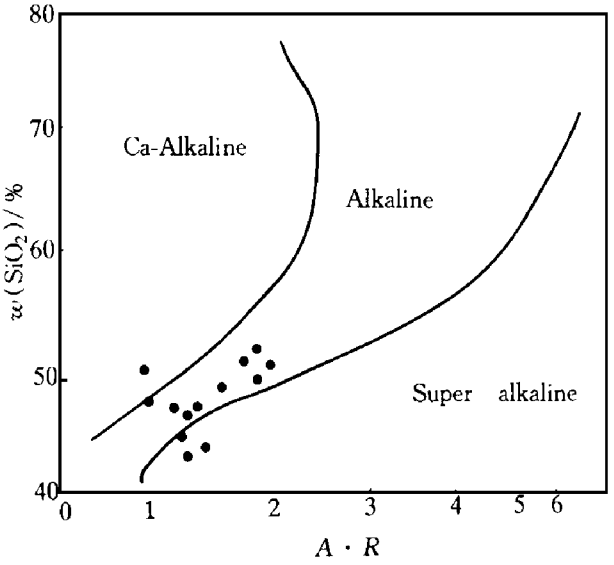

Fig. 1 Diagram of relationships between SiO_2-$A.R$ of basalt(Wright J B, 1969)

According to volcanic rock's data of Japan (Kuno, 1960) divided basalts into tholelite, high-alumina basalt and alkaline basalt with the variation diagram of Al_2O_3-(K_2O+ Na_2O). The values of Al_2O_3 and (K_2O+ Na_2O) of the basalts in the district are projected on Kuno's figure, then they are found to fall in alkaline basalt region, except three samples fall in tholelite region.

(3) Basalt series

Projecting the values of K_2O and Na_2O of basalts in the district on Middirnost's (1975) figure, the overwhelming majority of basalts are found lying on potash series and high-potash series, only a few soda series.

3.2 Characteristics of rare earth elements

The total content of rare earth elements of basalts in the district varies from 227×10^{-6} to 422×10^{-6}, average is 356×10^{-6}, quite higher than Vinogradov's value. It indicates that the district belongs to a rare earth elements-rich one; δEu is 1.08~ 1.12, average 1.1, and be normally without dificiency of Eu; Σ LREE/ ΣHREE is 3.54~ 4.37, average 3.85, and it is LREE-rich evidently.

The modal curve of rare earth element[1] is a smooth curve of dipping to the right, and extremely similar to standard curve of distribution ratio of rare earth elements of alkaline olivine basalt.

4 TECTONIC SETTING OF BASALT FORMATION

That the tectonic setting of formation of basalt is distinguished according to characteristics of petrology, rock chemistry and rare earth elements of basalt is a practically effective method. It is not difficult to distinguish the tectonic setting of formation of basalt in the district from the following several points.

(1) From the contrastive table(Table 2) of principal chemical composition of basalts in the district and those of various tectonic setting, the principal chemical composition of the former is similar to that of alkaline basalt under continental rift valley setting.

(2) Projecting K_2O, TiO_2 and MgO of basalts in the district on the figure (Fig. 2) of $3K_2O$-$2TiO_2$-MgO and tectonic setting, aforesaidines in the district are found wholely to fall in basalt region of continental rift valley.

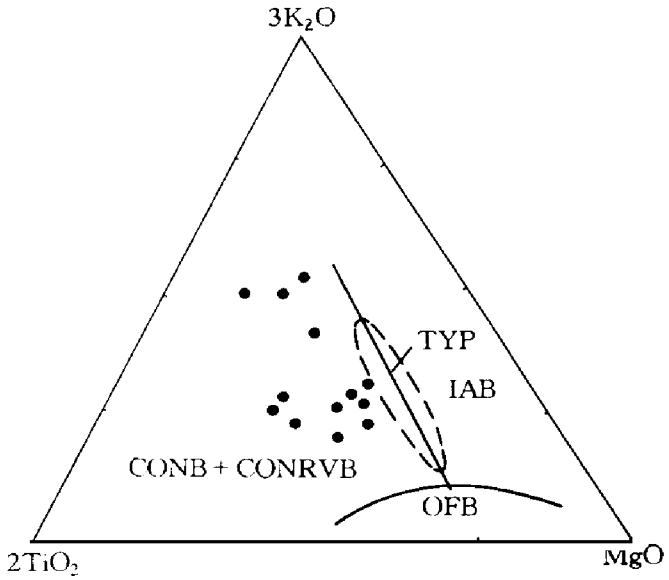

Fig. 2 Diagram of relationships between $3K_2O$-$2TiO_2$-MgO and geotectonic evidence of basalt

Table 2 Contrast between the petrochemical components of the basalt from Lancang and different structural environments

Petrochemical component	Island arc	Ocean ridge		Continental rift valley		Lancang rift valley basalt
		Tholelite	Plateau basalt	Tholelite	Alkali-basalt	
SiO_2	49.10	49.00	47.94	50.30	47.80	47.90
K_2O	2.13	0.21	1.09	2.50	2.86	2.02
Na_2O	0.88	2.90	2.37	0.66	1.31	2.67
TiO_2	2.50	1.40	0.73	2.22	2.20	3.01
Al_2O_3	13.90	15.50	17.45	14.20	15.30	16.26
Fe_2O_3	12.40	2.0	1.21	13.50	12.10	7.65
MgO	8.40	8.0	10.91	5.90	7.00	6.45
CaO	10.30	10.80	11.26	9.70	9.00	6.79
FeO		9.77	8.47			4.49
Na_2O/K_2O	0.37	13.80	2.17	0.26	0.47	1.32

(3) The curves of distribution ratio of rare earth elements, the ratio of LREE/HREE and δEu value of basalts in the district are very similar to those of continental rift ones established by Condie(1976)[2].

(4) Basalts in the district have good differentiation, belong to potash series and alkaline basalts of continental rift.

5 CONCLUSIONS

(1) Basalts in the district belong to alkaline basalts that mainly consist of alkali olivine basalt.

(2) In the basalts, the pyroxene is titaniferous augite; the An of plagioclases changes from 20% to 65%.

(3) The chemical compositions of basalts have characteristics to be titanium-rich and alkali-rich, they belong to alkaline basalts of high-potassium series.

(4) The basalts contain abundant ΣLREE; δEu is normal, no concentration or difficiency; the curve of distribution ratio of rare earth elements is a smooth curve dipped towards the right.

(5) According to chemical composition, minor elements, and the geochemical property of rare earth elements of the basalts, it may be believed that the basalts in the district belong to basalts of continental rift occurred under the environment of continental rift, a product of magmatic activity in Lancang rift.

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