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Sulfide-rich continental roots at cratonic margins formed by migration of carbonated melts and their implications for sulfide deposits

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The cratons are underlain by thick mantle lithospheres which contain a large volatile inventory including carbon, sulfur, and water, and they are also known to host abundant mineral deposits of metals such as gold, copper and rare earths at their margins. While volatiles are recognized as key components in metallogenesis, the distribution of these volatiles within the cratonic lithospheric mantle and their role in the initial enrichment of metals and in subsequent sulfide deposit formation remain inadequately explored. In this study, we compile sulfur and copper data from global cratonic peridotites, identifying sulfide- and copper-rich continental roots at depths at the depths of 160 to 190 km along the cratonic margins. Our new high-pressure experiments reveal that carbonated silicate melts originating from the asthenosphere undergo a loss of silicate components when interacting with lithospheric peridotite, transforming into carbonatite melts that accumulate at the cratonic margins. Therefore, we suggest that carbonatite melts arise in the deep continental lithosphere mostly as a result of the reaction of parental carbonated silicate melts with the lithospheric mantle. During this rection process, sulfur solubility in the melts dramatically decreases as the SiO_2 content decreases, triggering sulfide precipitation and the formation of sulfide-rich continental roots at the base of the mantle lithosphere, consistent with the compiled peridotite data. The migration of carbonated melts towards the cratonic margins replenishes these roots with sulfur, providing an explanation for the co-location of magmatic metal deposits and carbonatites near cratonic margins, as 93% of magmatic sulfide deposits and 62.5% of carbonatites globally are located within 200 km of craton edges. These findings underscore the critical role of carbonated melts in metallogenesis and suggest a promising avenue for metal ore exploration.