UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

U.S. GEOLOGICAL SURVEY-INGEOMINAS

MINERAL RESOURCE ASSESSMENT OF COLOMBIA: ORE DEPOSIT MODELS

By Dennis P. Cox, Editor

Open-File Report
83-423

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards.

Menlo Park, California
1983

PREFACE

This compendium of ore deposits models was assembled for the Colombia Mineral Resource Assessment Project. The objectives of the compendium are: (1) to define mineral deposit types so that all project members have a common vocabulary or deposit classification scheme to which mineral occurrences, favorable geologic environments, favorable geochemical anomalies, and tonnage-grade models may be related; (2) to provide data on the environments of ore deposition so that favorable rocks, structures, and tectonic settings can be easily recognized by project geologists; and (3) to relate possibly the associations of elements within geochemical anomalies to specific deposit types so that geochemical data may be more easily interpreted. A key-word index and an element association index are included to help in achieving the second and third objectives.

The compendium is not complete at this stage and many models useful in the Colombia assessment still need to be added. Appropriate models for the Proterozoic shield environments of eastern Colombia are needed.

The editor is pleased to acknowledge the cooperation of the authors of the models included in this report. Blank forms and instructions for their use are included in the following pages to encourage other authors to join in this effort. Send your models to Dennis P. Cox, Mail Stop 41, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025.

EXPLANATION OF DEPOSIT MODEL FORM

Deposit type: Fill in your preferred name for the deposit type.

Subtype: Optional. Use if it is convenient for your classification scheme.

Author: Author of model.

Date: When you filled out the form.

Approximate synonym: Optional. A different, but well-known name used by another author.

Of (reference): The author that used the synonym.

Description: A short description so that the casual user will not have to read the whole form.

General reference: Optional. May be a volume of papers on one deposit type, or a single comprehensive article.

Rock types: Rocks typical of the geologic terrane in which the deposits are found. (For igneous rock, use terminology of Williams and Turner, and Gilbert, 1954.)

Textures: Special textures associated with the rocks.

Age range: Ages of known deposits and ages in which such deposits might have formed.

Depositional environment: Plutonic, volcanic, or sedimentary environments related to ore-forming process.

Tectonic setting(s): Regional tectonic features important in the genesis of the deposit type.

Associated deposits: Example, copper skarns associated with copper porphyries.

Metal concentrations: Regional geochemical anomalies that might be indicative of the deposit or related to associated deposits.

Ore minerals: List ore and gangue minerals in assemblages. Show zonal or temporal relation between assemblages. List essential minerals with (+) signs, and varietal minerals with (±) signs. Group trace minerals separately. List biproduct metals i.e., Au, Ag, that may not form minerals. Do not include secondary minerals except for deposits formed by weathering.

Texture/structure: Describe appearance of ore.

Alteration: Minerals produced by reaction of ore-forming fluids with rocks. List in assemblages. Show zonal or temporal relation between assemblages. Use terms such as potassic (potassium-feldspar+biotite), phyllic (white mica+pyrite), argillic (clay+white mica), advanced argillic (clay+pyrophyllite$\pm$alunite$\pm Al_2O_3$ minerals) as they apply. Include skarn mineral assemblages where appropriate.

Ore controls: List special stratigraphic, structural, or geochemical features that are believed to have influenced ore-mineral deposition.

Weathering: Optional. List any special weathering characteristics or secondary minerals that might serve as prospecting guides.

Geochemical signature: Elements expected to be anomalous (enriched or depleted) in and near the deposit. List element assemblages and show zonal arrangement where possible.

Examples: A Colombian or Andean example should be included where possible.

References: One reference for each example. Give name and year. Include complete reference on a separate sheet.

Additional information needed

Sketch: Where possible, include a well-labeled map or section of a deposit, or a cartoon of an ideal deposit, showing ore controls, zoning, and approximate dimensions.

Key words: Underline in red those words or word combinations that should appear in an index. Pillow basalt is a key word for Cyprus-type massive sulfides, for example.

TABLE OF CONTENTS

DEPOSIT TYPE Podiform chromite SUBTYPE

AUTHOR John P. Albers DATE December 6, 1982

APPROXIMATE SYNONYM Alpine type chromite OF (REFERENCE) Thayer, 1964

DESCRIPTION Podlike masses of chromitite in ultramafic parts of ophiolite complexes.

GENERAL REFERENCE Dickey, 1975.

GEOLOGICAL ENVIRONMENT

Rock Types Highly deformed dunite and harzburgite of ophiolite complexes; commonly serpentinized.

Textures Nodular, orbicular, gneissic, cumulate, pull-apart; most relict textures are modified or destroyed by flowage at magmatic temperatures.

Age Range Phanerozoic.

Depositional Environment Lower part of oceanic lithosphere.

Tectonic Setting(s) Magmatic cumulates in elongate magma pockets along accreting plate boundaries.

Associated Deposit Types "Disseminated" chromite.

Metal Concentrations Platinum-group metals are common accessories.

DEPOSIT DESCRIPTION

Ore Minerals: Chromite, olivine, serpentine minerals.

Texture/Structure As above.

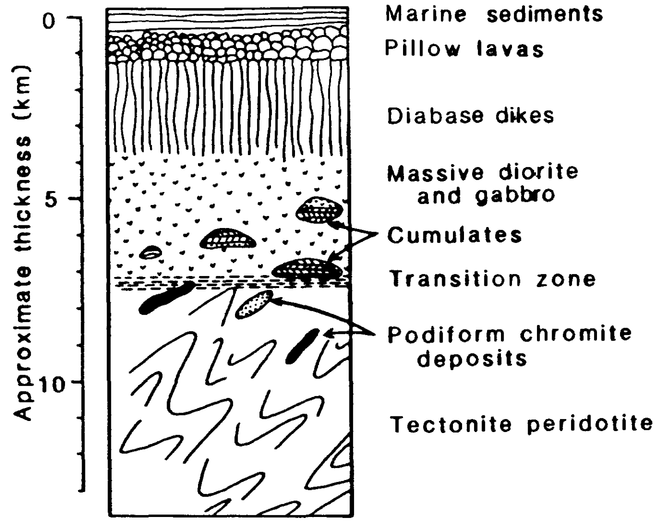
Alteration No

Ore Controls Restricted to dunite bodies in tectonized harzburgite.

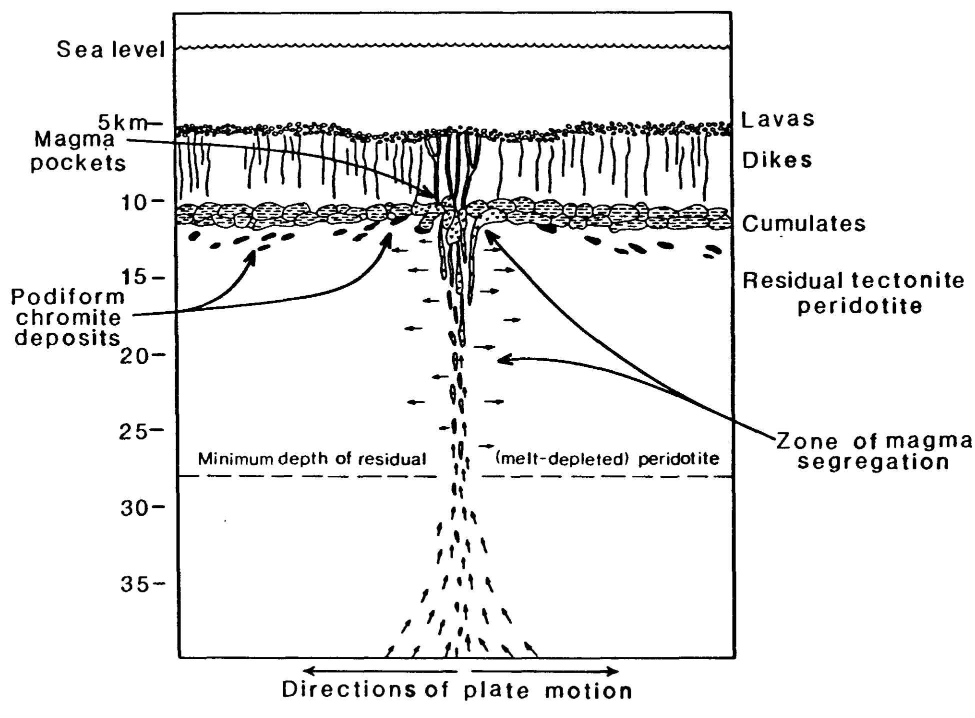
Weathering Highly resistant to weathering and oxidation but locally forms secondary minerals such as uvarovite.

Geochemical Signature: None recognized.

Examples High Plateau, Del Norte Cty, CA References Wells, F. G. et al 1946
Santa Helena, Antioquia, Colombia
Coto Mine, Luzan, P.I.



From Dickey, 1975



From Dickey, 1975

DEPOSIT TYPE Zoned ultramafic Cr Pt SUBTYPE

AUTHOR N. J Page DATE December 12, 1982

APPROXIMATE SYNONYM Alaskan, Uralan OF (REFERENCE)

DESCRIPTION Crosscutting ultramafic to felsic intrusives with approximately concentric zoning of rock types containing chromite, platinum and Ti- V-magnetite.

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Dunite, wehrlite, harzburgite, pyroxenite, magnetite-hornblende pyroxenite, 2 pyroxene gabbros, hornblende gabbro, hornblende clinopyroxenite hornblende magnetite clinopyroxenite, olivine gabbro, norite, tonalite, diorite.

Textures Cumulus textures poikilitic, mush flow textures, lineated fabrics, layered.

Age Range Precambrian to late Mesozoic, most Paleozoic and Mesozoic.

Depositional Environment Deposits occur in the layered ultramafic and mafic rocks that intrude into granodiorite terranes, island arc, or ophiolite terrains.

Tectonic Setting(s) Unstable tectonic areas.

Associated Deposit Types Platinum group elements (PGE) plus Au placer deposits.

Metal Concentrations Cr, Ni, PGE.

DEPOSIT DESCRIPTION

Ore Minerals: Assemblage 1: chromite, Pt-Fe alloys, Os-Ir alloys, PGE sulfides, pentlandite, pyrrhotite native gold, PGE arsenides. Assemblage 2: Ti-V magnetite, Pt-Fe alloys, Os-Ir alloys, cooperite, sulfides, arsenides, bornite, chalcopyrite.

Texture/Structure Assemblage 1: clots, pods, schlieren, wisps of chromite inclunite, clinopyroxenite, harzburgite. Assemblage 2: magnetite segregations, layers in wehrlites, pyroxenites, gabbro.

Alteration serpentinization--not as a result of the mineralization

Ore Controls Appear to be restricted to specific rock types by magmatic processes.

Weathering Mechanical weathering produces placers, chemical weathering could produce laterites.

Geochemical Signature: Cr, PGE, Cu, Ni, S, As, probably chondrite normalized PGE patterns from placer deposits are diagnostic.

Examples Urals, USSR	References Duparc and Tikonovitch, 1920
Duke Island, Alaska	Irvine, 1974
Choco River placer, Columbia	Wokitel, 1961, Taylor, 1967

DEPOSIT TYPE Porphry, Cu SUBTYPE Mo rich

AUTHOR D. P. Cox DATE December 1, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stockwork veinlets of quartz, chalcopyrite and molybdenite in or near a porphyritic intrusion.

GENERAL REFERENCE Titley, S. R., 1982.

GEOLOGICAL ENVIRONMENT

Rock Types Quartz monzonite to tonalite intrusives and breccia pipes into older batholithic, volcanic or sedimentary rocks.

Textures Intrusions contemporaneous with ore are porphyries with fine to medium grained aplitic groundmass.

Age Range Mainly Mesozoic--Tertiary but can be any age.

Depositional Environment In intrusive porphyry or in country rock rich in mafic minerals or carbonate minerals.

Tectonic Setting(s) Numerous faults.

Associated Deposit Types Cu, Zn, or magnetite skarns may be rich in gold, gold+base metal sulfosalts in veins, gold placers

Metal Concentrations Cu, Mo, Pb, Zn, W, Au, Ag

DEPOSIT DESCRIPTION

Ore Minerals: Chalcopyrite+pyrite+molybdenite. Peripheral vein/replacement deposits with chalcopyrite+sphalerite+galena±gold. Outermost zone may have veins of Cu, Ag, Sb, sulfides and gold.

Texture/Structure Veinlets and disseminations or massive replacement of favorable country rocks.

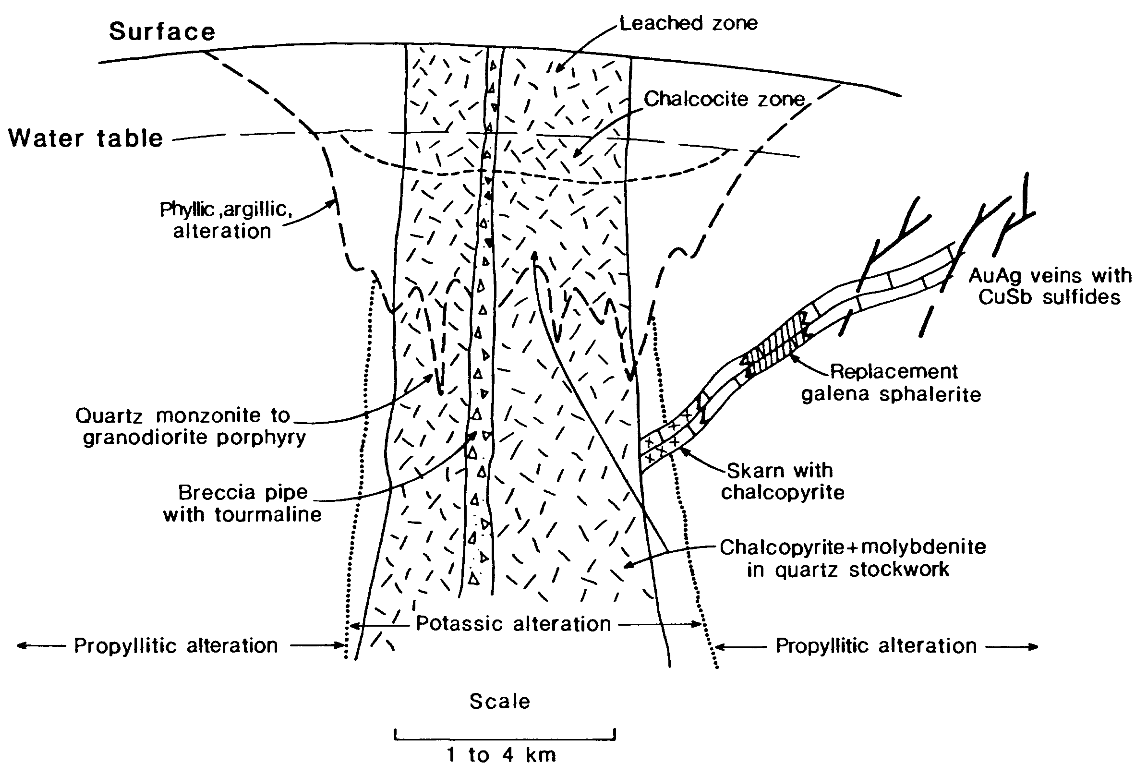
Alteration Quartz+K-feldspar+biotite (chlorite)± anhydrite grading outward to propylitic. Late white mica+clay alteration may form capping or outer zone or may affect the entire deposit.

Ore Controls Veinlets and mineralized fractures are closely spaced. Favorable country rocks are calcareous sediments; diabase tonalite or diorite.

Weathering Intense leaching of surface wide areas of iron oxide stain.
Geochemical Signature: Cu+Mo±W center; Pb, Zn, au, Ag, As, Sb, Te, Mn, and Rb in outer zone.

Examples El Salvador, Chile
Silver Bell, Arizona
Highland Valley, B.C. Canada

References Gustafson and Hunt, 1975
Graybeal, 1982
McMillan, 1976


Surface
Leached zone
Chalcocite zone
Water table
Phyllic, argillic, alteration
AuAg veins with CuSb sulfides
Replacement galena sphalerite
Quartz monzonite to granodiorite porphyry
Skarn with chalcopyrite
Breccia pipe with tourmaline
Chalcopyrite+molybdenite in quartz stockwork
Potassic alteration
Propyllitic alteration
Propyllitic alteration
Scale
1 to 4 km

DEPOSIT TYPE Porphyry Cu SUBTYPE Au rich

AUTHOR Dennis P. Cox DATE December 1, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stockwork veinlets of chalcopyrite, bornite and magnetite in porphyritic intrusions and coeval volcanic rocks.

GENERAL REFERENCE Sillitoe, 1979

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite, quartz monzonite; dacite, andesite flows and tuffs coeval with intrusives. Also syenite, monzonite, and shoshonitic volcanics.

Textures Intrusive rocks are porphyritic with fine to medium grained aplitic groundmass.

Age Range Cretaceous to Quaternary.

Depositional Environment In intrusive porphyry, coeval volcanic rocks and intrusion breccia. Porphyry bodies may be as dikes.

Tectonic Setting(s) Numerous faults, large scale breccias. Evidence of volcanic center, 1 to 2 km depth of emplacement.

Associated Deposit Types Porphyry copper molybdenum; gold placers.

Metal Concentrations Cu, Au, Zn, Mo, Pb, Ag.

DEPOSIT DESCRIPTION

Ore Minerals: Chalcopyrite±bornite, gold and silver do not form minerals.

Texture/Structure Veinlets and disseminations.
Alteration Quartz+magnetite+biotite (chlorite)± K-feldspar±actinolite, center. Outer propylitic zone. Late quartz+pyrite+white mica±clay may be present.

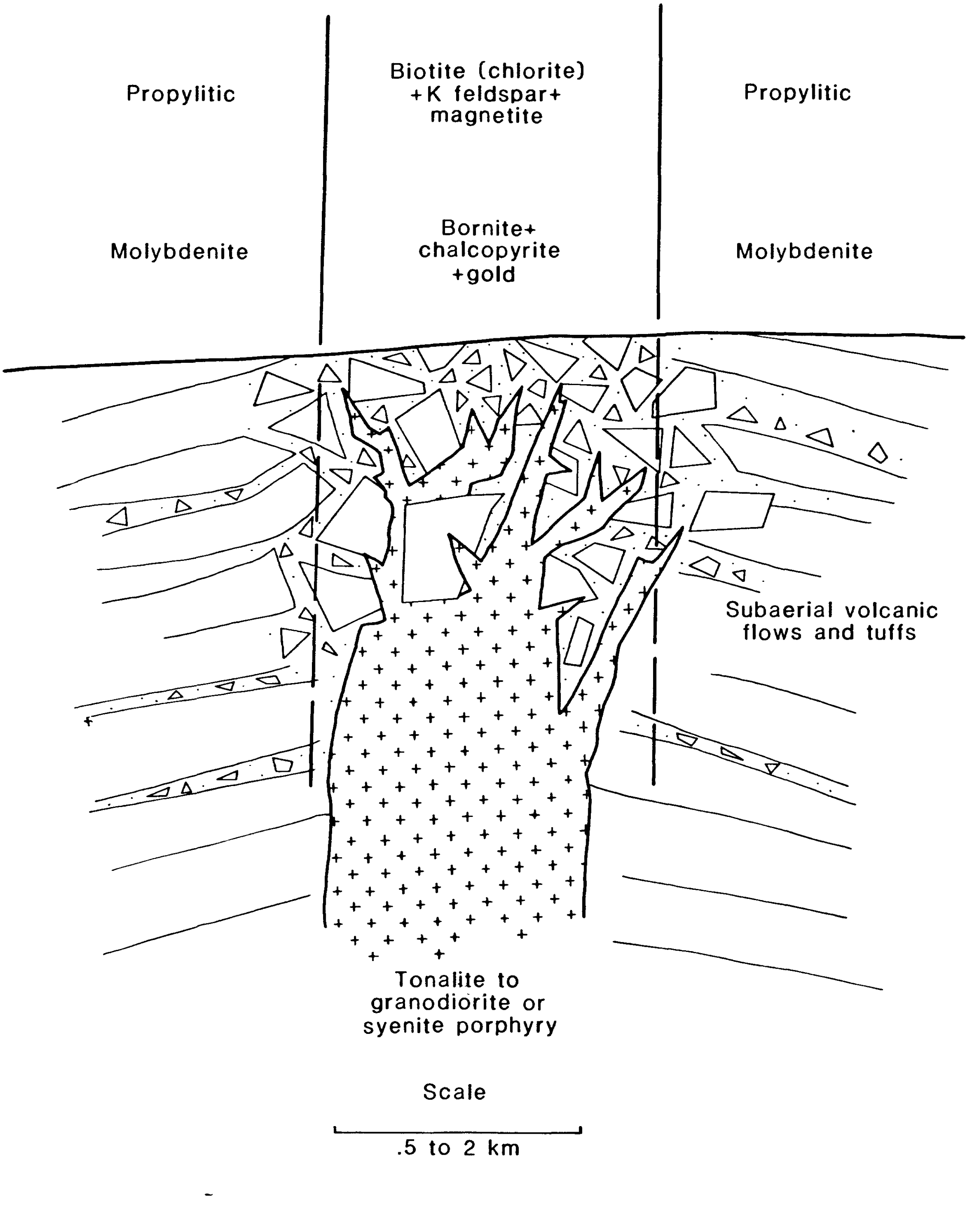
Ore Controls Veinlets and fractures of quartz, sulfides, K-feldspar magnetite, biotite, or chlorite are closely spaced.

Weathering Surface iron staining may be weak or absent if pyrite content is low in protore. Copper silicates and carbonates.

Geochemical Signature: Central Cu, Au, Ag; peripheral Mo, Pb, Zn, Mn

Examples
Tanama, Puerto Rico
Dos Pobres, Arizona
Copper Mountain, B.C., Canada

References
Cox, unpublished data
Langton and Williams, 1982
Fahrni, McCauley and Preto, 1976


Propylitic
Biotite (chlorite)
+K feldspar+
magnetite
Propylitic
Molybdenite
Bornite+
chalcopyrite
+gold
Molybdenite
Subaerial volcanic
flows and tuffs
Tonalite to
granodiorite or
syenite porphyry
Scale
.5 to 2 km

DEPOSIT TYPE Molybdenum Porphyry SUBTYPE Climax

AUTHOR Steve Luddington DATE December 6, 1982

APPROXIMATE SYNONYM Granite molybdenite OF (REFERENCE) Mutschler and others, 1981

DESCRIPTION Stockwork of quartz and molybdenite associated with fluorite in granite porphyry.

GENERAL REFERENCE White and others, 1981.

GEOLOGICAL ENVIRONMENT

Rock Types Granite-rhyolite with >75 percent SiO_2 content. Rhyolite dikes with spessartine garnets on periphery of system.

Textures Porphyry with fine to medium-grained aplitic groundmass.

Age Range Mesozoic, Tertiary.

Depositional Environment Hypabyssal intrusions. Mainly continental interior, thick continental crust.

Tectonic Setting(s) Mainly rift zones in cratons. Less commonly in continental margin mobile belts.

Associated Deposit Types Ag-base-metal Gold veins, fluorspar deposits.

Metal Concentrations Mo, F, W, Sn, U, Be, Li and rare earths.

DEPOSIT DESCRIPTION

Ore Minerals: Molybdenite+fluorite+pyrite$\pm$wolframite$\pm$cassiterite$\pm$topaz.

Texture/Structure Disseminated and in veinlets and fractures.

Alteration Intense quartz veining, K-feldspar veining. Outer phyllic and prophylitic zones. Halo of rhodochrosite, rhodonite, spessartine.

Ore Controls Stockwork ore zone draped over small <1 km^2 cupolas.

Weathering Yellow ferrimolybdite stains.

Geochemical Signature: Outer Cu zone, peripheral Pb, U, and RE anomalies. Rb and Cs in K-feldspar altered host rocks.

Examples Climax Colorado References White and others, 1981

DEPOSIT TYPE Molybdenum porphyry SUBTYPE Low fluorine

AUTHOR Ted G. Theodore DATE December 6, 1982

APPROXIMATE SYNONYM Calc-alkaline Mo Stockwork OF (REFERENCE) Westra and Keith, 1981

DESCRIPTION Stockwork of quartz-molybdenite veinlets in felsic porphyry

GENERAL REFERENCE Westra and Keith, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite granodiorite-quartz monzonite

Textures Porphyry, fine aplitic groundmass

Age Range Mesozoic-Tertiary

Depositional Environment Continental margin

Tectonic Setting(s) Numerous faults

Associated Deposit Types Vein deposits of chalcopyrite-enargite-bornite-molybdenite; or pyrite-gold; or sphalerite-galena-gold-silver

Metal Concentrations Mo, Cu, W, Ag, Au, Pb, Zn

DEPOSIT DESCRIPTION

Ore Minerals: Molybdenite+pyrite±scheelite±chalcopyrite

Texture/Structure Disseminated and in veinlets and fractures

Alteration Potassic outward to propylitic. Phyllic and argillic overprint

Ore Controls Stockwork

Weathering Yellow ferrimolybdite after molybdenite

Geochemical Signature: Zoning outward and upward from Mo+Cu to Cu, Au to Zn, Pb, Au, Ag

Examples Buckingham, Nevada; USSR deposits

References Blake and others, 1979; Pavlova and Rundquist, 1980

DEPOSIT TYPE Iron skarn — SUBTYPE

AUTHOR Dennis Cox — DATE December 8, 1982

APPROXIMATE SYNONYM — OF (REFERENCE)

DESCRIPTION Magnetite in calc silicate contact metasomatic rocks.

GENERAL REFERENCE Einaudi and Burt, 1982; Einaudi and others, 1981.

GEOLOGICAL ENVIRONMENT

Rock Types Gabbro, diorite, diabase syenite and coeval volcanic rocks.

Textures Granitic texture in intrusive rocks; granoblastic to hornfelsic.

Age Range Mainly Mesozoic and Tertiary, may be any age.

Depositional Environment Contacts of intrusion and carbonate rocks or calcareous clastic rocks.

Tectonic Setting(s) Oceanic island arc and rifted continental margin.

Associated Deposit Types

Metal Concentrations Fe, Cu, Co, Au

DEPOSIT DESCRIPTION

Ore Minerals: Magnetite±chalcopyrite±cobaltite±pyrite±pyrrhotite. Rarely cassiterite.

Texture/Structure Granoblastic with interstitial ore minerals.

Alteration Diopside-hedenbergite+grossular-andradite+epidote. Late stage amphibole±chlorite±ilvaite.

Ore Controls Carbonate rocks, calcareous rocks, igneous contacts and fracture zones near contacts.

Weathering Magnetite generally crops out or forms abundant float.

Geochemical Signature: Fe, Cu, Co, Au, possibly Sn

Examples Daiquiri, Cuba
Shinyana, Japan

References Lindgren and Ross, 1916
Uchida and Iiyama, 1982

DEPOSIT TYPE Copper skarn

SUBTYPE

AUTHOR Dennis P. Cox

DATE December 9, 1982

APPROXIMATE SYNONYM

OF (REFERENCE)

DESCRIPTION Chalcopyrite in calc-silicate contact metasomatic rocks.

GENERAL REFERENCE Einaudi and Burt, 1982; Einaudi and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Granodiorite to quartz monzonite intruding carbonate rocks or calcareous clastic rocks.

Textures Granitic texture, porphyry, granoblastic to hornfelsic.

Age Range Mainly Mesozoic but may be any age.

Depositional Environment Miogeoclinal sequences intruded by felsic plutons.

Tectonic Setting(s) Continental margin late orogenic magmatism.

Associated Deposit Types Porphyry Cu, zinc skarn, replacement Pb Zn

Metal Concentrations Cu, Pb, Zn, Au, Ag, Mo

DEPOSIT DESCRIPTION

Ore Minerals: Chalcopyrite+pyrite±hematite±magnetite±bornite±pyrrhotite± molybdenite±tennantite±gold and silver.

Texture/Structure Granoblastic with interstitial sulfides.

Alteration Diopside+andradite center; wollastonite outer zone; marble peripheral zone. Late stage actinolite±chlorite±montmorillonite. Igneous rocks may be altered to epidote pyroxene garnet or to potassic and phyllic assemblages.

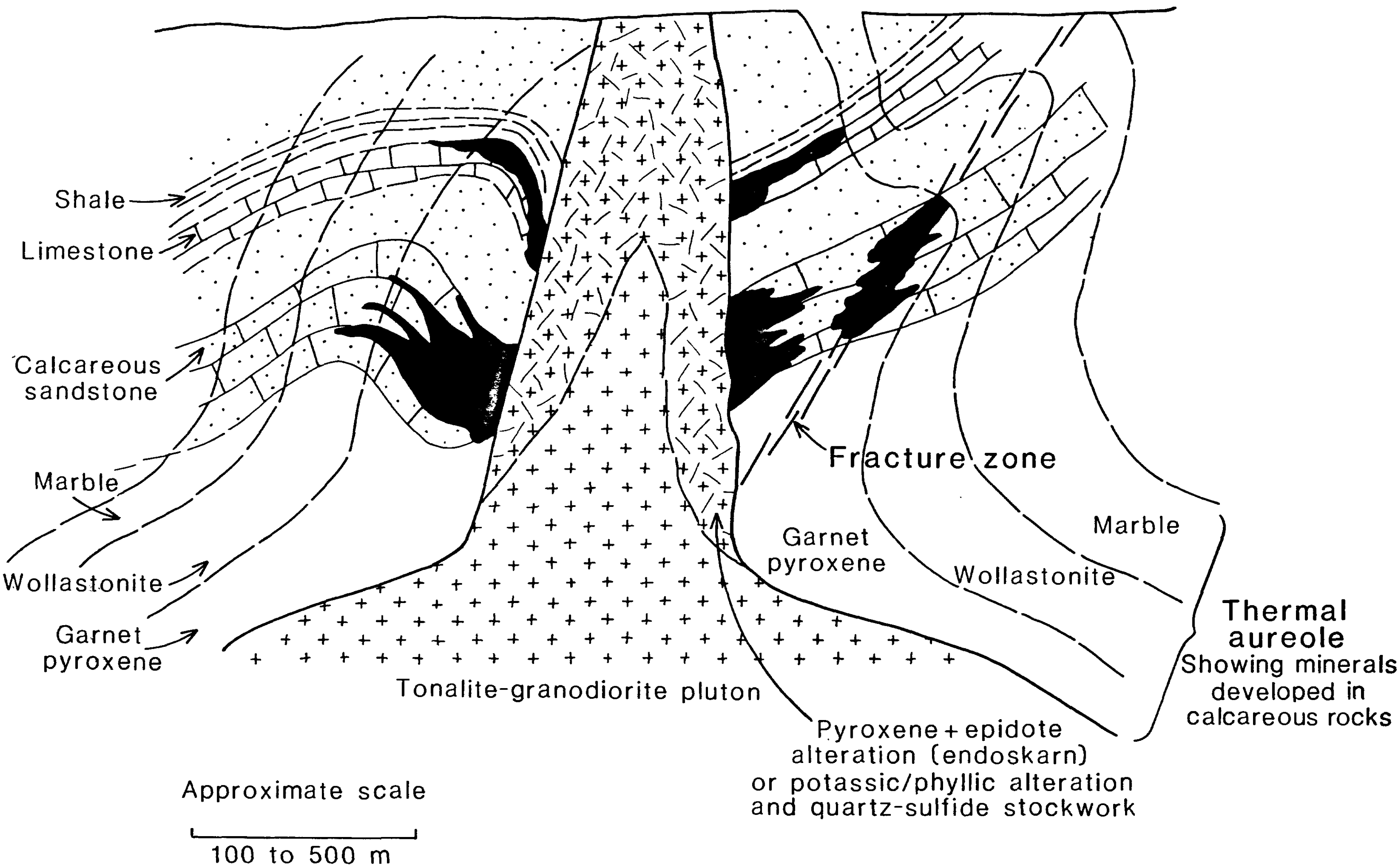
Ore Controls Carbonate rocks, calcareous rocks, igneous contacts and fracture zones near contacts.

Weathering Cu carbonates, gossan.

Geochemical Signature: Cu, Pb, Zn, Au, Ag, Mo possibly Bi.

Examples Carr Fork, Utah
Morococha, Peru
Mina Vieja, Colombia

References Atkinson and Einaudi, 1978
Petersen, 1965
Alberto Nunez, oral commun., 1982


Shale
Limestone
Calcareous sandstone
Marble
Wollastonite
Garnet pyroxene
Tonalite-granodiorite pluton
Fracture zone
Garnet pyroxene
Wollastonite
Marble
Thermal aureole
Showing minerals developed in calcareous rocks
Pyroxene + epidote alteration (endoskarn) or potassic/phyllic alteration and quartz-sulfide stockwork
Approximate scale
100 to 500 m

DEPOSIT TYPE Zinc-lead skarn

SUBTYPE

AUTHOR Dennis P. Cox

DATE December 9, 1982

APPROXIMATE SYNONYM

OF (REFERENCE)

DESCRIPTION Sphalerite and galena in calc silicate rocks.

GENERAL REFERENCE Einaudi and Burt, 1982; Einaudi and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Granodiorite to granite, diorite to syenite. Carbonate rocks, calcareous clastic rocks.

Textures Granitic to porphyritic; granoblastic to hornfelsic.

Age Range Mainly Mesozoic but may be any age.

Depositional Environment Miogeoclinal sequences intruded by generally small bodies of igneous rock.

Tectonic Setting(s) Continental margin, late orogenic magmatism.

Associated Deposit Types Copper skarn.

Metal Concentrations Zn, Pb, Ag, Cu, W.

DEPOSIT DESCRIPTION

Ore Minerals: Sphalerite+galena±pyrrhotite±pyrite+magnetite±chalcopyrite±bornite±arsenopyrite±scheelite±bismuthinite±stannite±fluorite. Gold and silver do not form minerals.

Texture/Structure Granoblastic, sulfides massive to interstital.

Alteration Mn-hedenbergite±andradite±grossular±spessartine±bustamite±rhodonite. Late stage Mn-actinolite±ilvaite±chlorite±dannemorite ±rhodochrosite.

Ore Controls Carbonate rocks. Deposit may be 100's of meters from intrusive contact. Shale-limestone contacts.

Weathering Gossan.

Geochemical Signature: Zn, Pb, Cu, Co, Au, Ag, As, W, Sn, F, Mn possibly Be.

Examples	References
Ban Ban, Australia	Ashley, 1980
El Sapo, Colombia	Alberto Nunez, oral commun., 1982

DEPOSIT TYPE Tungsten skarn SUBTYPE

AUTHOR Dennis P. Cox DATE December 9, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Scheelite in calc silicate contact metasomatic rocks.

GENERAL REFERENCE Einaudi and Burt, 1982; Einaudi and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite, granodiorite, quartz monzonite; limestone.

Textures Granitic, granoblastic.

Age Range Mainly Mesozoic, may be any age.

Depositional Environment Contacts and roof pendents of large batholith and thermal aureoles of apical zones of stocks.

Tectonic Setting(s) Continental margin. syn-late orogenic.

Associated Deposit Types Tin tungsten skarns, zinc skarns.

Metal Concentrations W, Mo, Zu, Cu.

DEPOSIT DESCRIPTION

Ore Minerals: Scheelite±molybdenite±pyrrhotite±sphalerite±chalcopyrite± bornite±arsenopyrite±pyrite±magnetite±traces of wolframite fluorite, cassiterite, and native bismuth.

Texture/Structure

Alteration Diopside-hedenbergite+grossular--andradite. Late stage spessartine+almandine. Outer barren wollastonite zone. Inner zone of massive quartz may be present.

Ore Controls Carbonate rocks in thermal aureoles of intrusions.

Weathering

Geochemical Signature: W, Mo, Zn, Cu, Sn, Bi, Be, As.

Examples	References
Pine Creek, California	Newberry, 1982
MacTung British Columbia	Dick and Hodgson, 1982
Strawberry, California	Nokleberg, 1981

DEPOSIT TYPE Sn-W skarn SUBTYPE

AUTHOR Dennis P. Cox DATE December 10, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Tin, tungsten, beryllium minerals in skarns, veins, stockworks and greissen near granite-limestone contacts.

GENERAL REFERENCE Einaudi and Burt, 1982; Einaudi and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Granite-rhyolite, carbonate rocks.

Textures Granitic, fine grained granitic, porphyritic aphanitic granoblastic to hornfelsic.

Age Range Mainly Mesozoic, may be any age.

Depositional Environment Late or anorogenic granites in carbonate terrain.

Tectonic Setting(s) Stable(?) continental interior.

Associated Deposit Types W skarn, Sn greissen deposits, Sn veins.

Metal Concentrations Sn, W, F, Be, Zn, Pb, Cu, Ag.

DEPOSIT DESCRIPTION

Ore Minerals: Cassiterite±scheelite±sphalerite±pyrrhotite±magnetite±pyrite±arsenopyrite±fluorite in skarn.

Texture/Structure Granoblastic skarn, stockwork veins, breccia.

Alteration Topaz tourmaline greissen. Idocrase+Mn-grossular-andradite±Sn-andradite±malayaite in skarn. Late stage amphibole+mica+chlorite and mica+touramaline+fluorite.

Ore Controls Intrusive contact with carbonte rocks. Crosscutting veins and rhyolite dikes.

Weathering

Geochemical Signature: Sn, W, F, Be, Zn, Pb, Cu, Ag, Li, Rb, Cs, Re, B.

Examples Lost River, Alaska References Dobson, 1982

DEPOSIT TYPE Cyprus massive sulfide SUBTYPE

AUTHOR Donald Singer DATE December, 1982

APPROXIMATE SYNONYM Cupreous pyrite OF (REFERENCE)

DESCRIPTION Massive pyrite, chalcopyrite, and sphalerite in pillow basalts.

GENERAL REFERENCE Franklin, and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Ophiolite assemblage: Tectonized dunite and harzburgite, gabbro, sheeted diabase dikes, pillow basalts, and fine-grained massive rocks such as chert and phyllite.

Textures Diabase dikes, pillow basalts, and in some cases brecciated basalt.

Age Range Archean(?) to Tertiary-majority are Ordovician or Cretaceous.

Depositional Environment Marine-believed to be ocean ridge.

Tectonic Setting(s) Local fault-controlled basins. May be adjacent to steep normal faults.

Associated Deposit Types

Metal Concentrations Mn and Fe-rich cherts regionally. Some deposits overlain by ochre (Mn-poor, Fe-rich bedded sediment containing goethite, maghemite, and quartz).

DEPOSIT DESCRIPTION

Ore Minerals: Massive: pyrite+chalcopyrite+sphalerite±marcasite±pyrrhotite. Stringer (stockwork): pyrite+pyrrhotite, minor chalcopyrite and sphalerite, (cobalt gold and silver present in minor amounts).

Texture/Structure Massive sulfides (>60 percent sulfides) with underlying sulfides stockwork or stringer zone.

Alteration Stringer zone--feldspar destruction, abundant quartz and chalcedony, abundant chlorite, some illite and calcite.

Ore Controls Pillow basalts or mafic volcanic breccias, diabase dikes below; in some cases in sediments above pillows. May be local faulting.

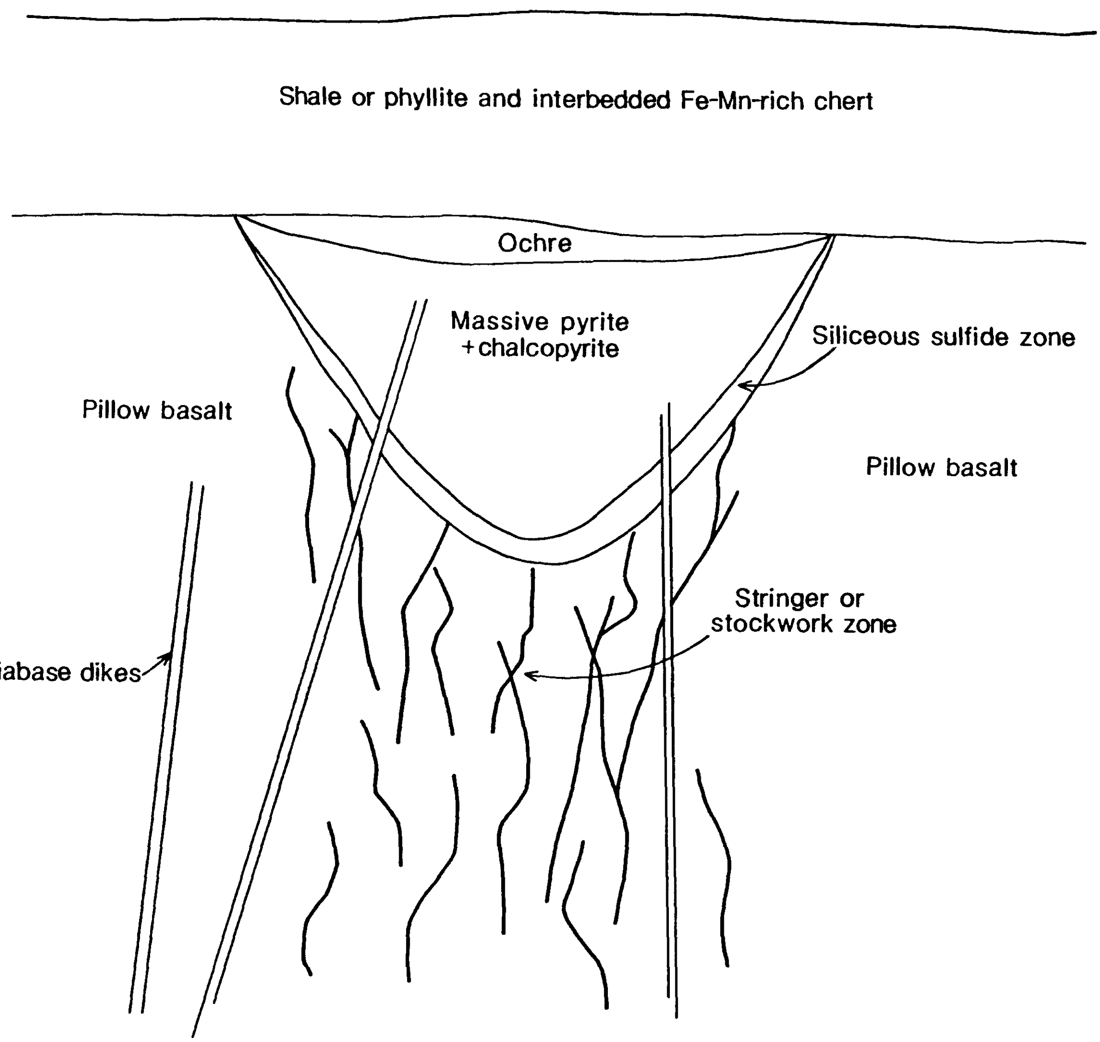
Weathering Many deposits overlain by orange-yellow to brown ochre.

Geochemical Signature: General loss of Ca and Na and introduction and redistribution of Mn and Fe in the stringer zone.

Examples Oxec (Guatemala)
Limi, (Cyprus), York Harbor, (Canada)
Turner-Albright, (USA)

References Petersen and Zantop, 1980

Cyprus type massive sulfide 3.1



DEPOSIT TYPE Massive sulfide in felsic to intermediate volcanics SUBTYPE

AUTHOR Donald Singer DATE December, 1982

APPROXIMATE SYNONYM Kuroko, Noranda, Volcanogenic massive sulfide OF (REFERENCE)

DESCRIPTION Copper and zinc-bearing massive sulfide deposits in marine volcanic rocks of intermediate to felsic composition.

GENERAL REFERENCE Franklin and others, 1981.

GEOLOGICAL ENVIRONMENT

Rock Types Felsic to intermediate marine volcanic rocks and associated sediments.

Textures Flows, tuffs, pyroclastics, breccias, beds, and in some cases felsic domes.

Age Range Archean through Cenozoic.

Depositional Environment Marine.

Tectonic Setting(s) Local extensional tectonic activity, faults or fractures.

Associated Deposit Types Gold-bearing quartz veins; bedded barite.

Metal Concentrations Ba, Au

DEPOSIT DESCRIPTION

Ore Minerals: Upper stratiform massive zone--pyrite+sphalerite+chalcopyrite± pyrrhotite±galena+barite; lower stratiform massive zone--pyrite+chalcopyrite± sphalerite±pyrrhotite±magnetite; Stringer (stockwork) zone--pyrite+ chalcopyrite (gold and silver).

Texture/Structure Massive (>60 percent sulfides); in some cases, an underlying stringer or disseminated sulfide zone.

Alteration Adjacent to and blanketing massive sulfide in some deposits-- zeolites, montmorillonite (and chlorite?); stringer (stockwork) zone--silica, chlorite, and sericite; below stringer-chlorite and albite.

Ore Controls Towards the more felsic top of volcanic or volcanic-sedimentary rocks. Near center of felsic volcanism. May be locally brecciated and/or have felsic dome nearby.

Weathering Yellow, red, and brown gossans.

Geochemical Signature: Gossan may be high in Pb and typically Au is present. Adjacent to deposit-enriched in Mg and Zn, depleted in Na. Within deposits-Cu, Zn, Pb, Ba, As, Ag, Au, Se, Sn, Bi, Fe.

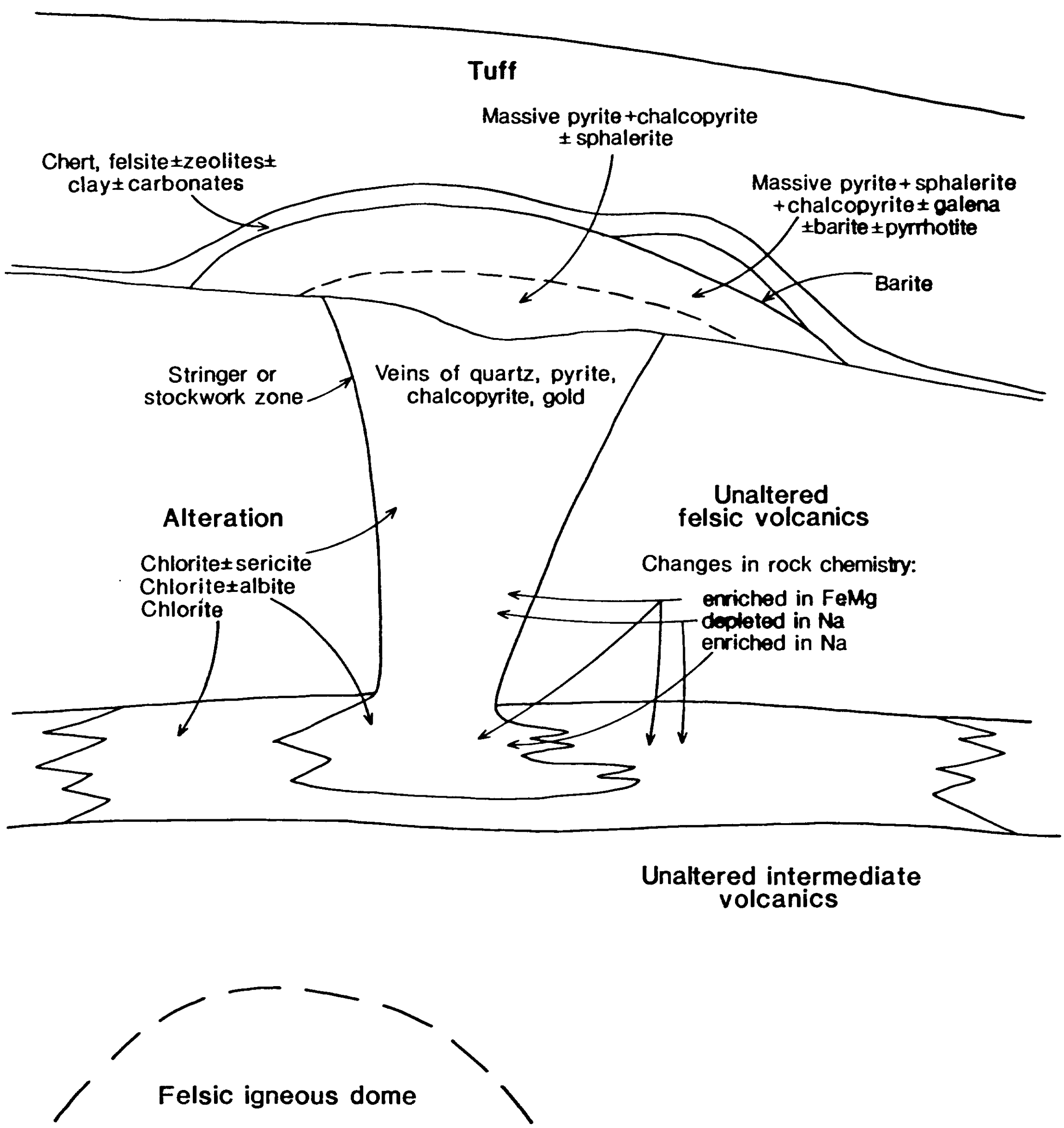
Examples Bailadores (Venezuela) References Carlson, 1977

Kidd Creek (Canada)

Hanaoka (Japan)

Macuchi, Equador Stoll, 1962

Massive sulfide in felsic to intermediate volcanics 3.2



DEPOSIT TYPE Volcanogenic Gold SUBTYPE

AUTHOR Byron R. Berger DATE December 1982

APPROXIMATE SYNONYM Massive sulfide gold OF (REFERENCE)

DESCRIPTION Stratabound to stratiform gold deposits in siliceous- or carbonate-iron formation in metavolcanic terrane

GENERAL REFERENCE Hutchinson and Burlington, unpublished report

GEOLOGICAL ENVIRONMENT

Rock Types Mafic or felsic metavolcanic rocks, volcaniclastic sediments, quartz porphyries, felsic plutonic rocks, banded iron formation (silica, carbonate)

Textures

Age Range Precambrian to Tertiary

Depositional Environment Active oceanic ridge spreading centers; submarine volcanic intruded by granitic stocks

Tectonic Setting(s)

Associated Deposit Types Base-metal massive sulfide deposits, iron formation, low sulfide gold quartz veins

Metal Concentrations Cu+Pb Cu+Zn Pb+Zn Cu+Pb+Zn

DEPOSIT DESCRIPTION

Ore Minerals: Native gold+pyrite+arsenopyrite+sphalerite+chalcopyrite. May get minor tetrahedrite±scheelite±wolframite±molybdenite±fluorite

Texture/Structure Narrow veins or lenses, stringers (stockworks)

Alteration Quartz+siderite and (or) ankerite+tourmaline+chlorite±magnetite in mafic volcanic terranes: chromian mica. Chlorite particularly around veins and stockworks

Ore Controls Bedded ores in chemical sediments with vein and stockworks in feeder zones to these sediments, often interlayered with flow rocks

Weathering Gossans from magnetite lateral from carbonate iron formation

Geochemical Signature: Au+As+B±Sb (+platinum-group metals in mafic volcanic terranes)

Examples Homestake, South Dakota
Passagem, Brazil
Kirkland Lake, Canada

References Rye and Rye, 1974
Fleisher and Routhier, 1973
Ridler, 1970

DEPOSIT TYPE Red-bed--Green-bed Cu SUBTYPE

AUTHOR D. P. Cox DATE December 14, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stratabound, disseminated copper sulfides in reduced beds of red-bed sequences

GENERAL REFERENCE Tourtelot and Vine, 1976

GEOLOGICAL ENVIRONMENT

Rock Types Red-bed sequence containing green or gray shale, siltstone, and sandstone. Thin carbonate and evaporite beds. Local channel conglomerate.

Textures Algal mat structures, mudcrackes, deltaic cross bedding. Fossil wood in channels.

Age Range Proterozoic, Permian-Lower Mesozoic. Any Phanerozoic age.

Depositional Environment Epicontinental shallow-marine basin near paleo equator. Sabkhas. High evaporation rate. Sediments highly permeable.

Tectonic Setting(s) Intracontinental rift. Aulacogen. Failed arm of triple junction of plate spreading. Major growth faults.

Associated Deposit Types Halite, sylvite, gypsum, anhydrite. Sandstone uranium. Native copper in basaltic rocks

Metal Concentrations Cu, Ag, Mo, Pb, Zn, V, U

DEPOSIT DESCRIPTION

Ore Minerals: Chalcocite and other Cu_2S minerals+pyrite±bornite±native silver. Cu_2S replacement of early fine-gr[illegible]ned pyrite is common. Deposits may be zoned with centers of chalcocite±bornite, rims of chalcopyrite, and peripheral galena+sphalerite.

Texture/Structure Fine disseminated, stratabound, locally stratiform

Alteration Green, white or gray (reduced) color in red beds. Regionally matmorphosed red beds may have purple color.

Ore Controls Reducing low pH environment such as fossil wood, algal mat. Abundant biogenic sulfur. Pyritic sediments. Petroleum in paleoaquifers.

Weathering Surface exposures may be completely leached. Secondary chalcocite enrichment down dip is common.

Geochemical Signature: Cu, Ag, Pb, Zn (Mo, V. U)

Examples	References
Kupferschiefer, Germany	Wedepohl, 1971
White Pine, Michigan	Brown, 1971
Western Montana (Belt)	Harrison, 1972

DEPOSIT TYPE Volcanic native Cu SUBTYPE

AUTHOR D. P. Cox DATE

APPROXIMATE SYNONYM Volcanic Red Bed Cu OF (REFERENCE) Kirkham, 1982

DESCRIPTION Disseminated native copper and copper sulfides in subaerial basalt flows and copper sulfides overlying sedimentary beds

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Subaerial basalt flows and breccias, red bed sandstone and conglomerate. Younger limestone and black shale

Textures Amygdules. Flow-top breccias

Age Range Proterozoic, Triassic-Jurassic, any Phanerozoic age

Depositional Environment Copper-rich (100-200 ppm) subaerial basaltic volcanism followed by shallow marine peralic basin, Near paleo equator

Tectonic Setting(s) Intracontinental rift, continental margin rift. Regional low-grade metamorphism may mobilize copper

Associated Deposit Types Copper shale, red-bed copper

Metal Concentrations Cu, Ag

DEPOSIT DESCRIPTION

Ore Minerals: Native copper, native silver±chalcosite and other Cu_2S minerals. Chalcopyrite in some deposits.

Texture/Structure Disseminated open-space filling. Stratabound and veins

Alteration Calcite-zeolite. Red coloration due to fine hematite

Ore Controls Flow top breccias, amygdules, fractures in basalt organic shale, limestone, in overlying sequence. Limestone is tidal, algal, with stromatolite fossils

Weathering Widely dispersed copper nuggets in streams

Geochemical Signature: Cu Ag

Examples Keweenaw, Michigan (White)
Wrangellia Terrane, Alaska (Bateman)
Sierra de Perija

References Maze, W. B., 1982
Champetier de Ribes and others, 1963

DEPOSIT TYPE Dolomitic copper cobalt SUBTYPE

AUTHOR D. P. Cox DATE

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Cu, Co, U in stratiform deposits in carbonates and shale

GENERAL REFERENCE Bartholome, 1974

GEOLOGICAL ENVIRONMENT

Rock Types Dolomite, limestone, shale, siliceous dolomite, carbonaceous shale

Textures Finely laminated dolomite, stromatolites, solution breccias

Age Range Proterozoic-Zaire; Devonian-Alaska

Depositional Environment Intertidal marine. Transgressive-regressive deposition. Reducing environment. Hypersaline

Tectonic Setting(s) Intracontinental rift. Passive margin rift.

Associated Deposit Types None

Metal Concentrations Cu, Co, U, V, Ge, Zn, Pb, Ga, Bi, Pt, Pd

DEPOSIT DESCRIPTION

Ore Minerals: Bornite+chalcopyrite+pyrite+carrollite±linnaeite+chalcocite± cobaltiferous pyrite. Traces of germanite, pitchblende. At Ruby Creek, assemblage includes sphalerite plus traces of galena and late tetrahedrite

Texture/Structure Finely laminated fine grained. At Ruby Creek, breccia filling

Alteration Dolomite-magnesite, relation to mineralization is not clear. Dolomite breccia with fine pyrite matrix

Ore Controls Paleoaquifers, paleo redox boundaries. At Ruby Creek, dolomite breccia with fine pyrite matrix.

Weathering Malachite, azurite, black Co oxide or pink arsenate

Geochemical Signature: Cu, Co, U, V, Ge, Ga, Pt, Pd. At Ruby Creek also Zn, Pb, As, Sb

Examples Zaire Copper Belt
Ruby Creek, Alaska
Kona Dolomite, Michigan

References

DEPOSIT TYPE Sandstone Uranium SUBTYPE Roll front, epigenetic carbonaceous

AUTHOR C. A. Hodges DATE December 15, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Concentrations of uranium oxides in localized reduced environments within medium- to coarse-grained sedimentary beds

GENERAL REFERENCE Nash and others, 1981

GEOLOGICAL ENVIRONMENT

Rock Types Feldspathic or tuffaceous sandstone, arkose, mudstone, conglomerate

Textures Permeable--medium to coarse grained; highly permeable during mineralization, subsequently restricted by cementation and alteration

Age Range Post-Silurian (<0.4 b.y.); roll-front deposits mainly Tertiary

Depositional Environment Continental--basin margins, fluvial channels, fluvial fans (especially mid-fan facies), stable coastal plain; nearby felsic plutons or felsic volcanics

Tectonic Setting(s) Stable platform or foreland-interior basin, shelf margin; adjacent major uplifts provide favorable topographic conditions

Associated Deposit Types Hydrocarbon source rocks; "red-bed Cu" deposits may be in similar host rocks and may contain U

Metal Concentrations FeS_2, Se, Mo, V

DEPOSIT DESCRIPTION

Ore Minerals: Pitchblende, coffinite, carnotite--almost invariably associated with pyrite; Se, Mo, V commonly in zonal arrangement, caused by geochemical gradient--Se generally richer in oxidized facies

Texture/Structure Stratabound deposits--tabular or roll front; disseminated mineralization

Alteration Host rocks typically contain both diagenetically reduced and oxidized facies; V ores in reduced facies (typically gray-green-white) or concentrated at interface (see diagram)

Ore Controls Permeability; adsorptive agents (humic materials, Ti oxides); reducing agents--C matter, reduced S species, "sour" gas, FeS_2; bedded sequences with low dips; felsic plutons or tuffaceous seds adjacent to or above host rock are favorable source rocks

Weathering Oxidation of primary pitchblende, coffinite carnotite; little effect on ore grade or localization

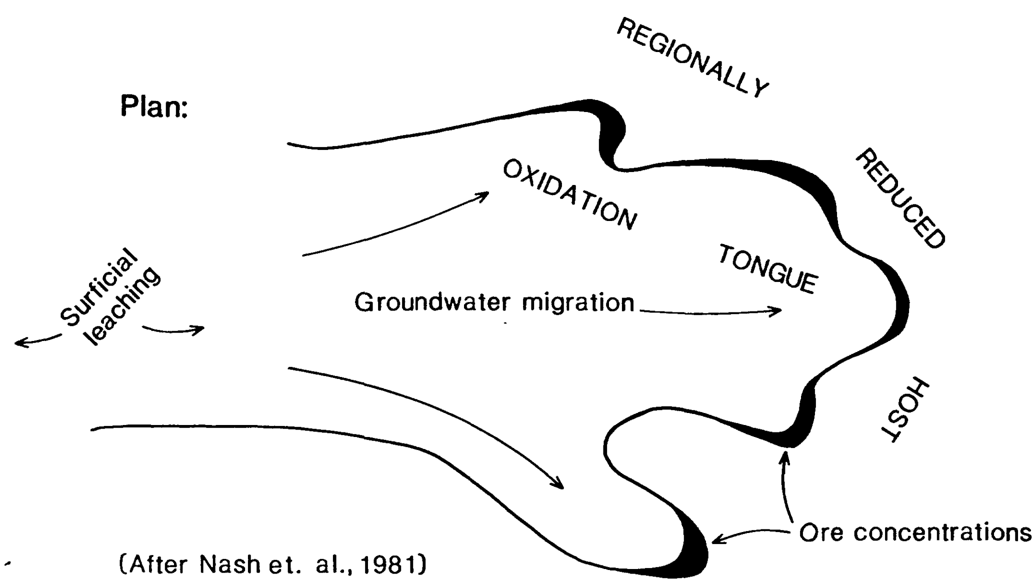
Geochemical Signature: Anomalous radioactivity (5 to 10 x normal background); low redox potential; carbonaceous material, FeS_2, other reducing agents required; Se, Mo, V, Cu commonly associated

Examples Colorado Plateau
Grants, New Mexico
Texas Gulf Coast (ross frong)

References Isachsen and Evernsen, 1956; Hilpert, 1969; Eargle and others, 1975

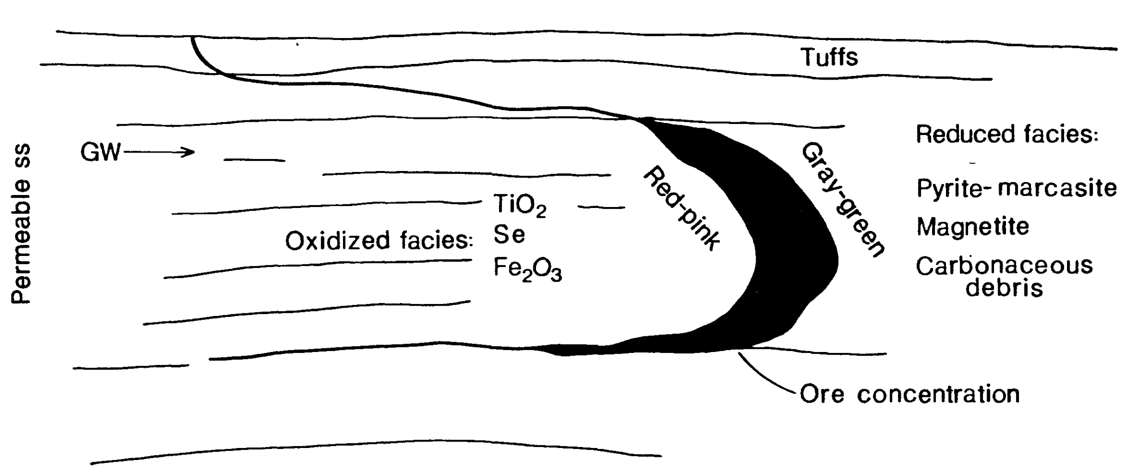
Roll type uranium deposit 4.4

Plan:



(After Nash et. al., 1981)

Cross-section:



DEPOSIT TYPE Sediment-hosted, submarine exhalative Zn-Pb   SUBTYPE

AUTHOR Joseph A. Briskey   DATE 12/28/82

APPROXIMATE SYNONYM Shale-hosted Zn-Pb   OF (REFERENCE)

DESCRIPTION Stratiform basinal accumulations of sulfide and sulfate minerals interbedded with euxinitic marine sediments

GENERAL REFERENCE Large (1980)

GEOLOGICAL ENVIRONMENT

Rock Types Euxinitic sedimentary rocks including: black shale, siltstone, sandstone, chert, dolostone, and micritic limestone

Textures Contrasting sedimentary thicknesses and facies changes across hinge zones. Slump breccias and conglomerates near synsedimentary faults

Age Range Middle Proterozoic (1,700-1,400 Ma); Ordovician to Mississippian (530-300 Ma)

Depositional Environment Epicratonic marine basins or embayments, with smaller local restricted basins

Tectonic Setting(s) Epicratonic basins or embayments associated with hinge zones controlled by synsedimentary faults

Associated Deposit Types Strataform barite deposits

Metal Concentrations Highest expected background in black shales: Pb = 500 ppm; Zn = 1,300 ppm; Cu = 750 ppm; Ba = 1,300 ppm

DEPOSIT DESCRIPTION

Ore Minerals: Pyrite, pyrrhotite, sphalerite, galena, sporadic barite, and chalcopyrite, and minor to trace amounts of marcasite, arsenopyrite, bismuthinite, molybdenite, enargite, millerite, freibergite, cobaltite, cassiterite, valleriite, and melnicovite

Texture/Structure Finely crystalline an disseminated. Metamorphosed examples are coarsely crystalline and massive

Alteration Stockwork and disseminated sulfide and alteration (silicification, tourmalization, carbonate depletion, albitization, chloritization, dolomitization) minerals representing the feeder zone of these deposits commonly present beneath or adjacent to stratiform deposits

Ore Controls Within larger fault-controlled basins, small local basins form the morphological traps that contain the stratiform sulfide and sulfate minerals. The faults are synsedimentary and serve as feeders for the stratiform deposits

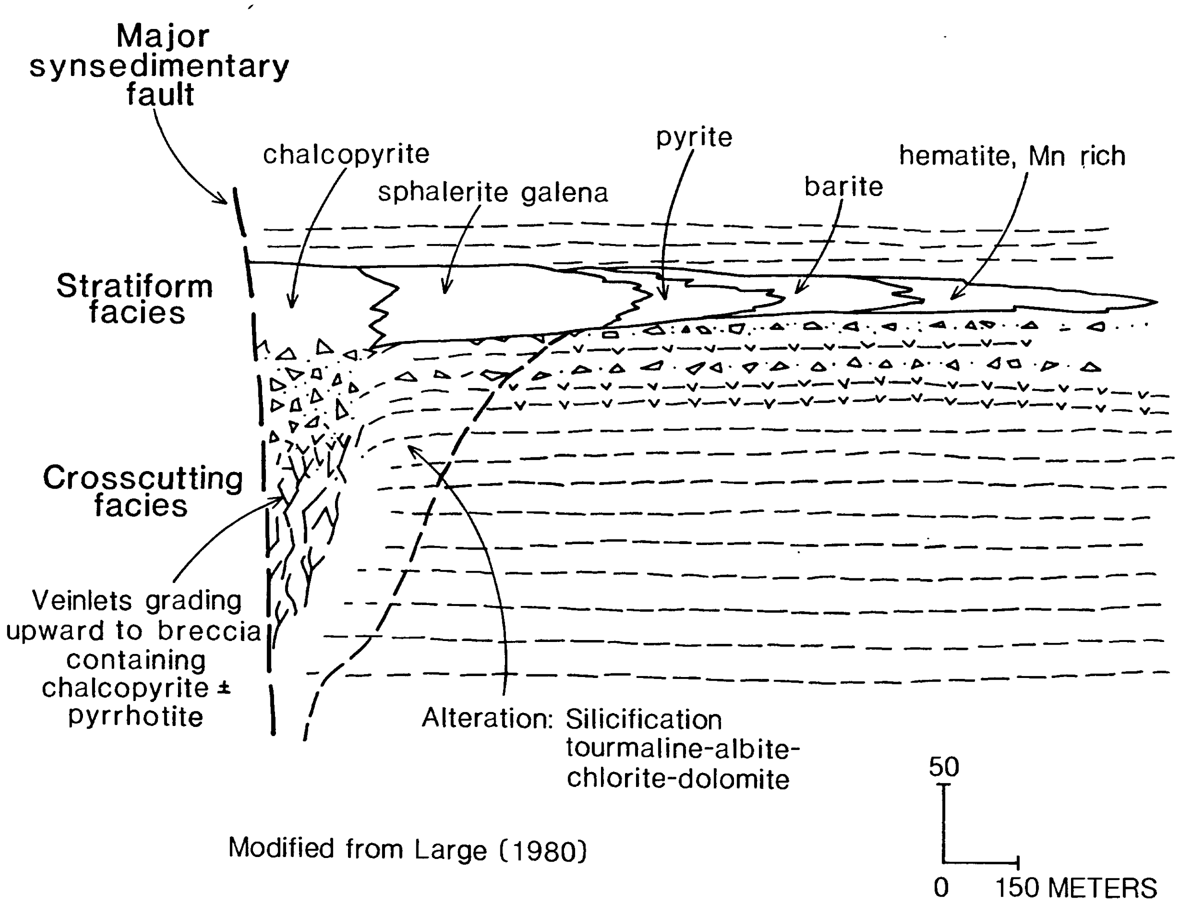
Weathering Surface oxidation may form large gossans containing abundant carbonates, sulfates, and silicates of lead, zinc, and copper

Geochemical Signature: Metal zoning includes lateral Cu-Pb-Zn-Ba sequence extending outward from feeder zone; or a vertical Cu-Zn-Pb-Ba sequence extending inward. Exhalative chert interbedded with stratiform sulfide and sulfate minerals. Regional Mn halos

Examples Sullivan mine, Canada

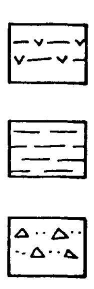
References Hamilton and others (1981)

Sediment hosted submarine exhalative zinc-lead deposit 4.5



Modified from Large (1980)

EXPLANATION



Tuffaceous layers

Black shale, siltstone, sandstone, chert, dolomite, micritic limestone

Intraformational slumping

DEPOSIT TYPE Stratabound Carbonate-hosted Pb-Zn SUBTYPE Southeast Missouri type

AUTHOR Joseph A. Briskey DATE 1/5/83

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stratabound carbonate-hosted deposits of galena, sphalerite, and chalcopyrite in rocks having primary and secondary porosity, commonly related to reefs on paleotopographic highs

GENERAL REFERENCE Snyder and Gerdemann (1968)

GEOLOGICAL ENVIRONMENT

Rock Types Dolomite; locally ore bodies also occur in sandstone, conglomerate, and calcareous shales

Textures Calcarenites are most common lithology. Tidalites, stromatolite finger reefs, reef breccias, slump breccias; oolites, cross bedding, slump breccias, micrites

Age Range Cambrian to Lower Ordovician

Depositional Environment Shallow-water marine carbonate sedimentation, with prominent facies control by reefs growing on flanks of paleotopographic basement highs

Tectonic Setting(s) Stable cratonic platform

Associated Deposit Types Precmabrian deposits of magnetite-hematite, and magnetite-copper (±Co, Ni, Ba); Ba-Pb deposits occur higher in the Cambrian section

Metal Concentrations Background for carbonates: Pb = 9 ppm; Zn = 20; Cu = 4

DEPOSIT DESCRIPTION

Ore Minerals: Galena, sphalerite, chalcopyrite, pyrite, marcasite, siegenite, bornite, tennantite, barite, bravoite, digenite, covellite, arsenopyrite, fletcherite, adularia, pyrrhotite, magnetite, millerite, polydymite, vaesite, djurleite, chalcocite, anilite, and enargite in order of abundance

Texture/Structure Early fine-grained replacement; main stage coarse grained; some colloform; dissolution

Alteration Regional dolomitization; latter brown, ferroan and bitumin-rich dolomite; extensive dissolution and development of residual shales; mixed-layer illite-chlorite altered to 2M muscovite; dickite and kaolinite in vugs; very minor adularia

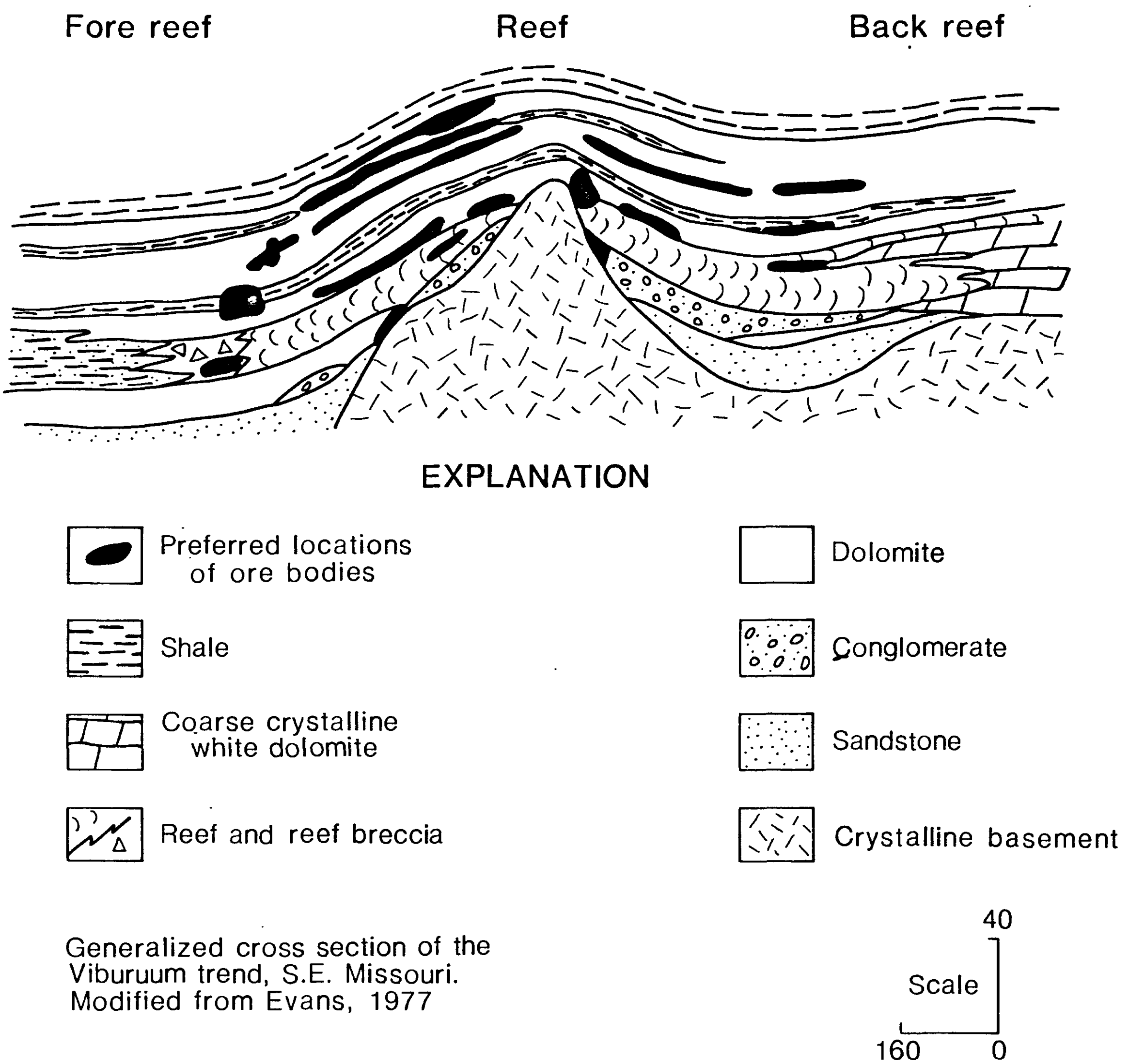
Ore Controls Numerous! Open-space filling and replacement, most commonly at the interface between gray and tan dolomite, but also in traps at any interface between permeable and impermeable units. Any porous units may host ore: sandstone pinchouts; dissolution collapse breccias; faults; permeable reefs; slump, reef, and fault breccias; coarsely crystalline dolostone; etc.

Geochemical Signature: Regional anomalous amounts of Pb, Zn, Cu, Mo, Ag, Co, and Ni in insoluble residues. Zoning is roughly Cu (+Ni+Co)-Pb-Zn-iron sulfide going up section; inconsistent lateral separation of metal zones

Examples Viburnum subdistrict

References Heyl (1982)

Carbonate hosted lead-zinc 4.6



Generalized cross section of the Viburuum trend, S.E. Missouri. Modified from Evans, 1977

DEPOSIT TYPE Stratabound carbonate-hosted zinc-lead deposits SUBTYPE Appalachian type

AUTHOR Joseph A. Briskey DATE January 5, 1983

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stratabound deposits of sphalerite and minor galena in primary and secondary voids in favorable beds or horizons in thick platform dolostone and limestone

GENERAL REFERENCE Hoagland (1976)

GEOLOGICAL ENVIRONMENT

Rock Types Dolostone and limestone

Textures Subtidal, intratidal, and supratidal textures are common, especially in the dolostones; limestones are commonly micritic, some with birdseye textures

Age Range Deposits occur in rocks of cambrian to middle Ordovician age.

Depositional Environment Shallow-water, tidal and subtidal marine environments

Tectonic Setting(s) Stable continental shelf

Associated Deposit Types Stratabound carbonate-hosted deposits of barite-fluorite-sphalerite, and of limonite-siderite-(±sphalerite)

Metal Concentrations Background in carbonate rocks: Zn = 20 ppm; Pb = 9 ppm

DEPOSIT DESCRIPTION

Ore Minerals: Sphalerite, with variable but subordinate pyrite and minor marcasite, and with minor barite, fluorite, gypsum, and anhydrite. Galena is usually absent or rare, but may be locally the third most abundant mineral behind sphalerite and pyrite

Texture/Structure Coarse to medium crystalline, with concentric growth banding

Alteration Extensive dolomitization occurs regionally and in close proximity to ore bodies. Silicification is typically closely associated with ore bodies. Extensive limestone dissolution and development of residual shales

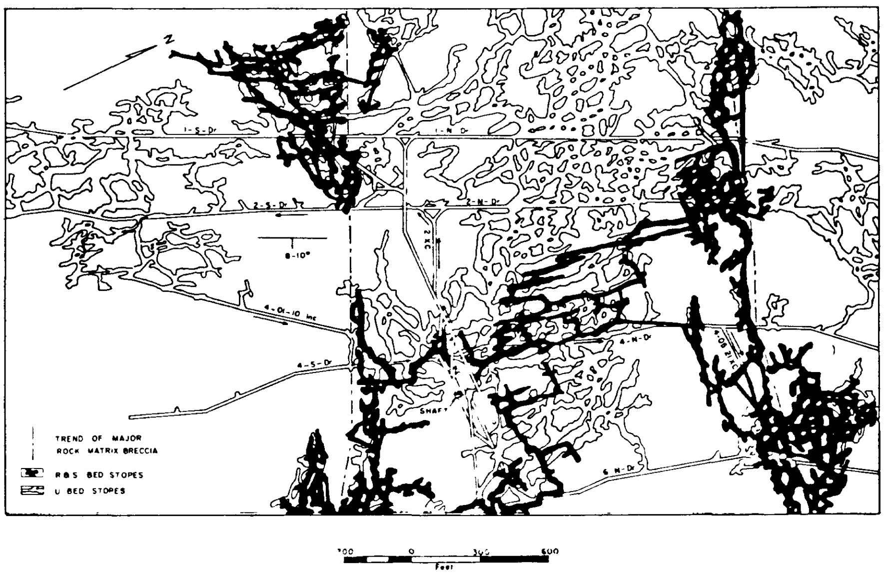
Ore Controls Ore occurs within dissolution collapse breccias that occupy (1) readily soluble limestone beds, or (2) paleo-aquifer solution channels controlled by fractures or folds in limestone

Weathering Zinc silicate and carbonate ores form in the zone of weathering and oxidation

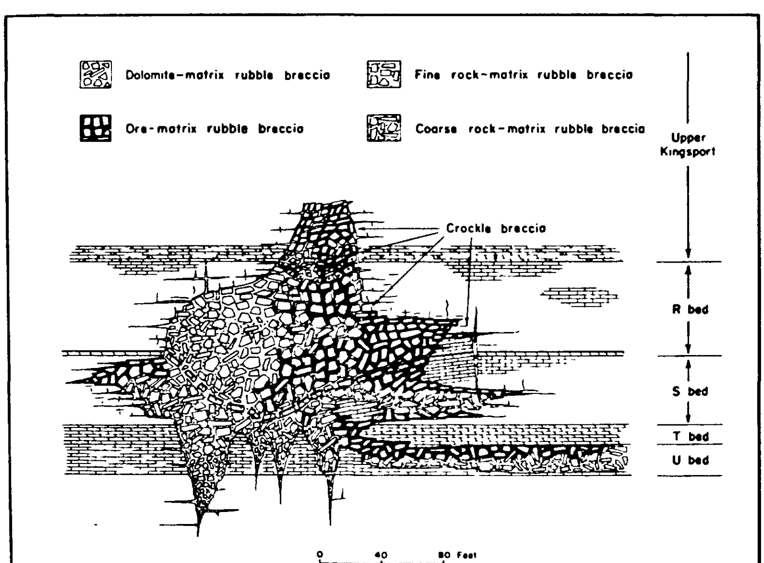
Geochemical Signature: Oxidized sphalerite at the surface caused readily detectable zinc anomalies in residual soils and in stream sediments. Primary zinc haloes in carbonate rocks near ore are not large enough to assist in exploration

Examples East Tennessee zinc district References Crawford and Hoagland (1968)

Carbonate-hosted zinc 4.7



Plan map of part of the Jefferson City mine, Jefferson City, Tennessee. After Fulweiler and McDougal, 1971.



Generalized cross section through an ore trend in the Jefferson City mine, Tennessee. After Crawford, Johnson, and Hoagland, A.D., 1968.

DEPOSIT TYPE Sandstone-hosted Pb-Zn SUBTYPE

AUTHOR Joseph A. Briskey DATE December 28, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Stratabound to stratiform galena and sphalerite in multiple, thin, sheetlike ore bodies in arenaceous sedimentary rocks

GENERAL REFERENCE Briskey (1982)

GEOLOGICAL ENVIRONMENT

Rock Types Continental, terrigenous, and marine arenaceous quartzitic and arkosic sandstones, conglomerates, grits, and siltstones

Textures Bedding, crossbedding, paleochannels, liquification structures, and intraformational slump breccias. Quartz and calcite cement

Age Range Proterozoic to Cretaceous host rocks

Depositional Environment Host rocks deposited in piedmont, lagoonal-lacustrine, lagoonal-deltaic, lagoonal-beach, and tidal channel-sand bar environments

Tectonic Setting(s) Marine platform or piedmont sedimentation associated with at least some orogenic uplift

Associated Deposit Types Sandstone-hosted copper deposits

Metal Concentrations Background in sandstone: Pb = 7 ppm; Zn = 16 ppm

DEPOSIT DESCRIPTION

Ore Minerals: Fine- to medium-crystalline galena with sporadic smaller amounts of sphalerite, pyrite, barite, and fluorite. Minor chalcopyrite, tetrahedrite-tennantite, chalcocite, freibergite, bournonite, bornite. Quartz and calcite are usual gangue minerals

Texture/Structure Clots 0.5 to several centimeters in diameter; disseminations 0.1-1 mm dia; locally massive

Alteration "Sericite" (white mica?) reported in some deposits; but may only be recrystallized sedimentary illite?

Ore Controls Intergranular porosity. Ore may be massive where localized by sedimentary structures (above), impermeable barriers, faults, joints, and fractures. Within or immediately above paleochannels or paleoridges. With organic matter.

Weathering Surface oxidation of galena to cerussite, chalcopyrite to malachite, and probably of sphalerite to smithsonite, hemimorphite, etc.

Geochemical Signature: Anomalous amounts of Pb and Zn in host rocks and derivative soils; Ba, Fl, and Ag are enriched in lowermost parts of some deposits

Examples Laisvall mine, Sweden References Rickard and others (1979)

DEPOSIT TYPE Replacement SUBTYPE Limestone Replacement

AUTHOR Hal T. Morris DATE December 15, 1982

APPROXIMATE SYNONYM Manto deposits OF (REFERENCE) Many authors

DESCRIPTION A hydrothermal, epigenetic, sulfide mineral deposit, commonly later oxidized, that replaces limestone, dolomite, or other soluble rock.

GENERAL REFERENCE Jensen, M. L., and Bateman, A. M., 1981, p. 134-146.

GEOLOGICAL ENVIRONMENT

Rock Types: Sedimentary rocks, chiefly including limestone, dolomite, and shale, commonly overlain by volcanics and intruded by porphyritic, calc-alkaline plutons.

Textures: The textures of the replaced sedimentary rocks are not important; associated plutons typically are porphyritic.

Age Range: Not important, but many are Late Mesozoic to Early Cenozoic.

Depositional Environment: Carbonate host rocks that commonly occur in broad sedimentary basins, such as epicratonic miogeosynclines.

Tectonic Setting(s): Most deposits occur in mobile belts that have undgergone moderate deformation and have been intruded by small plutons.

Associated Deposit Types: Veins that cut the more massive igneous or sedimentary rocks, skarns, and porphyry-type disseminated copper deposits.

Metal Concentrations Over a broad area associated metals include lead, zinc, silver, copper, gold, arsenic, antimony and bismuth.

DEPOSIT DESCRIPTION

Ore Minerals: Galena, sphalerite, argentite, tetrahedrite, pyrite, enargite chalcopyrite, proustite, pyrargyrite, jamesonite, bournonite, tennantite, jordanite, stephanite, polybasite, sylvanite, calaverite, native gold, bismuthinite, marcasite, barite, quartz, rhodochrosite, calcite, and dolomite.

Texture/Structure: Ranges from massive to highly vuggy and porous.

Alteration: Typical limestone wallrocks are dolomitized and silicified; shales and igneous rocks are chloritized and commonly are argillized; where syngenetic iron oxide minerals are present, rocks are pyritized.

Ore Controls: Tabular, podlike and pipelike ore bodies are locallized by faults or vertical beds; ribbonlike or blanketlike ore bodies are locallized by bedding-plane faults or by susceptible beds.

Weathering: Near the surface, these ore bodies commonly are oxidized to ochreous masses containing cerrusite, anglesite, hemimorphite, and cerargyrite

Geochemical Signature: On a district-wide basis ore deposits commonly are zoned outward from a copper-rich central area through a through a wide lead-silver zone, to a zinc- and manganese-rich fringe.

Examples: 1. East Tintic district, Utah, USA, 2. Mexican Manto desposits, 3. Parana and Sao Paulo, Brazil

References: 1. Morris, H. T., and Lovering, T. S., 1979; 2. Prescott, Basil, 1926; 3. Melcher, G. C., 1968

DEPOSIT TYPE Carbonate-hosted gold SUBTYPE Disseminated gold

AUTHOR Byron R. Berger DATE December 1982

APPROXIMATE SYNONYM Carlin-type or invisible gold OF (REFERENCE)

DESCRIPTION Very fine grained gold and sulfides disseminated carbonaceous calcareous rocks

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Host rocks: thin-bedded silty or argillaceous carbonaceous limestone or dolomite often with carbonaceous shales. Intrusive rocks: felsic dikes, often porphyritic

Textures

Age Range Mainly Tertiary, but can be any age

Depositional Environment Association with intrusive. Best host rocks formed as carbonate turbidites in somewhat anoxic environments. Deposits formed where these are intruded by igneous rocks under nonmarine conditions.

Tectonic Setting(s) High-angle normal fault zones

Associated Deposit Types Tungsten-moly skarn, porphyry molybdenum, placer gold, stibnite-barite veins

Metal Concentrations Hg, Sb, As, Mo, W

DEPOSIT DESCRIPTION

Ore Minerals: Native gold (very fine grained)+pyrite+realgar+orpiment± arsenopyrite±cinnabar±fluorite±barite

Texture/Structure Silica replacement of carbonate, generally less than 1 percent fine-grained sulfides

Alteration Unoxidized ore: "jasperoid"+quartz+illite+kaolinite+calcite. Hypogene oxidized ore: kaolinite+montmorillonite+illite+jarosite+alunite

Ore Controls Selective replacement of carbonaceous carbonate rocks adjacent to and along high-angle faults or regional thrust faults

Weathering Light red gray and (or) tan oxides, light brown to reddish brown iron-oxide stained jasperoid

Geochemical Signature: Au+As+Hg+W±Mo As+Hg+Sb+Tl±F (this stage superimposed on preceding)

Examples Carlin, Nevada
Getchell, Nevada
Mercur, Utah

References Radtke, Rye and Dickson, 1980
Joralemon, 1951
Gilluly, 1932

DEPOSIT TYPE Low-sulfide quartz veins SUBTYPE

AUTHOR Byron R. Berger DATE December 1982

APPROXIMATE SYNONYM Mesothermal quartz veins OF (REFERENCE)

DESCRIPTION Gold in massive persistent quartz veins mainly in regionally metamorphosed volcanics and volcanic sediments

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Greenstone belts; oceanic sediments: graywacke, shale, quartzite, batholithic terranes

Textures

Age Range Precambrian to Tertiary

Depositional Environment Continental margin mobile belts, accreted margins

Tectonic Setting(s) Fault and joint systems

Associated Deposit Types Massive sulfide, iron formation, volcanogenic gold, skarn

Metal Concentrations Ag+Pb+Zn, Cu+Pb+Zn

DEPOSIT DESCRIPTION

Ore Minerals: Native gold+pyrite+galena+sphalerite+arsenopyrite±pyrrhotite. May get tellurides±scheelite±bismuth±molybdenite±fluorite. Productive quartz is grayish or bluish in many instances because fine-grained sulfides

Texture/Structure Saddle reefs, ribbon quartz, absence of open-space filling

Alteration Quartz+siderite and (or) ankerite±albite in veins with selvage of quartz+chlorite±biotite. Wallrock alteration is minimal, chromium mica in areas of mafic volcanism

Ore Controls Veins are persistent along regional high-angle faults, joint sets. Best deposits overall in areas with greenstones

Weathering

Geochemical Signature: Arsenic best pathfinder in general

Examples Yellowknife, Canada References Boyle, 1970
Mother Lode, Grass Valley areas, Calif. Lindgren 1896, and
Knopf Appalachian slate belt, U.S.A. 1929

DEPOSIT TYPE Epithermal Gold, Silver SUBTYPE Quartz-Adularia

AUTHOR Byron R. Berger DATE December, 1982

APPROXIMATE SYNONYM Precious-and base-metal veins OF (REFERENCE)

DESCRIPTION Gold in vuggy quartz veins with abundant pyrite, arsenopyrite, sphalerite and galena.
GENERAL REFERENCE Buchanon, 1980

GEOLOGICAL ENVIRONMENT

Rock Types Areas of volcanism: andesite, dacite, quartz latite, rhyodacite, rhyolite
Textures Porphyritic

Age Range Mainly Tertiary for bonanza deposits, but may be any age

Depositional Environment Centers of volcanism and associated intrusive activity for bonanza deposits; batholiths
Tectonic Setting(s) Through-going fractures systems; major normal faults, fractures related to doming, ring fracture zones, joints
Associated Deposit Types Placer gold

Metal Concentrations Ag+Pb+Zn, Ag+W+Bi+Pb+Zn

DEPOSIT DESCRIPTION

Ore Minerals: Native gold+electrum+pyrite±arsenopyrite±galena±sphalerite in high Au: Ag deposits. Native gold+electrum+tetrahedrite+pyrite+ galena+sphalerite±barite±rhodaochrosite in high Ag: Au deposits in hypogene oxidized areas of supergene zones gold+ruby silver+native silver
Texture/Structure Banded veins, open space filling, lamellar quartz, stockworks

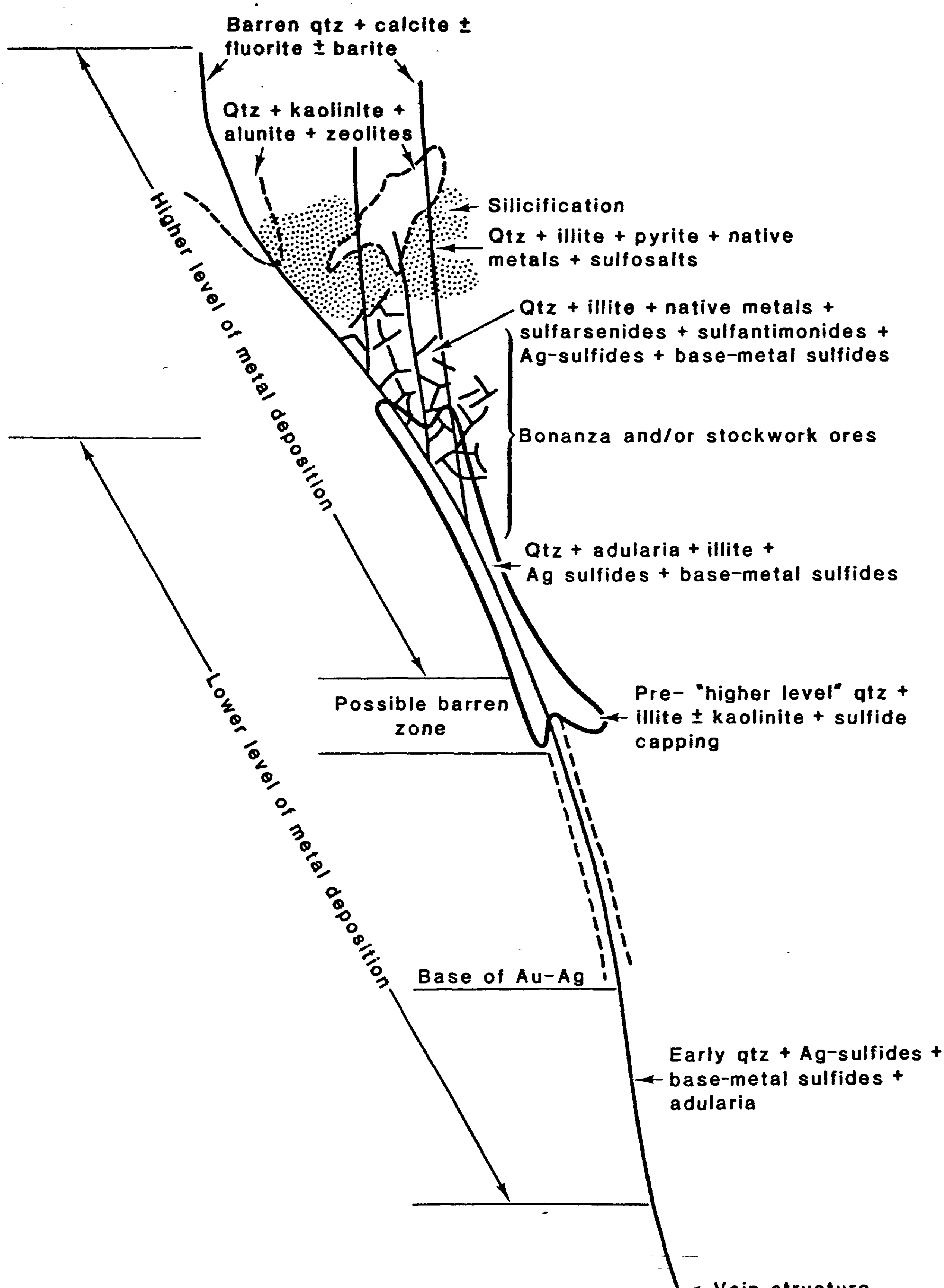
Alteration Top to bottom of system: quartz+kaolinites+montmorillenite± zeolites±barite±calcite; quartz+illite; quartz+adularia±illite; quartz±chorite presence of adularia is variable

Ore Controls Through-going, anastomosing fracture systems

Weathering Bleached country rock, goethite, jarosite, alunite--supergene processes often important factor in increasing grade of deposit

Geochemical Signature: Higher in system Au+As+Sb+Hg; Au+Ag+Pb+Zn+Cu; Ag+Pb+Zn, Cu+Pb+Zn, Base metals generally higher in deposits with silver.

Examples	References
Jarbidge, Nevada	Schrader, 1923
Comstock, Nevada	Becker, 1882
Guanajuato, Mexico	Buchanon, 1980, and Wandke and Martinez, 1928
Creede Colorado	Steven and Ratte, 1965


Barren qtz + calcite ± fluorite ± barite
Qtz + kaolinite + alunite + zeolites
Silicification
Qtz + illite + pyrite + native metals + sulfosalts
Qtz + illite + native metals + sulfarsenides + sulfantimonides + Ag-sulfides + base-metal sulfides
Bonanza and/or stockwork ores
Qtz + adularia + illite + Ag sulfides + base-metal sulfides
Higher level of metal deposition
Lower level of metal deposition
Possible barren zone
Pre- "higher level" qtz + illite ± kaolinite + sulfide capping
Base of Au-Ag
Early qtz + Ag-sulfides + base-metal sulfides + adularia
Vein structure

DEPOSIT TYPE Epithermal gold SUBTYPE Quartz-alunite

AUTHOR Byron R. Berger DATE December 1982

APPROXIMATE SYNONYM Acid-sulfate or enargite gold OF (REFERENCE)

DESCRIPTION Gold, pyrite and enargite in vuggy veins and breccias in zones of advanced argillic alteration related to felsic volcanism

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Volcanic: dacite, quartz latite, rhyodacite, rhyolite. Hypabyssal intrusions or domes

Textures Porphyritic

Age Range Generally Tertiary, but can be any age

Depositional Environment Within the volcanic edifice, ring fracture zones of calderas, or areas of igneous activity with sedimentary evaporites in basement

Tectonic Setting(s) Throughgoing fracture systems: keystone graben structures, ring fracture zones, normal faults, fractures related to doming, joint sets

Associated Deposit Types Porphyry copper, active or fossil acid-sulfate hot springs, pyrophyllite, hydrothermal clay

Metal Concentrations Copper, arsenic, antimony

DEPOSIT DESCRIPTION

Ore Minerals: Native gold+enargite+pyrite+silver-bearing sulfosalts± chalcopyrite±bornite±precious-metal tellurides±galena±sphalerite±huebnerite. May have hypogene oxidation phase with chalcocite+covellite±luzonite with late-stage native sulfur

Texture/Structure Veins; breccia pipes, pods, dikes; replacement veins often porous, vuggy

Alteration Highest temperature assemblage: quartz+alunite+pyrophyllite; may be early stage of quartz+alunite with pervasive alteration of host rock and veins of these minerals; zoned around quartz-alunite is quartz+alunite+ kaolinite+montmorillonite; pervasive propylitic alteration depends on extent of early alunitization:chlorite+calcite

Ore Controls Through-going fractures, centers of intrusive activity

Weathering Abundant yellow limonites, jarosite, goethite, white argillization with kaolinite, fine-grained white alunite veins, hematite

Geochemical Signature: Higher in system Au+As+Cu with increasing base metals at depth. Also Te, and at El Indio, W

Examples	References
Goldfield, Nevada	Ransome, 1909
Kasuga mine, Japan	Taneda and Mukaiyama, 1970

El Indio, Chile	Walthier and others, 1982 unpublished report)

DEPOSIT TYPE Hot Springs Gold Silver   SUBTYPE

AUTHOR Byron R. Berger   DATE December 1982

APPROXIMATE SYNONYM   OF (REFERENCE)

DESCRIPTION Fine-grained silica and quartz in silicified breccia with gold, pyrite and Sb and As sulfides

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Areas of volcanic activity: rhyolite
Textures Porphyritic

Age Range Mainly Tertiary and Quaternary

Depositional Environment Rhyolitic volcanic centers, rhyolite domes

Tectonic Setting(s) Through-going fracture systems

Associated Deposit Types Quartz veins, breccia pipes

Metal Concentrations: Mo, W, Ag-sulfosalts, placer gold

DEPOSIT DESCRIPTION

Ore Minerals: Native gold+pyrite+stibnite+realgar or arsenopyrite±sphalerite±chalcopyrite±fluorite or native gold+Ag-selenide or tellurides+pyrite

Texture/Structure: Structure banded veins, stockworks, breccias (cemented or uncemented w/silica)

Alteration: Top of bottom of system: Chalcedonic sinter, massive silicification, stockworks and veins of quartz+adularia and breccias cemented w/quartz, quartz+chlorite - Veins generally chalcedonic, some opal

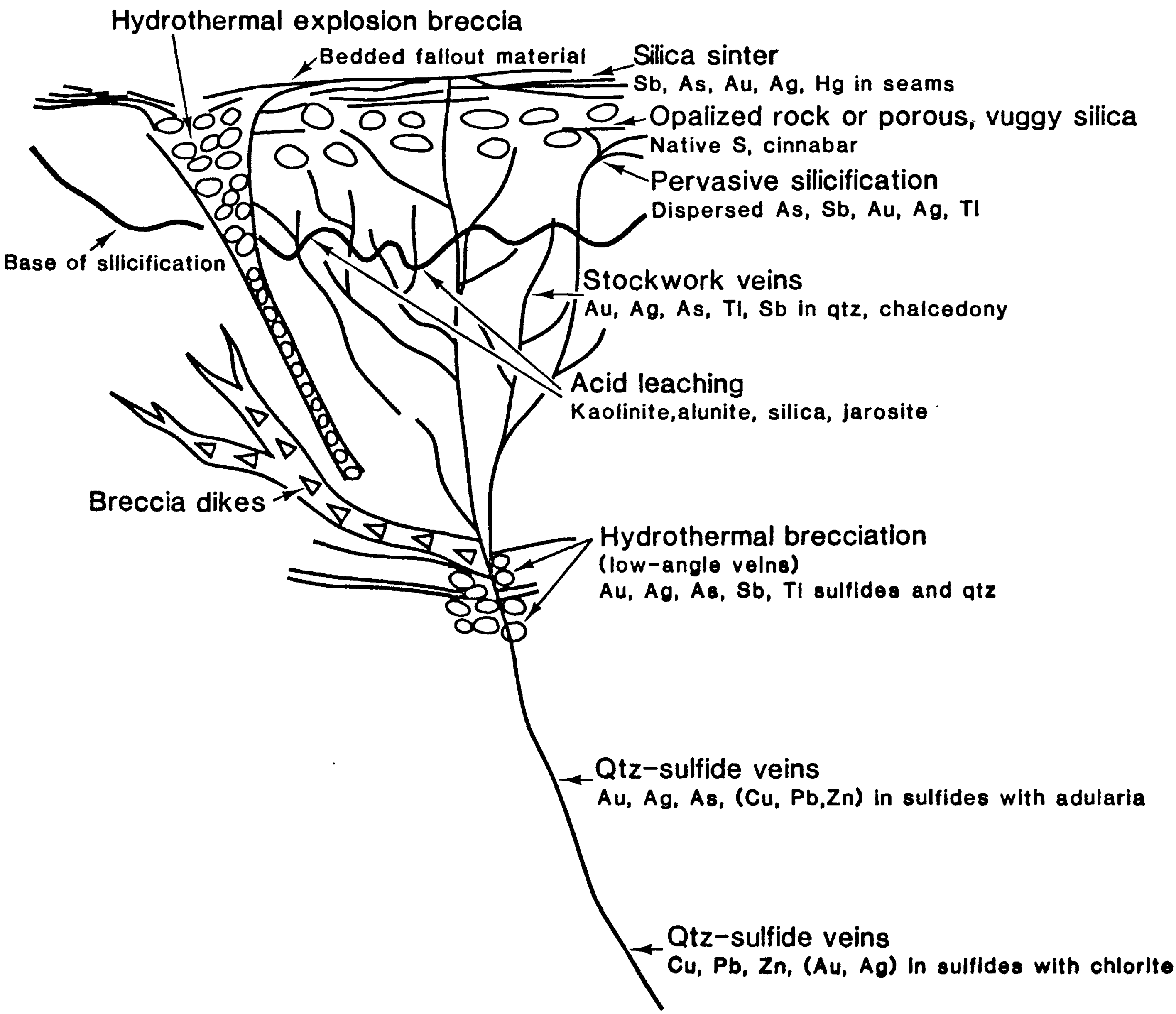
Ore Controls: Through-going fracture systems, brecciated cores of intrusive domes; cemented breccias important carrier of ore

Weathering: Bleached country rock, yellow limonites w/jarosite and fine grained alunite, hematite, goethite

Geochemical Signature: Au+As+Sb+Hg+Tl higher in system, increasing Ag w/depth, decreasing As+Sb+Tl+Hg with depth

Examples McLaughlin, California
Round Mtn., Nevada
Delamar, Idaho

References Averitt 1945 and Becker, 1888
Ferguson, 1921
Lindgren, 1900


Hydrothermal explosion breccia
Bedded fallout material
Silica sinter
Sb, As, Au, Ag, Hg in seams
Opalized rock or porous, vuggy silica
Native S, cinnabar
Pervasive silicification
Dispersed As, Sb, Au, Ag, Tl
Base of silicification
Stockwork veins
Au, Ag, As, Tl, Sb in qtz, chalcedony
Acid leaching
Kaolinite,alunite, silica, jarosite
Breccia dikes
Hydrothermal brecciation
(low-angle veins)
Au, Ag, As, Sb, Tl sulfides and qtz
Qtz-sulfide veins
Au, Ag, As, (Cu, Pb,Zn) in sulfides with adularia
Qtz-sulfide veins
Cu, Pb, Zn, (Au, Ag) in sulfides with chlorite

DEPOSIT TYPE Disseminated Hg | SUBTYPE Aranzazu type

AUTHOR D. Cox | DATE 12/1/82

APPROXIMATE SYNONYM Almaden type | OF (REFERENCE)

DESCRIPTION Stratabound disseminated native mercury in volcaniclastic sedimentary rocks

GENERAL REFERENCE Saupe, 1973

GEOLOGICAL ENVIRONMENT

Rock Types Shale, graywacke, calcareous graywacke, andesitic lava and tuff, andesite dikes. Volcanic vent breccia

Textures

Age Range Cretaceous

Depositional Environment Permeable sedimentary rocks, andesite dikes possibly near volcanic center

Tectonic Setting(s) Volcanic centers along major deep-seated fault zone

Associated Deposit Types Stibnite veins

Metal Concentrations Hg As Sb

DEPOSIT DESCRIPTION

Ore Minerals: Native mercury±cinnabar+pyrite+calcite+quartz

Texture/Structure Disseminated

Alteration

Ore Controls Mineralized zone follows major fault, highest grade ore in calcareous graywacke

Weathering

Geochemical Signature: Hg As Sb

Examples Nueva Esperanza, Caldas, Colombia; Almaden, Spain; Santa Barbara, Peru

References Lozano and others (1977); Saupe (1973)

DEPOSIT TYPE Silica-carbonate Hg SUBTYPE

AUTHOR J. Rytuba DATE January 11, 1983

APPROXIMATE SYNONYM New Almaden OF (REFERENCE)

DESCRIPTION Cinnabar at contact of serpentine and siltstone-graywacke above subduction-related thrust

GENERAL REFERENCE Bailey (1964)

GEOLOGICAL ENVIRONMENT

Rock Types Serpentine, siltstone-graywacke

Textures

Age Range Tertiary

Depositional Environment Serpentine intrusives (sill and dikes) into graywacke and siltstone, fractures in altered serpentine

Tectonic Setting(s) Deposits occur in accreted terrane above subduction-related thrust fault

Associated Deposit Types Stibnite veins

Metal Concentrations Unknown

DEPOSIT DESCRIPTION

Ore Minerals: Cinnabar, native Hg, other minor sulfides: pyrite, stibnite, chalcopyrite, sphalerite, galena, and bornite

Texture/Structure Replacement and minor veins

Alteration Replacement of serpentine by quartz and dolomite and minor hydrocarbons to form "silica-carbonate" rock

Ore Controls Contact of serpentine with siltstone especially where contact forms antiform ore primarily in silica-carbonate rock

Weathering

Geochemical Signature: Unknown, probably Hg Sb Cu Zn

Examples New Almaden, Calif. References Bailey (1964)

DEPOSIT TYPE Hot spring Hg   SUBTYPE

AUTHOR J. Rytuba   DATE January 11, 1983

APPROXIMATE SYNONYM Sulphur Bank   OF (REFERENCE) White, 1981

DESCRIPTION Cinnabar and pyrite disseminated in graywacke, shale, andesite, and basalt flows and diabase dikes

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Andesite-basalt flows, diabase dikes, andesitic tuffs, and tuff breccia

Textures

Age Range Tertiary

Depositional Environment Near paleo groundwater table in areas of fossil hot spring system

Tectonic Setting(s) Extensional faulting with associated small volume mafic to intermediate volcanism

Associated Deposit Types Hot Springs gold

Metal Concentrations

DEPOSIT DESCRIPTION

Ore Minerals: Cinnabar - native Hg

Texture/Structure Disseminated and coatings on fractures

Alteration Above paleo groundwater table, kaolinite-alunite-Fe oxides; below paleo groundwater table, pyrite, zeolites, potassium feldspar, chlorite, and quartz. Opal deposited at the paleo water table.

Ore Controls Paleo groundwater table within hot spring systems developed along high-angle faults

Weathering

Geochemical Signature: Hg As Sb ±Au

Examples Sulfur bank, California   References White and Roberson (1962)

DEPOSIT TYPE Emerald veins SUBTYPE

AUTHOR D. Cox DATE 2/24/83

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Emerald in plagioclase-dolomite veins in black shale

GENERAL REFERENCE Escovar, 1979

GEOLOGICAL ENVIRONMENT

Rock Types Black shale, claystone, siltstone. Minor sandstone, limestone and conglomerate. Locally coarse dolomite breccia filled by carbonates and oligoclase.

Textures Diabasic diorite dikes present but not prominent.

Age Range Cretaceous-Tertiary

Depositional Environment Thick epicontinental marine shale. Evaporites may have provided saline solutions.

Tectonic Setting(s) Major faults. Minor intrusions may have provided heat sources for fluid circulation.

Associated Deposit Types May be associated with Pb-Zn deposits

Metal Concentrations Be±Pb-Zn

DEPOSIT DESCRIPTION

Ore Minerals: Emerald+greenish berly+oligoclase+dolomite+calcite+ pyrite±fluorite±rutile±quartz

Texture/Structure Crustified banding, vuggy, coarsely crystalline

Alteration Shales altered to black hornfels, fossils replaced by oligoclase. Dolomitization

Ore Controls Major fault at intersections of minor cross faults sharp-walled veins and tabular breccia bodies

Weathering Plagioclase weathers to pockets of kaolinite

Geochemical Signature: In veins: high Be, Na, Mg; low Li, Ba, K, Mo, Pb relative to shales outside of mineralized areas

Examples Gachala District Colombia References Escobar, 1979

DEPOSIT TYPE Tin-tungsten veins SUBTYPE

AUTHOR William C. Bagby DATE February 1983

APPROXIMATE SYNONYM Dike-vein systems OF (REFERENCE)

DESCRIPTION Wolframite, cassiterite, quartz, siderite, arsenopyrite veins in metamorphic rocks above large granitic batholiths

GENERAL REFERENCE Grant, J. N., et al, 1980

GEOLOGICAL ENVIRONMENT

Rock Types Hornfels comprised of quartzites and shales; schists with volumetrically minor granitic intrusions

Textures Fine-grained sediments metamorphosed to schists and hornfels.

Age Range Mesozoic and younger

Depositional Environment Open fracture filling in country rocks above massive granitic intrusions

Tectonic Setting(s) Andean arc farthest from trench

Associated Deposit Types Sn-W placer deposits. Veins may grade into porphyry tin deposits with depth.

Metal Concentrations As, Sn, Be, Sb, Pb, Zn, Cu

DEPOSIT DESCRIPTION

Ore Minerals: Wolframite (ferberite, hubnerite) and cassiterite are major ore minerals accompanied by quartz, siderite, arsenopyrite, tourmaline, apatite, pyrrhotite, pyrite, vivianite, chalcopyrite, and sphalerite. See cartoon for zoning

Texture/Structure Veins are massive quartz siderite with Sn/W ore minerals

Alteration Quartz+tourmaline is intense at deposit center. This grades outward through sericite+pyrite to propylitic (calcite+pyrite)

Ore Controls Open fractures in shear zones and breccia pipes above diffentiating granitic batholiths. Temperatures are high (390°C for Chicote Grande)

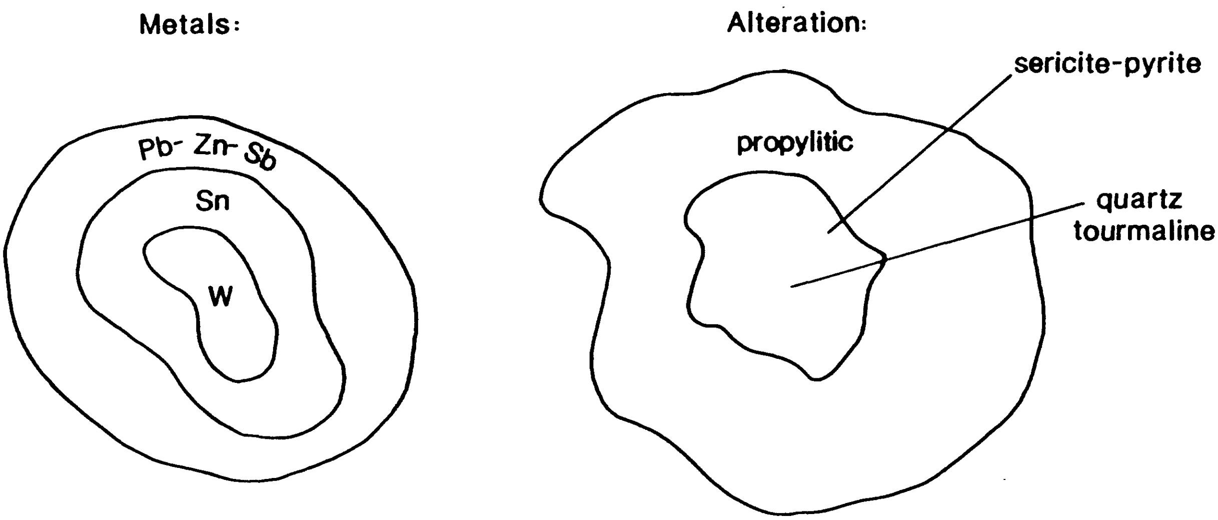
Weathering Weathering of arsenopyrite results in jarosite-rich deposits which are easily eroded creating placer deposits of wolfranite and cassiterite

Geochemical Signature: As and Sb are anomalously high

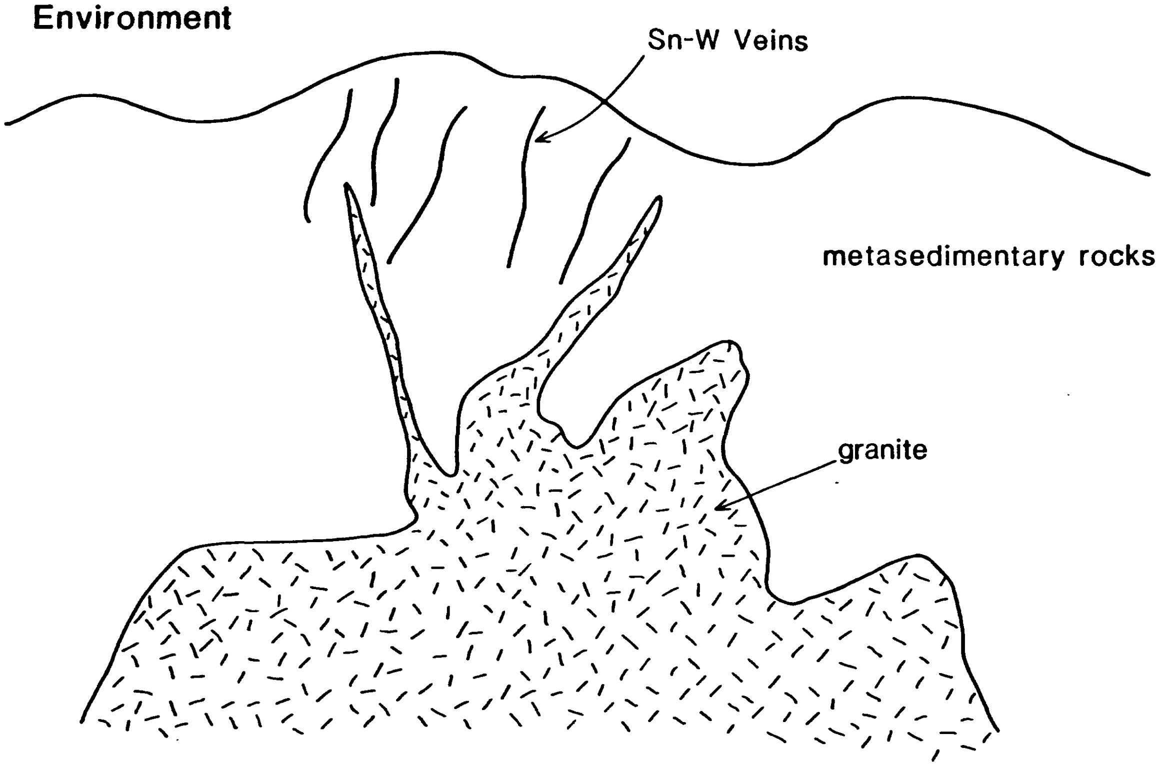
Examples Isla de Pinos, Cuba
Chicote Grande Bolivia
Huanuni, Bolivia

References Page L. R., and McAllister, J. F., 1944
Personal Visit
Grant, J. N., et al, 1980

Zoning Patterns



Depositional Environment



From Grant, J.N. and others 1980

DEPOSIT TYPE Volcanogenic Uranium SUBTYPE

AUTHOR William C. Bagby DATE February 14, 1983

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Uranium mineralization in epithermal veins comprised of quartz fluorite, and iron, arsenic, and molybdenum sulfides

GENERAL REFERENCE Nash, J. T., 1981

GEOLOGICAL ENVIRONMENT

Rock Types High silica alkali rhyolite and potash trachytes. Both peralkaline and peraluminous rhyolite, host ore

Textures Porphyritic to aphyric vesicular flows and shallow intrusives

Age Range Pre-Cambrian to Tertiary

Depositional Environment Subaerial to subaqueous volcanic complexes. Near-surface environment, association with shallow intrusives is important

Tectonic Setting(s) Continental rifts and associated calderas

Associated Deposit Types Roll front uranium in volcaniclastic sediments

Metal Concentrations Hg, Li, Be, Mo, ±B, ±REE

DEPOSIT DESCRIPTION

Ore Minerals: Coffinite, uraninite, brannerite are most common uranium minerals. Other minerals include pyrite, realgar/orpiment, jordisite, leuroxene, fluorite, quartz, adularia, and barite. Gold is present in some deposits. Deposits associated with alkaline complexes may contain bastnaesite.

Texture/Structure Open-space filling in breccias. Uraninite commonly encapsulated in silica.

Alteration Kaolinite, montmorillonite, and alunite are common. Silicification, accompanied by adularia, affects wall rocks spatially most closely associated with ore.

Ore Controls Through-going fractures and breccias formed along the margins of shallow intrusives. Vugs in surface flows are of minor importance

Weathering Near surface oxidation produces a variety of secondary uranium minerals. Supergene uranium enrichment is generally not important.

Geochemical Signature: Li and Hg are zoned away from the ore. High anomalous As, Sb, F, Mo, ±W occur near and with the ore. Mo is deep. Hg is shallow. REE maybe highly anomalous.

Examples Marysvale, Utah
Autota prospect, Oregon
Rexspar British Columbia

References Kerr, P. F., et al 1957
Roper, M. W., Wallace, A. B., 1981
Joubin, F. R., and James, D. G., 1957

DEPOSIT TYPE Cauca Valley Bauxite SUBTYPE

AUTHOR Dennis P. Cox DATE December 6, 1982

APPROXIMATE SYNONYM OF (REFERENCE)

DESCRIPTION Bauxite in weathered fluvio lacustrine deposits.

GENERAL REFERENCE

GEOLOGICAL ENVIRONMENT

Rock Types Andesitic tuffs, flows and agglomerate overlain by fine grained fluvio lacustrine sediments.

Textures

Age Range Plio-Pleistocene.

Depositional Environment Lake beds weathered in humid tropical environment.

Tectonic Setting(s) Horizontal beds.

Associated Deposit Types

Metal Concentrations

DEPOSIT DESCRIPTION

Ore Minerals: Cliachite, gibbsite, clay.

Texture/Structure Coarse gibbsite aggregates in clay matrix.

Alteration

Ore Controls Uppermost lake beds.

Weathering

Geochemical Signature:

Examples Upper Cauca Valley, Colombia References Rosas, 1978; oral commun., 1982

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INDEX TO GEOCHEMICAL ASSOCIATIONS

[M, Major element or recoverable metal; H, Anomalously high in ore zone; P, anomalously high in zones peripheral to ore; L, Anomalously low, depleted, below background]

Group and Model	Ag	Al	As	Au	B	Ba	Be	Bi	Br	C	Ca	Cd	Ce	Cl	Co	Cr	Cs	Cu	F
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-
1.2	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	M	-	H	-
1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1	H	-	P	P	H	-	-	-	-	-	-	-	-	-	-	-	-	M	-
2.2	H	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
2.3	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-	-	P	H
2.4	P	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	P	L
2.5	-	-	-	H	-	-	-	-	-	-	-	-	-	-	H	-	-	H	-
2.6	H	-	-	H	-	-	-	H	-	-	-	-	-	-	-	-	-	M	-
2.7	H	-	H	-	-	-	H	-	-	-	-	-	-	-	H	-	-	H	H
2.8	-	-	H	-	-	-	H	-	-	-	-	-	-	-	-	-	-	H	-
2.9	H	-	-	-	-	-	H	H	-	-	-	-	H	-	-	-	-	H	H
2.10	-	-	-	-	H	-	M	H	-	-	-	-	M	-	-	-	-	-	-
3.1	-	-	-	-	-	-	-	-	-	-	L	-	-	-	H	-	-	M	-
3.2	M	-	H	M	-	H	-	H	-	-	-	-	-	-	-	-	-	M	-
3.3	-	-	H	M	H	-	-	-	-	-	-	-	-	-	-	-	-	H	-
3.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
4.2	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
4.3	-	-	-	-	-	-	-	H	-	-	-	-	-	-	M	-	-	M	-
4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.5	-	-	-	-	H	H	-	-	-	-	-	-	-	-	-	-	-	H	-
4.6	H	-	-	-	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.8	H	-	-	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
5.1	M	-	H	M	-	-	-	H	-	-	-	-	-	-	-	-	-	M	-
5.2	-	-	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H
5.3	H	-	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.4	M	-	H	M	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
5.5	H	H	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.6	H	-	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-	H	H
5.7	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.9	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-
5.11	-	-	H	-	H	-	H	-	-	-	-	-	-	-	-	-	-	H	-
5.12	-	-	H	-	H	-	H	-	-	-	-	-	H	-	-	-	-	-	M
6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INDEX TO GEOCHEMICAL ASSOCIATIONS

[M, Major element or recoverable metal; H, anomalously high in ore zone; P, anomalously high in zones peripheral to ore; L, Anomalously low, depleted, below background]

Group and Model	Fe	Ga	Ge	Hg	In	K	Kr	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	PGE	Rb
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-	H	-
1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	P	-	P
2.2	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	P	-	-
2.3	-	-	-	-	-	-	-	H	-	-	-	M	-	-	-	-	-	-	-
2.4	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-
2.5	M	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-
2.6	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-	-	-	-	-
2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-
2.8	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-	-	-	-	-
2.9	-	-	-	-	-	-	-	H	H	-	-	-	-	-	-	-	H	-	H
2.10	-	-	-	-	-	-	-	M	M	-	-	-	-	M	-	-	-	-	M
3.1	H	-	-	-	-	-	-	-	-	P	P	-	L	-	-	-	-	-	-
3.2	H	-	-	-	-	-	-	-	-	P	H	-	L	-	-	-	M	-	-
3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	H	-
3.4	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-
4.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-
4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.3	-	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	H	H	-
4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-
4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	M	-	-
4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-
4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-
5.1	-	-	-	-	-	-	-	-	-	-	H	-	-	-	-	-	M	-	-
5.2	-	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-
5.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.5	-	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-
5.6	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.7	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.8	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11	-	H	-	-	-	M	-	-	-	-	-	-	-	-	-	M	-	H	-
5.12	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-
6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INDEX TO GEOCHEMICAL ASSOCIATIONS

[M, Major element or recoverable metal; H, Anomalously high in ore zone; P, anomalously high in zones peripheral to ore; L, Anomalously low, depleted, below background]

Group and Model	S	Sb	Sc	Se	Si	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1	-	P	-	-	-	-	-	-	H	-	-	-	-	-	H	-	P	-
2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-
2.3	-	-	-	-	-	H	-	-	-	-	-	-	P	-	H	-	-	-
2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-
2.5	-	-	-	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-
2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
2.7	-	-	-	-	-	H	-	-	-	-	-	-	-	-	H	-	M	-
2.8	-	-	-	-	-	H	-	-	-	-	-	-	-	-	M	-	H	-
2.9	-	-	-	-	-	M	-	-	-	-	-	-	-	-	H	-	H	-
2.10	-	-	-	-	-	M	-	M	-	M	-	-	M	-	-	H	H	H
3.1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
3.2	M	-	-	H	-	H	-	-	-	-	-	-	-	-	-	-	M	-
3.3	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
3.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.1	-	-	-	-	-	-	-	-	-	-	-	-	H	H	-	-	H	-
4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.3	-	-	-	-	-	-	-	-	-	-	-	-	H	H	-	-	H	-
4.4	-	-	-	H	-	-	-	-	-	M	-	-	M	-	-	-	-	-
4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.1	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
5.2	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3	-	-	-	-	-	-	-	-	H	-	-	-	-	-	-	-	H	-
5.4	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.5	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.6	-	H	-	H	-	-	-	-	H	-	-	P	-	-	-	-	H	-
5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-
5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DEPOSIT TYPE ______ SUBTYPE ______

AUTHOR ______ DATE ______

APPROXIMATE SYNONYM ______ OF (REFERENCE) ______

DESCRIPTION ______

GENERAL REFERENCE ______

GEOLOGICAL ENVIRONMENT

Rock Types ______

Textures ______

Age Range ______

Depositional Environment ______

Tectonic Setting(s) ______

Associated Deposit Types ______

Metal Concentrations ______

DEPOSIT DESCRIPTION

Ore Minerals: ______

Texture/Structure ______

Alteration ______

Ore Controls ______

Weathering ______

Geochemical Signature: ______

Examples ______ References ______