



Preface

Iron metallogeny in China – An introduction to the special issue

1. Introduction

China is well endowed with abundant iron resources and contains most of the major known types of iron deposits in the world. The occurrence and temporal-spatial distribution of iron deposits in the country are closely related to the complex architecture and prolonged evolution of three Precambrian cratons or blocks: (1) the North China Craton (NCC), (2) the South China Block (SCB) consisting of the Yangtze Craton and Cathaysian Block that were assembled in the Neoproterozoic, and (3) the Tarim Craton. All these three Precambrian cratons or blocks are surrounded by Phanerozoic orogens resulting from multistage collisions and/or oceanic subduction (Fig. 1). Tectono-magmatic events associated with the evolution of these cratons and orogens, including rifting, accretion, stabilization, and reactivation have resulted in multiple pulses of iron mineralization ranging in time from the Neoproterozoic to the Cenozoic, with peaks in the Neoproterozoic for banded iron formation (BIF) deposits, Early Devonian to Late Carboniferous for sedimentary hematite deposits and volcanic-hosted iron deposits, Middle-Late Permian for magmatic Ti–Fe–(V) deposits, and Early Cretaceous for skarn and apatite–magnetite deposits.

There is an increasing demand for iron resources in today's China due to its rapid industrialization and robust economic development. Although China is rich in iron resources, high-grade ores have been scarce and thus China largely relies on the global market for additional supplies. In this regard, research on, and exploration for, high-grade iron ore deposits have been, and will continue to be of a major interest. Historical production of iron resources in China has been mainly from the NCC and the SCB. However, an increasing number of large-tonnage iron deposits have been discovered in western China in the last decade. In addition, large areas of western China are marked by many positive aeromagnetic anomalies that have not been fully assessed. As such, there is great potential of finding new iron resources in western China.

Although most iron deposits have been mined and extensively studied for many years, knowledge of their nature and genesis remains poorly understood. Data on the composition, age, evolution, and tectonic setting of the major types of iron deposits in China have not been widely available in western literature until recently. It is our pleasure to present this thematic issue on iron metallogeny in China, which includes some of the latest research results. The special issue consists of 22 research papers and two overviews that describe the economically most important types of iron deposits (BIF, skarn, volcanic-hosted, and magmatic Ti–Fe–(V) deposits). Contributions to this special issue deal with the most representative iron deposits from major metallogenic belts or provinces. These deposits provide a good sampling for their geologic settings, tectonic controls, metallogenic processes, and effective mineral exploration methods. The contributions contain a wealth of

information retrieved both from the latest research results as well as previously published data and syntheses.

An initial overview is provided by Zhaochong Zhang and co-authors (Zhang et al., 2013a). In this overview, the authors first outline the occurrence and distribution of iron deposits, followed by a generalization of the geological and mineralizing features of major types of iron ores in China. In combination with numerous high-precision age data obtained in the last decade due to increasing utilization of a variety of modern geochronological methods (SHRIMP, LA-ICPMS, $^{40}\text{Ar}/^{39}\text{Ar}$ laser incremental heating analysis), they are able to establish the spatio-temporal evolution of the iron deposits in China, identifying the Neoproterozoic, Late Paleozoic and Early Cretaceous as the most important periods of iron mineralization.

As is the case for other major Fe-producing provinces, banded iron formations (BIFs) are the economically most important type of iron ore, accounting for >50% of the total iron reserves in China. These deposits are found mainly in the North China Craton (Fig. 1). A striking feature is that they are dominated by the Algoma-type BIFs, in contrast to other iron belts in the world where Superior-type BIFs are dominant. Six papers by Li et al. (2013a), Hou et al. (2013a), Li et al. (2013b), Wang et al. (2013a), Xu et al. (2013), and Yu et al. (2013a) provide an in-depth discussion on the spatio-temporal distribution and genesis of the Chinese BIFs. Li et al. (2013a) concluded that most BIFs in China were initially deposited during the Neoproterozoic (ca. 2.5 Ga) in the NCC, with a few developed in Paleoproterozoic and Meso- and Neoproterozoic time in the Yangtze Craton, all having subjected to intense metamorphism and deformation during the stabilization, collision, and reactivation of the Precambrian Blocks. Hou et al. (2013a) have systematically analyzed Fe, Si, and O isotopes of some major Superior-type BIFs in the NCC, and proposed that they were precipitated from submarine hydrothermal fluids, with a negligible terrestrial contribution, within an oxygen-deficient ocean even after the Great Oxidation Event (GOE). Similarly, Li et al. (2013b) postulated that each silicon–iron cyclothem marks a single great submarine hydrothermal exhalation event.

In comparison with Precambrian Cratons elsewhere in the world, the BIF deposits in China display distinct features. They are dominated by low-grade ores, with rare high-grade varieties, and consist predominantly of magnetite rather than hematite. This most likely reflects (1) the prolonged, complex evolution of the North China Craton that has been unfavorable for the preservation of any supergene enrichment of the BIFs in the geological past, and (2) a lack of weathering-prone climatic conditions in the Cenozoic epoch. The Gongchangling deposit in Liaoning province represents one of large-sized, high-grade BIF ores. A detailed geological and geochemical study has led Wang et al. (2013a) to propose that leaching of SiO_2 during the subsequent metamorphic and tectonic stages has significantly upgraded the BIFs in structurally favorable sites.

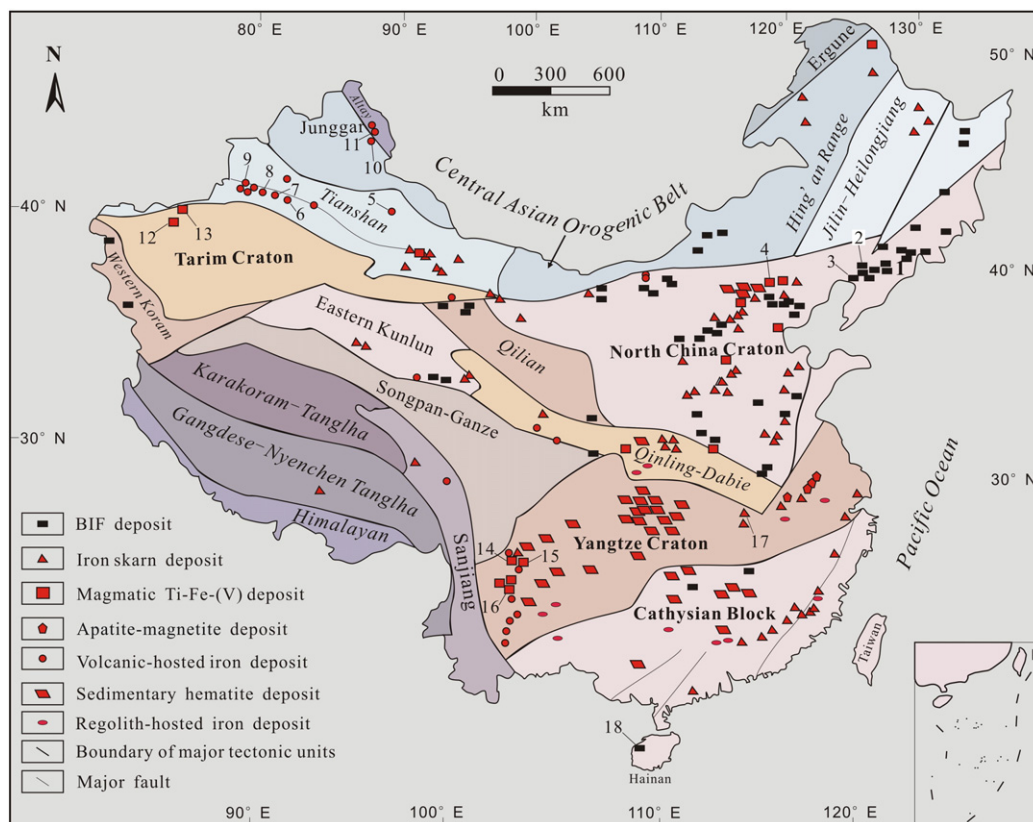


Fig. 1. Distribution of the major types of iron deposits in China (modified from Zhao et al., 2004). The regolith-hosted iron deposits are not discussed in this issue because they are economically not important, accounting for a very small (<1%) percentage of the total iron reserves in the country. The numbers in the map indicate the deposits mentioned in the text: 1-Gongchangling; 2-Qidashan; 3-Donganshan; 4-Damiao; 5-Yamansu; 6-Beizhan; 7-Dunde; 8-Zhibo; 9-Chagangnuoer; 10-Qiaoxiahala; 11-Abagong; 12-Wajilitage; 13-Puchang; 14-Taihe; 15-Pingchuan; 16-Hongge; 17-Chengchao; 18-Shilu.

The Shilu iron deposit in Hainan province, Cathaysia Block, is the only large-tonnage, high-grade hematite-dominated BIF-derived deposit in China. Its genesis has been hotly debated. Two papers in this issue provide new insight into the ore genesis. Based on petrographic and mineralogical evidence, Xu et al. (2013) proposed that the Shilu Fe deposit evolved from a precursor Neoproterozoic BIF that are dominated by sea floor-derived, pulsed high- to low-temperature Fe–Co–Cu–Si-rich hydrothermal solutions, with minor input of detrital components from seawater and fresh water-carrying continental landmasses. Yu et al. (2013a) conducted a detailed fluid inclusion and stable isotope study, and interpreted the formation of the high-grade ores at Shilu as a result of hydrothermal overprints associated with multi-stage Phanerozoic deformation and metamorphism. The addition of these new data has significantly advanced understanding of the evolution of the Shilu iron deposit. However, many aspects of the ore genesis remain unresolved and thus further investigations are still needed.

Skarn iron deposits are widespread (Fig. 1) and have been the major source of high-grade iron ores in China, accounting for >60% of the total high-grade ores of the country. These deposits are mostly clustered in several districts, including the Handan–Xingtai, Laiwu, Jinan, and Linfen districts from the North China Craton, the Daye district from the NE Yangtze Craton, and those in southern Fujian and eastern Guangdong Provinces in the Cathaysia Block. Three papers by Sun et al. (2013), Li et al. (2013c) and Hu et al. (2013) elaborate on the genesis of skarn iron deposits and ore-related magmatism from the Handan–Xingtai district and the Daye district. Li et al. (2013c) have conducted a detailed geochronological study of Fe and Cu-bearing Fe skarn deposits from Daye. The results, when combined with existing age data, reveal a prolonged magmatic and hydrothermal history lasting 25 million years from the

late Jurassic to early Cretaceous (157–132 Ma). The results also show that most large-tonnage deposits formed by repeated magmatic and hydrothermal pulses. The authors therefore suggest that episodic magmatic and hydrothermal pulses have played significant roles in the formation of the polymetallic ore deposits in the district by repeatedly supplying heat, fluids, and metals. Hu et al. (2013) provided a detailed textural and compositional characterization of magnetite from the Chengchao iron skarn deposit in Daye. They found that early-formed magnetite has been commonly altered by subsequent varieties during dissolution–reprecipitation processes. The results show that magnetite is much more susceptible to hydrothermal alteration than previously thought, and that the dissolution–reprecipitation process is critically important for the formation of skarn iron deposits, especially the high-grade and high-quality ores. The dissolution–reprecipitation processes may also reflect the episodic magmatic-hydrothermal activities as indicated by geochronological data in the Daye district (Li et al., 2013c). On the basis of systematic geochemical and Hf isotopic studies, Sun et al. (2013) proposed that the large-scale magmatism related to skarn iron mineralization in the Handan–Xingtai district in the NCC was genetically related to the delamination of the thickened lower crust during the early Cretaceous when the North China Craton was tectonically reactivated. They suggest that the ore-related intrusions in this district can be well explained by partial melting of delaminated lower crust and subsequent interactions of the crust-derived melts with the mantle peridotite.

The volcanic-hosted iron deposits, termed as “submarine volcanic iron deposits” by Chinese geologists, are the second most important source of high-grade iron ores in China. Recent discoveries of many large to medium sized volcanic-hosted iron deposits in the western Tianshan, NW China (Fig. 1), suggest great potential for exploration of

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