Mineral Deposit Models

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DESCRIPTIVE MODEL OF PODIFORM CHROMITE

By John P. Albers

APPROXIMATE SYNONYM Alpine type chromite (Thayer, 1964).

DESCRIPTION Podlike masses of chromitite in ultramafic parts of ophiolite complexes (see fig. 20).

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 spreading plate boundaries. Subsequently exposed in accreted terranes as part of ophiolite assemblage.

Associated Deposit Types Limassol Forest Co-Ni-S-As.

DEPOSIT DESCRIPTION

Mineralogy Chromite ± ferrichromite ± magnetite ± Ru-Os-Ir alloys ± laurite.

Texture/Structure Massive coarse-grained to finely disseminated.

Alteration None related to ore.

Ore Controls Restricted to dunite bodies in tectonized harzburgite or lower portions of ultramafic cumulate (see fig. 99).

Weathering Highly resistant to weathering and oxidation.

Geochemical Signature None recognized.

EXAMPLES

High Plateau, Del Norte Cty, USCA (Wells and others, 1946)
Coto Mine, Luzon, PLPN (LeBlanc and Violette, 1983)

GRADE AND TONNAGE MODEL OF MINOR PODIFORM CHROMITE

By Donald A. Singer and Norman J Page

DATA REFERENCES Singer and others (1980); Calkins and others (1978); Carlson and others (1985).

COMMENTS All deposits in this grade-tonnage compilation are from California and Oregon. The two largest tonnage deposits are actually districts rather than individual deposits. The majority of the grades represent shipping grades. Grades less than 35 percent typically represent in-place "ore". The mixture of shipping grades and in-place grades may explain the significant negative correlation (r = -0.25) between grade and tonnage. Rh, Ir, Ru, Pd, and Pt grades are based on reported analyses of samples from the deposits. Unreported PGE grades are probably similar to those presented here. Rhodium is correlated with chromite (r = 0.35, n = 69), platinum (r= 0.69, n = 31), iridium (r = 0.47, n = 35), ruthenium (r = 0.56, n = 28). Ruthenium is correlated with palladium (r = 0.72, n = 21) and iridium (r = 0.59, n = 29). See figs. 21-23.

DEPOSITS

Name	Country
Ace of Spades	USCA
Adobe Canyon Gp.	USCA
Ajax	USOR
Alice Mine	USCA
AlIan (Johnson)	USCA
Alta Hill	USCA
Althouse	USOR
Alyce and Blue Jay	USCA
American Asbestos	USCA
Anti Axis	USCA
Apex (Del Norte Co.)	USCA
Apex (El Dorado Co.)	USCA
Applegate	USOR
Associated Chromite	USOR
Babcock	USOR
Babyfoot	USOR
Beat	USCA
Big Bear	USOR
Big Bend	USCA
Big Chief	USOR
Big Dipper (Robr)	USCA
Big Four	USOR
Big Pine Claim	USCA
Big Yank No. 1	USOR
Binder No. 1	USCA
Black Bart (Great Western)	USCA
Black Bart Claim (Avery)	USCA
Black Bart Group	USCA
Black Bear	USCA
Black Beauty	USOR
Black Boy	USOR
Black Chrome	USCA
Black Diamond	USOR
Black Diamond (Grey Eagle GP.)	USCA
Black Hawk	USOR
Black Otter	USOR
Black Rock Chrome	USCA
Black Streak	USOR
Black Warrior	USOR
Blue Brush	USCA
Blue Creek Tunnel	USCA
Blue Sky (Lucky Strike)	USCA
Boiler Pit	USGA
Bonanza	USCA
Booker Lease	USCA
Bowden Prospect	USCA
Bowie Estate	USCA
Bowser	USOR
Bragdor	USCA
Briggs Creek	USOR
Brown Scratch	USOR
Bunker	USCA
Burned Cabin	USOR
Butler Claims	USCA
Butler, Estate Chrome, etc	USCA
Buttercup Chrome	USCA
Camden Mine	USCA
Campbell	USOR
Camptonville area	USCA
Castro Mine	USCA
Cattle Springs	USCA
Cavyell Horse C	USOR
Cavyell Horse Mountain	USOR
Cedar Creek	USOR
Celebration	USOR
Challange area	USCA
Chambers	USOR
Chicago	USCA
Christian Place	USCA
Chrome Camp	USCA
Chrome Gulch	USCA
Chrome Hill	USCA
Chrome King (Josephine Co.)	USOR
Chrome King (Jackson Co.)	USOR
Chrome No. 3,	USOR
Chrome Ridge	USOR
Clara H	USCA
Clary and Langford	USCA
Cleopatra	USOR
Clover Leaf	USCA
Codd Prospect	USCA
Coggins	USCA
Collard Mine	USOR
Commander	USCA
Coon Mt. Nos. 1-3	USCA
Copper Creek (Low Divide)	USCA
Courtwright	USCA
Courtwright (Daggett)	USCA
Cow Creek Gp.	USCA
Crouch	USOR
Crown	USOR
Cyclone Gap	USCA
Cynthia	USOR
Daisy (Aldelabron)	USCA
Dark Star	USOR
Barrington	USCA
Deep Gorge Chrome	USOR
Delare Prospect	USOR
Detert	USCA
Diamond	USCA
Dickerson	USCA
Dickey and Drisbach	USCA
Dirty Face	USOR
Doe Flat	USCA
Don Pedro	USCA
Dorriss	USCA
Dozier	USCA
Dry Creek	USOR
Earl Smith	USCA
Early Sunrise	USOR
Edeline	USCA
Eden	USCA
Eggling and Williams	USCA
El Primero	USCA
Elder Claim	USCA
Elder Creek	USCA
Elder Creek Gp.	USCA
Elk Creek Claim	USCA
Elkhorn Chromite	USOR

Model 8a--Con.

Ellingwood	USCA
Ellis	USCA
Esterly Chrome	USOR
Esther and Phyllis	USCA
Fairview	USCA
Fiddler's Green	USCA
Fields and Stoker	USCA
Finan	USCA
Forest Queen	USCA
Foster	USOR
Four Point	USOR
Fourth of July	USCA
French Hill	USCA
Friday	USOR
Gallagher	USOR
Gardner Mine	USOR
Gas Canyon	USCA
Geach	USCA
Gibsonville	USCA
Gill (Gill Ranch)	USCA
Gillan	USCA
Gillis Prospect	USCA
Glory Ho	USOR
Golconda Fraction	USCA
Gold Bug Claim	USCA
Goncolda	USOR
Gray Boy	USOR
Gray Buck Gp.	USOR
Green (Americus)	USCA
Green Mine	USCA
Green Ridge	USCA
Green's Capco Leases	USCA
Griffin Chromite	USOR
Gunn Claims	USCA
Half Chrome	USCA
Hanscum	USOR
Happy Go Lucky	USCA
Harp and Sons Ranch	USCA
Hawks Rest View	USOR
Hayden and Hilt	USCA
Helemar	USCA
Hendricks No. 2	USCA
High Dome	USCA
High Plateau	USCA
Hill-Top Chrome	USCA
Hedge Ranch	USCA
Hoff	USCA
Holbrook and McGuire	USCA
Holseman (and others)	USCA
Holston (Vaughn)	USCA
Horseshoe	USCA
Horseshoe Chrome	USOR
Houser & Burges	USOR
Hudson (Fuller Claims)	USCA
I-Wonder	USCA
Illinois River	USOR
Independence	USOR
Irene Chromite	USOR
Iron King	USOR
Iron Mountain	USOR
Jack Forth	USCA
Jack Sprat Gp.	USCA
Jackson	USOR
Jim Bus	USOR
Johns	USOR
Josephine	USCA
Josephine No. 4	USOR
Judy (Hicks)	USCA
Julian	USCA
Kangaroo Court Mine	USCA
Kingsley	USOR
Kleinsorge Gp.	USCA
Kremmel and Froelich	USCA
Lacey	USCA
Lambert	USCA
Langley Chrome	USOR
Lassie Peak	USCA
Last Buck	USOR
Last Chance (Coos)	USOR
Last Chance (Josephine)	USOR
Laton	USCA
Letty	USCA
Liberty	USCA
Liberty Bond Claim	USCA
Linda Marie	USOR
Little Boy	USOR
Little Castle Creek	USCA
Little Hope	USCA
Little Rock Mine	USCA
Little Siberia	USOR
Lone Gravel	USCA
Long Ledge Gp.	USCA
Lost Lee	USOR
Lotty	USCA
Lucky Boy	USCA
Lucky Friday	USOR
Lucky Girl	USCA
Lucky Hunch	USOR
Lucky L. & R.	USOR
Lucky Nine Gp.	USOR
Lucky Star	USOR
Lucky Strike (Lake Co.)	USCA
Lucky Strike (S.L.O. Co.)	USCA
Lucky Strike (Curry Co.)	USOR
Lucky Strike	USOR
Mackay	USCA
Madeira	USCA
Madrid	USCA
Manchester	USCA
Maralls Capro Leases	USCA
Marks & Tompson	USOR
Mary Jane	USCA
Mary Walker	USOR
Maxwell	USCA
Mayflower	USCA
McCaleb's Sourdough	USOR
McCarty	USCA
McCormick	USCA
McGuffy Creek Gp.	USCA
McMurty	USCA
Meeker (Sonoma Chrome)	USCA
Merrifield	USCA
Mighty Joe	USOR
Milton	USCA
Mockingbird	USOR
Moffett Creek Gp.	USCA

Mohawk Claim	USOR	Ray (Tip Top)	USOR
Moore	USCA	Ray Spring	USOR
Moscatelli	USCA	Red Ledge	USCA
Moscatelli No. 2	USCA	Red Mountain	USOR
Mountain View	USCA	Red Slide Gp.	USCA
Mountain View Gp.	USCA	Redskin	USCA
MuNaly	USCA	Richards	USCA
Mulcahy Prospect	USCA	Richey, U.S. & S.J.	USCA
Mule Creek	USCA	Robt. E.	USOR
Mum and Alice June Claim	USCA	Rock Creek	USOR
Murphy	USCA	Rock Wren Mine	USCA
Muzzleloader (Stevens No. 1)	USCA	Rose Claim	USCA
		Rosie Claim	USOR
New Hope	USCA	Round Bottom	USCA
New Hope Claim	USOR	Roupe	USCA
Newman	USCA	Sad Sack	USOR
Nichelini Mine	USCA	Saddle Chrome	USOR
Nickel Mountain	USOR	Saint	USCA
Nickel Ridge	USOR	Sally Ann	USOR
No. 5	USCA	Salt Rock	USOR
Noble Electric Co.	USCA	Saturday Anne	USOR
Norcross	USCA	Schmid	USOR
North End, West End, Spotted Fawn	USCA	Seiad Creek (Mt. View)	USCA
		September Morn	USCA
North Fork Chrome	USCA	Sexton Mountain	USOR
North Star	USOR	Shade Chromite	USOR
North Star (Red Mtn)	USCA	Shafer Lease	USCA
Norway	USOR	Shamrock	USCA
Oak Ridge	USCA	Shelly	USCA
Olive B.	USOR	Sheppard Mine	USCA
Olsen	USCA	Shotgun Creek	USCA
Onion Springs	USOR	Silver Lease	USOR
Oregon Chrome	USOR	Simmons	USCA
Oxford	USCA	Simon	USCA
P. U. P. (Zenith)	USCA	Sims	USCA
Paradise No. 1	USOR	Six-Mile	USOR
Paradise No. 2	USOR	Skyline Mine	USCA
Parkts Ranch	USCA	Skyline No. 1	USCA
Parker	USCA	Skyline No. 2	USCA
Parkeson	USCA	Smith Geitsfield	USOR
Pearson Peak	USOR	Snakehead (Jumbo)	USCA
Peewan	USCA	Snowy Ridge	USCA
Peg Leg (Lambert)	USCA	Snowy Ridge	USOR
Pennington Butte	USOR	Snyder	USCA
Perconi Ranch	USCA	Sour Dough	USOR
Pillikin	USCA	Sousa Ranch	USCA
Pine Mountain Claim	USCA	Southern Pacific Property	USCA
Pines	USOR	spot	USCA
Pleasant No. 1 & 2	USOR	Spring Hill	USCA
Poco Tiempo Quartz	USCA	St. Patrick (Camp 8)	USCA
Pony Shoe	USCA	Stafford	USCA
Poodle Dog	USCA	Stark Bee	USCA
Porter Property	USCA	State School	USCA
Powers	USOR	Stevens-Miller	USOR
Prater	USOR	Stewart	USCA
Pyramid	USCA	Stone & Haskins	USOR
Queen of May	USOR	Store Gulch	USOR
Quigg	USCA	Stray Dog	USOR
Rainbow	USOR	Sullivan and Kahl	USCA
Rainy Day	USOR	Sunnyslope	USCA
Rancherie	USOR	Sunrise	USCA
Randall	USCA	Sunset (Fresno Co.)	USCA
Rattlesnake Mountain	USCA	Sunset (Placer Co.)	USCA

Sunshine	USCA	Unknown Name	USOR
Sutro Mine	USCA	Valen Prospect	USOR
Suzy Bell (Lucky Strike)	USCA	Valenti	USCA
Swayne	USCA	Victory No. 3	USCA
Sweetwater	USCA	Violet	USOR
Tangle Blue Divide	USCA	Vogelgesang	USCA
Tennessee Chrome	USOR	Wait	USCA
Tennessee Pass	USOR	Waite	USCA
Thompson Gp.	USOR	Walker	USCA
Tomkin	USCA	War Bond	USCA
Toujours Gai	USCA	War Eagle-Miller	USCA
Trinidad	USCA	Ward	USOR
Twin Cedars	USOR	Ward and Lyons	USCA
Twin Valley	USOR	Washout	USCA
Unnamed	USCA	Welch Prospect	USCA
Uncle Sam	USOR	West Chrome	USCA
Unknown Name	USOR	Western Magnesite	USCA
Unknown Name	USOR	White Bear	USCA
Unknown Name	USOR	White Cedar	USCA
Unknown Name	USOR	White Feather	USCA
Unknown Name	USOR	White Pine Mine	USCA
Unknown Name	USOR	Wild Cat Claim	USOR
Unknown Name	USOR	Wilder (Fish Creek)	USCA
Unknown Name	USOR	Windy Point	USOR
Unknown Name	USOR	Wolf Creek	USCA
Unknown Name	USOR	Wolf Creek area	USCA
Unknown Name	USOR	Wonder	USOR
Unknown Name	USOR	Wonder Gp.	USOR
Unknown Name	USOR	Yellow Pine	USCA
Unknown Name	USOR	Young	USOR
Unknown Name	USOR	Youngts Mine	USOR
Unknown Name	USOR	Zerfirg Ranch	USCA
Unknown Name	USOR		

GRADE AND TONNAGE MODEL OF MAJOR PODIFORM CHROMITE

By Donald A. Singer, Norman J Page, and Bruce R. Lipin

DATA REFERENCES Page and others (1979), Page and others (1982b), Page and others (1984).

COMMENTS This model, number 8b, is provided as an alternative to the podiform chromite model, number 8a, based on California and Oregon deposits because of the significant difference in tonnage of the two groups. The two groups are geologically similar and share the same descriptive model. Rh, Ir, Ru, Pd, and Pt grades are based on reported analyses of samples from the deposits. Platinum grade is correlated with chromite grade (r = 0.76, n = 12) and iridium grade (r = 0.71, n = 8). Rhodium is correlated with iridium grade (r = 0.88, n = 7). See figs. 24-26.

DEPOSITS

Name	Country	Name	Country
Abdasht	IRAN	Bagin	TRKY
Akarca	TRKY	Bagirsakdire	TRKY
Akcabuk	TRKY	Balcicakiri	TRKY
Akkoya	TRKY	Batikef	TRKY
Alice Louise	NCAL	Bati-N. Yarma	TRKY
Alpha	NCAL	Bati-Taban	TRKY
Altindag	TRKY	Bati- W. Yarma	TRKY
Amores	CUBA	Bellacoscia	NCAL
Andizlik	TRKY	Bellevue	NCAL
Anna Madeleine	NCAL	Bereket	TRKY
Asagi Zorkum	TRKY	Bezkere-Bulurlii	TRKY
Aventura	CUBA	Bicir-Cakir	TRKY
Avsar	TRKY	Bicir-Gul	TRKY

Sunshine	USCA
Sutro Mine	USCA
Suzy Bell (Lucky Strike)	USCA
Swayne	USCA
Sweetwater	USCA
Tangle Blue Divide	USCA
Tennessee Chrome	USOR
Tennessee Pass	USOR
Thompson Gp.	USOR
Tomkin	USCA
Toujours Gai	USCA
Trinidad	USCA
Twin Cedars	USOR
Twin Valley	USOR
Unnamed	USCA
Uncle Sam	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Unknown Name	USOR
Valen Prospect	USOR
Valenti	USCA
Victory No. 3	USCA
Violet	USOR
Vogelgesang	USCA
Wait	USCA
Waite	USCA
Walker	USCA
War Bond	USCA
War Eagle-Miller	USCA
Ward	USOR
Ward and Lyons	USCA
Washout	USCA
Welch Prospect	USCA
West Chrome	USCA
Western Magnesite	USCA
White Bear	USCA
White Cedar	USCA
White Feather	USCA
White Pine Mine	USCA
Wild Cat Claim	USOR
Wilder (Fish Creek)	USCA
Windy Point	USOR
Wolf Creek	USCA
Wolf Creek area	USCA
Wonder	USOR
Wonder Gp.	USOR
Yellow Pine	USCA
Young	USOR
Young's Mine	USOR
Zerfirg Ranch	USCA

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By Donald A. Singer, Norman J Page, and Bruce R. Lipin

DATA REFERENCES Page and others (1979), Page and others (1982b), Page and others (1984).

COMMENTS This model, number 8b, is provided as an alternative to the podiform chromite model, number 8a, based on California and Oregon deposits because of the significant difference in tonnage of the two groups. The two groups are geologically similar and share the same descriptive model. Rh, Ir, Ru, Pd, and Pt grades are based on reported analyses of samples from the deposits. Platinum grade is correlated with chromite grade ($r = 0.76$, $n = 12$) and iridium grade ($r = 0.71$, $n = 8$). Rhodium is correlated with iridium grade ($r = 0.88$, n = i'). See figs. 24-26.

DEPOSITS

Name	Country
Abdasht	IRAN
Akarca	TRKY
Akcabuk	TRKY
Akkoya	TRKY
Alice Louise	NCAL
Alpha	NCAL
Altindag	TRKY
Amores	CUBA
Andizlik	TRKY
Anna Madeleine	NCAL
Asagi Zorkum	TRKY
Aventura	CUBA
Avsar	TRKY
Bagin	TRKY
Bagirsakdire	TRKY
Balcicakiri	TRKY
Batikef	TRKY
Bati-N. Yarma	TRKY
Bati-Taban	TRKY
Bati- W. Yarma	TRKY
Bellacoscia	NCAL
Bellevue	NCAL
Bereket	TRKY
Bezkere-Bulurlii	TRKY
Bicir-Cakir	TRKY
Bicir-Gul	TRKY

Bonsecours	NCAL
Bozkonus	TRKY
Bozotluk-No. 551	TRKY
Bugugan	TRKY
Buyiik Gurleyen	TRKY
Buyiik Karamanli	TRKY
Caledonia	CUBA
Camaguey	CUBA
Catak	TRKY
Catak-Koraalan	TRKY
Catolsinir I	TRKY
Catolsinir II	TRKY
Cenger	TRKY
Cenger-Adatepe	TRKY
Cenger-Demirk	TRKY
Cenger-Domuza	TRKY
Cezni	TRKY
Chagrin	NCAL
Child Harold	NCAL
Consolation	NCAL
Cosan	TRKY
Coto	PLPN
Cromita	CUBA
Dagardi	TRKY
Dagkuplu	TRKY
Danacik	TRKY
Dcev 7	NCAL
Delta	CUBA
Demirli	TRKY
Dinagat	PLPN
Dogu Ezan	TRKY
Dogu Kef	TRKY
Domuzburnu II	TRKY
Dovis	IRAN
East Ore Body	PLPN
El Cid	CUBA
Eldirek	TRKY
Ermenis	TRKY
Fanrouche	NCAL
Findikli	TRKY
Findikli #301	TRKY
Findikli #306-#307	TRKY
Findikli #326	TRKY
General Gallieni	NCAL
Gerdag	TRKY
Golalan	TRKY
Gorunur	TRKY
Govniikbelen	TRKY
Gr2h	NCAL
Guillermina	CUBA
Gunlet-Uckopur	TRKY
Gunliik Basi	TRKY
Herpit Yayla	TRKY
Ikisulu-Gercek	TRKY
Jose	CUBA
Kagit Octu	TRKY
Kandira	TRKY
Kapin	TRKY
Karaculha	TRKY
Karageban	TRKY
Karani	TRKY
Karaninar	TRKY
Karasivri	TRKY
Karatas-Kumocak	TRKY
Kartalkoyu	TRKY
Kavakcali	TRKY
Kavakdere	TRKY
Kazadere-Kandil	TRKY
Kefdag-East	TRKY
Kemikli Inbasi	TRKY
Kilic-Kafasi 1	TRKY
Kilic-Kafasi 2	TRKY
Kiranocak	TRKY
Koca	TRKY
Komek	TRKY
Koycegiz-Curukcu	TRKY
Koycegiz-Kurardi	TRKY
Koycegiz-Orta	TRKY
Kuldoden	TRKY
Kundikan-Keluskdere	TRKY
Kundikan-Kelusktepe	TRKY
Kurudere	TRKY
Kuyuluk Isletmesi	TRKY
Kuzkavak	TRKY
La Caridid	CUBA
Lagonoy	PLPN
La Victoria	CUBA
Lolita	CUBA
Marais Kiki	NCAL
Meululter	TRKY
Middle Ore Body	PLPN
Mirandag Koru	TRKY
Mirandag Mevki	TRKY
Morrachini	NCAL
Muss Danisman	TRKY
Narciso	CUBA
Ni Te Ocutes	CUBA
Ochanocagi	TRKY
Ofelia	CUBA
Orta Ezan	TRKY
Otmanlar-Harpuzlu	TRKY
Otmanlar-Mesebuku	TRKY
Panamana-An	PLPN
P. B.	NCAL
Pergini	TRKY
Potosi	CUBA
Ruff Claim No. 32	PLPN
Saka	TRKY
Salur	TRKY
Sarialan	TRKY
Sarikaya	TRKY
Saysin	TRKY
Sekioren	TRKY
Shahin	IRAN
Sicankale	TRKY
Sirac	TRKY
Sofulu	TRKY
Sogham	IRAN
Sta. Cruz	PLPN
Stephane	NCAL
Suluiyeh	IRAN
Sulu	TRKY
Suluk	TRKY
Sutpinar	TRKY
Suzanne	NCAL
Tekneli	TRKY

Tepebasi	TRKY	West Ore Body	PLPN
Terlik	TRKY	Yanikara	TRKY
Tiebaghi	NCAL	Yaprakli	TRKY
Tilkim-Karanlik	TRKY	Yayca Boyna	TRKY
Togobomar	PLPN	Yilmaz Ocagi	TRKY
Tosin	TRKY	Yukari Zorkum	TRKY
Toparlar-Alacik	TRKY	Yunus Yayla	TRKY
Tuzlakaya	TRKY	Yurtlak	TRKY
Uckopru	TRKY	Zambales Ch	PLPN
Vieille Montagne 1	NCAL	Zimparalik	TRKY
Vieille Montagne 2	NCAL		

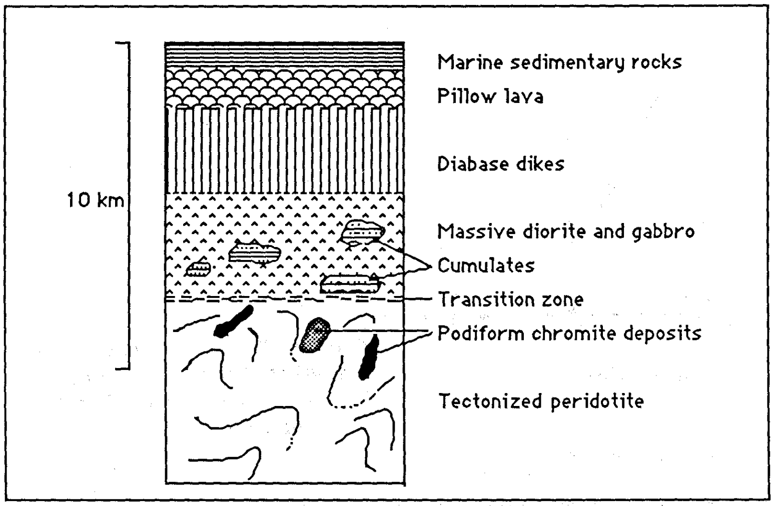


Figure 20. Cartoon cross section of a typical ophiolite sequence showing locations of podiform chromite deposits. From Dickey (1975).

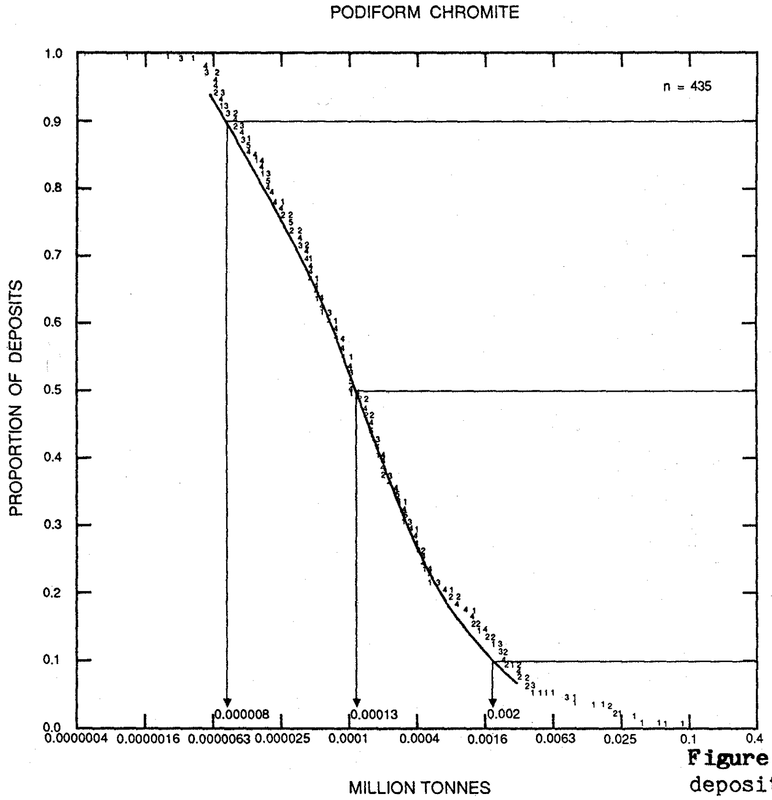


Figure 21. Tonnages of podiform chromite deposits from California and Oregon, U.S.A. Individual digits represent number of deposits.

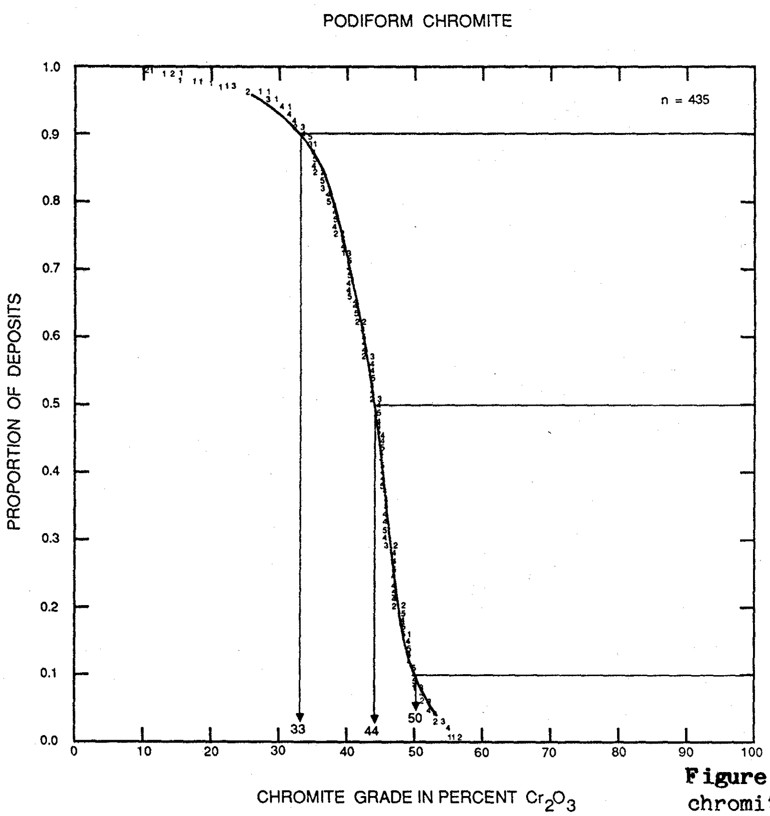


Figure 22. Chromite grades of podiform chromite deposits from California and Oregon, U.S.A. Individual digits represent number of deposits.

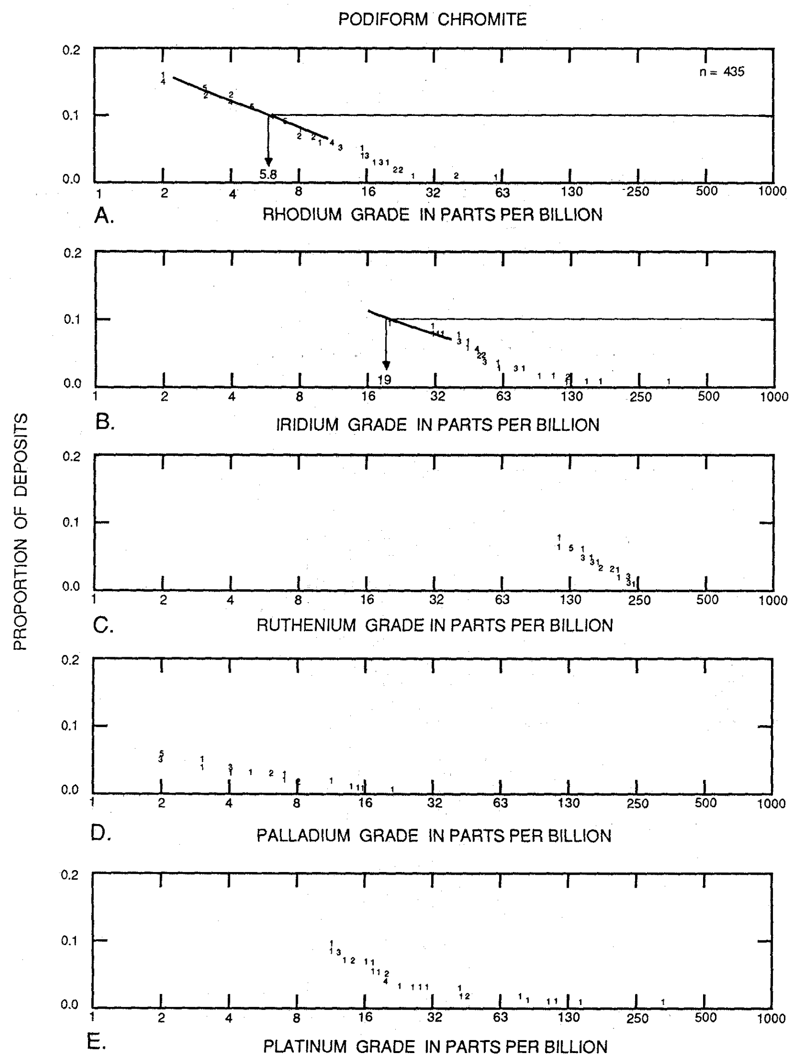


Figure 23. PGE grades of podiform chromite deposits from California and Oregon, U.S.A. A, Rhodium. B, Iridium. C, Ruthenium. D, Palladium. E, Platinum. Individual digits represent number of deposits.

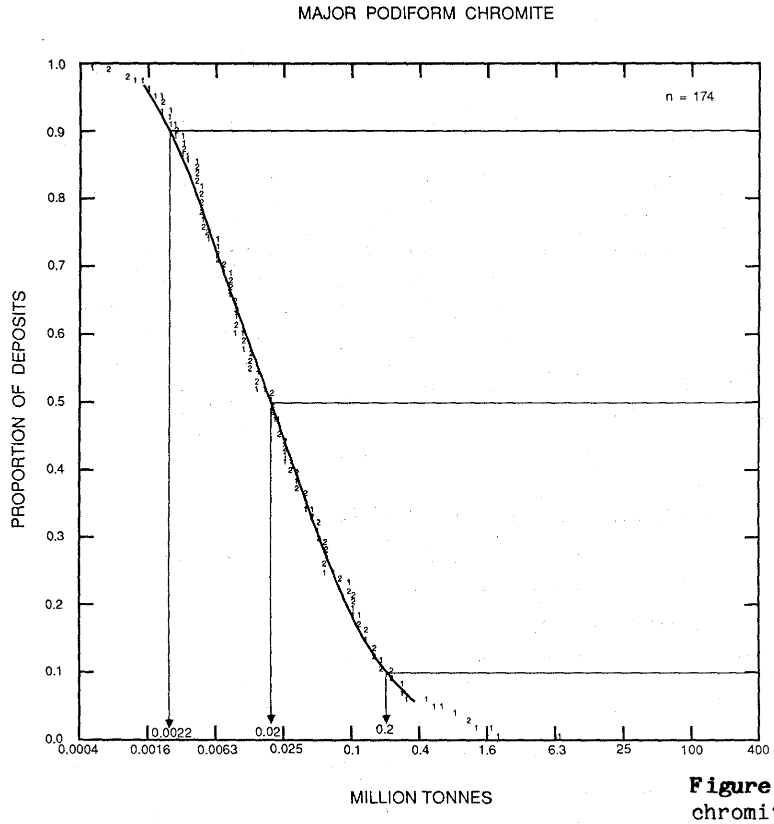


Figure 24. Tonnages of major podiform chromite deposits. Individual digits represent number of deposits.

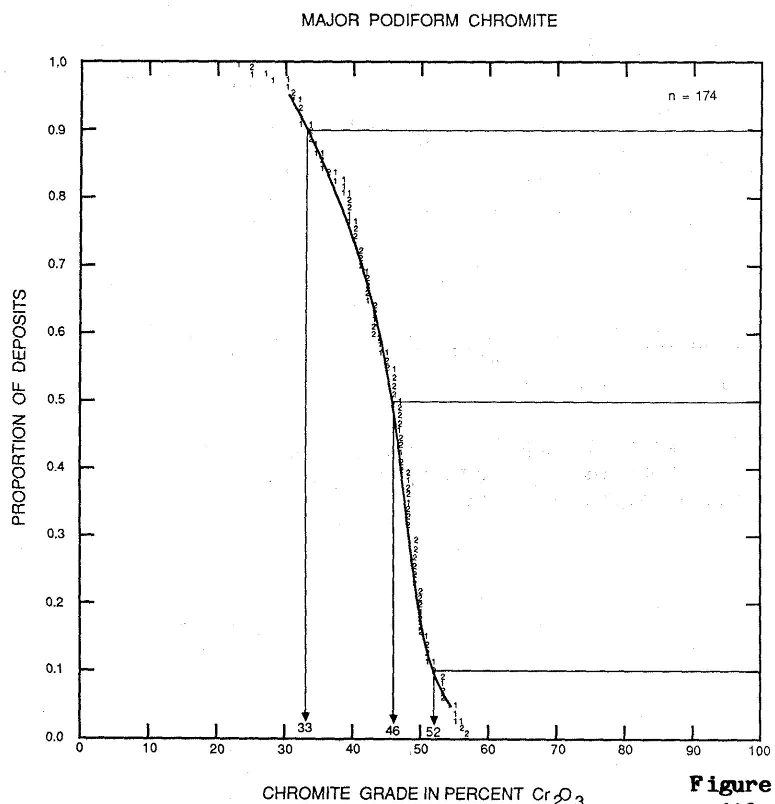


Figure 25. Chromite grades of major podiform chromite deposits. Individual digits represent number of deposits.

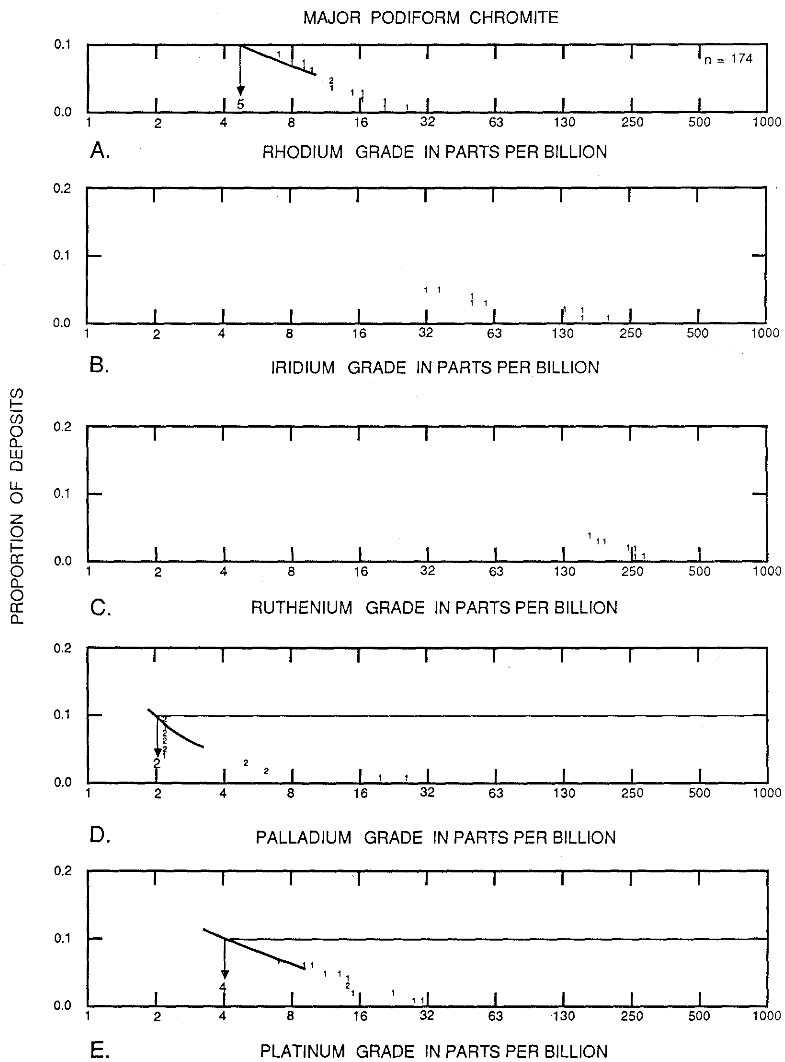


Figure 26. PGE grades of major podiform chromite deposits. _A_, Rhodium. _B_, Iridium. _C_, Ruthenium. _D_, Palladium. _E_, Platinum. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF PORPHYRY Cu

By Dennis P. Cox

DESCRIPTION This generalized model includes various subtypes all of which contain chalcopyrite in stockwork veinlets in hydrothermally altered porphry and adjacent country rock (see fig. 50).

GENERAL REFERENCE Titley (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite or syenitic porphyry intruding granitic, volcanic, calcareous sedimentary, and other rocks.

Textures Porphyry has closely spaced phenocrysts and microaplitic quartz-feldspar groundmass.

Age Range Mainly Mesozoic and Cenozoic, but may be any age.

Depositional Environment High-level intrusive rocks contemporaneous with abundant dikes, breccia fipes, faults. Also cupolas of batholiths.

Tectonic Setting(s) Rift zones contemporaneous with Andean or island-arc volcanism along convergent plate boundaries. Uplift and erosion to expose subvolcanic rocks.

Associated Deposit Types Base-metal skarn, epithermal veins, polymetallic replacement, volcanic hosted massive replacement. See also: Porphyry Cu-skarn related, porphyry Cu-Mo, and porphyry Cu-Au.

DEPOSIT DESCRIPTION

Mineralogy: Chalcopyrite + pyrite ± molybdenite; chalcopyrite + magnetite ± bornite ± Au; assemblages may be superposed. Quartz + K-feldspar + biotite ± anhydrite; quartz + sericite + clay minerals. Late veins of enargite, tetrahedrite, galena, sphalerite, and barite in some deposits.

Texture/Structure Stockwork veinlets and disseminated sulfide grains.

Alteration From bottom, innermost zones outward: sodic-calcic, potassic, phyllic, and argillic to propylitic. High-alumina alteration in upper part of some deposits. See table 3. Propylitic or phyllic alteration may overprint early potassic assemblage.

Ore Controls Stockwork veins in porphyry, along porphyry contact, and in favorable country rocks such as carbonate rocks, mafic igneous rocks, and older granitic plutons.

Weathering Green and blue Cu carbonates and silicates in weathered outcrops, or where leaching is intense, barren outcrops remain after Cu is leached, transported downward, and deposited as secondary sulfides at water table or paleowater table. Fractures in leached outcrops are coated with hematitic limonite having bright red streak. Deposits of secondary sulfides contain chalcocite and other Cu_2S minerals replacing pyrite and chalcopyrite. Residual soils overlying deposits may contain anomalous amounts of rutile.

Geochemical Signature: Cu + Mo ± Au + Ag + W + B + Sr center, Pb, Zn, Au, As, Sb, Se, Te, Mn, CO, Ba, and Rb outer. Locally Hi and Sn form most distal anomalies. High S in all zones. Some deposits have weak U anomalies.

EXAMPLES

Bingham, USUT	(Lanier and others, 1978)
San Manuel, USAZ	(Lowell and Guilbert, 1970)
El Salvador, CILE	(Gustafson and Hunt, 1975)

GRADE AND TONNAGE MODEL OF PORPHYRY Cu

By Donald A. Singer, Dan L. Mosier, and Dennis P. Cox

COMMENTS All porphyry copper deposits with available grades and tonnages were included in these order to provide a model for cases where it is not possible to use the gold-rich or molybdenum-rich models. Parts of the porphyry copper deposits which could be considered skarn were included in these data. Gold grade is correlated with tonnage (r = -0.49, n = 81) and with molybdenum grade (r = -0.45, n = 55). See figs. 51-53.

DEPOSITS

Name	Country	Name	Country
Afton	CNBC	Copper Cities	USAZ
Ajax	CNBC	Copper Creek	USAZ
Ajo	USAZ	Copper Flat	USNM
Am	CNBC	Copper Mountain	CNBC
Amacan	PLPN	Cordon	PLPN
Andacolla	CILE	Cuajone	PERU
Ann	CNBC	Cubuagan	PLPN
Ann Mason	USNV	Dexing	CINA
Arie	PPNG	Dizon	PLPN
Atlas Carmen	PLPN	Dorothy	CNBC
Atlas Frank	PLPN	Dos Pobres	USAZ
Atlas Lutopan	PLPN	Eagle	CNBC
Axe	CNBC	El Abra	CILE
Aya Aya	PLPN	El Arco	MXCO
Bagdad	USAZ	El Pachon	AGTN
Basay	PLPN	El Salvador	CILE
Bear	USNV	El Soldado	CILE
Bell Copper	CNBC	El Teniente	CILE
Berg	CNBC	Elatsite	BULG
Bethlehem	CNBC	Ely	USNV
Big Onion	CNBC	Escondida	CILE
Bingham	USUT	Esperanza	CILE
Bisbee	USAZ	Exotica	CILE
Bluebird	USAZ	Fish Lake	CNBC
Bond Creek	USAK	Florence	USAZ
Boneng Lobo	PLPN	Frieda River	PPNG
Bozshchaku	URRS	Galaxy	CNBC
Brenda	CNBC	Galore Creek	CNBC
Brenmac	USWA	Gambier Island	CNBC
Butilad	PLPN	Gaspe	CNQU
Butte	USMT	Gibraltar	CNBC
Campanamah	AGTN	Glacier Peak	USWA
Cananea	MXCO	Granisle	CNBC
Canariaco	PERU	Hale-Mayabo	PLPN
Cariboo Bell	CNBC	Heddleston	USMT
Carpenter	USAZ	Helvetia	USAZ
Cash	CNYT	Highmont	CNBC
Casino	CNYT	Hinobaan	PLPN
Castle Dome	USAZ	Huckleberry	CNBC
Catface	CNBC	Ingerbelle	CNBC
Catheart	USMN	Inguaran	MXCO
Cerro Blanco	CILE	Ino-Capaya	PLPN
Cerro Colorado	CILE	Inspiration	USAZ
Cerro Colorado	PANA	Iron Mask	CNBC
Cerro Verde	PERU	Island Copper	CNBC
Chaucha	ECDR	Ithaca Peak	USAZ
Chuquicamata	CILE	June	CNBC
Coalstoun	AUQL	Kadzharan	URAM
Copper Basin	USAZ	Kalamaton	PLPN

Kalamazoo-San Manuel	USAZ	Petaquilla	PANA
Kalmakyr	URUZ	Philippine	PLPN
Kennon	PLPN	Pima-Mission	USAZ
King-King	PLPN	Plurhinaler	THLD
Kirwin	USWY	Poison Mountain	CNBC
Kounrad	URKZ	Potrerillos	CILE
Krain	CNBC	Primer	CNBC
Kwanika	CNBC	Quebrada Blanca	CILE
La Alumbrera	AGTN	Quelleveco	PERU
La Caridad	MXCO	Ray	USAZ
La Florida	MXCO	Recsk	HUNG
La Verde	MXCO	Red Chris	CNBC
Lakeshore	USAZ	Red Mountain	USAZ
Lights Creek	USCA	Rio Blanco	CILE
Lornex	CNBC	Rio Vivi	PTRC
Lorraine	CNBC	Sacaton (E-W)	USAZ
Los Bronces	CILE	Safford (KCC)	USAZ
Los Pelambres	CILE	Saindak East	PKTN
Los Pilares	MXCO	Saindak North	PKTN
Lumbay	PLPN	Saindak South	PKTN
Luna-Bash	PLPN	Samar	PLPN
MacArthur	USNV	San Antonio	PLPN
Maggie	CNBC	San Fabian	PLPN
Majdanpek	YUGO	San Juan	USAZ
Mamut	MDGS	San Xavier	USAZ
Mantos Blancos	CILE	Sanchez	USAZ
Mapula	PLPN	Santa Rita	USNM
Marcopper	PLPN	Santo Nino	PLPN
Margaret	USWA	Santo Tomas	MXCO
Marian	PLPN	Santo Tomas	PLPN
Mazama	USWA	Sar Cheshmeh	IRAN
Metcalf	USAZ	Schaft Creek	CNBC
Michiquillay	PERU	Sierra Gorda	CILE
Middle Fork	USWA	Silver Bell	USAZ
Mineral Butte	USAZ	Sipalay	PLPN
Misty	CNBC	Star Mt.-Fubilan	PPNG
Mocha	CILE	Star Mt.-Futik	PPNG
Mocoa	CLBA	Star Mt.-Nong River	PPNG
Moniwa	BRMA	Star Mt.-Olgal	PPNG
Morenci	USAZ	Sugarloaf Hill	CNBC
Morococha	PERU	Tagpura	PLPN
Morrison	CNBC	Tanama	PTRC
Mountain Mines	PLPN	Tawi-Tawi	PLPN
Mount Canninda	AUQL	Taysan	PLPN
Namosi East	FIJI	Toledo	PLPN
Namosi West	FIJI	Toquepala	PERU
North Fork	USWA	Trojan	CNBC
Ok	CNBC	Twin Buttes	USAZ
Ok Tedi	PPNG	Tyrone	USNM
Orange Hill	USAK	Valley Copper	CNBC
Pampa Norte	CILE	Vekol	USAZ
Panguna	PPNG	Washington	MXCO
Paramillos	AGTN	Yandera	PPNG
Parks	AUNS	Yeoval	AUNS
Pashpap	PERU	Yerington	USNV

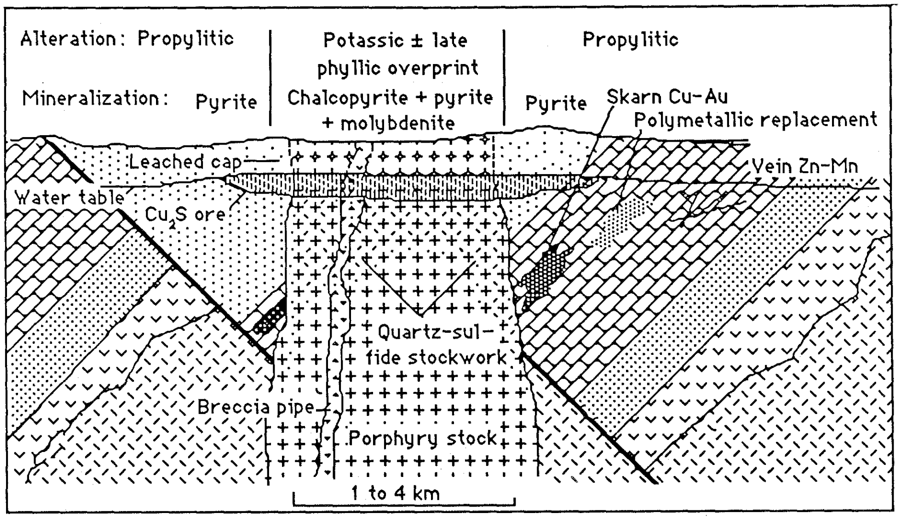


Figure 50. Cartoon cross section illustrating generalized model for porphyry Cu deposits showing relation of ore minerals, alteration zoning, supergene enrichment and associated skarn, replacement, and vein deposits.

Table 3. Types of hydrothermal alteration characteristic of porphyry copper and other deposit models

Type of alteration and synonyms	Original mineral	replaced by	Appearance
Potassic alteration (K-silicate)	plagioclase------- hornblende--------	K-feldspar fine-grained biotite + rutile + pyrite or magnetite. Anhydrite	Rocks look fresh but may have pinkish K-feldspar veinlets and black biotite veinlets and clusters of fine biotite after mafic phenocrysts.
Sodic-calcic alteration (albitic)	K-feldspar-------- biotite-----------	oligoclase or albite actinolite + sphene	Rocks are hard and dull white. Biotite is absent. Veinlets of actinolite, epidote, and hematite have hard, white alteration haloes.
Phyllic alteration (quartz-sericite)	plagioclase------- hornblende and biotite-----------	sericite sericite + chlorite + rutile + pyrite	Rocks are soft and dull to lustrous white. Pyrite veinlets have distinct, soft translucent gray, sericite haloes. Tourmaline rosettes may be present.
Propylitic alteration	plagioclase------- hornblende and biotite-------	albite or oligoclase + epidote or calcite chlorite + rutile + magnetite or pyrite	Rocks are hard and dull greenish gray. Veinlets of pyrite or chlorite and epidote lack prominent alteration haloes.
Argillic alteration	plagioclase------- mafic minerals----	clay + sericite clay + sericite + chlorite + pyrite	Rocks are soft and white. Tongue will stick to clay-altered minerals.
High alumina (alsic, advanced argillic)	All original and earlier hydrothermal minerals converted to pyrophyllite, alunite, andalusite, corundum, and diaspore with variable amounts of clay and sericite.		Rocks are light colored and moderately soft.

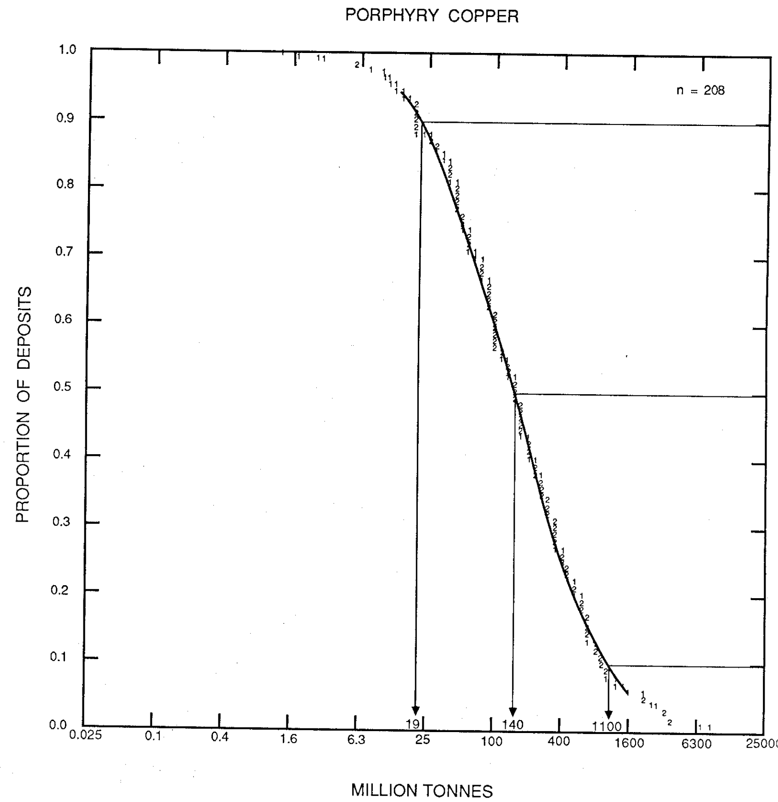


Figure 51. Tonnages of porphyry Cu deposits. Individual digits represent number of deposits.

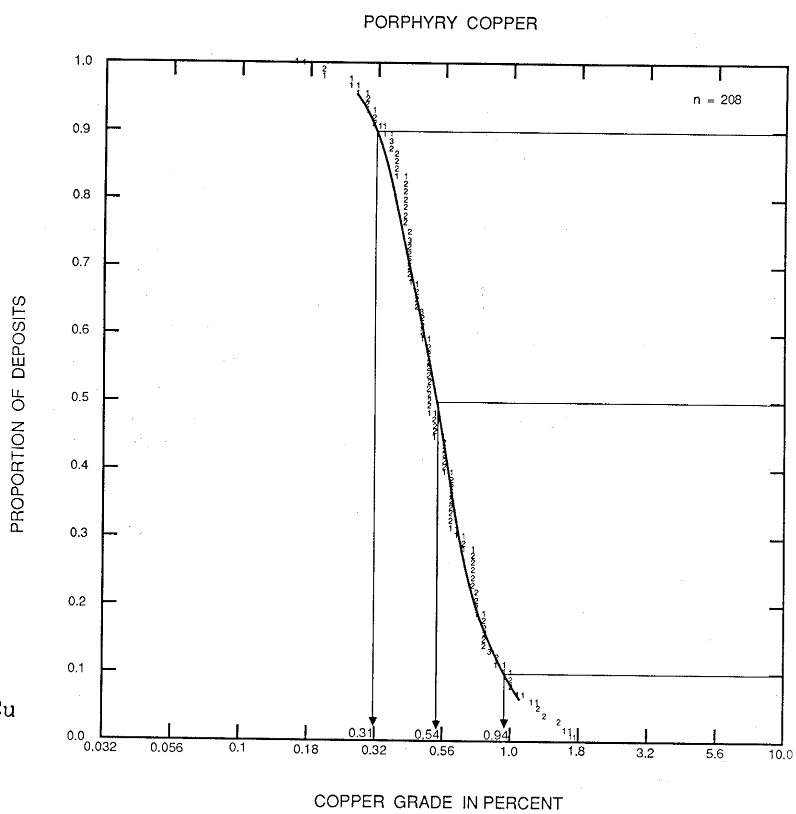


Figure 52. Copper grades of porphyry Cu deposits. Individual digits represent number of deposits.

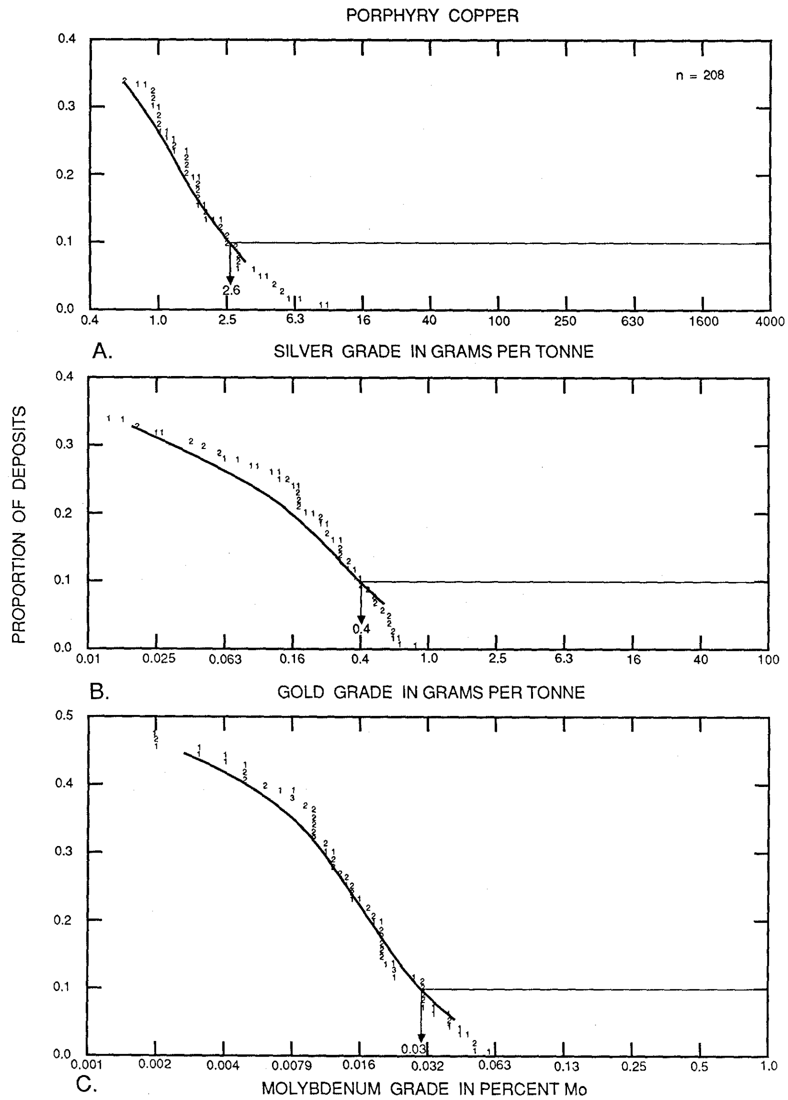


Figure 53. By-product grades of porphyry Cu deposits. _A_, Silver. _B_, Gold. _C_, Molybdenum. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF Cu SKARN DEPOSITS

By Dennis P. Cox and Ted G. Theodore

DESCRIPTION Chalcopyrite in talc-silicate contact metasomatic rocks (see fig. 57).

GENERAL REFERENCES Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite intruding carbonate rocks or calcareous elastic rocks.

Textures Granitic texture, porphyry, granoblastic to hornfelsic in sedimentary rocks.

Age Range Mainly Mesozoic, but may be any age.

Depositional Environment Miogeosynclinal sequences intruded by felsic plutons.

Tectonic Setting(s) Continental margin late erogenic magmatism.

Associated Deposit Types Porphyry Cu, zinc skarn, polymetallic replacement, Fe skarn.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite + pyrite ± hematite ± magnetite ± bornite ± pyrhotite. Also molybdenite, bismuthinite, sphalerite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite, and tetrahedrite may be present. Au and Ag may be important products.

Texture/Structure Coarse granoblastic with interstitial sulfides. Bladed pyroxenes are common.

Alteration Diopside + andradite center; wollastonite + tremolite outer zone; marble peripheral zone. Igneous rocks may be altered to epidote + pyroxene + garnet (endoskarn). Retrograde alteration to actinolite, chlorite, and clays may be present.

Ore Controls Irregular or tabular ore bodies in carbonate rocks and calcareous rocks near igneous contacts or in xenoliths in igneous stocks. Breccia pipe, cutting skarn at Victoria, is host for ore. Associated igneous rocks are commonly barren.

Weathering Cu carbonates, silicates, Fe-rich gossan. Calc-silicate minerals in stream pebbles are a good guide to covered deposits.

Geochemical Signature Rock analyses may show Cu-Au-Ag-rich inner zones grading outward to Au-Ag zones with high Au:Ag ratio and outer Pb-Zn-Ag zone. Co-As-Sb-Bi may form anomalies in some skarn deposits. Magnetic anomalies.

EXAMPLES

Mason Valley, USNV	(Harris and Einaudi, 1982)
Victoria, USNV	(Atkinson and others, 1982)
Copper Canyon, USNV	(Blake and others, 1979)
Carr Fork, USUT	(Atkinson and Einaudi, 1978)

GRADE AND TONNAGE MODEL OF Cu SKARN DEPOSITS

By Gail M. Jones and W. David Menzie

COMMENTS Data used in this model were restricted to copper skarns associated with barren stocks as recommended by Einaudi and others (1981). Some of the data are from districts. See figs. 58-60

DEPOSITS

Name	Country	Name	Country
Agordo-Brosso	ITLY	Loei-Chiengkarn	THLD
Arctic Chief	CNYT	Ludwig	USNV
B. C.	CNBC	Mackey	USID
Benson Lake	CNBC	Malko Trnova	BULG
Best Chance	CNYT	Marble Bay	CNBC
Black Cub	CNYT	Mason Valley-Malachite	USNV
Blue Grouse	CNBC	McConnell	USNV
Bluestone	USNV	Meme	HATI
Caledonia	CNBC	Mina El Sapo	CLBA
Cassius	HATI	Mina Vieja	CLBA
Casting	USNV	Mother Lode-Sunset	CNBC
Cerro de Cobre	CLBA	Obira	JAPN
Chalcobamba	PERU	Oregon	CNBC
Coast Copper	CNBC	Oro Denoro (Ema)	CNBC
Cobriza	PERU	Phoenix	CNBC
Concepcion Del Oro	MXCO	Queen Victoria (Swift)	CNBC
Copper Queen	CNBC	Rosita	NCRG
Cornell	CNBC	San Pedro	USNM
Cowley Creek	CNYT	Sasca Montana	RMNA
Douglas Hill	USNV	Sasagatani	JAPN
Gem	CNYT	Snowshoe	USNM
Hiragane	JAPN	Strandzha	BULG
Hope	CNBC	Tasu-Wesfrob	CNBC
Iide	JAPN	Tintaya	PERU
Indian Chief	CNBC	Traversella	ITLY
Kamaishi	JAPN	Tsumo	JAPN
Kedbeg Copper	URRS	Vananda	CNBC
Keewenaw	CNYT	War Eagle	CNYT
Kodiak Cub	CNYT	Western Nevada	USNV
Lily (Ikeno)	CNBC	Wexford	CNBC
Little Chief	CNYT	Yreka	CNBC
Lucky Four	CNBC	Zip	CNBC

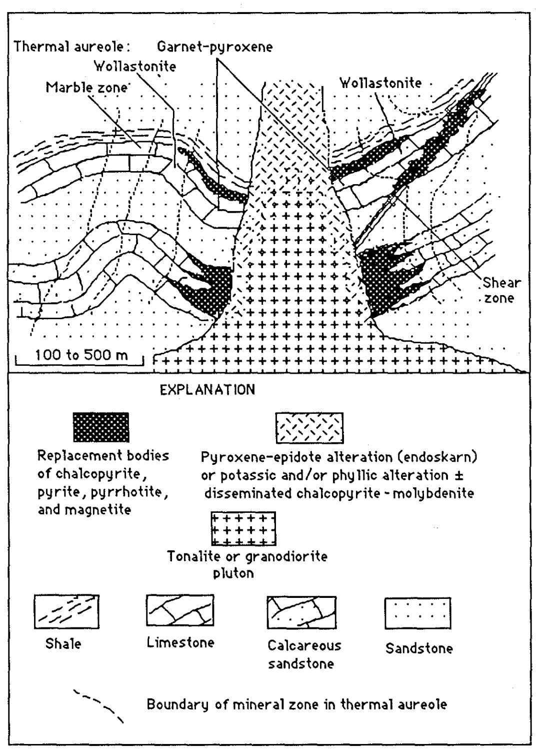


Figure 57. Cartoon cross section of Cu skarn deposit showing relationship between contact metamorphic zones, ore bodies, and igneous intrusion.

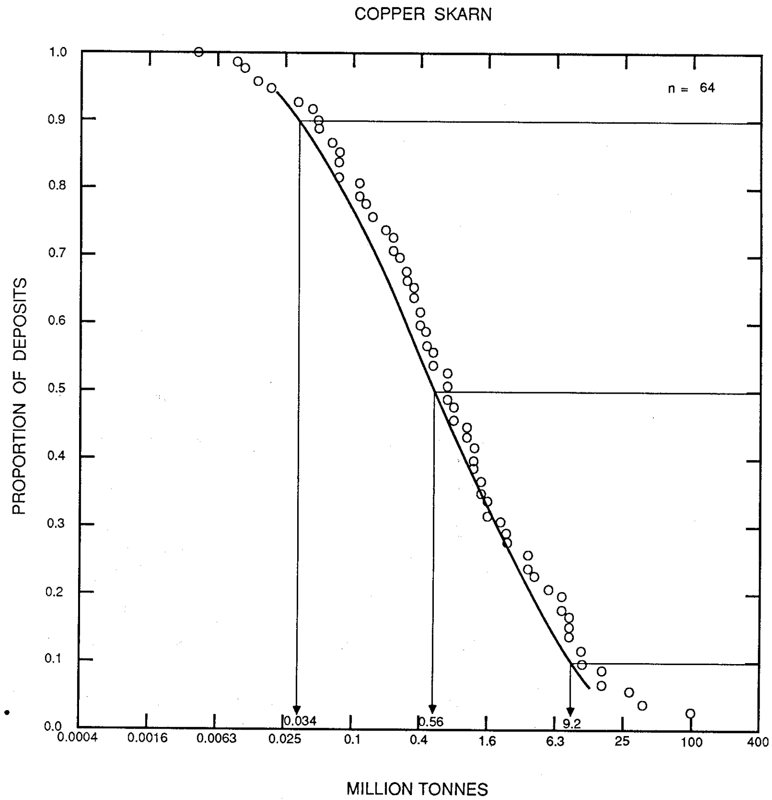


Figure 58. Tonnages of Cu skarn deposits.

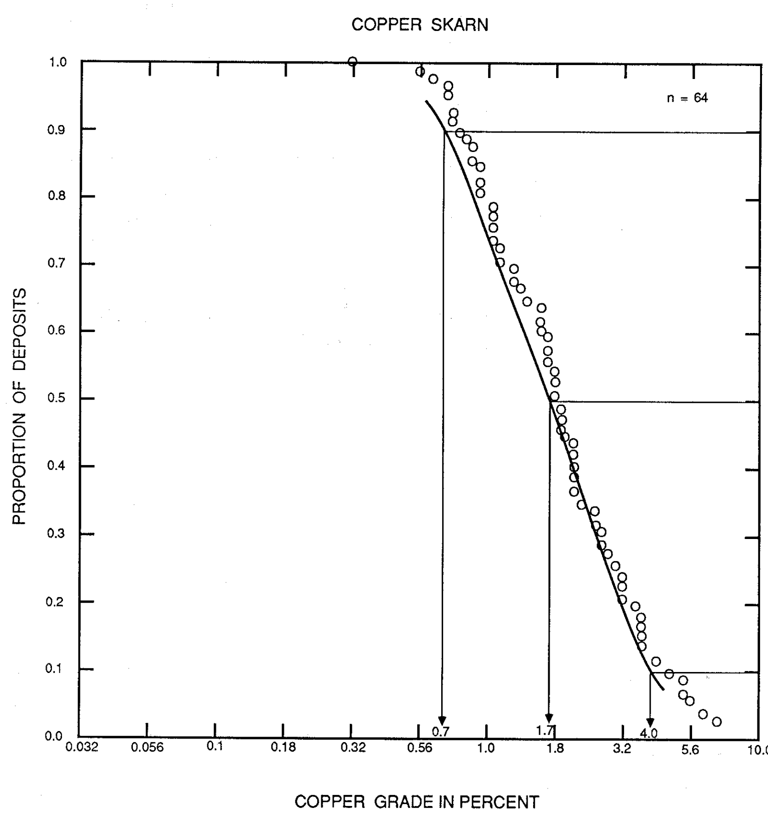


Figure 59. Copper grades of Cu skarn deposits.

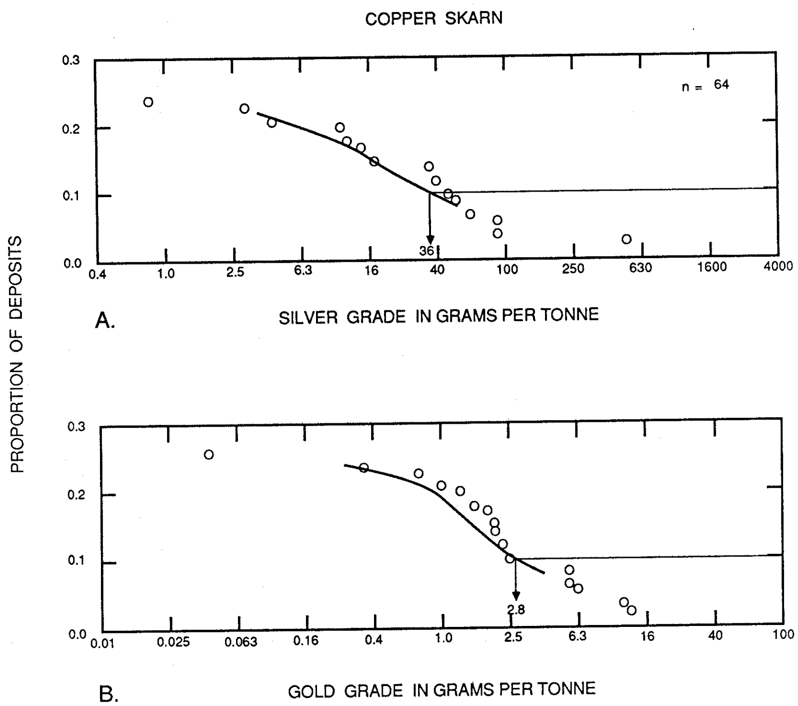


Figure 60. Precious-metal grades of Cu skarn deposits. A, Silver. B, Gold.

DESCRIPTIVE MODEL OF Fe SKARN DEPOSITS

By Dennis P. Cox

DESCRIPTION Magnetite in talc-silicate contact metasomatic rocks.

GENERAL REFERENCES Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Gabbro, diorite, diabase, syenite, tonalite, granodiorite, granite, and coeval volcanic rocks. Limestone and calcareous sedimentary rocks.

Textures Granitic texture in intrusive rocks; granoblastic to hornfelsic textures in sedimentary rocks.

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

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

Tectonic Setting(s) Miogeosynclinal sequences intruded by felsic to mafic plutons. Oceanic island arc, Andean volcanic arc, and rifted continental margin.

DEPOSIT DESCRIPTION

Mineralogy Magnetite ± chalcopyrite ± Co-pyrite ± pyrite ± pyrhotite. Rarely cassiterite in Fe skarns in Sri-granite terranes.

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. Fe skarn ores can also form in gabbroic host rocks near felsic plutons.

Weathering Magnetite generally crops out or forms abundant float.

Geochemical and Geophysical Signature Fe, Cu, Co, Au, possibly Sn. Strong magnetic anomaly.

EXAMPLES

Shinyama, JAPN	(Uchida and Iiyama, 1982)
Cornwall, USPA	(Lapham, 1968)
Iron Springs, USUT	(Mackin, 1968)

GRADE AND TONNAGE MODEL OF Fe SKARN DEPOSITS

By Dan L. Mosier and W. David Menzie

COMMENTS Some of the data represent districts. See figs. 66-67.

DEPOSITS

Name	Country	Name	Country
Adaevka central	URRS	Alagada	PORT
Adaevka north	URRS	Aleshinka	URRS
Adaevka south	URRS	Argonaut	CNBC
Agalteca	HNDR	Asvan	TRKY
Ain Mokra	ALGR	Auerbach	URUR
Ain Oudrer	ALGR	Ayazmant	TRKY
Akatani	JAPN	Baghain	IRAN

Baisoara	RMNA
Beck	USCA
Beni Douala	ALGR
Benkala	URRS
Bessemer	CNON
Bizmisen-Akusagi	TRKY
Blairton	CNON
Bolsherechensk	URRS
Bulacan	PLPN
Brynor	CNBC
Calabogie	CNON
Camiglia	ITLY
Capacmarca	PERU
Capitan	USNM
Carmen	CILE
Cave Canyon	USCA
Cehegin	SPAN
Chichibu	JAPN
Childs Mine	CNON
Colquemarca	PERU
Copper Flat	USNM
Cuchillo-Negro	USNM
Daiquiri	CUBA
Ilammer Nissar	PKTN
Dannemora	SWDN
Dayton	USNV
Divrigi	TRKY
Dungun	MDGS
Dzama	URRS
Eagle Mountain	USCA
El Pedroso	SPAN
El Sol y La Luna	MXCO
El Volcan-Piedra Iman	MXCO
Eltay	URRS
Estyunin	URRS
Fierro-Hannover	USNM
Gallinas	USNM
Giresun	TRKY
Gora Magnitnaya	URRS
Gora Vysokaya	URRS
Hatillo	DMRP
Hierro Indio	AGTN
Huacravilca	PERU
Hualpai	CNBC
Huancabamba	PERU
Hull	CNQU
Imanccasa	PERU
Ino	JAPN
Iron Duke	CNBC
Iron Hat	USCA
Iron Mike	CNBC
Iron Mountain (Colfax Co.)	USNM
Iron Mountain (Sierra Co.)	USNM
Iron Springs	USUT
Jedway	CNBC
Jerez de 1os Caballeros	SPAN
Jib	CNBC
Jicarilla	USNM
Jones Camp	USNM
Juncos	CNBC
Kachar	URRS
Kalkan	TRKY
Kambaikhin central	URRS
Kambaikhin east	URRS
Kambaikhin north	URRS
Karamadazi	TRKY
Kaunisvaara-Masugnsbyn	SWDN
Kesikkopru	TRKY
Kozyrevka	URRS
Kroumovo	URRS
Kruglogorsk	URRS
Kurzhunkul	URRS
La Carmen	MXCO
La Laguna	DMRP
La Paloma	MXCO
La Piedra Iman	MXCO
Las Animas Cerro Prieto	MXCO
Las Truchas	MXCO
Larap-Calambayungan	PLPN
Lava Bed	USCA
Lebyazhka	URRS
Livitaca-Velille	PERU
Lomonosov	URRS
Maanshan	HONG
Mac	CN13C
Marbella	SPAN
Marmoraton	CNON
Martinovo	BULG
Maslovo	URRS
Mati	PLPN
Mogpog	PLPN
Monte Carmelo	NCRG
Munesada	JAPN
Nimpkish	CNBC
Novo Maslovo	URRS
Novo Peschansk	URRS
Ocna de Fier	RMNA
Old Dad Mountains	USCA
Orogrande	USNM
Osokino-Aleksandrovsk	URRS
Pambuhan Sur	PLPN
Pampachiri	PERU
Paracale	PLPN
Pena Colorada	MXCO
Perda Niedda	ITLY
Persberg	SWDN
Peschansk	URRS
Picila	MXCO
Piddig	PLPN
Plagia	GREC
Pokrovsk	URRS
Rankin	CNON
Recibimiento	MXCO
Rondoni	PERU
Rose	CNBC
Rudna Glava	YUGO
Sabana Grande	DMRP
Samli	TRKY
San Carlos	MXCO
San Juan de Chacna	PERU
San Leone	ITLY
Sankyo	JAPN
Santa Lucia	PERU
Santa Rita	USNM
Sarbay	URRS
Senor de Huarquisa	PERU

Model 18d--Con.

Severnoe I	URRS	Tepustete	MXCO
Severnoe II	URRS	Texada	CNBC
Severnoe III	URRS	Tovarnica	YUGO
Shagyrkul	URRS	Tsaitsukou	CINA
Shasta-California	USCA	Val Di Peio	ITLY
Shinyama	JAPN	Valuev	URRS
Silver Lakes	USCA	Vorontsovka	URRS
Sorka	URRS	Vulcan	USCA
Sosva	URRS	Vyhne	CZCL
South Sarbay	URRS	Wagasennin	JAPN
Takanokura	JAPN	Yellow Jacket	USNM
Tapairihua	PERU	Zanitza	MXCO
Techa	URRS	Zarikan	IRAN
Tecolote	USNM	Zeballos	CNBC

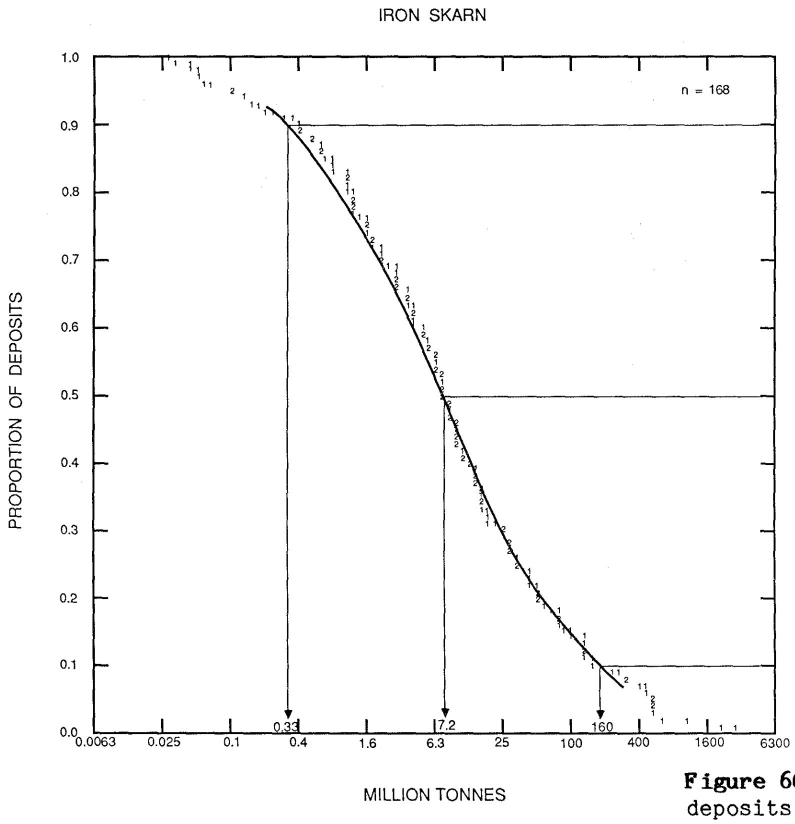


Figure 66. Tonnages of Fe skarn deposits. Individual digits represent number of deposits.

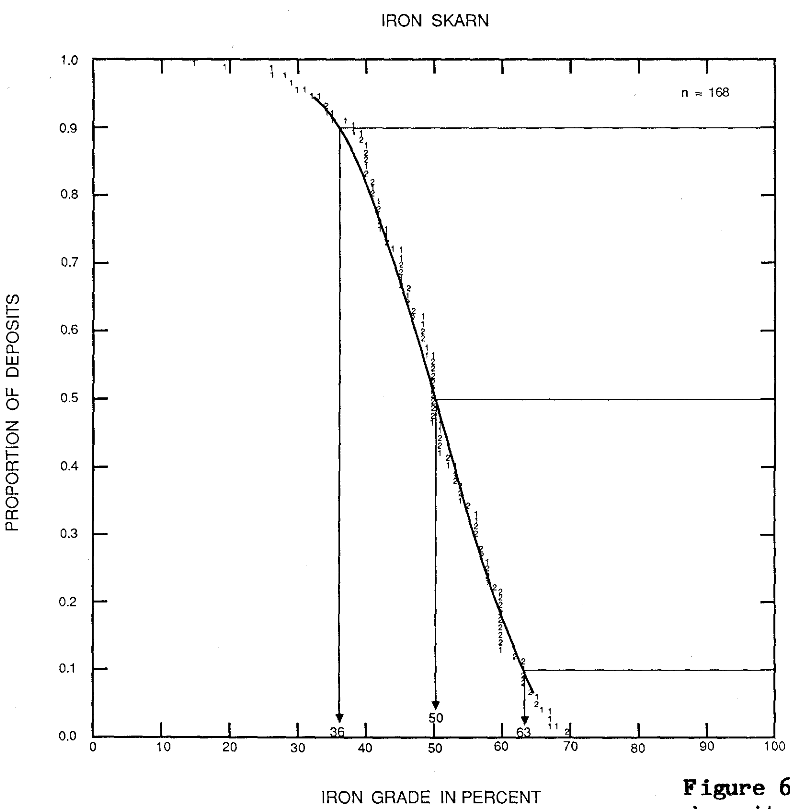


Figure 67. Iron grades of Fe skarn deposits. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF PORPHYRY Cu-Au

By Dennis P. Cox

DESCRIPTION Stockwork veinlets of chalcopyrite, bornite, and magnetite in porphyritic intrusions and coeval volcanic rocks. Ratio of Au (ppm) to Mo (percent) is greater than 30 (see fig. 77).

GENERAL REFERENCES Sillitoe (1979), Cox and Singer (in press).

GEOLOGICAL ENVIRONMENT

Rock Types Tonalite to monzogranite; dacite, andesite flows and tuffs coeval with intrusive rocks. Also syenite, monzonite, and coeval high-K, low-Ti volcanic rocks (shoshonites).

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

Age Range Cretaceus to Quaternary.

Depositional Environment In porphyry intruding coeval volcanic rocks. Both involved and in large-scale breccia. Porphyry bodies may be dikes. Evidence for volcanic center; 1-2 km depth Of emplacement.

Tectonic Setting(s) Island-arc volcanic setting, especially waning stage of volcanic cycle. Also continental margin rift-related volcanism.

Associated Deposit Types Porphyry Cu-Mo; gold placers.

DEPOSIT DESCRIPTION

Mineralogy Chalcopyrite ± bornite; traces of native gold, electrum, sylvanite, and hessite. Quartz + K-feldspar + biotite + magnetite ± chlorite ± actinolite ± anhydrite. Pyrite + sericite ± clay minerals ± calcite may occur in late-stage veinlets.

Texture/Structure Veinlets and disseminations.

Alteration Quartz ± magnetite ± biotite (chlorite) ± K-feldspar ± actinolite, ± anhydrite in interior of system. Outer propylitic zone. Late quartz + pyrite + white mica ± clay may overprint early feldspar-stable alteration.

Ore Controls Veinlets and fractures of quartz, sulfides, K-feldspar magnetite, biotite, or chlorite are closely spaced. Ore zone has a bell shape centered on the volcanic-intrusive center. Highest grade ore is commonly at the level at which the stock divides into branches.

Weathering Surface iron staining may be weak or absent if pyrite content is low in protore. Copper silicates and carbonates. Residual soils contain anomalous amounts of rutile.

Geochemical Signature Central Cu, Au, Ag; peripheral Mo. Peripheral Pb, Zn, Mn anomalies may be present if late sericite pyrite alteration is strong. Au (ppm):Mo (percent) 30 in ore zone. Au enriched in residual soil over ore body. System may have magnetic high over intrusion surrounded by magnetic low over pyrite halo.

EXAMPLES

Dos Pobres, USAZ	(Langton and Williams, 1982)
Copper Mountain, CNBC	(Fahrni and others, 1976)
Tanama, PTRC	(COX, 1985)

GRADE AND TONNAGE MODEL OF PORPHYRY CU-AU

By Donald A. Singer and Dennis P. Cox

COMMENTS See figs. 78-81.

DEPOSITS

Name	Country	Name	Country
Afton	CNBC	Mamut	MDGS
Amacan	PLPN	Mapula	PLPN
Atlas Lutopan	PLPN	Marcopper	PLPN
Basay	PLPN	Marian	PLPN
Bell Copper	CNBC	Mountain Mines	PLPN
Boneng Lobo	PLPN	Ok Tedi	PPNG
Cariboo Bell	CNBC	Panguana	PPNG
Copper Mountain	CNBC	Red Chris	CNBC
Cubuagan	PLPN	Rio Vivi	PTRC
Dizon	PLPN	Saindak South	PKTN
Dos Pobres	USAZ	San Antonio	PLPN
Fish Lake	CNBC	San Fabian	PLPN
Frieda River	PPNG	Santo Nino	PLPN
Galore Creek	CNBC	Santo Tomas	PLPN
Hinobaan	PLPN	Star Mt.-Fubilan	PPNG
Ingerbelle	CNBC	Star Mt.-Futik	PPNG
Kennon	PLPN	Tanama	PTRC
La Alumbrera	AGTN	Tawi-Tawi	PLPN
Lorraine	CNBC	Taysan	PLPN
Lumbay	PLPN	Toledo	PLPN

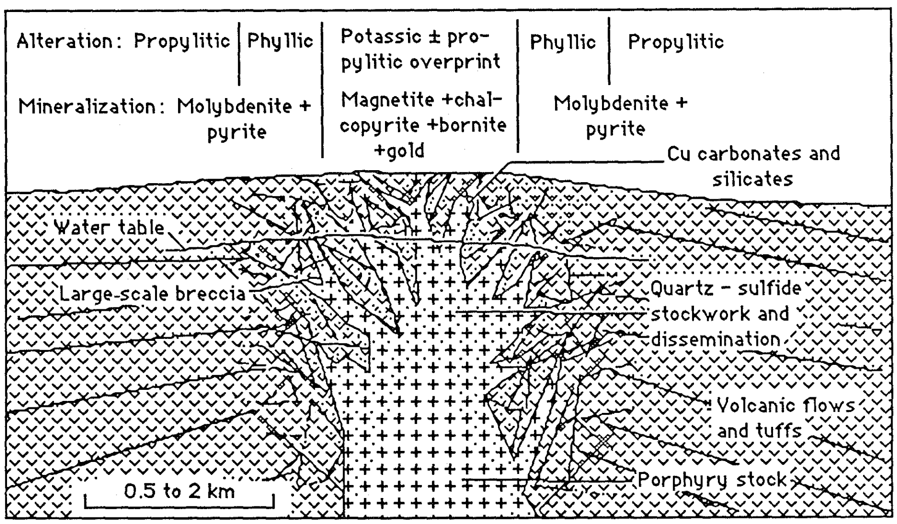


Figure 77. Cartoon cross section of porphyry Cu-Au deposit. Modified from Langton and Williams (1982).

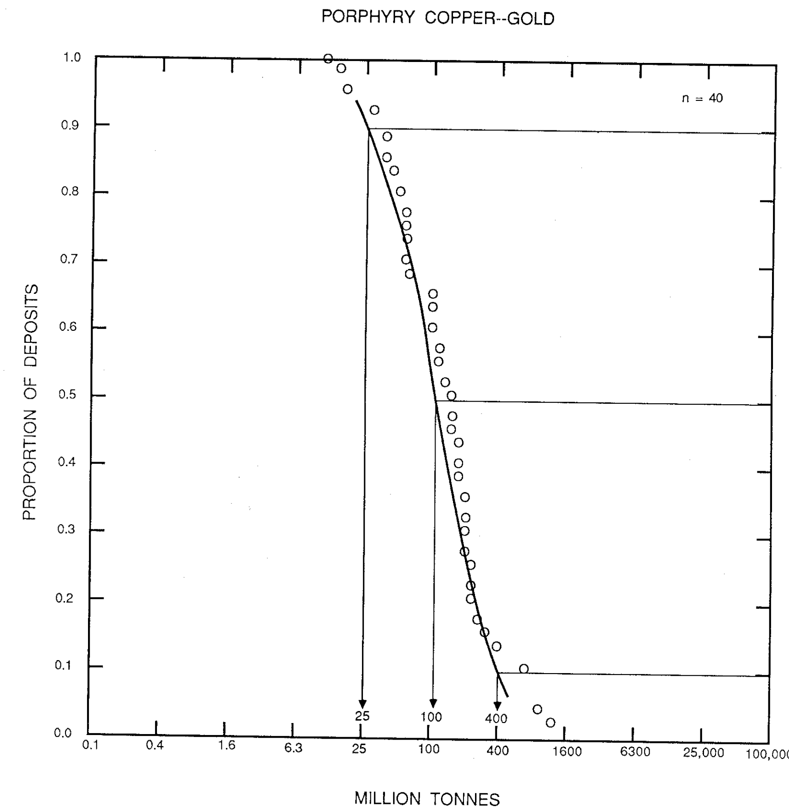


Figure 78. Tonnages of porphyry Cu-Au deposits.

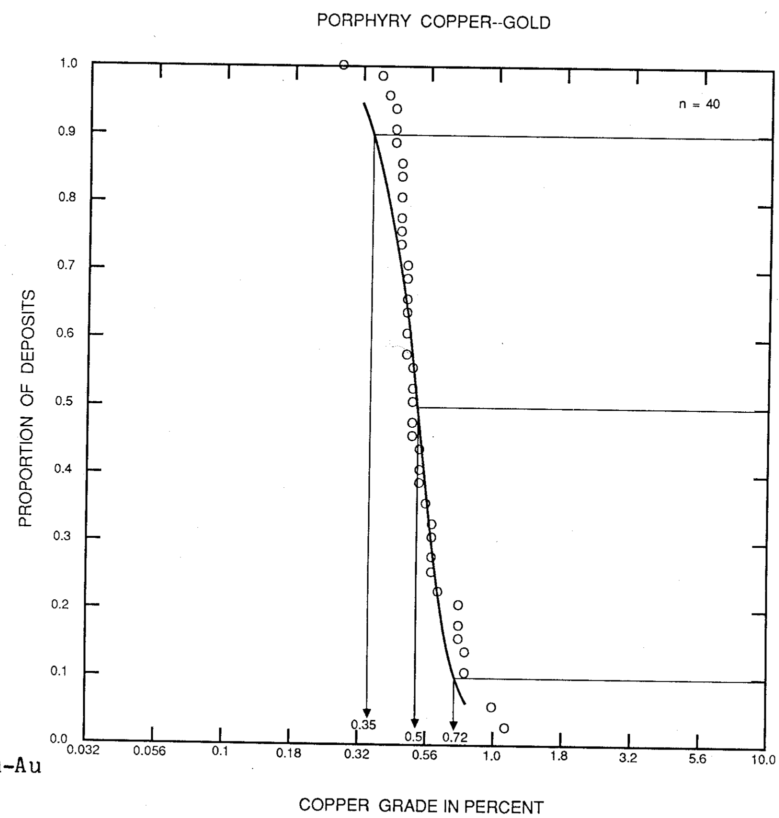


Figure 79. Copper grades of porphyry Cu-Au deposits.

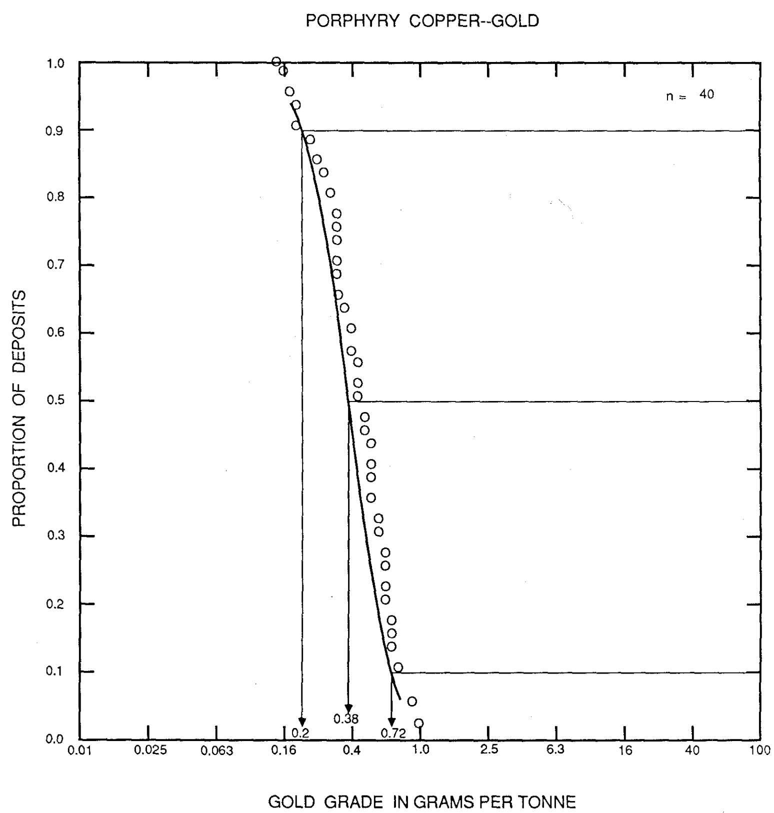


Figure 80. Gold grades of porphyry Cu-Au deposits.

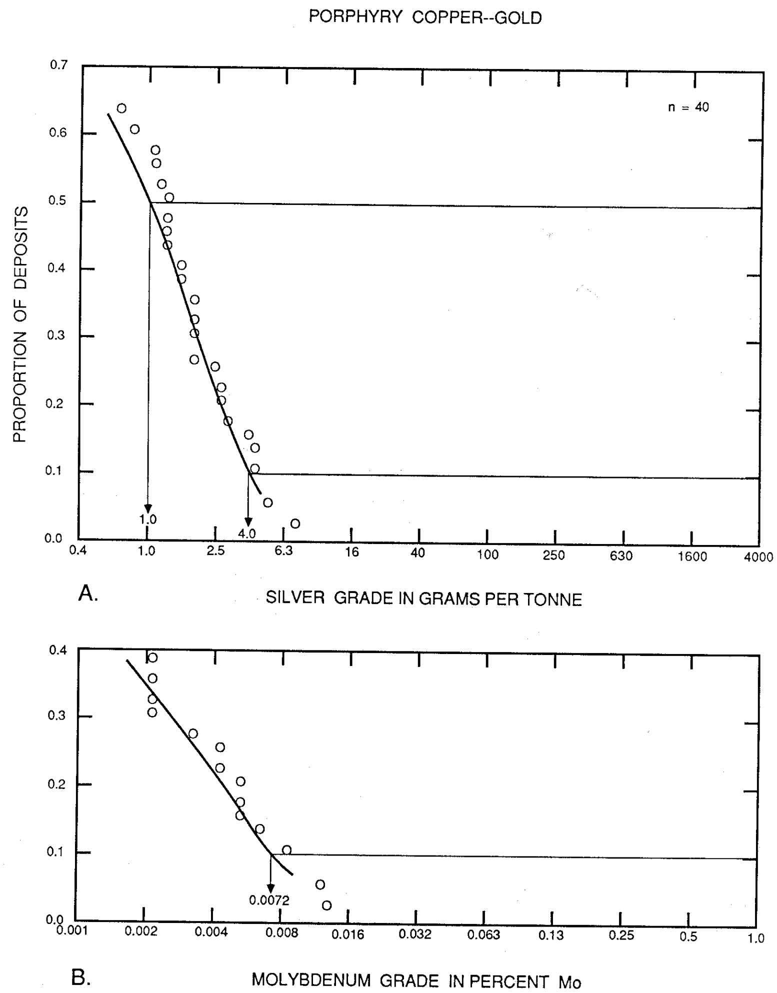


Figure 81. By-product grades of porphyry Cu-Au deposits. A, Silver. B, Molybdenum.

DESCRIPTIVE MODEL OF POLYMETALLIC VEINS

By Dennis P. Cox

APPROXIMATE SYNONYM Felsic intrusion-associated Ag-Pb-Zn veins (Sangster, 1984).

DESCRIPTION Quartz-carbonate veins with Au and Ag associated with base metal sulfides related to hypabyssal intrusions in sedimentary and metamorphic terranes.

GEOLOGICAL ENVIRONMENT

Rock Types Calcalkaline to alkaline, diorite to granodiorite, monzonite to monzogranite in small intrusions and dike swarms in sedimentary and metamorphic rocks. Subvolcanic intrusions, necks, dikes, plugs of andesite to rhyolite composition.

Textures Fine- to medium-grained equigranular, and porphyroaphanitic.

Age Range Most are Mesozoic and Cenozoic, but may be any age.

Depositional Environment Near-surface fractures and breccias within thermal aureol of clusters of small intrusions. In some cases peripheral to porphyry systems.

Tectonic Setting(s) Continental margin and island arc volcanic-plutonic belts. Especially zones of local domal uplift.

Associated Deposit Types Porphyry Cu-Mo, porphyry Mo low-F, polymetallic replacement. Placer Au.

DEPOSIT DESCRIPTION

Mineralogy Native Au and electrum with pyrite + sphalerite ± chalcopyrite ± galena ± arsenopyrite ± tetrahedrite-tennantite ± Ag sulfosalts ± argentite ± hematite in veins of quartz + chlorite + calcite ± dolomite ± ankerite ± siderite ± rhodochrosite ± barite ± fluorite ± chalcedony ± adularia.

Texture/Structure Complex, multiphase veins with comb structure, crustification, and colloform textures. Textures may vary from vuggy to compact within mineralized system.

Alteration Generally wide propylitic zones and narrow sericitic and argillic zones. Silicification of carbonate rocks to form jasperoid.

Ore Controls Areas of high permeability: intrusive contacts, fault intersections, and breccia veins and pipes. Replacement ore bodies may form where structures intersect carbonate rocks.

Weathering Minor gossans and Mn-oxide stains. Zn and Pb carbonates and Pb sulfate. Abundant quartz chips in soil. Placer gold concentrations in soils and stream sediments. Supergene enrichment produces high-grade native and horn silver ores in veins where calcite is not abundant.

Geochemical Signature Zn, Cu, Pb, As, Au, Ag, Mn, Ba. Anomalies zoned from Cu-Au outward to Zn-Pb-Ag to Mn at periphery.

EXAMPLES

St. Anthony (Mammoth), USAZ	(Creasey, 1950)
Wallapai District, USAZ	(Thomas, 7949)
Marysville District, USMT	(Knopf, 1913)
Misima I., PPNG	(Williamson and Rogerson, 1983)
Slocan District, CNBC	(Cairnes, 1934)

GRADE AND TONNAGE MODEL OF POLYMETALLIC VEINS

By James D. Bliss and Dennis P. Cox

COMMENTS The data used to generate grade and tonnage models for polymetallic veins reflect considerable complexity in the geology and economic conditions under which deposits are produced or evaluated; This model represents a first attempt to resolve these complexities. Four important factors may affect the adequacy of this model.

1. Zinc grades are subject to considerable uncertainty because smelters have in the past penalized producers for ore containing zinc which in turn caused mine operators to avoid zinc-bearing ore in their mining and milling. Zinc grades are likely underestimated. Irregular behavior in the zinc-grade model may be due to these factors.

2. Polymetallic veins of two types appear to exist--a base-metal polymetallic vein worked primarily for a base metal or metals and silver and a gold-silver polymetallic vein with copper, lead, and zinc production likely in less than half the deposits. Grade and tonnage models are presented for the base-metal polymetallic veins. Grade and tonnge models are not presented for the gold-silver polymetallic veins because preliminary data are inadequate. In our data, districts in which both types occur generally have six times as many base-metal polymetallic veins as gold-silver polymetallic veins.

3. The Slocan Mining District, British Columbia, Canada, contributed nearly 60 percent of the deposit data for the base-metal polymetallic veins, and this may bias the models in ways not identified.

4. Deposits are defined as all workings within 1 km of each other and having a minimum of 100 tonnes of ore. A few deposits are for districts with workings of unknown spacing. See figs. 90-94.

Name	Country	Name	Countrv
Albert Lea Group	USAZ	Mammoth-St. Anthony	USAZ
Altoona-Elkhor-Mercury	CNBC	Marietta	USMT
Amazon	USMT	Mineral Park	USAZ
Antoine	CNBC	Minniehaha	CNBC
Arlington	CNBC	Molly Gibson	CNBC
Badger	USAZ	Monitor	CNBC
Baltic and Revenue	USCO	Montezuma	CNBC
Baltimore	USMT	Mountain Chief and vicinity	CNBC
Bell	CNBC	Mountain Con	CNBC
Bell and California	USCO	Noonday	CNBC
Bell Boy-Niles-Towsley	USMT	North Cerbat (Golconda)	USAZ
Big Four	USMT	Northern Bell-Jackson	CNBC
Bosum	CNBC	Payne Group	CNBC
Bullion	USCO	Pennsylvania	USCO
C.O.D.	USAZ	Queen Bess and vicinity	CNBC
California-Hartney-Marion	CNBC	Rambler-Cariboo	CNBC
Carnation-Jennie Lind	CNBC	Rio	CNBC
Central Cerbat District	USAZ	Robert Emmet	USMT
Champion-New London	USAZ	Santiago-Commonwealth-Centennial	USCO
Chlorite District	USAZ	Scraton-Pontiac-Sunset	CNBC
Comstock	CNBC	Silversmith-Richmond-Ruth-Hope	CNBC
Cork-Province	CNBC	Slocan-Sovereign	CNBC
Dardanelles	CNBC	Soho	CNBC
Defiance	USAZ	Standard and vicinity	CNBC
Eva May	USMT	Stockton	USAZ
Fisher Maiden Group	CNBC	Sunshine-Corinth	CNBC
Flint-Martin	CNBC	Surprise-Noble Five and vicinity	CNBC
Galena Farm and vicinity	CNBC	Treasure Hill	USAZ
Gray Eagle	USMT	Tybo	USNV
Idaho-Alamo Group	CNBC	Union	USNV
Idaho-Alamo-Silver Bell	CNBC	Utica	CNBC
Ivanhoe-Canadian	CNBC	Vancouver Group	CNBC
Keno Hill-Galena Hill	CNYT	Von Roi-Hewitt-A.U.	CNBC
King Solomon	USMT	Wellington	CNBC
Leadsmith	CNBC	Wintrop	CNBC
Legal Tender	USMT	Wonderful-Elkhorn	CNBC
Little Nell	USMT		
Liverpool	USMT		
Majestic-Sapphire	CNBC		

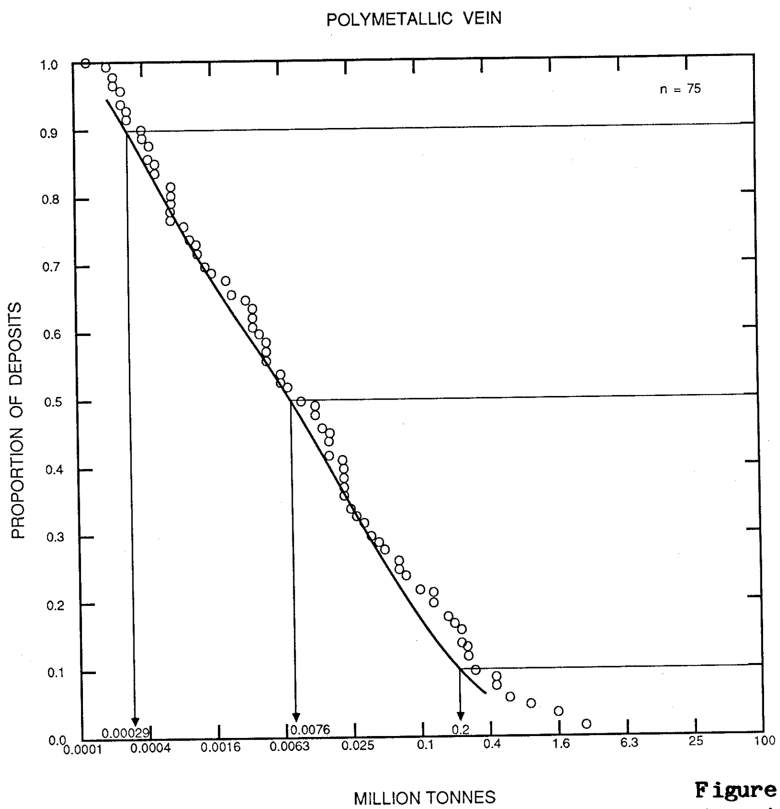


Figure 90. Tonnages of polymetallic vein deposits.

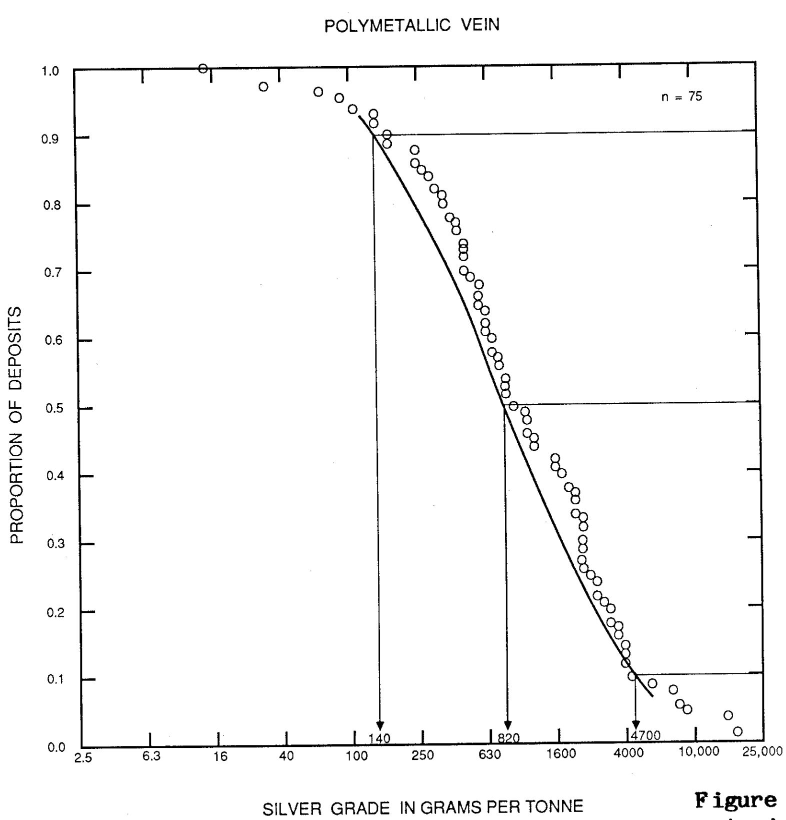


Figure 91. Silver grades of polymetallic vein deposits.

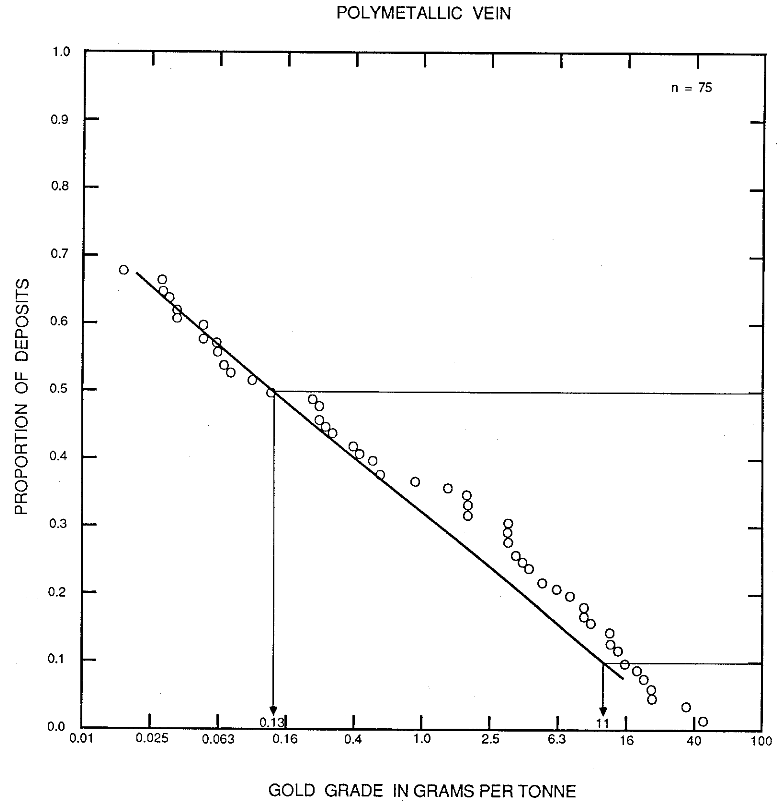


Figure 92. Gold grades of polymetallic vein deposits.

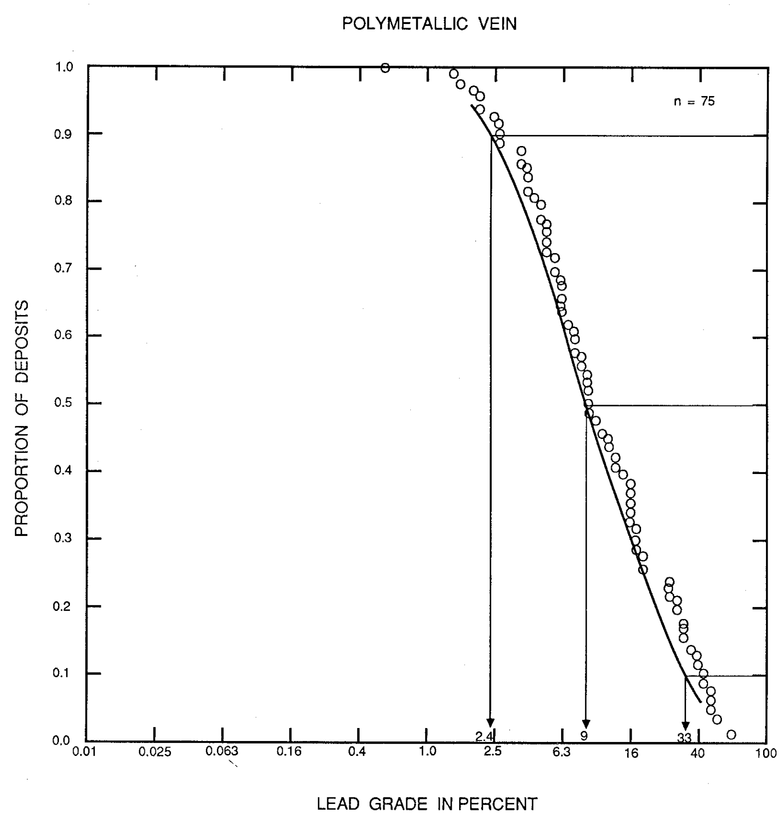


Figure 93. Lead grades of polymetallic vein deposits.

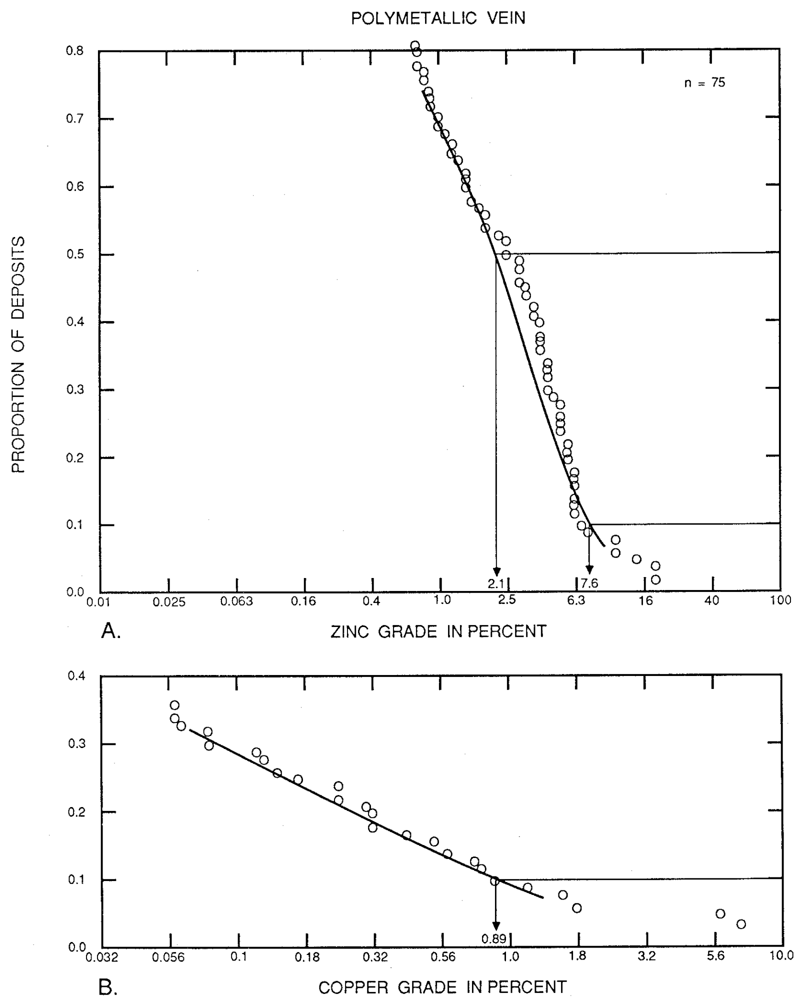


Figure 94. Zinc and copper grades of polymetallic vein deposits. A, Zinc. B, Copper.

DESCRIPTIVE MODEL OF VOLCANOGENIC Mn

By Randolph A. Koski

APPROXIMATE SYNONYM Volcanogenic-sedimentary (Roy, 1981)

DESCRIPTION Lenses and stratiform bodies of manganese oxide, carbonate, and silicate in volcanic-sedimentary sequences. Genesis related to volcanic (volcanogenic) processes.

GENERAL REFERENCE Roy (1981).

GEOLOGICAL ENVIRONMENT

Rock Types Chert, shale, graywacke, tuff, basalt; chert, jasper, basalt (ophiolite); basalt, andesite, rhyolite (island-arc); basalt, limestone; conglomerate, sandstone, tuff, gypsum.

Age Range Cambrian to Pliocene.

Depositional Environment Sea-floor hot spring, generally deep water; some shallow water marine; some may be enclosed basin.

Tectonic Setting(s) Oceanic ridge, marginal basin, island arc, young rifted basin; all can be considered eugeosynclinal.

Associated Deposit Types Kuroko massive sulfide deposits.

DEPOSIT DESCRIPTION

Mineralogy Rhodochrosite, Mn-calcite, braunite, hausmannite, bementite, neotocite, alleghenyite, spessartine, rhodonite, Mn-opal, manganite, pyrolusite, coronadite, cryptomelane, hollandite, todorokite, amorphous MnO_2.

Texture/Structure Fine-grained massive crystalline aggregates, botryoidal, colloform in bedded and lensoid masses.

Alteration Spilitic or greenschist-facies alteration of associated mafic lavas, silicification, hematitization.

Ore Controls Sufficient structure and porosity to permit subsea-floor hydrothermal circulation and sea-floor venting; redox boundary at seafloor-seawater interface around hot spring; supergene enrichment to upgrade Mn content.

Weathering Strong development of secondary Mn oxides (todorokite, birnessite, pyrolusite, amorphous MnO_2, at the surface and along fractures.

Geochemical Signature Although Mn is only moderately mobile and relatively abundant in most rocks, Mn minerals may incorporate many other trace elements such as Zn, Pb, Cu, and Ba.

Examples

Olympic Peninsula, USWA	(Park, 1942, 1946; Sorem and Gunn, 1967)
Franciscan type, USCA, USOR	(Taliaferro and Hudson, 1943; Crerar and others, 1982; Snyder 1978; Kuypers and Denyer, 1979)

GRADE AND TONNAGE MODEL OF VOLCANOGENIC Mn

By Dan L. Mosier

COMMENTS Tonnage is correlated with manganese grade (r = -0.32) and with phosphorus grade (r = -0.94, n = 8). See figs. 103-104.

Model 24c--Con.

DEPOSITS

Name	Country
Abuhemsin (Abiulya)	TRKY
Abundancia	TRKY
Akcakilise Topkirazlar	TRKY
Akoluuk	TRKY
Akseki Gokceovacik	TRKY
Antonio	CUBA
Augusto Luis and others	CUBA
Avispa	CUBA
Black Diablo	USNV
Blue Jay	USCA
Boston Group	CUBA
Briseida Group and others	CUBA
Buckeye	USCA
Bueycito	CUBA
Buritirama	BRZL
Cadiz	CUBA
Castillode Palanco	SPAN
Cavdarli-Komurluk	TRKY
Cayirli Koy	TRKY
Charco Redondo-Casualidad	CUBA
Crescent	USWA
Cubenas	CUBA
Cubuklu KOYU	TRKY
Cummings	USCA
Curiol-Playa Real-Pavones	CORI
Danisment	TRKY
Dassoumble	IVCO
Djebel Guettara	ALGR
Durnovskoe	URRS
El Cuervo	SPAN
Esperancita	CUBA
Estrella-Sopresa	CUBA
Fabian	USCA
Faucogney	FRNC
Foster Mountain	USCA
Glib en Nam	MRCO
Gloria-Elvira-Polaris	CUBA
Gocek Koyu	TRKY
Gran Piedra	CUBA
Guanaba Group	CUBA
Gunbasi (Akcakese)	TRKY
Hyatt No. 1	PANA
Idikel	MRCO
J07	NCAL
Jutinicu	CUBA
Komurluk Koyunun	TRKY

Name	Country
Korucular	TRKY
La Calanesa	SPAN
Ladd	USCA
Lagnokaha	UVOL
Lasbela	PKTN
La Unica	CUBA
Laverton-Mt. Lucky	AUWA
Liberty	USCA
Lucia (Generosa)	CUBA
Lucifer	MXCO
Magdalena	CUBA
Manacas Group	CUBA
Manuel	CUBA
Montenegro-Adriana	CUBA
Mrima	KNYA
Pirki	TRKY
Piskala	TRKY
Ponupo	CUBA
Ponupo de Manacal	CUBA
Pozo Prieto	CUBA
Progreso	CUBA
Quarzazate	MRCO
Quinto	CUBA
Raymond	NCAL
Rhiw	GRBR
Sabanilla	CUBA
Santa Rosa	CUBA
Sapalskoe	URRS
Sereno	BRZL
Sigua	CUBA
Soloviejo	SPAN
South Thomas	USCA
Taratana	CUBA
Taritipan	INDS
Thatcher Creek	USCA
Thomas	USCA
Tiere	UVOL
Tiouine	MRCO
Tokoro	JAPN
Topkirozlar	TRKY
Toscana (Cerchiara)	ITLY
Tutunculer	TRKY
Vane de Maganeso	CUBA
Welch	USCA
Woody Woody	AUWA
Yeya	CUBA

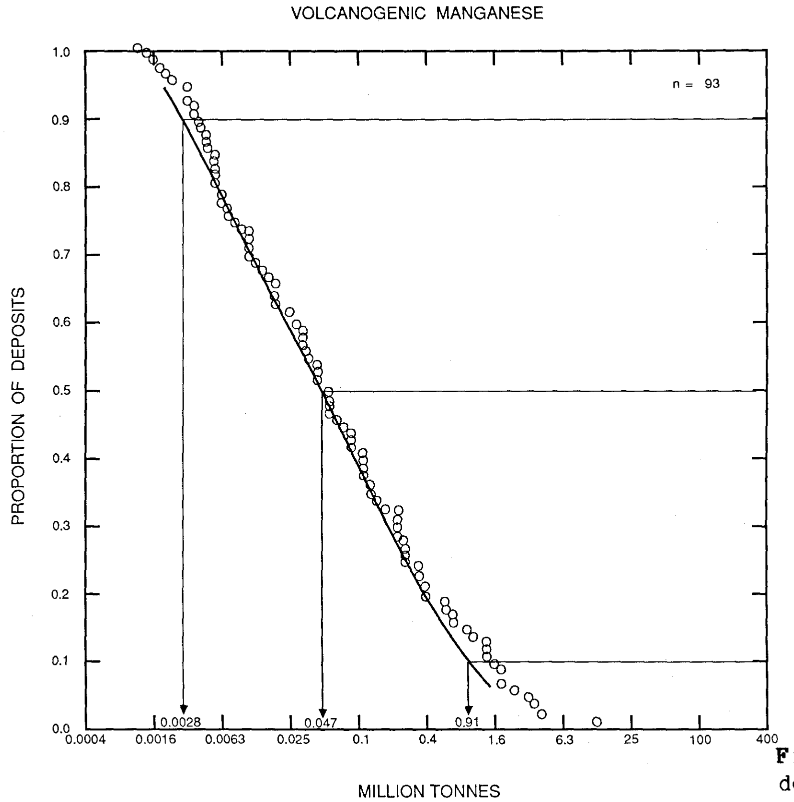
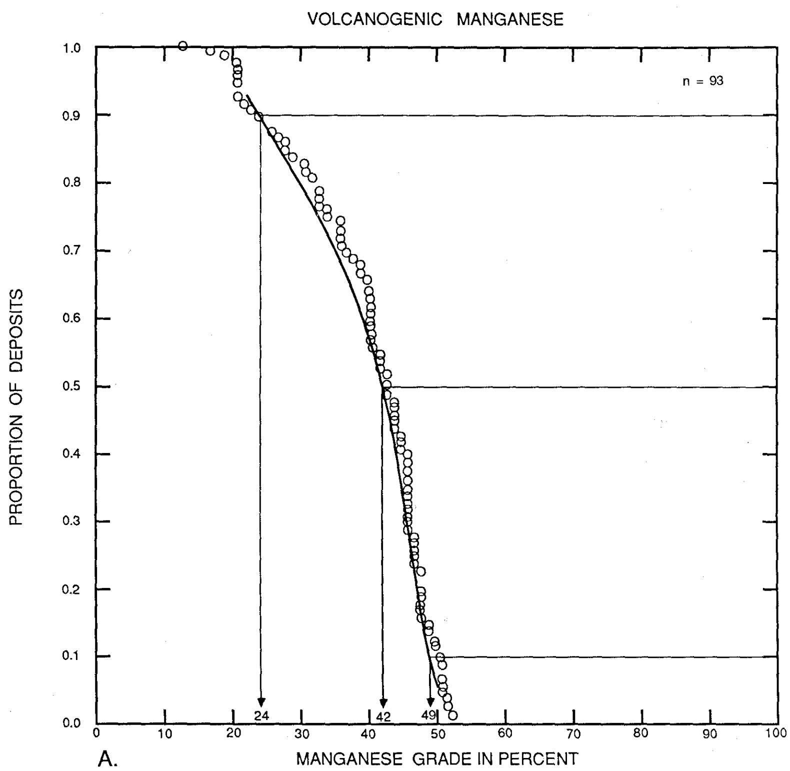


Figure 103. Tonnages of volcanogenic Mn deposits.



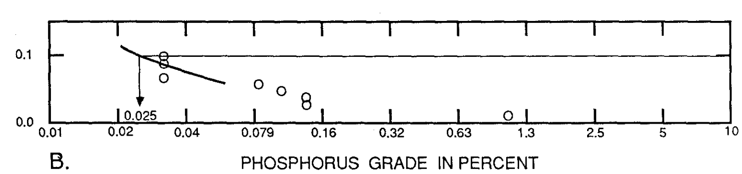


Figure 104. Metal grades of volcanogenic Mn deposits. A, Manganese. B, Phosphorus.

DESCRIPTIVE MODEL OF EPITHERMAL QUARTZ-ALUNITE Au

By Byron R. Berger

APPROXIMATE SYNONYM Acid-sulfate, or enargite gold (Ashley, 1982),

DESCRIPTION Gold, pyrite, and enargite in vuggy veins and breccias in zones of high-alumina alteration related to felsic volcanism.

GENERAL REFERENCE Ashley (1982).

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 evaporates in basement.

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

Associated Deposit Types Porphyry copper, polymetallic replacement, volcanic hosted Cu-As-Sb. Pyrophyllite, hydrothermal clay, and alunite deposits.

DEPOSIT DESCRIPTION

Mineralogy 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, and vuggy, with comb structure, and crustified banding.

Alteration Highest temperature assemblage: quartz + alunite + pyrophyllite may be early stage with pervasive alteration of host rock and veins of these minerals; this zone may contain corundum, diaspore, andalusite, or zunyite. Zoned around quartz-alunite is quartz + alunite + kaolinite + montmorillonite; pervasive propylitic alteration (chlorite + calcite) depends on extent of early alunitization. Ammonium-bearing clays may be present.

Ore Controls Through-going fractures, centers of intrusive activity. Upper and peripheral parts of porphyry copper systems.

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

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

EXAMPLES

Goldfield, USNV	(Ransome, 1909)
Kasuga mine, JAPN	(Taneda and Mukaiyama, 1970)
El Indio, CILE	(Walthier and others, 1982)
Summitville, USCO	(Perkins and Nieman, 1983)
Iwato, JAPN	(Saito and Sate, 1978)

GRADE AND TONNAGE MODEL OF EPITHERMAL QUARTZ-ALUNITE Au

By Dan L. Mosier and W. David Menzie

COMMENTS See figs. 120-123.

DEPOSITS

Name	Country
Chinkuashih	TIWN
El Indio	CILE
Goldfield	USNV
Iwato	JAPN
Kasuga	JAPN
Masonic	USCA
Mohave	USCA
Stedman	USCA

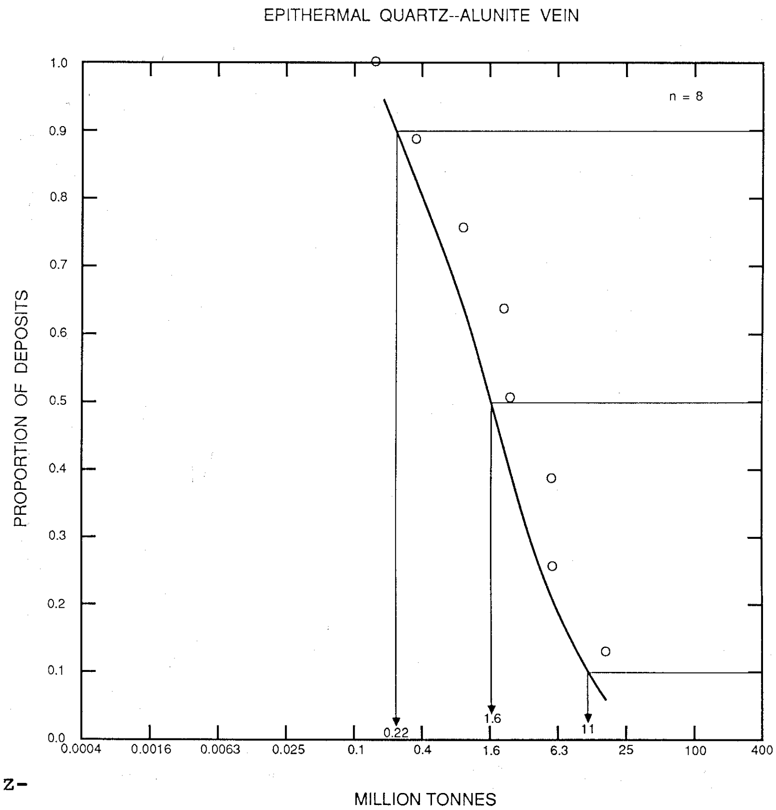


Figure 120. Tonnages of epithermal quartz-alunite vein deposits.

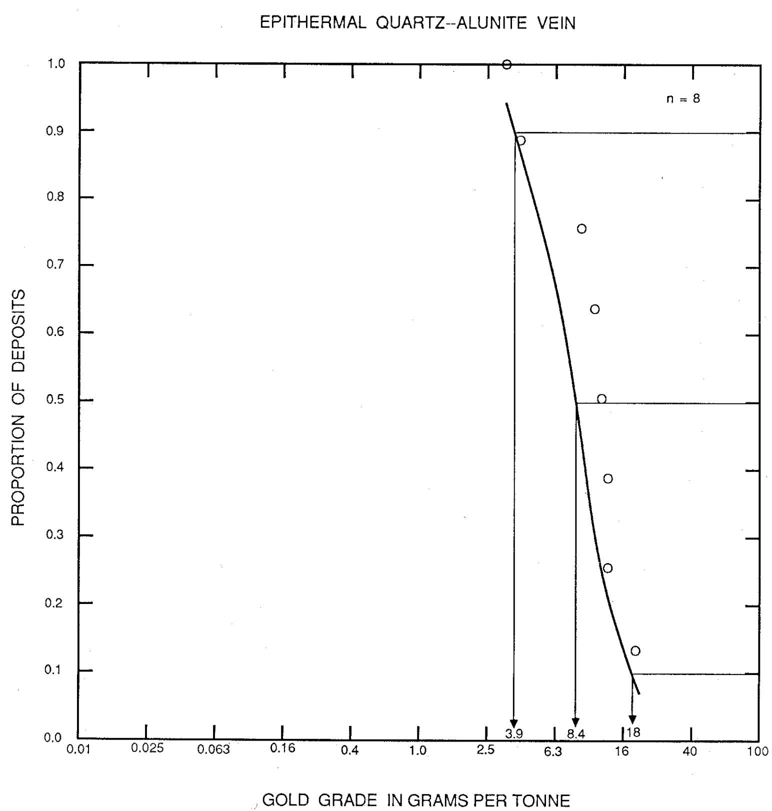


Figure 121. Gold grades of epithermal quartz-alunite vein deposits.

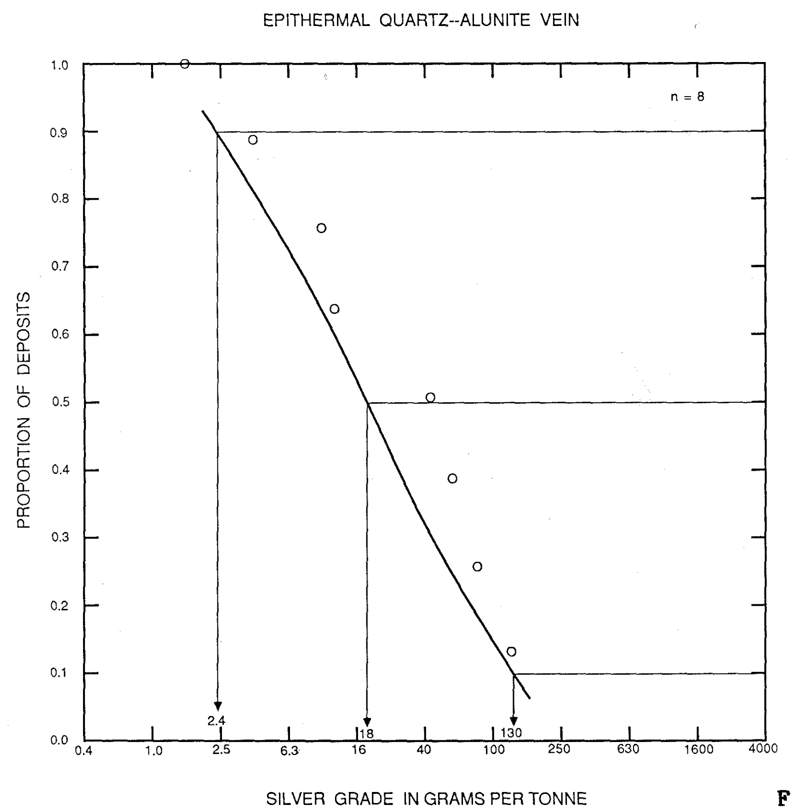


Figure 122. Silver grades of epithermal quartz-alunite vein deposits.

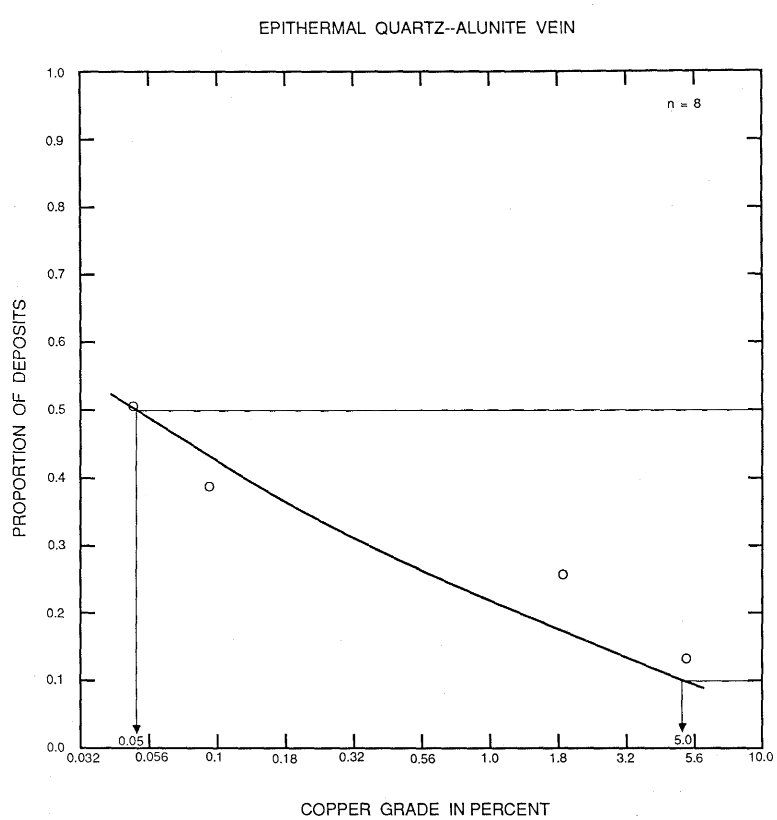


Figure 123. Copper grades of epithermal quartz-alunite vein deposits.

DESCRIPTIVE MODEL OF KUROKO MASSIVE SULFIDE

By Donald A. Singer

APPROXIMATE SYNONYM Noranda type, volcanogenic massive sulfide, felsic to intermediate volcanic type.

DESCRIPTION Copper- and zinc-bearing massive sulfide deposits in marine volcanic rocks of intermediate to felsic composition (see fig. 145).

GENERAL REFERENCES Ishihara (1974), Franklin and others (1981), Hutchinson and others (1982), Ohmoto and Skinner (1983).

GEOLOGICAL ENVIRONMENT

Rock Types Marine rhyolite, dacite, and subordinate basalt and associated sediments, principally organic-rich mudstone or shale. Pyritic, siliceous shale. Some basalt.

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

Age Range Archean through Cenozoic.

Depositional Environment Hot springs related to marine volcanism, probably with anoxic marine conditions. Lead-rich deposits associated with abundant fine-grained volcanogenic sediments.

Tectonic Setting(s) Island arc. Local extensional tectonic activity, faults, or fractures. Archean greenstone belt.

Associated Deposit Types Epithermal quartz-adularia veins in Japan are regionally associated but younger than kuroko deposits. Volcanogenic Mn, Algoma Fe.

DEPOSIT DESCRIPTION

Mineralogy Upper stratiform massive zone (black ore)--pyrite + sphalerite + chalcopyrite ± pyrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore)--pyrite + chalcopyrite ± sphalerite ± pyrhotite ± magnetite; stringer (stockwork) zone--pyrite + chalcopyrite (gold and silver). Gahnite in metamorphosed deposits. Gypsum/anhydrite present in some deposits.

Texture/Structure Massive (>60 percent sulfides); in some cases, an underlying zone of ore stockwork, stringers or disseminated sulfides or sulfide-matrix breccia. Also slumped and redeposited ore with graded bedding.

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. Cordierite and anthophyllite in footwall of metamorphosed deposits, graphitic schist in hanging wall.

Ore Controls Toward the more felsic top of volcanic or volcanic-sedimentary sequence. Near center of felsic volcanism. May be locally brecciated or have felsic dome nearby. Pyritic siliceous rock (exhalite) may mark horizon at which deposits occur. Proximity to deposits may be indicated by sulfide clasts in volcanic breccias. Some deposits may be gravity-transported and deposited in paleo depressions in the seafloor. In Japan, best deposits have mudstone in hanging wall.

Weathering Yellow, red, and brown gossans. Gahnite in stream sediments near some deposits.

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

Kidd Creek, CNON	(Walker and others, 1975)
Mt. Lyell, AUTS	(Corbett, 1981)
Brittania, CNBC	(Payne and others, 1980)
Buchans, CNNF	(Swanson and others, 1981)

GRADE AND TONNAGE MODEL OF KUROKO MASSIVE SULFIDE

By Donald A. Singer and Dan L. Mosier

DATA REFERENCE Mosier and others (1983).

COMMENTS Includes all deposits listed by Mosier and others (1983) that are associated with felsic or intermediate volcanic rocks. Tonnage is correlated with copper grade (r = -0.17) and with gold grade (r = -0.19, n = 238). Zinc grade is correlated with lead-grade (r = 0.55, n = 184) and with silver grade (r = 0.52, n = 249). Lead grade is correlated with silver (r = 0.55, n = 153) and with gold grade (r = 0.34, n = 124). Gold and silver grades are correlated (r = 0.39, n = 227). See figs. 146-149.

DEPOSITS

Name	Country	Name	Country
Abeshiro (Sakura)	JAPN	Bell Allard	CNQU
Adak-Lindskold	SWDN	Bell Channel	CNQU
Afterthought	USCA	Bidjovagge (A)	NRWY
Aijala	FNLD	Bidjovagge (B)	NRWY
Akarsen	TRKY	Bidjovagge (C)	NRWY
Akkoy	TRKY	Bidjovagge (D)	NRWY
Akulla Vastra	SWDN	Big Bend	USCA
Albert	CNQU	Big Hill	USME
Aldermac	CNQU	Binghamton	USAZ
Allard River	CNQU	Birch Lake	CNSK
Almagrera-Lapilla	SPAN	Bjorkasen	NRWY
Amulet A	CNQU	Bjurfors	SWDN
Amulet F	CNQU	Bjurliden	SWDN
Anayatak-Cakmakkaya	TRKY	Bjurtrask	SWDN
Anderson Lake	CNMN	Blue Ledge	USCA
Angelo	AUWA	Blue Moon	USCA
Anne	NRWY	Bodennec	FRNC
Antler	USAZ	Boliden	SWDN
Arctic	USAK	Bossmo	NRWY
Armstrong (A)	CNNB	Britannia	CNBC
As Safra	SAAR	Bruce	USAZ
Asen-east	SWDN	Brunswick No. 12	CNNB
Asen-west	SWDN	Brunswich No. 6	CNNB
Ash Shizm	SAAR	Buchans (LS-Roth.)	CNNF
Austin Brook	CNNB	Buchans (McLean)	CNNF
Avoca	IRLD	Buchans (OB-Orient.)	CNNF
Aznacollar	SPAN	Bully Hill-Rising St.	USCA
Bagacay	PLPN	Bursi	NRWY
Bailadores	VNZL	Campanario	SPAN
Balaklala	USCA	Canadian Jamieson	CNON
Bald Mountain	USME	Canoe Landing	CNNB
Bandgan	PKTN	Captain	CNNB
Barrett	USME	Captains Flat	AUNS
Barrington Lake	CNMN	Caribou	CNNB
Barvallee-Mogador	CNQU	Carpio	SPAN
Baskoy	TRKY	Castillo Buitron	SPAN
Bathurst-Norsemines	CNNT	Castro Verde	PORT
Bawdin	BRMA	CC	CNBC
Beatson	USAK	Centennial	CNMN
Bedford Hill	CNQU	Chestatee	USGA

Chester	CNNB
Chisel Lake	CNMN
Clinton	CNQU
Conception	SPAN
Conigo	CNQU
Copper Crown	CNBC
Copper George	AUWA
Copper Hill	USCA
Corbet	CNQU
Coronation	CNSK
Crandon	USWI
Cronin	CNBC
Cueva de la Mora	SPAN
Cupra D'Estrie	CNQU
Cuprus	CNMN
Davis	USMA
Deer Isle	USME
Delbridge	CNQU
Despina	CNQU
Detour	CNQU
Devils Elbow	CNNB
Dickstone	CNMN
Don Jon	CNMN
Double Ed	CNBC
Dumagami	CNQU
Dumont Bourlamque	CNQU
Dunraine	CNQU
Duthie	CNBC
Dyce Siding	CNMN
Early Bird	USCA
East Sullivan	CNQU
Ego	CNON
Embury Lake	CNMN
Emerson	USME
Empire Le Tac	CNQU
Errington	CNON
Estacao	CNON
Eulaminna	AUWA
Eustis	CNQU
F Group	CNON
Farewell Lake	CNMN
Filon Sur-Esperanza	SPAN
Fjeldgruve	NRWY
FL & DH	CNMN
Flambeau	USWI
Flexar	CNSK
Flin Flon	CNMN
Fonnfjell	NRWY
Fox	CNMN
Freddie Wells	AUNS
Fretais	PORT
Frotet Lake	CNQU
Fukazawa	JAPN
Furuhaugen	NRWY
Furutobe-Ainai	JAPN
Gamle Folldal	NRWY
Garon Lake	CNQU
Gaviao	PORT
Gelvenakko	SWDN
George Copper	CNBC
Ghost Lake	CNMN
Giken-Charlotta	NRWY
Girilambone	AUNS
Gjersvik	NRWY
Golden Grove	AUWA
Goodenough	CNMN
Gray Eagle	USCA
Green Coast	CNON
Greens Creek	USAK
Gullbridge	CNNF
Hacan	TRKY
Half Mile Lake (SG)	CNMN
Halliwell	CNQU
Hanaoka (Doy.-Tsut.)	JAPN
Hanaoka (Mats.-Sha.)	JAPN
Hanawa (Aket.-Osak.)	JAPN
Hanson Lake	CNSK
Harkoy	TRKY
Heath Steele (A-C-D)	CNNB
Heath Steele (B)	CNNB
Heath Steele (E-F)	CNNB
Hercules	AUTN
Herrerias	SPAN
Hersjo	NRWY
High Lake	CNNT
Hixbar	PLPN
Hoidal	NRWY
Hood River	CNNT
Horne-Quemont	CNQU
Hunter	CNQU
HW	CNBC
Hyers Island	CNMN
Iron Dyke	USOR
Iron King	USAZ
Iron Mountain	USCA
Irsahan	TRKY
Iso-Magusi-New Insco	CNQU
Israil	TRKY
Iwami east	JAPN
Iwami west	JAPN
Izok Lake	CNNT
Jabal Sayid	SAAR
Jakobsbakken	NRWY
Jameland	CNON
Jerome	USAZ
Joanne	CNMN
Joliet	CNQU
Josselin	CNQU
Joutel	CNQU
Kalkanli	TRKY
Kam Kotia	CNON
Kamitkita (Kominosawa)	JAPN
Kankberg	SWDN
Kedtrask	SWDN
Kelly-Desmond	CNQU
Key Anacon	CNNB
Keystone	USCA
Ketstone-Union	USCA
Khans Creek	AUNS
Khnaiguiyah	SAAR
Kidd Creek	CNON
Killingdal	NRWY
Kimheden	SWDN
Kittelgruvan	SWDN
Kizilkaya	TRKY
Koff Zone	CNMN

Model 28a--Con.

Koprubasi	TRKY	Murray Brook	CNNB
Kosaka (Motoyama)	JAPN	Myra Falls-Lynx	CNBC
Kosaka (Uch.-Uwa.)	JAPN	Nasliden	SWDN
Kostere	TRKY	Nepisiguit	CNNB
Kristineberg	SWDN	New Bay Pond	CNNF
Kunitomi (3-4-6)	JAPN	New Hosco	CNQU
Kunitomi (7-8)	JAPN	Newton	USCA
Kunitomi (1-5-lN-Fud.)	JAPN	Nine Mile Brook	CNNB
Kurosawa	JAPN	Nordre Gjetryggen	NRWY
Kutcho Creek	CNBC	Norita	CNQU
Kutlular	TRKY	Normetal	CNQU
Kuvarshan	TRKY	North Boundary	CNNB
La Joya	SPAN	North Keystone	USCA
La Torrera	SPAN	North Star	CNMN
La Zarza	SPAN	Northair	CNBC
Lagunazo	SPAN	Nuqrah	SAAR
Lahanos	SPAN	Old Waite	CNQU
Lake Dufault	CNQU	Orange Point	USAK
Lancha	SPAN	Orchan	CNQU
Langdal	SWDN	Orijarvi	FNLD
Langsele	SWDN	Osbourne Lake	CNMN
Lenora-Twin J	CNBC	Oshio	JAPN
Levi	SWDN	Ostra Hogkulla	SWDN
Lingwick	CNQU	Pabineau River	CNNB
Lomero Poyatos	SPAN	Paronen	FNLD
Lost Lake	CNMN	Parys Mountain	GRBR
Lousal	PORT	Pater	CNON
Louvem	CNQU	Paymogo	SPAN
Lyndhurst	CNQU	Pecos	USNM
Lynx	CNQU	Pelican	USWI
Lyon Lake	CNON	Penn	USCA
MacBride Lake	CNMN	Penobscot	USME
Madenkoy	TRKY	Perrunal	SPAN
Malaiba	PLPN	Phelps Dodge	CNQU
Mamie	CNBC	Pilleys Island	CNNF
Mammoth	USCA	Pine Bay	CNMN
Mandy	CNMN	Piray	PLPN
Mankayan	PLPN	Point Leamington	CNNF
Marcos	PLPN	Poirier	CNQU
Mattabi	CNON	Port Aux Moines	FRCN
Mattagami Lake	CNQU	Pot Lake	CNMN
McMaster	CNNB	Price	CNBC
Metsamonttu	FNLD	Pyhasalmi	FNLD
Mic Mac	CNQU	Que River	AUTS
Milan	USNH	Radiore E	CNQU
Millenbach	CNQU	Rail Lake	CNMN
Mobrun	CNQU	Rakkejaur	SWDN
Mofjell	NRWY	Rambler-Ming	CNNF
Moinho	PORT	Ramsey	CNSK
Mokoman Lake	CNSK	Ravliden	SWDN
Moleon Lake	CNQU	Ravlidmyran	SWDN
Monpas	CNQU	Rosebery-Read	AUTS
Mons Cupri	AUWA	Red Wing	CNBC
Mordey	CNON	Reed Lake	CNMN
Mos	NRWY	Renstrom	SWDN
Moskogaissa	NRWY	Rieppe	NRWY
Moulton Hill	CNQU	Rio Tinto	SPAN
Mount Bulga	AUNS	Rocky Turn	CNNB
Mount Chalmers	AUQL	Rod	CNMN
Mount Lyell	AUTS	Rodhammeren	NRWY
Mount Morgan	AUQL	Rodkleiv	NRWY
Mount Mulcahy	AUWA	Romanera	SPAN
Murgul	TRKY	Romerito	SPAN

Rostvangen	NRWY	Teahan	CNNB
Rudtjebacken	SWDN	Tedi	CNBC
Ruttan	CNMN	Terra Nova	CNNF
Sabetjok	NRWY	Teutonic Bore	AUWA
Sagmo	NRWY	Texas	CNNB
Sain Bel	FRNC	Third Portage	CNNB
San Antonio	SPAN	Tjokkola	SWDN
San Domingos	PORT	Tomogonops	CNNB
San Guillermo-Sierra	SPAN	Trininty	CNQU
San Mateo	PLPN	Trout Bay	CNON
San Pedro	SPAN	Tsuchihata (Hatabira)	JAPN
San Platen	SPAN	Tsuchihata (Honniozaw.)	JAPN
San Telmo	SPAN	Tsuchihata (Shiratsuc.)	JAPN
Santa Rosa	SPAN	Tsuchihata (Uenono-Ok.)	JAPN
Schist Lake	CNMN	Tsuchihata (Washinosu)	JAPN
Selco-Scott	CNQU	Tulk's Pond	CNNF
Shasta King	USCA	Tulsequah	CNBC
Shunsby	CNON	Tunca	TRKY
Sierrecilla	SPAN	Tverrfjellet	NRWY
Silver Queen	CNBC	Uchi	CNON
Skaide	NRWY	Udden	SWDN
Solbec	CNQU	Undu	FIJI
Sotiel	SPAN	Vaddas	NRWY
Sourdough Bay	CNMN	Vamp	CNMN
South Dufault	CNQU	Vauze	CNQU
South Rusty Hill	CNQU	Vermilion	CNON
Spenceville	USCA	Vigsnes	NRWY
Spruce Point	CNMN	Viscaria	SWDN
Stall Lake	CNMN	Waden Bay	CNSK
Stekenjokk	SWDN	Waite East	CNQU
Stirling	CNNS	Wallaroo	AUWA
Stowell	USCA	Wedge	CNNB
Stralak	CNON	Weedon	CNQU
Stratmat	CNNB	Weiss	TRKY
Sturgeon Lake	CNON	Westarm	CNMN
Suffield	CNQU	Whim Creek	AUWA
Sulat	PLPN	White Lake	CNMN
Sun	CNMN	Whundo	AUWA
Sunshine	CNBC	Wildcat	PLPN
Susu Lake	CNNT	Willecho	CNON
Sutro	USCA	Wim	CNMN
Tache Lake	CNQU	Windy	CNBC
Taisho (Nishimata)	JAPN	Woodlawn	AUQL
Takijug Lake	CNNT	Yava	CNNT
Taknar I	IRAN	Yoichi	JAPN
Taknar II	IRAN	Yokota (Motoyama-Hama.)	JAPN
Tapley	USME	Yoshino (Hisaka)	JAPN
Tashiro	JAPN	Yoshino (Main)	JAPN
Taslica	TRKY	Z	CNMN

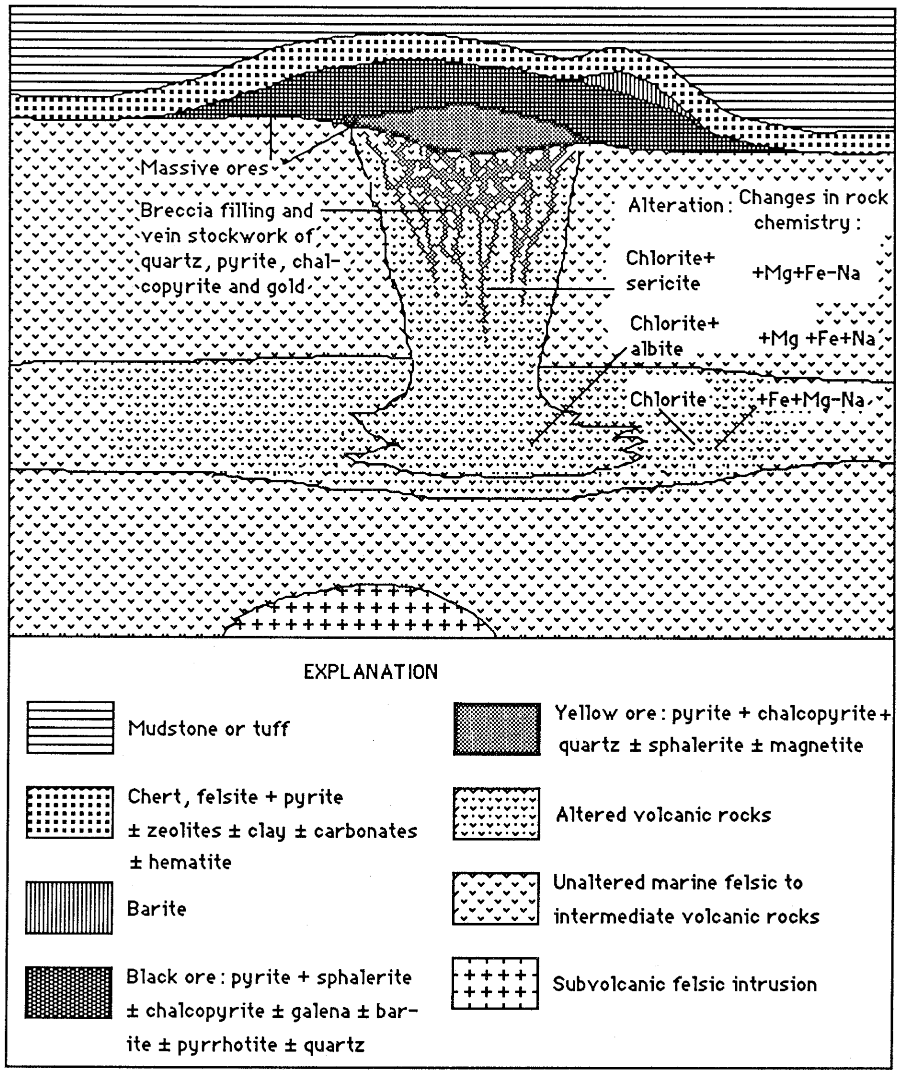


Figure 145. Cartoon cross section of kuroko massive sulfide deposit. Modified from Franklin and others (1981).

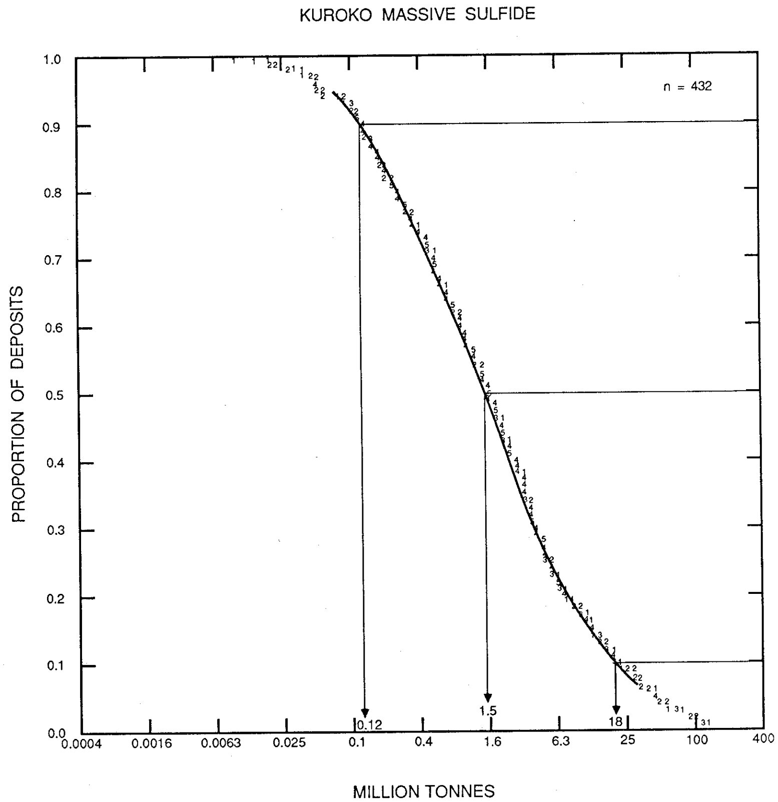


Figure 146. Tonnages of kuroko massive sulfide deposits. Individual digits represent number of deposits.

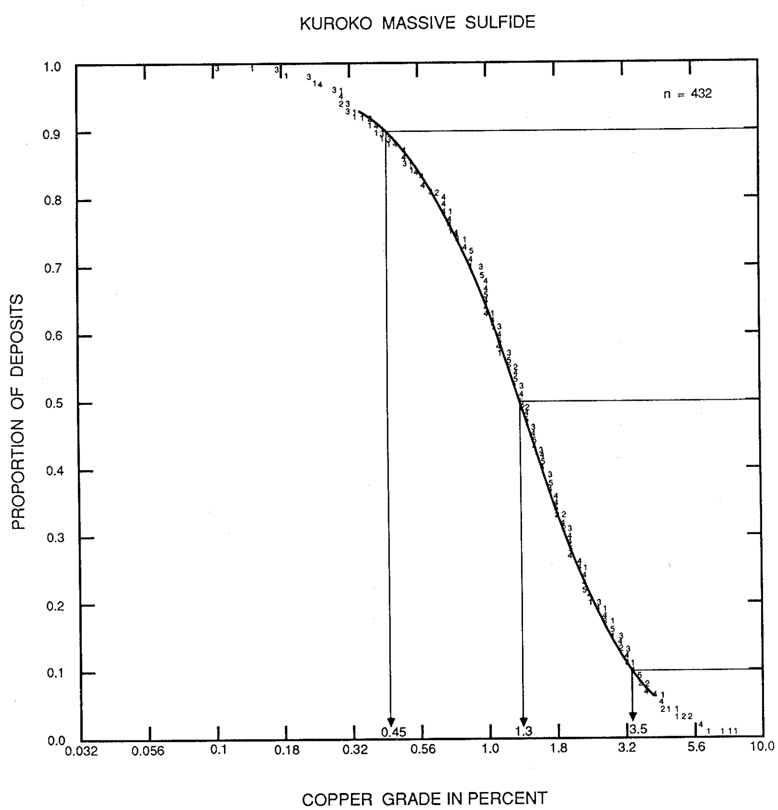


Figure 147. Copper grades of kuroko massive sulfide deposits. Individual digits represent number of deposits.

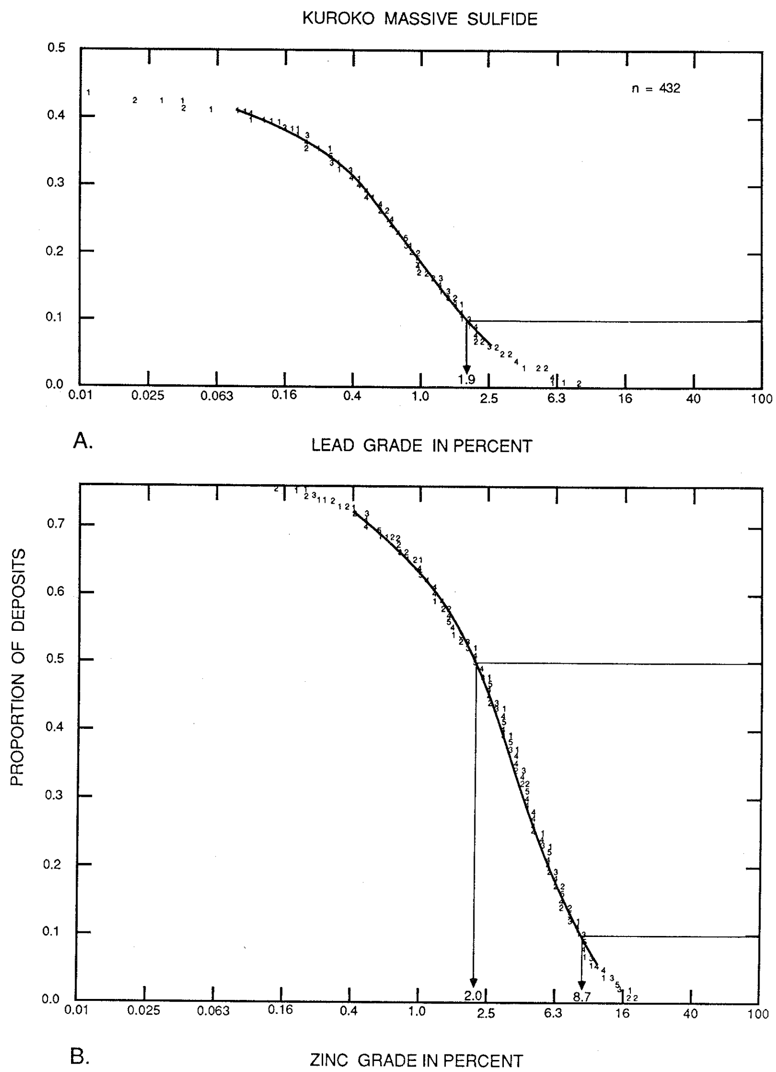


Figure 148. Lead-zinc grades of kuroko massive sulfide deposits. A, Lead. B, Zinc. Individual digits represent number of deposits.

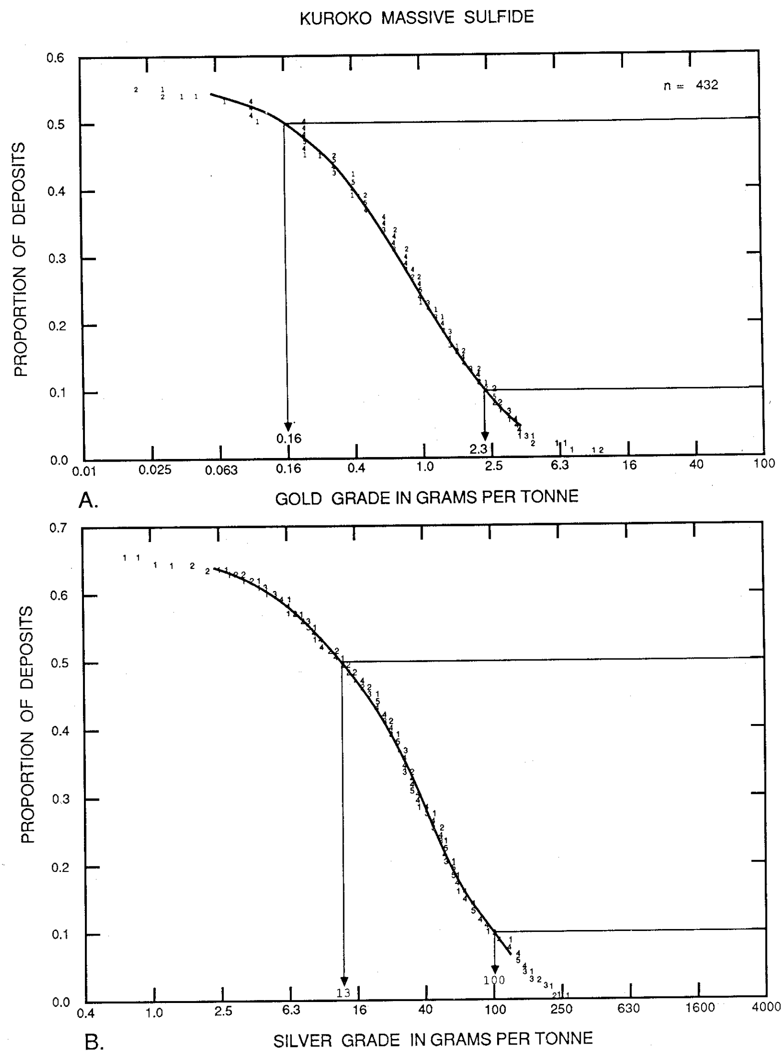


Figure 149. Precious-metal grades of kuroko massive sulfide deposits. A, Gold. B, Silver. Individual digits represent number of deposits.

DESCRIPTIVE MODEL OF LATERITIC Ni

By Donald A. Singer

DESCRIPTION Nickel-rich, in situ lateritic weathering products developed from dunites and peridotites. Ni-rich iron oxides are most common. Some deposits are predominantly Ni silicates.

GENERAL REFERENCE Evans and others (1979).

GEOLOGICAL ENVIRONMENT

Rock Types Ultramafic rocks, particularity peridotite, dunite, and serpentinized peridotite.

Age Range Precambrian to Tertiary source rocks, typically Cenozoic weathering.

Depositional Environment Relatively high rates of chemical weathering (warm-humid climates) and relatively low rates of physical erosion.

Tectonic Setting(s) Convergent margins where ophiolite have been emplaced. Uplift is required to expose ultramafic to weathering.

Associated Deposit Types Podiform chromite, PGE placers, serpentine-hosted asbestos.

DEPOSIT DESCRIPTION

Mineralogy Garnierite, poorly defined hydrous silicates, quartz, and goethite. Goethite commonly contains much Ni.

Texture/Structure Red-brown pisolitic soils, silica-rich boxworks.

Alteration Zoned--from top: (1) Red, yellow, and brown limonitic soils; (2) saprolites--continuous transition from soft saprolite below limonite zone, hard saprolite and saprolitized peridotite, to fresh peridotite. Boxwork of chalcedony and garnierite occurs near bedrock-weathered rock.

Ore Controls Upper limonite zone containing 0.5-2 percent Ni in iron-oxides; lower saprolite and boxwork zone typically contains 2-4 percent Ni in hydrous silicates. The oxide and silicate ores are end members and most mineralization contains some of both.

Weathering The profile from red-brown pisolitic soil down to saprolite represents the products of chemically weathered ultramafic rocks.

Geochemical Signature Enriched in Ni, Co, Cr; depleted in MgO relative to fresh peridotite (less than 40 percent MgO).

EXAMPLES

Poro, NCAL	(Troly and others, 1979)
Cerro Matoso, CLBA	(Gomez and others, 1979)
Nickel Mountain, USOR	(Chace and others, 1969)
Greenvale, AUQL	(Burger, 1979)

GRADE AND TONNAGE MODEL OF LATERITIC Ni

By Donald A. Singer

COMMENTS Higher grades are typically associated with the silicate type. Numerous low-grade (less than 1 percent Ni) and low-tonnage deposits are not included. Nickel grade is correlated with tonnage (r = -0.31). See figs. 189, 190.

DEPOSITS

Name	Country	Name	Country
Ambatory	MDGS	Moa Bay	CUBA
Analumay	MDGS	Moorsom	PLPN
Barro Alto	BRZL	Moramanga	MDGS
Berong	PLPN	Morro de Engenho	BRZL
Bhimatangar	INDA	Mwaytung	BRMA
Blue Ridge	PLPN	Nepoui	NCAL
Br. Solomon 1s.	SLMN	New Frontier	PLPN
Buka	PLPN	Niquelandia	BRZL
Cabo Rojo	PTRC	Nonoc	PLPN
Cerro Matoso	CLBA	Obi	INDS
Claude Hills	AUSA	Ora Banda	AUWA
Cyclops	INDS	Orsk	URRS
Dinagat Is.	PLPN	Pujada Pen.	PLPN
Euboea	GREC	Pomalea	INDS
Exmibal	GUAT	Poro	NCAL
Falconbridge	DMRP	Poum	NCAL
Gag Is.	INDS	Pratapoli.s	BRZL
Golesh Mt.	YUGO	Prony	NCAL
Golos	YUGO	Ramona-Loma	CUBA
Goro	NCAL	Riddle	USOR
Greenvale	AUQL	Rio Tuba	PLPN
Hagios Ioannis	GREC	Sablayon	PLPN
Halmahera	INDS	Sao Joaodo Piaui	BRZL
Ipaneme	BRZL	Santa Cruz	PLPN
Jacupuenga	BRZL	Saruabi	INDA
Kaliapani	INDA	S.E. Kalimantan	INDS
Kansa	INDA	Sidamo	ETHP
Kauadarci	YUGO	Simlipal	INDA
Laguney	PLPN	Soroako	INDS
Lake Joanina	GREC	Sukinda	INDA
Leviso R.	CUBA	Suriagao	PLPN
Loma de Hierro	VNZL	Taco Bay	CUBA
Long Point	PLPN	Thio	NCAL
Marlborough	AUQL	Tiebaghi	NCAL
Masinloc	PLPN	Wingelinna-Daisy	AUWA
Mayari	CUBA		

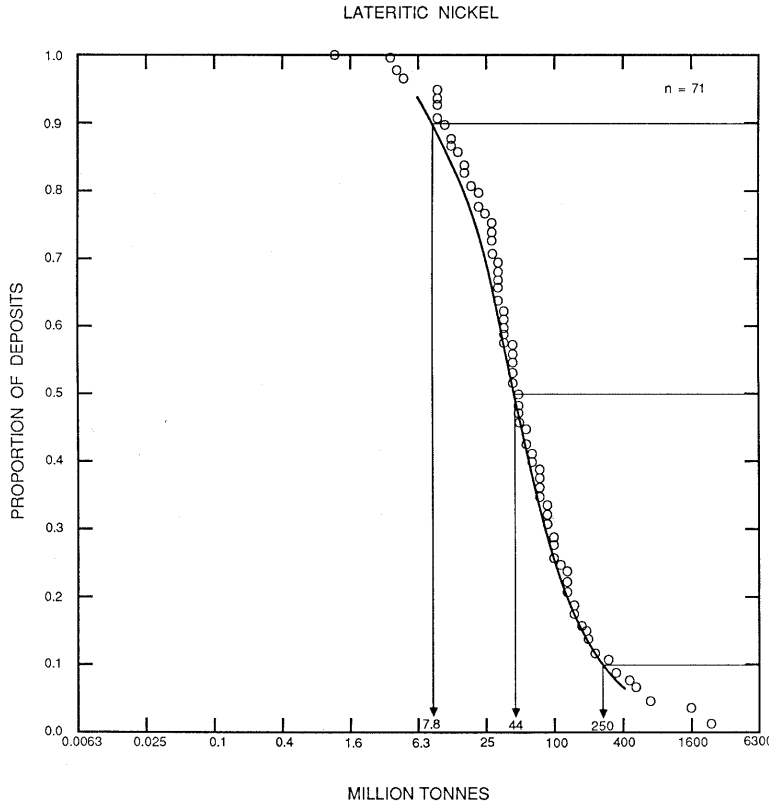


Figure 189. Tonnages of lateritic Ni deposits.

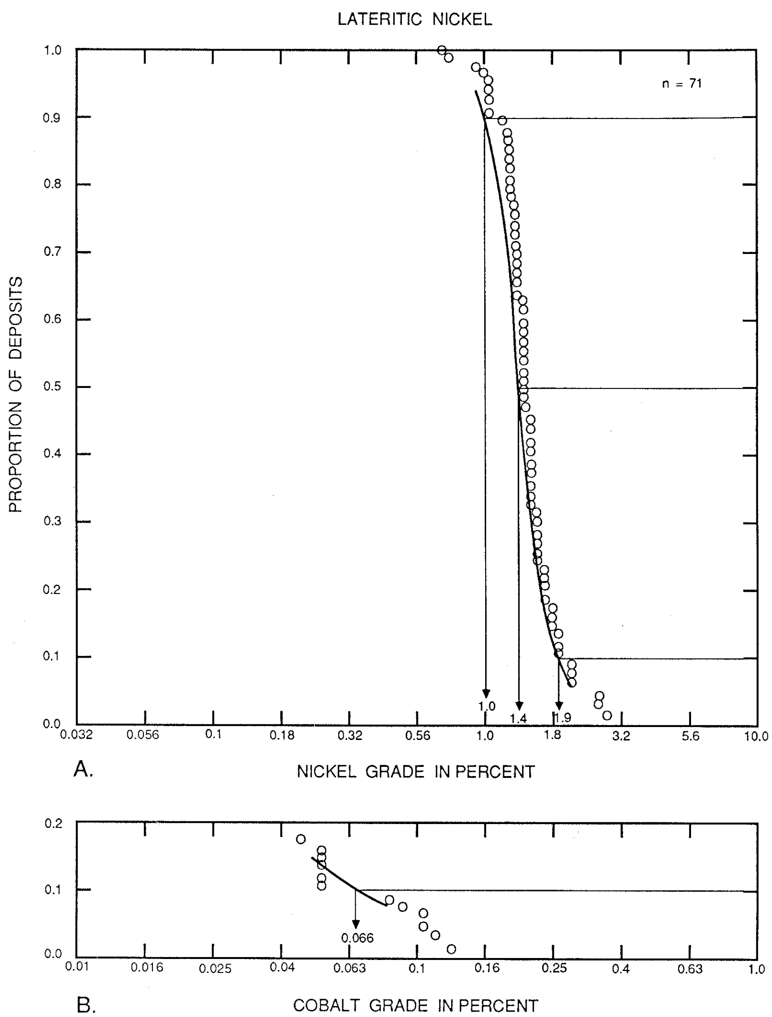


Figure 190. Metal grades of lateritic Ni deposits. A, Nickel. B, Cobalt.

DESCRIPTIVE MODEL OF KARST TYPE BAUXITE DEPOSITS

By Sam H. Patterson

APPROXIMATE SYNONYM Aluminum ore (Bardossy, 1982).

DESCRIPTION Weathered residual and transported materials.

GENERAL REFERENCE Bardossy (1982).

GEOLOGICAL ENVIRONMENT

Rock Types Residual and transported material on carbonate rocks. Transported material may be felsic volcanic ash from a distant source or any aluminous sediments washed into the basin of deposition.

Textures Pisolitic, nodular, massive, earthy.

Age Range Paleozoic to Cenozoic.

Depositional Environment Surficial weathering mainly in wet tropical area.

Tectonic Setting(s) Stable land areas allowing time for weathering and protected from erosion.

Associated Deposit Types Limestone, dolomite, and shale; some are associated with minor coal and are low in Fe due to organic completing and removal of Fe during formation.

DEPOSIT DESCRIPTION

Mineralogy Mainly gibbsite in Quaternary deposits in tropical areas. Gibbsite and boehmite mixed in older Cenozoic deposits, boehmite in Mesozoic deposits and in Paleozoic deposits; gangue minerals hematite, goethite, anatase, kaolin minerals, minor quartz.

Texture/Structure Pisolitic, massive, nodular.

Alteration Formation of bauxite is itself a form of alteration of aluminous sediments.

Ore Controls Deposits tend to be concentrated in depressions on karst surfaces.

Weathering Intense weathering required to form bauxite. Bauxite continues to form in the present weathering environment in most deposits.

Geochemical Signature Al, Ga.

EXAMPLE European and Jamaican examples are reviewed in Bardossy (1982).

GRADE AND TONNAGE MODEL OF KARST TYPE BAUXITE DEPOSITS

By Dan L. Mosier

COMMENTS See figs. 193, 194.

DEPOSITS

Name	Country	Name	Country
Abruzzi	ITLY	Camarasa-Oliana	SPAN
Aceitillar	DMRP	Campania	ITLY
Adana-Saimbeyli	TRKY	Clarendon Plateau	JMCA
Akeski	TRKY	Drnis-Obrovac	YUGO
Beceite-Fuendesplada	SPAN	Fenyoto	HUNG
		Gant	HUNG
Bulbula	IRAN	Halimba	HUNG

Imotski-Mostar	YUGO	Padurea Craiului	RMNA
Islahiye	TRKY	Parnassus-Helikon	GREC
Iszkaszentgyorgy	HUNG	Payas	TRKY
Jajce	YUGO	Punch	INDA
LangSen	VTNM	Rochelois Plat.	HATI
Maggotty	JMCA	San Giovanni Rotondo	ITLY
Manchester Plat.	JMCA	Seydisehr	TRKY
Megara-Eleusis	GREC	Sohodol-Cimpeni	RMNA
Muzaffarabad	PKTN	Spinazzola	ITLY
Nagyegyhaza	HUNG	St. Ann Plateau	JMCA
N.C. Puerto Rico	PTRC	Unterlaussa	ASTR
N.E. Alabama	USAL	Vlasenica	YUGO
Niksicka Zupa	YUGO	Zonguldak	TRKY
N.W. Georgia	USGA		
Nyirad	HUNG		

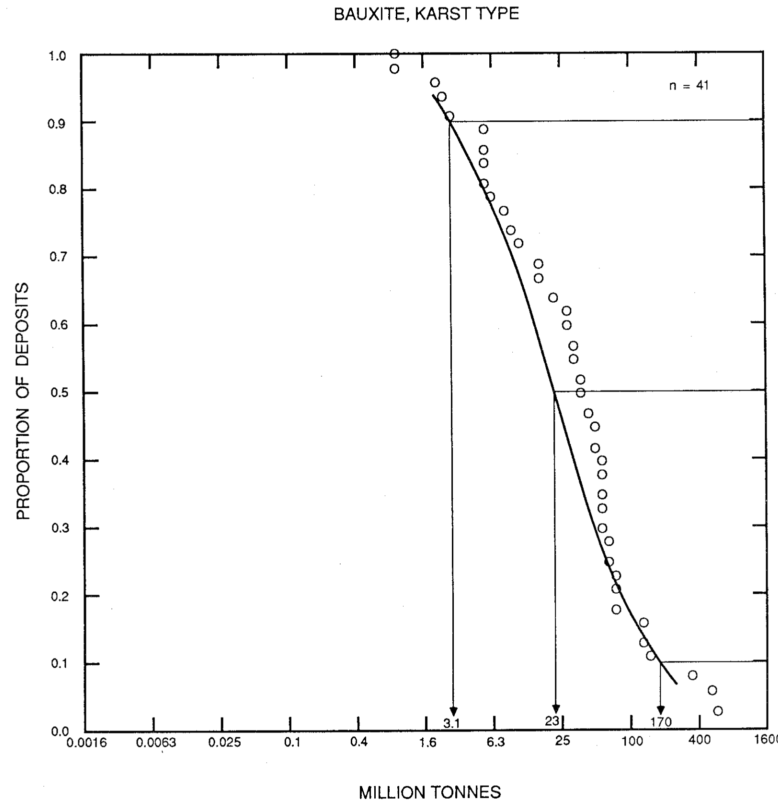


Figure 193. Tonnages of karst-type bauxite deposits.

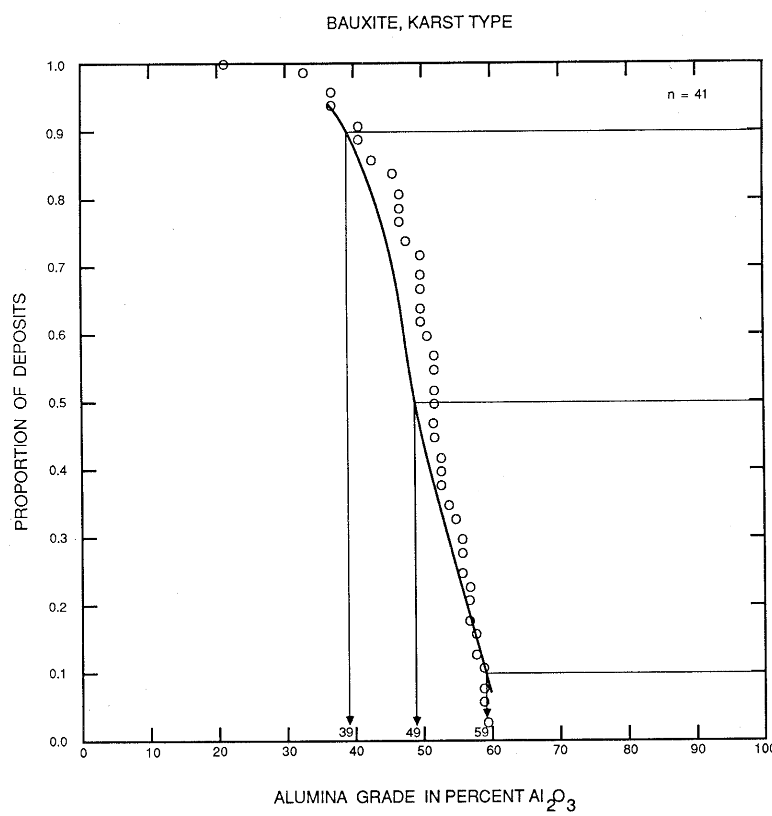


Figure 194. Alumina grades of karst-type bauxite deposits.

DESCRIPTIVE MODEL OF PLACER Au-PGE

By Warren E. Yeend

DESCRIPTION Elemental gold and platinum-group alloys in grains and (rarely) nuggets in gravel) sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, eolian, and (rarely) glacial deposits (see fig. 195).

GENERAL REFERENCES Boyle (1979), Wells (1973), Lindgren (1911).

GEOLOGICAL ENVIRONMENT

Rock Types Alluvial gravel and conglomerate with white quartz clasts. Sand and sandstone of secondary importance.

Textures Coarse elastic.

Age Range Cenozoic. Older deposits may have been formed but their preservation is unlikely.

Depositional Environment High-energy alluvial where gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused Au concentrations in raised, present, and submerged beaches.

Tectonic Setting(s) Tertiary conglomerates along major fault zones, shield areas where erosion has proceeded for a long time producing multicycle sediments; high-level terrace gravels.

Associated Deposit Types Black sands (magnetite, ilmenite, chromite); yellow sands (zircon~ monazite). Au placers commonly derive from various Au vein-type deposits as well as porphyry copper, Cu skarn, and polymetallic replacement deposits.

DEPOSIT DESCRIPTION

Mineralogy Au, platinum-iron alloys, osmium-iridium alloys; gold commonly with attached quartz, magnetite, or ilmenite.

Texture/Structure Flattened, rounded edges, flaky, flour gold extremely fine grained flakes; very rarely equidimensional nuggets.

Ore Controls Highest Au values at base of gravel deposits in various gold "traps" such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dikes, bedding planes, all structures trending transverse to direction of water flow. Au concentrations also occur within gravel deposits above clay layers that constrain the downward migration of Au particles.

Geochemical Signature Anomalous high amounts of Ag, As, Hg, Sb, Cu, Fe, S, and heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, rutile. Au nuggets have decreasing Ag content with distance from source.

EXAMPLES

Sierra Nevada, USCA	(Lindgren, 1911; Yeend, 1974)
Victoria, AUVT	(Knight, 1975)

GRADE AND TONNAGE MODEL OF PLACER Au-PGE

By Greta J. Orris and James D. Bliss

REFERENCE Orris and Bliss (1985).

COMMENTS Placers used for this model are predominantly Quaternary in age and alluvial in nature. Many of the placer deposits contain a mix of depositional environments and energy level--deposits along minor tributaries have been worked with deposits downstream on a higher order stream, bench (or terrace) gravels have been mined with more recent deposits on valley floor. Some of the placers included in this model were formed by complex glacial-fluvial processes. Deposits not included in this model are those primarily cataloged as desert placers, pre-Tertiary or Tertiary age placers, beach placers, eolian placers, residual placers, eluvial placers, and gravel-plain deposits. These types, however, may be minor components of those deposits selected to be included. In most cases, the grade and tonnage figures are for districts or for placer operations within one mile (1.6 km) of one another. For some placers, early production figures were missing due to poor records of early gold rush work. In most cases, reserve figures (if a reserve is known) are not available. Some tonnage figures were estimated from approximate size of workings. Some grades were based on very limited information and in some cases extrapolated from information on manpower figures, type of equipment used, and estimates of the total contained gold produced.

Cutoff grades are dependent on the mining methods used to exploit placers. Methods of placer mining included in this model are as diverse as the depositional environment. These methods include panning, sluicing, hydraulic mining, and dredging. Draglines were used to mine some placers. Cut-off grades are also dependent on the value of gold during the period, or periods, of operation.

Some placer deposits were excluded due to grade or tonnage figures not compatible with the majority of placers found in the model. Placers exploited through drift mining exhibit grades that are too large and tonnages that are too small to be included in this model. Similarly, the large regional placers formed at the junction of mountainous areas and an adjacent plain or valley were excluded because they can be mined with large-volume dredges which are economic at grades not viable under other conditions. Both grades and tonnages of these placers are incompatible with this model.

Placer sizes were initially recorded in terms of cubic meters and the grades recorded as grams per cubic meter. In order to conform to other deposit models herein, deposit volume and grades have been converted to metric tons and grams per metric ton using 2.0 metric tons per cubic meter--the average density of wet sand and gravel. Gold grade is correlated with tonnage (r = -0.35) and with silver grade (r = 0.66, n = 16). See figs. 196, 197.

DEPOSITS

Name	Country	Name	Country
Adelong Creek	AUNS	Humbug Creek	USOR
Alma (Mills) Placer	USCO	Hundred Dollar Gulch	USID
Araluen Valley	AUNS	Iowa Gulch	USCO
Bannack	USMT	Jembaicumbene Creek	AUNS
Big Badja River	AUNS	Jordan Creek	USID
Blue River	USCO	Lamb Creek	USID
Boulder River	USMT	Llano de Oro	USOR
Bullrun Placer	USOR	Lowe Placer	USCO
Buxton Creek	CNBC	Lower Beaver Creek	USCO
Camanche	USCA	Lowland Creek	USMT
Cobweb Diggings	AUNS	Lynx Creek	USAZ
Copper Basin	USAZ	Missouri Creek	USCO
Corduroy Creek	USID	Mitchell Creek	USMT
Crooked Creek	USID	Nugget Creek (South Fork)	USID
Cullengoral	AUNS	Ophir	USMT
Deep Gravel	USOR	Pactolus	USCO
Dixie Placer	USOR	Picuris	USNM
El Dorado	USMT	Pioneer	USMT
Elkhorn Creek	USMT	Prickly Pear Creek	USMT
Elliston	USMT	Rio Challana	BLVA
Fall Creek	USID	Rio Chimate	BLVA
Foots Creek	USOR	Rio Tuichi (upper reach)	BLVA
Forest Creek	USOR	Rio Yolosano	BLVA
French Gulch	USCO	Rio Yuyo	BLVA
George Prezel	USID	Sand Creek	USID
Georgia Gulch	USCO	Schissler Creek	USID
Gold Run (Summit Co.)	USCO	Snowstorm area	USCO
Gold Run (Boulder Co.)	USCO	Sterling Creek	USOR
Golden Rule	USID	Sumpter Bar	USOR
Green River	USUT	Swan River	USCO
Horse Praire	USMT	T93-R77W Placer	USCO

Vermilion River	USMT	Wombat Creek	AUNS
Wellington	AUNS		

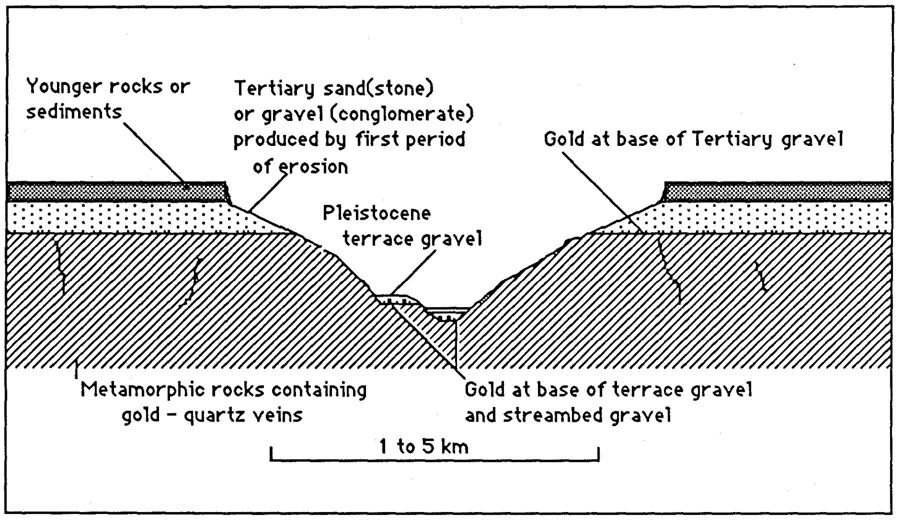


Figure 195. Cartoon cross section showing three stages of heavy mineral concentrations typical of placer Au-PGE deposits.

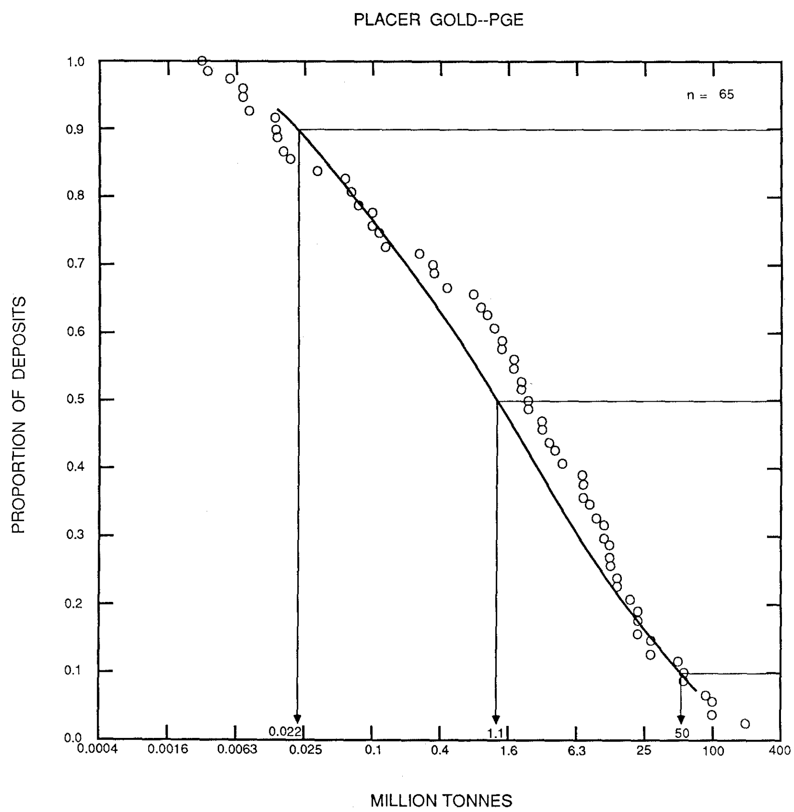


Figure 196. Tonnages of placer Au-PGE deposits. Individual digits represent number of deposits.

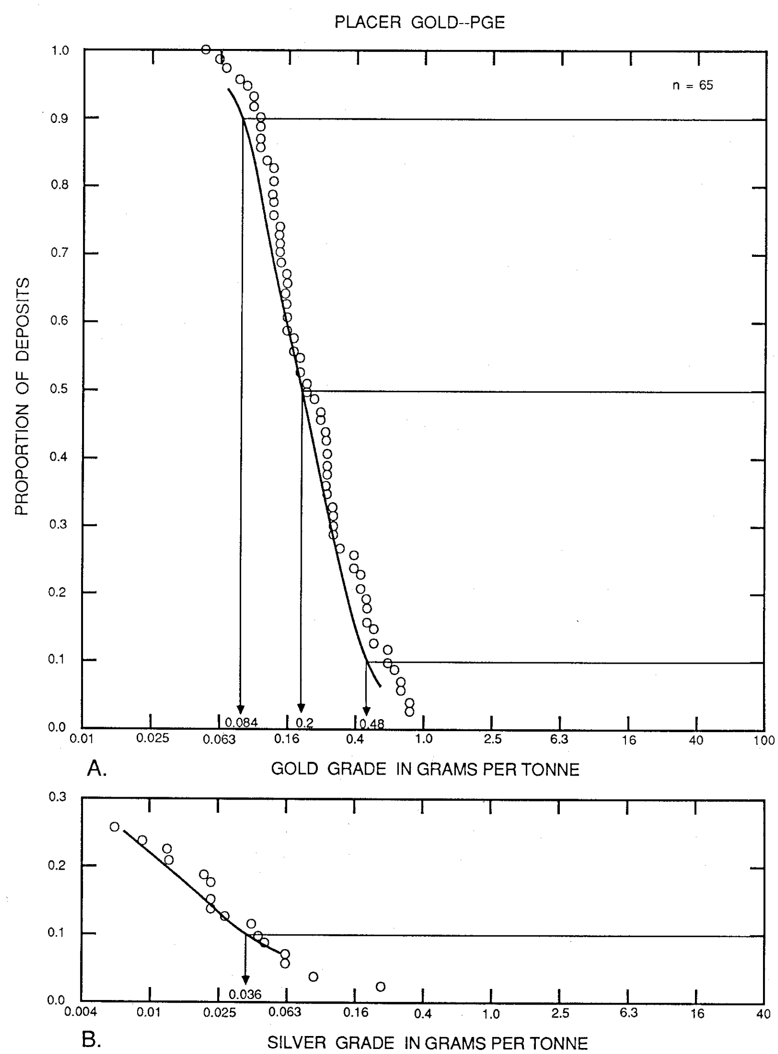


Figure 197. Precious-metal grades of placer Au-PGE deposits. A, Gold. B, Silver.

DESCRIPTIVE MODEL OF SHORELINE PLACER Ti

By Eric R. Force

DESCRIPTION Ilmenite and other heavy minerals concentrated by beach processes and enriched by weathering.

GENERAL REFERENCE Force (1976).

GEOLOGICAL ENVIRONMENT

Rock Types Well-sorted medium- to fine-grained sand in dune, beach, and inlet deposits commonly overlying shallow marine deposits.

Age Range Commonly Miocene to Holocene, but may be any age.

Depositional Environment Stable coastal region receiving sediment from deeply weathered metamorphic terranes of sillimanite or higher grade.

Tectonic Setting(s) Margin of craton. Crustal stability during deposition and preservation of deposits.

DEPOSIT DESCRIPTION

Mineralogy Altered (low Fe) ilmenite ± rutile ± zircon. Trace of monazite, magnetite, and pyroxene; amphibole rare or absent. Quartz greatly exceeds feldspar.

Texture/Structure Elongate “shoestring” ore bodies parallel to coastal dunes and beaches.

Ore Controls High-grade metamorphic source; stable coastline with efficient sorting and winnowing; weathering of beach deposits.

Weathering Leaching of Fe from ilmenite and destruction of labile heavy minerals results in residual enrichment of deposits.

Geochemical and Geophysical Signature High Ti, Zr, REE, Th and U. Gamma radiometric anomalies resulting from monazite content. Induced-polarization anomalies from ilmenite.

EXAMPLES

Green Cove Springs, USFL	(Pirkle and others, 1974)
Trail Ridge, USFL	(Pirkle and Yoho, 1970)
Lakehurst, USNJ	(Markiewicz, 1969)
Eneabba, AUWA	(Lissiman and Oxenford, 1973)

GRADE AND TONNAGE MODEL OF SHORELINE PLACER Ti

By Emil D. Attanasi and John H. DeYoung, Jr.

COMMENTS Grade and tonnage estimates represent mining units rather than individual lenses. Grades are represented as percent TiO_2 from rutile, ilmenite, leucoxene, percent ZrO_2 from zircon, and percent rare-earth oxides from monazite. Zircon is correlated with rutile (r = 0.49, n = 50), ilmenite (r = 0.58, n = 52), leucoxene (r = 0.55, n = 24), and monazite (r . 0.55, n = 29). Ilmenite is correlated with leucoxene (r = 0.66, n = 24) and with monazite (r = 0.66, n = 29). See figs. 201-205.

DEPOSITS

Name	Country	Name	Country
Agnes Waters	AUQL	Boulougne-Folkston	USFL
Barrytown	NZLD	Bridge Hill Ridge	AUNS
Birchfield	NZLD	Brunswick-Altamaha	USGA
Bothaville-Wolmaransstad	SAFR	Camaratuba	BRZL
		Capel Shoreline	AUWA

Carolina	SAFR
Charleston-B	USSC
Charleston-C	USSC
Charleston-I	USSC
Charleston-K	USSC
Charleston-L	USSC
Charleston-N	USSC
Cumberland Island	USGA
Curtis Island	AUQL
East Rosetta	EGPT
Eneabba Shoreline	AUWA
Evans Head-Wooli area	AUNS
Fraser Island	AUQL
Gingin Shoreline	AUWA
Gladstone Mainland	AUQL
Green Cove Springs	USFL
Highland-Trail Ridge	USFL
Hilton Head Island	USSC
Hokitika North	NZLD
Hokitika South	NZLD
Inskip Point (Cooloola area)	AUQL
Jacksonville Area	USFL
Karamea	NZLD
Lakehurst (Glidden)	USNJ
Manavalakurichi	INDA
Manchester (Asarco)	USNJ
Moreton Island	AUQL
Munbinea Shoreland	AUWA
Munmorah	AUNS
Muriwai	NZLD
N.L. Industries (Aurora)	USNC
N. Stradbroke Island	AUQL
Natchez Trace State Park	USTN
North Camden (Keer-McGee)	USTN
Oak Grove (Ethyl)	USTN
Orissa (Chatrapur)	INDA
Poerua River	NZLD
Pulmoddai	SRIL
Quilon (Chavara)	INDA
Richards Bay	SAFR
Ross	NZLD
Scott River	AUWA
Ship Island	USMS
Silica Mine	USTN
Stockton Bight	AUNS
Tuncurry-Tomago area	AUNS
Waiho River	NZLD
Waroona Shoreline	AUWA
Westport	NZLD
Yoganup Shoreline	AUWA
Yulee	USFL

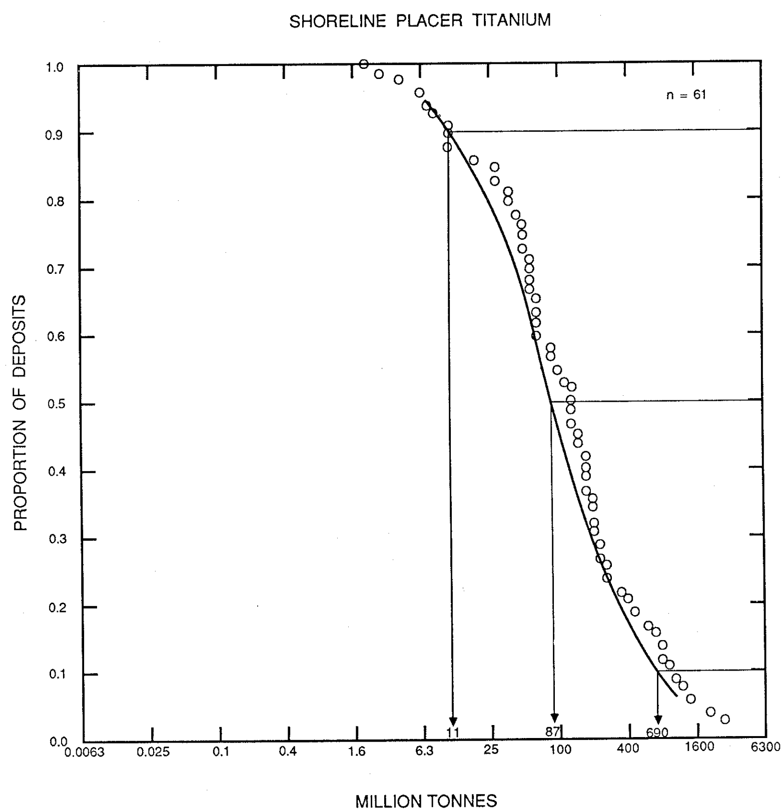


Figure 201. Tonnages of shoreline placer Ti deposits.

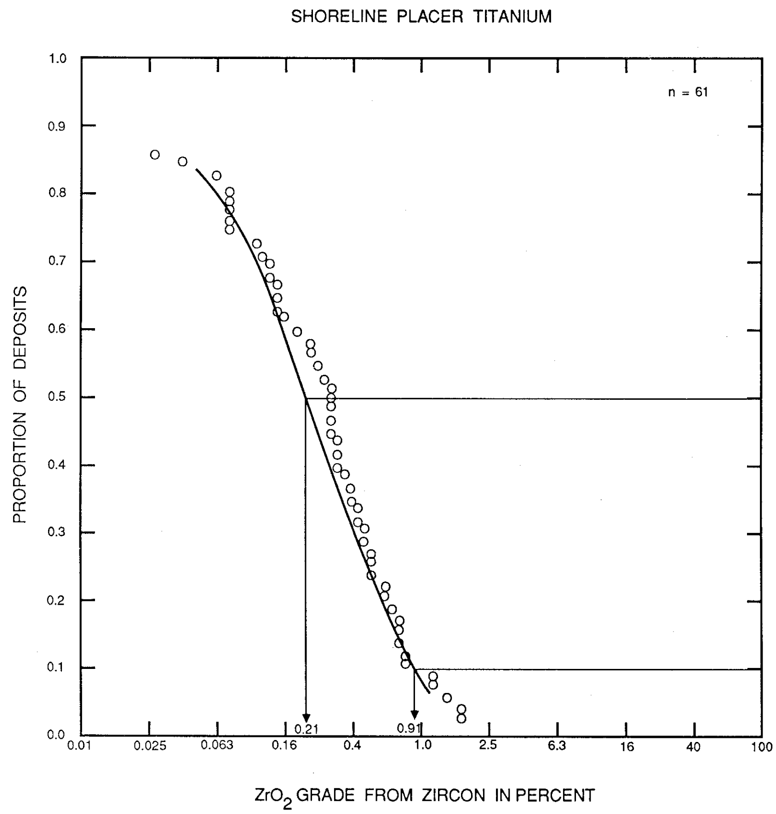


Figure 202. ZrO_2 grades from zircon in shoreline placer Ti deposits.

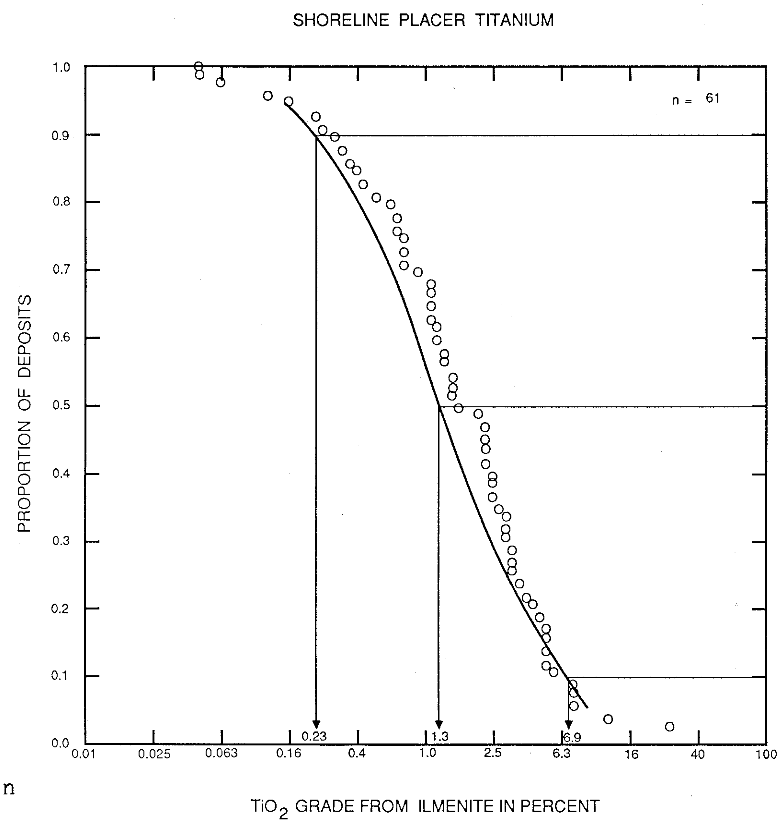


Figure 203. TiO_2 grades from ilmenite in shoreline placer Ti deposits.

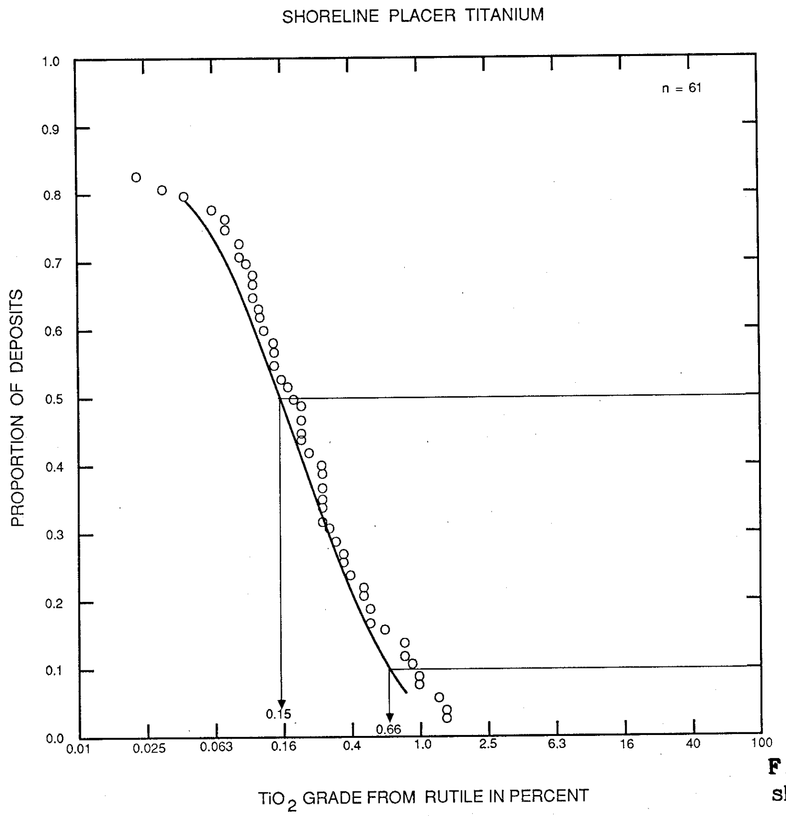


Figure 204. TiO_2 grades from rutile in shoreline placer Ti deposits.

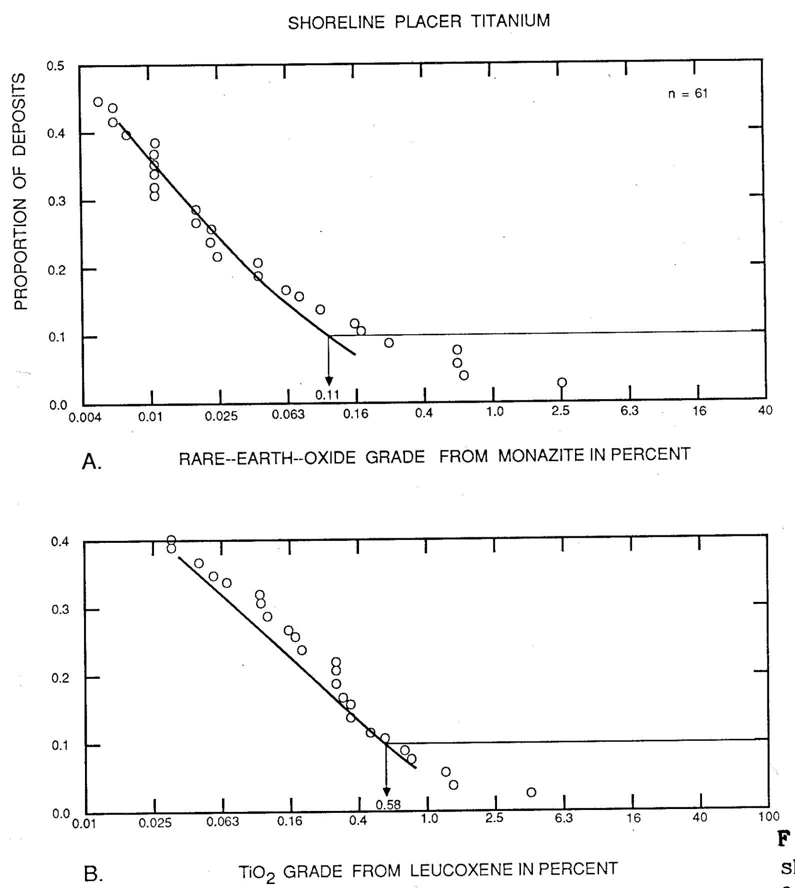


Figure 205. Other metal grades of shoreline placer Ti deposits. A, REE oxide from monazite. B, TiO_2 from leucoxene.