Characteristics and Genesis of the Aktubaik Gold Deposit in Altay, Xinjiang

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Abstract The Aktubaik gold deposit lies in the Altay middle-high mountains area, Xinjiang, hosted by the Palaeo- and Mesoproterozoic Xemirxek Group. It is the first gold deposit found in Precambrian rocks in Altay. The deposit is controlled by the NW-trending fracture-alteration zone, in which rocks have been strongly altered and bleached. The main wall-rock alterations include silicification, sericitization (muscovitization), carbonation, pyritization and tourmalinization. Several gold mineralization zones of this type have been found in the study area. The dominant gold mineral is native gold, which is distributed very unevenly, so special methods such as peeling and bulk sampling are required in exploration. The discovery of this gold deposit has laid a foundation for gold exploration in Precambrian rocks in the Altay middle-high mountains area, Xinjiang.

Key words: genesis, Aktubaik, gold deposit, alteration, Precambrian

1 Regional Geology

The study area is located at the NW-plunging end of the Kara Ertix anticlinorium, in the northwestern part of the Kanasi-Qinggilik metamorphic-plutonic magmatic arc, on the southwestern active continental margin of the Siberian plate (Rui et al., 1993). The strata consist of schist, gneiss and migmatite of the Palaeoproterozoic Xemirxek Group and the Sinian flyschoid sequence, overlain by intermediate-acic volcanic rocks and carbonate rocks of the Ordovician-Silurian Dongxileke Formation and Devonian Nuoerte Formation with local conglomerate intercalations. Magmatic rocks consist dominantly of Caledonian granitoids, and Variscan alkali granites occur in the upper reaches of the Kanasi River and Hemu River. Structures are complex, mainly including the NW, E-W and N-S sets of folds and faults, of which the NW set is mostly represented by strike-slip faults and ductile shear zones, which have more marked ore-controlling effects (Zhang Xiangbing et al., 1996; Dong, 1999). In the area there are many ore occurrences and mineralization spots, containing mainly gold, copper and rock crystals (Fig. 1).

2 Deposit Geology

The host rocks of the deposit are greyish black and greyish green chloridized biotite-plagioclase gneiss, biotite-quartz schist, granulitite (leptynite), leucogranulitite (leucoleptynite) and two-mica-quartz schist of the Palaeo- and Mesoproterozoic Xemirxek Group, of which two-mica-quartz schist is intimately associated with gold mineralization. The two-mica-quartz schist is distributed along the NW-trending fault, in which quartz veins and tourmaline-quartz veins are well developed. Quartz veins usually occur in vein-like, irregular, nodular, lenticular and branched shapes. The wall-rock alterations mainly include silicification, sericitization, muscovitization, tourmalinization, pyritization, succharoidal albitization and chloridization. Gold mainly occurs within the two-mica-quartz schist and the contact zone between it and biotite-plagioclase gneiss. Gold mineralization is mainly related to silicification, pyritization and albitization. The quartz veins and quartz nodules within the two-mica-quartz schist and albitized two-mica-quartz schist are the main carriers of gold.

Ores are mainly of sparsely disseminated and veinlet-disseminated types. For the former type, gold min-

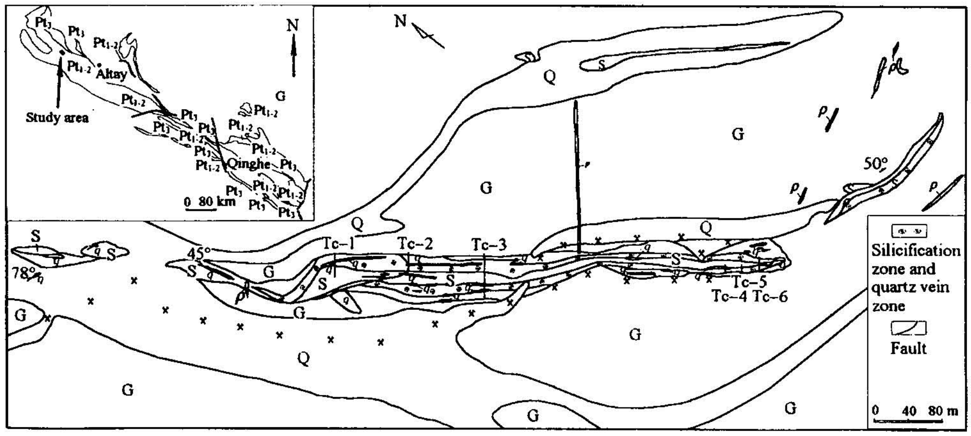

Fig. 1. Geological sketch map of the Aktubaik gold district, Xinjiang.

Q–Quaternary; Pt_3–Neoproterozoic Fuyun Group; Pt_{1-2}–Palaeo- and Mesoproterozoic Xemirxek Group; G–biotite-plagioclase gneiss; S–two-mica-quartz schist; *q*–quartz vein; *ρ*–pegmatite vein; Tc-1–trench and its no.

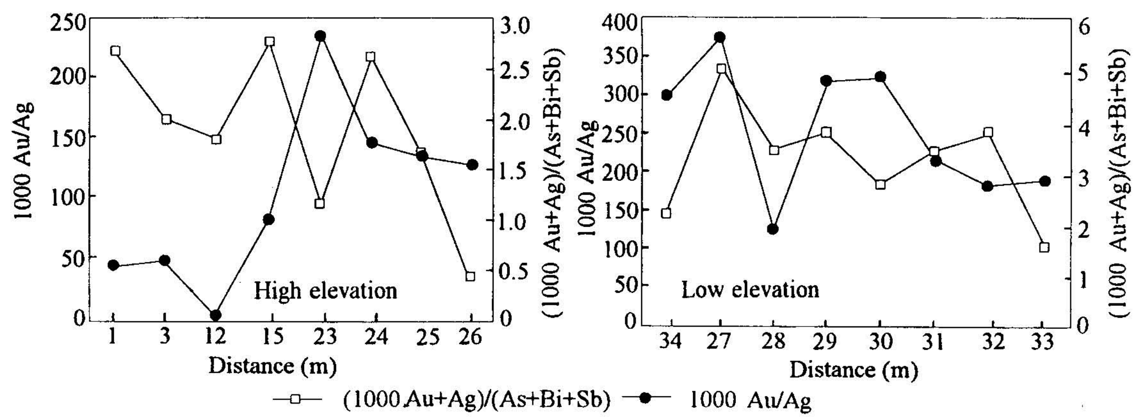

Fig. 2. Curves showing the variations of the element ratios at different elevations (the left side is the Au/Ag ratio; the right side is the (Au+Ag)/(As+Bi+Sb) ratio).

erals and sulphides such as pyrite occur evenly as sparse disseminations in altered rocks such as two-mica-quartz schist and the contents of gold minerals and sulphides in ores may reach 0.5 to 1%. For the latter type, gold minerals and sulphides occur as veinlets and disseminations in quartz veins and altered rocks such as two-mica-quartz schist. The gold content in ores shows a sympathetic relation to the sulphide content.

Gold mineralization in the area is very uneven and gold is greatly enriched locally. In places where gold is most enriched, spotted native gold grains may be observed with the naked eye to be scattered within quartz veins or in two-mica-quartz schist on edges of the quartz veins. Native gold has a good crystal form, being pentagonal-dodecahedral is shape. Sampling, including chip sampling, channel sampling and peeling, were conducted at a site favourable for mineralization. Apart from assaying, amalgam and artificial heavy concentrate analyses were performed on peeling samples. 34 g/t channel samples were obtained in this site. Gold analysis on the samples indicates that the gold contents of the chip and channel samples are highly varied, but the gold grade tends to be stable with enlarging volume of individual samples. The grade of gold recovered from amalgams in sample No. 10 is up to over 4 g/t, whereas the grade of gold recovered from artificial heavy concentrates of sample No. 11 is higher than 5 g/t.

Table 1 Trace element ratios of the Aktubaik gold deposit

Sample No.	Au/Ag	Co/Ni	(Au+As+Sb+Bi+Ag)/ (Cu+Pb+Zn+W+Mo)	(Au+Ag)/ (As+Bi+Sb)
s98j-01	44.11	0.25	0.0485	2.6448
s98j-03	46.5	0.82	0.1666	1.9791
s98j-12	2.61	1.33	0.0358	1.7803
s98j-15	81.81	0.62	0.0814	2.7606
s98j-23	233.33	0.5	0.1647	1.1430
s98j-24	146.67	0.54	0.1204	2.6058
s98j-25	138	0.50	0.2382	1.6547
s98j-26	128	0.52	0.1975	0.4108
s98j-34	300	0.21	0.1158	2.2024
s98j-27	375	0.71	0.3797	5.0133
s98j-28	125	0.63	0.1985	3.4363
s98j-29	320	0.74	0.3924	3.8214
s98j-30	325	0.48	0.4756	2.7744
s98j-31	216.67	0.76	0.2203	3.4368
s98j-32	185.71	0.8	0.2297	3.8411
s98j-33	193.33	0.21	0.0755	1.6194
s98j-35	1.08	0.19	0.1104	0.1024

Table 2 Homogenization temperatures of inclusions in quartz

T (°C)	150–179	180–209	210–239	240–269	270–299	300–329	330–359
No. of samples	8	20	6	5	3	1	1
%	18	45	14	11	7	2	2

*measured by the laboratory of the Nanjing Institute of Geology and Mineral Resources.

3 Trace Element and Isotope Geochemistry

Two geological-geochemical sections were measured at different elevations of the deposit. The difference in elevation between the two sections is about 170 m. The element ratios show that the average Au/Ag ratio of the section with lower elevations is 225, more than double that (103) of the section with higher elevations. Likewise, the average (Au+Ag+As+Sb+Bi)/(W+Mo+Cu+Pb+Zn) ratio also exhibits the same variation: that of the lower elevation section is 0.26, being also double that (0.13) of the higher elevation section (Fig. 2).

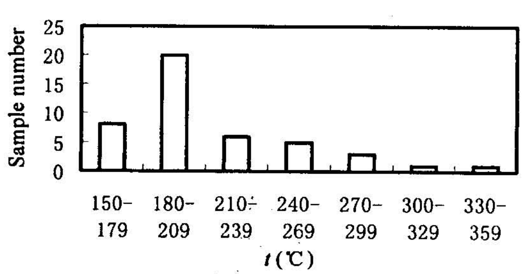

Fig. 3. Histogram of homogenization temperatures of inclusions from the Aktubaik gold deposit.

In light of the variation of the element ratios at different positions of a gold orebody, the Au/Ag ratio is higher towards the gold orebody. Thus it may be deduced that the lower section is nearer to the orebody (Wang, 1999). The average (Au+Ag)/(As+Sb+Bi) ratios of the two sections are 1.87 and 3.27 respectively, which also supports our deduction (Table 1).

Homogenization temperatures of different types of inclusions in quartz from the deposit were measured. The results show that the homogenization temperatures range from 150 to 390°C and cluster at 180 to 270°C, with only one peak value (Table 2; Fig. 3).

Rare earth elements (REE) in two-mica-quartz schist (sample Nos. sm-2-1, sm11-1 and sm-1) and biotite monzogneiss (sample Nos. sm-2-3 and sm10-1) from the gold deposit were measured. The results indicate that the two kinds of rock have similar total REE contents and negative Eu anomalies, but the former has markedly lower heavy-REE (HREE) and higher light-REE (LREE) (Table 3; Fig. 4), which indicates that with intensifying late-stage reworking of the rocks, the HREE content in the rocks decreases, while the LREE content increases.

Two quartz samples from ores in the Aktubaik gold deposit were analyzed for hydrogen and oxygen isotopic compositions. Their δO values are −87 and −106 respectively and the δD values are 0.098 and 4.320 respectively (Table 4). According to the equation $\delta O_{q\text{-}H_2O}=3.42\times10^{6}T^{-2}-2.86$ (Zhang Ligang, 1985), the δO_q values are converted into the δO_{H_2O} values, and the δO_{H_2O} values of the two samples are 4.6887 and 0.0986 respectively. In the δD versus δO_{H_2O} diagram (Fig. 5), the data are plotted at the lower-left side of the field of metamorphic water and magmatic water, indicating multiple sources of the ore-forming fluids.

4 Genesis of the Deposit

The Aktubaik gold deposit is strictly controlled by the NW-trending ductile shear zone in the study area. The

Table 3 REE contents of different rocks in the deposit

No.	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
sm-1	12.1	25.9	4.1	13.4	3.27	0.56	4.38	0.87	5.35	1.17	3.31	0.54	3.54	0.53
sm-2-1	6.37	13.2	2.89	8.7	3.52	0.91	5.86	1.39	10.7	2.41	6.97	1.07	6.93	0.96
sm-2-3	29.7	52.9	6.52	24.8	4.72	0.97	4.31	0.71	3.37	0.76	2.06	0.35	2.03	0.32
sm11-1	13.1	26.4	4.28	14	3.75	0.59	4.66	0.93	5.79	1.26	3.6	0.59	3.67	0.55
sm10-1	22.9	41	5.25	19.4	3.83	0.84	3.66	0.65	2.94	0.67	1.74	0.3	1.66	0.27

Note: Determined by the laboratory of the Nanjing Institute of Geology and Mineral Resources, Ministry of Land and Resources of P.R. China.

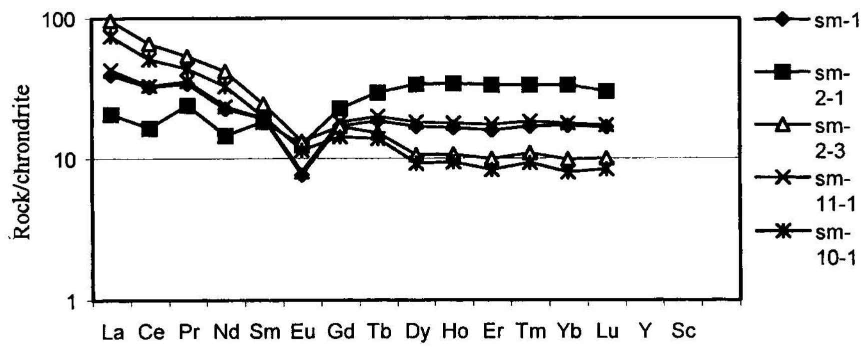

Fig. 4. REE distribution patterns of the Aktubaik gold deposit.

Table 4 Hydrogen and oxygen isotopic compositions of the Aktubaik gold deposit

No.	δD	δO_q	δO_{H_2O}	T(°C) (average)	δD
smb-1	−107.6	15.94	4.68872	219.3	−107.6
smb-2	−82.8	12.07	0.09861	207.2	−82.8

formation of this deposit was closely related to the schist, gneiss and migmatite complex series of the Palaeo- and Mesoproterozoic Xemirxek Group and the NW-trending ductile shear zone. The Xemirxek Group was just the source bed. Ore-forming material mainly came from the schist, gneiss and migmatite complex series of the Xemirxek Group and the ore-forming fluids were the mixture of metamorphic water and meteoric water. When rocks underwent ductile shear deformation, on the one hand, structural fluids were formed (Hu et al., 1997; Dong, 2000) and mixed with meteoric water, and, on the other hand, the elements in rocks were redistributed and especially ore-forming elements were remobilized. They migrated together with the structural fluids along the ductile shear zone and were precipitated at favourable sites, especially at sites of brittle-ductile shear deformation, thus forming the gold deposit (Li et al., 1990; Boulter et al., 1987). The element ratio analysis shows that the downward extension of the deposit has great ore prospects.

smb-2	-82. 8	12. 07	0.09861	207. 2	-82. 8

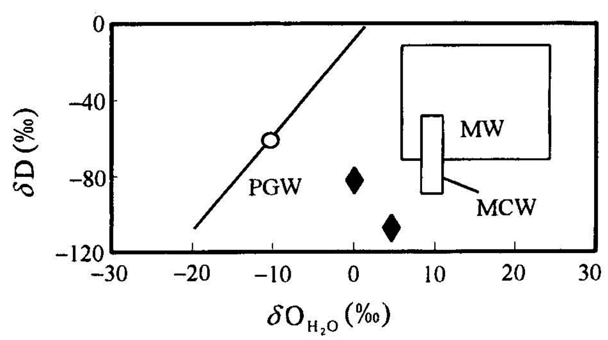

Fig. 5. Plot of hydrogen and oxygen isotopic compositions of the Aktubaik gold deposit.

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