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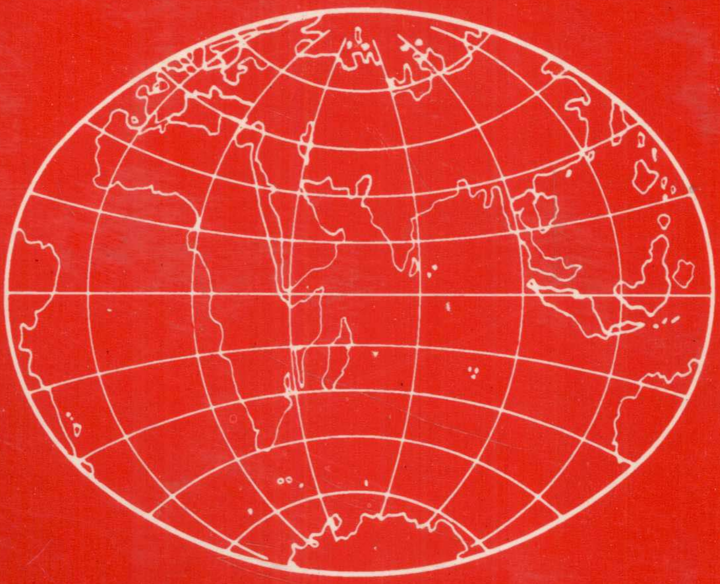

沈阳黄金学院地质系

Department of Geology, Shenyang Institute of Gold Technology

1992.9

序 言

沈阳黄金学院是国家黄金管理局所属的一所为黄金事业培养专门人才的高等学校，地质系是我院建系较晚的系部之一。建系十二年来，在各级领导的关心和帮助下，经过全系教职工的不懈努力，有了较大发展，特别是1987年我院晋升本科以来，地质系在教学、科研等方面有了长足的进步。《国际地质会议论文集》就是我系教师近几年在黄金地质基础研究与应用研究方面的部分成果，谨以此作为一份薄礼献给沈阳黄金学院40周年校庆。

《国际地质会议论文集》收集了我系教师自1988年以来，在日本、澳大利亚、新西兰和中国等国家召开的9次国际会议上发表的34篇论文（摘要）。其中绝大多数是由我系（中）青年教师发表的。展示了我系蓬勃向上的生机与活力！

我院40周年校庆为我们提供了一个开拓思路、结交良友、增进友谊与合作的极好机会，我们热情欢迎各位专家、学者在黄金地质教学与科研中给予广泛的合作与指导！由于时间仓促，未对原稿进行详细修改，加之水平所限，书中错误恐系难免，敬请批评指正。

沈阳黄金学院

地质系　张忠生

1992年9月

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On the Potential Significance of Gold Mineralization in Archean High Grade Terranes: Evidences from North China Craton

Gan Shengfei, Qiu Yumin, Zhang Zhongshen

Gold mineralization in high grade metamorphic rocks, which was almost omitted by most geologists before and has attracted our attention now, is one of the most controversial problems in Archean geology and gold deposit geology. It was widely accepted that gold deposit could not be formed in granulite facies condition and that exploration of gold deposit in high grade terranes is difficult or beyond possibility. Granulite facies metamorphism which is considered unfavorable for the concentration of gold and forming temperature of gold deposits which are described as "mesothermal" are the two main factors that affect our thought.

In the high grade metamorphic basement of North China craton, more than 100 gold deposits have been discovered and explored these years. The typical representatives are Hadamengo Gold Mine and Jinchangyu Gold Mine. The former occurs in late Archean Wulashan group granulite facies rocks in Inner Mongolia, the latter is set in Early Archean Qianxi group which experienced high temperature granulite facies metamorphism during Archean in Eastern Hebei. A lot of geological evidences demonstrate that, in most gold deposits of North China craton basement, gold mainly comes from the high grade metamorphic rocks. Although the final episode of gold mineralization might be as late as Mesozoic, Archean granulite facies metamorphism caused the primitive concentration of gold in the rocks. These gold deposits are distributed mainly along middle to high temperature ductile shear zones and have a long forming history.

Based on the observation of gold deposits in North China craton, it is concluded that the depositional temperature of gold ranges from 200℃ to 700℃. Granulite facies metamorphism is not unfavorable for gold deposit formation. In Archean, gold could be brought into lower crust with CO_2-rich fluid from mantle and exists in minerals as very fine particles. It in completely possible to find large scale but low-grade gold deposits in Archean high grade terranes.

太古宙高级区金矿化的潜在意义—来自华北克拉通的证据

甘盛民　邱玉民　张忠生

（第 29 届国际地质大会・1992・日本　京都）

North China Granulite Belt: a Brief Review

Gan Shengfei, Qiu Yumin, Yu Mingxu, Yang Hongying

One of the most important events in the early geological evolving history of the Earth is the wide appearance of granulite facies metamorphic rocks belts on the surface of the Earth during the transition period from Archean to Proterozoic, which just means a change of tectonic mechanism of crustal evolution.

At the north margin of North China craton, the Archean granulite facies metamorphic rocks outcrop continuously in E-W direction and make up a special tectonic unit named North China granulite belt which extends more than 1000 km from InnerMongolia to Eastern Hebei, located between lat. 40°42°N and long. 108° 125°E (Fig. 1). The rocks in North China granulite belt experienced two phases of granulite facies metamorphism at 3000 Ma ago and 2500 Ma ago. The metamorphic temperature and pressure are 750°~950℃ and 0.7~1.2 GPa respectively with geothermal gradient of 19°~29℃/km. In this granulite belt, large or small isoclinal folds and granulite facies mylonite zones exist everywhere. Two or three sets of shistosity, which strike east-westernly and dip to north or south with dip angle of 70°~90°, can be distinguished.

North China granulite belt had been shaped on the surface of the Earth during the period between 2400~2500 Ma as the result of continental collision of North China craton with Siberian platform. Generally speaking, Archean granrlite belt is just the earliest product of modern-style plate tectonics of the Earth.

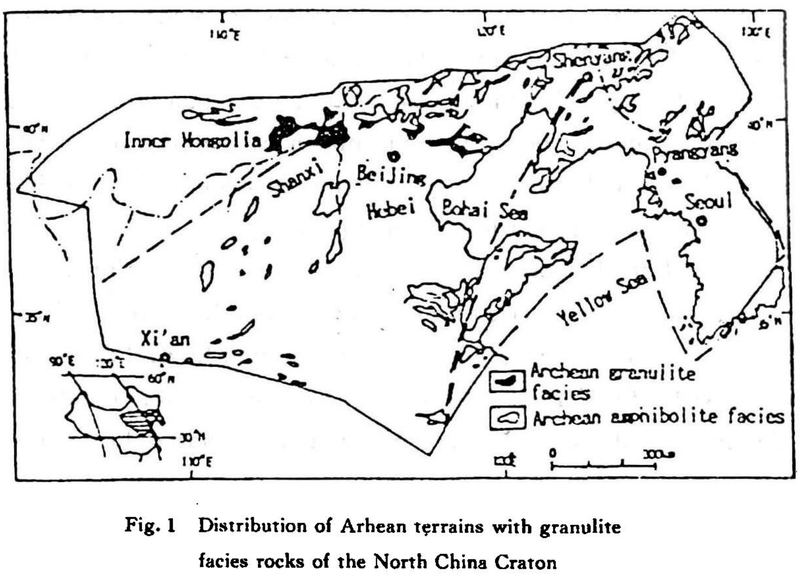

Fig. 1 Distribution of Arhean terrains with granulite facies rocks of the North China Craton

华北麻粒岩带简述

甘盛飞　邱玉民　于明旭　杨红英

（第 29 届国际地质大会 · 1992 · 日本　京都）

The Characteristics of the Fluid Inclusion in Minerogenetic Quartz for Some Types of Gold Deposits in China

Li Li, Zheng Chao, Yu Zhikai and Mao Dongqing

It' s a fresh topic to do research on the fluid inclusions of gold deposits in china. We have got some succeecd in this area. The research have been done to determine the minerogenetic temprature and pressure of the Gold deposits and consist of the fluid inclusion in some famous gold minerogenetic regions, for example, liaodong, Western Henan (Xiaoqinling) and Eastern Shandong of China. It is useful to determine the formation of the deposits, the minerogenetic material resources and the mineralized fluid of gold deposits. Limited by instruments and techniques, the research is not popular in china.

Fluid inclusion in quartz, which has close relation with mineralization in quartz vein and altered rock types of gold deposits, is mainly studied in this paper. The physical-chemical environment where gold is dissoved, removed and deposited is studied from the research of the fluid inclusion. And then the mineraliztion principle can be drawn.

Eastern Shandong is one of the very famous gold minerogenetic regions. more than 50 gold deposits have been found in the region. and more than 90 percent of them are rich-gold deposits which include gold-quartz deposits (58%), altered rock of gold deposits (29%) skarn gold deposits (9%) and glod placer deposits (4%). there are old layer, complex geologic structure, frequently volcanism and tensive metamorphism in the area, which are good conditions for gold removement and mineraliztion. the types of quartzs in the gold deposits include mainly all kinds of quartz, which present in drusy block, chalcedony and opal and so on, Drusey quartz is mainly found in crystal hole.

In quartz vein gold deposits, most quartzs present in veins or crystallic blocks; some present in drusey, chalcedony is rarelymet. The crystal forms of quartz are mainly hexagonal prism, plus rhombohedron and miners rhombodron; triangle can be met as well. All quartz in the gold deposit is produced in multirange and multistage. the quartz produced in different stages has different crystal forms, grain size, mineral combinations and relationships with gold.

(1) the quartz produced in the early stage of the mineralization period, are milkwhite coloured, clear, massive structured; the grain size varies in 5—45mm; recrystal quartz can be met sometimes. Usually, quartz presents in great vein (different in altered rock deposit). The Paragenetic mineral combination are pyrite, wolframite scheelite, siderite etc. The quartz produced in this stage only has little native gold.

(2) The quartz produced in the midle stage of the mineralization period. The quartz is

grey or white-grey;not very much clear;the grain size varies is 0. 1—5. 5 mm. It is stringerly inserted in the quartz produced in the early stage or closes the quartz. The paragentic mineral combination are mainly fine pyrite, chalcopyrite, sphalerite, calena etc. In some gold feilds, such as Sanshandao in the area, arsenopyrite is found sometimes.

(3)The quartz produced in the late stage of the mineraliztion period. It's clourless clear, fine grained. The grain size varies in 0. 01 ~ 0. 06 mm, mainly. It is paragenetic with carbinates and a little sulfid.

It is not all equal in different gold fields of the characterstics of fluid inclusions in quartz which has close relationship with mineralization in the area. For example, in Ling Long gold field, the fluid inclusions in the quartz which produced in the early stage include air-liquid facies mainly;next is fluid inclusion of liquid facies;the inclusion of CO_2 is rarely. The ratio of air to liquid in volume varies in 20~40%. The inclusion sizes vary in 2. 5~10% mainly;some of them are more than 10 pl big. There are a good number of inclusions in the quartz;the arrangement is unregularly. The shapes of the inclusion are long circle or elliptical. The homogenous temperature varies in 335°~350℃.

The inclusions in quartz qroduced in main mineralization period present in shape of elliptical circle mainly. Some of them are long prism or minus crystal. The grain size not equal usually varies in 5~15%. The great grain size is more than 50% big. The main facies are liquid-air. There are not only clear liquid facies. the percentage of inclusion of CO_2 increases with apperently, which reaches 10%. Ratio of the air to liquid in volume varies in 25~50%. The homogeneous temperature varies in the rang of 280°~315℃ mainly.

there are not many inclusions in quartz produced in the late stage. And the most of them are liquid facies. There are few liquid-are facies inclusions in the stage. And no inclusion of CO_2 is found in the stage. The grain size is not more than 3%. The homogeneous temperature varies in 220°~280℃. From all above as we know that the variation of the stages in the main mineralization period can be drawn from the characteristics of the inclusions. From the begin to the end of the period. The percentage of the inclusions of liquid facies increases obviously, the rate of air to liquid in volume decreases gradually. And the grain size of the inclusions has an increasing trend.

In Jiaodong gold field, except H_2O, CO_2, N_2, H_2, CH_4, Ca^{2+}, Mg^{2+}, Cl^-, F^-, HCO_3^-, SO_4^{2-}, there are Fe^{2+}, Cu^{2+}, Pb^{2+}, Zn^{2+} in the inclusions as well. The inclusions composition in the quartz of the field shows that the percentage of H_2O is much more than that of CO_2, which indicates that the minerogenetic material is migrated in liquid facies. And the infitration and substitution take place under the same conditions. The percentage of N_2 is low, while the ratio of $CO_2+H_2+CH_4$ to N_2 is high. It indicates the high percentage of CO_2 and CH_4. And it indicates the change of the physical-chemical characteristics of the minerogenetic fluid. The ratio Na^+/K^+ is low, which indicates the same geological enviroment.

The percentage of Cl^- is much more than that of F^-, and there is a high percentage of SO_4^{2-} at the same time, which shows in some sense that there is a quantity of mineralized agents in the fuid. It makes gold dissoved, removed, and deposited. It can be drawn from above that gold may be migrated in the forms of $AuFecl_4$. $AuAlcl_4$, $[Au(S_2O_3)_2]^{2-}$ and $[Au(HS)_2]^-$.

Xiaoqinling is another famous gold minerogenetic region in China. The mineralized type is Au-sulfide-quartz vein. More than a thousand Au-quartz veins have been found around granite erupted in Yanshan movement. The quartz present in vein which are limited by fault structures.

The facies of the inclusion in the quartz of the region are air, liquid, air-liqid, multifacies and inclusion of CO_2. Three of them, multi facies, CO_2 facies and air-liquid facies, has a close relationship with mineralization. Their grain size is mostly great, colur is less and clear. The shapes are long-cirrcle, long prism, and so on.

Dongchuang gold deposit is located in the region. The homogeneous temperature of the inclusions in the quartz, which have a closely relationship with main mineralization period, is limited to 200°～260℃.

The compositions of the inclusions produced in minerogenetic period shows that there is high percentage of CO_2, CH_4, K^+, Na^+, H_2O, and SO_4^{2-} etc. Which indicates that gold is removed in fluid. The big ratio of Na^+/K^+ and Cl^-/F^-, and the high percentage of Na^+ and Cl^-, and malti-facies in clusion indicates that the minerogenetic fluid is a weak alkaline clorinate-bicarbonate liquid which has a high percentage of Na^+ and K^+, but it has a low percentage of Ca^{2+} and Mg^{2+}. According to MOIXINC, a Russian geologist, this type of fluid is found in different types of quartz vein deposits. In the fluid, gold may be removed in the forms of $[AuCl_4]^-$, $[AuS_2]^-$, etc.

Above all, some types of gold deposits in china have some same characteristics of fluid inclusion in quartz produced in minerogenetic period. They are:

(1) The main face of the fluid in conclusion is air-liquid facies.

(2) The grain size of the inclusions is great mostly. There is big ratio of air to liquid, which usually reaches 10～40% in volume. Heated, they usuall change into air facies, a little of liquid facies.

(3) The homegeneous temperature is concentration. It varies between 200°～400℃.

(4) The percentage of H_2O, CO_2, Na^+, Cl^- in the fluid is high, the K^+ and F^- is low. Usually there is some of SO_4^{2-}. It indicates that minerogenetic material is removed in liquid to be carbonates of weak alka-line. Gold is removed by complex of Cl^- and S. Gold deposits are formed in appropriate conditions.

中国几类金矿床成矿石英中流体包体特征

李 力 郑 超 于志凯 毛冬青

（第 29 届国际地质大会·1992·日本 京都）

Geochemistry and Petrogenesis of Kaligranite in Honghuagou Gold Deposit, Inner Mongolia, China

Qiu Yumin, Hou Genqun, Zhang Zhongsheng

Studies on granitoids associated with mineralization have been one of the important research subjects for petrologists and mineral deposit geologists. Geology of granitoids in south China and their Metallogenetic relations have been systermatically and profoundly studied (Tu Guangchi, 1979; Xu Keqin, 1981; Yuan kuirong, 1982 etc). However, little research has been made on the granites in north China. The kaligranite in Honghuagou gold mine of Inner Mongolia has not yet been researched up to now. Honghuagou gold mine was one of the ten largest gold deposits in China in 1980. The author (1988) noticed that most gold-bearing quartz veins in the mine occured at the outer contact zone between Honghuagou kaligranite and Archean Jianping group (Qiu Yumin, 1990). Based on field geology, the analysis of REE, trace elements, stable and radioactive isotopes, and petrochemical compositions of the granites, the geochemical characteristics, petrogenetic age and the origin of Honghuagou kaligranite have been studied for the first time in this paper.

1 Geological Background and General Features of the Kaligranite

Chifeng region in Inner Mongolia, situated at the east part of the northern margin of North China Platform, is one of the important gold concentrating regions in China. Honghuagou gold deposit, located at Yunwushan uplift in west Chifeng city, is one of the largest gold deposits in this region, and it is divideel into two ore districts, namely Honghuagou and Lianhuashan, by the Shelugahe fault which strikes east to west.

Late Archean metamorphic rocks of Jianping group and upper Jurassic volcanic rocks are the main strata outcrops in the gold ore field. Tertiary Hannoba basalt is distributed along the bank of Shelugahe river.

Archean Jianping group, chiefly composed of issite, hornblende plagioclasegneiss, biotite hornblend-gneiss and quartz-granulite etc., is a series of metavolcanic sedimentary complex suffering middle-high metamorphism. Their primary rocks mainly are basalt-basaltic andesites and a few tuffaceous-pelitic sedimentary rocks (Qiu, 1992). The strata emerged best at Chedaogou, Guibogou, Zhujiagou and Lalagangou etc. Its U-Pb isotopic age of zircon of issite is 2481～2579 Ma.

Mesozoic strata are located at the margins and the outside of the ore districts and are unconformable with Jianping group. Tertiary Hannoba basalt are located at the bank of Shelugahe river.

Magmatic activities is relatively intensive in the ore field. Granitic rocks occur here and there. Vein-shape or banded migmatite and migmatitic granite distributed along the bedding or bedding schistosity of Jianping group, with light grey to grey-white colour, fine grain texture, which is the products of regional metamorphism. 12～15 km to the west of the gold mine is the Yanshanian Nujiayengzi granite batholith, its K-Ar isotope age is 164.4 Ma with coarse texture and massive structure. Late Yanshanian granite-porphyry and quartz-porphyry are located at the SW part of the ore field. There are all S-type granite. No gold mineralization has been discovered around the granitic rocks.

Kaligranite is the most widely distributed granitic rocks in the gold field. It emerged best in the surface at Longtoushan and Chedaogou etc. It can also be seen at the mine-wells of H15, H2-3, H23, H1, L51, L6, L2 and L4. The kaligranite occurs as intrusion or fault contacts with Jianping group. Enclaves of issite or hornblendic gneiss, ellipsoidal or irregular in shape and generally several km^2 to tens of km^2 in area, can be found in the granite, which is often cut by aplite and granite-pegmatite veins.

There are many vein rocks in the gold field, chiefly intermediate-acidic vein rocks. It is diorite-porphyrite vein that has the most close relation to gold-bearing quartz veins. More than 150 quartz veins have been discovered in the gold field, which strike NS, NNW or NNE. NW or dip SE, located in the outer contact zone between kaligranite and Archean Jianping group. The length of the mineralized zone is usually several hundred meters, distribute along its strike disjointedly, more than 200 meters in depth. The bottom of ore-vein becomes wider as it gets near the kaligranite, sulfides decrease and gold grade lower. Metallic minerals are pyrite, magnitite, pyrrhotite, chalcopyrite, sphalerite and galena etc, of which more than 80% is pyrite. Quartz is the main gangue mineral. Gold ore occurs as banded, taxitic, fine vein-disseminated, stockwork and massive structures. The purity of gold is relatively high, varing in 736～896, generally larger than 800. Ore deposit geochemical studies show that the gold deposit is a mesothermal gold-bearing quartz vein type gold deposit, and the ore-fluids came mainly from the kaligranite as well as a little precipitated water.

2 Petrology and Petrochemical Characteristics

Frash kaligranite is meat red, and greish white when weathered; with massive structure, fine, medium and coarse grain textures, and is mainly composed of plagioclase (20～30%), potash feldspar (30～40%), quartz (30～35%) and biotite (0～5%). Carbonitation, sericitization and chloritization are very common. Main textures are: hypidiomorphic-granular, resorption-crystalloblastic fabric, metasomatic and myrmekitic structures etc. Wire-drawing quartz, undulatory extinction and crack of quartz, and granulation are very common.

The chemical compositions of Honghuagou Kaligranite is shown in Table 1. SiO_2 varies in 63.69～75.06 wt %, mean value is 70.82 wt%. The alkalinity of the granite is high. $Na_2O + K_2O$ varies in 6～10 wt%, $K_2O > Na_2O$, $Al_2O_3 > K_2O + Na_2O + CaO$, It belongs to aluminium over saturated rock. Compared to the average compositions of granite of China (Li Tong,

Table1. **Petrochemical compositions and CIPW calculating results of Honghuagou kaligranite**

Sample No. Rocks	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
1 QH151 kaligranite	63.69	0.35	14.80	0.13	2.42	0.06	1.87	3.68	3.53	2.49	0.18
2 QH089 kaligranite	75.06	0.05	12.94	0.30	0.46	0.01	0.41	0.85	3.74	5.49	0.07
3 QH043 kaligranite	73.94	0.05	12.87	0.00	0.69	0.01	0.61	1.19	3671	5.83	0.07
4 QH044 kaligranite	72.74	0.12	13.47	0.04	1.12	0.02	0.61	1.89	3.50	3.95	0.14
5 QH054 kaligranite	69.46	0.18	13.94	0.41	1.57	0.04	1.02	1.46	4.83	4.87	0.14
6 QH062 kaligranite	66.46	0.21	18.32	1.27	0.92	0.02	0.31	3.16	6.13	1.20	0.15
7 QH053 kaligranite	70.16	0.10	14.06	0.18	0.81	0.01	1.30	1.36	3.26	7.08	0.14
8 QH077 kaligranite	71.34	0.26	14.53	0.97	1.00	0.09	0.73	1.13	4.12	4.51	0.11
9 QH093 kaligranite	71.14	0.07	14.80	0.15	1.07	0.02	0.88	2.27	5.12	2.23	0.08
10 QH069 kaligranite	74.20	0.12	13.63	0.02	1.07	0.01	0.68	1.04	2.45	5.91	0.08
Sample No. Rocks	**IL**	**AP**	**MT**	**HM**	**OR**	**Ab**	**An**	**C**	**En**	**Fs**	**Q**	**Er**
1 QH151 kaligranite	0.66	0.42	0.19	0.00	14.71	29.87	17.08	0.044	4.66	3687	21.7	0.0022
2 QH089 kaligranite	0.09	0.16	0.43	0.00	32643	31.64	2.30	0.00	0.65	0.34	30.14	0.0051
3 QH043 kaligranite	0.09	0.16	0.00	0.00	34.44	31.39	1.24	0.00	0.57	0.45	27.15	0.0060
4 QH044 kaligranite	0.23	0.32	0.06	0.00	23.34	29.61	8.46	0.33	1.52	1.86	31.86	0.0023
5 QH054 kaligranite	0.34	0.32	0.59	0.00	28.77	40.87	1.97	0.00	1.61	1.47	18.36	0.0073
6 QH062 kaligranite	0.40	0.35	1.84	0.00	7.09	51.87	14.70	1.55	0.77	0.33	19.25	0.0038
7 QH053 kaligranite	0.19	0.32	0.26	0.00	41.83	27.58	2.82	0.00	2.39	0.88	19.76	0.9700
8 QH077 kaligranite	0.49	0.25	1.41	0.00	26.64	34.85	4.89	1.08	1.82	0.77	26.57	0.0046
9 QH093 kaligranite	0.13	0.19	0.22	0.00	3.17	43.32	10.74	0.03	2.19	1.76	26.08	0.0019
10 QH069 kaligranite	0.23	0.19	0.03	0.00	34.92	20.73	4.64	1.50	1.69	1.77	33.52	0.0052

Analysized by Shenyang testing center of mutiple rocks and minerals of Ministry of Geology and Mineral Resource of China

Table2. **Petrochemical parameters of the kaligranite in Honghuagou gold deposit**

Sample No. Rocks	б	A.R	D.I	Oconnor, 1965			F. Barker, 1976		
				OR%	Ab%	An%	K%	Na%	Ca%
1 QH151 kaligranite	1.75	1.97	66.28	23.86	48.44	27.7	25.7	36.4	37.9
2 QH089 kaligranite	2.66	3.37	94.22	48.86	47.67	3647	54.5	37.1	8.4
3 QH043 kaligranite	2.94	3.23	92.99	51.36	46.8	1.85	54.3	34.6	11.1
4 QH044 kaligranite	1.87	2.67	84.81	38.0	48.22	13.78	42.3	37.5	20.2
5 QH054 kaligranite	3.56	4.37	88.00	40.18	57.07	2.75	43.6	43.3	3.1
6 QH062 kaligranite	2.29	2.04	78.21	9.63	70.42	19.95	11.4	58.4	30.1
7 QH053 kaligranite	3.94	2.47	89.17	57.91	38.19	3.9	60.1	27.9	11.6
8 QH077 kaligranite	2.63	3.22	88.07	40.13	52.51	7.36	46.2	42.2	11.6
9 QH093 kaligranite	1.92	2.51	82.57	19.6	64.43	15.97	23.2	53.2	23.6
10 QH069 kaligranite	2.24	2.00	89.16	57.92	34.49	7.69	62.8	26.1	11.1

Sample No. Rocks	R. Dhana Raju, 1972			S. Nakada, 1979			CIPW minerals		
	Na%	K%	Ca%	A%	C%	F%	Q%	Ab%	Or%
1 QH151 kaligranite	36.64	28.92	34.43	29.8	31.6	38.6	32.7	45.1	22.2
2 QH089 kaligranite	35.24	57.88	6.88	20.7	37.9	41.4	32.0	33.6	34.4
3 QH043 kaligranite	32.85	57.78	9.37	9.2	41.9	48.9	29.2	33.8	37.0
4 QH044 kaligranite	36.6	46.22	17.18	34.4	34.3	31.3	37.6	34.9	27.5
5 QH054 kaligranite	41.97	47.35	10.68	8.80	32.4	58.7	20.9	46.4	32.7
6 QH062 kaligranite	59.36	13.0	27.64	47.0	38.9	14.1	24.6	66.3	9.1
7 QH053 kaligranite	26.47	64.33	9.2	13.1	31.1	55.9	22.2	30.6	46.9
8 QH077 kaligranite	40.73	49.89	9.38	35.0	25.1	39.9	30.2	39.6	30.2
9 QH093 kaligranite	52.79	25.72	21.5	33.5	34.9	31.6	31.6	52.5	16.0
) QH069 kaligranite	24.59	66.37	9.04	38.4	22.7	38.9	37.6	23.2	39.2

1976), the contrasts of CaO, Na_2O and K_2O is larger than 1.0, SiO_2, Al_2O_3 and MgO is about 1.0, and other components lower than 1.0. Contrasted to the mean compositions of I type granite in Australia, K_2O and Na_2O riched, the contrasts of SiO_2, Al_2O_3, P_2O_5 and FeO are near 1.0, and Fe_2O_3, MnO, MgO and CaO depleted in some extent. Contrast it with Archean kaligranite in east Liao ning province (such as Anshan, Gongchangling and Lianhuaguan etc), Honghuagou kaligranite is rich in CaO, the contrasts of MgO, Na_2O, MnO are larger than 1.2, SiO_2, Al_2O_3, P_2O_5 and MnO near 1.0, K_2O, FeO and TiO_2 vary in 0.63～0.82, and Fe_2O_3 0.44. Generally speaking, the petrochemical compositions of Honghuagou kaligranite is very similar to those of Archean kaligranite in east Liaoning. Therefore, the Honghuagou kaligranite shows the characteristics of Precambrian granite on the view of composition evolution. Petrochemical variation diagram for kaligranite and Jianpiny group in the gold mine is shown in Figure 1. Their SiO_2 versus CaO, k_2O and TiO_2 etc have similar variation trends, illustrats the consistence of source of Kaligranite and Jianping group.

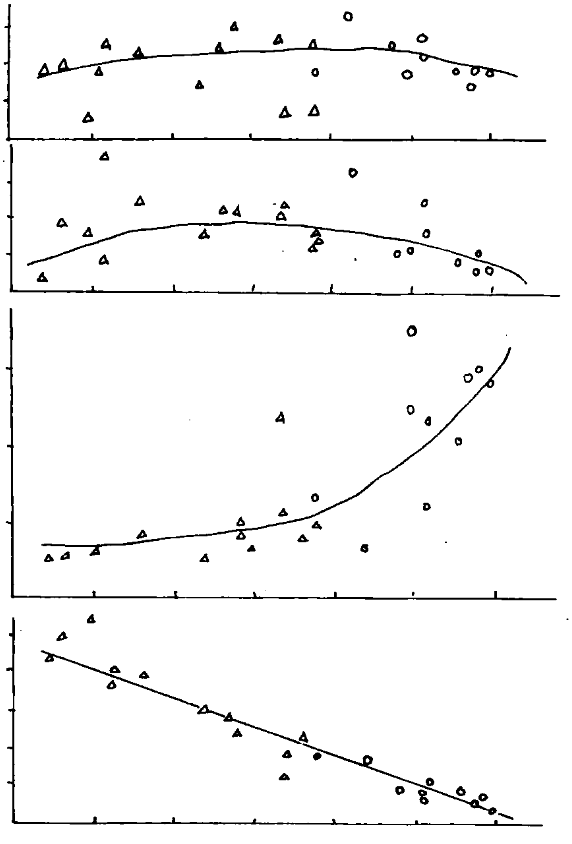

Fig. 1 Petrochemical diagram for the kaligranite in Honghuagou gold deposit

○ kaligranite

+ Metamorphic rocks and migmatite occured as wall rock or enclave of the kaligranite

Calculating results of CIPW and other petrochemical parameters for samples from the kaligranite is shown in Table 2. In O'connor (1965) An-Ab-Or diagram (Fig. 2) only one sample falls in area of granodiorite, two in area of trondhjemite, all others in common granite area. Multiple index changes at 1.75～3.94, average 2.58. alkalinity index varies in 1.97～4.32, average 2.97. In K-Na-Ca diagram (Fig. 3), samples concentrte on the nearby trend line of calc-alkali rock series, only two samples near the trondhjemite trend line, which show that Honghuagou kaligranite is chiefly cala-alkali granite, and there is a little trondhjemite. The differential index changes in 66.28～94.22, average 85.35, which means that the granite differentiated well. In a word, Honghuagou kaligranite has the general petrochemical characteristics of granitoids associated with gold mineralization (Xu Koqin, 1992).

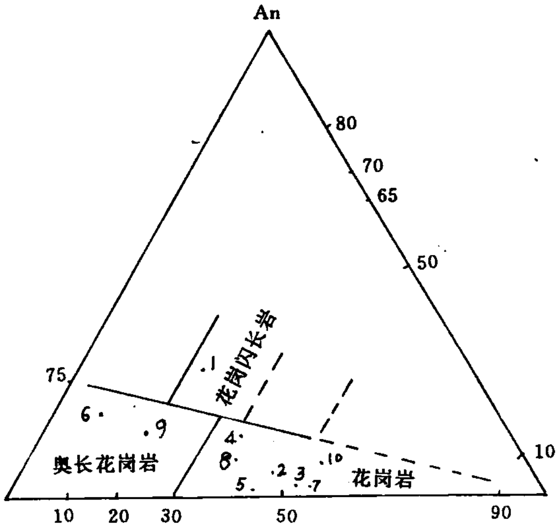

Fig. 2 Oconnor diagram for the kaligranite
in Honghuagou gold deposit

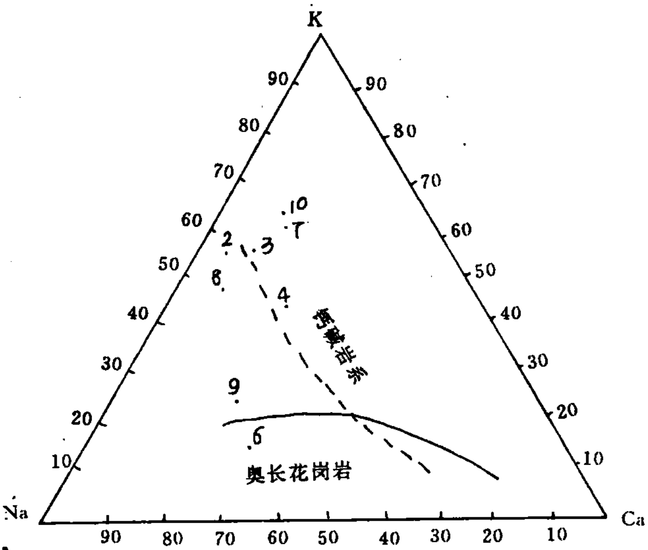

Fig. 3 K-Na-Ca diagram for kaligranite
in Honghuagou gold deposit

3 REE and Trace Element Features

3.1 Characters of trace element geochemistry

Trace element abundance of main rocks in Honghuagou gold mine is shown in Table3. And it is concluded that: (1). Contrasted to average values of granite all over the world, the contrasts of Cr, Co, Ni, Pb, As and Sb greater than 1.0, they enriched relatively in the kaligranite. Others changes in 0.27～0.92, relatively diluted. Concentration-Clark values of Mn, Cr, Pb, Sb and Au in the kaligranite are greater than 1,0, others less than 1.0. (2). Concentration Clark values of Cr and Sb in Yan shanian granitoids is less than 1.0, their gold abundance (4.14ppb) is higher than that of Jianping group. Therefore, it is impossible that Jianping group remelted into Yanshanian granite and formed the gold mineralization, if so, gold contents in the metasomatic-anatectic granites should be lower than that of Jianping group. Gold associated Linglong and Guojialing granites in Zhaoyuan-Yexian gold belt belongs to the latter situation (Qiu Yumin, 1990). (3). Compared with world basic rocks, Pb, Sb in Jianping group enriched obviously, gold is almost the same, the contrasts of Ti, V, Ni and Mn are less than 0.5, concentrated Clark values of Mn, Pb, Cr, Au are larger than 1.0, which mean that Jianping group in this region is characterized by Pb-enrichment.

Unlike the trace elements characters of Yanshanian granitoids in the region, the kaligranite and Jianping group, compared with their correspondents, enriched in Pb and Sb, diluted in Mn, and contrasted to the Clark values, Mn, Cr, Pb, Sb and Au relatvely enriched, which show that they have close relationships not only in space but also in origin.

3.2 REE geochemical characteristics

Abundance of REE in Honghuagou kaligranite is shown in Table 4. The REE distribution patterns of the granite has right inclined curve and negative anomaly of Ce, which is very similar to that of Proterozoic Dushan granite in the same regional area (Fig. 4). The REE pattern of gold ore is relatively flat, but it is still similar to that of the kaligranite genereally in shape. All of these suggest that gold mineralization is associated with the petrogenesis of the kaligranite.

Table 3. Abundance of trace elements of main types of rocks in Honghuagou gold field (ppm, but ppb for gold)

Rocks and contrasts	Zn	Cu	Ti	Mn	Co	Cr	Pb	V	Ni	As	Sb	Ag	Au
Archean Jianping Group(88)	68.1	5469	2436	591.2	23.5	158.8	33.4	98.7	5068	1.6	0.47	0.062	3.96
Proterozoic kaligranite(20)	25.7	16.8	1095	162.8	6.2	120.1	22.3	20.2	20.2	2.2	0.65	0.046	3.9
Yanshanian granite(7)	42	9.9	647.4	265.4	4.14	84.3	27	10.3	15.7	4.83	0.5	0.05	4.14
Jianping group/world basic rocks	0.52	0.55	0.27	0.3	0.52	0.78	4.18	0.49	0.32	0.8	4.7	0.62	0.99
Jianping group/Clark value	0.72	0.87	0.38	4.55	0.94	1.44	2.78	0.71	0.57	0.73	0.78	0.78	1.13
Kaligranite/Clark value	0.43	0.27	0.17	1.25	0.25	1.09	1.86	0.14	0.23	1.0	1.08	0.58	1.11
Kaligranite/world granite	0.45	0.84	0.48	0.27	1.24	4.8	1.12	0.51	2.5	1.47	2.5	0.92	0.87

Table 4. The analyzed results of REE for main rocks in Honghuagou gold deposit, Inner Mongolia (ppm)

Sample No.	Rocks or ore	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb
1 KLT7	Kaligranite	14.4	23.2	3.39	9.80	1.79	0.59	1.22	0.16
2 QH044	Kaligranite	16.9	24.3	3.00	6.71	1.18	0.72	0.87	0.16
3 QH052	Kaligranite	22.0	36.4	5.16	16.5	3.05	0.84	2630	0.39
4 Mean(3)	Kaligranite	17.8	28.0	3.85	11.0	2.01	0.72	1.46	0.24
5 Mean(5)	issite	19.0	40.6	5.95	17.96	4.58	1.41	3.90	0.65
6 Mean(5)	gold ore	1.23	2.38	0.36	1.28	0.39	0.093	0.40	0.60
7 Mean(3)	granite(r5)	49.3	65.8	8.58	22.3	3.46	0.64	2.52	0.37

Sample No.	Rocks or ore	Dy	Ho	Er	Tm	Yb	Lu	Y	REE
1 KLT7	Kaligranite	0.79	0.17	0.51	0.08	0.50	0.80	4.61	61.29
2 QH044	Kaligranite	0.38	0.10	0.23	0.07	0.21	0.16	3.22	58.21
3 QH052	Kaligranite	1.36	0.26	0.82	0.18	0.69	0.19	10.2	100.34
4 Mean(3)	Kaligranite	0.84	0.18	0.52	0.08	0.47	0.14	6.01	73.26
5 Mean(5)	issite	3.60	0.66	1.94	0.33	1.92	0.33	16.6	119.44
6 Mean(5)	gold ore	0.31	0.06	0.17	0.02	0.13	0.02	1.86	8.76
7 Mean(3)	granite(r5)	1.64	0.31	0.96	0.18	1.11	0.17	7.73	165.02

Analyzed by the Department of Geology at Peking University

The REE geochemical parameters of main kinds of rocks in the gold mine are shown in Table 5. All the rocks and gold ores showed a negative anomaly of Ce, similar to those of Zhaoyuan-yexian gold belt in Jiaodong peninsular (Qiu Yumin, 1990). W. B. Nance (1977) suggested that the early crust is (>1500Ma) is rich in Eu and the Archean sedimentary rocks have a positive anomaly of Eu, and ΣREE< 173ppm (Nance, 1977). Kaligranite and Archean issite in the region showed these features: δ Eu of them is 1.429 and 1.141 respectively, ΣREE of kaligranite is 73.26 ppm and issite 119.44ppm which suggested, in some extent, that they are all old products and have relationship in origin. Meanwhile, REE of Yanshanian granite in this region is much higher than that obviously rich in LREE, Eu anomaly is negative, illustrating that they are different from the kaligranite in origin.

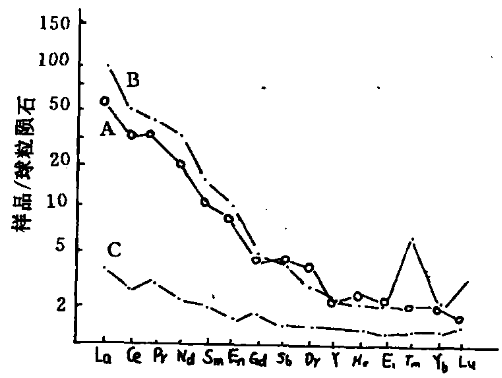

Fig. 4 REE distribution patterns nomalized to chondrite of kaligranite in Honghuagou gold deposit
A: kaligranite
B: Dushan Proterozoic granite
C: gold ore

4 Isotope Chronology and Petrogenetic Age

Rb-Sr isotopic geochemical studies on the kaligranite had been carried out (Qiu Yumin, 1992), which concluded that the age of whole rock Rn-Sr isochron is 1887±93 Ma ($(^{87}Sr/^{86}Sr)_0$=0.70137±0.0009. Whole rock-potash-feldspar Rb-Sr isochron is 1178 Ma, $(^{87}Sr/^{86}Sr)_0$=0.7103. The single stage model ages of ore-Pb, from gold -bearing quarez veins which located at the nearby of the kaligranite, concentrated in 1700—1800 Ma (Li Yanhe etc, 1990; Qiu Yumin, 1991). K-Ar isotopic age fo a quartz diorite-porphyrite which has a close relationship in space with gold-bearing quartz veins is 1507 Ma. Considering the dating principle of K-Ar isotope, and the time difference between gold mineralization and petrogenesis of the kalgranite, it is believed that the three isotope ages are consistance. Moreover, the kaligranite associated with gold mineralization in Jiapigou gold mine, also situated at tha north margin of North China Platform aged 1800 Ma (Wu Shangquan, 1991), and famous Linglong granite in Zhaoyuan-yexian gold belt dated 1900-1800 Ma. Therefore, a regional tectonic magmatic activeity was taken place at about 1800 Ma in North China Platform. The age of whole rock Rb-Sr isochron is the petrogenetic age of Honghuagou kaligranite, i.e. it is formed at the end of Proterozoic era (1800Ma).

Table 5. REE geochemical parameters of main kinds of rocks in Honghuagou gold deposit

Rock or ore	REE	LREE/HREE	Ce/Y	Ce	Eu	(La/Yb)	(La/Lu)N	(La/Sm)N
kaligranite(3)	73.26	16.11	6.37	0.732	1.429	22.6	12.0	5.54
granite porphyry(3) *	165.02	20.67	10.01	0.661	0.738	26.4	27.5	8.9
granite(3) *	209.39	13.46	5.64	0.676	0.783	16.5	16.95	6.25
issite(5)	119.44	6.71	2.99	0.796	1.141	5.9	5.52	2.59
gold ore(5)	8.76	4.90	1.89	0.748	0.805	5.5	5.41	1.99

* Yanshanian granitic rocks

In addition to this, the single stage age of lead isotope of the kaligranite is 1098 Ma. K-