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Carbon-oxygen isotopes and rare earth elements as an exploration vector for Carlin-type gold deposits: A case study of the Shuiyindong gold deposit, Guizhou Province, SW China

Qin-Ping Tan[a,b], Yong Xia[a,*], Xueqiu Wang[b], Zhuo-Jun Xie[a], Dong-Tian Wei[a,c]

[a] State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, Guizhou, China
[b] Key Laboratory of Geochemical Exploration, Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences, Langfang 065000, Hebei, China
[c] University of Chinese Academy of Sciences, Beijing 100049, China

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ABSTRACT

The Shuiyindong gold deposit is a deeply concealed strata-bound Carlin-type deposit in southwestern Guizhou Province, China. The deposit lies on the eastern limb of the Huijiabao anticline with ores mainly along the anticline axis and hosted in bioclastic limestone, containing calcite veins, of the Permian Longtan Formation units. In this study, we measured carbon and oxygen isotopic ratios and rare earth element (REE) concentrations of the host rocks and calcite veins along a profile across the Shuiyindong deposit. Orebodies in the upper unit of the Longtan Formation have higher $\delta^{18}O$ values (20.6–22.4‰) and lower $\delta^{13}C$ values (−3.7 to −0.5‰) than the country rocks ($\delta^{18}O$: 18.8–21.4‰; $\delta^{13}C$: −0.7 to 0.8‰). However, there are no obvious trends of $\delta^{18}O$ and $\delta^{13}C$ values from the country rocks to the orebodies in the middle unit of the Longtan Formation. The spatial distribution of the calcite veins displays distinct halos of $\delta^{13}C$ and $\delta^{18}O$ values and REE concentrations. Calcite veins along the anticlinal axis and major reverse fault are enriched in Middle REE (Sm, Eu, Gd, and Tb) and ^{18}O and depleted in ^{13}C. Surficial veining calcite-filled fractures/faults that connect to deep concealed strata-bound gold mineralization systems can be vectors toward deep ores in southwestern Guizhou Province, China.

1. Introduction

Carlin-type gold deposits in China are mainly distributed in the Yunnan-Guizhou-Guangxi “gold triangle” in southwestern China (Fig. 1), and most of the deposits are located in southwestern Guizhou Province (Liu et al., 2002; Zhang et al., 2003; Xia et al., 2012; Cline et al., 2013; Chen et al., 2015; Hu et al., 2017a). These deposits have been subdivided into two types based on the ore body geometry, characterized by strata-bound and fault-controlled mineralization (Wang, 1994; Feng and Guo, 2002; Liu and Liu, 2005; Guo and Zhou, 2006). The strata-bound mineralization is anticline-controlled, with concealed orebodies hosted in Permian bioclastic limestone, such as the Zimudang and Shuiyindong deposits. The fault-controlled mineralization occurs mainly along reverse faults with orebodies hosted in Middle or Lower Triassic calcareous siltstone and mudstone, such as the Lannigou and Yata deposits. The Shuiyindong deposit is a deeply concealed strata-bound gold deposit, with orebodies mainly located at depths from 200 to 1400 m below the surface.

Traditional exploration methods, such as soil and drainage sediment surveys of gold and other relevant elements, were unsuccessful in the discovery of blind strata-bound gold deposits in southwestern Guizhou Province. For example, from 1982 to 1993, in the Shuiyindong area, only few fault-controlled oxidized orebodies were discovered along reverse faults using geological and geochemical surveys and further drilling engineering, and thus geologists believed there is limited prospecting potential (Liu et al., 2009). In 1995, concealed strata-bound orebodies below the surface at 150–300 m were verified by drilling based on the exploration experience of the Zimudang gold deposit (Xia, 2005; Liu et al., 2009), which is located to the west of the Shuiyindong deposit (Fig. 2). However, the direct geochemical signals related to concealed strata-bound Carlin-type gold mineralization in southwestern Guizhou Province are still unclear.

Carbon and oxygen isotope compositions from typical unaltered limestone to high-grade ores have been used to map the extent of hydrothermal systems and have provided useful guides for the exploration of hydrothermal deposits worldwide (Naito et al., 1995; Vazquez et al., 1998; Large et al., 2001; Bierlein et al., 2004; Kelley et al., 2006), particularly for Carlin-type gold deposits in Nevada, USA (Arehart and

* Corresponding author.
E-mail addresses: 565310821@qq.com (Q.-P. Tan), xiayong@vip.gyig.ac.cn (Y. Xia).

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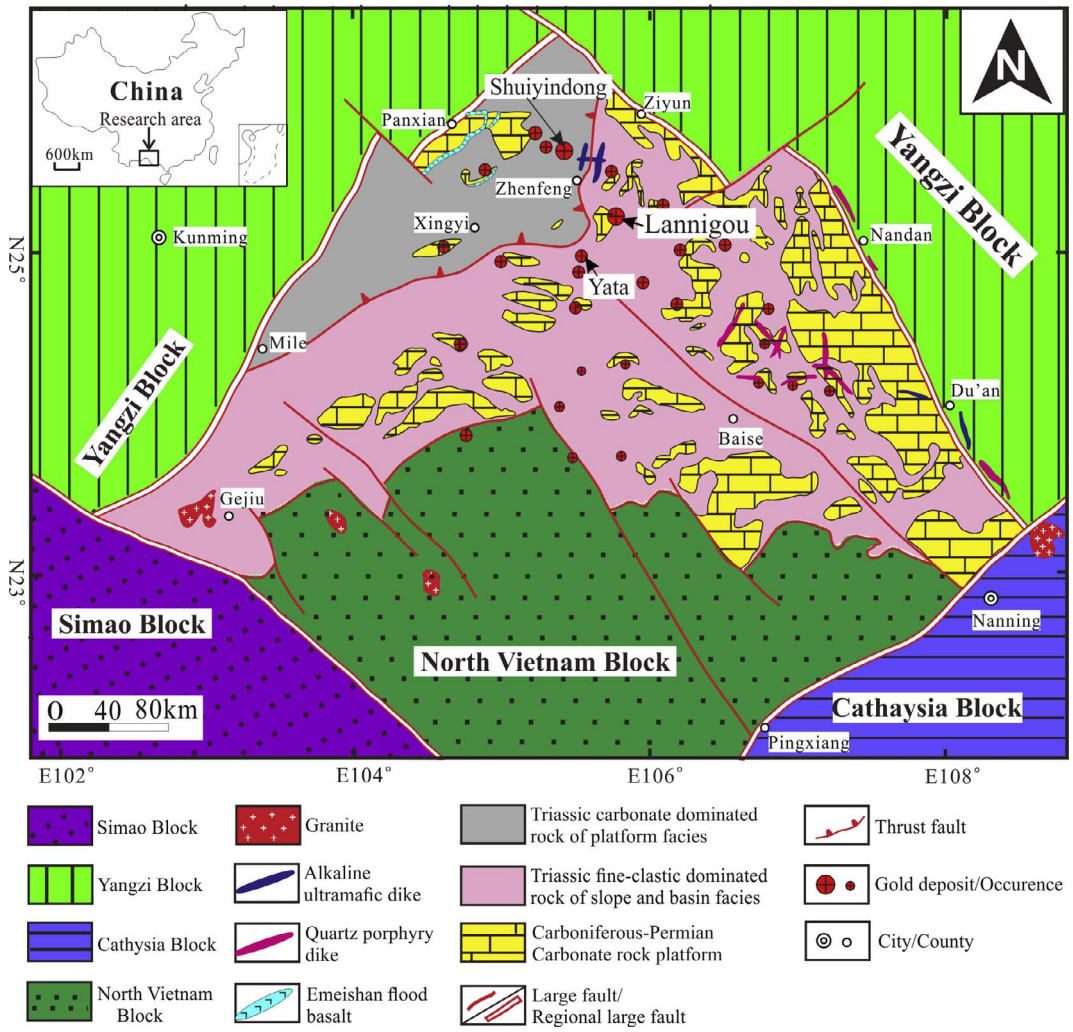

Fig. 1. Regional geologic map showing the distribution of Carlin-type gold deposits in the Yunnan-Guizhou-Guangxi "Golden Triangle" region (modified from Chen et al., 2011).

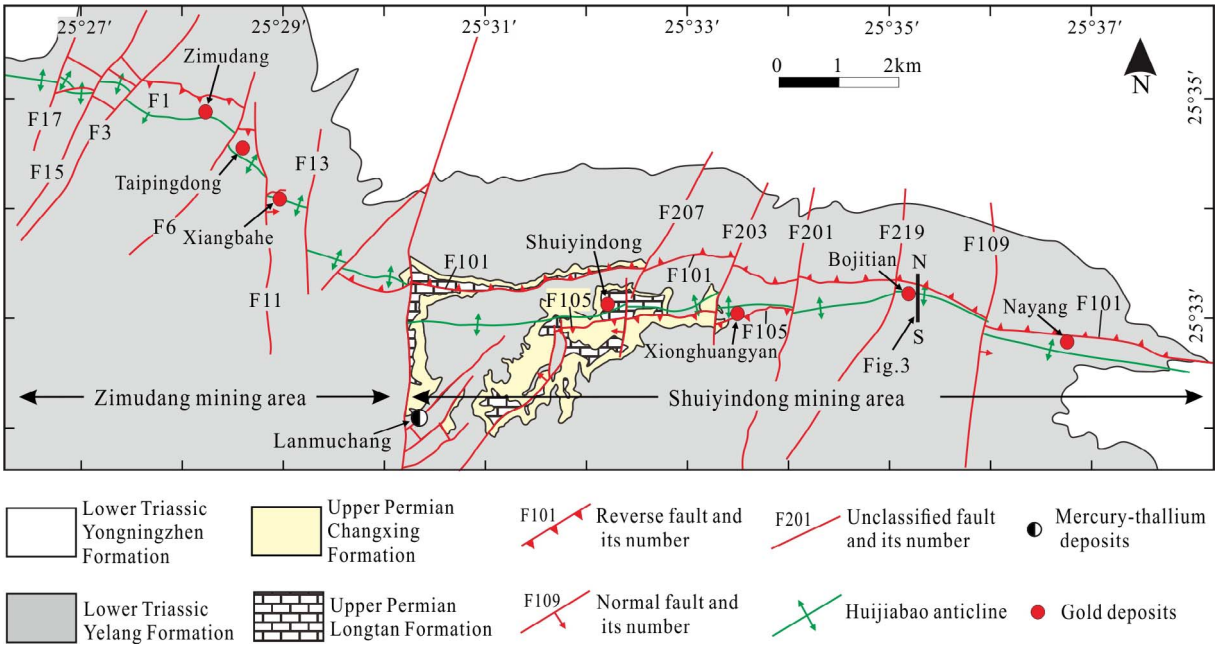

Fig. 2. Geological map of the Shuiyindong gold deposit. The Shuiyindong deposit lies on the east-plunging limb of the Huijiabao anticline, where the fold limbs are cut by approximately east–west-trending reverse faults (e.g., F101, F105).