Chemical modification of lithosphere and the origin of intracontinental magmatism and deformation

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The origin of intracontinental magmatism and deformation has been long debated. One example is the ~1000 km wide Cordilleran orogenic belt in western North America. Since the mid-Cenozoic, this region has undergone extension and widespread magmatism. While the most recent magmatism is intimately linked with extension, earlier magmatic flare-ups show no apparent correlation with extensional patterns. It has been argued that low angle subduction of the Farallon plate during the early Cenozoic influenced all subsequent tectonism and magmatism and that much of the lithosphere was hydrated by fluids released from the flat-subducting slab. To test and bulid upon this hypothesis, we examined the trace-element compositions of mantle xenoliths along a transect extending from near the trench to ~1000 km inboard of the trench. Near the trench, xenoliths are enriched in Cs, Rb, Sr and Pb (the first to be mobilized during subduction) and far from the trench they are depleted in Cs, Rb, Sr, and Pb and enriched in LREEs. These compositional variations are consistent with fluids derived from a slab undergoing prograde metamorphism, supporting the notion that slab fluids were transported some 1000 km inboard of the trench. However, if all the available fluids from the subducting Farallon plate were dehydrated and evenly distributed throughout the North American lithospheric mantle, the viscosity of the lithospheric mantle would have decreased by 2 orders of magnitude and such lithosphere would no longer remain stable. The fact that one region of the Cordillera, the Colorado Plateau, has remained undeformed and is still underlain by a thick lithosphere, renders this scenario unlikely. More likely is that the slab-derived fluids concentrated at the base of the lithosphere. After slab rollback, these hydrated zones could have partially melted, but the total volume of melting, averaged over the entire Cordillera, was probably not large. However, if these melts infiltrated the lithosphere in the form of pyroxenite dikes and veins, their very high densities could have resulted in a compositional densification of the lithospheric mantle, rendering such lithosphere unstable and prone to convective downwelling (only lithospheres made up of highly refractory peridotite, such as beneath the Colorado Plateau, would be spared). Could magmatic flareups be associated with the aftermath of “metasomatism-induced delamination”? Xenolith and host magma thermobarometry show that some regions of western North America are characterized by a transient thermal state, which requires rapid thinning of the lower lithosphere, consistent with the aftermath of delamination. If our interpretations are correct, the implications are that the dynamic and compositional evolution of continents cannot be divorced.