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Discussion

Comment on "Origin of high-Mg adakitic magmatic enclaves from the Meichuan pluton, southern Dabie orogen (central China): Implications for delamination of the lower continental crust and melt–mantle interaction" by C. Zhang, C.Q. Ma, F. Holtz [Lithos 119 (2010) 467–484]

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The North China and Yangtze blocks collided in the Triassic in central Eastern China (e.g., Li et al., 2000), forming the Dabie–Sulu orogen with an over-thickened crust similar to the one beneath the present Himalaya. Results of seismological studies indicate that the current crustal thickness of the Dabie–Sulu orogen is about 35 km (Wang et al., 2000; Sodoudi et al., 2006), indicating that a significant amount of mountain root of this orogen was removed and recycled into the convective upper mantle. The foundering mechanism of the eclogitic lower crust of the Dabie–Sulu orogen is still poorly understood. Studies on the post-collisional igneous rocks from the Dabie–Sulu orogen have provided important constraints on the timing and processes of mountain root removal as well as lithospheric thinning of central China (Wang et al., 2007; Xu et al., 2007; Huang et al., 2008; Zhang et al., 2010).

In a recent study, Zhang et al. (2010) reported high quality geochronological and geochemical data for the Meichuan pluton from the Southern Dabie orogen and suggested that the Meichuan pluton is a high-Mg adakite formed during the early Cretaceous. However, these authors believed that "high-Mg adakites have not been found yet in the Dabie orogen" because they argued that the Chituling intrusion previously published in Huang et al. (2008) is not a primitive high Mg adakite as it may have been formed by fractional crystallization of hornblende (+/−clinopyroxene). Zhang et al. (2010) further proposed that the Meichuan pluton was derived from partial melting of delaminated mafic lower continental crust as a result of lithospheric extension and asthenospheric upwelling along the Yangtze River fault zone. We do agree that the Meichuan pluton has higher Sr/Y than the Chituling intrusion. However, for a number of reasons, it is highly unlikely that the Chituling intrusion was formed by fractionation of a small amount of amphibole and/or clinopyroxene as claimed in Zhang et al. (2010).

(1) Zhang et al. (2010) did not use appropriate partition coefficient data in their modeling of fractional crystallization of amphibole or clinopyroxene. The ${}^{cpx/melt}D_Y$ and ${}^{hornblende/melt}D_Y$ used in Zhang et al. (2010) are from samples 23,876 and 63, respectively, in Ewart and Griffin (1994), who derived the partition coefficient values from trace element compositions of glass matrix and phenocrystals in volcanic rocks. A careful examination indicates that the silicate melts of these two samples are highly polymerized with low NBO/T (non-bridging oxygen/tetrahedron cations), CaO, FeO, and MgO, but high SiO_2, Al_2O_3, and alkali contents. Because of the dramatic effect of melt structure on the partitioning of middle-heavy rare earth elements and Y between minerals and a highly polymerized silicate melt (e.g., Gaetani, 2004; Huang et al., 2006), the ${}^{cpx/melt}D_Y$ (2.4) and ${}^{hornblende/melt}D_Y$ (11.3) are too high for modeling the Chituling intrusion with a dioritic composition. Instead, Y is moderately incompatible to slightly compatible in low-Al clinopyroxene and amphibole in a hydrous basaltic or basaltic andesitic system (Adam and Green, 1994; Bottazzi et al., 1999; Green et al., 2000; Gaetani, 2004). Given that Y is highly incompatible in magnetite (Nielsen and Beard, 2000), a small amount of clinopyroxene (+magnetite) or amphibole fractionation from a basaltic or basaltic andesitic melt cannot decrease the Y content of the residual melt by a factor of two. Hence, the modeling of mineral fractionation in the inset of Fig. 11a in Zhang et al. (2010) is misleading and inaccurate.

(2) The major and trace element compositions of the Chituling intrusion don't support fractionation of clinopyroxene (+magnetite) or amphibole (Fig. 10b in Zhang et al., 2010). Because Dy is slightly

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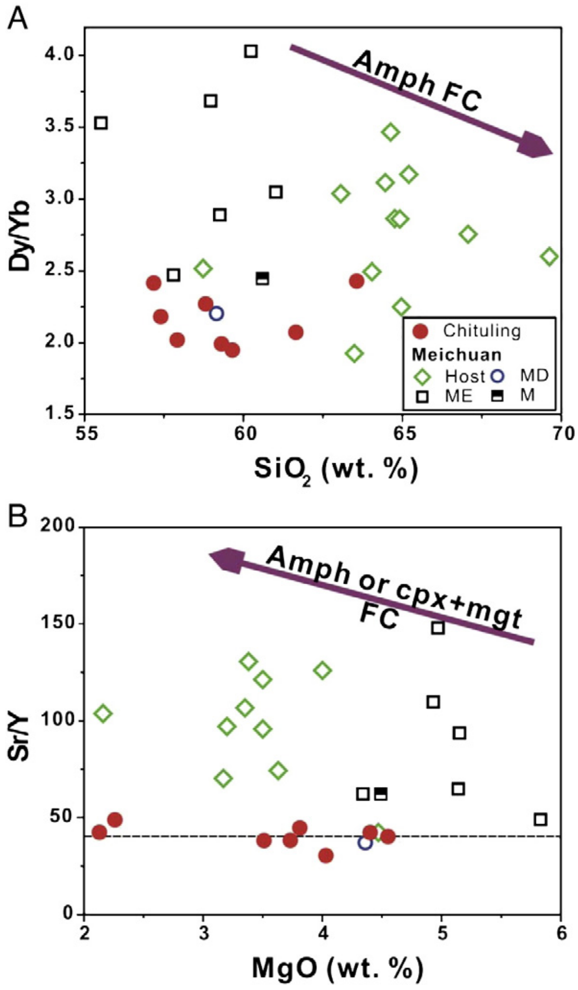

Fig. 1. A, There is no clear correlation between SiO_2 and Dy/Yb in the samples from Chituling and Meichuan plutons. B, The correlation between MgO and Sr/Y in the samples from Chituling and Meichuan plutons does not support fractionation of amphibole or clinopyroxene (+magnetite). The arrow in Fig. 1A represents amphibole fractionation (amph FC) trend, while the arrow in Fig. 1B shows amphibole or clinopyroxene fractionation (amph or cpx+mgt) trend. ME, MD, and M represent mafic enclaves, mafic dike, and mixture, respectively.
Data sources: Chituling, Huang et al. (2008); Meichuan, Zhang et al. (2010).

more compatible than Yb in amphibole (Bottazzi et al., 1999), fractionation of amphibole can decrease Dy/Yb and increase SiO_2 as shown in Fig. 1A, while fractionating amphibole or clinopyroxene (+magnetite) can decrease MgO and increase Sr/Y (Fig. 1B). Neither is consistent with the observations in the Chituling samples (Fig. 1). Furthermore, the two most primitive Chituling samples (00CT-5 and 00CT-6) with the highest magnesium number (Mg#) and MgO have high Sr/Y and La/Yb and low Y (<18 ppm) (Huang et al., 2008), in good agreement with the definition of high-Mg adakites (Defant and Drummond, 1990; Defant et al., 2002; Martin et al., 2005; Moyen, 2009).

(3) In sharp contrast to the Meichuan pluton, the Chituling intrusion is a small homogeneous pluton without any synchronous pyroxene-hornblende gabbro enclaves (Huang et al., 2008). Therefore, field observations do not support that fractionally crystallized phases are hosted in the Chituling diorite.

(4) The Chituling samples have lower $\varepsilon_{Nd}(130\,Ma)$ (−20.7 to −24.9) than most Mesozoic granitoids and mafic igneous rocks in the Dabie orogen (e.g., Jahn et al., 1999; Zhang et al., 2002; Huang et al., 2007; Wang et al., 2007; Xu et al., 2007), suggesting that the Chituling intrusion cannot be formed by hybridization and mixing between mafic and felsic magmas during ascent and emplacement in the crust.

Based on the lines of evidence above, we argue that the Chituling diorite is a primitive high-Mg adakite and its origin can be best explained by partial melting of delaminated lower continental crust followed by reaction with mantle peridotites. The Meichuan pluton is another occurrence of the early Cretaceous high-Mg adakites in the Dabie orogen, confirming the existence of a high-Mg adakite belt along the Tanlu fault as proposed in Huang et al. (2008).

The Yangtze River fault merges with the Tanlu fault near the southern end of the Dabie orogen. Although development of the two fault zones may be the trigger for lithospheric delamination and thinning, it is not clear yet which fault dominates these deep processes in the Mesozoic. Overall, the Mesozoic magmatism occurred more widely in the north Huaiyang, north Dabie, and south Dabie than in the central Dabie Unit (Fig. 1a in Zhang et al. (2010)). Although the Yangtze River fault could be critical in triggering magmatism in the adjacent Meichuan pluton, it cannot explain the distribution of Mesozoic igneous rocks in the areas far away from this fault zone (i.e., north Dabie and north Huaiyang). Furthermore, the early Cretaceous mantle-derived basaltic intrusions are mainly distributed along fault zones in north Dabie, but they are absent in south Dabie (Jahn et al., 1999). If the large scale of mafic magmatism in the Dabie orogen reflects the upper mantle upwelling, then an upwelling center existed in the north Dabie or north Huaiyang. This means that the Yangtze River fault may not be the unique and dominant control of tectonism and magmatism of the Dabie orogen in the Mesozoic. In contrast, the Tanlu fault is a giant trans-lithosphere fault belt extending from central Eastern China to Northeast China, and it is also coupled with the Mesozoic high-Mg adakite belt (e.g., Xuzhou-Suzhou area, Jiashan, Feidong, Guanghui, and Chituling) and thinnest lithosphere (Xu et al., 2006; Chen et al., 2007; Huang et al., 2008; Xu et al., 2008; Liu et al., 2010). The weak suture zone between the North China and South China blocks could have become an extensional zone by strike-slip movement along the Tanlu fault in the Mesozoic. Hence, the Tanlu fault zone should have played an important role in magmatism in the areas far away from the Yangtze River. The Yangtze River fault may only trigger the magmatism in the south margin of Dabie orogen.

Finally, Zhang et al. (2010) proposed that the felsic host rocks in the Meichuan pluton are also high-Mg adakites, which could be formed by hybridization between a felsic and a mafic end-member. In their model, the felsic end-member is similar to the low-Mg adakites in the Dabie orogen (Wang et al., 2007; Xu et al., 2007), while the mafic one is similar to the mafic magmatic enclaves (MME) or dikes in the Meichuan pluton. However, this mixing model is not fully supported by geochemical data of the Meichuan pluton. First, the

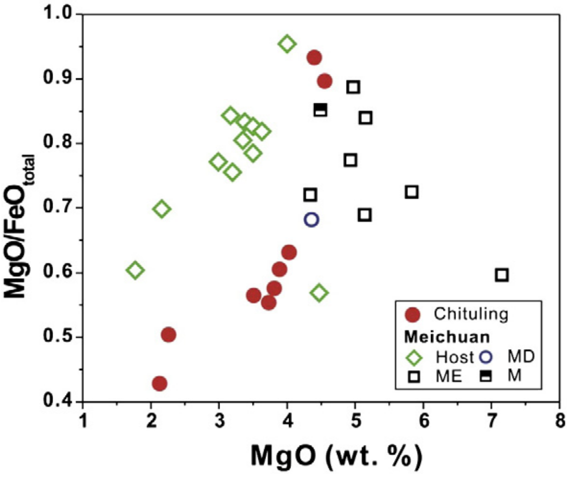

Fig. 2. Comparison of MgO content and MgO/FeO_{total} in the Chituling high-Mg adakite with those in the felsic host rocks (Host) and MME from the Meichuan pluton. ME, MD, and M represent mafic enclaves, mafic dike, and mixture, respectively. Data sources are same as in Fig. 1.

mafic end-member used in the model is sample MC12-2 which has Mg# of 61.3, slightly lower than the felsic sample DB168 with Mg# of 63. Second, the range of Mg# of the felsic host rocks (46.4 to 63) is similar to that of the MME (50.4 to 61.3) (Fig. 12a in Zhang et al. (2010)), not consistent with the prediction of mixing with a low-Mg# magma. Third, the SiO_2–Sr plot shows two parallel trends for the felsic host and MME (Fig. 7 in Zhang et al. (2010)). These trends more likely reflect two independent differentiation processes instead of mixing. And fourth, in the plot of MgO versus MgO/FeO_{total} (Fig. 2), the felsic host rocks and MME also show different trends. All the evidences above do not agree with the model of mixing between the MME and low-Mg adakites. Although we do not doubt this process could have happened in the Meichuan pluton, a better and more careful modeling is clearly required.

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