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A study of iron deposits in the Anshan area, China based on interactive inversion technique of gravity and magnetic anomalies

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ABSTRACT

The Anshan area in Liaoning province, Northeast China is famous for the richest banded iron formation (BIF) sources in the country. Whether they belong to volcano-sedimentary formation (Algoma-type) or sedimentary formation (Superior-type) remains controversial. Here we apply an interactive inversion technique on profile of gravity and magnetic anomalies to study the deep geological structure of the Anshan area. Combined with previous petrological and sedimentological studies on these rocks, the inversion results indicate that both Donganshan and Qidashan iron deposits consist of several syncline-shaped iron ore bodies. Among these, the majority might be considered as part of Archean and Paleoproterozoic Superior-type mineralization, whereas Algoma-type mineralization has been recognized only in the intervals during the volcanic eruption. Exploration for deep-seated iron deposits outside the Anshan area has led to the discovery of large amount of iron ores. Although the large aeromagnetic anomaly could be the signal of the buried huge iron ore bodies at depth in Anshan area, this has not been confirmed by deep drilling exploration. In order to solve this puzzle, we computed the aeromagnetic and gravity anomalies along a profile in the proven iron deposit of the Donganshan–Qidashan district. The results reveal marked contrast between the calculated and observed anomalies. Based on these results and previous studies on the metallogenic features, we predict the presence of large iron ore bodies at depth beneath the Anshan area.

1. Introduction

Banded iron formations (BIFs) represent sedimentary iron deposits formed in the early Precambrian (Eriksson et al., 2013; Trendall, 2002, and references therein), and constitute one of the major sources of iron on the globe. Based on their genesis, BIFs are subdivided into Algoma-type and Superior-type. As against the BIF iron deposits found in Russia, Brazil, Australia and India, which are primarily Superior-type, the BIF iron ores in China are generally Algoma-type, and were formed mainly in the Middle–Late Archean (2.5–2.8 Ga) (Shen et al., 2005; Zhai and Santosh, 2011, 2013; L. Zhang et al., 2011; X. Zhang et al., 2011).

The Anshan region in the Liaoning province, the northeastern part of the North China Craton (NCC), is one of the richest iron deposit areas in China. A number of large-scale iron deposits such as Qidashan, Hujiamiaozi, Xidabei, Yanqianshan, Guanmenshan, Dagushan, Heishilazi, Donganshan and Xianshan have been found within 100 km^2 in the region (Fig. 1). The iron ores discovered so far have been estimated to be more than 7 billion tons at <500 m, although several deposits contain some iron ore bodies up to 1000 m in depth.

The origin of these iron deposits remains uncertain. Several workers have suggested that the Qidashan, Hujiamiaozi and Xidabei deposits are primarily of Algoma-type, and that the protoliths of the ore-bearing layers belong to volcano-sedimentary formation (Ren et al., 2007; Wang, 1986; Wang et al., 1992; Xu and Chen, 1984; Zhai et al., 1990). The major rock types in the area are quartz mica schist, hornblende quartz gneiss and amphibolite with enclaves of biotite leptynite. The protoliths are considered to be tholeiites together with dacitic–rhyolitic volcanic rocks and minor komatiites sandwiched with silty mudstone. Also it has been proposed that the Yingtaoyuan, Guanmenshan, Yanqianshan, Dagushan, Heishilazi, Donganshan and Xianshan iron deposits are of Superior-type, and that the protoliths of the ore-bearing layers are sedimentary formation consisting of argillaceous siltstone, conglomerate and tuffaceous sedimentary rocks as represented by chlorite–phyllite–schist, andradite and black sismondite (Ren et al., 2007; Wang, 1986; Wang et al., 1992; Xu and Chen, 1984; Zhai et al., 1990) (Fig. 2). However, some other workers argued that the Yingtaoyuan, Guanmenshan, Yanqianshan, Dagushan, Heishilazi, Donganshan and Xianshan iron deposits, and the iron ore bodies at

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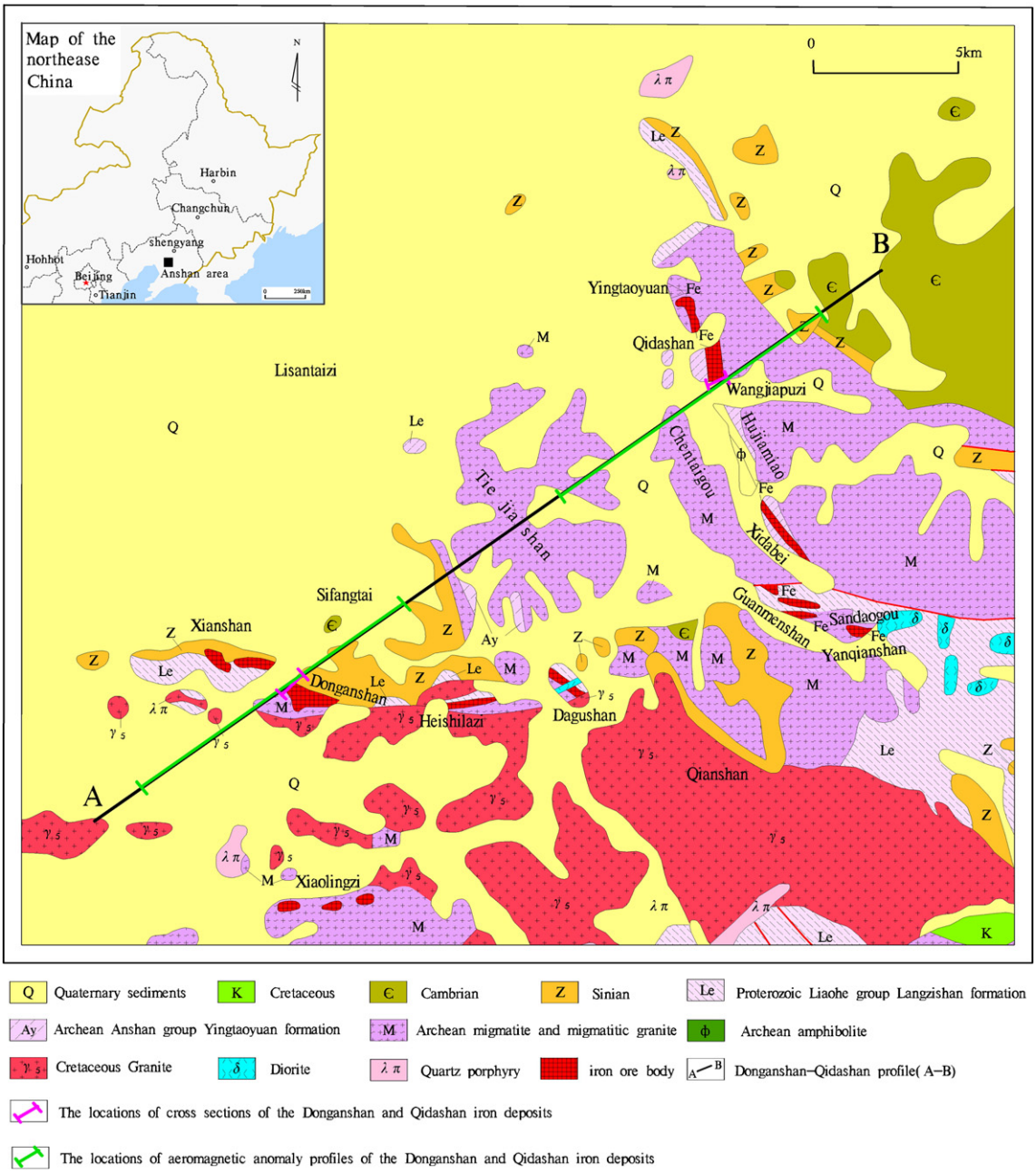

Fig. 1. Geological map of the Anshan area.
Modified from Liu, 1977.

the shallow level in the Qidashan, Hujiamiaozi, Wangjiapuzi and Xidabei iron districts belong to Superior-type mineralization, whereas those at deep level in the latter iron deposits are of Algoma-type (Jiang, 1988; Li, 1975).

Although the depth of exploration conducted so far is shallow, there are some clues to indicate the presence of greatly potential iron ores at depth in the Anshan area. Liu (1977) proposed that there were some iron ore bodies at deep level of the Yingtaoyuan, Heishilazi and Donganshan deposits. Fu et al. (2006) have suggested that the known deposits may not have appeared in their overlapping anomaly regions of 1:50,000 ΔT reduced-to-pole upwards vertical second derivative and ΔT reduced-to-pole downwards continuation, and that these regions correspond to the high Bouguer gravity anomalies mainly covered by Quaternary cover. Thus, there is a significant possibility that some potential iron deposits could be discovered in these anomaly regions, possibly with a reserve of more than 1 billion tons. In 2004, the Liaoning Metallurgical Geological Prospecting Institute conducted deep iron ore drilling in the Heishilazi area and found more than 600 million tons of iron ores (Ren et al., 2007). Through an analysis of aeromagnetic anomaly, Fan et al. (2012a) suggested that the deep levels beneath the Heishilazi, Sandaogou and Qidashan–Wangjiapuzi districts are benefit space for future prospecting. However, no quantitative estimates have so far been made.

The interactive inversion technique on profile of gravity and magnetic anomalies is a new method that can be used to infer the depth and attitude of deeply buried ore bodies through geophysical data inversion, and has been successfully applied for the prediction of several iron ore bodies (Fan et al., 2010, 2012b; Yu et al., 2007). To evaluate the possibility of deep iron ore bodies in the Anshan area, we conducted a gravity and magnetic inversion across Donganshan–