Contrasting footprints and characteristics of IOCG-type and porphyry-type hydrothermal systems related to episodic Mesozoic arc magmatism in coastal northern Chile

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New deposit- to region-scale mapping and related lab studies demonstrate that multiple hydrothermal systems affected large volumes in the upper 6-10 km of the Mesozoic coastal batholith and coeval volcanic rocks of northern Chile (26-28°S). Field relationships, geochronology (~500 dates including ~60 new U-Pb on zircon, titanite), and petrology (geobarometry, volatile content) show that episodic magmatism between 240 and 60 Ma drove (1) non-magmatic brine-dominated hydrothermal systems (IOCG clan), and (2) magmatic-hydrothermal systems (porphyry Cu clan). Magmas were mainly calcalkaline, dioritic, and mantle-dominated. Most intrusions exsolved little fluid (based on igneous crystallization sequences) but all circulated external brines (shown by 87Sr/86Sr) to paleodepths of 6-10 km. These alteration systems occupy >3/4 of the total exposed crust, of which Na/Fe alteration systems comprise >90% by volume. Hydrothermal alteration formed intermittently over 180 m.y., is most extensive in the shallow crust, and reflects superposition of many short-lived (<1 m.y.) thermal events. Secular patterns reflect petrologic linkages, levels of crustal exposure, and the magmatic pulse of the arc. The older, mainly granodioritic (240-190 Ma) western part of the arc is deeply eroded (6-12 km) and contains mainly the roots of porphyry and IOCG type systems. Younger pulses are largely quartz dioritic (140-100 Ma) or granodioritic (70-60 Ma); they are less exhumed retaining more of their volcanic superstructure, they contain extensive hydrothermal alteration, and they preserve widespread IOCG and some porphyry systems.

The two broad system types differ in type and extent of hydrothermal alteration and in their relationships to magmatism: (1) Non-magmatic brines generated zones of Na-Ca alteration that extend up to 25 km along the strike of the arc, 5 km laterally, and 5 km or more vertically. Deep Na-Ca metasomatism removed Fe and base metals; shallow exposures contain Na-Ca, but also abundant K(±Ca), acid and skarn alteration, and varied types of S-poor Fe-oxide(±P±Cu±Au) mineralization. These features are best developed with dioritic rocks but occur with all magma types. Na-Ca alteration spans paleodepths from 1 to 8 km, whereas Fe±Cu mineralization is strongly zoned, sometimes telescoped, and extends from at or near the contemporary surface to depths of 1-4 km. Cu-Fe sulfides are most abundant in the upper levels. Fe-oxides change from Hm-dominated (which locally form exhalative deposits) to deeper Mt-dominated assemblages (including Mt-rich, silicate-poor skarns in carbonate rocks). Deeper still are sulfide-poor Mt(-Act/Cpx±Ap) associations (i.e., Kiruna or 'IOA' type); deepest is Fe- and base metal-depleted intense Na-Ca alteration. Exceptional areas show this entire sequence in <2 km vertical exposure. (2) Conversely, magmatic-hydrothermal fluids generated smaller (2-3 km maximum dimension) alteration zones of K-silicate ± H+ alteration with little or no Na-Ca or Fe alteration, but with numerous Cu(±Mo) breccia pipe and porphyry-style occurrences. Consistent with predictions for
magmatic fluid sources, these are restricted to Qz-rich, Hbl-bearing plutons (granodiorites and
tonalites). Isotopic and petrologic data demonstrate that these systems, unlike the IOCG-clan
systems, are magmatic in origin; this alteration lacks evidence of external components although
unrelated external brines encroached in many systems. Similar patterns occur throughout the
Cordillera of the Americas.