

Geochemistry and geochronology of native copper mineralization related to the Emeishan flood basalts, Yunnan Province, China

Zhu Bing-Quan ^{a,*}, Hu Yao-Guo ^a, Zhang Zheng-Wei ^{a,b}, Cui Xue-Jun ^a, Dai Tong-Mo ^a, Chen Guang-Hao ^a, Peng Jian-Hua ^b, Sun Yong-Ge ^a, Liu De-Han ^a, Chang Xiang-Yang ^a

^a *Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, 510640, People's Republic of China*

^b *Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, 550002, People's Republic of China*

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Abstract

Native copper mineralization in northeastern Yunnan is related to the Emeishan flood basalts, which have high Cu background concentrations. The deposits are located in the Ludian, Maoling and Yiche synclines between the flood basalts and the overlying Xuanwei Formation. Evidence from REE and HSFE concentrations, oxygen isotope compositions, bitumen reflectance, and mineral paragenesis indicates that the high-grade copper orebodies were deposited from moderate to low temperature hydrothermal solutions (420 to 100 °C) in a reducing environment. ⁴⁰Ar/³⁹Ar spectra for the laumontites that coexist with native copper in the high-grade ores yield consistent plateau and isochron ages (226 to 228 Ma). These are interpreted to represent the age of the first stage of hydrothermal mineralization, which took place at temperatures of 200 to 350 °C, concordant with that of Zn–Pb–Ag–Ge mineralization also occurring in the area. The heulandites yield a stable ⁴⁰Ar/³⁹Ar plateau age of 134.0 ± 1.7 Ma, consistent with isochron ages indicated by U–Th–Pb isotopic systematics, indicating a second stage of native copper mineralization at lower temperatures (100 to 200 °C) that took place during the Early Cretaceous.

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1. Introduction

Cu–Ni–PGE sulfide, Fe–Ti–V oxide, native Cu–Ag and Zn–Pb–Ag–Ge sulfide mineralization are commonly related to continental flood basalts (CFB). Large deposits of these metals have been found, for example, in the Midcontinent, Siberia, Emeishan and Newark CFB provinces. Copper mineralization in CFB provinces, in which native copper is the major ore mineral, such as the Keweenaw district, U.S.A., are scarce

(Lefebure and Church, 1996; Cannon et al., 1999). Although research on these deposits has continued for about eighty years, questions remain about the source of Cu and relationship of ore to CFB magmatism, hydrothermal activity, and organic matter (Hamilton, 1967; Bornhorst et al., 1988; Davis and Paces, 1990; Ho et al., 1990; Lefebure and Church, 1996; Ho and Mauk, 1996; Zhu et al., 2003; Li et al., 2004). In this study, we focus on native copper mineralization in northeastern Yunnan Province, China (Zhu et al., 2003), which is very similar to that in the Keweenaw region. Our data provide new information on the age and geologic setting of these important deposits.

* Corresponding author.

E-mail address: bqzhu@gig.ac.cn (Z. Bing-Quan).

2. Geological setting

The area of native copper mineralization in Sichuan, Yunnan and Guizhou provinces is situated at the triple junction of the Yangtze, Cathaysia and Indochina Blocks (Fig. 1a). The area has undergone four CFB eruption cycles that are found in four Upper Permian stratigraphic units that make up the Emeishan CFB.

From the lower to upper part, these units are the P₂β₁, P₂β₂, P₂β₃ and P₂β₄ (Guizhou Bureau of Geology and Mineral Resources, 1990; Yunnan Bureau of Geology and Mineral Resources, 1990). The fourth eruption cycle (P₂β₄), which covers an area of about 150,000 km², has high-Ti–P (TiO₂>3%; P₂O₅>0.35%) features (Zhu et al., 2005a,b), and comprises a massive basalt bed in the lower part and pyroclastic bed including

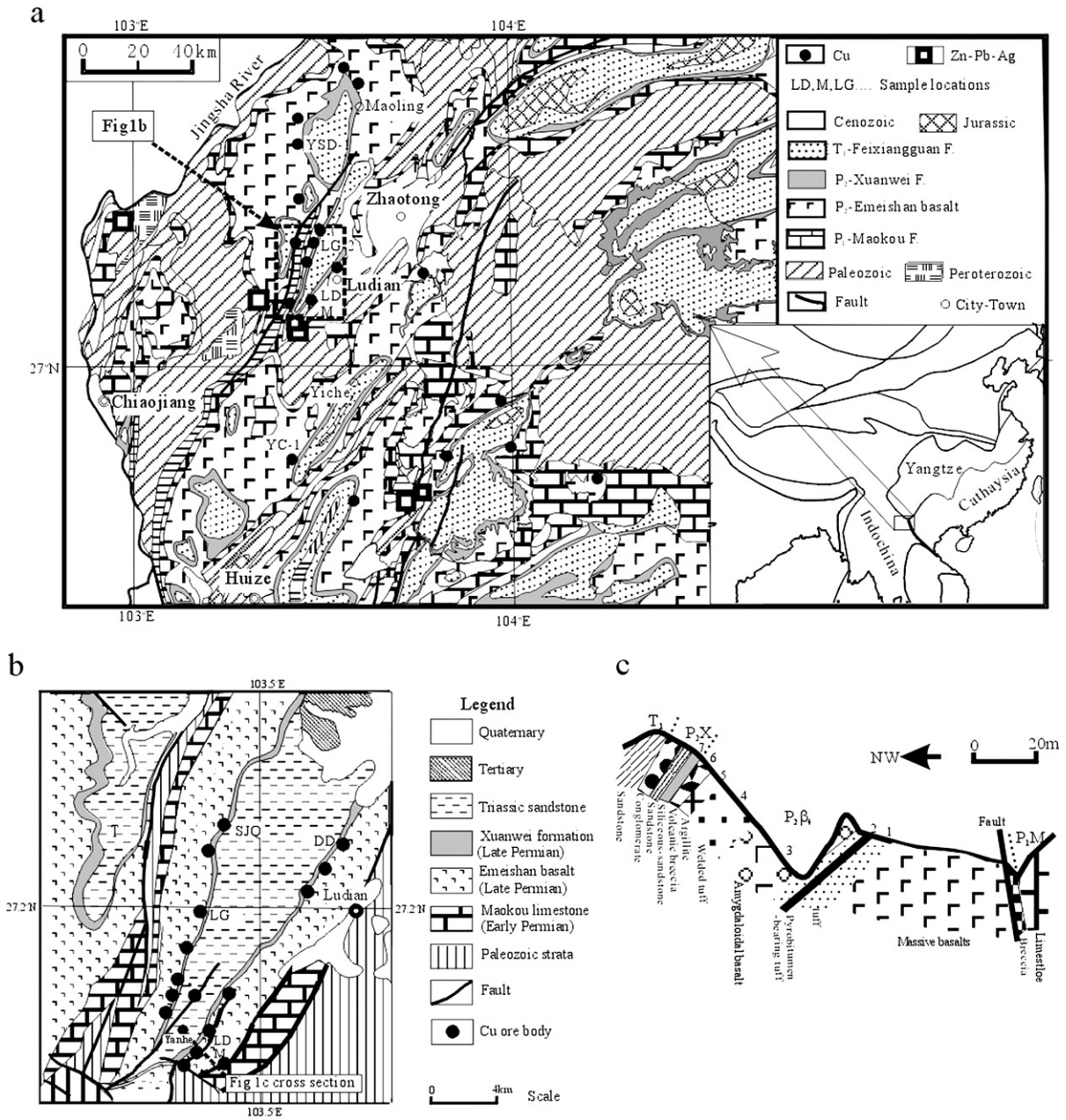


Fig. 1. a. Geological and sample location map of native copper mineralization in northeastern Yunnan Province, China. b. Geological map of the Ludian syncline. c. Cross section of Cu mineralization at the southeastern side of the Ludian syncline. Abbreviations and numbers are the names of orebodies. DD—Dadi, LD—upper part of Laoyingyan, M—middle part of Laoyingyan, LG—Longjinggou, SJQ—Sujiqing, YSD—Yongshunde, YC—Yiche.

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