Reassessment of the sources and space-time patterns of Late Cretaceous and younger magmatism, Colorado

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Late Cretaceous to mid-Tertiary igneous activity in Colorado, western U.S., can be divided into two discrete pulses, Laramide (~70-55 Ma) and mid-Tertiary (35-25 Ma). Most workers link both episodes of continental interior magmatism to subduction of oceanic lithosphere beneath North American continent, although the exact relationship between subduction and either magmatic event is enigmatic. Laramide magmatism was restricted to the SW-NE trending Colorado Mineral Belt (COMB), which consists largely of alkaline intrusive igneous rocks at its southern and northern end and calc-alkaline intrusive rocks inbetween. Mafic lower crust has been invoked as the source of the magmas parental to the COMB igneous rocks, but new isotopic data from Laramide volcaniclastic clasts in the Front Range demonstrate that mafic magmas generated at this time ranged to ε_{Nd}~0 and $^{87}Sr/^{86}Sr$~0.7045. These isotopic compositions do not overlap the isotopic compositions of mafic lower crust in this region as directly determined from “high” $(La/Yb)_N$ mafic xenoliths entrained in Devonian age kimberlite diatremes in the Front Range (ε_{Nd}(65 Ma)~-6 to –10). The isotopic data suggest that the COMB parental magmas were mantle-derived and were not solely the products of lower crustal anatexis. The trigger mechanism for mantle melting is unknown but one speculative possibility is that melting occurred in response to local convective upwelling of asthenospheric mantle along the northern margin of a “flat slab” segment of subducted oceanic lithosphere.

Mid-Tertiary magmatism in Colorado was dominated by silicic magmatism that spatially overlapped, but was not confined to, the position of earlier COMB igneous activity. Many workers have attributed the magmatism to melting during slab rollback of mantle metasomatized during the early Tertiary by slab derived fluids. The large volumes of mid-Tertiary magmas produced (10,000 km^3 of silicic magma in the San Juan volcanic field alone) require either “dynamic” melting in upwelling asthenosphere, or “static” melting of recently hydrated lithosphere over a large area. The latter possibility could account for the wide spacing (~300 km) between major mid-Tertiary silicic volcanic centers in the southern Rocky Mountain area.

Post-Laramide Tectonomagmatics of the U.S. Cordillera

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Arc magmatism was nearly continuous through most of the Mesozoic until the Laramide (~70-55 Ma), when the arc ceased in most of the Western U.S. Contractional orogenesis spread to the stable interior as the subducting plate flattened and lithospheric thickness doubled.

A basalt-poor subalkalic continental-interior andesite-rhyolite association dominated between about 55 and 17 Ma in the southeast U.S. Cordillera and in transverse belts that migrated episodically from the northern and southern margins of the Laramide magmatic gap toward its center; tectonic extension was locally extreme in these belts. Arcs were active adjacent to the migrating belts, and small alkalic centers dotted the interior forelands.

Beginning about 17 Ma regional extension became widely distributed and dominant regional magmatic associations changed to basaltic and bimodal, typically alkalic or tholeiitic but in places calcalkalic. Greatest magmatic productivity has been in the northwest, including the northern Great Basin, Columbia Plateau, and Snake River Plain-Yellowstone regions. Flood basalts of the Columbia Plateau and adjacent areas erupted from dike swarms adjacent to the cratonic margin, beginning near a prong of thick Archean crust, then propagating north and south, followed by widespread bimodal volcanism. Many interpret this as reflecting the head of a deep-mantle plume; alternatively, it might reflect edge convection and incipient back-arc separation of relatively thin, warm, and weak accreted terranes from the older, colder, and stronger cratonic interior.

Since about 12 Ma voluminous caldera-forming rhyolitic volcanism has propagated about 600 km into the craton along zone of lithospheric weakness from near the initial flood-basalt locus, accompanied by uplift, enhanced extension, a gradually subsiding trace, and a major discontinuity in amounts of extension on opposite sides of the zone. This Eastern Snake River Plain-Yellowstone zone, often regarded as the trail of a plume tail overrun by the North America plate, alternatively might reflect thermal feedback following inception of upper-mantle flood-basalt melting by edge-convection, consequent enhanced melting near the base of the lithosphere, crustal intrusion and partial melting, and voluminous volcanism to unload the source region and promote cyclic replenishment of fertile mantle and further partial melting.