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Journal of Asian Earth Sciences 27 (2006) 230–240

Journal of Asian Earth Sciences

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Mesozoic adakitic rocks from the Xuzhou–Suzhou area, eastern China: Evidence for partial melting of delaminated lower continental crust

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Received 20 July 2004; revised 15 February 2005; accepted 23 March 2005

Abstract

Adakitic rocks in the Xuzhou–Suzhou area, eastern China, consist of dioritic and monzodioritic porphyries and were dated at 131–132 Ma by the SHRIMP U–Pb zircon method. These rocks have high MgO content (1.47–5.73%), high $Mg^{\#}$ values (0.49–0.61), and high La/Yb and Sr/Y ratios. These features are similar to rocks derived from partial melting of a subducted oceanic slab. However, their high initial $^{87}Sr/^{86}Sr$ (0.7053–0.7075) and low $\varepsilon_{Nd}(t)$ values (−4.43 to −13.14) are inconsistent with the origin from slab melting. These rocks often contain garnet residual crystals and eclogite, garnet clinopyroxenite, and garnet amphibolite xenoliths. Petrographical characteristics and estimated P–T conditions of these xenoliths indicate that they were once deeply subducted and subsequently underwent rapid exhumation in the early Mesozoic. Garnet residual crystals from the porphyries show similar chemical compositions to garnets from garnet clinopyroxenite and garnet amphibolite xenoliths. Ages of the inherited zircons of the xenoliths and their host rocks likely indicate that sources for the adakitic magma and protoliths of the eclogite and garnet clinopyroxenite xenoliths in the study area were from Precambrian basement of the North China Craton. The data also suggest that the lower continental crust in the eastern North China Craton was thickened during the early Mesozoic and delaminated in the early Cretaceous. The high-Mg adakitic magma resulted from partial melting of this delaminated lower continental crust and its subsequent interaction with the mantle during upward transport, leaving garnet as the residual phase.
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Keywords: Adakite; Xenolith; Delaminated continental crust; Partial melting; Eastern China

1. Introduction

It is known that adakites can be produced by partial melting of the subducted oceanic slab (termed 'slab melting', Defant and Drummond, 1990) in subduction zones. Nevertheless, alternative models for the petrogenesis of adakites have also been proposed, e.g. melting at the base of tectonically thickened crust (Atherton and Petford, 1993; Barnes et al., 1996; Kay and Kay, 2002), assimilation-fractional crystallization (AFC) processes involving a basaltic magma (Castillo et al., 1999), and partial melting of the underplated basaltic lower crust (Rapp et al., 2002) or delaminated lower continental crust (Xu et al., 2002a; Gao et al., 2004). Experimental studies have also suggested that melting of mafic material produces adakitic magmas at about 1.2 GPa pressure, with the residual phase containing garnet but no plagioclase (Rapp and Watson, 1995; Rapp et al., 1999, 2002). Although most well-known adakites are distributed in intraoceanic island arc settings and continental arcs, such as the Andes (Atherton and Petford, 1993; Barnes et al., 1996; Kay and Kay, 2002; Rapp et al., 2002), adakitic rocks within cratons have also been reported, such as those from eastern China (Zhang et al., 2001; Pan et al., 2001; Xu et al., 2001, 2002a; Gao et al., 2004). It is still controversial whether partial melting of the lower continental crust can produce adakitic magma along continental margin or continent–continent collisional tectonic settings.

In this paper, we present petrological, geochemical, and Nd–Sr isotopic data for adakitic rocks and their eclogite xenoliths exposed in the Xuzhou–Suzhou area and further propose a genetic model for these adakitic intrusive rocks.

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1367-9120/$ - see front matter © 2005 Published by Elsevier Ltd.
doi:10.1016/j.jseaes.2005.03.005

2. Geological setting

The Xuzhou–Suzhou area is located along the southeastern margin of the North China Craton (NCC), about 100 km west of the Tan-Lu fault zone on the southwestern end of the Su–Lu orogen and about 300 km north of the Dabie orogen (Fig. 1). The deformed Neoproterozoic to late Paleozoic strata in the region constitute a Xu(zhou)-Huai(nan) structural nappe (Wang et al., 1998), intruded by several small intrusives named the Liguo, Banjing and Jiagou intrusions from north to south (Fig. 1). They are mainly composed of dioritic porphyry and monzodioritic porphyry. These intrusives were not subjected to structural deformation, but were chiefly controlled by extensional faults (Lin et al., 2000). The uppermost strata intruded by the intrusives in the Xu-Huai nappe are late Permian in age, indicating emplacement after the late Permian. SHRIMP zircon U–Pb ages for the Liguo dioritic porphyry and the Jiagou monzodioritic porphyry are 131.1 ± 3.4 and 132.2 ± 4.1 Ma, respectively (Xu et al., 2004a). Eclogite, garnet-clinopyroxenite and garnet-amphibolite xenoliths, as well as garnet residual crystals, can be found in these Mesozoic intrusives (Xu et al., 2002b).

3. Samples and petrography

Samples used for this study from the Xu-Huai area are hornblende (Hb) dioritic porphyry (the Liguo intrusion), dioritic porphyry (the Banjing intrusion), and monzodioritic porphyry and quartz (Q) monzonitic porphyry (the Jiagou intrusion) (Table 1). These rocks all show porphyritic texture with phenocryst contents of 10–30 vol%. The phenocrysts consist dominantly of zoned hornblende and plagioclase (Fig. 2(a)), implying a magmatic origin. The groundmasses are composed of hornblende, plagioclase and minor orthoclase and quartz.

Abundant xenoliths such as eclogite, garnet clinopyroxenite, garnet amphibolite and garnet residual crystals have been found in these porphyries. The xenoliths occur in the ellipsoidal form, ranging from about $8 \times 10\ cm^2$ (Fig. 2(b)) to $0.5 \times 1.0\ cm^2$ in size. A narrow reaction rim of amphibole is frequently observed between the xenolith and the host rock.

Eclogite xenoliths are medium-coarse grained and consists of garnet, omphacite, quartz, and rutile. Primary amphibole occasionally exists in some eclogite xenoliths (Fig. 2(c)). The retrograde amphiboles often occur around clinopyroxene and garnet. Their pleochroism is light yellow-brown and yellow-

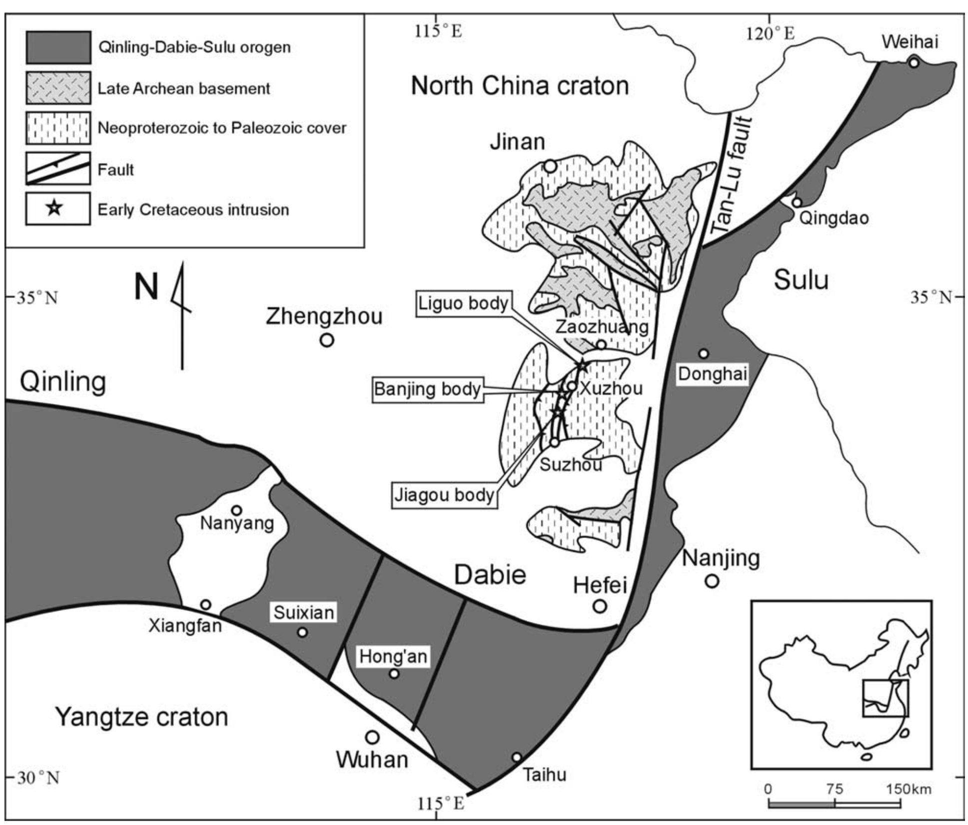

Fig. 1. Tectonic map of the Qinling–Dabie–Sulu collisional belt, showing the distribution of the early Cretaceous intrusives and eclogite xenoliths in the Xuzhou–Suzhou area, eastern China.

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