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NEVADA ALLUVIAL GOLD MINING

Introduction

In all of history, 100,000 metric tons of gold has been mined, over half of it in this century, representing a solid cube of gold just less than 20 x 20 x 20 m.

Over one-third of this gold was mined in South Africa, about one-fifth in the Soviet Union, and one-tenth in the United States. There is some indication that the Soviet Union has become, or is close to becoming, the largest producer of gold in the World.

Historically, the largest producers of gold in the United States are:

State	Tons of gold
California	3300
Colorado	1300
South Dakota	1100
Nevada	1000
Alaska	900
Utah	600
Montana	500

Nevada is now the largest gold producing state in the U.S.A. The most productive bedrock (lode) mines in the U.S. have been:

Mother Lode) Grass Valley)	California
Homestake	South Dakota
Comstock Lode) Goldfield) Carlin, Cortez, etc.)	Nevada
Cripple Creek	Colorado
Fairbanks, Nome	Alaska

Historically (1849-presentdate), U.S. gold production has come from:

Lode gold mines	50%
Alluvial mines	35%
By-product	15%

In 1978, the source of newly mined gold was:

Lode	60%
By-product	29%
Alluvial	1%

Three lode mines produce 66% of the gold mined in the United States today:

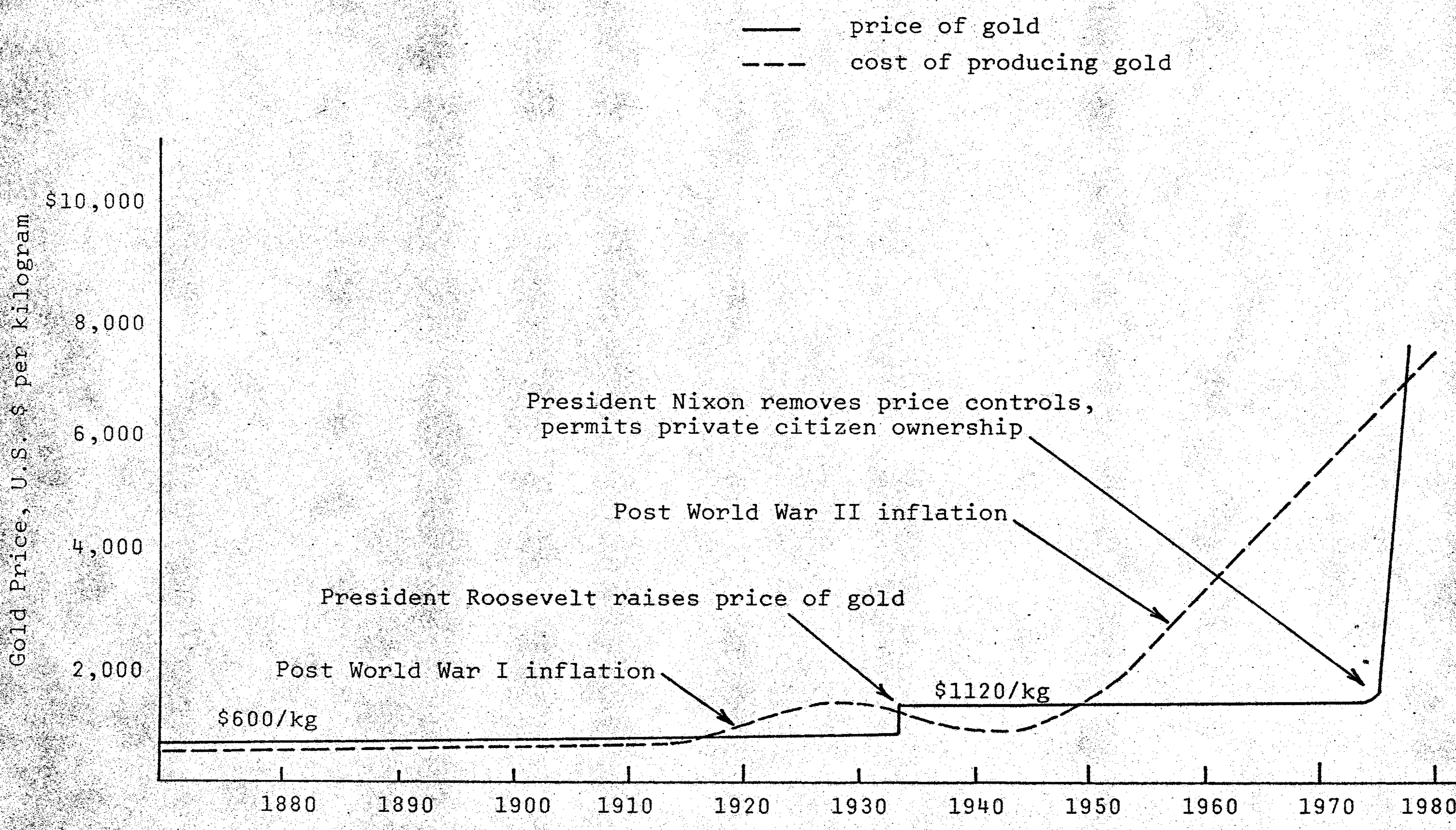
1. Carlin, Nevada (disseminated gold)
2. Homestake, South Dakota (veins)
3. Bingham, Utah (open-pit copper mine)

The Homestake mine was not profitable to operate during the 1950's and 1960's, because of the government-controlled gold price of the post World War II period (see Graph on following page). The rich epithermal veins of gold and gold-silver, so productive in the last century, can no longer be operated at a profit, for they do not lend themselves to mechanical mining methods. The Comstock Lode, 30 km southeast of Reno, which produced over 30 tons of gold and 800 tons of silver, is not being mined today.

The many gold dredging operations, shut down during World War II, could not be profitably re-opened because of inflated operating costs. When gold passed the $7 per gram ($200 per Troy ounce) price a year ago, interest was shown, but there are two very serious problems today; (1) concern for the environment, and (2) the difficulty in obtaining the capital needed for land acquisition, development, and the design and construction of a dredge.

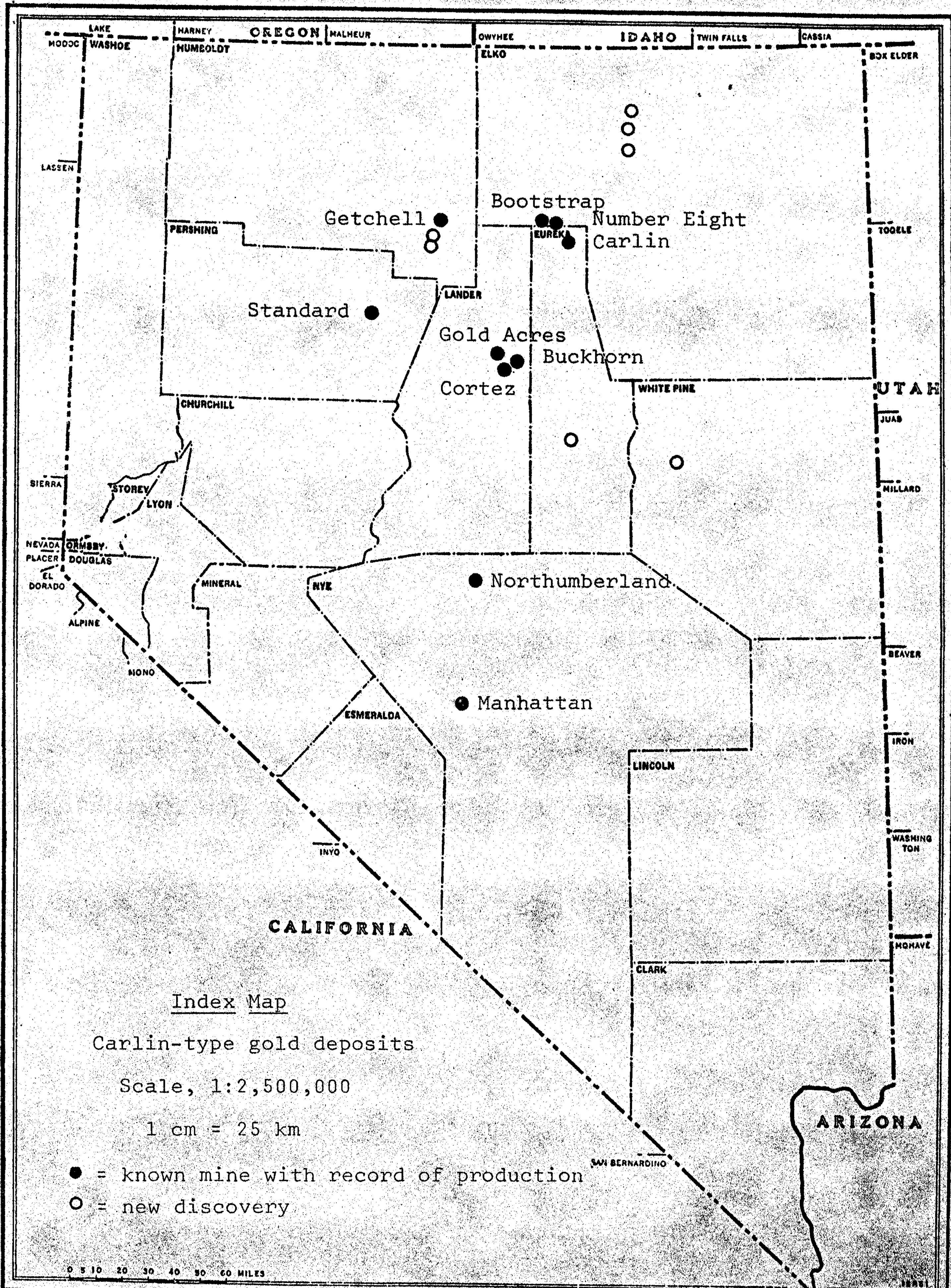
<u>"Carlin" type bedrock mineralization</u>

About ten years ago the "Carlin" type of bedrock gold mineralization became recognized, offering an exploration target of a bulk-mineable ore easily treated by cyanidation. New discoveries of this kind of ore continue to be made using a combination of geologic (structural-stratigraphic) and geochemical (rock chip samples analyzed by atomic absorption spectrophotometry) methods. The conceptual mode of occurrence for this type of ore deposit is the work of Dr. R. J. Roberts, of the United States Geological Survey. These deposits, at present gold prices, can be mined at 1 to 4 grams of gold/ton in the 10 to 100 million ton size range. These deposits promise to become even more important in the near future, as from 4 to 6 new discoveries are now being drilled out and put through ~~the~~ preliminary feasibility analysis, as shown on Map 1.



GRAPH

<u>The Last Century of Gold Pricing in the U.S.</u>



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Carlin-type gold deposits

Scale, 1:2,500,000

1 cm = 25 km

● = known mine with record of production

○ = new discovery

Alluvial gold

Most U.S. gold experts today consider a significant new gold mine development as one capable of producing at least 3 to 5 tons of metal. Reference to Map 2 on the following page will demonstrate that only a few of Nevada's 60 alluvial gold districts can be said to be significant by this definition:

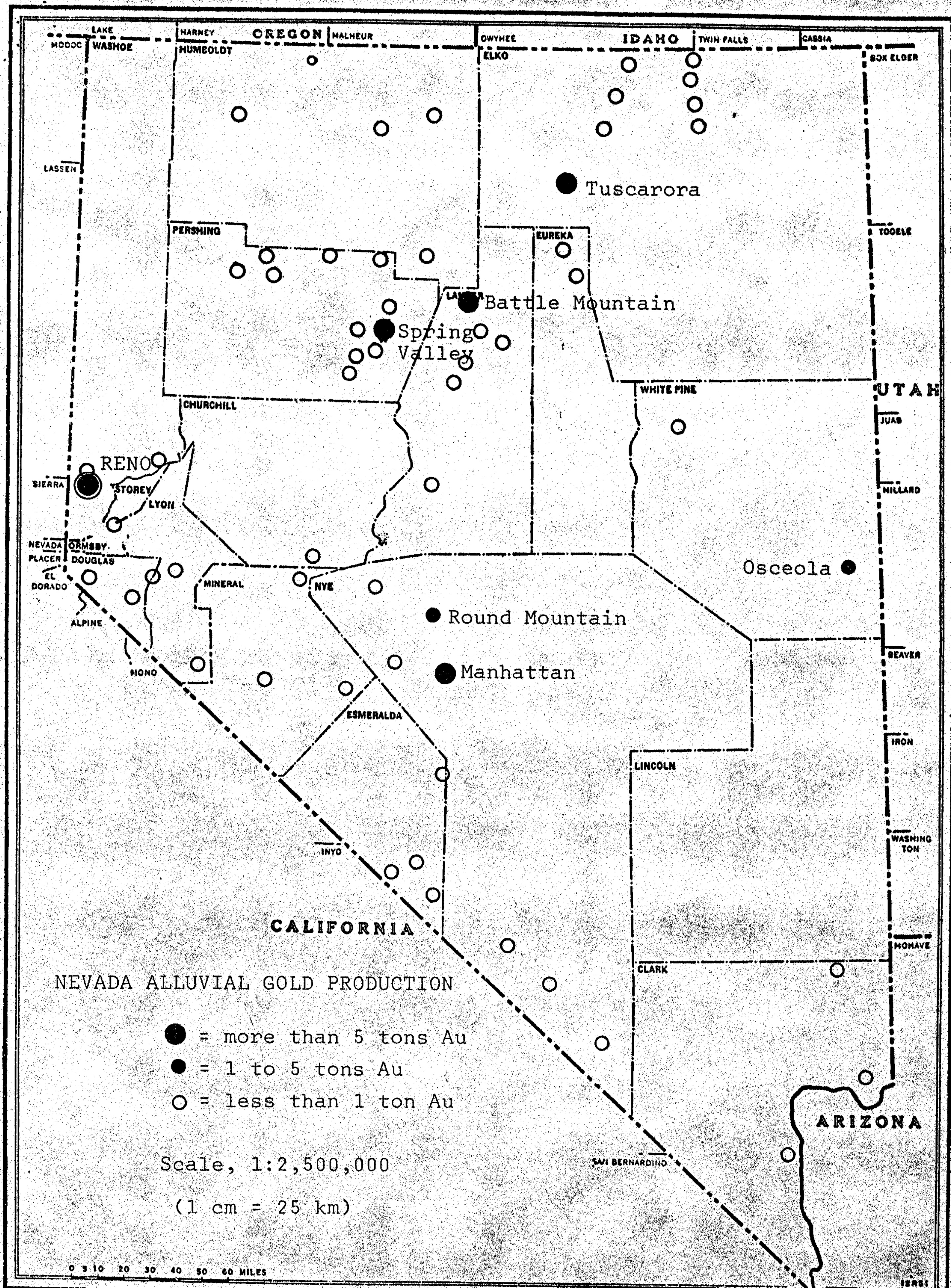
Spring Valley	10 t Au
Tuscarora	7
Battle Mountain	5
Manhattan	3
Round Mountain	2
Osceola	1

Nevada alluvial gold can usually be proven to be derived from one of four bedrock gold sources:

1. Carlin-type disseminated gold ores
2. Gold in porphyry copper deposits
3. Gold in "volcanigenic" or "massive sulphide" ores
4. Epithermal gold and gold-silver vein in volcanics

Surprisingly, the epithermal gold and gold-silver veins rarely result in important alluvial gold deposits. Many such districts, as at Aurora, have absolutely no record of alluvial gold production. The most favorable bedrock source is apparently the Carlin-type of gold mineralization.

Nevada's present climate is not conducive to the formation of alluvial gold, conditions are too cold and dry to weather mineralized terrains deeply, so as to decompose sulphides and other primary minerals and liberate the gold. The relatively warm and humid conditions favoring such decomposition occurred during several epochs of the Paleogene (65 to 25 million years ago). During such periods of warmth and moisture, deep soils and heavy vegetation developed. The roots of such vegetation have been found to have the remarkable ability to adjust pH, to develop cyanide and other solvents at the root-tip, and to adjust membranes in the root wall so as to selectively admit or reject nutrients or toxics. In this fashion, large gold nuggets form literally at the "grass roots" as described in many ancient accounts.


OREGON
IDAHO
UTAH
ARIZONA
CALIFORNIA
LAKE
MODOC
WASHOE
HARNEY
HUMBOLDT
MALHEUR
OWYHEE
ELKO
TWIN FALLS
CASSIA
BOX ELDER
LASSEN
TOOELE
PERSHING
EUREKA
LANDER
CHURCHILL
WHITE PINE
JUAB
MILLARD
SIERRA
STOREY
LYON
NEVADA
ORMSBY
PLACER
DOUGLAS
EL DORADO
ALPINE
MINERAL
NYE
MONO
BEAVER
ESMERALDA
IRON
LINCOLN
WASHINGTON
INYO
MOHAVE
CLARK
SAN BERNARDINO
Tuscarora
Battle Mountain
Spring Valley
RENO
Osceola
Round Mountain
Manhattan
NEVADA ALLUVIAL GOLD PRODUCTION
= more than 5 tons Au
= 1 to 5 tons Au
= less than 1 ton Au
Scale, 1:2,500,000
(1 cm = 25 km)
0 5 10 20 30 40 50 60 MILES

MAP 2

Following warm and moist epochs, the climate may shift to cold, dry conditions. Vegetation dies, and the flash-flood conditions characteristic of the desert return. As floods recur, soil and contained gold is swept into adjacent depressions, where the gold is concentrated by the fluvial process, forming an alluvial gold deposit. Many such cycles of weathering and erosion formed Paleogene auriferous gravels that can be found today near areas of bedrock mineralization. Most modern alluvial gold deposits, those related to present topography and climate, can be proven to result from re-working these ancient Paleogene gravels. In this manner, relatively small amounts of gold from extensive mineralized bedrock terrains can result in large, rich alluvial deposits containing large gold nuggets.

The terminology of desert placers reflects the genetic processes just outlined.

Eluvial deposits.--Eluvial deposits lie immediately over or just downhill from the primary source of the gold. They may consist of coarsely fragmented, unsorted material. Eluvial deposits are usually developed in response to modern climatic conditions, and are rarely of economic importance. Much attention has been devoted to them because of the Spanish explorer's idea that every "placer" would lead to a "veta madre" (mother lode).

Alluvial deposits.--Alluvial gold deposits result when earlier Eluvial deposits, or adjoining Paleogene auriferous gravels are washed in a modern stream bottom (American = Creek; Spanish = Arroyo). In the desert, such stream beds flow water only intermittently. Multiple stages of flooding wash the alluvium, so that gold concentrates in important quantities. Arroyo alluvial deposits may be buried under younger alluvium that contains little or no gold.

Bajada.--Bajada deposits (called "proluvial" by Europeans") are so-named by the early Spanish explorers of the southwest. Bajada is the name for sloping fan-like gravel deposits at the mouth of the arroyos where they discharge into the intermontane basins of the region. Bajada deposits represent the coarse alluvial debris swept down from the mountains, through the arroyos, and deposited at the edge of the valley as the stream gradient flattens and the energy of the system is correspondingly reduced. During exceptionally powerful floods, nothing is large enough or heavy enough to resist the force of the flood, and the gold of arroyo alluvial deposits is carried out in a slurry of mud, sand, and boulders. The finer silt and mud is washed on out into a "playa" lake beyond, the word in Spanish for beach-- reference to the dry condition of the entire system most of the time. Bajada deposits are characterized by variation in the size of nuggets, and by the large size of some of the nuggets found. Individual nuggets in the range 10 to 100 kg have been found in desert alluvial deposits of the American Southwest, Mexico, Australia, etc. Bajada deposits are immediately buried beneath normal gravels, usually barren of gold.

Dredging at the mouths of large streams and rivers in California was on deposits formed in an environment analagous to the desert bajada, but formed under relatively quiet fluvial conditions, resulting in larger, more uniform deposits of lower grade.

Exploration for Alluvial Gold

Exploration of known or suspected new alluvial gold depositsshould employ every modern geological tool. Geophysical and geochemical methods are little used. Of particular value are geomorphological studies utilizing large scale aerial photographs, 1:5000 to 1:10000, upon which can be plotted features of paramount interest such as old terraces, meanders and bends, etc. These photographs can be used in the preparation of a photogrammetric topographic map, for example by the Kelsh method on a scale of 1:1000 to 1:2000, contour interval 1 to 5 m. Such detailed topographic maps are invaluable in dredge design work and dredge pond lay-out.

Exploration Drilling

Most serious exploration of alluvial deposits in the U.S. is done by drilling vertical holes through the gravel into bedrock. The largest possible diameter drill should be used, and samples collected on short intervals. My present practice is to use Reverse Circulation Rotary drilling, with a drill pipe almost 15 cm in diameter. A separate sample is collected for each meter of advance, producing a sample volume of about 1/100th of a cubic meter of gravel in place.

An idea of the problems introduced by small-diameter drill holes can be gained by observing that only one milligram of gold obtained in the 15 cm diameter x 100 cm sample is indicative of 100 mg of gold per cubic meter of gravel or U.S.$1/m^3 at todays gold price. If a smaller diameter hole is used, there is too much danger of recovering a slightly larger-than-average gold particle-- throwing calculations completely off. Desert alluvial deposits are notoriously inhomogenous-- small drill samples are to avoided in evaluation of these deposits.

Some experts drill alluvial ground by putting down rows or "fences" of drill holes 50 m apart along rows spaced 200 m apart, positioned so that the fences are perpendicular to the suspected trend of the deposit. Others prefer to drill rectangular, square, or triangular patterns so that some such hole density as one drill per hectare is acheived.

Drill Hole Sampling

Because of the relatively rapid penetration rate of modern drills, there is a temptation to collect all of the sample from a drill hole as one large sample, which is washed down in a mechanical washing device, or a sluice, to save time. This technique should be avoided, for much of the geological information is lost, as well as engineering data needed in dredge design. Splitting of drill samples coming from the hole is another temptation to be avoided. Introduction of grease and oil should be closely guarded against, for fine gold can be floated away under these conditions.

Drill holes should be taken well into bedrock, one or two meters at least, for often the best gold values are trapped in the fracturing of the bedrock surface. Modern dredges will take this bedrock along with the gravel, and the free gold will recovered. The "pay" zone may lie on real bedrock, or on a "false" bedrock such as hard clay bed, and the sooner this is determined the better the relationship will be tested in drilling.

The method of washing the drill samples should correspond to the recovery method used on the dredge. For example, if fine gold in clay is not going to be recovered in the dredging operation, there is no point in careful breaking down the clay in the drill hole samples in order to liberate the gold.

Fire Assaying

Under no circumstances should fire assaying or wet analytical procedures be used in evaluation of alluvial samples. In desert alluvial deposits particularly, there is a tendency for the poorly abraded gold particles to be enclosed within or attached to fragments of relatively lightweight gangue such as quartz. The simple gravity methods of concentration employed in most gold washing cannot separate the gold from the buoyant gangue, and the particle may be washed right through the recovery system.

The only time assaying is done in alluvial evaluation work is in a check of the purity, or "fineness" of the gold. Many Nevada alluvial deposits contain electrum (the natural alloy of gold and silver). California deposits contain some base metal. This alloyed material is relatively worthless, and reduces the value of the nuggets and fine gold. After about 100 mg of gold has been washed from the drill samples, it should be sent to a gold refinery for precise analysis and determination of purity. This figure is necessary for calculations from the very earliest stages of evaluation, and estimates can be misleading, particularly in work in a new district.

Reno, Nevada
11 March 79

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