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Crustal thickness controls the differentiation style and composition of arc magmas and continental crust formation

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Arc magmas, the building blocks of the modern continents, are compositionally diverse. What causes this diversity is important for understanding continent formation but remains unclear. Here, we use pressure-sensitive geochemical proxies to evaluate the differentiation processes of arc magmas that traverse through crusts of various thicknesses. We show that the high-pressure conditions in the lower-middle crusts of thick-crust arcs (continental arcs) favor garnet, rather than magnetite, fractionation, producing evolved magmas having FeO_T/MnO (FeO_T, total Fe as FeO) and Dy/Yb similar to those of the modern upper continental crust. By contrast, magmas from thin-crust arcs (oceanic arcs) fractionate amphibole and magnetite, and the derivative evolved magmas show lower FeO_T/MnO and Dy/Yb than those of the modern upper continental crust. Thus, crustal thickness exerts a first-order control on arc magma composition and high-pressure intracrustal differentiation in thickened crust is critical to modern continental crust formation. Our results also suggest that caution must be exercised when using elemental ratios to infer crustal composition through time when the tectonic settings are largely unknown.