Geodynamics and geochemistry of arc mobility: the apparent advance and retreat of Cordilleran arc systems

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The advancing and retreating nature of magmatic arc systems is controlled by contrasting slab dynamics. Advancing and retreating arc systems are associated with contrasting radiogenic isotopic signals (e.g., Nd and Hf) as magmatic systems in advancing and retreating arcs respectively incorporate an increased proportion of continental crust and mantle-derived component.

We suggest the isotopic signatures of the North American Cordilleran can be explained by the advance and retreat of the arc system driven by the dispersal of continents away from a mantle upwelling (i.e., the African superplume) towards the degree-2 girdle of mantle downwelling. Prior to Pangaea breakup (ca. 200 Ma), the North American Cordillera was dominated by continental arc systems. Subsequent breakup of Pangaea was facilitated as the African and Pacific superplumes developed (the African being beneath Pangaea) and the complimentary 'super-downwelling' formed as a longitudinal great circle "subduction girdle" between the two superplumes.

The development of this super-downwelling led to the rapid outboard migration of the subduction zones fringing the western margin of North America, generating retreating ocean arc system as slab rollback towards the girdle outpaced westward continental migration. Westward migration of the arc system stalled above the mantle downwelling along the subduction girdle, and stabilized due to slab suction. The continued westward drifting of North America led to subduction polarity flip and the apparent migration of the arc system back to the continental margin as it arrived at the subduction girdle at ca. 100 Ma. Arrival of the continent at and potential overriding of the subduction girdle was accompanied by accretion of the outboard terranes, and onset of shallow subduction and the generation of an advancing arc system geochemically evidenced by an increase in continental contamination in arc magmas. This model provides a link between secular changes in the isotopic signal of advancing and retreating arc systems and large-scale supercontinent geodynamics.