LU Yiguan, YANG Liqiang, ZHAO Kai, XIONG Yiqu, LI Po, DU Dayang and YUAN Mingwei, 2014. Origin of the Jinbaoshan Pt-Pd Deposit, Western Yunnan: Implications for the Relationship of Crustal Contamination and Mineralization. *Acta Geologica Sinica* (English Edition), 88(supp. 2): 302-303.

Origin of the Jinbaoshan Pt-Pd Deposit, Western Yunnan: Implications for the Relationship of Crustal Contamination and Mineralization

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1 Introduction

Magmatic sulfide deposits in the Emeishan large igneous province, SW China, have variable chalcophile and siderophile metal contents and can be divided into PGE, Cu-Ni-PGE and Cu-Ni deposits. Jinbaoshan Pt-Pd deposit is the only large-scale PGE deposit in the Emeishan large igneous province, which has a huge regional prospecting potential, so a correct understanding of the mineralization and a new idea of prospecting is quite significant (Deng et al., 2011; Yang et al., 2014). The Jinbaoshan Pt-Pd deposit is located in the west side of Yangtze archicontinent and the east side of the Red River faults (Yang et al., 2010, 2011), inside the Ninglang-Midu mafic-ultramafic intrusion zone. The ore body is situated in wehrlites, presenting as a stratoid or lentoid body, and with ore grades ranging from 1 to 5 ppm Pt+Pd. The factors that control the formation of the PGE-rich ore body are a matter of debate. One of the major questions still posed with respect to Jinbaoshan Pt-Pd deposit is if crustal contamination is an essential ingredient in the process. This research tries to make clear of the relationship between mineralization and crustal contamination.

2 Trace and PGE Geochemistry

We collect 14 samples from the adit1495 and 1508 for this study and the samples including wehrlites and PGE rich ores. In the primitive mantle normalised spidergram it is clear that compared with HFS such as Nb、Ta and Th, LILE like Rb、Ba、K and Sr are more mobile in the process of alteration. All samples have similar chondrite-normalised REE patterns that ΣREE are in the ranges of 14.2-38.1ppm and (La/Sm) and (Gd/Yb) ratios are in the range of 3.73-7.13 and 1.8-3.0. Compared with ores, the samples of wehrlites have higher REE.

The contents of PGE of all the samples are significantly higher than primitive mantle and the contents of PPGE (Pt, Pd) are much higher than IPGE(Ir, Ru, Rh). Ores contain PGE from 765~15954 ppb and have an average of 5525 ppb. Wehrlites contain PGE from 22-625 ppb and have an average of 5525 ppb. The primitive mantle-normalized PGE patterns of the Jinbaoshan intrusion samples illustrated that both sulfide-enriched and sulfide-poor samples have similar patterns. They show moderate negative Ru anomaly and depletion in Ir, Ru and Rh relative to Pt and Pd. The good correlations between S and PGE indicate that the PGE are mainly occurred in the sulfide.

3 Discussion

Our trace element data clearly show that the Jinbaoshan intrusion magma had undergone crustal contamination, and that the contaminant was enriched in the LREE and had elevated Th/Yb, and Zr/Ti ratios, geochemical features typical of crustal rocks. Besides, compared with N-MORB, wehrlites have a lower $(Nb/Th)_{PM}$ and a higher $(Th/Yb)_{PM}$ ratio, which also means Jinbaoshan magma experienced crustal contamination. By estimation, the magma experienced 55%-70% crustal contamination using $(Nb/Yb)_{PM}$-$(Nb/Th)_{PM}$ scattergram. However, the S/Se data do indicate that there may have been some minor in situ assimilation of crustal S during emplacement. The majority of our samples have S/Se ratios of 300 to 2828; even lower to the mantle range of 2850 to 4350, which don't represent the features of crustal rocks. The decoupled for these two opposite phenomenon is not only been found in the Jinbaoshan intrusion. Holwell (2014) also suggested a similar origin for the River Valley intrusion mineralization, that although the River Valley intrusion had undergone strong crustal contamination, the

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ratio of S/Se is lower than the primitive mantle, and this appears to be most consistent with our evidence for contamination and the mineralization discussed above. In this way, the emplacement of the Jinbaoshan intrusion and its mineralization may be similar to the River Valley intrusion. To account for this, researchers owe it to a multistage crustal contamination process. Sulfur saturation was driven by early-stage crustal contamination that occurred within a staging chamber or conduit prior to emplacement, but localized in situ contamination also occurred during emplacement (Holwell et al., 2014).

Wang (2010) points out that Jinbaoshan PGE-rich magmas likely resulted from a multistage-dissolution upgrading process in an open magma conduit system. Alternatively, Kerr and Leitch (2005) showed that partial or total dissolution of sulfide may occur in deep magma chambers and conduits as multiple batches of S-undersaturated magmas interact with a sulfide liquid. The PGE and Se have a much higher $D_{sul/sil}$ values compared with Fe and S so these elements will therefore stay in the sulfide liquid preferentially, while conversely, elements with low partition coefficients such as Fe and S will be resorbed by the magma, increasing the Pd and Se tenor of any remaining sulfide liquid. Thus, the highest tenor sulfides will exhibit the lowest S/Se ratios, which is what is observed in our data. Therefore, an initially crustal or even mantle S/Se ratio can be lowered if the sulfide liquid was partially redissolved.

4 Conclusion

We propose a two-stage model for the formation of the mineralization in the Jinbaoshan intrusion with a major contamination event at depth with the addition of S from local crustal rocks, inducing sulfide saturation. Sulfide droplets were then enriched in PGE within a conduit system with possible further upgrading of sulfide metal tenors (and reduction of S/Se ratios) via partial dissolution of sulfide. The later stage of minor in situ contamination which does not make the magma become S-saturated and only cause little sulfide segregation.

Acknowledgements

Thanks are given to Prof. Jun Deng for the significant comments on this manuscript. This research was jointly supported by the National Basic Research Program of China (Grant No. 2009CB421008), the Geological investigation work project of China Geological Survey (Grant No. 12120114013501) and the 111 Project (Grant No. B07011).

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