

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 + pyrrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore)--pyrite + chalcopyrite ± sphalerite ± pyrrhotite ± 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

<u>Name</u>	<u>Country</u>	<u>Name</u>	<u>Country</u>
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-Cakmakaya	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	Brunswick 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	Gjersvik	NRWY
Chisel Lake	CNMN	Golden Grove	AUWA
Clinton	CNQU	Goodenough	CNMN
Conception	SPAN	Gray Eagle	USCA
Conigo	CNQU	Green Coast	CNON
Copper Crown	CNBC	Greens Creek	USAK
Copper George	AUWA	Gullbridge	CNNF
Copper Hill	USCA	Hacan	TRKY
Corbet	CNQU	Half Mile Lake (SG)	CNMN
Coronation	CNSK	Halliwell	CNQU
Crandon	USWI	Hanaoka (Doy.-Tsut.)	JAPN
Cronin	CNBC	Hanaoka (Mats.-Sha.)	JAPN
Cueva de la Mora	SPAN	Hanawa (Aket.-Osak.)	JAPN
Cupra D'Estrie	CNQU	Hanson Lake	CNSK
Cuprus	CNMN	Harkoy	TRKY
Davis	USMA	Heath Steele (A-C-D)	CNNB
Deer Isle	USME	Heath Steele (B)	CNNB
Delbridge	CNQU	Heath Steele (E-F)	CNNB
Despina	CNQU	Hercules	AUTN
Detour	CNQU	Herrerias	SPAN
Devils Elbow	CNNB	Hersjo	NRWY
Dickstone	CNMN	High Lake	CNNT
Don Jon	CNMN	Hixbar	PLPN
Double Ed	CNBC	Hoidal	NRWY
Dumagami	CNQU	Hood River	CNNT
Dumont Bourlamque	CNQU	Horne-Quemont	CNQU
Dunraine	CNQU	Hunter	CNQU
Duthie	CNBC	HW	CNBC
Dyce Siding	CNMN	Hyers Island	CNMN
Early Bird	USCA	Iron Dyke	USOR
East Sullivan	CNQU	Iron King	USAZ
Ego	CNON	Iron Mountain	USCA
Embury Lake	CNMN	Irsahan	TRKY
Emerson	USME	Iso-Magusi-New Insko	CNQU
Empire Le Tac	CNQU	Israil	TRKY
Errington	CNON	Iwami east	JAPN
Estacao	CNON	Iwami west	JAPN
Eulaminna	AUWA	Izok Lake	CNNT
Eustis	CNQU	Jabal Sayid	SAAR
F Group	CNON	Jakobsbakken	NRWY
Farewell Lake	CNMN	Jameland	CNON
Filon Sur-Esperanza	SPAN	Jerome	USAZ
Fjeldgruve	NRWY	Joanne	CNMN
FL & DH	CNMN	Joliet	CNQU
Flambeau	USWI	Josselin	CNQU
Flexar	CNSK	Joutel	CNQU
Flin Flon	CNMN	Kalkanli	TRKY
Fonnfjell	NRWY	Kam Kotia	CNON
Fox	CNMN	Kamitkita (Kominosawa)	JAPN
Freddie Wells	AUNS	Kankberg	SWDN
Fretais	PORT	Kedtrask	SWDN
Frotet Lake	CNQU	Kelly-Desmond	CNQU
Fukazawa	JAPN	Key Anacon	CNNB
Furuhaugen	NRWY	Keystone	USCA
Furutobe-Ainai	JAPN	Ketstone-Union	USCA
Gamle Folldal	NRWY	Khans Creek	AUNS
Garon Lake	CNQU	Khnaiguiyah	SAAR
Gaviao	PORT	Kidd Creek	CNON
Gelvenakko	SWDN	Killingdal	NRWY
George Copper	CNBC	Kimheden	SWDN
Ghost Lake	CNMN	Kittelgruvan	SWDN
Giken-Charlotta	NRWY	Kizilkaya	TRKY
Girilambone	AUNS	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 (1-5-1N-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
Matabi	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	Trinity	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

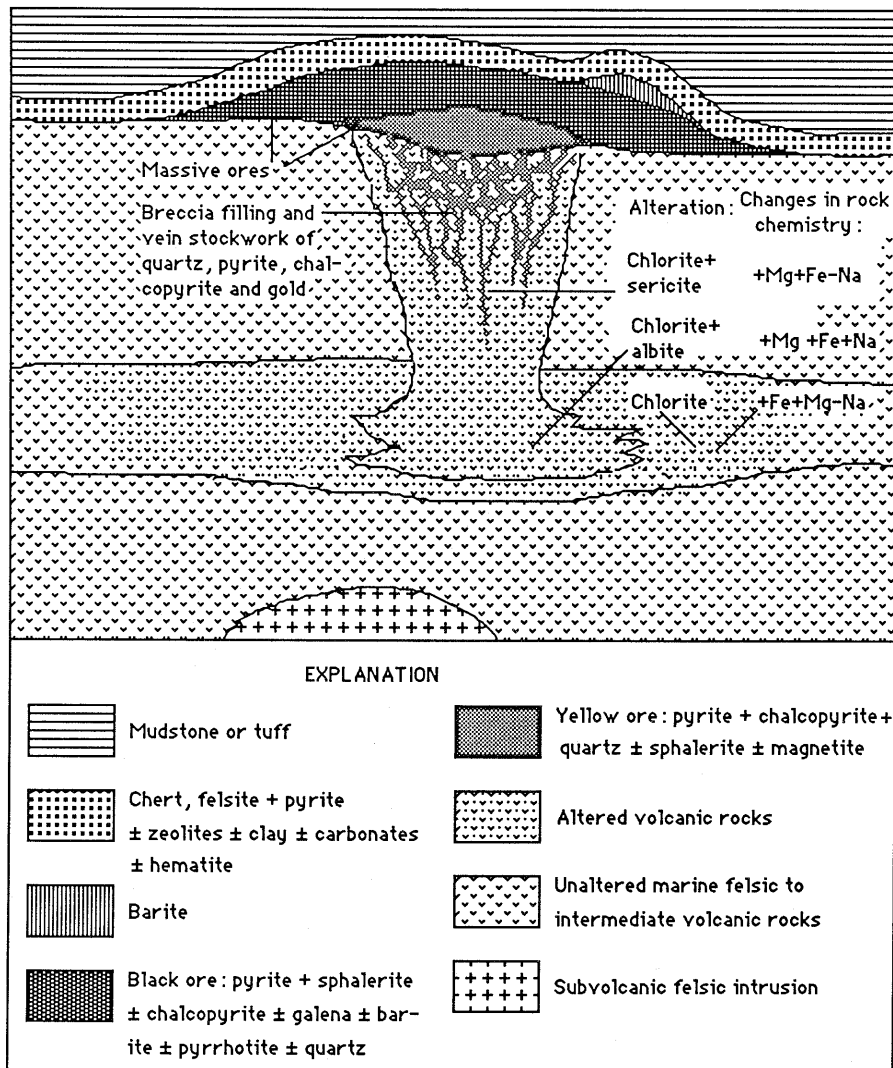


Figure 145. Cartoon cross section of kuroko massive sulfide deposit. Modified from Franklin and others (1981).

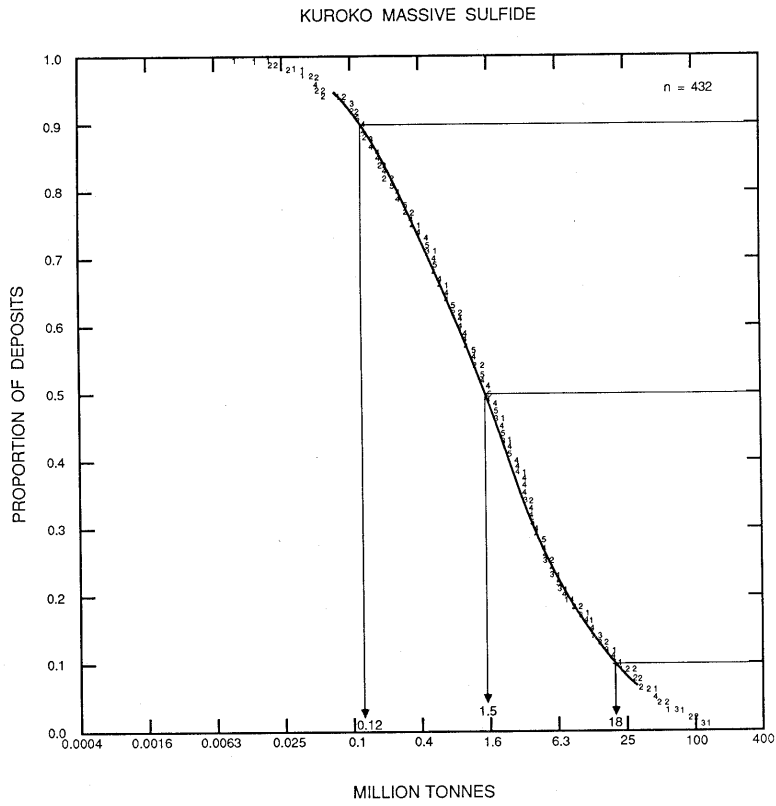


Figure 146. Tonnages of kuroko massive sulfide deposits. Individual digits represent number of deposits.

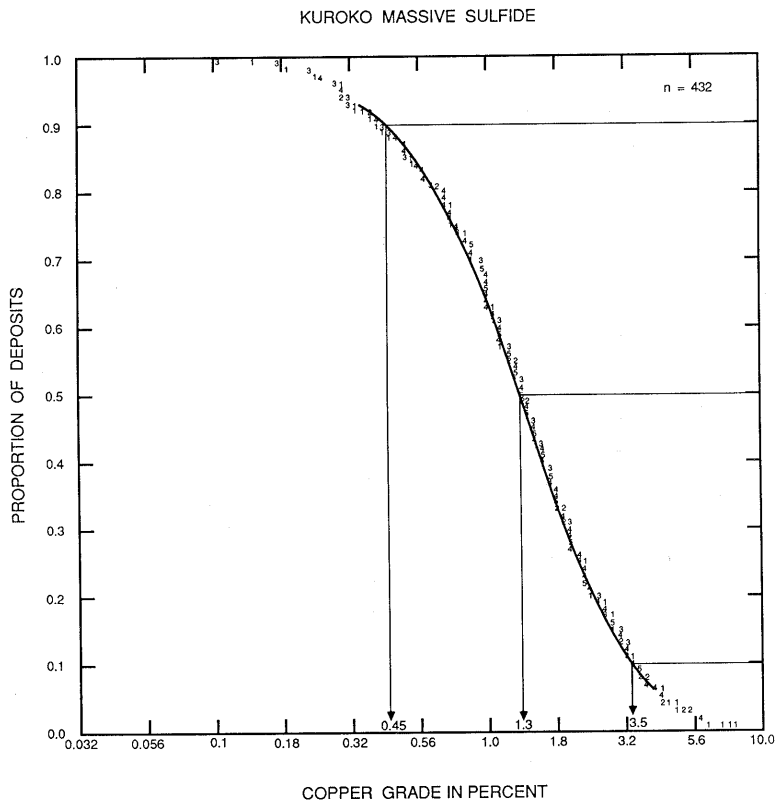


Figure 147. Copper grades of kuroko massive sulfide deposits. Individual digits represent number of deposits.

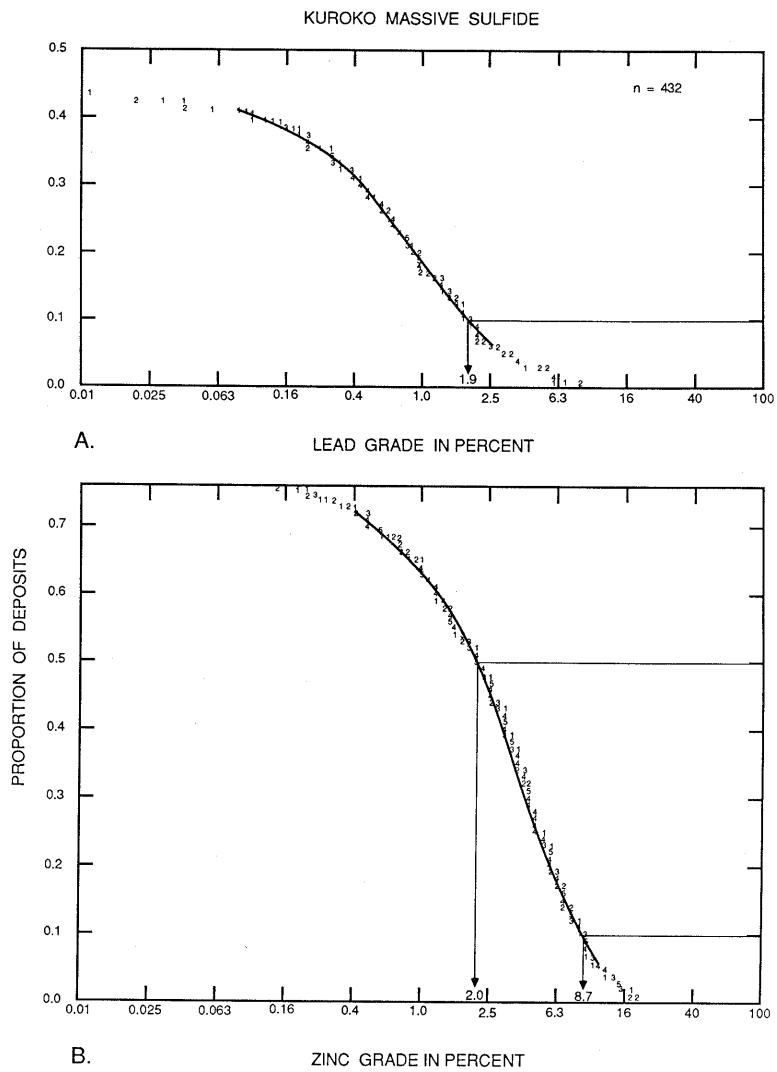


Figure 148. Lead-zinc grades of kuroko massive sulfide deposits. **A**, Lead. **B**, Zinc. Individual digits represent number of deposits.

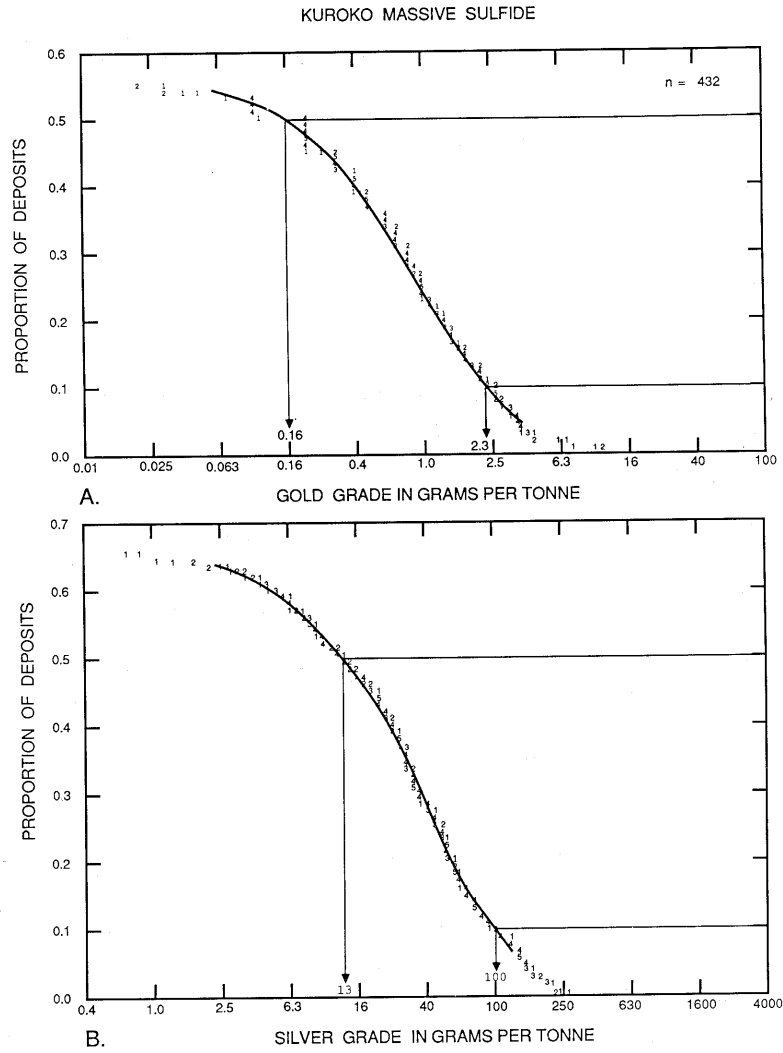


Figure 149. Precious-metal grades of kuroko massive sulfide deposits. **A**, Gold. **B**, Silver. Individual digits represent number of deposits.