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Geochronological, geochemical and Sr-Nd–Hf isotopic constraints on the petrogenesis of Cretaceous monzonitic plutons in Zhejiang Province, Southeast China

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Monzonitic rocks usually show specific characteristics transitional between those of the calc-alkaline and alkaline rocks, thus can provide important information about the nature of the mantle sources and the mechanism of crust–mantle interactions. The Cretaceous monzonitic intrusions in Zhejiang Province are distributed roughly along an EW-trending belt to the south of the Jiangshan-Shaoxing fault in the Cathaysia Block. Typical examples of these intrusions include the Muchen, Matou, Dalai, Huangtanyang, Maoliling and Kanggu plutons from west to east. This paper presents comprehensive whole-rock geochemical, Sr–Nd isotopic and zircon U–Pb and Hf isotopic data for these plutons, with the aim of elucidating their petrogenesis, and providing new insights into the process of crust–mantle interaction beneath Southeast China.

The monzonitic intrusions in Zhejiang Province are composed mainly of quartz monzonites and quartz monzodiorites. Mafic microgranular enclaves (MMEs) with various plastic shapes are widely dispersed in most of these plutons. Zircon U-Pb ages show that they were emplaced at 112~100 Ma, and all MMES are coeval with their host monzonitic rocks. Chemically, these Cretaceous monzonitic intrusions show intermediate to acidic, subalkaline to calc-alkaline, metaluminous to weakly peraluminous, and K-rich signatures, with SiO_2 from 57.2% to 68.6%. They can be divided into two groups, i. e., the eastern and the western parts of Zhejiang Province, bounded by the Zhenghe-Dapu fault. Monzonitic rocks from the western part show higher and variable alkali, potassium, aluminum contents, whereas those from the eastern part are relatively homogeneous in composition. All the Cretaceous monzonitic rocks are enriched in large ion lithophile (e.g., Rb, Th, U and Pb) and light rare earth elements, depleted in high-field strength elements (e.g., Nb, Ta, P and Ti). With respect to the monzonitic rocks from the eastern part, those from the western part have higher concentrations of heavy rare earth elements and show variable degrees of Eu, Ba, and Sr negative anomalies. Isotopically, monzonitic rocks from western part have lower initial $^{87}Sr/^{86}Sr$ ratios (I_{Sr}) and more depleted Nd isotopic compositions (I_{Sr} = 0.7058~0.7083, $\varepsilon_{Nd}(t)$ = -5.60~-2.29) than those from the eastern part (I_{Sr} =0.7079~0.7090, $\varepsilon_{Nd}(t)$ = -8.06~-6.84). These monzonitic intrusions generally show negative and highly variable zircon $\varepsilon_{Hf}(t)$ values, but most of samples plot above the fields of the Hf isotope evolutionary area for the crustal basement in the Cathaysia Block. As with the $\varepsilon_{Nd}(t)$ values, the zircon $\varepsilon_{Hf}(t)$ values of the monzonitic rocks from western part are also somewhat higher than those from the eastern part.

The integrated geochronological, petrological, geochemical, and Sr-Nd-Hf isotopic data indicate that monzonitic intrusions in Zhejiang Province were mostly generated by mixing of mantle-derived, mafic magmas and felsic magmas produced by partial melting of Palaeoproterozoic crustal materials. Melts

from both enriched lithospheric mantle and depleted asthenospheric mantle have contributed to the generation of the primitive mafic magmas associated with the genesis of these monzonitic plutons, and more depleted mantle melts have involved in the generation of the monzonites from the western part than those from the eastern part. All the studied monzonitic rocks were formed in a post-collisional extensional tectonic setting, and their generation time (112~100 Ma) may correspond to the period with most intensive crust-mantle interaction in the coastal area of Zhejiang and Fujian Provinces. The formation of these monzonitic intrusions was mainly triggered by roll-back subduction of the palaeo-Pacific plate and subsequently induced underplating of mantle-derived mafic magmas.