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Geology and geochemistry of the Macheng Algoma-type banded iron-formation, North China Craton: Constraints on mineralization events and genesis of high-grade iron ores

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ABSTRACT

The Macheng iron deposit is located in the eastern Hebei province of the North China Craton (NCC). It is hosted in Neoarchean metamorphic rocks of Baimiaozi formation in the Dantazi Group, consisting of biotite-leptynite, plagioclase-gneiss, plagioclase-amphibolite, migmatite, migmatitic granite and quartz schist. Geochemical analyses of the host biotite leptynite and plagioclase amphibolites show that their protoliths are both volcanics, inferred to be trachytic basalt and basaltic andesite, respectively. Based on the geochemical signature of the host rocks, together with geology of the iron deposit, it is inferred that the Macheng BIF is an Algoma-type iron exhalative formation, formed in an arc-related basin in the Neoarchean.

Post-Archean Australian Shale (PAAS)-normalized rare earth elements (REEs) plus yttrium (Y) concentrations of different BIF ores with gneissic, striated and banded structure in the Macheng deposit, show similar patterns with depletions in light rare earth elements (LREEs) and middle rare earth elements (MREEs) relative to heavy rare earth elements (HREEs) and with apparently positive La, Y and Eu anomalies. Y/Ho ratios of the gneissic, striated and banded BIF ores vary from 37 to 56. These geochemical features of the BIF ores reveal their affinity with the sea water and the presence of a high-temperature hydrothermal component, indicating that both the seawater and high temperature hydrothermal fluids derived from alteration of oceanic basalts and komatiites may contribute to formation of the Macheng BIF.

Geological, mineralogical and geochemical studies of the Macheng deposit recognized two kinds of high-grade iron ores. One is massive oxidized high-grade ore ($Fe_2O_3^T$ = 74.37–86.20 wt.%), mainly consisting of hematite with some magnetite, which shows geochemical characteristics of the gneissic, striated and banded BIF ores. The other type is magnetite high-grade ore, also massive and consisting of magnetite, with distinct characteristics in trace elements of the gneissic, striated and banded BIF ores but show similarity to those of the migmatitic iron ores with significantly negative Eu anomalies. The geochemical discrepancy or duality between the two types of high-grade ores in Macheng suggests that they formed by two different mechanisms. One is related to supergene enrichment, caused by oxidation of magnetite and the leaching of gangue minerals from BIF to form high-grade ore. The other is probably related to intensive migmatization which produced high-grade ores by altering the primary iron ores.

1. Introduction

Banded Iron-Formations (BIF), are most common in Precambrian sedimentary and volcano-sedimentary successions, constituting an important iron resource and contributing a significant role in the understanding of the early evolution of the Earth's crust, in defining the boundary between the Archean and Proterozoic, and the composition of the Earth's early hydrosphere and atmosphere (Boyle and Davies, 1973; Bekker et al., 2010; Huston and Logan, 2004; Ohmoto et al., 2006; Trendall, 2002). Those BIF which are distributed within Precambrian cratons, and are associated with greenstone belts, such as the greenstone belts of the Yilgarn and Pilbara Cratons of Australia, the Abitibi belt of

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the Superior Province of Canada, the greenstone belt of the Baltic Shield and the Amazon Craton of Brazil, the Kaapvaal Craton and the West African Craton of South Africa and the North China Craton (NCC) (Beukes and Klein, 1992; Garrels, 1987; Hoffman, 1987; Trendall, 2002; Zhang et al., 2011), are referred to as Algoma-type or as exhalative type, in contrast to Superior type or continental margin BIF, which are laterally very extensive and constitute a major iron ore resource world-wide, such as those of the Hamersley Basin in Australia and the Superior Province in North America (Pufahl and Fralick, 2004; Pirajno, 2009; Pufahl, 2010; Trendall, 2002). The oldest BIF deposits occurred at ~3.8 Ga, with three metallogenic pulses of 2.8–2.7, 2.5–2.4 and 1.9–1.8 Ga, and then the occurrences of the BIF deposits decreased sharply after 1.8 Ga (Bekker et al., 2010; Huston and Logan, 2004; Isley and Abbott, 1999).

The eastern Hebei in the NCC is one of the most important iron ore provinces in China, and is highly prospective for iron mineral resources. In recent years, with more medium to large BIF iron deposits being gradually discovered, many of the iron deposits have been successively reported in the Chinese and international literature (Li et al., 2012, 2014; Shen et al., 2005, 2006; Wang et al., 2014; Zhang et al., 2011, 2012a,b, 2014). These studies mainly focus on the deposit geology, geochronology and geochemistry of the host rocks in order to constrain the metallogenic age and the geodynamic evolutionary trends. Recently, according to the latest aeromagnetic data and deephole drilling, large concealed iron deposits, locally of high-grade, have been discovered in eastern Hebei, including the Macheng iron deposit, which is the topic of this contribution. The Macheng iron deposit, has more than 1 Bt of iron ore, and is located in the southern part of the eastern

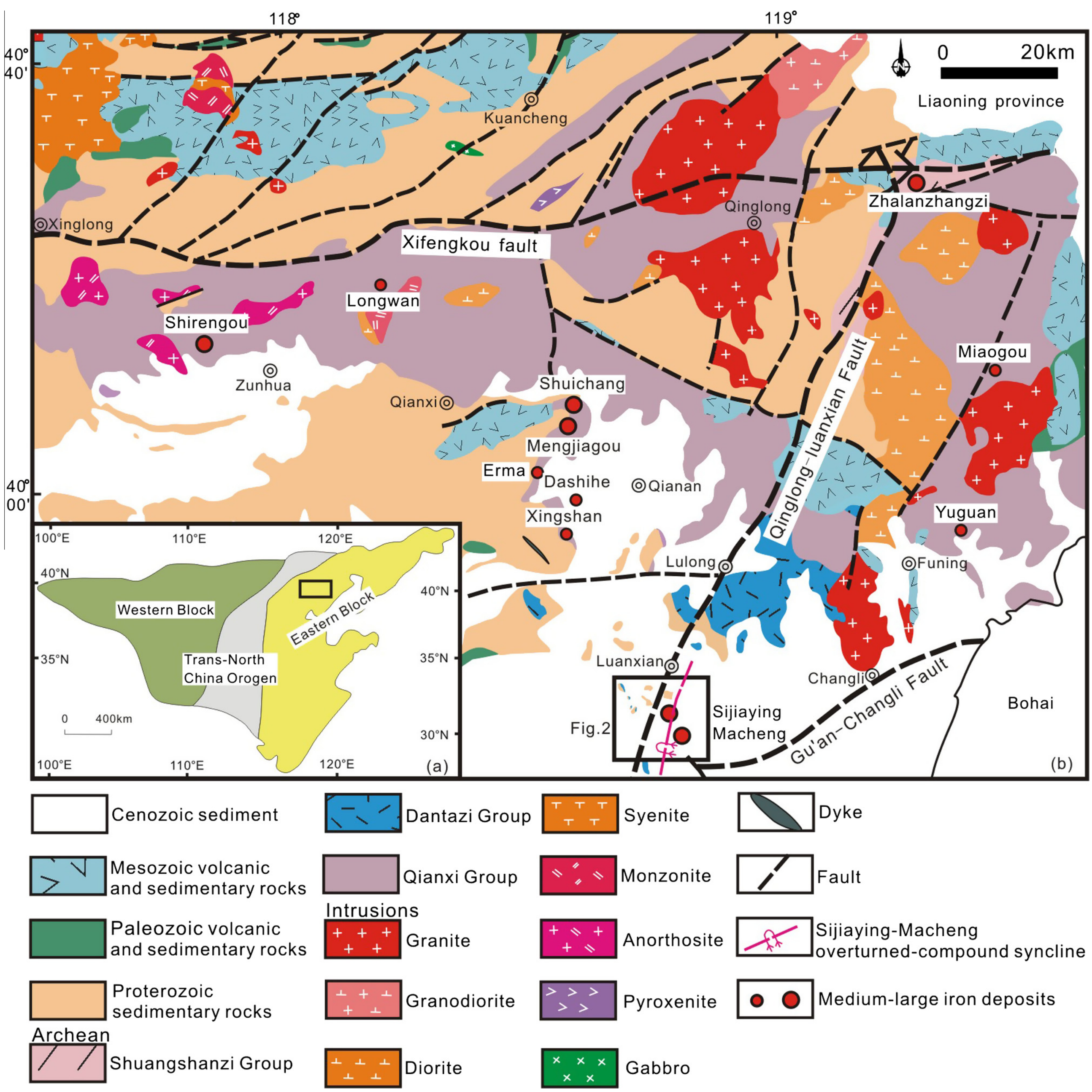

Fig. 1. Tectonic subdivisions of the North China Craton (a) (after Zhao et al., 2001) and simplified geological map of the eastern Hebei iron metallogenic belt with locations of BIF iron deposits including the Macheng deposit (b) (modified from Zhang et al., 2011).