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Plagioclase stability dominates the crustal thickness-dependent differentiation trend of global arc magmas

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The continental crust possesses an andesitic bulk composition and arc-like trace element signatures, and is thus believed to form mainly at subduction zones (Taylor and White 1965; Rudnick and Gao, 2014). However, compared to basaltic primitive arc magmas, the crust is depleted in bulk iron (FeO_T), and enriched in SiO_2 and alkalines (K_2O+Na_2O), suggesting that intra-crustal differentiation of arc basalts and subsequent delamination of the cumulates are required to form the crust (Kay and Kay, 1991,1993; Lee and Anderson, 2015). Previous studies have shown that the differentiation trends of global arc magmas are crustal thickness-dependent (Farner and Lee 2017). Specifically speaking, arc magmas tend to differentiate following a calc-alkaline trend beneath thick crust and a tholeiitic trend beneath thin crust. Compared to the tholeiitic trend, which shows a progressive increase in magma FeO_T content during differentiation, the calc-alkaline trend is characterized by decreasing magma FeO_T content with advancing differentiation, and thus is believed to be responsible for the formation of the continental crust. To fully explore the mechanism for the formation of continental crust, we must thoroughly investigate the controlling factor(s) for the crustal thickness-dependent differentiation trend of global arc magmas. In this study, we compiled the global arc magma compositions from GeoROC database and isolate the effect of crustal thickness on the differentiation trend of arc magmas. The major and trace element characters indicate that the mineral that controls the crustal thickness-dependent differentiation trend of global arc magmas should be deficient in Fe, Mg and most trace elements. These lines of evidence suggest that plagioclase is the very mineral responsible for the crustal thickness-dependent differentiation trend of global arc magmas. Furthermore, we proposed a plagioclase index, which clearly confirmed the importance of plagioclase stability. We emphasize that this study not only elucidates the controlling factor for the crustal thickness-dependent differentiation trend of global arc magmas, but also proposed a plagioclase index which may be potentially applicable to identify the formation of continental crust in Earth history.