Ore Geology Reviews 63 (2014) 444–464

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Reprint of "Depositional environment and tectonic implications of the Paleoproterozoic BIF in Changyi area, eastern North China Craton: Evidence from geochronology and geochemistry of the metamorphic wallrocks"

Ting-Guang Lan [a,b,*], Hong-Rui Fan [a], Fang-Fang Hu [a], Kui-Feng Yang [a], Ya-Chun Cai [a], Yong-Sheng Liu [c]

[a] *Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China*
[b] *State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002, China*
[c] *State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China*

A R T I C L E I N F O

Article history:
Received 25 June 2013
Received in revised form 20 October 2013
Accepted 23 January 2014
Available online 9 June 2014

Keywords:
Banded iron formation
Metamorphic wallrock
Protolith
Paleoproterozoic
Continental rift
North China Craton

A B S T R A C T

The Changyi banded iron formation (BIF) in the eastern North China Craton (NCC) occurs within the Paleoproterozoic Fenzishan Group. Three types of metamorphic wallrocks interbedded with the BIF bands are identified, including plagioclase gneisses and leptynites, garnet-bearing gneisses and amphibolites. Protolith reconstruction suggests that the protoliths of the plagioclase gneisses and leptynites are mainly graywackes with minor contribution of pelitic materials, the garnet-bearing gneisses are Fe-rich pelites contaminated by clastics, and the amphibolites are tholeiitic rocks. Trace elements of La, Th, Sc and Zr of the plagioclase gneisses and leptynites and the garnet-bearing gneisses support that these meta-sedimentary rocks were probably derived from recycling of Archean rocks with felsic and mafic materials differentiated into different rock types. $^{207}Pb/^{206}Pb$ ages of detrital zircons from the meta-sedimentary rocks concentrate at 2.7–3.0 Ga, confirming their derivation from the Archean rocks. The presence of several Paleoproterozoic detrital zircons (2240 to 2246 Ma), however, also suggests minor involvement of Paleoproterozoic materials. The Archean detrital zircons have $\varepsilon_{Hf}(t)$ values varying from −0.7 to 7.6, which mainly fall between the 3.0 Ga and 3.3 Ga average crustal evolution lines on the age vs. $\varepsilon_{Hf}(t)$ diagram, further illustrating that the rocks providing materials for the meta-sedimentary rocks mainly originated from partial melting of a Mesoarchean crust. This is strongly supported by their crust-like trace element distribution patterns (such as Nb, Ta, P and Ti depletion) and ancient Nd depleted mantle model ages (T_{DM} = 2.9–3.4 Ga). In addition, the remarkably high $\varepsilon_{Hf}(t)$ values (7.5 to 9.3) of the Paleoproterozoic detrital zircons constrain the Paleoproterozoic materials to originate from a depleted mantle. The amphibolites show low SiO_2 (46.5 to 52.8 wt.%) and high MgO (5.68 to 10.9 wt.%) contents, crust-like trace element features and low $\varepsilon_{Nd}(t)$ values (−4.5 to −0.3), suggesting that these ortho-metamorphic rocks were mainly derived from subcontinental lithospheric mantle with some contamination by Archean crustal materials. Since an intra-continental environment was required for the formation of the above metamorphic rocks, these rocks not only confine the depositional environment of the Changyi BIF to be an intra-continental rift, but also support the rifting processes of the eastern NCC during Paleoproterozoic.

1. Introduction

As the unique product in Precambrian, the deposition of iron formation (IF) not only relates to the evolution of life, ocean and atmosphere, but also to the origin and growth of continents (Trendall, 2002). Since depositional environment is vital in controlling the lithological and mineralogical features of IF, Gross (1980) proposed a popular classification of IF into Lake Superior-type and Algoma-type. Gross (1983) considered that the Lake Superior-type hosted in clastic and carbonate sediments without obvious volcanic associations commonly developed along the margins of cratons or continental platforms, whereas the Algoma-type typically associated with volcanic rocks and graywackes occurred under more dynamic tectonic conditions, possibly comparable to present day spreading ridges on the ocean floor. However, Trendall (2002) regarded that the above classification tends to break down if a global view was taken and thus a division of IF into BIF (banded iron formation) and GIF (granular iron formation) was recommended based on lithological criteria. The principal features of GIF that differentiate it

DOI of original article: http://dx.doi.org/10.1016/j.oregeorev.2014.01.007.
* Corresponding author at: Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China. Tel.: +86 851 5603298.
E-mail address: lantingguang@126.com (T.-G. Lan).

0169-1368/$ – see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.oregeorev.2014.06.003

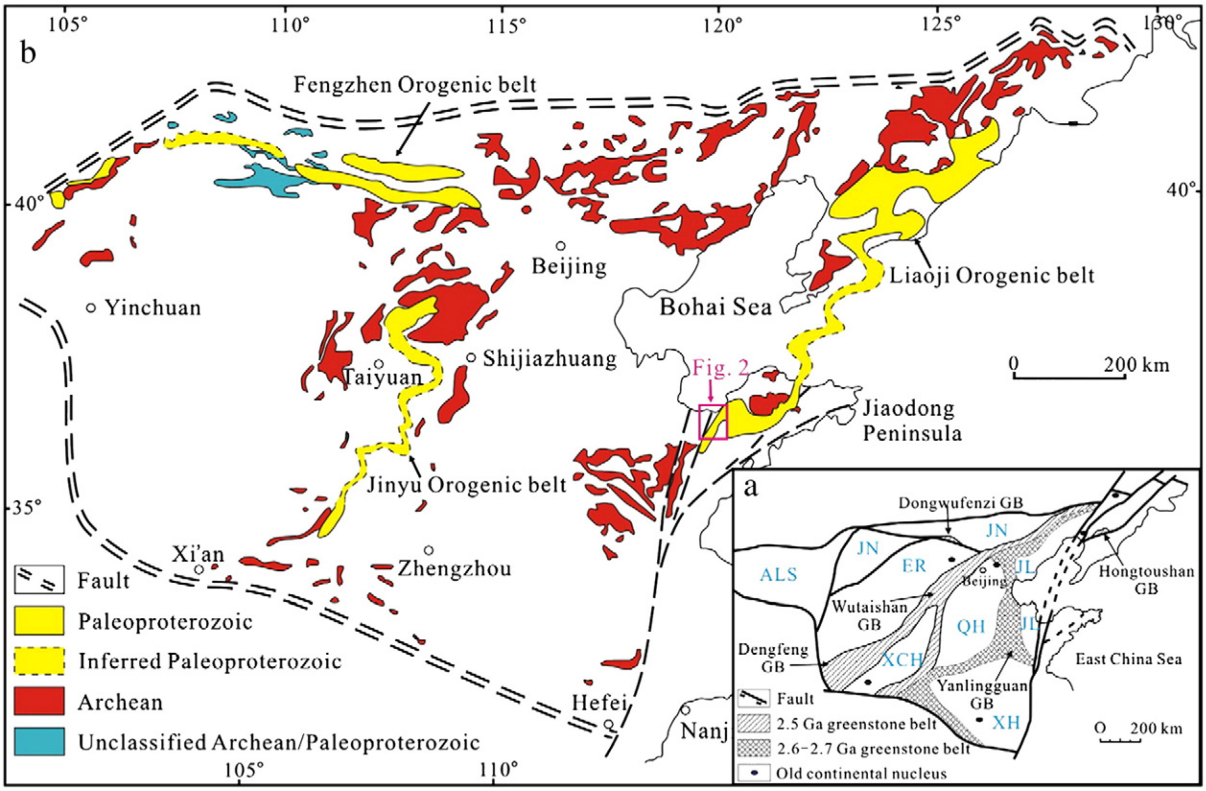

Fig. 1. (a) Sketch map of the NCC showing distribution of ancient nuclei, Archean micro-blocks and greenstone belts. (b) Distribution of Palcoproterozoic mobile belts of the North China Craton. Both (a) and (b) are modified after Zhai and Santosh (2011). JL: Jiaoliao Block; QH: Qianhuai Block; OR: Ordos Block; JN: Jining Block; XCH: Xuchang Block; XH: Xuhuai Block; ALS: Alashan Block; GB: greenstone belt.

from BIF are the granular, sandstone-like texture, the presence of current-generated structures and coarser banding, which suggest a shallow-water, high-energy environment (Trendall, 2002). No matter which division is more reasonable, both of them suggest that the IFs could occur in different depositional environments and the depositional background could be reconstructed according to their lithological associations.

BIFs have been widely found in the North China Craton (NCC), which are mostly Archean Algoma-type (Shen et al., 2005; Wan et al., 2012; Zhang et al., 2012a). Paleoproterozoic BIFs were only sporadically found with small scale in restricted areas. This distribution feature strongly contrasts with that of the BIFs around the world. Based on the statistics from Huston and Logan (2004), it is concluded that the Archean Algoma-type BIFs only occupy the majority in number, whereas the Paleoproterozoic Lake Superior-type BIFs constitute the vast abundance. The scarcity of Paleoproterozoic BIFs in the NCC, therefore, suggests that the NCC may have experienced a particular Paleoproterozoic evolutional history.

The Changyi BIF, located at the eastern NCC and mainly associated with metamorphic wallrocks of plagioclase gneisses and leptynites, garnet-bearing gneisses and amphibolites, was produced during Paleoproterozoic (2193–2240 Ma, Lan et al., 2013). As one of the rare Paleoproterozoic BIFs in the NCC, the Changyi BIF provides an important key to reveal the origin of the Paleoproterozoic BIFs and the Paleoproterozoic geological evolution of the eastern NCC. Therefore, in this paper, we report petrological, geochronological and geochemical data of the wallrocks of the Changyi BIF with a view to constrain the depositional environment of the Paleoproterozoic BIF and further to evaluate the Paleoproterozoic tectonic background of the eastern NCC.

2. Regional geology

Covering an area of about 1,500,000 km^2 and containing Archean cores of 2.5–3.8 Ga, the North China Craton (NCC) is the largest and oldest craton in China (Zhao et al., 2001). The craton is mainly composed of basements of Archean to Paleoproterozoic tonalite–trondhjemite–granodiorite (TTG) gneisses and greenschist to granulite facies volcano-sedimentary rocks (Zhao et al., 2001) covered by Paleo-Mesoproterozoic to Ordovician volcano-sedimentary rocks, Carboniferous to Permian terrestrial clastic rocks, and Mesozoic basin deposits. It has been widely accepted that the NCC formed by amalgamation of a number of micro-continental blocks (Zhai and Santosh, 2011; Zhao et al., 2012). However, the number of constituent blocks, and when and how they were assembled to form the coherent basement of the craton remain unresolved, resulting in a variety of models for the tectonic subdivision and amalgamation of the craton (Zhao et al., 2012, and references therein). At least two main models have been hotly debated in recent years. One considers that at least seven Archean micro-blocks (include the Jiaoliao, Qianhuai, Ordos, Jining, Xuchang, Xuhuai and Alashan blocks) built the basic tectonic architecture of the NCC at ca. 2.5 Ga through amalgamation (cratonization), and subsequently the NCC experienced an orogenic cycle from rifting to subduction–collision along three major Paleoproterozoic orogenic belts (termed the Fengzhen, Liaoji and Jinyu Orogenic belts) during 2350–1970 Ma with following regional high-grade metamorphism at 1950–1820 Ma (Zhai and Santosh, 2011, and references therein). The other model is remarkably different, which suggests that four micro-continental blocks (termed the Yinshan, Ordos, Longgang and Nangrim blocks) separated by three Paleoproterozoic tectonic belts (include the Khondalite Belt, Jiao-Liao-Ji Belt and Trans-North China