

Paleo-Asian oceanic slab under the North China craton revealed by carbonatites derived from subducted limestones

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Chen et al. (2016) present an interesting study on recycled limestones via paleo-Asian oceanic slab subduction under the North China craton (NCC) and forming a ‘carbonatite intrusion’ that intruded the Neogene alkali basalt in the Hanuoba region (China). However, the nature of the ‘carbonatite intrusion’ needs to be discussed, because (1) the data set presented in this paper suggests that this carbonate body is likely a limestone block (i.e., xenolith) in the basalt, rather than a ‘carbonatite intrusion’, and (2) the paper lacks key field and petrographic evidence to support the carbonate body being carbonatitic in origin.

Chen et al.’s paper does not have key field descriptions of the ‘carbonatite intrusion,’ leaving its conclusion apprehensive. Only one sentence was provided for the occurrence of this carbonate body: “a carbonatite intrusion (0.5–3 m thick, and >35 m wide) that intrudes Neogene basalts (22–10 Ma; Zhu, 1998) at Hannuoba (eastern China; Fig. 1)” (Chen et al., 2016, and references therein). This sentence is a part of the section on Samples, Petrology, and Geochemical Compositions. Sample descriptions seem missed in both the text and the Data Repository (Item 2016347). No sample locations are marked in their figure 1B; neither are GPS coordinates of the samples given in table DR2 (all figures and tables mentioned here refer to figures and tables in the Chen et al. paper). There is no evidence of a field relationship (e.g., fenitization) to indicate that this carbonate body is a ‘carbonatite.’ There are no other peralkaline intrusive rocks associated with the ‘carbonatite intrusion’ in the area, commonly seen in a carbonatite-alkali intrusive complex (see Jones et al., 2013).

Chen et al.’s figures 1C and 1D do not show a texture of a carbonatite, but display some similarity to limestone block (or xenolith) in igneous rocks or at their contact zones. There is no adequate petrographic information provided for the mineral assemblage in the ‘carbonatite.’ Moissanite and graphite identified in the rock are not indicative of carbonatite, but are likely a products of contact metamorphism or mantle-derived xenocrysts (figure DR1) as suggested in this paper. This carbonate rock is composed dominantly of calcite, but its chemical composition is not diagnostic for the conclusion that it crystallized from a carbonatite melt (table DR3; cf. Jones et al., 2013); it is similar to sedimentary carbonate in metamorphosed limestone (marble). Unfortunately, key characteristic elements (i.e., Sr, Mn) in the carbonate are not provided in table DR3, leaving it suspicious that these calcite grains, both in phenocrysts and matrix, are carbonatitic in origin. Nickel contents in the calcite range from 1.4 to 116 ppm (table DR3) and are within the uncertainty of LA-ICPMS technique; thus the statement of ‘high Ni concentration in calcite’ cannot be drawn from the chemical data.

The ($^{143}\text{Nd}/^{144}\text{Nd}$)_i values of the carbonates appear consistent and similar to the aragonite veinlets, but their ($^{87}\text{Sr}/^{86}\text{Sr}$)_i ratios display a large variation (~0.705–0.708) (figure 3B), suggesting that late geological event(s) may have significantly affected the strontium isotopes, but the neodymium isotopes remained unchanged. Such a signature cannot be attributed to a mixing process between the limestone and Hannuoba peridotite (or mantle) as suggested by the authors. If so, the neodymium isotopes must have also been influenced. Therefore, this evidence (figure 3B) does not support the conclusion that the carbonate body is a ‘carbonatite intrusion derived from partial melting of subducted limestone into the mantle.’

The whole-rock geochemical data of the 21 samples from the ‘carbon-

atite intrusion’ (table DR2) indicate that they are distinctly different from typical carbonatites, but are indistinguishable from common limestones (figure 2). This geochemical evidence alone rules out that the carbonate body is carbonatitic (cf. Jones et al., 2013), but reveals it is most likely a sedimentary limestone xenolith in the basalt. The authors appear to notice this sedimentary signature, but argue that this carbonate body is ‘a carbonatite intrusion’ (figure 4). One problem of this claim is how the subducted limestone retains its geochemical signature of sedimentary carbonates, avoiding the chemical exchange or equilibrium between them and the mantle under such a T-P-X_{H₂O} (e.g., 770–930 °C, lithostatic pressure of ~50 km deep) for a duration of over 338 m.y. [i.e., from Paleozoic (580–360 Ma) to Neogene (ca. 22 Ma); see figure DR5]. If the isolation of the subducted limestone from surrounding mantle could not be maintained, then chemical exchange with the mantle could not be escaped. Consequently, partial melting or re-melting of this subducted limestone (figure 4) should have the signature of the mantle, i.e., high light rare earth elements and incompatible elements (including Sr, Ba, Rb), and would not display pronounced Nb and Ta negative anomalies as shown in figure 2.

Carbon and oxygen isotope compositions of the carbonate components in the ‘carbonatite intrusion’ (table DR2) indicate that they are sedimentary limestone rather than a carbonatite. A true carbonatite cannot have values of $\delta^{13}\text{C}$ ranging from –14.4‰ to –11.2‰ and values of $\delta^{18}\text{O}$ ranging from +22.3‰ to +23.0‰. The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values are much beyond those of carbonatites (Deines, 1989), but are similar to those of sedimentary limestone-bearing organic-carbon materials (cf. Rollinson, 1993). Degassing of the mantle would result in the increasing $\delta^{13}\text{C}$ values of carbonatites. Higher $\delta^{18}\text{O}$ values of carbonatites could be achieved by interaction with low-temperature groundwater, but their $\delta^{13}\text{C}$ values would mostly remain at the mantle value (–4‰ to –8‰) (Deines, 1989; Jones et al., 2013).

True carbonatites occur in the Bayan Obo area at the northern margin of the NCC (Le Bas et al., 1992), but they are mid-Proterozoic in age (Le Bas et al., 2007) and formed in a rifting environment. Whether the presence of Neogene carbonatites related to Paleo-Asian oceanic plate subduction occurred in the northern margin of the NCC requires further investigation.

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