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## Geochemical Characteristics and Significance of Basalt in the Hongshiyuan Pb-Zn-Cu Polymetallic Deposit in Southeastern Yunnan Province

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### 1 Introduction

Southeast Yunnan is the convergent place of the Yangtze, Indochina blocks (Xu Wei, *et al.* 2008). The Hongshiyuan Pb-Zn-Cu polymetallic deposit is located in Wenshan Prefecture, Yunnan Province. It is a typical large sized VMS-type deposit discovered in recent years. The major ore minerals are sphalerite, galena, chalcopyrite *ect.* The strata in the mining area belongs to Middle-Cambrian Tianpeng Formation. Its rocks are basalt, tuff, siliceous, slate *ect.* The relationship between mineralization and basalt is very close. Therefore, researching on the geochemical characteristics of basalt has an important geological significances in ore finding in this area.

### 2 Lithostratigraphic Characteristics

The ore-bearing strata in this mining area belongs to Tianpeng Formation, which is the metamorphosed rock series and mainly includes basalt, tuff, siliceous, slate *ect.* The basalt is more widely exposed. It altered to epidosite in Indo-Chinese epoch. The major types are diopside epidosite, uralitization epidosite and so on. Its original rock is an andesitic-basalt volcanic rock, which belongs to tholeiites.

### 3 Geochemical Characteristics

#### 3.1 Major element compositions

The content of SiO<sub>2</sub> varies from 42.65% to 43.59%, with an average of 43.13%. The average contents of major elements are: Al<sub>2</sub>O<sub>3</sub> 12.33%, FeO\* 13.27%, MgO 3.91%, CaO 12.09%, Na<sub>2</sub>O 0.20%, K<sub>2</sub>O 1.97%, MnO 1.24%, P<sub>2</sub>O<sub>5</sub> 0.14%, TiO<sub>2</sub> 0.59%.

The contents of FeO\*, CaO, MnO are high, nevertheless the contents of MgO, P<sub>2</sub>O<sub>5</sub> and TiO<sub>2</sub> are low. The results indicate that the basaltic magma experienced obvious crystallization differentiation and the magma union dyed the shell material during the ascending process. The content of TiO<sub>2</sub> is low and the content of P<sub>2</sub>O<sub>5</sub> (0.1% -0.22%) is moderate. The basaltic magma's characteristics are similar with the island-arc basalt.

#### 3.2 Trace element compositions

Diopside epidosite: Th/Ta is from 14.75 to 17.8, with an average of 16.12 > 2 showing the characteristics of island-arc basalt; Nb/Zr is from 0.07 to 0.12, with an average of 0.08 > 0.04, La/Nb is from 3.47 to 5.73, with an average of 4.48 > 1.11, reflecting the characteristic of the back-arc basin extensional environment.

Uralitization epidosite: Th/Yb and Ta / Yb are low, but Th/Ta and La / Nb are high. It shows the characteristics of island-arc volcanic rocks. Th/Ta is relatively stable (16-18), with an average of 16.79 (>10), having a clear characteristics of plate convergence; the variation range of Rb / Sr is large (0.07-0.83), but it is higher than that of the mantle, which shows that the magma undergoes a high degree of differentiation process.

The trace element primitive mantle-normalized spider diagrams of uralitization epidosite and diopside epidosite show "uplift" characteristics. The enrichment of lithophile elements (LILE) and the loss of Sr, Ta, Nb, Ti, the reason is that the magma source region influenced by paleo subduction zone fluid-metasomatism. It indicates the characteristics of arc-volcanic rocks, low abundance of high field strength elements (HFSE) and high abundance of low field strength elements (LFSE). (Rb/Yb)<sub>N</sub> is from 23.61 to 76.81, with an average of 45.25. Shows highly incompatible elements enrichment type and display the characteristic of back-arc basin volcanic rock (XU

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Qidong, 1998). The outliers of trace elements are: Nb\* 0.13-0.43, with an average of 0.27; P\* 0.23-0.77, with an average of 0.42; Sr\* 0.32-1.28, with an average of 0.84; Zr\* 0.57-1.85, with an average of 1.10. It is shown that the rock is a basaltic rock with assimilation and contamination continental crust (Wu Lina, *et al.* 2003). Meanwhile, Nb, Ta, Ti and P are obviously in a loss, which implies that the source region suffered from varying degrees of subduction zone fluid-metasomatism.

### 3.3 REE compositions

Diopside epidosite has a lower  $\Sigma$ REE ( $\Sigma$ REE=48.71 $\times 10^{-6}$ -93.54 $\times 10^{-6}$ ), with an average of 74.57 $\times 10^{-6}$ ; The ratio of LREE/HREE is from 6 to 9.14, average 7.97; La<sub>N</sub>/Yb<sub>N</sub> is from 5.68 to 9.41, with an average of 7.67; the average of  $\delta$ Eu(0.61-1.02) is 0.77;  $\delta$ Ce is from 1.06 to 1.16, with an average of 1.09; the average of  $\Sigma$ Ce/ $\Sigma$ Y is 3.44.

Uralitization epidosite has a higher content of  $\Sigma$ REE ( $\Sigma$ REE=157.1 $\times 10^{-6}$ -179.6 $\times 10^{-6}$ ), with an average of 169.18 $\times 10^{-6}$ ; LREE/HREE is from 8.78 to 9.17, with an average of 8.94; La<sub>N</sub>/Yb<sub>N</sub> is from 9.32 to 9.58, with an average of 9.42;  $\delta$ Eu is from 0.59 to 0.73, with an average of 0.68;  $\delta$ Ce is from 1.02 to 1.08, with an average of 1.05; the average of  $\Sigma$ Ce/ $\Sigma$ Y is 3.8.

Epidosite has a lower  $\Sigma$ REE, the chondrite-normalized rare earth distribution patterns are declined to the right, belonging to the feature which is enriched in light REE within the range of rare earth distribution patterns of island-arc volcanic rock. The average of Eu/Sm is around 0.24. The average of (La/Sm)<sub>N</sub> is 4.04. Ce positive anomaly is not obvious, Eu medium negative anomaly.  $\Sigma$ Ce/ $\Sigma$ Y>3, (La/Yb)<sub>N</sub>>7 and an obvious LREE and HREE fractionation.

### 4 Tectonic setting analysis

According to Cr-Y diagram, all of the samples fall into Volcanic arc basalt (VAB); in the Ti/Cr-Ni diagrams, all of the samples fall into the island-arc tholeiite (IAT); 2Nb-Zr / 4-Y diagrams shows that the samples fall into the volcanic-arc basalt (VAB), where the plate tholeiite and the MORB overlap; in Nb/Y-Zr/P<sub>2</sub>O<sub>5</sub> diagrams, all of the samples fall into the continental tholeiite and partially fall into the overlapping area of continental tholeiite and oceanic tholeiite, showing the transitional type of MORB and volcanic-arc basalt (VAB), that is, the characteristics of the back-arc basins.

The major elements of basalt in the area are characterized by poor Al<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, nevertheless abundant FeO\* and

CaO. The trace element primitive mantle-normalized spider diagrams show "uplift" characteristics. The enrichment of lithophile elements (LILE) and the loss of Sr, Ta, Nb, Ti, its show the characteristics of continental tholeiite of assimilation and contamination of crust-derived material, low field strength elements (LFSE) have a high abundance while high field strength elements (HFSE) have a low abundance. The outliers (Rb/Yb)<sub>N</sub> is far greater than 1. The average of Nb/Zr is 0.07 and La/Nb is 4.34. The results show the characteristics of the rift, back-arc basin basalt.

### 5 Conclusion

(1) The major elements of the epidosite have the characteristics of abundant FeO\*, MnO, CaO and poor MgO, P<sub>2</sub>O<sub>5</sub>, TiO<sub>2</sub>. TiO<sub>2</sub> content is lower and P<sub>2</sub>O<sub>5</sub> (0.1%-0.22%) content is moderate. Thus it is closed to the island-arc basalt environment.

(2) The trace elements shows the characteristics of the back-arc basin. It shows the original rock of the epidosite is a basaltic rock with assimilation and contamination continental crust. It indicates the source region has been suffered to varying degrees of subduction zone fluid-metasomatism.

(3)  $\Sigma$ REE is lower, it indicates the characteristics of the island-arc volcanic rock.

(4) Based on the characteristics of regional geological, combined with tectonic setting discrimination diagram and geochemical characteristics, it is considered that the original rock of epidosite in research area is tholeiite produced in the back-arc basin.

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