Distribution of Fossil Metallogenic Systems and Magma Geochemical Belts within the Great Basin and Vicinity from 145 Million Years Ago to Present

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ABSTRACT

The southwestern United States (including the Great Basin) contains over 2000 Mesozoic-Cenozoic fossil hydrothermal systems with commercial metallic production. No significant correlation exists between metal content of ore deposit type and metal content of the enclosing tectonic terrane. For example, "Carlin-type" disseminated gold deposits with anomalous amounts of Hg, As, Sb, W, Tl occur in western Arizona in Precambrian Granite and lower Paleozoic quartzites and in the California coast range mercury belt in Franciscan graywacke-serpentinite hostrocks in addition to the more familiar Antler carbonate rocks of north-central Nevada. In contrast, a strong correlation exists between alkalinity (expressed by $K_{57.5}$ index) of time-related metaluminous igneous rock series and overall metal content of over 1000 worldwide sulfide systems (see Table below).

OVERALL METAL CONTENT OF MINERAL DEPOSITS ASSOCIATED WITH METALUMINOUS IGNEOUS ROCK SERIES[1]

SUBALKALINE[4] $K_{57.5} \leq 2.45$[2]; PI ≥ 56[3]; $Ca_{70} > 1.5$; F content of magmatic biotite < 0.7%		ALKALINE $K_{57.5} \geq 2.45$; PI ≤ 56; $Ca_{70} < 1.5$; F content of magmatic biotite commonly >0.7%	
CALCIC $K_{57.5}$ = 0.0-1.15	CALC-ALKALI $K_{57.5}$ = 1.15-2.45	ALKALI-CALCIC $K_{57.5}$ = 2.45-3.8	ALKALIC $K_{57.5}$ = $\geq$ 3.8
Fe[5], Mn, V, Ti, Cu, Bn, Sn, Pb, Cd, Ag, Au, Platinoids, Co, Cr, Ni, S; Lack of U, Th, F, Li, Hg, Sb, Mo, Ba, and generally W, As (except for exhalative calcic gold systems) and Sn (except exhalative Cu-Zn massive sulfide facies systems).	Fe[5], Cu, Zn, Pb, Ag, Au, Sb, Hg, S, Ba, W, Mo, Mn, Bi, (As, Se, Tl); Lack of Ni, Cr, Sn, F, U, Th, Ti and generally Co and platinoids; W occurs strictly as scheelite; S is apparently maximized in this class; pyrite: pyrrhotite ratio is much higher than in calcic systems.	Fe[5], Mn, Pb, Zn, Ag, Cu, Au, Mo, Sn, Be, U, F, W, (Te); general lack of Hg (except peralkalic), Sb, Co, Ni, Ti, Cr, platinoids; lower S than in subalkalic systems; W occurs as huebnerite-wolframite series ± scheelite.	Cu[5], Pb, Zn, Au, Ag, F, U, Th, P, Mo, Fe, Mn, rare earths, Nb (Te); lacks same elements as alkali-calcic systems; W occurs mostly as huebnerite-wolframite series.

Notes: (1) Metaluminous igneous rocks series are where molecular (Al_2O_3/ $CaO + K_2O + Na_2O$) < 1.0 somewhere in the differentiation continuum. (2) $K_{57.5}$ index = K_2O content at 57.5% SiO_2 on a K_2O-SiO_2 variation diagram. (3) PI = Peacock alkali-lime index. (4) CA_{70} = CaO content at 70% SiO_2 on a CaO-SiO_2 variation diagram. (5) Nonunderlined elements have major production with respect to other classes; underlined elements have minor production with respect to other classes; double underlined elements have very minor production (by-product only) with respect to other classes; elements enclosed by parentheses are consistently occurring trace elements in anomalous but generally noncommercial amounts.

One interpretation of the above table is that the different metallic suites and their correlative alkali magma chemistry represent chemically distinct layered source regions in the upper 700 km of the earth's mantle with lower layers progressively more enriched in incompatible elements.

In Southwest North America, time-slice treatment of magmatic and metallogenic data for fossil hydrothermal systems reveals that in any time-slice (1) spatial patterns of magmatism form linear belts of equal alkalinity that generally parallel the inferred position of the paleotrench. (2) Alkalinity within the magmatic arc generally increases continentward away from the trench except for periods younger than 14-12 m.y. in Arizona-Southeast California and 8-6 m.y. in the Great Basin when truly basaltic magma chemistry and no regional alkalinity gradients are apparent. (3) Each alkalinity zone is systematically associated with a metallogenic belt that contains the metallic elements outlined in the above table. (4) Between 145 and 0 m.y. the magmatic arc migrates eastward (145-43 m.y. with a dramatic eastward acceleration at 85 m.y.) and then southwestward (43-0 m.y.). (5) Migration of the magmatic arc in space and time produces a cumulative overprinting of magma chemistry and metallogenic types. For example, the region around Tonopah, Nevada was the site of hypothermal tungsten (scheelite) skarn mineralization associated with calc-alkali granodiorite plutons 95-80 m.y. ago, lithophile-poor mesothermal Mo systems (Hall, Redlich) associated with calc-alkali granites about 85-70 m.y. ago, lithophile-poor tungsten (heubnerite-wolframite)-bearing veins associated with peraluminous muscovite-bearing granites 74 to 60 m.y. ago, epithermal Au-Cu mineralization (Goldfield) associated with 25-22 m.y. calc-alkali volcanism, epithermal silver, lead-zinc mineralization (Tonopah, Divide) associated with alkali-calcic volcanism 22-17 m.y. ago, and Au-F mineralization (Bullfrog) associated with alkalic volcanism 15-8 m.y. ago.