Tectonic evolution of the Cerro Casale Cu-porphyry system, Chile: Implications for mineralisation

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The Cerro Casale porphyry Cu-Au deposit is located at the southern end of the Maricunga belt, near the northern boundary of the modern nonvolcanic, flat-slab region of the Chilean Andes (28-33ºS). Oligocene andesitic volcanic rocks in the Casale district have been intruded by the Cerro Casale, Roman, Eva, Estrella and Anfiteatro dioritic to granodioritic plutons, of which the Casale diorite is the main host to mineralisation (1300 Mt @ 0.7 g/t Au and 0.35% Cu).

U-Pb dating of zircon from the mineralized granodiorite yielded an age of 13.9 ± 1.1 Ma, consistent with previous Ar-Ar ages of 13.89 - 13.91 Ma from hydrothermal biotite and alunite [1]. Weakly mineralised to barren intrusions in the district range in age from 28 to 14 Ma, with a major porphyry-high sulfidation system forming at the Caspiche prospect ~10 km to the north in the late Oligocene, implying repeated mineralising episodes in the region.

The volcanic and intrusive rocks from the Casale district are predominantly medium-K andesites and diorites. The intrusive rocks show a trend to increasing Gd/Yb_n ratios in younger samples comparable to trends in Miocene rocks related to porphyry mineralisation in Central Chile interpreted to be the result of subduction of the Juan Fernandez ridge and associated slab flattening [2]. ε_{Nd} values for the intrusive rocks are uniformly negative (-0.6 to -2.8), consistent with contamination by older crustal sources, and show a weak trend to less negative values with time. $^{87}Sr/^{86}Sr_i$ values range from 0.70490 to 0.70547 and increase in younger intrusions. The less negative ε_{Nd} in the younger intrusions in conjunction with a slight increase in Ni contents suggests a more primitive source for the mineralising magmas.

[1] Muntean, J.L., and Einaudi, M.T. (2000), *Economic Geology* 95, 1445-1472. [2] Hollings, P., Cooke, D.R., and Clark, A. (2005), *Economic Geology* 100, 887-904.

Natural Cu-Al-Fe metallic quasicrystals in the new CV3 meteorite find, Khatyrka

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Khatyrka occurs as clastic grains within clay-rich layers along the banks of a small stream in the Koryak Mountains of far eastern Russia. The recovered grains share in common the presence of metallic Cu-Al-Fe alloys that include the quasicrystalline phase icosahedrite ($Al_{63}Cu_{24}Fe_{13}$), along with khatyrkite ($CuAl_2$) and cupalite (CuAl). Some of the ~ mm-sized meteorite grains clearly are CV3 (oxidized) chondrite fragments having Type IA porphyritic olivine chondrules enclosed in matrices that have the characteristic platy olivine texture, matrix olivine composition, and mineralogy of oxidized-subgroup CV3 chondrites. Other grains are fine-grained spinel-rich calcium-aluminum-rich inclusions (CAIs) with spinel oxygen isotopic compositions ($\Delta^{17}O$ ~ -19 – -23 ‰) typical of such objects in CV3 chondrites. One grain is an achondritic intergrowth of Cu-Al-Fe metal alloys with forsteritic olivine ± diopsidic pyroxene. The latter, along with silicates from the chondritic grains, have ^{16}O-enriched ($\Delta^{17}O$ ~ -4 – -8 ‰) oxygen isotopic compositions that plot on the CCAM mixing line in the region occupied by bulk CV3 chondrites [1, 2]. Finally, some grains consist almost entirely of Cu-Al-Fe alloys The Cu-Al-Fe metal alloys and the alloy-bearing achondrite clast are either a unique accretionary component of what otherwise is a fairly normal CV3 (oxidized) chondrite, or else formed in place via an as-yet undetermined process. Either way, the reducing conditions required to form such metallic aluminum-bearing alloys are approximately those of a hot gas of solar composition. Understanding what specific process(es) formed these alloys of two such cosmochemically-dissimilar elements as aluminum and copper remains the focus of our on-going research program.

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