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Origin of LateTriassic high-Mg adakitic granitoid rocks from the Dongjiangkou area, Qinling orogen, central China: Implications for subduction of continental crust

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ABSTRACT

The origin of high-Mg adakitic granitoids in collisional orogens can provide important information about the nature of the lower crust and upper mantle during the orogenic process. Late-Triassic high-Mg adakitic granite and its mafic enclaves from the Dongjiangkou area, the Qinling orogenic belt, central China, were derived by partial melting of subducted continental crust and underwent interaction with the overlying mantle wedge peridotite. Adakitic affinity of the different facies of the Dongjiangkou granite body are: high Sr, Ba, high La/Yb and Sr/Y, low Y,Yb, Yb/Lu and Dy/Yb, and no significant Eu anomalies, suggesting amphibole + garnet and plagioclase-free restite in their source region. Evolved Sr-Nd-Pb isotopic compositions [$(^{87}Sr/^{86}Sr)_i = 0.7050$ to $0.7055, \varepsilon_{Nd}(t) = -6.6$ to -3.3; $(^{206}Pb/^{204}Pb)_i = 17.599$ to 17.799, $(^{207}Pb/^{204}Pb)_i = 15.507$ to 15.526, $(^{208}Pb/^{204}Pb)_i = 37.775$ to 37.795] and high K_2O, Rb, together with a large variation in zircon Hf isotopic composition ($\varepsilon_{Hf}(t) = -9.8$ to $+5.0$), suggest that the granite was derived from reworking of the ancient lower continental crust. CaO, P_2O_5, K_2O/Na_2O, Cr, Ni, Nb/Ta, Rb/Sr and Y increase, and SiO_2, Sr/Y and Eu/Eu* decrease with increasing MgO, consistent with interaction of primitive adakitic melt and overlying mantle peridotite. Zircons separated from the host granites have U-Pb concordia ages of 214 ± 2 Ma to 222 ± 2 Ma, compatible with exhumation ages of Triassic UHP metamorphic rocks in the Dabie orogenic belt. Mafic microgranular enclaves and mafic dykes associated with the granite have identical zircon U-Pb ages of 220 Ma, and are characterized by lower SiO_2, high TiO_2, Mg# and similar evolved Sr-Nd-Pb isotopic composition. Zircons from mafic microgranular enclaves (MMEs) and mafic dykes also show a large variation in Hf isotopic composition with $\varepsilon_{Hf}(t)$ between -11.3 and $+11.3$. It is inferred that they were formed by partial melting of enriched mantle lithosphere and contaminated by the host adakitic granite magma.

In combination with the regional geology, high-Mg# adakitic granitoid rocks in the Dongjiangkou area are considered to have resulted from interaction between subducted Yangtze continental crust and the overlying mantle wedge. Triassic continental collision caused detachment of the Yangtze continental lithosphere subducted beneath the North China Craton, at ca. 220 Ma causing asthenosphere upwelling and exhumation of the continental crust. Triassic clockwise rotation of the Yangtze Craton caused extension in the Dabie area which led to rapid exhumation of the subducted continental lithosphere, while compression in the Qinling area and high-P partial melting (amphibole ± garnet stability field) of the subducted continental crust produced adakitic granitic magma that reacted with peridotite to form Mg-rich hybrid magma.

1. Introduction

The geochemistry of many granites in post-collisional continental–continental orogens is characterized by an adakitic signature, i.e., high Sr, low Y and HREE concentration (e.g. Q. Zhang et al., 2001; Chung et al., 2003; Wang et al., 2006), and they have been termed "C (continental)-type adakite" granite (Q. Zhang et al., 2001). The petrogenesis of these adakitic granites is a key to understanding the nature of the orogenic lower crust and the dynamic process of continental collision. However, the meaning of the "adakitic signatures" of these granites is still a matter of debate (Moyen, 2009). Some workers have argued that adakitic granites were formed by partial melting of thickened lower continental crust to produce a high-P (1.5 to 2 GPa) garnet-rich, plagioclase-free restite (Rapp and Watson, 1995; Petford and Atherton, 1996; Q. Zhang et al., 2001). Others, e.g., Moyen (2009), consider that because the continental crust has higher Sr/Y ratios (15 to 20) than oceanic crust, high pressures are not necessary for the formation of high Sr/Y adakitic rocks, especially

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when their source rocks are aluminum-rich sediments. Typical MORB have Mg# of ~60 (Taylor and McLennan, 1995), melts derived from MORB have Mg#<45 (Rapp and Watson, 1995), and intermediate to felsic adakitic rocks that have Mg# >45 are generally termed high-Mg# adakitic rocks. These are considered to have been produced by reaction with mantle peridotite (Rapp et al., 1999). Therefore, the presence of high-Mg adakitic granitic rocks in continental collision orogens (Xu et al., 2002a; Gao et al., 2004) could provide evidence for crustal recycling in the mantle lithosphere and the contribution of mantle components to their petrogenesis. Some workers consider that melts derived from ancient mafic lower continental crust (eclogite) that foundered into convecting mantle, subsequently melted and interacted with peridotite (Xu et al., 2002a; Gao et al., 2004) can explain the formation of high-Mg# adakitic granites in intracontinental setting. In addition, ion microprobe analyses of clinopyroxene phenocrysts in 'primitive' adakites in the Yanji area of northeastern China (Guo et al., 2007) suggest that magma mixing between primitive adakitic magma and melts from the lithospheric mantle can account for the genesis of high-Mg# andesite. Identifying the magmatic process is therefore crucial before the petrogenetic or geodynamic significance of these rocks can be fully appreciated.

The Qinling-Dabie orogen is a major tectonic feature in central China. Triassic collision between the North China and Yangtze cratons along the Mianlue suture caused extensive deformation that led to final amalgamation of the two continental blocks (G.W. Zhang et al., 2001; Meng and Zhang, 2000; Lai et al., 2004a,b, 2008). This continental collision formed the Dabie orogen that contains the largest Triassic ultrahigh-pressure (UHP) metamorphic terrane in the world (Zheng, 2008, and references therein) in the eastern part, and the Qinling orogen that contains abundant Late-Triassic granitoids exposed as a ca. 400 km-long belt along the Mianlue suture in the western part (Fig. 1b). This petrological contrast may imply a particular dynamics during the Triassic continental collision. Exhumation of UHP rocks in the Dabie orogen is generally considered to be the result of slab-breakoff following the continental collision (Li et al., 2002; Zheng, 2008). However, the petrogenesis of Triassic granites in the Qinling orogen remains controversial. G.W. Zhang et al. (2001) argue that the granites are subduction-related. The granites have zircon U-Pb ages of 205 to 220 Ma (Sun et al., 2002; Qin et al., 2007, 2008a,b), slightly younger than the peak UHP metamorphic ages of 240 to 225 Ma (Zheng et al., 2003; Wan et al., 2005), implying that they formed in a post-collisional setting.

In this paper, we present new zircon U-Pb ages and Hf isotopes data, element and isotope geochemistry for a zoned Triassic granite body in the Dongjiangkou area of the Qinling orogen, central China. The granites have a high-K, calc-alkaline affinity and a high-Mg# adakitic signature, suggesting that they could have been derived from partial melting of continental crust amphibolite, with subsequent interaction of melt and peridotite to account for their high Mg# values. The Dongjiangkou high-Mg# adakitic granite also provides

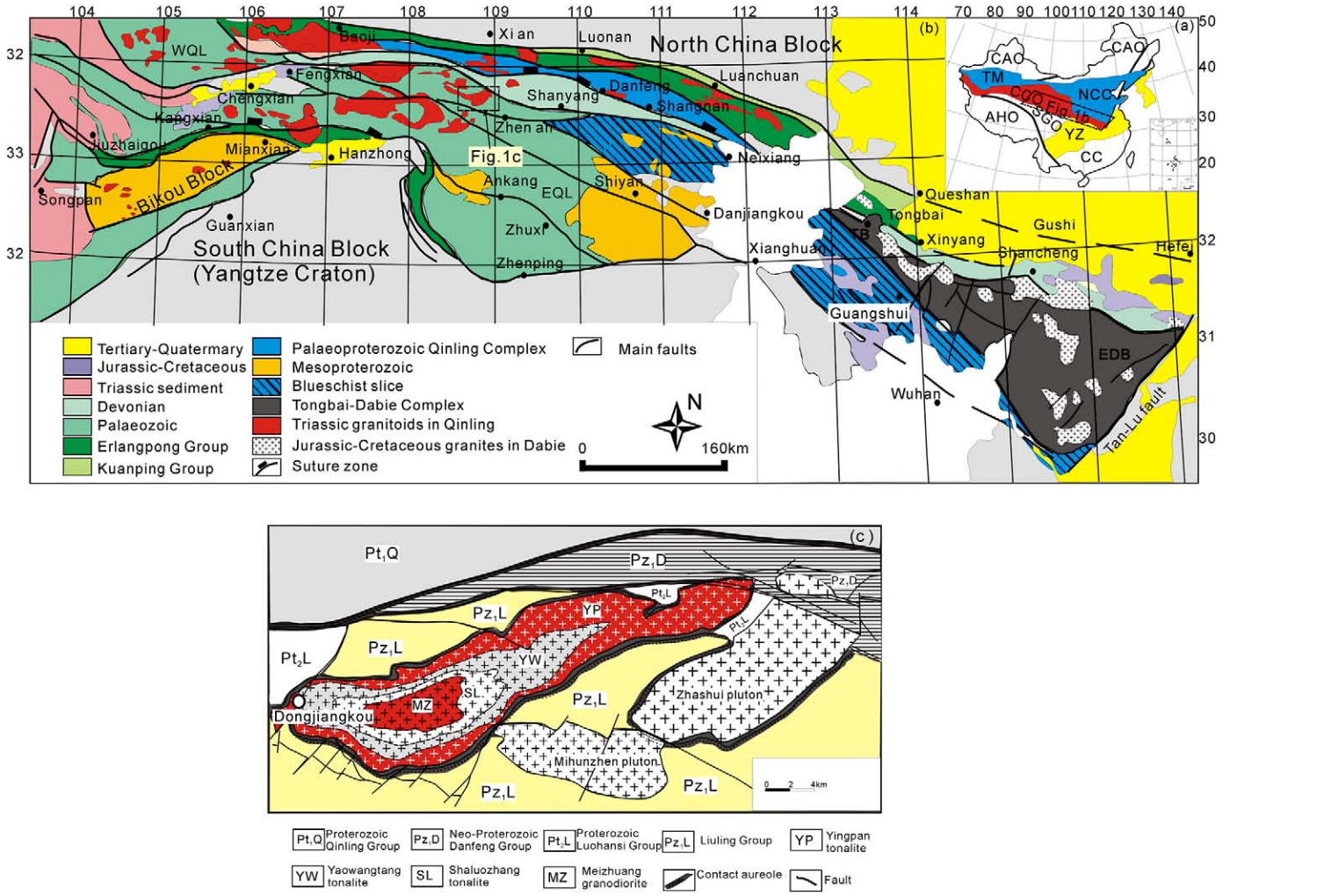

Fig. 1. (a) Simplified geological map of China, showing major tectonic units (after Li et al., 2006); (b) geological map of the Qingling–Dabie orogen (after Li et al., 2006); and (c) geological map of the Dongjiangkou area, South Qinling. Inset shows location of study area. Abbreviations in inset in Fig. 1a are: NCC, North China Craton; TM, Tarim terrane; CAO, Central Asia orogen; SGO, Songpan Ganzi orogen; CCO, Central China orogen; YC, Yangtze Craton; CC, Cathaysia Craton; AHO, Alpine–Himalaya orogen.