DESCRIPTIVE MODEL OF DETACHMENT-FAULT-RELATED POLYMETALLIC DEPOSITS

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BRIEF DESCRIPTION

SYNONYM: Detachment-fault-related gold, flat-fault gold.

DESCRIPTION: Massive replacements, stockworks, and veins of iron and copper oxides and locally sulfides along detachment-fault structures. These deposits sometimes contain economic concentrations of gold and silver. Distal veins of quartz-barite-fluorite-Mn oxides emplaced along high-angle faults in the upper plate of detachment-faulted terranes.

GENERAL REFERENCE: Wilkins and others (1986).

TYPICAL DEPOSITS: Bullard (Roddy and others, 1988), Copperstone (Spencer and others, 1988), Osborne (Allen, 1985), Planet (Lehman and Spencer, 1989), Harris (Roddy and others, 1988), Tiger Wash (Allen, 1985).

COMMODITIES: Cu + Au + Ag ± Pb ± Zn.

OTHER COMMODITIES: Fe-Ba-F-Mn-Mo-V.

ASSOCIATED DEPOSIT TYPES (*suspected to be genetically related): *Lacustrine Mn.

REGIONAL GEOLOGIC ATTRIBUTES

TECTONOSTRATIGRAPHIC SETTING: Extensional terranes characterized by regional detachment faulting.

REGIONAL DEPOSITIONAL ENVIRONMENT: Half-graben mountain ranges and hydrographically closed basins that formed syntectonically with extensional deformation above detachment faults.

AGE RANGE: Known deposits range from middle to late Tertiary in age.

LOCAL GEOLOGIC ATTRIBUTES

HOST ROCKS: (1) Lower-plate mylonitic rocks, chlorite breccias, and structurally emplaced slivers of upper-plate rocks. (2) Upper-plate Paleozoic to Mesozoic (meta)sedimentary and (meta)volcanic rocks, Mesozoic to early Tertiary felsic intrusive rocks, middle to late Tertiary mafic to intermediate lavas, silicic tuffs, and sedimentary rocks deposited in alluvial fan, fluvial, and saline lake environments.

ASSOCIATED ROCKS: Syn- to posttectonic alkali basalts, microdiorite dikes, and sedimentary rocks deposited in half-graben basins.

ORE MINERALOGY: Specular and earthy hematite, chrysocolla, and gold or electrum. Locally abundant chalcopyrite and other copper sulfides. Rare galena, sphalerite, and tetrahedrite. Sulfides accompany chloritic alteration in early-stage mineralization along and below detachment fault. Quartz-hematite-calcite-chrysocolla mineralization follows along and above detachment fault. Late-stage quartz-barite-fluorite-manganese oxide veins with locally abundant copper oxides, cerargyrite, argentite, gold, and hematite occur above detachment fault.

GANGUE MINERALS: Quartz (sometimes chalcedonic or amethystine), calcite (often ferrous and (or) manganiferous), barite, fluorite, and manganese oxides. Locally abundant pyrite, jasperoid, gypsum, and clays.

ZONING: Intensity of mineralization and alteration decreases away from detachment fault. Many districts zoned from polymetallic deposits outward to Ba-F-Mn veins. Mineralization tends to be base metal–rich and precious metal–poor near the detachment fault but precious metal–rich/base metal–poor away from the detachment fault.

ORE CONTROLS: Deposits commonly located above axis or flanks of synformal structures in underlying detachment surface. Orebodies are localized along high-angle fault zones below the detachment fault, along the detachment fault, and in high-angle, sometimes listric, normal faults in the upper plate. Gold is often associated with local silica flooding and amethystine quartz veins in brittle, fractured upper-plate rocks. Massive specularite replacements and chrysocolla veins occur in reactive calcareous units in both the upper and lower plates.

ISOTOPIC SIGNATURES: Quartz associated with oxide ore minerals has 6 to 8 per mill $\delta^{18}O$, and that associated with sulfide ore minerals has 10 to 12 per mill $\delta^{18}O$. Calcite associated with oxide ore minerals has 4 per mill $\delta^{18}O$ and –4 to –6 per mill $\delta^{13}C$ PDB. K-metasomatized rock has lower $\delta^{18}O$ than unaltered rock by 2 to 4 per mill.

FLUID INCLUSIONS: In quartz, calcite and barite associated with sulfide ore homogenization temperatures are higher (220 to 350 °C) than those associated with oxide ore (150 to 350 °C). Salinities, however, are similar at 10 to 23 equivalent weight percent NaCl. These fluids are thought to be saline brines derived from syntectonic, hydrographically closed, arid basins. Quartz in distal Ba-F-Mn veins have low-temperature (90 to 200 °C) and saline (6 to 20 weight percent equivalent NaCl) fluid inclusions.

STRUCTURAL SETTING: Local flexures of a regional detachment fault with strong development of upper-plate, high-angle, listric and planar normal faults.

ORE DEPOSIT GEOMETRY: (1) Narrow fracture and fault fillings that are 3 cm to 12 m in width with strike lengths of 30 to 2,000 m. (2) Irregular, pod-shaped massive replacements of reactive lithologies up to 900 m long, 100 m wide and 3 to 30 m thick. (4) Pods and anastomosing veins along low-angle faults. (5) Veinlets and breccia clasts in fault breccia.

ALTERATION: Wall rock dependent. Distinct alteration suites are observed: (1) Pre-ore to early chloritic (chlorite-epidote-hematite) alteration of lower-plate mylonites and fault breccias, sometimes with associated quartz-pyrite-chalcopyrite±galena mineralization. (2) Pre-ore to early K-metasomatism of upper-plate volcanic rocks. Mafic rocks are converted into K-feldspar-hematite-calcite-chlorite-epidote rocks, and silicic rocks are converted into K-feldspar-hematite-quartz rocks. (3) Pre-ore to early massive carbonate replacement of carbonate rocks. (4) Propylitic (chlorite-calcite-epidote-sericite-clay) alteration envelopes around veins hosted by mafic rocks. Quartz-chrysocolla veins often have clay selvages. (5) Weak sericite-silica-dolomite envelopes around Ba-F-Mn veins in calcareous rocks.

TYPICAL ALTERATION/OTHER HALO DIMENSIONS: (1) Chloritic alteration may extend from the top of the detachment fault down to 300 m below the detachment fault. (2) K-metasomatism may extend more than 2 km above the detachment fault in zones more than 10 km in extent. (3) Massive carbonate replacements range up to 900 m in length, 100 m wide, and about 30 m thick. (4) Propylitic alteration halos are narrow, up to a few centimeters around veins and fracture fillings.

EFFECT OF WEATHERING: Most ore consists of primary oxides. Locally abundant sulfides may be oxidized.

EFFECT OF METAMORPHISM: Metamorphosed deposits are not known.

GEOCHEMICAL SIGNATURES: Host rocks are enriched in Cu, Pb, Zn, Au, Ag, and Ba and depleted in Mn, Sr, Ni, and Rb. As, Sb, Hg, and Tl are also very low.

GEOPHYSICAL SIGNATURES: There may be a resistivity contrast between oxide ores along and above the detachment fault and the mylonite zone beneath the detachment fault. Silica flooded zones may have high resistivity. Massive hematite orebodies may produce a magnetic dipole anomaly. Shallow reflection seismic might detect detachment-fault structures.

OTHER EXPLORATION GUIDES: Conodont alteration of upper-plate Paleozoic sediments may serve as a guide to regional paleo-heat flow related to fluid movement along and above detachment faults.

OVERBURDEN: Variable, owing to differing degrees of uplift along half-graben structures and regional warps. Polymetallic deposits are thought to have formed at a depth of 1 to 3 km (Spencer and Welty, 1986), and Ba-F-Mn veins at a depth of 0.5 km (Allen, 1985).