Lithos 205 (2014) 185–207

Contents lists available at ScienceDirect

Lithos

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

Crust/mantle interaction during the construction of an extensional magmatic dome: Middle to Late Jurassic plutonic complex from western Liaoning, North China Craton

Xiaohui Zhang [a,*], Lingling Yuan [a,b], Simon A. Wilde [c]

[a] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[b] University of Chinese Academy of Sciences, Beijing 100039, China
[c] Department of Applied Geology, Curtin University, Perth, WA 6845, Australia

ARTICLE INFO

Article history:
Received 2 April 2014
Accepted 10 July 2014
Available online 21 July 2014

Keywords:
Middle–Late Jurassic
Calc-alkaline batholith
Petrogenesis
Crust–mantle interaction
North China Craton

ABSTRACT

Differentiating magmatic doming and low-angle normal faulting remains critical for fully understanding the thermal, mechanical and chemical evolution of continental landmasses under extension. This zircon U–Pb dating and geochemical study documents two Middle to Late Jurassic batholiths (Lüshan and Haitangshan) from the Yiwulüshan range of western Liaoning, North China Craton. They consist of a variety of lithologies including gabbro, diorite, granodiorite, monzogranite, together with microgranular magmatic enclaves (MME) and mafic dykes. Synthesizing petrologic, elemental, whole-rock Sr–Nd and zircon Hf isotopic data leads to the characterization of multiple mafic and felsic end-members and their concomitant interaction in building the magmatic dome. A subduction-related metasomatized lithospheric mantle source is fingerprinted by the gabbroic to dioritic rocks with enriched large ion lithophile elements, depleted high field strength elements and heterogeneous isotopic compositions ($^{87}Sr/^{86}Sr_i = 0.70541$ to 0.70577, $\varepsilon_{Nd}(t) = -1.78$ to -5.54 and zircon $\varepsilon_{Hf}(t) = -6.0$ to 8.1). One felsic magma end-member of ancient mafic lower crustal parentage is discernable from adakitic granites with high Sr/Y and evolved isotopic composition ($^{87}Sr/^{86}Sr_i = 0.70533$ to 0.70792, $\varepsilon_{Nd}(t) = -18.8$ to -21.7, zircon $\varepsilon_{Hf}(t) = -18.5$ to -28.8), whereas another felsic magma end-member of newly underplated crustal heritage manifests itself from some monzogranites with non-adakitic elemental affinity and juvenile isotopic composition ($^{87}Sr/^{86}Sr_i = 0.70429$ to 0.70587, $\varepsilon_{Nd}(t) = -4.47$ to -5.87, zircon $\varepsilon_{Hf}(t) = 4.3$ to 1.3). Hybridization processes between mantle-derived mafic magma and ancient crustal-derived felsic magma result in the formation of MME-bearing granodiorites with intermediate isotopic signatures ($^{87}Sr/^{86}Sr_i = 0.70491$ to 0.70499, $\varepsilon_{Nd}(t) = -15.3$ to -15.8, zircon $\varepsilon_{Hf}(t) = -12.7$ to -17.4). Subsequent fractional crystallization of the hybridized magmas endows the differentiated monzogranites with low Sr/Y and highly evolved isotopes ($^{87}Sr/^{86}Sr_i =$ 0.70496 to 0.70605, $\varepsilon_{Nd}(t) = -16.0$ to -18.7, zircon $\varepsilon_{Hf}(t) = -14.3$ to -21.5). Apart from distinguishing Middle–Late Jurassic extensional magmatic doming from Early Cretaceous detachment faulting, this complex mafic–felsic magma association encapsulates a multi-level crust/mantle interaction leading to lithospheric thinning and concomitant crustal architectural reorganization in the Yanshan belt during the Late Mesozoic. Near-synchronization of a two-stage extensional pattern in the Yanshan belt and even across NE continental Asia accords well with gravitational collapse and convective removal of lithospheric mantle within an evolved post-collisional to within-plate extensional regime.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Metamorphic core complexes (MCCs) and extensional gneiss domes are crustal-scale structures that develop during extension and exhumation of thickened and thermally mature crust (Coney, 1980; Whitney et al., 2004). Their common spatial and temporal association indicates that they are genetically linked at some stage in their exhumation history. Gneiss domes, a term coined by Eskola (1949) to describe structural domes cored primarily by foliated metamorphic or plutonic rocks, have been widely documented in orogenic systems of various ages and tectonic settings (Teyssier and Whitney, 2002; Whitney et al., 2004; Yin 2004). Typical Phanerozoic examples occur in the Himalaya, the North American Cordillera, the Alps, the Hercynian/Variscan belt in Europe, the Bering Sea region, the Appalachians, as well as in the Greenland and Ireland Caledonides (Whitney et al., 2004 and references therein). In the past 30 years since the discovery of extensional detachment faults, the disproportionate number of studies on the mechanism of

* Corresponding author at: State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, P.O. Box 9825, Beijing 100029, China. Tel.: +86 10 82998540.
E-mail address: zhangxh@mail.iggcas.ac.cn (X. Zhang).

http://dx.doi.org/10.1016/j.lithos.2014.07.006
0024-4937/© 2014 Elsevier B.V. All rights reserved.

detachment faulting have obscured the difference between gneiss domes and MCCs and thus overshadowed the thermal and mechanical significance of gneiss domes in orogeny (Whitney et al., 2004). However, they are distinct structures, and the doming phase and the low-angle normal faulting phase are not necessarily equivalent even in MCCs with footwalls entirely comprised of structural domes (Fayon et al., 2004). Clarifying this distinction is critical for obtaining a full picture of the thermal, mechanical and chemical evolution of extended continental landmasses. Nevertheless, this discrimination is not always straightforward. This largely results from the polarized views on the relationship between MCC formation and plutonic activity as documented for instance in those of the Basin and Range Province (Coney, 1980; Liu, 2001), the Canadian Cordillera (e.g. Foster et al., 2001; Vanderhaeghe, 1999) and the Mediterranean Region (Caby et al., 2001; Denèle et al., 2011; Erkül and Erkül, 2012). Numerous case studies and numerical modeling have stressed the importance of prior magmatic doming in triggering the detachment (Brun et al., 1994; Foster et al., 2001; Lister and Baldwin, 1993; Tirel et al., 2008; Vanderhaeghe and Teyssier, 2001), whereas a few other studies documented dome formation as being a consequence of displacement along the detachment fault (Brichau et al., 2008; Denèle et al., 2011; Koyi and Skelton, 2001). The key to making this distinction lies not only in the nature of the magmatic rocks that may record the protracted mafic and felsic magma interaction during magmatic doming and detachment faulting stages, but also in the adoption of an integrated strategy in fully characterizing these complex crust–mantle interactions.

With a distance of ~2500 km from the Mogul–Okhotsk suture to the Pacific margin and an areal extent of over 3,000,000 km^2 (Fig. 1), a huge crustal extensional province of Late Mesozoic age has been recognized in northeast Asia (T. Wang et al., 2011; W. Wang et al., 2011; Wang et al., 2012 and references therein). This includes a series of MCCs, as documented in areas from the Transbaikalia region (e.g., Donskaya et al., 2008; Zorin, 1999) across the Sino-Mongolia border tract (Webb et al., 1999; Zheng et al., 1991) to the North China Craton (NCC) (e.g., B. Zhang, et al., 2012; Charles et al., 2011; Darby et al., 2004; Davis and Darby, 2010; Davis et al., 1998, 2002; Lin et al., 2013; T. Wang et al., 2011; W. Wang et al., 2011; Wang et al., 2012; Zhang et al., 2002). As opposed to the intense interest in depicting Early Cretaceous extension along the detachment faults during the past decade (T. Wang et al., 2011; W. Wang et al., 2011 and references therein), only a few recent studies noted the middle–lower crustal fabrics as recorded by pre- to syn-kinematic intrusions (B. Zhang et al., 2012; Charles et al., 2011; Daoudene et al., 2012; Wang et al., 2012). However, what is critically needed is a case study that includes a multi-faceted approach and a complex combination of mafic and felsic magmatic rocks.

An excellent opportunity arises from the Yiwulüshan range of western Liaoning along the northern NCC (Fig. 1b). On the one hand, recent studies have established it as being a typical MCC (B. Zhang, et al., 2012; Darby et al, 2004; Lin et al., 2013; T. Wang et al., 2011; W. Wang et al., 2011; Wang et al., 2012; Zhang et al., 2002). On the other hand, the area hosts a whole spectrum of mafic and felsic intrusions with poor geochemical characterization. In this contribution, we present an integrated geochronologic, petrological, elemental, whole rock Sr–Nd and zircon Hf isotopic study of a Middle–Late Jurassic plutonic complex from the Yiwulüshan range with the aim of (1) constraining the emplacement ages of the various rock types; (2) describing their mineralogical and geochemical variations; (3) tracing their sources and characterizing the petrogenesis of the main rock types; and (4) discerning the nature of crust/mantle interaction during the construction of the magmatic dome and identifying the inherent geodynamic processes involved.

2. Geological background

The NCC is generally divided into two Archean continental blocks (Eastern and Western) and an intervening Trans-North China orogenic belt (Zhao et al., 2001). These two blocks are considered to have collided to form a coherent craton at ~1.85 Ga (Zhao et al., 2001). The craton features a basement of dominantly Archean to Paleoproterozoic tonalitic–trondhjemitic–granodioritic (TTG) gneisses and meta-volcanic and sedimentary rocks. Post-cratonization cover sequences include a Mesoproterozoic clastic sedimentary succession, Cambrian to Middle Ordovician marine sedimentary rocks, Carboniferous–Permian continental clastic rocks and Mesozoic basinal deposits (Zhao et al., 2001).

The east–west trending Central Asian Orogenic Belt (CAOB) lies to the north of the NCC and represents a huge accretionary orogen, and includes micro-continents, island arcs, oceanic islands, accretionary wedges, seamounts and ophiolitic complexes (Windley et al., 2007; Xiao et al., 2003). Along its eastern segment is the northern China–Mongolia tract, with the Solonker suture zone being the most prominent tectonic feature (Jian et al., 2010; Xiao et al., 2003), marking the final closure of the Paleo-Asian Ocean between the NCC and the southern Mongolia terranes and in turn establishing the combined North China–Mongolian plate (Davis et al., 2001; Zhang et al., 2010a).

Extending from southern Inner Mongolia through the Beijing Municipality and Hebei Province to northern and western Liaoning Province, the northern NCC is tectonically equivalent to the Yinshan–Yanshan orogenic belt (Davis et al., 2001) (Fig. 1a). It was a convergent plate margin during the Paleozoic and witnessed episodic magmatic activities, including Devonian alkali intrusions (Zhang et al., 2010b), Carboniferous calc-alkaline intrusions (Zhang et al., 2009a,b) and appinitic suites with ages ranging from 325 to 300 Ma (X. Zhang et al., 2012a), Early Permian mafic–ultramafic complexes and high-K calc-alkaline granitoids (Zhang et al., 2009a,b, 2011), and Late Permian to Early Triassic calc-alkaline to alkaline intrusions with ages from 254 to 237 Ma (Zhang et al., 2009a,b, 2010a). The Early Mesozoic saw the establishment of a post-orogenic extensional regime in the region subsequent to the final closure of the Paleo-Asian Ocean (Meng et al., 2014; Zhang et al., 2009a,b), with the occurrence of numerous Middle to Late Triassic mafic–ultramafic complexes (Niu et al., 2012) and ferroan intrusions (X. Zhang et al., 2012b). Following this period of extension there were multiple intra-continental tectono-magmatic events, with two episodes of contraction manifested by regional Jurassic unconformities (ca. 180 and 160 Ma) and cross-cutting relationships (Davis et al., 2001). In the Early Cretaceous, the orogenic fabric of the region was overprinted by widespread extensional features in the form of multiple MCCs (Davis et al., 2001) and rift basins (Meng et al., 2003).

Western Liaoning occupies the eastern segment of the northern NCC (Fig. 1a, b). The basement therein comprises Archean to Paleoproterozoic gray gneisses and greenstones of the Jianping Complex and Neoproterozoic low-grade metamorphic to unmetamorphosed rock sequences of the Changcheng System. The Jianping Complex records a major magmatic event from 2590 to 2490 Ma and granulite facies metamorphism at ca. 2490 Ma (W. Wang et al., 2011). With sporadic distribution of Carboniferous to Permian marine to continental volcano-sedimentary sequences in the northern part, Western Liaoning records episodic plutonism and volcanism as well as alternating compressional and extensional events during the Mesozoic. Recent studies have identified four pulses of intrusive and extrusive activities (e.g., Gao et al., 2004, 2008; Yang and Li, 2008; Zhang et al., 2003). The intrusive events include a Late Triassic dioritic stock (Wu et al., 2006a), 180–190 Ma granitic plutonism (Wu et al., 2006a), a 170–150 Ma plutonic complex, minor Early Cretaceous granite (Wu et al., 2006a) and scattered mafic

Fig. 1. (a) Tectonic map showing the major units of North China Craton and surrounding areas, with the study area indicated by a rectangle. Dashed lines within the Mesozoic sedimentary basins are the trends of Jurassic–Cretaceous extensional faults. (b) Simplified geological map of the Yiwulüshan range, western Liaoning Province, showing major structures and plutons. LB = Lüshan batholith; HB = Haitangshan batholith. BZ = Beizhen; FX = Fuxin; YX = Yixian; JZ = Jinzhou. MCC = metamorphic core complex.
Panel a is modified from Davis et al. (2001). Panel b is from Darby et al. (2004).

Download English Version:

https://daneshyari.com/en/article/4715833

Download Persian Version:

https://daneshyari.com/article/4715833

Daneshyari.com