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Natural evidence for primitive alkaline basalts sourced from carbonate-bearing eclogite

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There is a growing consensus that subducted oceanic crust, especially with sequestered carbonates, contributes to the formation of many alkaline basalts. Based on extensive experimental results, carbonated eclogites have been proposed as a candidate for the mantle source of many intraplate alkaline basalts. However, evidence from natural basalts for this hypothesis remains scarce. Here we document that the Cenozoic continental intraplate alkaline basalts from Hannuoba in North China Craton display primary geochemical features consistent with their origin as partial melts of carbonated eclogite. Our data for major elements overlap with the compositions of melts from experiments on carbonated eclogites. We demonstrate that the low-MgO (<5.25%) alkaline basalts with strong signatures of carbonated eclogite (e.g., Dy/Yb>7) are primitive melts, rather than highly evolved products. The Hannuoba alkaline basalts show good linear correlations among ε_{Nd}, Ti/Eu and Dy/Yb. In combination with the lack of significant amounts of crystallization of clinopyroxene and garnet, neither fractional crystallization nor variable degrees of partial melting can explain these correlations, which largely reflect the interaction between primary melts and lithospheric mantle during ascent. The anomalously low CaO/Al_2O_3 (<0.41) and high Dy/Yb (>7.1) of the primitive alkaline basalts require the presence of clinopyroxene and garnet in their mantle sources, and the Zr/Hf and Ti/Eu ratios further highlight the role of carbonates in the source. Our findings unveil that partial melting of a carbonated eclogite source can directly produce alkaline basalts with low MgO contents in the intra-plate setting, an explanation which is often overlooked because they are often considered to be highly evolved magmas. Therefore, altered, carbonated oceanic crust not only introduces metasomatic melts/fluids which modify the chemical composition of the deep mantle but also serve as a direct source of mafic melts. This result strengthens the role of subducting carbonated altered oceanic crust and also indicate its diverse fate in the mantle.