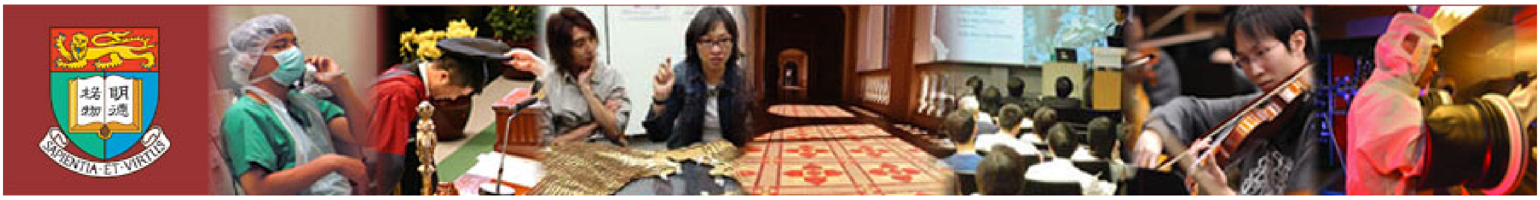
View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by HKU Scholars Hub

The HKU Scholars Hub The University of Hong Kong 香港大學學術庫



Title	Origin of the Yangliuping Ni-Cu-(PGE) Sulfide Deposit Within the Emeishan Large Igneous Province, SW China
Author(s)	Song, X; Zhou, MF; Cao, Z; Zhang, C
Citation	The 9th International Platinum Symposium, Billings, MT, 21-25 July 2002
Issued Date	2002
URL	http://hdl.handle.net/10722/117279
Rights	This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

Origin of the Yangliuping Ni-Cu-(PGE) Sulfide Deposit Within the Emeishan Large Igneous Province, SW China

Xie-Yan Song[1], Mei-Fu Zhou[1], Zhi-Min Cao[2], Cheng-Jiang Zhang [3]
[1]Department of Earth Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong
[2] College of Earth Sciences, Ocean University of Qingdao, Qingdao, 266003, P. R. China
[3] Third Department, Chengdu University of Technology, Sichuan, 610059, P. R. China
e-mail: xsong@hkusua.hku.hk

The Ni-Cu-(PGE) sulfide Yangluiping deposit is related to the 260 Ma Emeishan Large Igneous Province (ELIP), SW China (Zhou et al., 2002). The mineralized sill-like intrusions, including the Yangliuping, Zhengziyanwuo, Xiezuoping and Daqiangyanwuo intrusions, are located in the Yangliuping tectonic dome. The intrusions are 200~300 m thick and 1000~2000 m long (Fig. 1).

The Yangliuping dome consists of Devonian-Triassic strata (Fig. 1), which underwent greenschist-facies to chlorite amphibolite-facies metamorphism as a result of the Late Triassic Indosinian orogenic event (Ca. 175 Ma) (Arne, et al., 1997). The Devonian strata consist of the Weiguan Formation of mica schist, quartzite, graphite-schist, slate and marble bearing graphite. The mineralized intrusions intruded the Devonian marble and graphite schist. The Permian strata include the Early Permian Sandaoqiao Formation, and the Late Permian Dashibao and Bocigou Formations. The Dashibao Formation (500-1500 m thick) in the Yangliuping area is part of the ECFB, which is composed of eight basalt flows pillow basalt, basaltic tuff, and basaltic agglomerate.

All of the mineralized intrusions are completely altered and metamorphosed. No primary olivine and pyroxene have been found. From the bottom to the top, the intrusions consist of serpentinite (40-60% by volume), talc schist (25-40% by volume), chlorite amphibolite (10-30% by volume), and altered gabbro (5-7% by volume). Figure 2 shows the general proportions and positions of these rock types in the four ore-bearing intrusions.

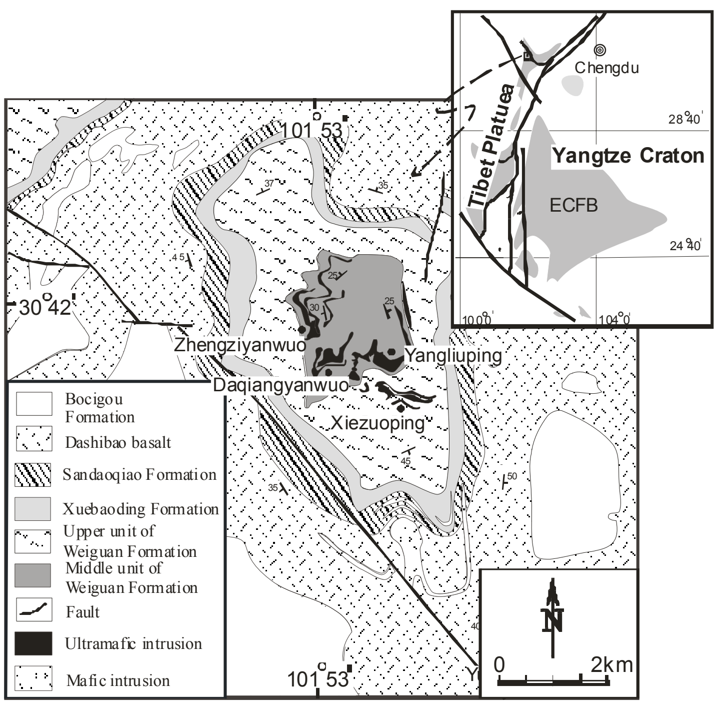


Figure 1. *Geological map of the Yangliuping area, showing the distribution of the ore-bearing intrusions.*

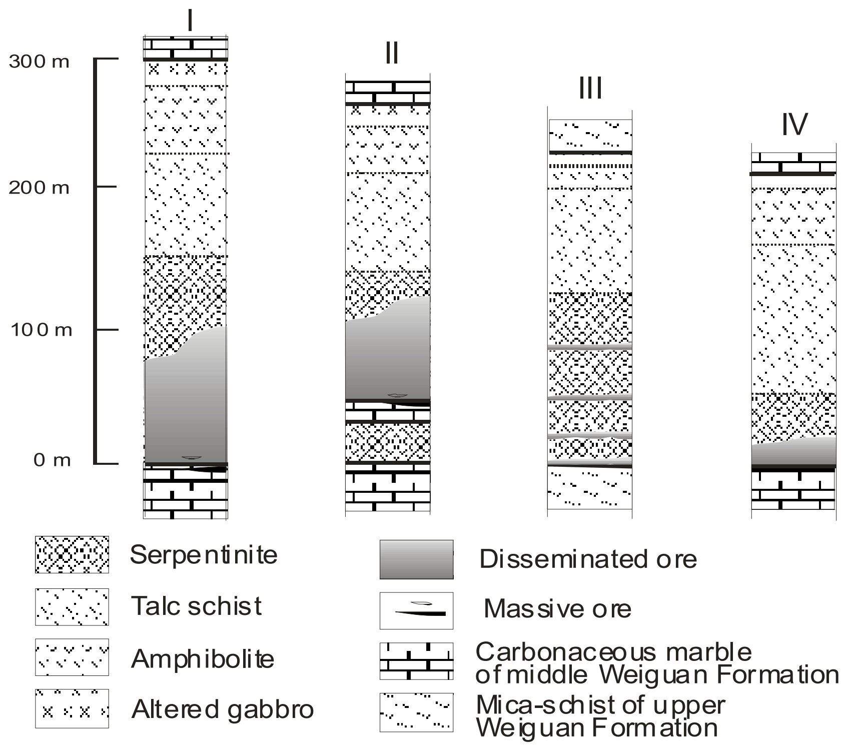


Figure 2. *Idealized column section of the ore-bearing intrusions. Intrusions: I Yangliuping, II Zhengziyanwuo, III Xiezuoping, and VI Daqianyanwuo.*

Three principal types of mineralization are recognized: 1) disseminated ores within the serpentinite; 2) massive ores within the footwall marble; and 3) mineralized veinlets along fractures within the intrusion. The main sulfide minerals are pyrrhotite, pentlandite and chalcopyrite. The proportions of pyrrhotite, pentlandite and chalcopyrite are 70:10:20, and in massive ores are 80:15:5. The disseminated ores, which are restricted to the serpentinite, account for more than 95 % of the Ni+Cu (and PGEs) reserve. The ores change gradually from densely disseminated in the lower part of the ore bodies, with more than 30% volume sulfide, to sparsely disseminated in the upper part, with less than 10% volume sulfide (Fig. 2). Massive ore bodies occur along the basal contact in the footwall rocks or along fractures within the large lenticular marble xenoliths in the intrusions, and a few on the bottom of the intrusions. Sulfide mineralization occurs in some fractures, extending NEE-SWW within the intrusions, with 30~40 cm thick.

The mafic-ultramafic intrusive rocks in the Yangliuping area and the ECFB show comparable oxide and trace element abundance and similar magmatic evolution trend (Fig. 3A, B), and primitive-mantle normalized trace element patterns (Song et al., 2001).

These similarities suggest that the intrusive rocks and the eruptive successions were genetically linked. The positive correlation between $(La/Yb)_N$ and Ni/Mg, and a narrow range of Ni/Mg ratios (Fig. 3C) of the ECFB from other locations show the importance of crystal fractionation in controlling Ni abundance. However, the fact that the Ni/Mg ratios of the intrusive and extrusive rocks in the Yangliuping area have large variation (0.06-1.5) while the $(La/Yb)_N$ remain in a narrow range (Fig. 3C) can be explained by sulfide segregation. The low Pd/Ir ratios of the ores (3~40) indicate that they were magmatic sulfide deposits, other than hydrothermal Ni sulfide mineralization, which has very high Pd/Ir ratios (Keays et al., 1982; Keays, 1995). The Pd/Pt ratios of the rocks and disseminated ores (<1.2) are much lower than that of the contact Ni-Cu-(PGE) mineralization (average ~3) (Peck et al., 2001). This indicates that the Yangliuping deposit is a magmatic Ni-Cu-(PGE) sulfide deposit.

Model for the genesis of the Yangliuping Ni-Cu-(PGE) sulfide deposits highlights the importance of fractional crystallization, decreasing of temperature and introducing of S, CO and CO_2.

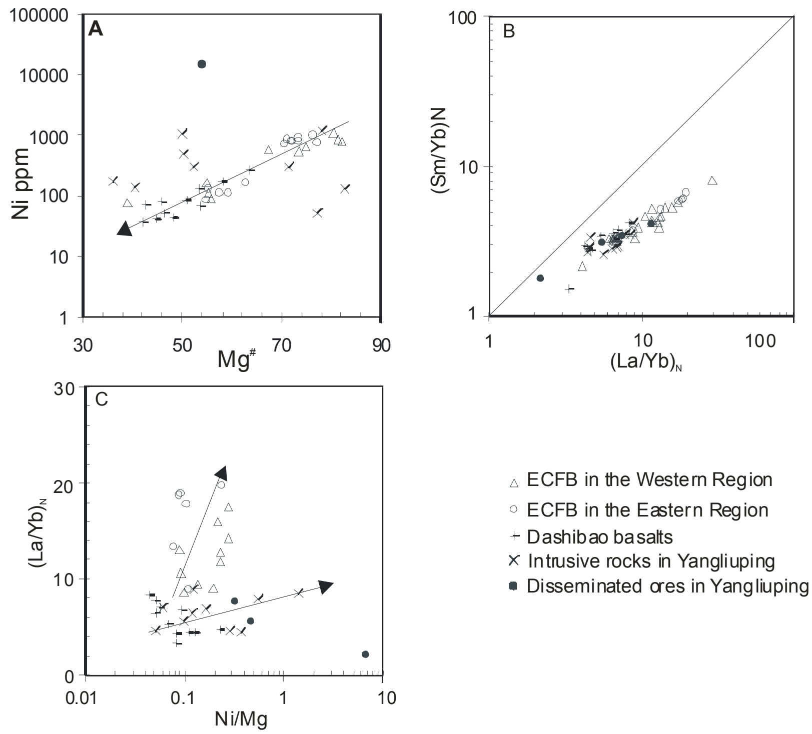


Figure 3. *A) Variation diagram for Ni (ppm) against* $Mg_{\#}$ *for the ECFB and intrusive rocks (fields of high-Ti and low-Ti are based on Lightfoot et al., 1993).* $Mg_{\#}=Mg/(Mg+Fe_{total})$*. B) Plot of (Sm/Yb)c versus (La/Yb)c for the ECFB, (Sm/Yb)c and (La/Yb)c are chondrite-normalized ratios of rare earth elements. The values of the rare earth element of the chondrite are from Talor and McLennan (1985). C) Variation diagrams of (La/Yb)c versus Ni/Mg for the ECFB, intrusive rocks and sulfide ores.*

The basaltic magmas in the shallow chamber would experience fractional crystallization of olivine and pyroxene as temperature drops, resulting in the increase of SiO_2 and decrease of FeO and MgO in the residual melt. This residual liquid, with it's inherent low density, would have strong tendency to separate from olivine and pyroxene and cause convection. At the same time, S, CO and CO_2 might be absorbed by the magma as the wallrock contamination and the decarbonation reaction occurred in the contact metamorphic zone. Introduction of CO_2, and reaction between O_2 and CO (and C) decreased the fo_2 of the silicate melt. Then, S-oversaturation in the residual melts was triggered by the decrease of temperature, segregation of olivine and pyroxene, which resulted in the increase of SiO_2 in the residual melt, and the introduction of S, CO and CO_2. Convection would not only promote the fractional crystallization, but also segregation of the sulfide and formation of the disseminated ore (Peck et al., 2001). It is likely that a great amount of sulfide may penetrate to and concentrate on the bottom of the intrusions as a number of basaltic magma pulses injected into the chamber and experienced fractional crystallization successively. When the sulfide melt injected along the fractures in the lower contact zone, the lens or irregular shaped ore bodies, with massive texture, would be formed.

References

Arne, D., Worley, B., Wilson, C.F.C.S., Foster, D., Li, L.Z., Gen, L.S., Dirks, P., 1997, Differential exhumation in response to episodic thrusting along the eastern margin of the Tibetan Plateau: Tectonophysics, vol. 280, 239-256.

Keays, R.R., 1995, The role of komatiitic and picritic magmatism and S-saturation in the formation of ore deposits: Lithos, vol. 34, 1-18.

Keays, R.R., Nickel, E.H., Groves, D.I., McGoldrick, P.J., 1982, Iridium and palladium as discriminants of volcanic-exhalative, hydrotyermal, and magmatic nickel sulfide mineralization. Econ. Geol., vol. 77, 1535-1547.

Peck, D.C., Keays, R.R., James, R.S., Chubb, P.T., Reeves, S.J., 2001, Controls on the formation of contact-type platinum-group element mineralization in the East Bull Lake Intrusion: Econ. Geol., vol. 96, 559-581.

Song, X-Y, Zhou, M-F, Hou, Z-Q, Cao, Z-M, Wang, Y-L, Li, Y-G 2001, Geochemical constrains on the mantle source of the Upper Permian Emeishan Continental Flood Basalts, Southwestern China: Int. Geol. Rev., vol. 43, 213-225.

Taylor, S.R., and McLennan, S.M., 1985, The continental crust: Its composition and evolution, Blackwell Sci. Publ., Oxford, UK., 312p.

Zhou, M-F, Malpas, J, Song, X-Y, Robinson, P.T., Sun, M., Kennedy, A.K., Lesher, C.M., Keays, R.R. 2002, A temporal link between the Emeishan Large Igneous Province (SW China) and the end-Guadalupian mass extinction: Earth Planet. Sci. Lett., Vol. 196, 113-122.