

Contribution of the post-collisional A-type granite to the formation of the Tebai gold deposit in Alxa League, Inner Mongolia, China

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Abstract. The Tebai gold deposit is located in the Yabulai - Bayinuoer archaean continental arc fold belt in the east of Alashan platform uprise. The ore bodies occur in the Carboniferous slate and phyllite of the Mesoproterozoic Agulucou Formation, surrounding by the Hercynian Guancaitaolugai granite porphyry. This gold deposit belongs to the black rock series gold deposit. The ore-forming fluid has the characteristics of low temperature (150°C - 250°C), low salinity (1% - 6%), low density (0.7g/cm³ - 0.9g/cm³). The hydrogen and oxygen isotopes and trace elements features of the ore-forming fluid accoed with the characteristics of the magmatic hydrothermal mixing meteoric water. Concerning the geology characteristics, it is confirmed that this fluid sourced from the Guancaitaolugai granite porphyry. This granite porphyry is a post-collisional A-type granite, which may be formed by the post-collisional extension of the Zongnaishan-Shalazha volcanic arc and the Alxa Block. The metallogenic process and fluid feature of the Tebai gold deposit are similar with the other black rock series gold deposits along western part of the northern margin at the North China Craton, which reflect the unique characteristics of the black rock series gold deposits in this area.

Introduction

Nowadays the black rock series gold deposit has been an important gold deposit. Gold deposits of this kind have some distinctive features, such as the wall rocks are always rich of organic carbon, the ore bodies are always layered, and metallogenic process normally includes two or more stages[1,2,3]. The most important area that pregnants black rock series gold deposits around the world is the Central Asia, which has an accumulated gold reserves of more than 8000t[4]. In recent years, some black rock series gold deposits have been explored in Xinjiang region and Inner Mongolia region, China, which has been a hot topic in modern mineral deposits. Among those newly explored deposits mention above, the Tebai gold deposit is a special one, because it is located in the Alxa League, Where great confusions about geology have been existed for a long time but mineral resources are in great need. In this case the author carried out related research works on the Tebai gold deposit.

Metallogenic Geological Background

The Tebai gold deposit is located in the Yabulai - Bayinuoer archaean continental arc fold belt in the east of Alashan platform uprise. The orebodies occur in the Carboniferous slate and phyllite of the Mesoproterozoic Agulucou Formation. The deposit is located in the axis of a small anticline that has steep(about 75°) wings. The magma activities were quite strong. The Hercynian Tebai quartz diorite and Guancaitaolugai granite porphyry have instructed into the mining area as a result.

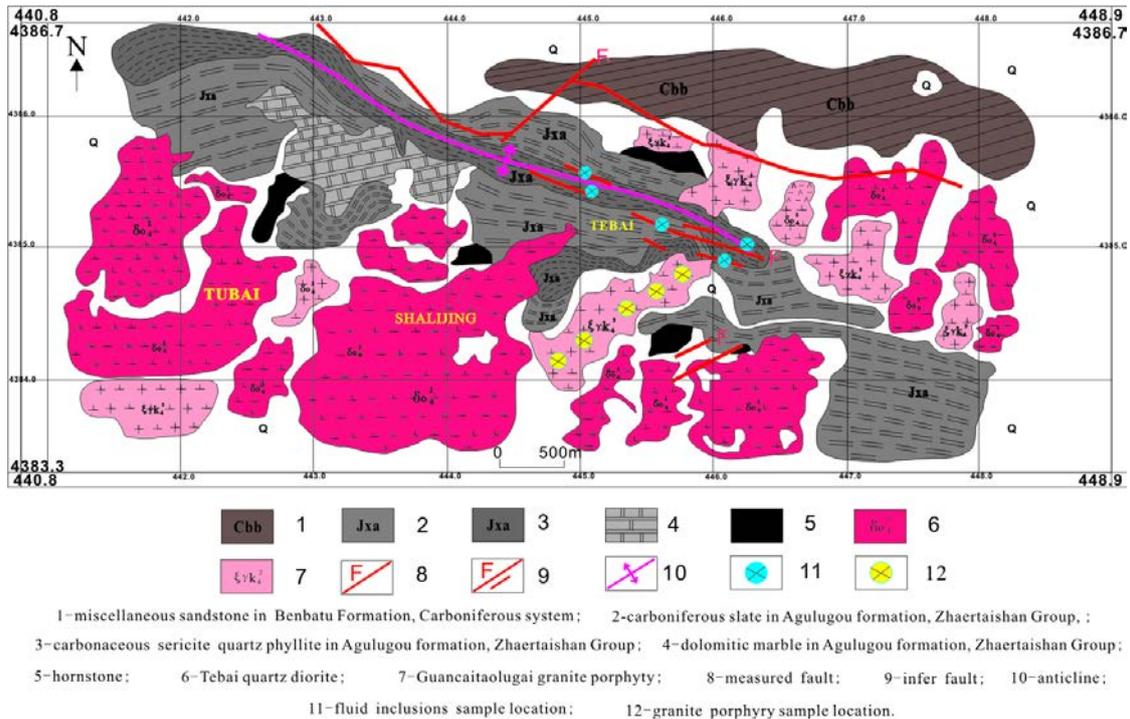


Fig. 1 Geological map of the Tebai mining area

There are two ore bodies in the mining area, and the northern ore body is the main one. The main ore body is layered with the 300° strike that is in accordance with the strike of anticline axis. The dip of ore body is NE with the dip angle 45° to 78°. The ore body is 83m to 680m in length, 2.1m to 3.5m in thickness, and its grade is 3.1 to 4.4 ppm. There are 2 kinds of the ores: lenticular quartz vein type ore and reticulate quartz vein type ore. The ores are in crystal grain texture, lenticular structure or reticular vein structure. The main minerals in the ores are pyrites and limonites. The alteration of wall rocks is weak relatively, which are mainly silicification, pyrite mineralization and sericitization.

The mineralization process of this gold deposit can be divided into 3 stages based on generation order of the minerals seen in the field: (1) quartz vein-metal sulphides stage; (2) lenticular quartz vein-gold bearing pyrite stage; (3) reticulate quartz vein-gold bearing pyrite stage.

Ore-forming Fluid Features

Temperature, Salinity, Density, and Pressure.

Through the microscopic temperature measurement to fluid inclusions in the gold-bearing quartz veins, the characteristics can be described as follows. In the 1st mineralization stage, the temperature of the fluid inclusions concentrated into 300°C to 350°C, and the salinity into 16% to 20%, while the average density is 0.8 g/cm³, and pressure varies from 60MPa to 90MPa. In the 2nd mineralization stage, the temperature of the fluid inclusions concentrated into 200°C to 250°C, and the salinity into 4% to 8%, while the density is 0.7 g/cm³ to 0.8 g/cm³, and pressure is about 45MP. In the 3rd mineralization stage, the temperature of the fluid inclusions concentrated into 150°C to 200°C, and the salinity into 1% to 4%, while the density is around 0.9g/cm³, and pressure is about 20MPa.

Hydrogen and Oxygen Isotopes.

The hydrogen and oxygen isotopic composition of the 4 samples are similar. δD_{V-SMOW} in the 2nd mineralization stage varies from -84.6‰ to -84.5‰, while $\delta^{18}O_{H_2O}$ varies from 1.8‰ to 2.3‰. δD_{V-SMOW} in the 3rd mineralization stage varies from -91.6‰ to -91.1‰, while $\delta^{18}O_{H_2O}$ varies from 2.1‰ to 3.5‰.

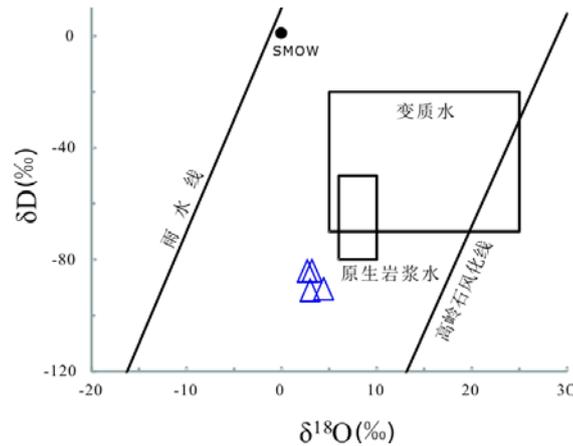


Fig. 2 $\delta^{18}\text{O}_{\text{H}_2\text{O}}-\delta\text{D}$ diagram of the ore-forming fluids in the Tebai gold deposit(after H.P. Taylor,1974[5])

Trace elements and REEs.

The samples texted are among 1st to 3rd mineralization stage. The curve shapes of these samples are close. The fluid is relatively rich of Ba, Pb, Sr and lack of Rb, Th, Nb, Zr, Y, Yb. All the REE distribution model of these samples are right-leaning type, and 3 of them show the W-type four components effect. The ΣREE content ranges from 0.106×10^{-9} to 66.933×10^{-9} .

Geochemical Features of the Guancaitaolugai Granite Porphyry

Whole Rock Geochemistry.

Among the 5 samples, the SiO_2 content varies from 72.84% to 79.37% with the average 74.59%, which shows the rock is a kind of acidic magma rocks. The all alkali content($\text{Na}_2\text{O}+\text{K}_2\text{O}$) of these samples changes from 7.10% to 9.35% with the average 8.75%. The Al_2O_3 content varies from 10.63% to 14.04% with the average 13.28% and the Aluminum saturation index(A/CNK) is 1.10 to 1.16. The CaO content changes from 0.19% to 0.45% with the average 0.29%. It is known from the samples that the rock is rich of LILE like Rb, Th, U, K and LREE relatively, and the rock is lack of HFSE like Ta, Nb, P, Ti and Ba, Sr, Eu. The REE distribution model of these samples are similarly right-leaning type. The ΣREE content ranges from 158.61×10^{-6} to 249.07×10^{-6} with the average 210.05×10^{-6} .

Sr-Nd Isotopic Geochemistry.

The granite porphyry have relatively high Rb/Sr(1.4580 to 1.5660) and higher I_{Sr} (0.707221 to 0.707365). $^{87}\text{Sr}/^{86}\text{Sr}$ is 0.723768 to 0.724725 . $^{143}\text{Nd}/^{144}\text{Nd}$ is 0.512289 to 0.512329. $\epsilon\text{Nd}_{(t)}$ is -3.7 to -3.0.

Discussion

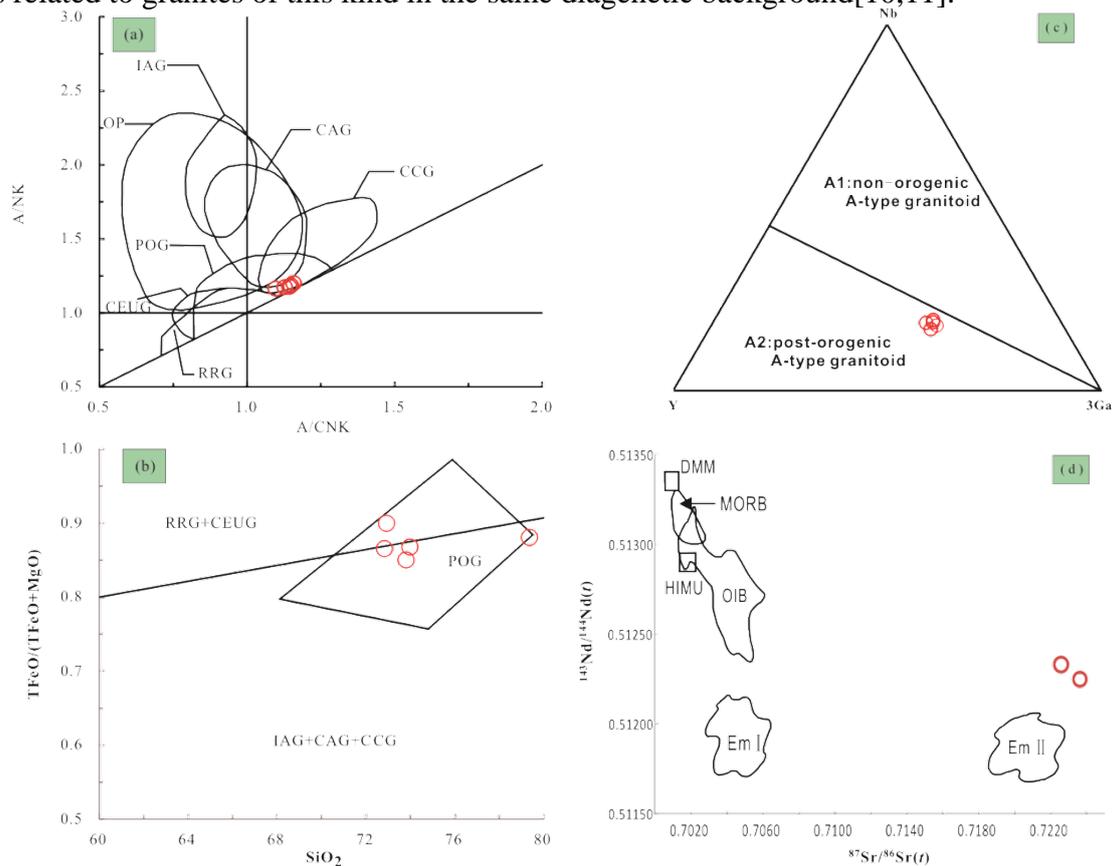
Source of the Fluid.

The main mineralization stage ore-forming fluid has the characteristics of low temperature (150°C - 250°C), low salinity (1% - 6%), low density ($0.7\text{g}/\text{cm}^3$ - $0.9\text{g}/\text{cm}^3$), which are close to magmatic hydrothermal. On the hydrogen and oxygen isotopes features, $\delta\text{D}_{\text{V-SMOW}}$ ranges from -91.6‰ to -84.5‰, and $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ ranges from 1.8‰ to 3.5‰, which show the features of magmatic hydrothermal mixing meteoric water. On the trace elements features, the fluid has low Rb/Sr, high Zr/Hf, relatively low Nb content and very low Ta content, which are also close to the magmatic hydrothermal. The source of the ore-forming fluid is unique because different samples show the similar curves of trace elements spidergram (primitive mantle-normalized) and REE distribution patterns (chondrite-normalized). Concerning the contact relationship of the intrusions in deposit area, it is inferred that the fluid sourced from the Guancaitaolugai granite porphyry.

Diagenetic Background of the Guancaitaolugai Granite Porphyry.

All of the Guancaitaolugai granite porphyry samples fall into the overlapping regions of post-collisional granite and continental collisional granite in the A/CNK-A/NK diagram. But all of

the samples mention above fall into the post-collisional granite region in the $\text{SiO}_2\text{-}^{\text{T}}\text{FeO}/(^{\text{T}}\text{FeO}+\text{MgO})$ diagram. That is to say this granite porphyry is an A-type granitoid originated by the post-collisional magma activity[6]. It is distinguished that this granite belongs to A2-type granitoid, also named as post-collisional granitoid[7], in the Nb-Y-3Ga diagram. In the $^{87}\text{Sr}/^{86}\text{Sr}\text{-}^{143}\text{Nd}/^{144}\text{Nd}$ diagram, samples of this granite occurred close to the EM II area, which indicates a lot of crust material have been mixed in as the process of granite conformation[8]. Concerning the tectonic background[9], this granite porphyry may be formed by the post-collisional extension of the Zongnaishan-Shalazha volcanic arc and the Alxa Block. In fact, other black rock series located along the western part of the northern margin at the Northern China Craton are always related to granites of this kind in the same diagenetic background[10,11].



a—A/CNK-A/NK diagram (after H. Ran et al., 2012[6]);

b— $\text{SiO}_2\text{-TFeO}/(\text{TFeO}+\text{MgO})$ diagram (after H. Ran et al., 2012[6]);

c—A type granitoid Nb-Y-3Ga diagram(after X.H. Zhang et al., 2010[11]).

d—Sr—Nd isotope diagram(after A. Zindler et al., 1986[8]).

Fig. 3 Diagenetic setting discrimination of the Guancaitaolugai granite porphyries

Conclusions

The metallogenic process of the Tebai gold deposit is closely related with its surrounding granite porphyry, just the same with the other black rock series gold deposits along western part of the northern margin at the North China Craton. This granite porphyry was formed by the post-collisional extension of the Zongnaishan-Shalazha volcanic arc and the Alxa Block. Furthermore, the ore-forming fluid of this gold deposit has the feature of magmatic hydrothermal mixing meteoric water, which reflect the unique characteristics of the black rock series gold deposits in this area.

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