Blowing in the mantle wind: Migration of Cordilleran arcs

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The migration of modern volcanic arcs has been demonstrated by geophysical methods to be controlled by mantle convection patterns. It is hypothesized that like an inverted sail, subducted oceanic slabs 'blow in the mantle wind'. However, identifying geologic data supporting the long term and widespread migration patterns has remained elusive. Luckily, the geochemical signature of oceanic and continental arcs is controlled by the amount of continental material assimilated in the magmas and therefore can be distinguished by distinct signatures. We demonstrate a consistent evolution of the geochemical signature of the Cordilleran subduction system from Antarctica to northeast Russia that attests to a dramatic migration of subduction zone magmatism from a continental to oceanic position and then back to a continental position within the past ~150 million years. These data suggest that volcanic arc migration is controlled at the first-order by large-scale, and long-lived mantle convection patterns.

We interpret degree-2 whole mantle convection as powerfully predictive with regards to the evolution of subduction zone system behaviour in that: 1) mantle flow is a primary driver of plate motions, plates move away from antipodal upwellings and towards meridional downwellings; 2) as continental lithosphere experiences more mantle traction than oceanic lithosphere, continents will override their flanking oceanic basins; 3) as subduction zones dipping against mantle flow should steepen and retreat at approximately the rate of mantle flow until they reach the meridional downwelling; 4) the rate of trench retreat will outpace continental drift causing back-arc basins to open; 5) radiogenic isotopic signatures of the arc system are predicted to become more mantle-like during arc retreat; 6) continental dispersion and arrival of the arc above the downwelling requires back-arc closure; 7) back-arc closure causes development of a landward-dipping subduction zone and greater crustal assimilation; and 8) early subducted slabs are carried with the mantle wind until it is favourable for them to sink further, thus complicating the interpretation of tomographically-identified slab positions.