



PGE geochemistry of the Fengshan porphyry–skarn Cu–Mo deposit, Hubei Province, Eastern China

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ABSTRACT

The Fengshan Cu–Mo deposit is located in the western part of the Jiurui Cu–Au–Mo district in the Late Mesozoic Middle–Lower Yangtze River Metallogenic Belt (YRMB), Eastern China. The mineralization is spatially associated with the Fengshan granodiorite porphyry stock (149–138 Ma), where two types of ore bodies (porphyry, skarn) occur. The Fengshan deposit is located on the Yangtze Craton, i.e., in an intracontinental extensional environment, a geological setting not considered by previous studies of PGE abundance and distribution in porphyry systems. For the present investigation the PGE geochemistry of fourteen samples of the granodiorite, ore and flotation concentrates were determined by ICP–MS, after preconcentration by the Lead Fire Assay technique from large (30 g) samples. A maximum of 32 ppb Pd and 81.2 ppb Pt is reported for the molybdenum flotation concentrate. Cu, Au, Pt, Pd contents from flotation concentrate samples are almost 1 to 2 orders of magnitude higher than those reported for ore samples; this is especially true for the Pt content. Covariant diagrams of Cu and Mo with noble metals (Au, Ag, Pt and Pd) reveal weak correlation between Cu vs. Au, Ag, and Mo vs. Pt. Also, Au shows a slightly positive relationship with Pt and Pd.

It is apparent that Pd and Pt contents of flotation concentrate from the Fengshan deposit are considerably lower than those reported for porphyry deposits in an island arc setting. However, Au and Ag appear to be elevated in the Fengshan deposit. The intrusion derived from an enriched mantle source, high oxygen fugacity (fO_2), and liberation of mantle sulfates during partial melting, are the first steps for PGE enrichment in porphyry Cu deposits. However, the Fengshan granodiorite was most likely generated by partial melting of enriched mantle that was previously metasomatized by slab melts related to an ancient subduction system. Au, Pt, and Pd in potassic alteration zones and/or endocontact zones are transported as an aqueous chloride complex in high temperature, hypersaline fluid. In contrast, Au, Pt and Pd would be transported by bisulfide complex in low temperature, intermediate salinity fluid in phyllic alteration zones and/or exocontact marble. That is distinctly different from the porphyry Cu deposits in an island arc environment, where intrusion derived directly from slab melting and Pd and Pt are transported only as chloride complexes.

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1. Introduction

The platinum-group elements (PGEs – Ru, Rh, Pd, Os, Ir and Pt) are of great economic importance due to their increasing use in advanced technologies, such as microelectronics, chemical catalysis, etc. The platinum group elements belong to the transition metals, like iron (Fe), nickel (Ni), and cobalt (Co). Mineable concentrations of platinum group elements are generally associated with nickel–copper sulfides in mafic and ultramafic rocks, and 96–99% of the world's production currently stems from only five mining districts linked to five intrusive complexes: the Great Dyke in Zimbabwe, the Stillwater deposit in the USA, the Norilsk–Talnakh deposit in Russia, the Sudbury deposit in Canada

and the Bushveld deposit in South Africa (Maier, 2005; Naldrett, 2010; Stribny, 1996; Xiong, 2006). Recently, elevated concentrations of PGEs, particularly Pt and Pd, have been described from a number of porphyry–Cu deposits worldwide, such as the Cordillera in British Columbia (Copper Mountain, Galore Creek), Allard Stock, La Plana Mountains and Copper King Mine in the USA, Skouries porphyry deposit in Greece, Elatsite in Bulgaria, and Santo Tomas II in the Philippines, etc. (Economou-Eliopoulos, 2010; Mutschler et al., 1985; Tarkian and Stribny, 1999; Werle et al., 1984). In their reconnaissance study, Tarkian and Stribny (1999) investigated sulfide and flotation concentrates (separated from ore samples of hypogene mineralization zones), from 33 different porphyry copper deposits worldwide and recorded high Pd and Pt contents in some of these deposits. Moreover, platinum group minerals (PGMs) have been identified in some of these deposits, such as Elatsite, Majdanpek, Mamut, Biga and Skouries. Since then, PGMs have been reported in an increasing number of porphyry deposits;

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these PGMs are mostly merenskyite or solid solutions of merenskyite–moncheite, 50–100 μm in size, and always as inclusions in chalcopyrite, or textural relation with bornite (Pašava et al., 2010; Piestrzynski et al., 1994; Tarkian and Koopmann, 1995; Tarkian and Stribny, 1999; Tarkian et al., 1991; Tarkian et al., 2003). Although PGEs are a subject of intense investigation, information on their distribution in various ore-forming environments and mechanism of enrichment remains incomplete.

There are some reports on PGE enrichment in porphyry Cu deposits in China. Average PGE contents in ore samples from the Dexing porphyry Cu deposit, South China, is 3 to 50 ppb; in the Yulong porphyry Cu deposit in Tibet, the PGE prospective reserves have been reported as 3.4 t (Xiang and Ru, 1999). In addition, China National Nonferrous Metals Industry Corporation (CNNC) has investigated the PGE potential in the Middle–Lower Yangtze River Metallogenic Belt (YRMB), and Pd and Pt enrichment has been mentioned in some porphyry–skarn deposits (Gu and Chen, 1993; Tan, 2001, 2002). However, these reports provided only qualitative data. In this paper, we investigate the PGE concentrations and spatial distribution in the Fengshan Cu–Mo deposit. The Fengshan Cu–Mo deposit is located in the Jiurui mineralized district of the YRMB, consisting mainly of porphyry and skarn orebodies associated with the Fengshan granodiorite.

2. Regional geological setting

The YRMB is located on the eastern portion of the Yangtze Craton, Eastern China, and bounded by the Xiangfan–Guangji fault (XGF) to the northwest, the Tan–Lu regional strike-slip fault (TLF) to the northeast, and the Yangxin–Changzhou fault (YCF) to the south (Fig. 1). It comprises seven deposit districts, including Edong, Jiurui, Anqing, Luzong, Tongling, Ningwu and Ningzhen, in which more than 200 ore

deposits, such as porphyry and porphyry-related skarn and stratabound deposits have been recognized, being one of the most important Cu–Fe–Au–Mo-producing regions of China for the past three decades (Mao et al., 2011; Pan and Dong, 1999; Shu et al., 1992; Xie et al., 2011; Zhai et al., 1996). The Yangtze Craton is separated from the North China Craton by the Triassic Dabie orogenic belt to the north and from the Cathaysian block by a Grenvillian-age suture to the south (insert of Fig. 1).

The Yangtze Craton comprises an Archean to middle Neoproterozoic basement consolidated during Grenvillian time, when the Cathaysian block accreted to and collided with the Yangtze Craton (Li et al., 2002). This basement is overlain by a thick cover sequence (>10–12 km) of late Neoproterozoic to early Mesozoic age (Yang et al., 1986). The oldest basement rocks are the upper amphibolite to granulite facies suites of the Kongling complex exposed in a 360-km² dome, northern Yangtze Craton. This comprises of tonalitic–trondhjemitic–granitic gneisses with SHRIMP zircon U–Pb ages of 2.9–2.95 Ga (Qiu et al., 2000). Archean rocks are rarely exposed on the eastern Yangtze Craton; the ubiquitous presence of 2.5–3.0 Ga inherited zircons in Paleozoic or Mesozoic igneous rocks, however, suggests widespread presence of Neo- and Mesoarchean basement (Wang et al., 2004; Zheng et al., 2006).

The Paleoproterozoic Dongling Group covers several tens of km² in the Anqing area, consisting of felsic gneiss and muscovite quartz schist with intercalated amphibolite (Chang et al., 1991). Meso- and Neoproterozoic rocks occur widely along the southeastern margin of the Yangtze Craton and are dominated by calc-alkaline basalts, rhyolites, and shallow marine sedimentary rocks that have undergone lower to upper greenschist facies metamorphism (Chen et al., 2001). Extensive marine carbonates, shales, and sandstones characterize the Paleozoic and Early Triassic sequences over a vast area of the Yangtze Craton (Chang et al., 1991; Zhai et al., 1992). The Post-Late Triassic sedimentary cover succession

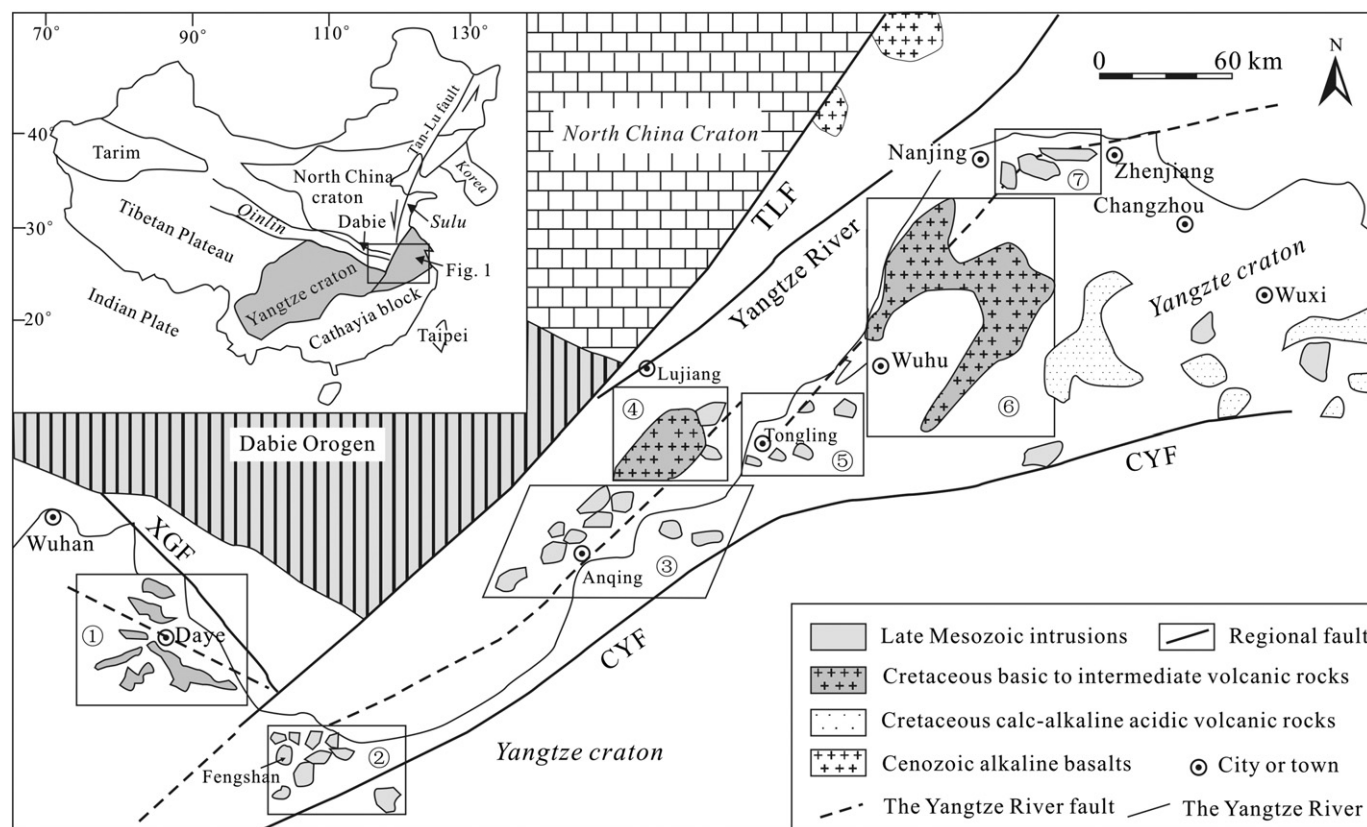


Fig. 1. Simplified geological map of the Middle–Lower Yangtze River Metallogenic Belt, modified from Zhai et al. (1992, 1996). Mineralized districts: 1: Edong, 2: Jiurui, 3: Anqing, 4: Luzong, 5: Tongling, 6: Ningwu, 7: Ningzhen. Abbreviations of faults: TLF: Tan–Lu fault, YCF: Yangxin–Changzhou fault, XGF: Xiangfan–Guangji fault.

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