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Late Paleoproterozoic rift-related magmatic rocks in the North China Craton: Geological records of rifting in the Columbia supercontinent

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A B S T R A C T

Late Paleoproterozoic (1.84 1.62 Ga) magmatic rocks including dykes/sills/intrusions and volcanic rocks occur throughout the North China Craton (NCC), which is considered to be part of the Columbia supercontinent by ca. 1.9–1.85 Ga. On the basis of petrogeochemical data, these magmatic rocks can be classified into three major magma types: HN (Nb/La > 0.8, Ce/Nb = 1.7 3, $(Th/Nb)_N$ = 0.6 1.2), MN (Nb/La = 0.8–0.5, Ce/Nb = 3 5, $(Th/Nb)_N$ = 0.9 3.5) and LN (Nb/La < 0.5, Ce/Nb = 5 80, $(Th/Nb)_N$ = 1 60). The geochemical variation of the MN and LN rocks can be explained by lithospheric contamination of asthenosphere- (or plume-) derived magmas, whereas the parental magmas of the HN rocks did not undergo, during their ascent, pronounced lithospheric contamination. These magmatic rocks exhibit at least two characteristics: (1) most displaying a spectrum of compositions from mafic to silicic; (2) forming in an intracontinental rift setting. This Late Paleoproterozoic rift-related magmatism is the most distinguishing feature of the rifting of the Columbia supercontinent.

Contents

1. Introduction

As one of the fundamental Precambrian nuclei of Asia, the North China Craton (NCC) has recently been the focus of studies on the history of assembly, evolution and breakup of the Paleoproterozoic

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supercontinent Columbia (Zhai et al., 2000; G.C. Zhao et al., 2002a, 2003a; Zhai and Liu, 2003; Zhao et al., 2005; Kusky et al., 2007; Santosh et al., 2007a,b; Hou et al., 2008b; G.C. Zhao et al., 2009; Kusky and Santosh, 2009; Rogers and Santosh, 2009; Santosh et al., 2009a,b,c; Santosh, 2010b; Santosh et al., 2010; Meng et al., 2011; N. Li et al., 2011; S.Z. Li et al., 2011; X.P. Li et al., 2011; Yang et al., 2011; Zhai and Santosh, 2011; Zhao et al., 2011; Hou, 2012; Chen et al., 2013; Deng et al., 2013) (Figs. 1 and 2).

Late Paleoproterozoic (1.84 1.62 Ga) magmatic rocks including dykes/sills/intrusions and volcanic rocks, which occur throughout the NCC (Figs. 3 and 4), have attracted a number of recent studies (Xia et al., 1990, 1991; Lu and Li, 1991; Li et al., 1995; Halls et al., 2000; Ren et al., 2000; Hou et al., 2001; Li et al., 2001; T.P. Zhao et al., 2001, 2002a,b, 2004a,b; Peng et al., 2004; Wang et al., 2004; Peng et al., 2005; Pirajno and Chen, 2005; Shao et al., 2005; Yang et al., 2005; Hou et al., 2006a,b; Peng et al., 2006, 2007; Han et al., 2007; J. Zhang et al., 2007; S.H. Zhang et al., 2007; Xu et al., 2007; Wang et al., 2007a,b, 2008; He et al., 2008; Hou et al., 2008a,b; Peng et al., 2008; He et al., 2009; G.C. Zhao et al., 2009; T.P. Zhao et al., 2009; He et al., 2010a,b; Peng, 2010; Wang et al., 2010; Cui et al., 2011; Hou, 2012).

The petrogenesis and tectonic affiliations of these rocks in the NCC are still controversial. Some have considered that they are products of intraplate magmatism attributed to mantle plumes or a mantle superplume that caused rifting and fragmentation of the Columbia supercontinent (Sun et al., 1981; Qian and Chen, 1987; Zhang, 1989; Xia et al., 1990, 1991; Halls et al., 2000; Zhai et al., 2000; Hou et al., 2001; T.P. Zhao et al., 2002a,b; Kusky and Li, 2003; Peng et al., 2004, 2005; Pirajno and Chen, 2005; Hou et al., 2006a,b; Peng et al., 2006, 2007; Xu et al., 2007; Hou et al., 2008a,b; Peng et al., 2008; Peng, 2010; Wang et al., 2010; Cui et al., 2011; Hou, 2012). Others have proposed that these rocks were formed in either subduction/collision (Wang et al., 2004, 2007a,b, 2008) or a continental magmatic arc (Jia, 1985; Hu and Lin, 1988; Chen et al., 1992; G.C. Zhao et al., 2003a; He et al., 2008, 2009; G.C. Zhao et al., 2009; He et al., 2010a, b; Zhao et al., 2011) environments.

This paper, in aiming to test the proposed Late Paleoproterozoic mantle plume or superplume hypothesis, presents a brief synthesis of the distribution, age, and petrogeochemical data of the Late Paleoproterozoic magmatic rocks from the NCC and reassesses the nature, tectonic setting and petrogenesis of this magmatic suite.

2. Geological background

2.1. Supercontinent Columbia

Perhaps the first coherent supercontinent in earth history is the Paleoproterozoic supercontinent called Columbia by Rogers (2000) (Santosh et al., 2009a). The existence of a Paleo Mesoproterozoic supercontinent was first speculated by Piper (1976) largely based on paleomagnetic data. The term Nuna was applied by Hoffman (1989) to describe the Paleoproterozoic amalgam of North American terranes. The pre-Rodinian history of continental assembly is less well understood and thus different reconstructions of the Paleo Mesoproterozoic supercontinent have been proposed such as Paleopangaea (Piper, 2000), Hudson (Zhao et al., 2000c), Columbia (Rogers, 2000; G.C. Zhao et al., 2002a; Rogers and Santosh, 2002), and Hudsonland (Pesonen et al., 2003).

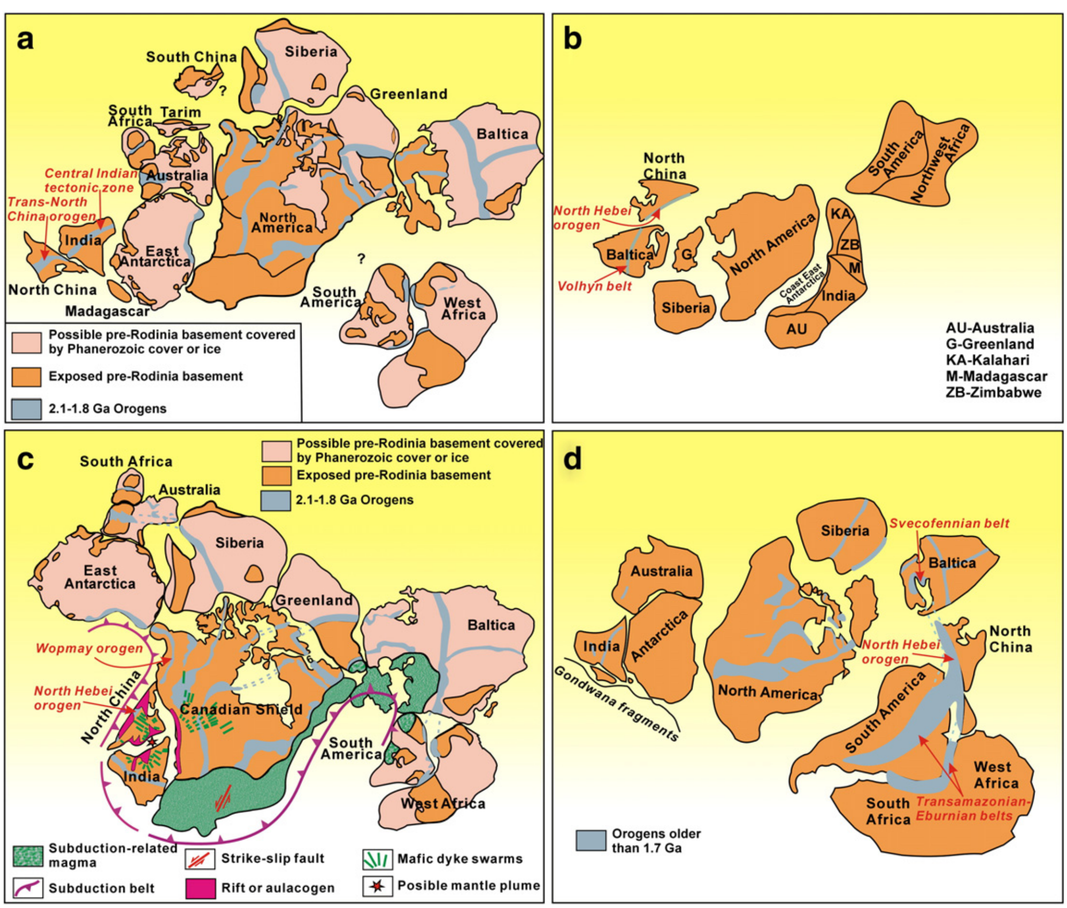

Fig. 1. The proposed Paleo-Mesoproterozoic supercontinent Columbia, configured by (a) G.C. Zhao et al. (2002a, 2004), (b) by Rogers and Santosh (2002, 2009), (c) by Hou et al. (2008b) and (d) by Kusky and Santosh (2009).