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Redox-Sulfidation Relationships of Porphyry Copper, IOCG and Sediment-Hosted Deposits to Source-Rock Hydrocarbons and Brines: The Tops of Deep Sediment-Hosted Porphyries

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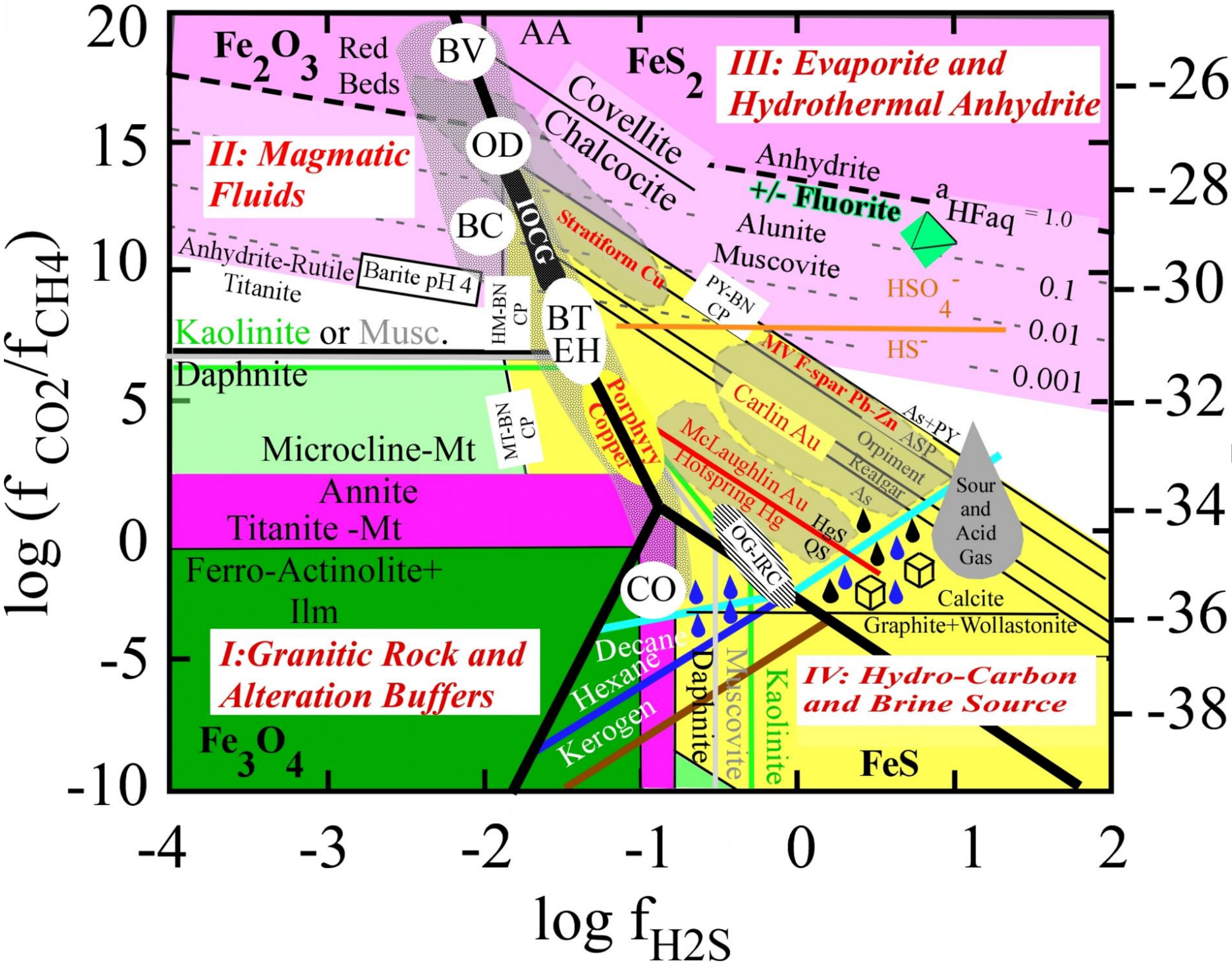
Presented here is a comparative geochemical framework for magmatic-hydrothermal and sediment-hosted ore deposits in relation to sedimentary source rocks of basinal brines and hydrocarbons. The phase diagram has been computed using thermodynamic equilibrium constants (300°C and 50 MPa) showing mineral-solution-gas reactions within CO_2/CH_4-H_2S gas fugacity coordinates. The figure shows in thick black lines stability fields of pyrite, magnetite, hematite, and pyrrhotite. Chalcopyrite is shown in yellow surrounded by bornite in the pyrite field and in the hematite and magnetite fields chalcopyrite is surrounded by bornite alone. Key geological domains are depicted in red in the four corners of the diagram: I: Granitic Rocks and Alteration Buffers show the nested Fe end member stability fields of actinolite in dark green, biotite in purple, chlorite in light green, and muscovite. II: Magmatic Hydrothermal fluids, III: Evaporite and Hydrothermal Anhydrite, and IV: Hydrocarbon and Brine Source Sediments showing the location of diagenetic maturation reactions of kerogen (C_{128} $H_{68}O_7$), hexane $C_6H_{14\ aq}$ and n-decane ($C_{10}H_{22\ gas}$) to methane, siderite, and water. Using mineral assemblages as guideposts the porphyry copper deposit trend is shown where "BT" is the Butte high-temperature assemblage, "BC" is Bingham, and high-grade Butte veins with covellite-chalcocite with advanced argillic alteration are shown as "BV." Chalcopyrite-bearing Orbicular Actinolite alteration "CO" completes the array of porphyry systems from magma to host sediments. The Olympic Dam IOCG deposit is "OD" and Ernest Henry is "EH," which lacks bornite. Although the geotectonic framework is different, porphyry and IOCG deposits show a similar path. Anhydrite in porphries, however, contrasts sharply with fluorite in the IOCGs, which reflects extremely high HF_{aq} concentrations. In contrast, a family of reactions involving Hg and As plot with shallower negative slopes connecting the spectrum of basinal petroleum/brine reduced H_2S and metamorphic fluids with magmatic fluids as buffer-controlled mixing lines revealing varied source of brines, petroleum, and metals in hot spring Hg, Au, and fluorspar Pb-Zn. Orogenic Au and reduced intrusion-related Cu lack barite (OG-IRC). Sediment-hosted deposits occur along these buffered reaction lines in accord with the amount of amagmatic sediment-derived species, carbonaceous hydrocarbons, and brines relative to magmatic sources. These reaction lines bridge inorganic and organic sources of ore-forming components and operate when fluid potential gradients support advection. The Hg and As mineral equilibria bridging the sedimentary source rocks to porphyry trends are the missing link that ensures that stratiform ores fall on a spectrum from syngenetic to magmatic processes, thus explaining enigmatic features like high-K fluids and rutile. CO_2, CH_4, and H_2S are sufficiently high that the patterns described are substantiated by Raman spectroscopy of fluid inclusions. Chalcopyrite-bearing orbicular actinolite alteration along the porphyry trend at both Bingham and the Clementine Prospect with soil Hg-Ag-Zn anomalies and peripheral barite and arsenopyrite at depth is reason to rethink the nature of the tops of deep porphyries confined by regional fold-and-thrust anticlines. Furthermore, passive tectonic margin host-rock stratigraphy ensures that deep sediment-hosted porphyry deposits afford multiple opportunities for Leadville Colorado-style high-grade replacement mineralization along multiple Sloss-sequence stratigraphy unconformities.



Fe2O3
Red Beds
BV
AA
FeS2
III: Evaporite and Hydrothermal Anhydrite
OD
Covellite
Chalcocite
II: Magmatic Fluids
Anhydrite
+/- Fluorite
aHFaq = 1.0
BC
IOCG
Stratiform Cu
Alunite
Muscovite
Anhydrite-Rutile Titanite
Barite pH 4
HM-BN CP
PY-BN CP
HSO4-
0.1
BT
EH
0.01
HS-
Kaolinite or Musc.
MV F-spar Pb-Zn
Daphnite
0.001
Porphyry Copper
Carlin Au
As+PY
ASP
Orpiment
Realgar
As
MT-BN CP
Microcline-Mt
McLaughlin Au
Hotspring Hg
Annite
Titanite -Mt
Sour and Acid Gas
HgS
QS
OG-IRC
Ferro-Actinolite+ Ilm
CO
Calcite
Graphite+Wollastonite
I:Granitic Rock and Alteration Buffers
Decane
Hexane
Kerogen
Daphnite
Muscovite
Kaolinite
IV: Hydro-Carbon and Brine Source
Fe3O4
FeS
20
15
10
5
0
-5
-10
-4
-3
-2
-1
0
1
2
-26
-28
-30
-32
-34
-36
-38
log (fCO2/fCH4)
log fH2S
log fO2