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The geology and geochemistry of Jinchangyu gold deposit, North China Craton: Implications for metallogenesis and geodynamic setting

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ABSTRACT

The Jinchangyu Au deposits contained an original resource of 50 t of gold and is located close to the northeastern margin of the North China Craton (NCC). The orebodies are controlled by structures in the amphibolite units of the Archaean Zunhua Group. Mineralization is generally associated with albite and hematite which is indicative of Na–Al–Si–Fe alteration. The most common styles of mineralization are subdivided based on the cross-cutting relationships of mineral assemblages as follows: (i) quartz–albite–hematite; (ii) quartz–albite–polymetallic sulfides with gold and molybdenite; (iii) quartz–pyrite; and (iv) quartz–carbonate. Quartz samples from the second (Stage II) and third (Stage III) assemblages contain two-phase fluid inclusion types; these are: (i) CO_2–H_2O fluid inclusions, and (ii) daughter mineral-bearing inclusions, which have homogenization temperatures of 270°–350 °C (for assemblage Stage II) and 180°–240 °C (for Stage III), and salinities of ≤13 wt.% NaCl equiv. A few S-type fluid inclusions suggesting salinities of 27.6–28.3 wt.% NaCl equiv. The S isotope composition of pyrite and molybdenite from Stage II ($\delta^{34}S = -4.4$ to 1.9‰) indicates that the mineralizing fluid originated predominantly from a magmatic source. The H–O isotope signatures from Stage II indicate a magmatic-dominated source for the mineralizing fluid with some addition of meteoric fluids. Previously published Pb and C isotope data indicate that ore and magma in the eastern part of the Hebei Province of China interacted with Precambrian country rocks, and so the fluids moved from the lower crust to shallower level during mineralization. The red quartz–albite–hematite veins from Jinchangyu were generated under strongly oxidizing alkaline conditions that were favorable for the incorporation of gold into the fluid and the crystallization of albite during the early stage of gold deposition.

Seven molybdenite samples from Jinchangyu yield Re–Os model ages of ca. 233 to 219 Ma with a weighted mean age of 225 ± 4 Ma and an isochron age of 223 ± 5 Ma. This indicates that at least some of the gold associated with molybdenite is Late Triassic in age, and could be associated with buried intrusions that are part of the Late Triassic Dushan granites in the eastern portion of the NCC. This mineralization was formed after the closure of the Paleo-Asian Ocean. These results indicate that the intrusion-related Jinchangyu deposit is the far-field structural product of the collision of the NCC with the Siberian Craton to the north along the northern margin of the NCC.

1. Introduction

The Eastern Hebei Province is an important precious metal source in the North China Craton (NCC; Fig. 1) and is famous for providing gold for royal dynasties for thousands of years. The Jinchangyu gold deposit, located 140 km northeast of Beijing, was first discovered and explored during the Tang Dynasty between 907 and 618 AD. Since 1958, ca. 32 t of gold has been mined with an average grade of 5.30 g/t Au. The gold deposit is one of the largest in eastern Hebei Province with a remaining resource of 20 t of gold at depth.

Red quartz–albite veins host the Jinchangyu Au deposit in an Archean greenstone belt, which consists of the Qianxi–Zunhua Groups. Previous studies have been focused on the geology, ore-controlling structures, geochemistry, mineralogy, and geochronology (Lin et al., 1994; Niu et al., 2012; Song et al., 2011; Yu and Jia, 1989; Zhang et al., 1991), but the timing of the mineralization remains a matter of debate. Some scholars believe that the mineralization is Archean in age (Lin et al., 1994; Wang, 1989; Zhang et al., 1991). Lin et al. (1994) proposed that the deposit was deposited in a ductile shear zone during 2191 ± 58 Ma, based on Ar–Ar dating of quartz from mylonite schist. Luo et al. (2001) argue that the gold is Paleoproterozoic (1858 ± 8 Ma) in age, and others have suggested that the Au mineralization is late Mesozoic (197–169 Ma; Li et al., 2002; Lin and Guo, 1985; Yu and Jia, 1989). Much of the debate relates to the quality of previous data and the limited understanding of the ore genesis and tectonic setting of the deposit.

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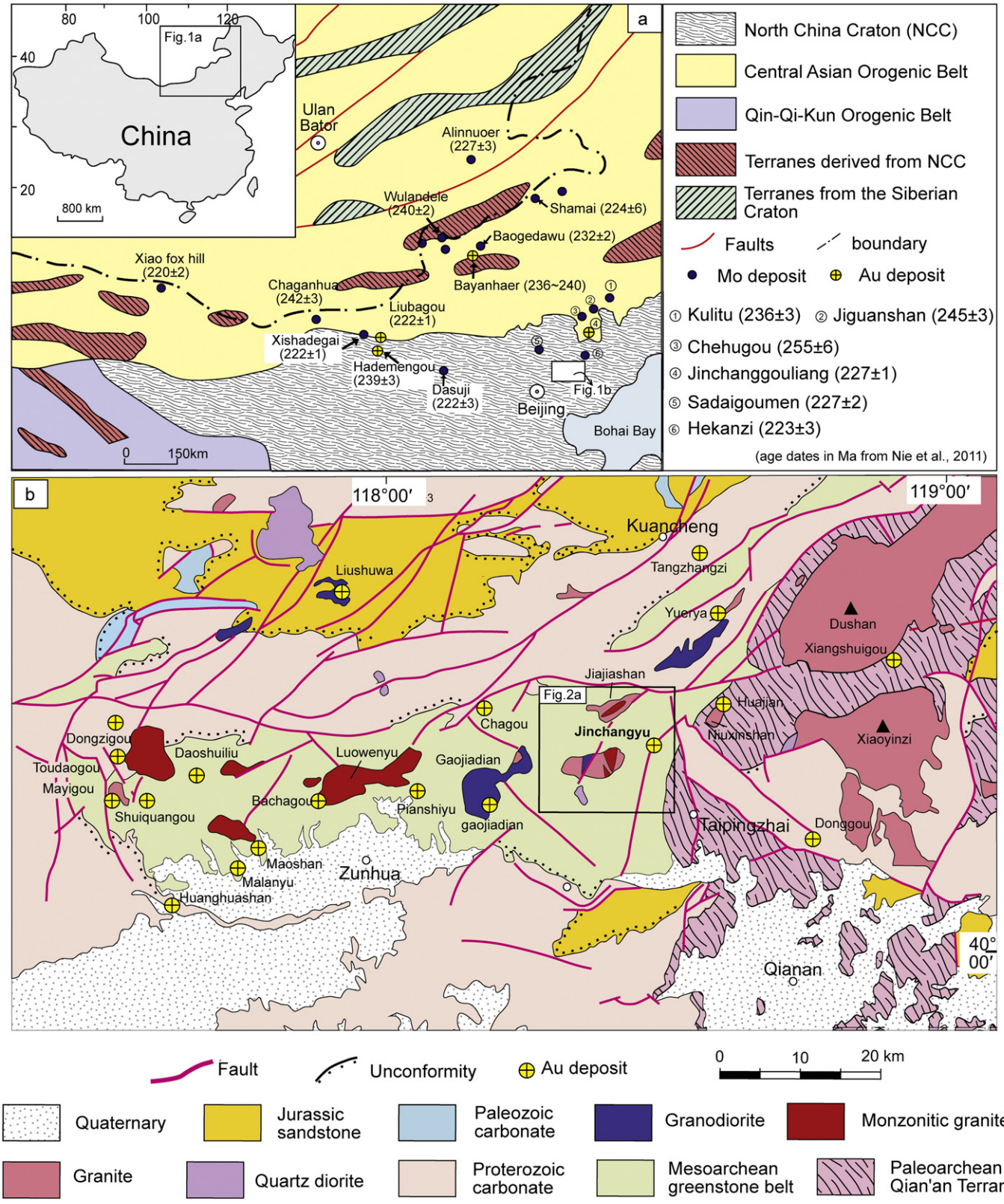

Fig. 1. Simplified geological maps: (a) showing the distribution of Triassic Mo and Au deposits along the northern margin of the North China Craton and adjacent areas (modified after Nie et al., 2011); and (b) East Hebei Province (modified after Mei, 1997).

The red coloration at the Jinchangyu Au deposit is related to alteration associated with the mineralization, but this alteration has not previously been studied. Traditionally, the alteration has been regarded as "red K-feldspathization" or "red albitization" (Lin et al., 1994; Luo et al., 2001; Zhang et al., 1991). The questions of why the albite-quartz veins are red in color, and what the relationship is between the red alteration and the mineralization are important in understanding the genesis of the deposit.

This paper reports new data on the geological and geochemical characteristics of the Jinchangyu Au deposit, in an attempt to elucidate the