Placer Mine Model for the Steese-White PMSES Study

Prepared by Thomas W. Camm

The model is based on using ~~hydraulic excavators~~ dozers to remove pay gravel. Dozers will be used to move pay gravel to the plant and overburden to the spoil pile. Front-end loaders will feed the plant. The model includes a sluice plant for primary treatment with tabling of sluice concentrates for final cleanup (fig. 1). Two settling ponds will be required. Used equipment costs were used for this study.

To allow for the unique conditions of Alaska, a capital cost factor of 2.3 was used, and a labor adjustment factor of 1.412 (Bottge, 1986). The mines operate 12 h/d, 100 d/yr, plus 2 weeks preparation prior to mining for overburden removal and site preparation. Initially, it has been assumed 50% of rock moved is non-paying overburden; however, later in the discussion, a factor will be given which allows costs to be adjusted for depth and thus, percent waste.

Given these resource tonnages and capacities, a general capacity relationship has been determined.

$$\text{Capacity (LCY/h)} = 0.1814(\text{Tpg})^{0.4429}$$

where LCY/h = loose cubic yards per hour

and Tpg = Resource in metric tons pay gravel

The life of a prospective operation can also be determined from this relationship by dividing the annual capacity in metric tons into the total resource.

$$\text{Life} = \text{Tpg}/[0.1814(\text{Tpg})^{0.4429}100(12)(1.342)]$$

$$= [(\text{Tpg})^{0.5571}]/292.13$$

Costs were generated using the 'Cost Estimating Handbook for Small Placer Mines,' BuMines OFR 17-87. Escalation factors were applied to express all costs in January 1987 dollars. Deposit sizes of 27,000, 134,000, 805,000, 2,684,000, and 13,420,000 mt were used for the evaluation. Corresponding plant capacities of 20, 25, 75, 150, and 250 LCY/h were evaluated to generate the model. The mine life varies from one season for 27,000 mt to 29 yr for deposits of 13,420,000 mt.

Using these parameters, capital and operating costs were generated for each of the five capacities. Each of these costs then had to be analyzed and divided into capital and operating costs for both mining and milling. These four subcategories were then divided among the following individual cost categories: labor, equipment, steel, fuel, and construction materials. These individual costs were then evaluated using regression analysis, and the final 17 equations in table 1 were developed. Each of these equations is based on moving an equal amount of pay gravel and overburden. For circumstances where a higher stripping ratio is expected, the depth factor must be applied.

The mine and mill capital and operating costs are summarized in table 1. All costs are in January 1987 dollars.

TABLE 1. - Placer model cost equations

Category	Mine capital cost, \$	Mill capital cost, \$	Mine operating cost, \$/mt	Mill operating cost, \$/mt
Labor............	$299.6(X)^{0.3413}$	$2,745.9(X)^{0.2578}$	$277.7(X)^{-0.4173}$	$30.457(X)^{-0.2400}$
Equipment........	$11,871.2(X)^{0.2729}$	$11,861.0(X)^{0.2220}$	$5.449(X)^{-0.2105}$	$1.633(X)^{-0.0938}$
Steel............	$0.300(X)^{0.5281}$	$7.727(X)^{0.2207}$	-	-
Fuel............	$2.718(X)^{0.5276}$	$147.2(X)^{0.2804}$	$9.631(X)^{-0.2405}$	$1.186(X)^{-0.1059}$
Construction materials.	$6.308(X)^{0.4192}$	$1,476.3(X)^{0.2460}$	-	$0.184(X)^{-0.1909}$

X = Total resource in metric tons.

To convert \$/mt to \$/LCY, multiply operating cost x 1.342 mt/LCY.

Depth Factor

To account for varying amounts of overburden, a depth factor was developed for mine capital and operating cost curves. Similar adjustment to mill operating and capital costs has not been made as increased overburden removal while keeping pay gravel volume constant will have no affect on these costs.

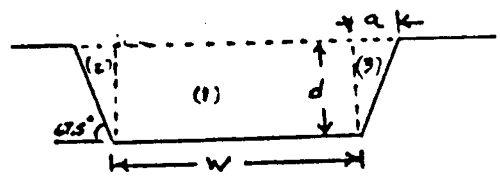
Volume of (1) = width x depth x length = $w \times d \times L$

Volume of (2) = $1/2\ a\ d = 1/2(d/2)d = (d^2/4) \times L$

Volume of (3) = same as (2) = $(d^2/4) \times L$

Volume of (2)+(3) = $2\ (d^2/4) \times L = (d^2/2) \times L$

Total volume = $(wd + d^2/2) \times L$



Assuming a constant average width in all cases of 100 ft,

$$\text{Volume} = (100d + d^2/2) \times L$$

To calculate length (L), we must know the size of the resource (Tpg). If we assume that the pay zone has a constant thickness of 10 feet and using a conversion factor of 1.53 mt/bcy, we can determine L by the following equation:

Tonnage (mt) of pay gravel (Tpg) = $(100 \times 10 \times L)\ (1.53\ \text{mt/bcy})/(27\ \text{ft}^3/\text{bcy})$

$= 56.7\ L$

L (in feet) = $Tpg/56.7$

Tonnage (mt) of overburden (Tov) = $(100d + d^2/2)(L)(1.53)/27\ \text{ft}^3/\text{bcy}$

$= (5.67\ d + 0.03\ d^2)(L)$

$\therefore$ Stripping Ratio (S) = mt overburden/mt pay gravel = Tov/Tpg

$S = (5.67d + 0.03\ d^2)(L)/Tpg$

where Tpg = deposit resource (T) in mt

TABLE 3. - Placer model cost equations with depth factors

egory	Mine capital cost, $	Mill capital cost, $	Mine operating cost, $/mt	Mill operating cost, $/mt
or............	$300.8(X)^{0.3413}(S)^{0.2432}$	$2{,}745.9(X)^{0.2578}$	$273.0(X)^{-0.4173}(S)^{0.0856}$	$30.457(X)^{-0.2400}$
ipment........	$11{,}693.1(X)^{0.2729}(S)^{0.7076}$	$11{,}861.0(X)^{0.2220}$	$5.269(X)^{-0.2105}(S)^{0.4739}$	$1.633(X)^{-0.0938}$
el............	$0.302(X)^{0.5281}(S)^{0.2670}$	$7.727(X)^{0.2207}$	-	-
l............	$2.734(X)^{0.5276}(S)^{0.2670}$	$147.2(X)^{0.2804}$	$9.323(X)^{-0.2405}(S)^{0.4565}$	$1.186(X)^{-0.1059}$
struction erials.	$6.308(X)^{0.4192}$	$1{,}476.3(X)^{0.2460}$	-	$0.184(X)^{-0.1909}$

Stripping ratio.
Total resource in metric tons.

convert $/mt to $/LCY, multiply operating cost x 1.342 mt/LCY.

References

Bottge, R. Company Towns Versus Company Camps in Developing Alaska's Mineral Resources. BuMines IC 9107, 1986, 19 pp.

Cox, D. P., and D. S. Singer (ed.). Mineral Deposit Models. U.S. Geol. Suv. Bull. 1693, 1986, 379 pp.

Stebbins, S. A. Cost Estimation Handbook for Small Placer Mines. BuMines OFR 17-87, 1987, 130 pp.

Appendix - Manpower, Fuel & Acreage requirements

MANPOWER

Using the operating cost equations for mining and milling labor, calculate Y_0 in \$/mt.

\# workers = 1.342(\$/mt) x (lcy/hr) / \$22.15/hr(mine)
\$22.03/hr(mill)

where lcy/hr capacity = $0.1814(T_{pg})^{0.4429}$
T_{pg} = tons pay gravel in deposit

FUEL

Assume 90% of fuel category is for fuel, and the other 10% for lube and misc. Using the operating cost equations for mining and milling fuel cost, calculate Y_0 in \$/mt.

\# gallons of fuel required = (\$/mt) x T_{pg} / (\$2.14/gal)

where T_{pg} = tons pay gravel in deposit
\$/mt = Y_0 for fuel costs
\$2.14/gal = assumed cost of fuel at site

ACREAGE

To calculate acreage disturbed, use the depth factor equations:

Area (acres) = [(w + d) x L x 1.5] / (43,560ft^2/acre)

where w = width of pay gravel (ft)
d = depth of overburden (ft)
L = length of pay gravel zone (ft) = T_{pg}/56.7 (from depth factor)
T_{pg} = tons pay gravel
1.5 = increase area 50% to account for spoil piles, mill site, and settling ponds

To convert acres to hectares, multiply Area (acres) x 0.405 hectares/acre

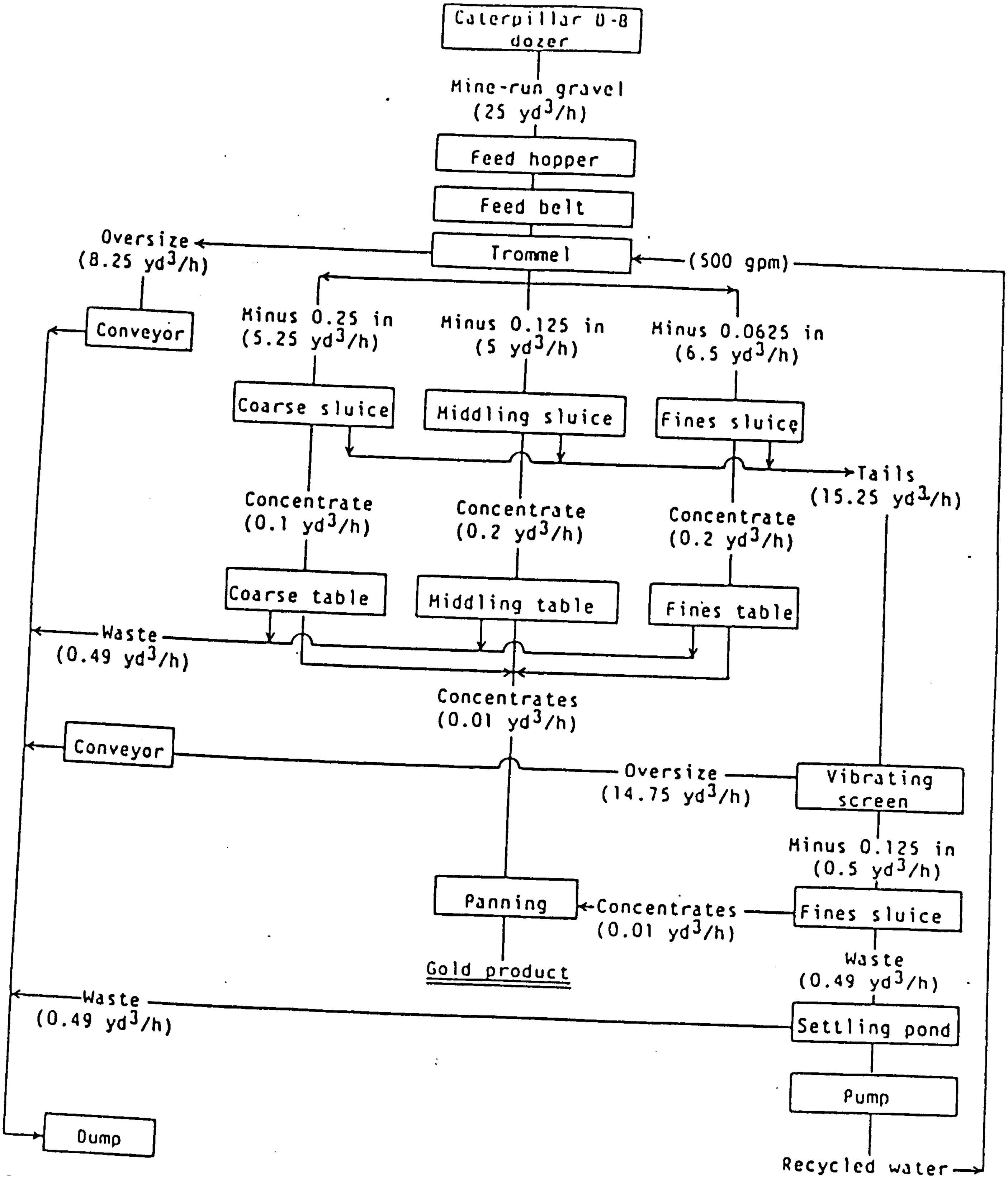


FIGURE ~~3~~ 1. - Sample flow sheet, table plant.

 (From Stebbins, 1987)

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 clastic.

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 luded in this model are those primarily cataloged as desert placers, pre-Tertiary or Tertiary 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
ong 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
Colden Rule	USID	Sumpter Bar	USOR
River	USUT	Swan River	USCO
Praire	USMT	T93-R77W Placer	USCO

Vermilion River	USMT	Wombat Creek	AUNS
Wellington	AUNS		

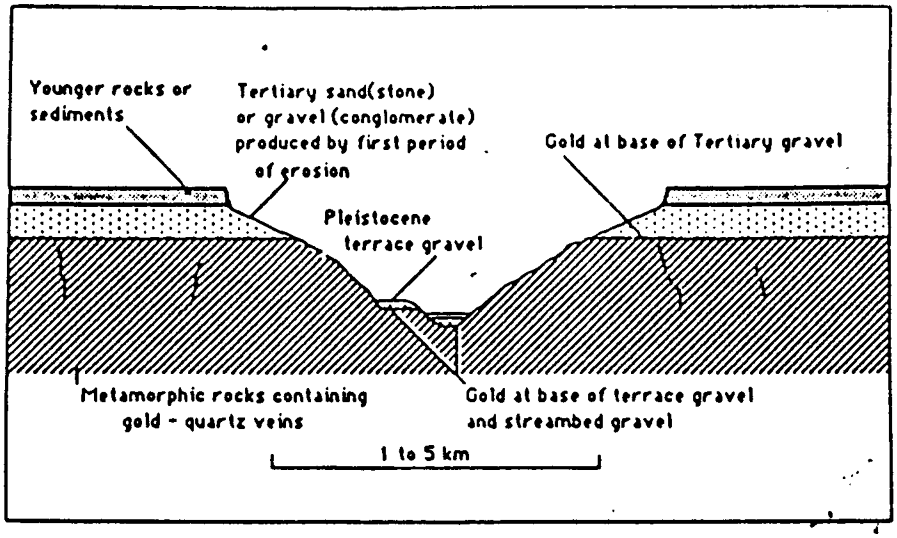


Figure 195. Cartoon cross section showing three stages of heavy mineral concentrations typical of placer Au-PGE deposits.

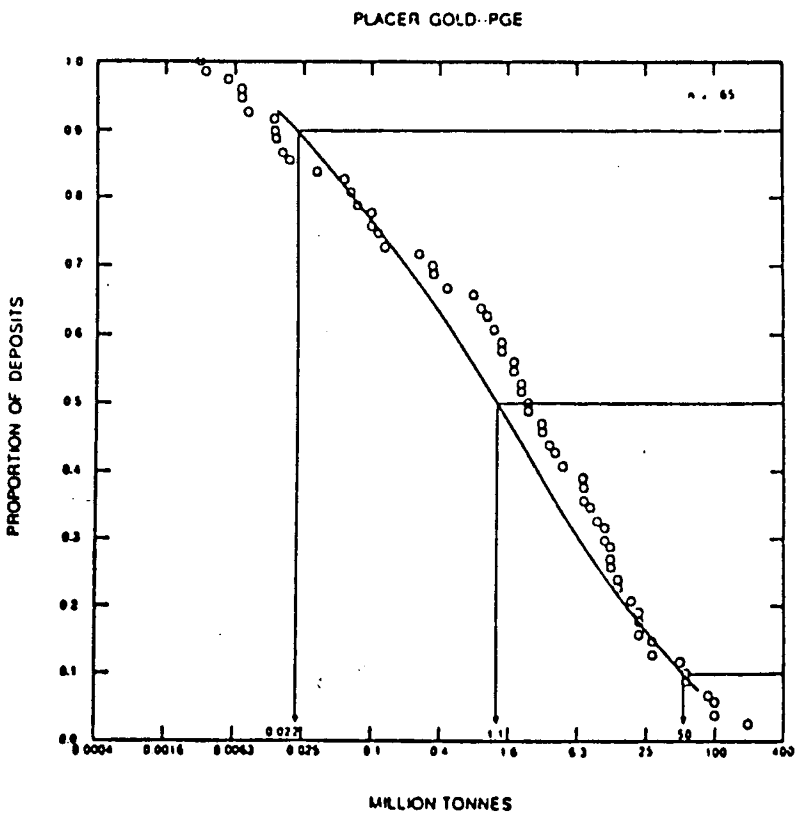


Figure 196. Tonnages of placer Au-PGE deposits. Individual digits represent number of deposits.

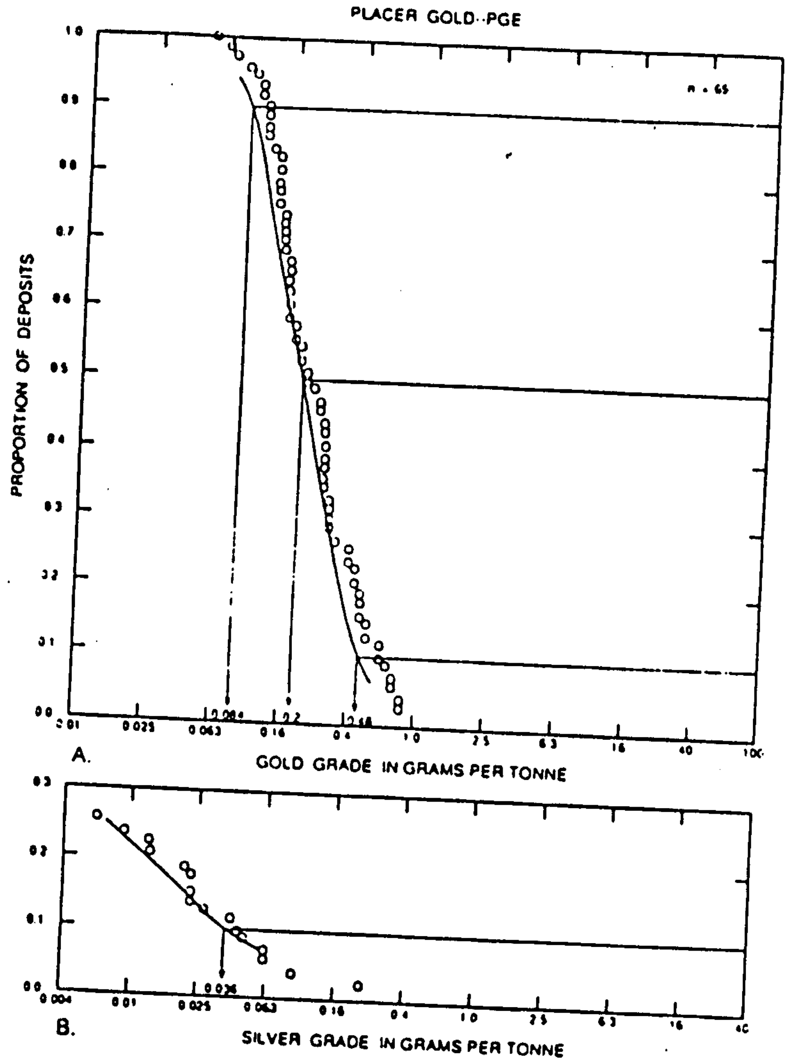


Figure 197. Precious-metal grades of placer Au-PGE deposits. A, Gold. B, Silver.