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The Characteristics and Mineralization of Xiaya Rockbody in Changdu area, eastern Tibet

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1 Introduction

The metallogenic belt of three rivers (the Jinsha river, Lancang river, and Nujiang river) in southeast of china, which covering the eastern part of the Tibet, northwest corner of Sichuan Province, the southeast corner of Qinghai Province and northwest Yunnan Province, are the important parts of the Tethys-Himalayan metallogenic belt. And it is rich in the resource of copper, lead, zinc and silver. Eastern Tibet area, locating in the middle sector of the Nujiang-Lancang-Jinsha Rivers metallogenic belt, has well mineralization geological background, and it is one of the important bases of non-ferrous metals-precious metals mineral resource. The regional prospecting work in eastern Tibet has made great progress in recent years, besides Yulong porphyry copper mine has been exploration oversize in last century, there are more deposits have been found, such as Narigongma large Cu deposit, Duoxiasongduo and Malasongduo large Cu deposits. Deposits like Eluoqiao large arsenic-mercury deposits, Duri large silver-lead polymetallic deposit, Lanuoma lead-zinc-antimony medium-sized deposit and Cuona lead-zinc-silver deposit have been found only in Changdu basin. The Changdu basin has good metallogenic background and metallogenic potential of Polymetallic Ore. Chengdu Institute of Geology and Mineral Resources did some researches on the ore potentiality of Granitoids in eastern Tibet in the 19’s century. After the monographic study on Xiaya rockbody, they made a conclusion that the granites in Neiwugi-Dongda mountain intrusive rock belt has well metallogenic potential of W and Sn. Xiaya rockbody has well ore potential, and magmatic hydrothermal activities produce lead-zinc mineralization in the wall rock contact zone. The prospecting work around Xiaya rockbody has made some progress, Xiaya W(Sn) ore occurrence and Xiaba together with Cuona Pb-Zn deposits have been discovered consecutively. Previous studies mainly considered that the Xiaya rockbody only offer the dynamic effect for the mineralization, ignoring the role of providing the source of metallogenic material and the mineralization of itself. Combining the geological condition with the analysis of results of petrochemistry, trace element and REE of Xiaya biotite adamellite, this article makes a preliminary study of the mineralization of Xiaya rockbody.

2 The geochemical characteristics of Xiaya rockbody

Xiaya rockbody exposes at Zhannong ditch-Snow Waka area in eastern Xiaya. The shape of rockbody is oval-shaped rock strains of the axial NW, and it’s length and width are 10km and 4km. The rockbody emplaced in sandslate and limestone of the Upper Triassic. Surface greisenization and linear greisenization occurs in the innner contacting belt, and they also have well Sn mineralization. There is a cassiterite-tourmaline-quartz type Sn mineralization in fractures of the sandstone in the outer contacting belt. The pluton output as apophysis and dykes, and the main rock type is biotite adamellite.

Xiaya biotite adamellite has high silica and high alkali characteristics. Xiaya granite is is abundant in SiO_2, TiO_2, K_2O compared with Chinese acid rock(average value), but it is slightly lower of other oxide contents. It also has higher content of SiO_2 and K_2O+Na_2O, but with lower content of Al_2O_3, TiO_2, Fe_2O_3+FeO, MgO and CaO than the granite average value of western Sichuan, western Yunnan, China and the other region of the world. In addition, the granite rock’s chemical compositions are consistent with Tin-granite, with the outstanding features of the high total alkali content that the average value is 8.18%, and K_2O is higher than Na_2O. Xiaya granite belongs to Q+ An + Ab+ Or+ C + Hy peraluminous type in CIPW standard mineral assemblages, and the A/CNK

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value less than 1.1. The high differentiation index(DI), varing from 85.15 to 92.50(average 89.07), showing a high degree of magmatic differentiation. The consolidation index(SI) varies from 2.09 to 5.70(average 3.95), and it shows not only a high degree of magma acidic, also reflects a high degree of magmatic differentiation. The avage alkalic rate is 3.52, which is higher than the average of China acid rock of 2.70, showing high alkaline degree. It belongs calc-alkalic rock series with the average of Rittman index is 2.22 and Higher K_2O content. The Xiaya rockbody belongs to A-type granites according to K_2O-Na_2O discrimination diagrams of genetic types (Liwei, 2013, unpublished). The tectonic setting discrimination diagrams of Xiaya biotite adamellite belongs to the post-orogenic environment's granite(Fig1-A.B), not the A-type granites inthe environment of Orogenic phase. The Initial $^{87}Sr/^{86}Sr$ ratios of Xiaya granite is 0.71572, which is similar with the continental crust value of 0.719. The avage value of TiO_2 is 0.32%, which is also closer to the upper continental crust. The whole rock K-Ar isotopic value age is 88Ma, the Rb-Sr isochron age of 75Ma, which equivalent to the Late Cretaceous (Liwei, 2013, unpublished). In summary, Xiaya biotite adamellite were formed by re-melting of the upper crust substances in a post orogenic environment.

The average of ΣREE is 252.18×10^{-6}, which is higher than average value of granite in South China. The average of ΣCe/ΣY and $(La/Yb)_N$ are 7.44 and 22.33. The Chondrite normalized REE patterns are LREE-rich, and curve tilt right significantly. The average of δEu is 0.42 (all less than 1.0), the europium loss significantly. The value of δCe are all close to 1.0, changing from 0.95 to 0.99. There is no Ce abnormality and the abnormal curve belongs to flat-type. The elements of F, B, W and S are enriched in Xiaya rockbody. The element of W is higher than the average contents of diorite from Vinogladv(1962) average 50 times, some samples are over 275 times; the element of Sn is 1.72 times than Vinogladv(1962) average, and the maximum is 267 times. The average of Rb/Sr is 4.69, which is less than the transformation-type granites in South China of 5.77, but higher than the continental crust average of 0.24. Obviously, the period adamellite should be the result of the re-melting continental crust.

3 The mineralization of Fluorine-Boron fertile magma

The Xiaya rockbody is rich in Fluorine-Boron volatile, but the elements of Fluorine-Boron play an important role in the distribution of the ore-forming elements between the fluid and melt in the magma immiscibility. The fluorinated granite magma's liquid immiscibility is process that the conjugate composions of volatile-rich, silicon-poor melt and volatile-poor, silicon-rich melt that separate from parent magma. The features of that process are fluorine-rich, and most associated with rare metal mineralization. According to researches on the fluorine fertile granite's liquid immiscibility at home and abroad, the Fluorine-Boron fertile volatile has an affinity for the rare metals, which make the elements of Na, Li and alkaline earth metal first into the volatile-rich melt. The characteristics of strong depolymerization of volatiles promote the reaction of liquid immiscibility in fluorine-rich granitic magma, which make the volatile fertile melt Separate from parent magma. During this process, the fluid reach saturation in relatively early, which makes volatile-rich fluid and volatile-rich melt can long-term coexistence, and continuous extracting the trace components from the granite magma, the enrichment even up to the level of mineralization. Therefore, there elements (like W, Sn, Li, Nb and Ta, with partition coefficient KDM/V>1) are

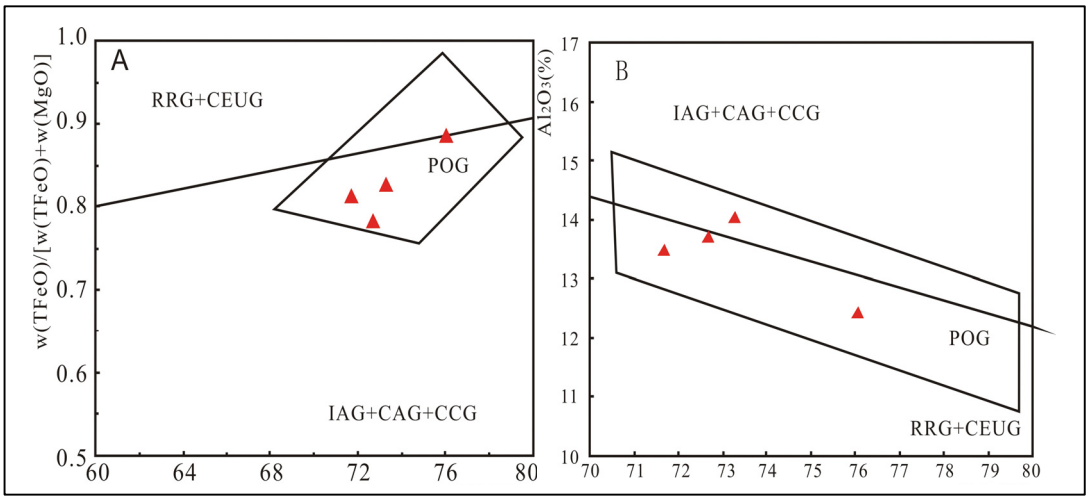

Fig. 1. The tectonic setting discrimination diagrams of Xiaya biotite adamellite(After Wang Min et al., 2006)

easier to form a deposit immiscibility with fluorine in magma's liquid immiscibility in the early of the magmatic evolution; other elements (like Na, K, Fe, Mn, Zn, Rb, Cs, Ag, Sn, Pb and T) lean to enter into high salinity (Cl-rich) aqueous solution phase (Zhang Dehui, et al. 2001a.2001b;2004). The magma of the late stage of magma in shallow or super shallow can evolve into high salinity fluid that rich in the elements of Pb, Zn, Ag, etc. This will increase the hydrothermal activity greatly, coupling with strong tectonic activity, which will promote hydrothermal ore-forming fluid's migration and having mineralization in geochemical barrier. Trace element analysis of Xiaya rockbody shows that it rich in not only Fluorine-Boron volatile , etc., but also the elements of W and Sn. This is consistent with domestic and foreign research on the Fluorine-Boron rich volatile magma's mineralization. This also indicates that Xiaya rockbody has great metallogenic potential.

Audetat A et al.(2000a,2000b) obtained the general laws from the studies on the 1200 deposits in Mole granite zone of Australia that Sn mineralization mainly occurred inner the granite pluton, but the edge most have W mineralization, and the mineralization of base metal elements (As, Pb, Zn, Cu, Sb and Ag) mainly took place in the sedimentary rocks of wall rock; the Quartz vein-type and greisenization-type mineralization mainly happened in the rockbody, but pegmatite-type, tectono-fracture zone type and shear zone type occurred in the outside of the pluton. There are many Pb, Zn-rich orebodies have been found in the fracture zone of Sandstone in granite peripheral of Xieba deposit, and the biotite adamellite in limestone contact zone are rich in the element of W; there are still many hydrothermal breccias have been found during the geological survey. There are some similarities with the Mole mining area. The chemical analysis data of the biotite adamellite indicate in Xieba deposit show the elements such as W, Sn are rich, but the ability to form industrial deposit scale need to be further verified.

4 Conclusion

Xiaya rockbody, which is mainly constituted by the biotite adamellite (the moyite outcrop less), being the acid intrusions in the late Yanshanian period. The petrochemistry of Xiaya biotite adamellite has the characteristics of rich in elements of F, B, W, Sn, and high DI, AR index. The LREE and HREE have strong differentiation. The biotite adamellite is rich in LREE, and with negative Eu anomalies. It was formed by re-melting of the upper crust substances in a post orogenic environment. The elements of fluorine and boron are easily combined with the rock-forming elements and tend to be fixed in the structure of the volatile-rich melt. The F-B fertile volatile has an affinity for the rare metals, which make the elements of W and Sn first into the volatile-rich melt. Through the comparative study of metallogenic model with the Mole granite zone in Australia, affiliated the good metallogenic potential of Xiaya pluton with the srong structure-hydrothermal activities in Changdu basin, we can speculate that Xiaya rockbody has great mineralization potential, and has the potential of forming large deposits. And it is easy to form the granite type Tungsten-tin deposits in the granite pluton, and greisenization type tin deposits inner contact zone or at the top of the rockbody, also with the structural altered rock type lead-zinc-silver deposits.

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