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Hydrothermal alteration and ore-forming fluids associated with gold-tellurium mineralization in the Dongping gold deposit, China

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ABSTRACT

The Dongping gold deposit hosted in syenites is one of the largest hydrothermal gold deposits in China and composed of ore veins in the upper parts and altered zones in the lower parts of the ore bodies. Pervasive potassic alteration and silicification overprint the wall rocks of the ore deposit. The alteration minerals include orthoclase, microcline, perthite, quartz, sericite, epidote, calcite, hematite and pyrite, with the quartz, pyrite and hematite assemblages closely associated with gold mineralization. The phases of hydrothermal alteration include: (i) potassic alteration, (ii) potassic alteration - silicification, (iii) silicification - epidotization - hematitization, (iv) silicification - sericitization - pyritization and (v) carbonation. Mass-balance calculations in potassic altered and silicified rocks reveal the gain of K_2O, Na_2O, SiO_2, HFSEs and transition elements (TEs) and the loss of REEs. Most major elements were affected by intense mineral reactions, and the REE patterns of the ore are consistent with those of the syenites. Gold, silver and tellurium show positive correlation and close association with silicification. Fluid inclusion homogenization temperatures in quartz veins range from 154 °C to 382 °C (peak at 275 °C–325 °C), with salinities of 4–9 wt.% NaCl equiv. At temperatures of 325 °C the fluid is estimated to have pH = 3.70–5.86, log fO_2 = −32.4 to −28.1, with Au and Te transported as Au $(HS)_2^-$ and Te_2^{2-} complexes. The ore forming fluids evolved from high pH and fO_2 at moderate temperatures into moderate-low pH, low fO_2 and low temperature conditions. The fineness of the precipitated native gold and the contents of the oxide minerals (e.g., magnetite and hematite) decreased, followed by precipitation of Au- and Ag-bearing tellurides. The hydrothermal system was derived from an alkaline magma and the deposit is defined as an alkaline rock-hosted hydrothermal gold deposit.

1. Introduction

Discovered in the 1980s, the Dongping gold deposit with a pre-mining resource of about 100 t Au (Zhang and Mao, 1995) is dominantly characterized by telluride assemblages. The gold-bearing ore veins occur in the upper parts of the ore bodies with the lower domains characterized by alteration and ore bodies spatially associated with alkaline intrusions (Song and Zhao, 1996; Nie, 1998; Bao and Zhao, 2006). Previous studies of the Dongping gold deposit investigated the geological setting, geochemistry, and isotopic characteristics of the ore-forming fluids in the upper parts of the ore bodies (Mo et al., 1996; Song and Zhao, 1996; Wei et al., 2000; Fan et al., 2001; Mao et al., 2003; Jiang, 2005).

However, fluid-rock interactions and the physicochemical conditions in the lower parts of the ore bodies are poorly understood. Three genetic models have been proposed for this deposit: (i) gold mineralization associated with alkaline rocks (Zhang and Mao, 1995; Nie, 1998; Wang et al., 1998; Qi and Li, 2000; Zhang et al., 2005); (ii) the mineralization is an orogenic gold deposit (Chen et al., 1998; Miller et al., 1998; Hart et al., 2002); and (iii) gold, silver and polymetallic mineralization is associated with a mantle plume (Niu et al., 2008).

In this paper, we use a combination of mineralogy, petrography, major and trace element geochemistry, and fluid inclusions to determine the relationship between alteration and mineralization. Based on the results, we evaluate the physicochemical (T, P, pH, fO_2, $\alpha\Sigma Au(HS)_2^-$ and $\alpha\Sigma Te_2^{2-}$) conditions in order to better understand the origin of the Dongping gold deposit.

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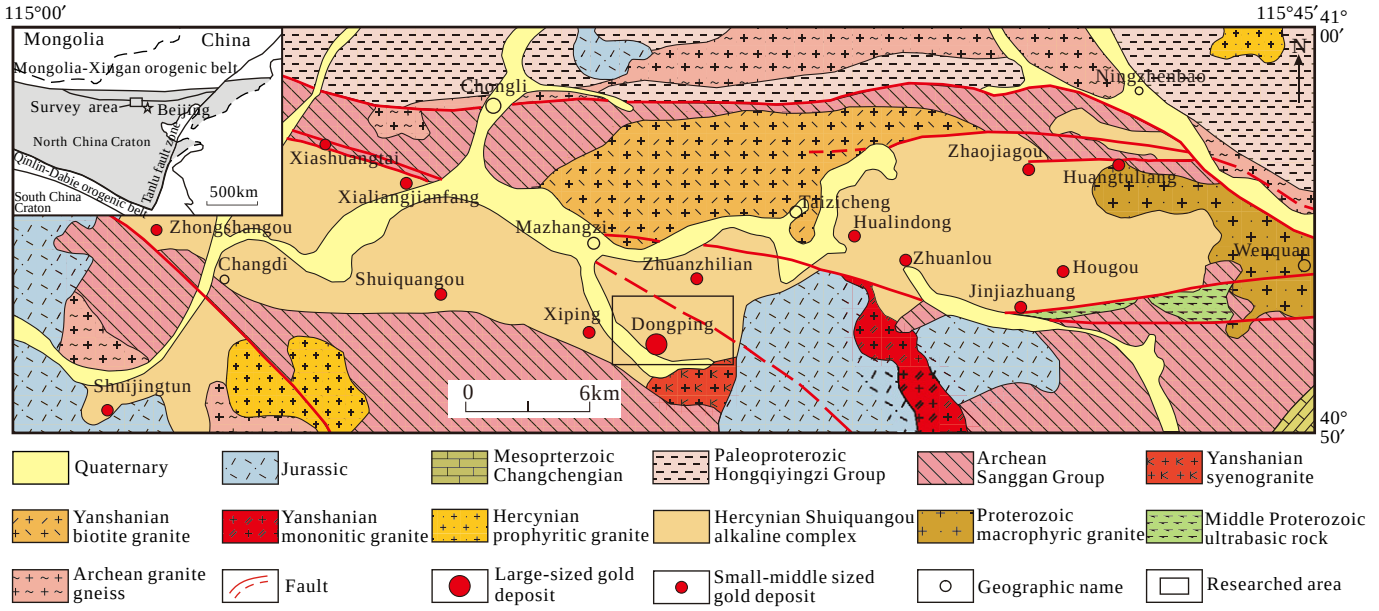

Fig. 1. Geological sketch map of the area surrounding the Dongping gold deposit in the Hebei province (modified after Song and Zhao, 1996; Li et al., 2010).

2. Geological setting

The Dongping gold deposit is located in the central part of the northern margin of the North China Craton, and occurs at the intersection of NNE- and NW-striking faults that terminate the large Shangyi – Chongli – Chicheng Fault system in the north. The deposit occurs at the contact zone between the Hercynian Shuiquangou alkaline intrusive complex and the late Archean Jiangouhe Formation belonging to the Sanggan Group (Fig. 1). The major rock types in the area include those of Late Archean Sanggan Group, Early Proterozoic Hongqiyingzi Group, Middle Proterozoic Changcheng Group, as well as Jurassic and Quaternary rocks. The major magmatic units are the Archean- early Proterozoic intrusions, the Hercynian Shuiquangou alkaline intrusive complex and the Yanshanian granite (Fig. 1). Zircon LA-ICP-MS U-Pb dating suggests

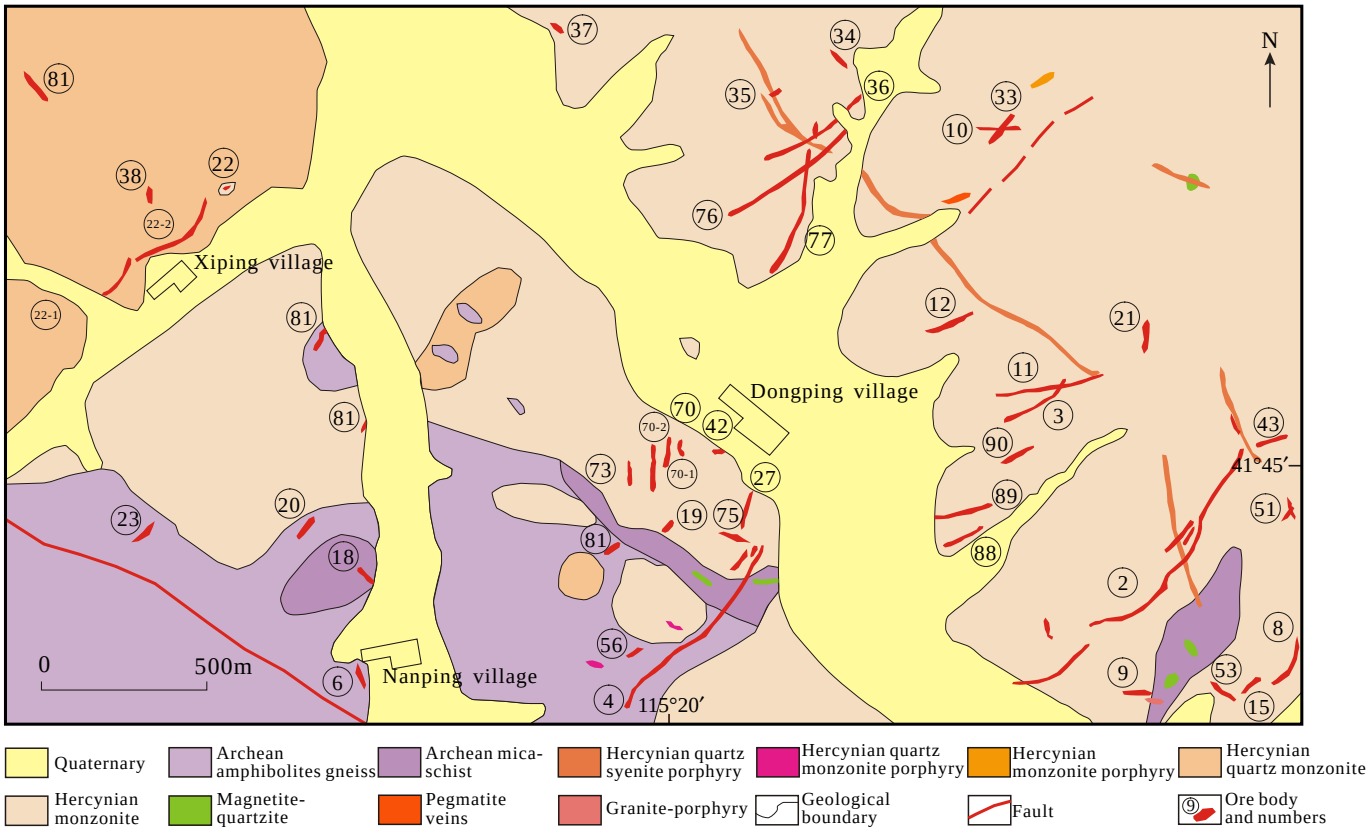

Fig. 2. Simplified geological map of the Dongping gold deposit (modified after Zijin Mining in Chongli, 2011; Zhang et al., 2012).