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Petrogenesis of the Early Cretaceous Laojunshan monzogranite at the southern margin of the North China Craton: Constrains on the transition of the tectonic regime

CAO Leitao, TANG Huayun*, ZHENG Jianping, REN Hongwei, YU Chunmei, XU Zhou and HE Shuai

State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences, Wuhan 430074, China

1 Introduction

Voluminous Mesozoic magmatic rocks containing abundant Au-Mo polymetallic mineralization resources are developed in the Xiaoqinling-Xiong'ershan district of the southern margin of the North China Craton (NCC). The widely distributed intrusions are mainly of intermediate-acidic in composition and formed during the Late Jurassic-Early Cretaceous (Ding et al., 2011; Hu et al., 2012; Li N et al., 2012; Mao et al., 2010; Zhao et al., 2012). Previous studies on representative Late Triassic -early Early Cretaceous plutons such as the Laoniushan, Fangshanyu, Wenyu and Niangniangshan granites in the western and northern regions of the Xiaoqinling-Xiong'ershan district have revealed that they are characterized by high Sr/Y ratios and thus indicate the existence of thickened crust under compressional setting beneath the Xiaoqinling-Xiong'ershan district prior to ca. 130 Ma (Hu et al., 2012; Zhao et al., 2012). However, precise timing of the tectonic transformation of the lithosphere from compression to extension remain unclear. Here, the detailed petrography and new zircon U-Pb ages and Hf isotope as well as whole rock geochemistry and Sr-Nd-Pb isotopes are presented for the Laojunshan pluton, with the aim to investigate their petrogenesis, and to further constrain the geodynamic process of the lithosphere evolution in the southern margin of the NCC.

2 Result and Petrogenesis

The Laojunshan pluton, intruded in the amphibolites of the Kuanping Group and the clastic rocks of the Erlangping Group, consists of medium phenocryst monzogranites, phenocryst-bearing fine-grained monzogranites and coarse-grained monzogranites. These rocks emplaced during the Early Cretaceous (117-124 Ma). They have high SiO_2 (69.47-72.72 wt.%), K_2O+Na_2O (8.14-9.54 wt.%), Al_2O_3 (13.88-15.01 wt.%) and low Fe_2O_3 (1.32-2.34 wt.%) and MgO (0.42-0.73 wt.%) contents. The Laojunshan samples are characterized by enriched LREE, flat HREE and strongly negative Eu anomalies (δEu=0.39-0.56). Moreover, the samples are also enriched in the LILE but depleted in the HFSE, and have positive Pb anomalies. They have $\varepsilon_{Nd}(t)$ values ranging from -1.94 to -0.81 and $(^{87}Sr/^{86}Sr)_i$ values varying from 0.7092 to 0.7116. The initial $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios of the rocks are 18.177-18.454, 15.472-15.498 and 38.227-38.563, respectively. In addition, the Laojunshan rocks have positive $\varepsilon_{Hf}(t)$ values from +4.3 to +12.2 with two stage Hf model ages (T_{DM2}) of 400-900 Ma.

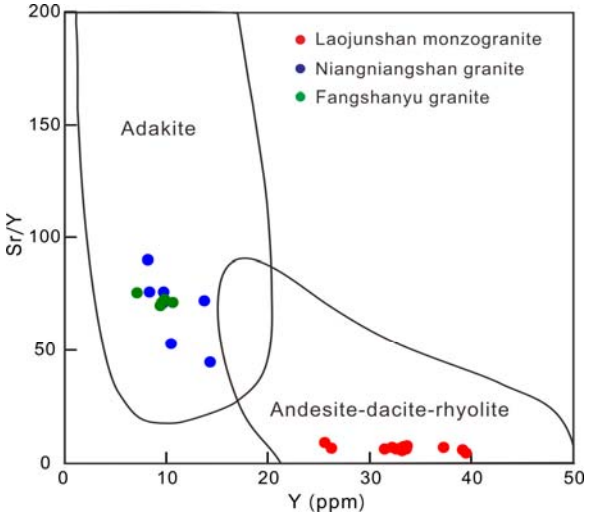

Fig. 1. Sr/Y vs Y plot of the Laojunshan monzogranites.

* Corresponding author. E-mail: hytang2005@163.com

The high SiO_2, low Fe_2O_3 and MgO ($Mg^{\#}$=38.1-43.1) contents, suggest that the Laojunshan pluton were most probably derived from partial melting of the crustal materials. Compared with the ~135 Ma Fangshanyu and Niangniangshan adakitic granites (Hu et al., 2012; Zhao et al., 2012), the Laojunshan complex shows different flat HREE pattern and obviously lower Sr/Y ratios, and plots in the normal andesite-dacite-rhyolite field (Fig. 1), indicating the lack of garnet as a residual mineral in the melting source. Hence, we consider that the Laojunshan monzogranites were produced by partial melting of crust source at relatively shallow depth. The positive $\varepsilon_{Hf}(t)$ values and young two stage Hf model ages (400-900 Ma) of the Laojunshan monzogranites, are not only different from those of the Niangniangshan and Fangshanyu adakitic granites, which are characterized by negative $\varepsilon_{Hf}(t)$ values (-31 to -18) and ancient T_{DM2} of 2300-3100 Ma (Fig. 2; Hu et al., 2012; Zhao et al., 2012), but also inconsistent with those of the Kuanping and Qinling Groups (Shi et al., 2013; Dong et al., 2014). All these suggest that the Laojunshan pluton was probably derived from partial melting of the juvenile crustal materials. The Neoproterozoic T_{DM2} of the Laojunshan rocks indicates that the juvenile crust is likely associated with the Neoproterozoic magmatism that derived from depleted mantle source beneath the northern margin of the Yangtze Craton. Hence, we interpreter that the Laojunshan monzogranites to be the product of partial melting of the basic crustal materials of the subducted Yangtze Craton under normal crust thickness.

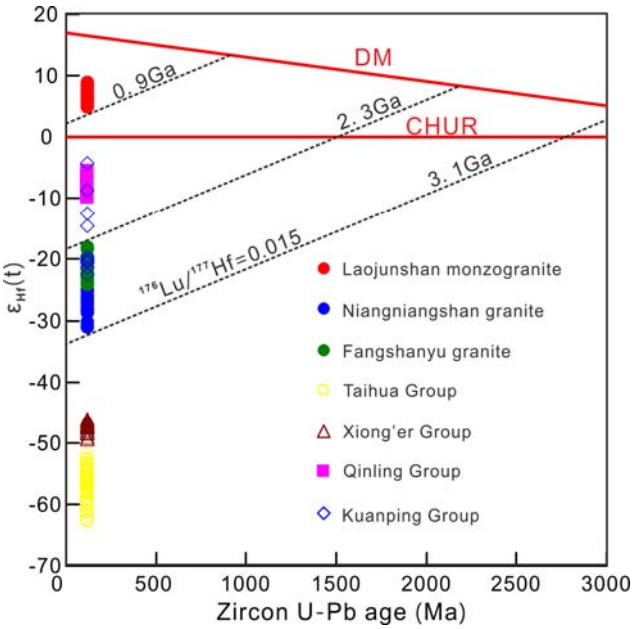

Fig. 2. Evolution of $\varepsilon_{Hf}(t)$ vs. Zircon U-Pb age (Ma) of the Laojunshan monzogranites.

3 Transition of the Tectonic Regime

Integrated comparison of the ages and petrogenesis of the Mesozoic magmatism indicates that prior to 130 Ma, the early Early Cretaceous granites in the Xiaoqinling-Xiong'ershan district and even in the interior of the Trans-North China Orogen mainly exhibit adakitic feature, and have resulted from partial melting of the thickened ancient crustal basement of the NCC. However, those late Early Cretaceous (<125 Ma) intrusions, as represented by the Laojunshan pluton, were mainly derived from partial melting of crustal materials at shallow depth. This transformation implies that since 130-125 Ma, the tectonic regime in the Xiaoqinling-Xiong'ershan district has changed from compression to extension, accompanied by significant lower crust delamination (lithospheric thinning).

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