ORIGIN AND PETROLOGY OF YINYAN TIN-BEARING GRANITE PORPHYRY①

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ABSTRACT The characteristics of Yinyan tin-bearing granite porphyry in view of geology, petrochemistry and mineralogy have been presented. Furthermore, the origin of the granite porphyry from REE distribution patterns, trace-elments, Rb-Sr istopes etc, are also discussed. It could be concluded that the Yinyan tin-bearing granite porphyry belongs to remelting-regenerated granitoids of the continental crust reworking type.

Key words granite porphyry petrography geochemistry petrogenesis

1 GEOLOGICAL ASPECTS

Yinyan is located in Guangdong, China. The porphyry body lies in the west side of Wuchuan-Shihui fracture and the axis of Datian arc structure zone of the Yunkai culmination. In this region uncovered layers are quartz-schist, gneiss and eye-chorismite of pre-Devonian Period. The rockybody mainly consists of granite porphyry and quartz porphyry. All rocks in the granite porphyry have tin-mineralization. Ore body is mainly distributed in the top of the granite porphyry and in the part of the wallrocks. Affected by the mineralizing solution, tin-bearing porphyry and wallrocks have more intensive thermal fluid alteration. According to the formers research, this kind of thermal fluid alteration may be divided into chlorite breccia zone, kalisilicate and sericitic quartz rocks' lamination zone, topaz-sericitie-quartz rock and kalisilicate-sericite-quartz rocks' zone. Under the ore body, there are wolfram and molybdeum ore bodys, the utilizable mineral stannolite is mainly distributed in the slender-veins and dyed-state.

2 PETROGRAPHY CHARACTERISTICS OF GRANITE PORPHYRY

2.1 Rocky body form, occurrence and age

The granite porphyry rockybody lies under the earth's surface. On the earth's surface several strips of quartz porphyry viens can be seen. The gallerys show that the Yinyan tin-bearing granite porphyry is a small stock covering an area of 0.06 km^2 and extending 200 m underground. It is a tubuler body with elliptic cross-section (Fig. 1). The contact plane is steep and smooth. The top of the rockybody shows explosive characteristics. Explosive breccias and net-viened crack system formed by the explosion can be seen everywhere.

According to Ref. [1], the K-Ar ages of the rock altered slenderly are 80 Ma and 83 Ma. The age measured again by the authors this time in Rb-Sr isotopic method is 86.9 Ma. It shows that this rockybody belongs to the late Yanshanian Period.

2.2 Petrochemistry characteristics

In order to discuss conveniently, some parameters and the results of C. I. P. W. standard mineral component of the Yinyan granite porphyry, Gejiu granite and Dachang granite petrochemistry component are listed in Table 1.

According to Table 1, compared with the granite in the world, the granite in the south of China and the hostrocks of other tin deposits, the Yinyan granite porphyry has the following characteristics on petrochemistry, standard mineral component and some parameters.

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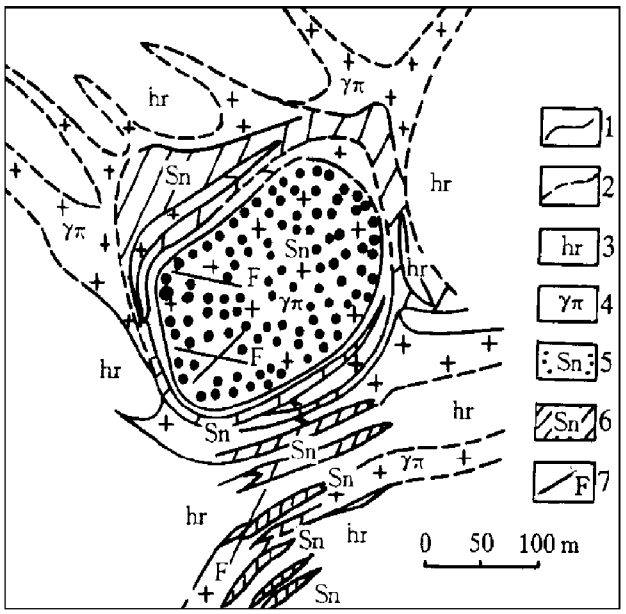

Fig. 1 The 1 050 m level plane of tin ore body of Yinyan porphyry

1—the practically surveyed border of the wallrocks, the porphyry and ore body; 2—the deduced border of the porphyry and the wallrocks; 3—hornstone; 4—granite porphyry of the Yanshanian; 5—tin ore body; 6—external tin ore body; 7—fault

(1) Enriching in silicon

The average of SiO_2 is more than that of the former two;

(2) Enriching in alkali

$Na_2O + K_2O = 8.33\%$, and $K_2O > Na_2O$;

(3) Poor in kalk

Content of CaO has only 1/3 of the average content in the others;

(4) Enriching in fluorine

The average content is 0.76%;

(5) Bigger divergent index

$DI = 91$;

(6) Small solid index

$SI = 1.6$.

According to these characteristics, it shows that the Yinyan tin-bearing porphyry has evolved for a long time, and belongs to the late outcome. It has better crystallization-fractionation.

2.3 Rocky mineral components and characteristics

Main mineral components of the granite porphyry consist of orthoclase (35% ~ 34%), quartz(40% ±), plagioclase(10% ±), and biotite. Accessory mineral of the rockybody belongs to the type of xenotime-zircon-monazite.

(1) Porphyritic crystal and matrix are made of orthoclase. Porphyritic orthoclase is almost hypautomorphic crystal. The granular diametre is from 1 mm to 2 mm. Carlsbad twin often appears. With X-ray powder analysis, according to the formulas[2]:

$$O_r\% = 1962.77 - 89.1 \times 2Q(\bar{2}01)$$

$$S_T = 1.754 \times [14.267 + 2Q(060) - 0.813 \times 2Q(\bar{2}04)]$$

$$T_1 = t_{10} + t_{1m} = 13.015 + 0.695 \times 2Q(060) - 0.813 \times 2Q(\bar{2}04)$$

the component and serial degree of orthoclase of the Yinyan granite porphyry are calculated separately. The results are given in Table 2.

After infrared spectroscopy analysis, according to the following formula:

$$Q = 0.05(\Delta J - 90)$$

the serial degree of orthoclase can be given:

$$Q = 0.05(100 - 90) = 0.5$$

The component of O_r, triclinicity and T place that are almost indentical, they are almost identical to the average measured on the Feishi platform also. The results indicate that O_r of the Yinyan granite porphyry is andesine, and belongs to the hypergenic outcome. Data of T_1 were projected in Al/Si serial law figure of different origin granite in the south of China. The figure was designed by Xuejiyue and Zhanggendi[3]. The projective points lie in the above line segment of AB line in that figure. It shows that the Yinyan granite porphyry belongs to magmagenesis granite.

(2) Porphyritic crystal and matrix are made of plagioclase also. The An value measured on the Feishi platform is equal to 9%, so it belongs to sodaclase.

With infrared spectroscopy analysis method, according to the following formula

$$Q = 0.048(\Delta J - 96)$$

the serial degree of plagioclase is 0.67.

It is proved that serial degree of plagioclase is almost identical to that of orthoclase. Their textures can confirm that the Yinyan tin-bearing granite porphyry belongs to the hypergenetic

Table 1 Chemistry components of the Yinyan, Dachang and Gejiu granites, C. I. P. W. standard mineral component and parameters

Items	Petrophyry components											
Ore regions	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	MnO	CaO	K_2O	Na_2O	P_2O_5	F
Yinyan granite porphyry	73.69	0.02	13.04	0.17	1.98	0.17	0.08	0.58	4.82	3.51	0.02	0.76
Dachang granite porphyry	71.69	0.13	14.83	0.53	1.54	0.72	0.07	1.45	3.63	2.90	0.29	0.24
Mashong granite in Gejiu	72.00	0.25	13.90	0.37	1.97	0.03	0.49	1.61	4.93	3.36	0.13	0.19
Average of granite in the south of China	72.29	0.28	13.69	0.90	2.65	0.59	0.08	1.37	4.76	3.09	0.13	–
Average of granite in the world	71.30	0.31	14.32	1.21	1.64	0.71	0.05	1.84	4.07	3.68	0.12	–

Items	C. I. P. W. standard mineral compoments										Parameters	
Ore regions	Ap	Im	Mt	Or	Ab	An	En	Fs	C	Q	*DI*	*SI*
Yinyan granite porphyry	–	–	0.230	28.38	29.4	3.60	0.50	3.56	0.92	33.0	9.75	1.60
Dachang granite porphyry	0.63	0.23	0.840	25.06	22.8	2.28	0.16	1.78	–	40.3	88.2	3.50
Mashong granite in Gejiu	0.300	0.60	0.700	28.9	28.3	7.20	0.10	2.90	0.40	29.3	86.5	0.28
Average of granite in the south of China	0.300	0.60	1.400	28.0	25.7	6.20	1.20	2.60	1.20	31.4	85.1	5.2
Average of granite in the world	0.100	0.30	1.600	23.9	30.9	8.10	1.70	1.80	0.90	29.2	84.0	6.3

Table 2 Triclinicity and component percent content of orthoclase measured by X-ray diffraction method

Number of sample	Place of sample	Rocks	$\bar{2}01$	060	$\bar{2}04$	δ	O_r	$t_{10}+t_{1m}$
Yin-1	ZK402	Granite porphyry	21.048	41.667	50.673	0.52	83	0.76
Yin-4	ZK101	Granite porphyry	20.900	41.682	50.692	0.51	100	0.77
Yin-5	ZK-5	Granite porphyry	20.962	41.679	50.704	0.48	92.6	0.76

outcome.

(3) Quartz is porphyritic crystal and matrix also. All porphyritic quartz are almost corroded, most of them are perfectly round and harbour-like. Matrix quartz is non-colour and transparent, most of them are granulitic. Their diameter is popularly less than 0.02 mm.

(4) Most of biotite are porphyritic crystal also, but content of biotite is less. Darkened margin is obvious. Biotite in the above rocky-

body almost has been altered into chlorite.

Analysed with electronic probe, biotite has high content of SiO_2 and (Fe_2O_3 + FeO), but has less content of MgO and CaO. It can be proved that biotite of this rockybody belongs to iron-mica, because biotite is always evolved towards rich-iron end in the course of magmatic differentiation[4].

2.4 Typomorphic characteristics of stannolite

Main color of stannolite of the Yinyan granite porphyry is black-brown and brown, polychroism is not obvious. Crystal outline appear biconic, square prism and granular aggregate. Occasionally, false octahedral and knee-bicrystal appear. Main crystal faces are made of {110} and {111}. Prism face have vertical viens. Main diametre is 0.04~0.2 mm. They are well distributed into the granite porphyry in the dyed state, and often alternated and warped by quartz, topaz and fluorite.

According to the result of electronic probe analysis, content of Nb, Ta, Sc is less, but that of WO_3 and TFe is more. So the Yinyan tin-bearing granite porphyry is different from the tin-bearing granite in the other regions.

3 GENESIS OF GRANITE PORPHYRY

3.1 REE results

REE pattern curve of the Yinyan granite porphyry indicates that both flanks are nearly horizontal. Eu lies in the curve like "V" symbol (Fig. 2).

The total content of REE(ΣREE) changes from 0.027% to 0.041%. The average is 0.036%. Ratio of LREE and HREE is nearly equal to 1, relatively rich-HREE. Eu loses greatly, and is remarkably less than the average of the granite in the south of China.

According to the above characteristics, the Yinyan granite porphyry is very similar to the remelting-regenerated granitoid of the reworking type in the south of China.

Compared with the REE pattern curve of the wallrocks, the shape of the REE pattern curve of the rockybody is not simliar to its shape. It is obvious that Eu of the rockybody is lost greatly. Ratio of LREE and HREE is 5.6, it shows that the wallrocks relatively enrich in light REE. From the above characteristics, it is believed that the rockybody is not simply reworked by the substance of the wallrocks, perhaps the substance origin generating the rockybody is in the depth.

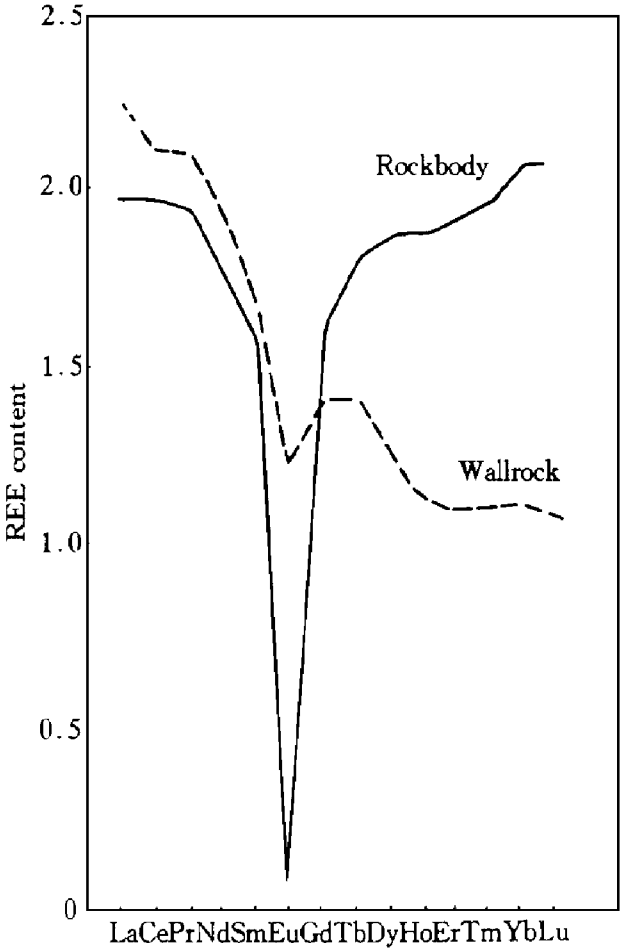

Fig. 2 REE pattern of Yinyan granite porphyry

(Ordinate is logarithm of the ratio of the rocky REE content and half-aerolite)

3.2 Characteristics of trace-elements in the Yinyan granite porphyry

Compared with the granite in the south of China, content of trace-elements in the Yinyan granite porphyry is nearly similar to that in the remelting-regenerated granitoids of the continental crust reworking type, but they are different in the following aspects.

(1) The Yinyan granite porphyry is rich in Rb, poor in Sr and Ba, and Rb/Sr is 82, Ba/Sr is 7.7, because Rb is mainly in place of K of pla-

gioclase in the course of magmatic crystallization. With the magmatic evolution and crystalliztion-fractionation, richer is Kali, more poor is Kalk, because orthoclase increases gradually, and plagioclase decrease greatly. It causes rich Rb, poor Sr and Ba.

On the triangle diagram of Rb-Ba-Sr (Fig. 3), projected points of the Yinyan granite porphyry lies in the area of the intensive fractionation granite[4], it has been shown that Yinyan tin-bearing granite porphyry has evolved for a long time and fractionized intensively.

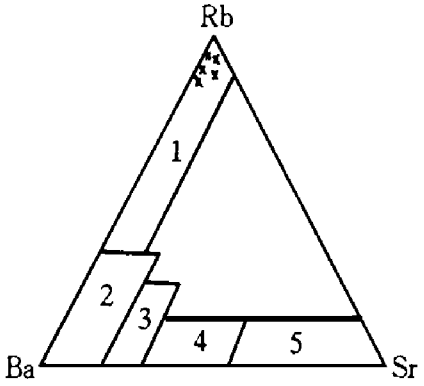

Fig. 3 Rb-Ba-Sr triangle diagram

× —the projection of the Yinyan granite porphyry; 1—intensively differential granite; 2—normal granite; 3—abnormal granite; 4—granodiorite; 5—diorite

(2) Ratio of Nb and Ta in the Yinyan granite porphyry is low, relatively rich in Ta. The ratio is 1.24. It is more than that of the remelting-regenerated granitoids of the continental crust reworking type in the south of China. Because the Yinyan granite porphyry is the outcome of the magmatic evolution in the late date, and the content of K_2O is more than that of Na_2O. Ta is relatively richer than Nb.

(3) The content of ore-forming elements is high in the Yinyan granite porphyry, for instance, Cu, Pb, Zn, W, Mo, Sn etc. are more than that in the granite of the continental crust reworking type. That is one of the prerequisite that the Yinyan granite porphyry can form the big tin-deposit of the porphyry type.

3.3 Research of Rb-Sr isotope

Four samples of the Yinyan granite porphyry and one of orthoclase are analysed by the Rb-Sr isotope method.

The data of all samples are contents with mono-variable regression equation, $r = b + mx$. it forms an isochron digram. Its slope m is equal to $0.001\,234\,39 \pm 0.000\,080\,34$. Decay constant is 1.42×10^{-11}/a. First ratio b of ^{87}Sr and ^{86}Sr is more than that of ultramafite in the above mantle. It is more than that of the comelting granitoid of the transitional crust type also. It is correspond to the remelting-regenerated granitoids of the contiental crust reworking type, but the ratio is less than the ratio, 0.719, of the contiental crust rocks.

To sum up, it is preliminarily considered that the substance of the Yinyan tin-bearing granite porphyry comes from the remelting-regenerated substance of the earth's crust. After the magma is formed, it is evolved for a long time and fractionized intensively. In about ^{86}Ma it elevates to the earth's surface, and forms the tin-bearing granite porphyry that can be seen at present. Petrogenetic type may belong to the remelting-regenerated granitoid of the continental crust reworking type divided by Xu Keqing[5].

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