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A unique Mo deposit associated with carbonatites in the Qinling orogenic belt, central China

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ABSTRACT

The Qinling molybdenum belt is a prominent metallogenic structure in central China hosting several significant porphyry- and porphyry–skarn-type deposits. The Huanglongpu Mo deposit in the north-western part of the belt is unique in that it is associated with carbonatite dykes, rather than felsic magmatism. The carbonatites are composed largely of Sr–Mn-rich calcite and characterized by high concentrations of Sr and rare-earth elements (REE), and stable-isotope values indicative of a mantle source ($\delta^{13}C_{PDB} = -6.7 \pm 0.2‰$ and $\delta^{18}O_{SMOW} = 8.2 \pm 1.0‰$). Molybdenite is associated with galena and REE minerals (parisite, bastnäsite and monazite). Both molybdenite and galena are characterized by high Re contents (up to 0.4 and 0.2 wt.%, respectively) and Re/(Mo, Pb) ratios approaching the primitive-mantle values. In contrast to the rock-forming calcite, the REE minerals are enriched in light REE, whose relative proportion increases from parisite-(Ce) [average $(La/Nd)_n = 2.1$] to bastnäsite-(Ce) and monazite-(Ce) [average $(La/Nd)_n = 3.1$, 4.6, respectively]. The whole-rock compositions are characterized by some of the highest Mo and heavy REE abundances reported for carbonatites to date: up to 1010 ppm Mo, 1130 ppm Y + Gd…Lu and $(La/Yb)_n = 1.2–2.7$. The unusual trace-element geochemistry of the Huanglongpu rocks may ultimately reflect the composition of their mantle source, but their enrichment in Mo + Re was undoubtedly enhanced through preferential partitioning of these elements into a light REE–Pb–S-rich fluid derived from the carbonatitic magma modified by calcite fractionation. The present work shows that Mo can be retained, transported and deposited by carbonatitic fluids capable of generating economic Mo deposits.

1. Introduction

The global molybdenum supply is derived almost exclusively from porphyry-type ore deposits, such as the famous Climax-type deposits in Colorado and New Mexico, USA (Carten et al., 1993; Klemm et al., 2008), Endako mine in the Canadian Cordillera (Villeneuve et al., 2001), and Qinling in China (Hu et al., 1988; Chen et al., 2000). These deposits are associated with shallow intrusions of granites and high-silica rhyolites, and form where magmatic–hydrothermal fluids are expelled by crystallizing magmas of felsic to intermediate composition in regions of plate convergence (Burnham, 1997; Xu et al., 1998). Cooling, depressurization and reaction of fluids with wall-rock cause metals to precipitate in and around fractures, forming veins accompanied by an alteration envelope. Owing to superposition of multiple mineralizing events, fluid inclusions that trapped fluids of different composition and age are commonly juxtaposed within a single vein. Such superposition obscures the textural and temporal relations between the fluid inclusions, primary minerals and alteration assemblages and, thus, complicates the interpretation of fluid origin and evolution (e.g., Seedorff and Einaudi, 2004a; Seedorff et al., 2005; Rusk et al., 2008). The current models for Mo porphyry mineralization are not entirely consistent with many of the complex geological characteristics of porphyry orebodies (Seedorff et al., 2008), and many aspects of the genesis of Mo mineralization remain poorly understood. In the East Qinling orogenic belt, this type of mineralization is associated with carbonatites and, thus, may provide important insights into Mo transport and deposition beyond felsic porphyry systems.

The Qinling area is an important metallogenic belt hosting Au, Ag, Pb–Zn, W and Sb deposits, as well as the most important Mo ore camp in China. Its total measured reserves amount to 50×10^5 t of Mo metal and include five world-class superlarge ($>5 \times 10^5$ t Mo), five large ($5–20 \times 10^4$ t Mo) and several medium and small ($<5 \times 10^4$ t Mo) deposits (Li et al., 2007; Mao et al., 2008). The majority of these deposits are hosted by granitic porphyry bodies, but some are transitional porphyry–skarn deposits (Zhang et al., in press). The Huanglongpu deposit is unique and unparalleled worldwide in that it is associated with carbonatites, rather than silica-oversaturated

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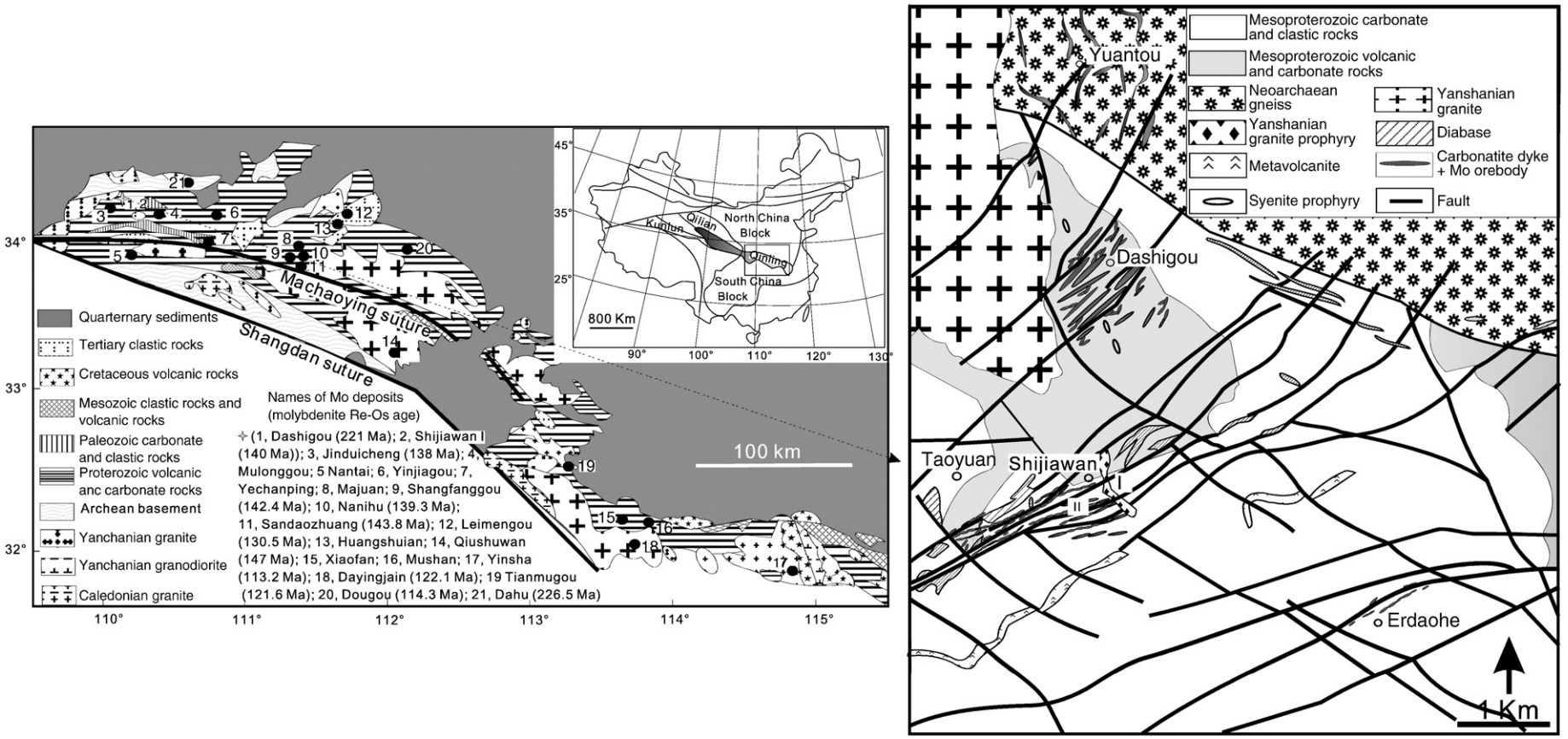

Fig. 1. Distribution of Mo deposits in the Qinling orogenic belt and geological sketch of the Hunaglongpu deposit (modified after Geological Team no. 13, 1989; Li et al., 2007; Mao et al., 2008).