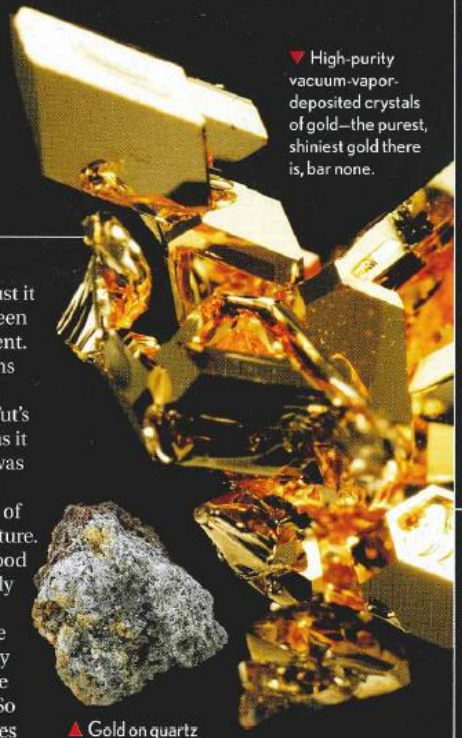
Gold

Au

79

Gold



▼ High-purity vacuum-vapor-deposited crystals of gold—the purest, shiniest gold there is, bar none.

▲ Gold on quartz

▼ Cheap mall jewelry can be plated with a thin layer of real gold, which makes it just as pretty as the solid alternative.

GOLD IS THE GOLD standard of metals. Rhodium (45) may be more valuable, but no one lusts after it the way they lust after gold. Only carbon (6), in the form of diamond, inspires the same feverish desire, but diamonds are temporary, easily destroyed by heat, and soon to be worthless when large synthetic diamonds become available.

Diamonds are a fraud, but gold is the real thing, richly deserving the adoration it inspires.

Gold is inherently valuable. There is very little of it around—all the gold ever mined in the history of the human race would fit into a cube about 60 feet on edge. (And if you meet one of the nuts suggesting that our money should go back on the gold standard, you might point out that, at current prices, this is worth only a few trillion dollars, significantly less than the money in circulation. There simply isn't enough gold to go around.)

Gold is undeniably beautiful. Of all the metals it is the only one that is both colored and whose color keeps its shine and beauty forever. You can find a piece of gold lying on the ground where it has been for a million years, pick it up, dust it off, and it will shine for you as if it's been waiting the whole time for this moment. Billions of years from now, when aliens come to rescue the last artifacts from earth before our sun explodes, King Tut's solid-gold mask will be just as shiny as it is today—which is just as shiny as it was 3,300 years ago when it was new. Not skin-deep, not temporary, the beauty of gold is built into its very atomic structure.

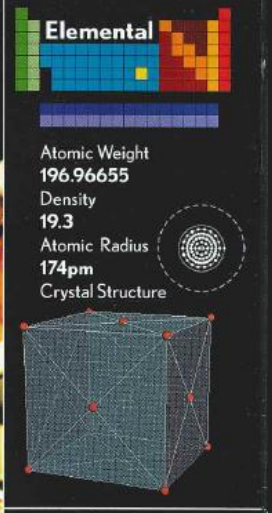
Gold is terrifically useful. It is a good conductor of electricity that absolutely does not tarnish, making it the best material for electrical contacts. Where conductors join two circuits merely by touch, any corrosion on either surface could interfere with the connection. So much gold is used in electronic devices that recycling them to recover the gold is a big business.

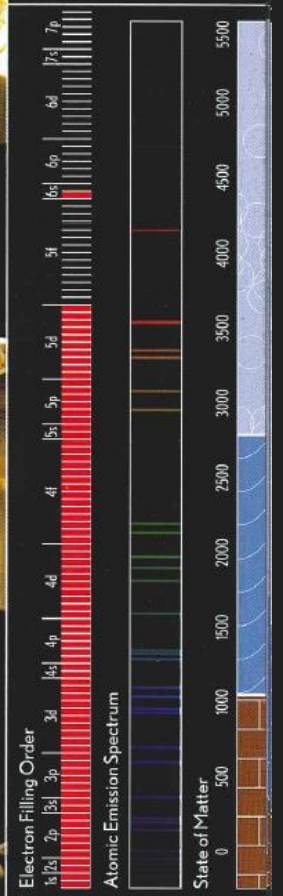
Gold has fascinated and inspired us since before those words existed. Wonder and fascination of a very different kind have been inspired almost as long by an element known to the ancients as the living, or "quick," silver: mercury.

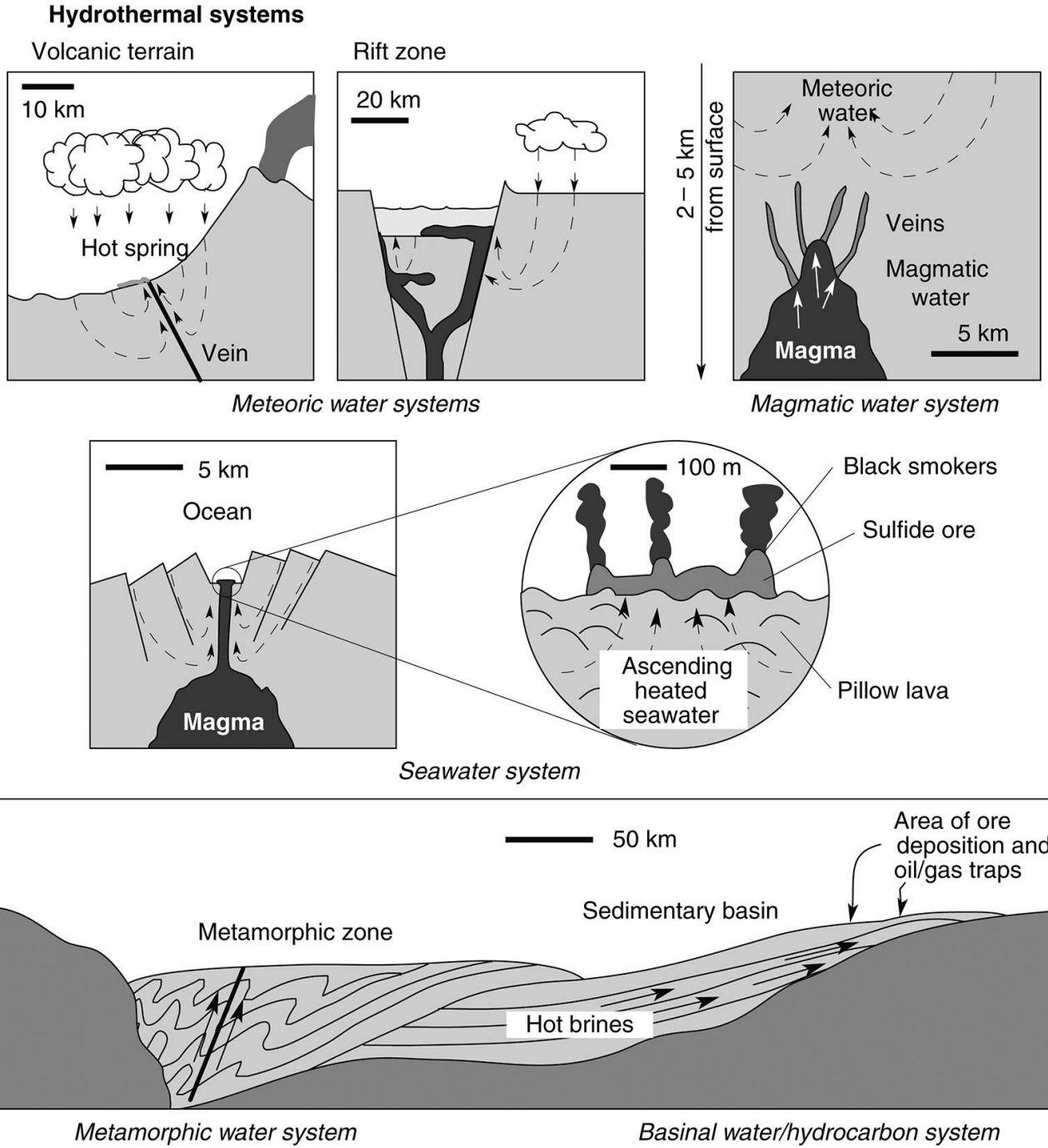
▼ "Healey gold" is made with a plating process that uses uranium, but no radioactivity is left in the final article.

▶ Gold paint may or may not contain real gold leaf, depending on how old or how expensive it is.

◀ This 1-ounce nugget of pure gold was found in Alaska in 1890 by Hormidas O. Marion while on a trip to sell shoes to Eskimos. Seriously.

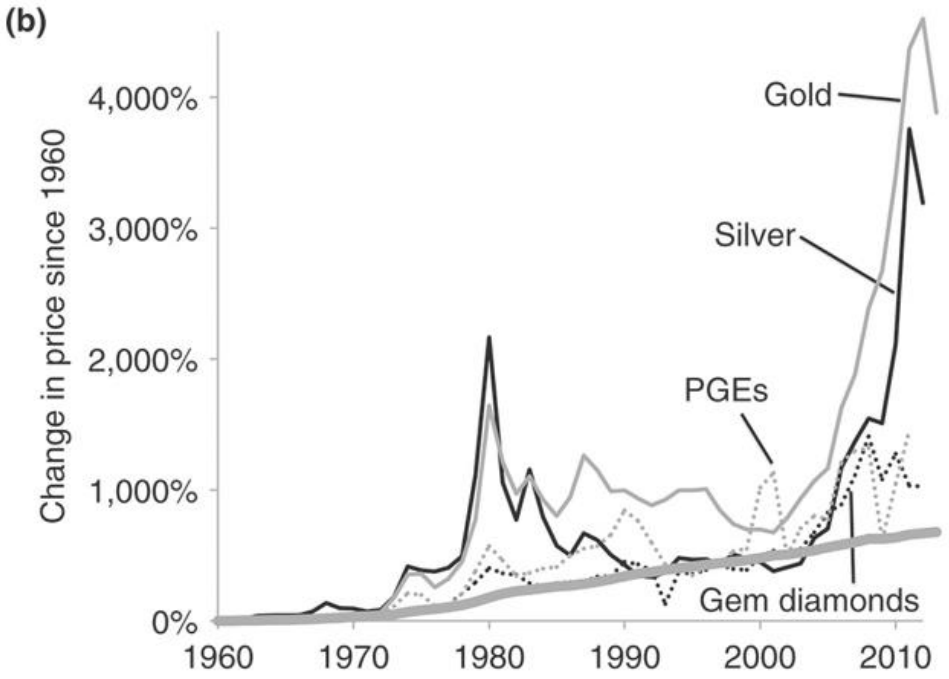


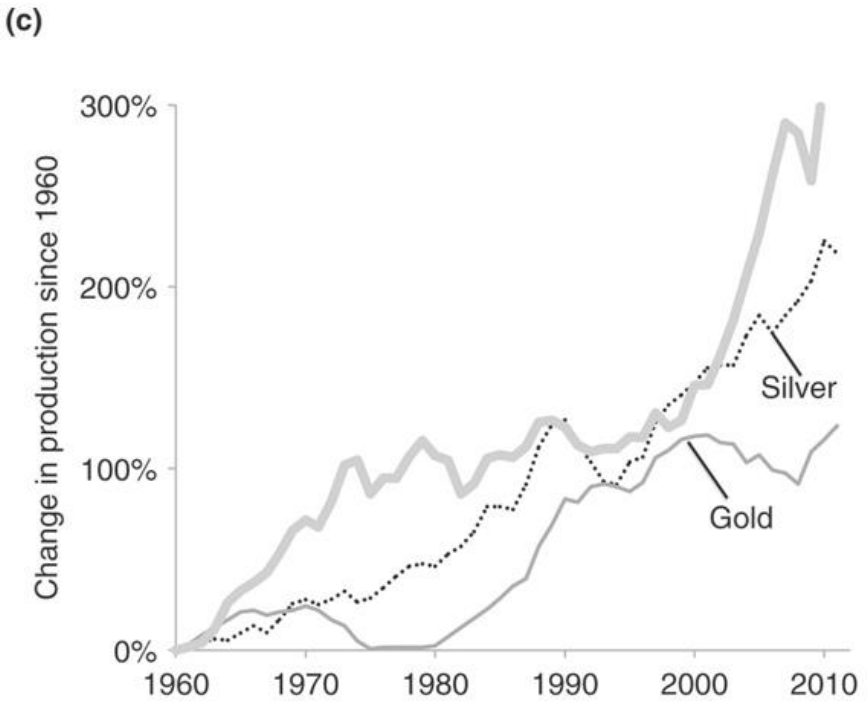



Hydrothermal systems
Volcanic terrain
Rift zone
10 km
20 km
Hot spring
Vein
2 – 5 km from surface
Meteoric water
Veins
Magmatic water
5 km
Magma
Meteoric water systems
Magmatic water system
5 km
Ocean
Magma
100 m
Black smokers
Sulfide ore
Ascending heated seawater
Pillow lava
Seawater system
50 km
Area of ore deposition and oil/gas traps
Sedimentary basin
Metamorphic zone
Hot brines
Metamorphic water system
Basinal water/hydrocarbon system

Commodity	Country	Production	Reserves
Gold	China	420	1,900
	Australia	255	9,900
	United States	227	3,000
	Russia	220	5,000
Silver	Mexico	5,400	37,000
	China	4,000	43,000
	Peru	3,500	87,000
	Australia	1,700	88,000
Platinum	South Africa	140	63,000
	Russia	25	1,100
	Zimbabwe	12	
Palladium*	South Africa	82	
	Russia	82	
	Canada	13	310

Value and Production of Gold (and other precious metals / gemstones)





~18% ROI for gold bought in 2001, sold in 2012

Gold Occurrence:

- Native Gold (Au)
- Electrum
- Telluride Minerals

Geologic Setting:

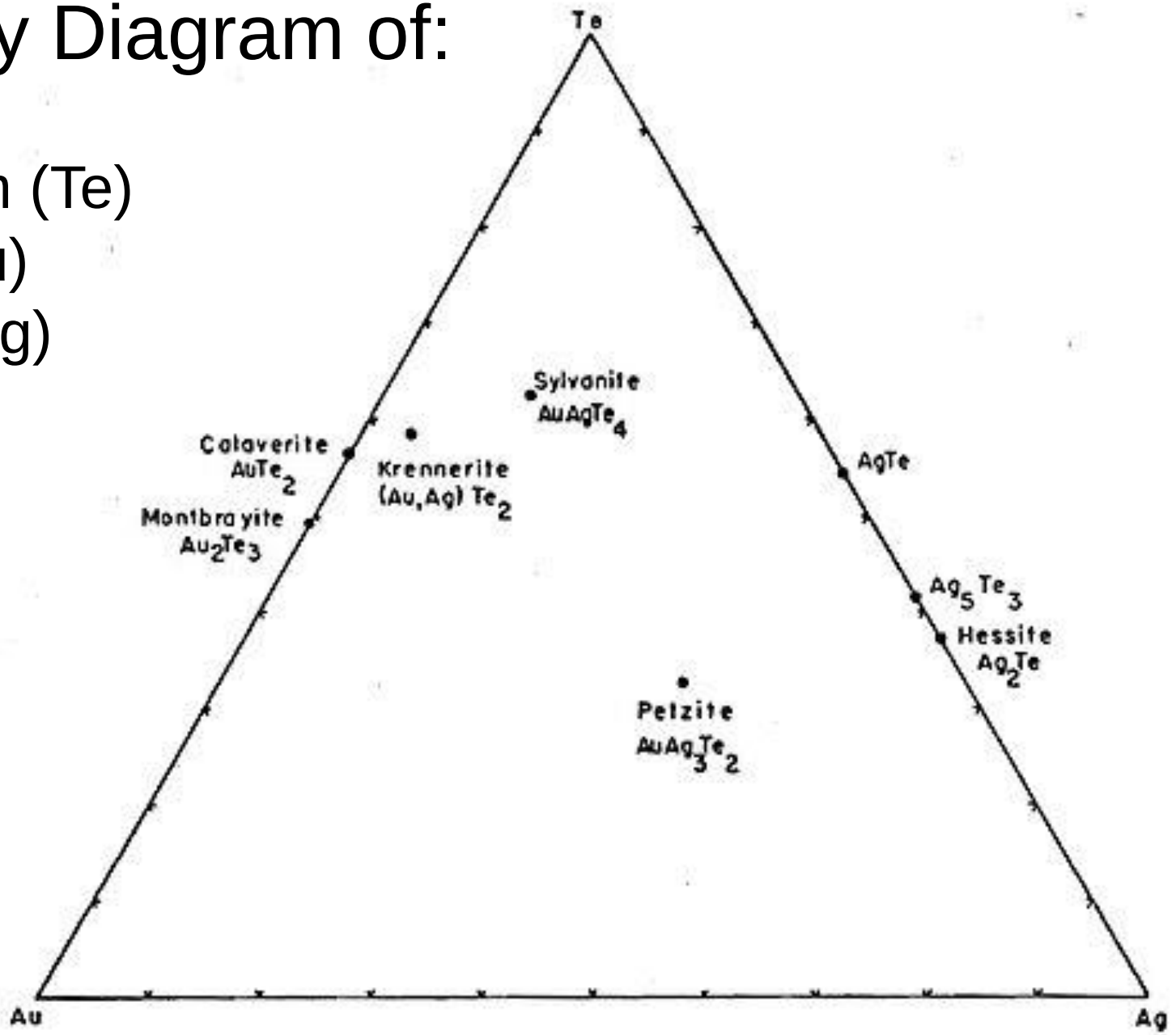
- Hydrothermal (57%)
- Placer (43%)

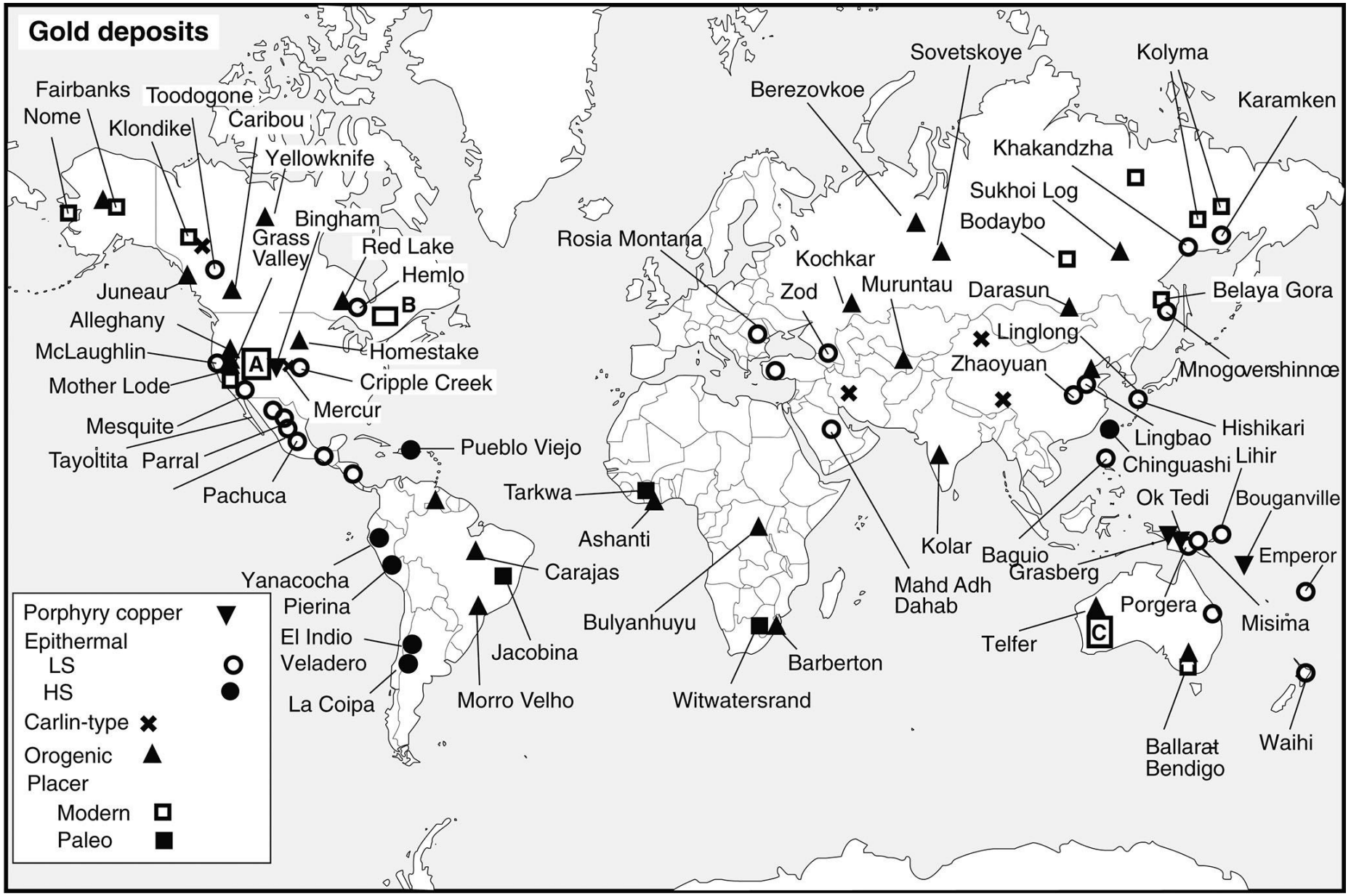
Electrum: Natural alloy of silver and gold

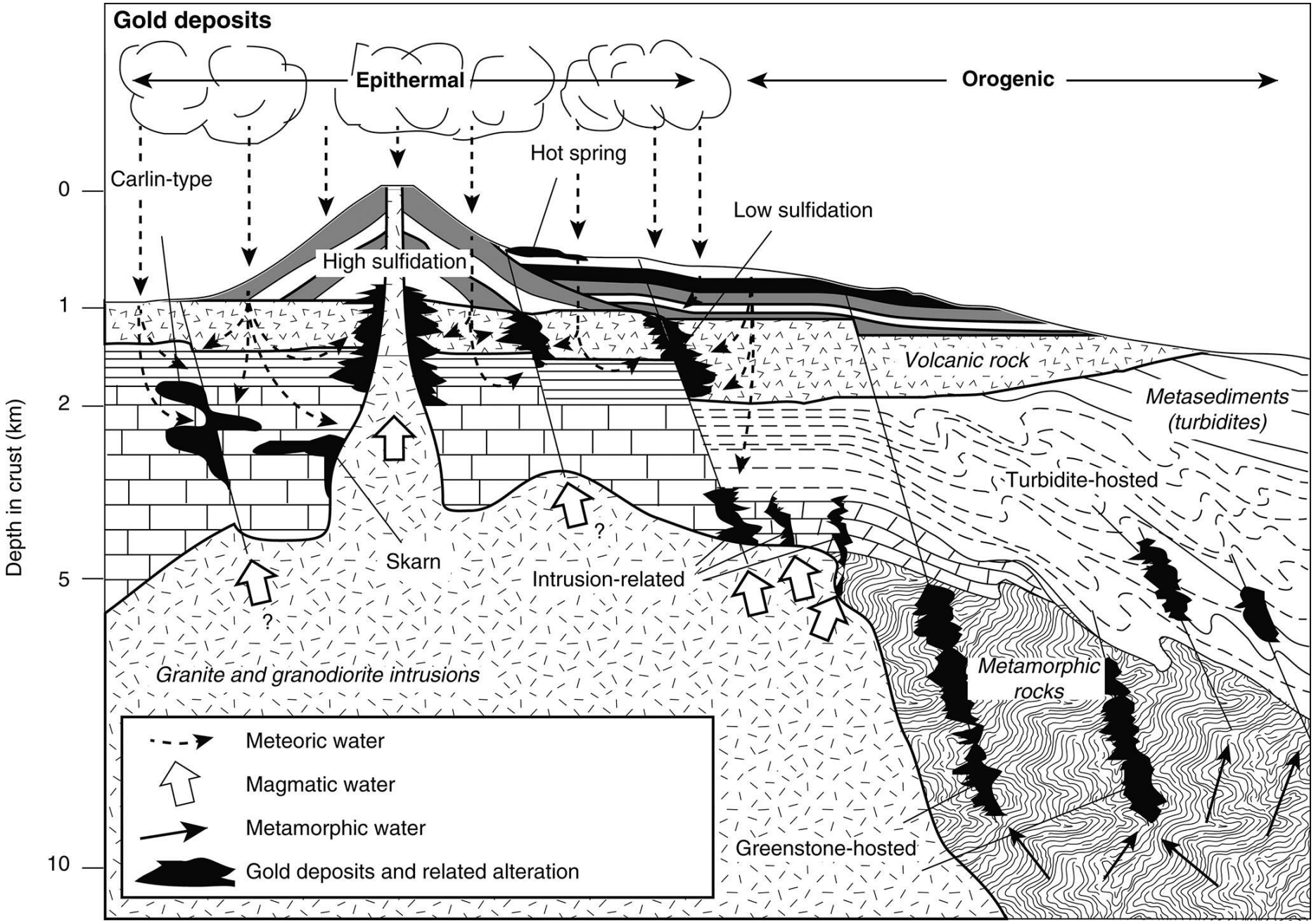
Telluride Minerals

Ternary Diagram of:

Tellurium (Te)
Gold (Au)
Silver (Ag)




Gold deposits
Fairbanks
Nome
Toodogone
Klondike
Caribou
Yellowknife
Bingham
Grass Valley
Red Lake
Hemlo
B
Juneau
Alleghany
McLaughlin
A
Homestake
Mother Lode
Cripple Creek
Mercur
Mesquite
Tayoltita
Parral
Pachuca
Pueblo Viejo
Tarkwa
Ashanti
Yanacocha
Pierina
Carajas
El Indio
Veladero
Jacobina
La Coipa
Morro Velho
Bulyanhuyu
Witwatersrand
Barberton
Rosia Montana
Berezovkoe
Sovetskoye
Kochkar
Zod
Muruntau
Kolar
Mahd Adh Dahab
Kolyma
Karamken
Khakandzha
Sukhoi Log
Bodaybo
Darasun
Belaya Gora
Linglong
Zhaoyuan
Mnogovershinnoe
Lingbao
Hishikari
Chinguashi
Lihir
Ok Tedi
Bouganville
Baguio
Grasberg
Emperor
Porgera
Misima
Telfer
C
Ballarat
Bendigo
Waihi
Porphyry copper
Epithermal
LS
HS
Carlin-type
Orogenic
Placer
Modern
Paleo

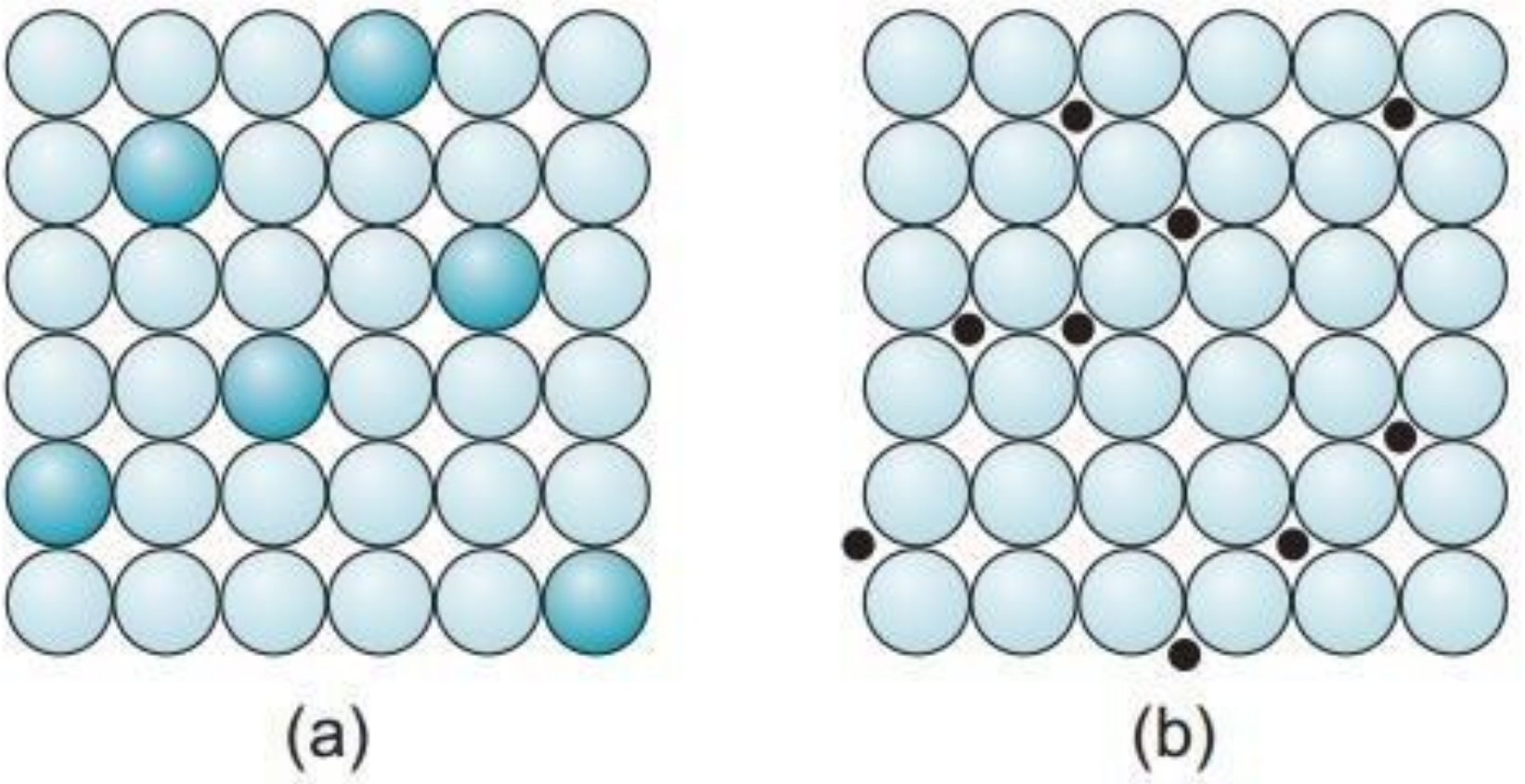

Gold deposits
Epithermal
Orogenic
Hot spring
Carlin-type
Low sulfidation
High sulfidation
Volcanic rock
Metasediments
(turbidites)
Turbidite-hosted
Skarn
Intrusion-related
Granite and granodiorite intrusions
Metamorphic
rocks
Greenstone-hosted
Depth in crust (km)
0
1
2
5
10
Meteoric water
Magmatic water
Metamorphic water
Gold deposits and related alteration

Epithermal Gold Deposits

- "Low" temperature (200-300°C)
- ~1km depth (3,280 ft) Geothermal gradient is ~25°C / km
- Three main types:
  1. Magmatic fluid derived so acidic (CO_2, SO_2, HCl)
  2. Meteoric water influenced (further from magma)
  3. "Carlin-type": Au is in solid solution within a form of pyrite (fool's gold!)

Solid Solution

a) Substitutional
b) Interstitial



RPA

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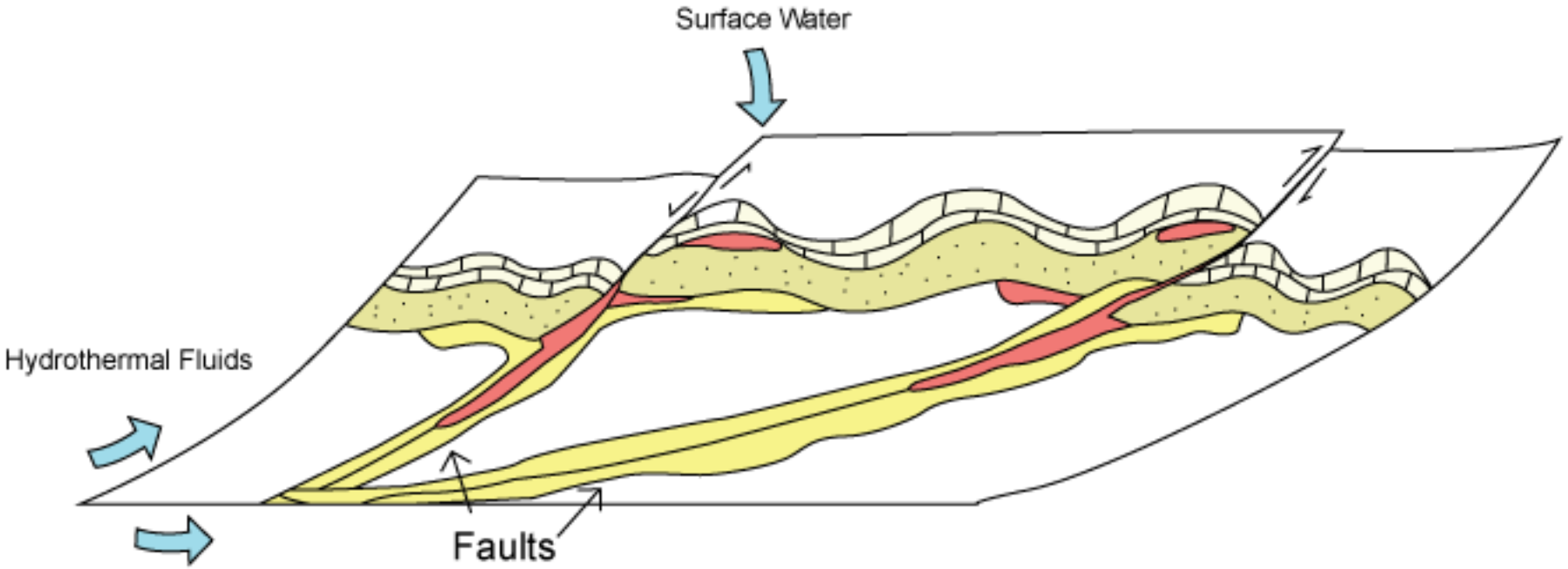
BARRICK GOLD CORPORATION

TECHNICAL REPORT ON THE GOLDSTRIKE MINE, EUREKA AND ELKO COUNTIES, STATE OF NEVADA, USA

NI 43-101 Report

Qualified Persons:
Jason J. Cox, P.Eng.
Philip A. Geusebroek, P.Geo.
Wayne W. Valliant, P.Geo.
Steve Haggarty, P.Eng.

For Geology, see Pg. 47

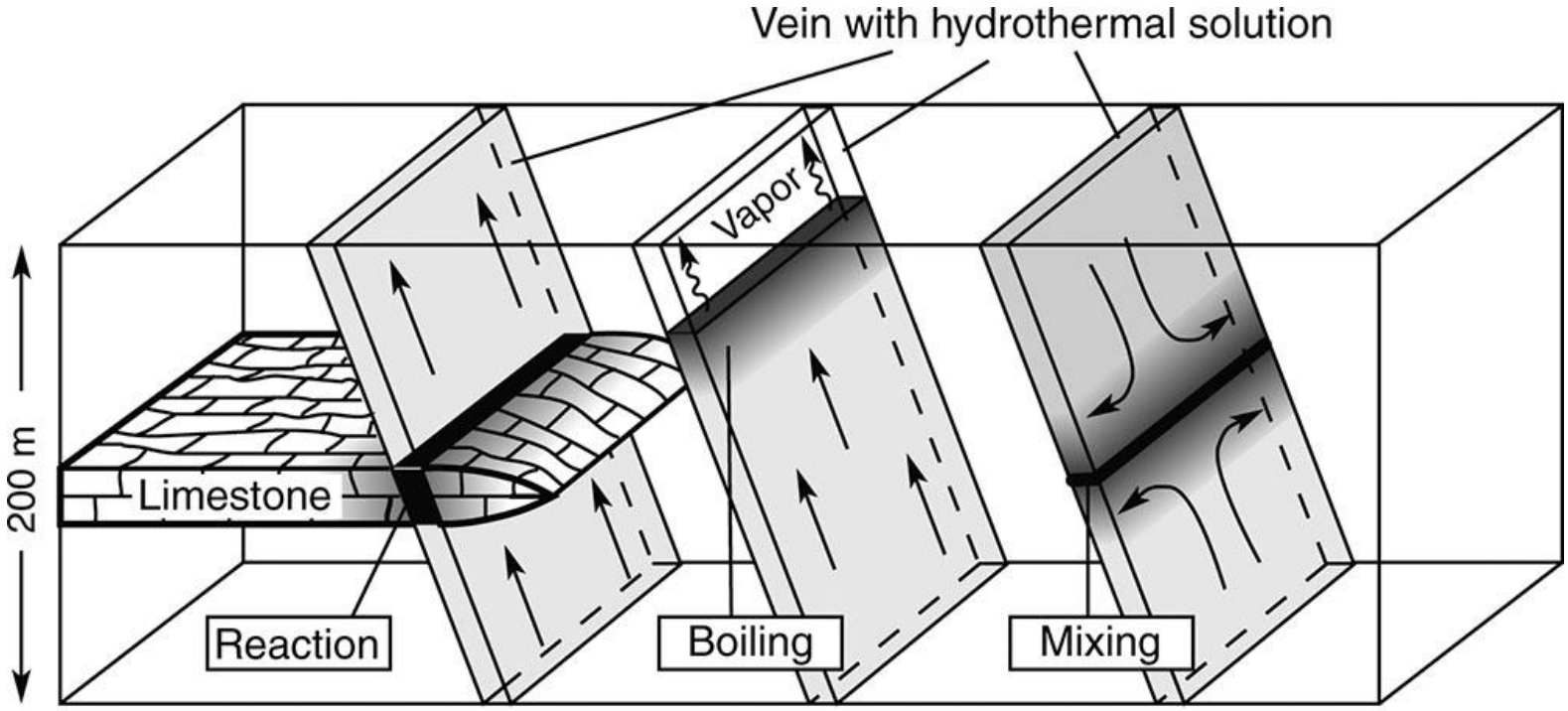


Carbonate Rocks

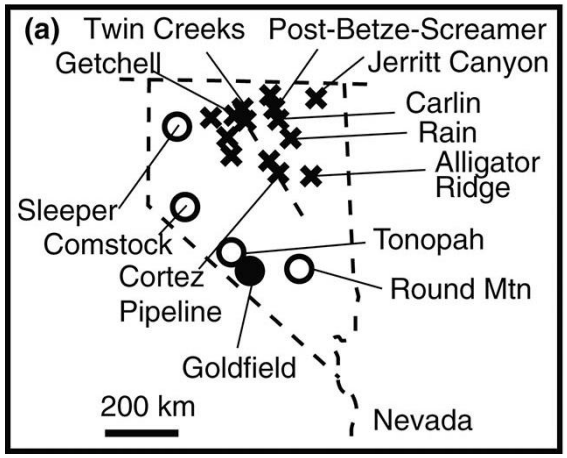
Silty Sandstone

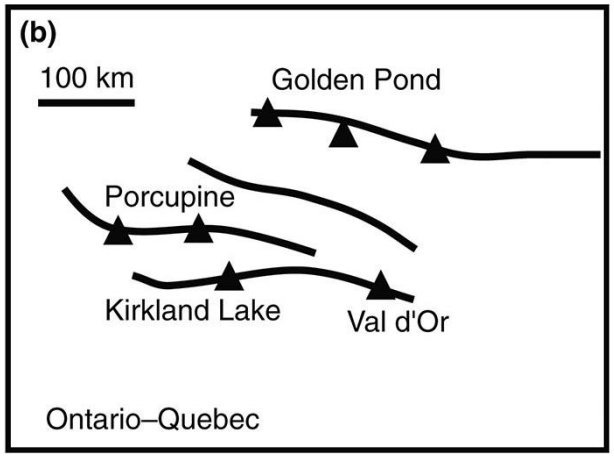
Jasperoid

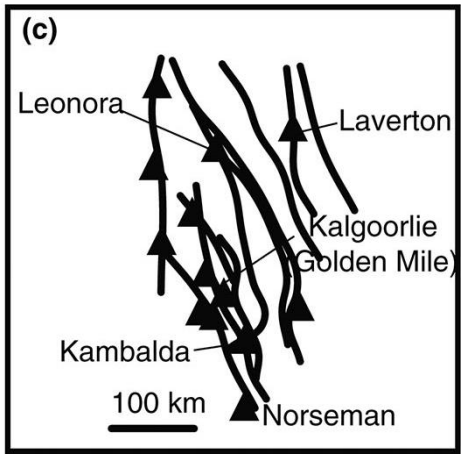
Alteration Halo



Depositional mechanisms in hydrothermal solutions







Porphyry Copper Deposits

Bingham copper mine in Salt Lake City, Utah

Produces 237,000 tonnes of Cu

Produces 13 tonnes Au

Witwatersrand, South Africa

- 41,000 tonnes mined, ~40,000 tonnes remain
- 20 times larger than the biggest epithermal deposit
- 4km deep (~13,000 ft!) in the TauTona Mine
- 55°C (130°F), A/C lowers to 28°C (82°F)
  …but 90% humidity!
- Low wages and ~150,000 laborers

Gold Mining Wages and Production

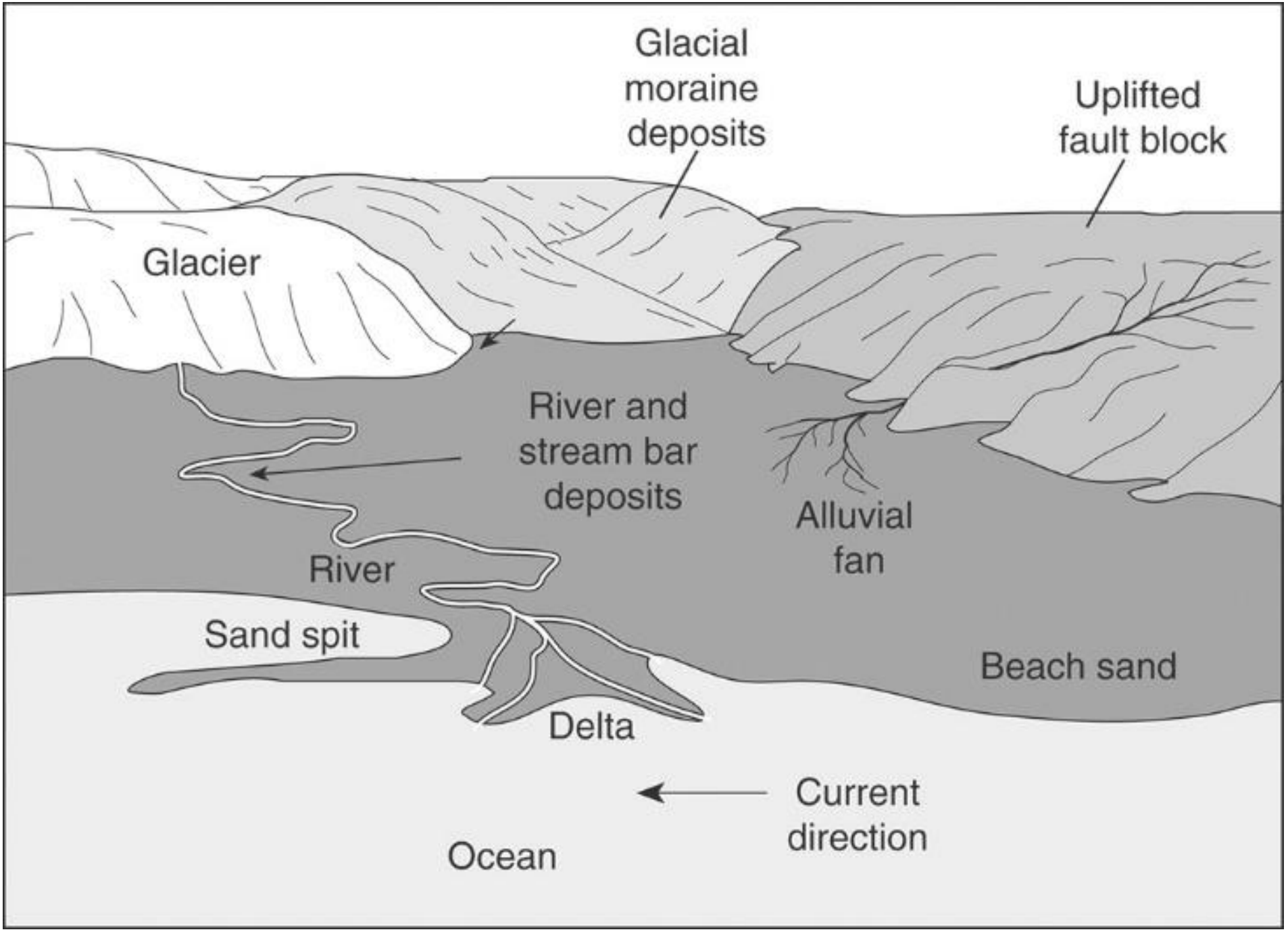
Witwatersrand miners make ~$15,600 / person / year

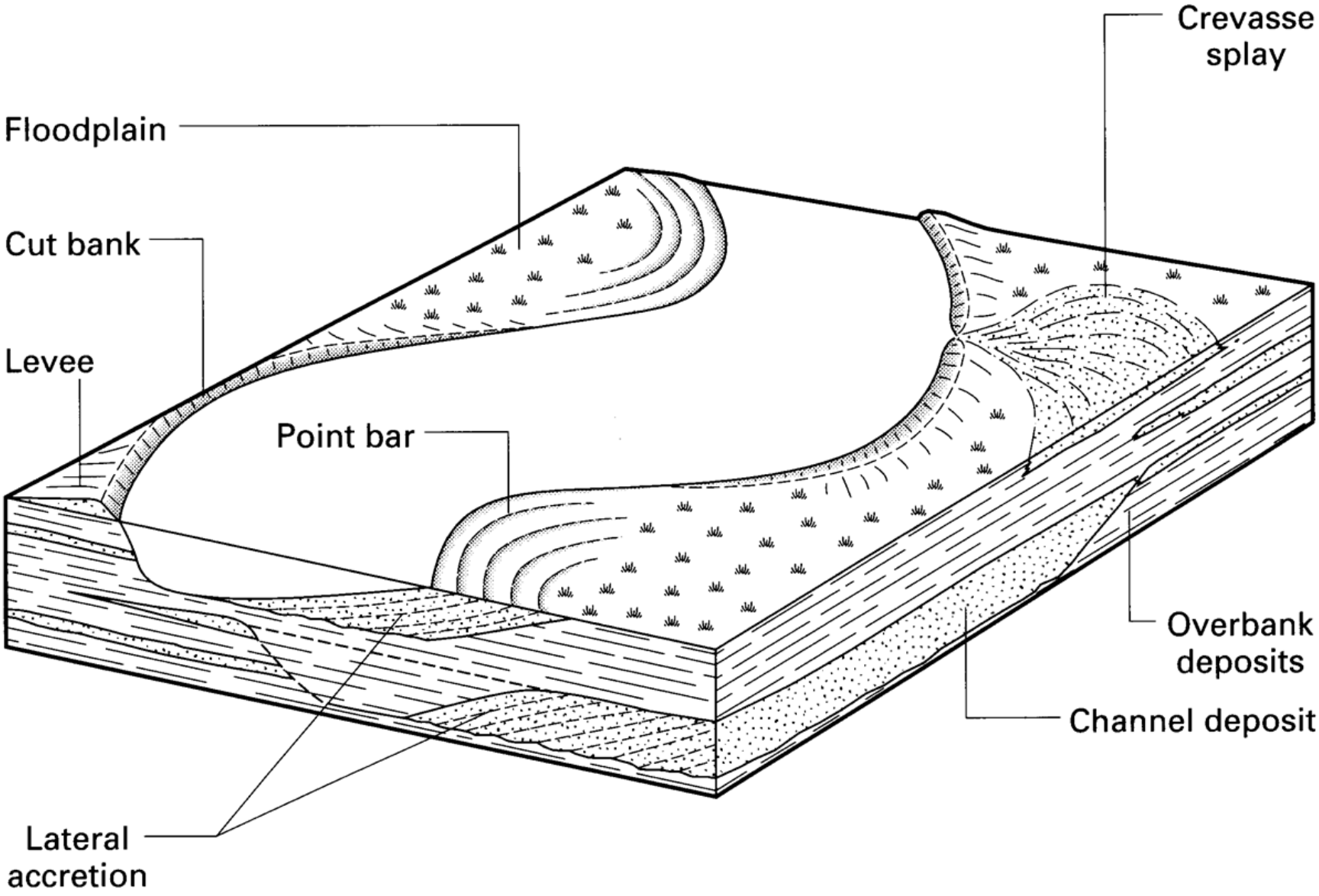
…this is ~10% the average wage of American miners

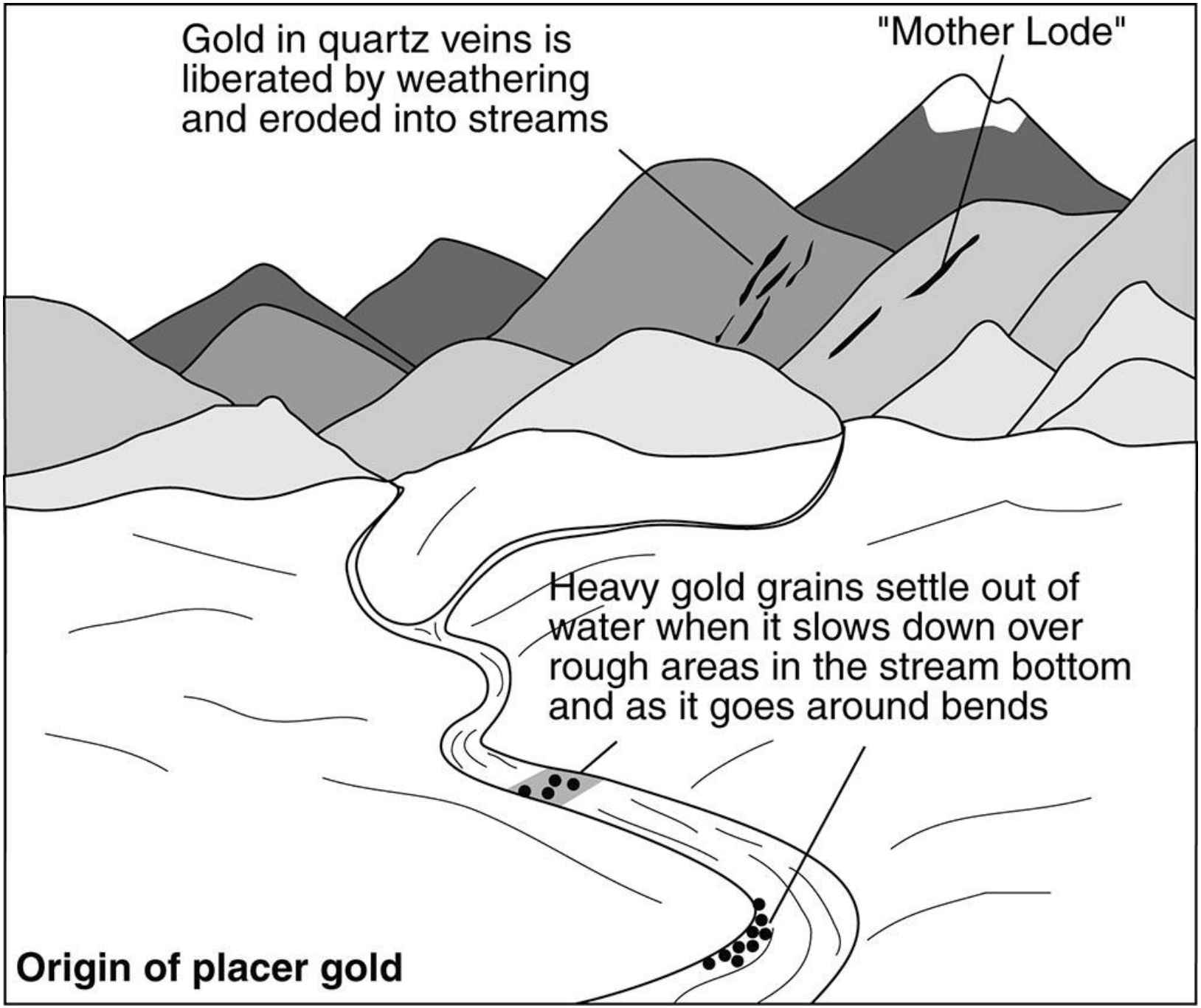
Company	*Gold production (ounces)**	*Fraction of gold produced in South Africa# (%)*	*Employees*	*Ounces per employee*
Agnico–Eagle	1,100,000	0	3,250	338.5
Newmont	5,100,000	0	15,100	337.7
Kinross	2,600,000	0	8,230	315.9
Barrick	7,160,000	0	23,000	311.3
Goldcorp	2,670,000	0	11,500	232.2
AngloGold Ashanti	4,100,000	37	61,000	67.2
Sibanye	1,440,000	100	35,227	40.9
Harmony	1,300,000	100	39,440	33.0

* 32.105 ounces of gold in 1 kg.

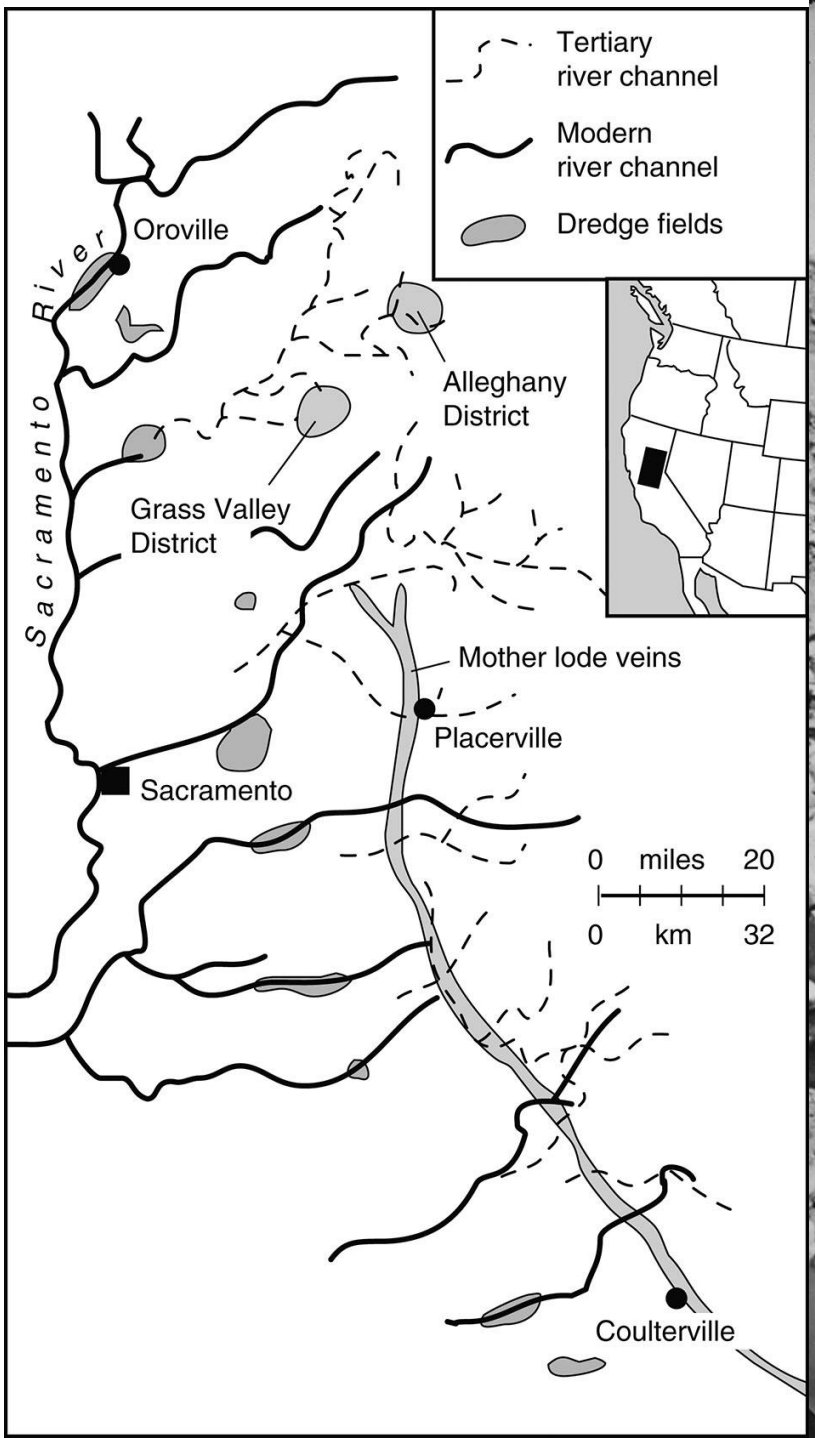
No other African contry is a major producer of gold for these countries.


Glacial moraine deposits
Uplifted fault block
Glacier
River and stream bar deposits
Alluvial fan
River
Sand spit
Beach sand
Delta
Current direction
Ocean

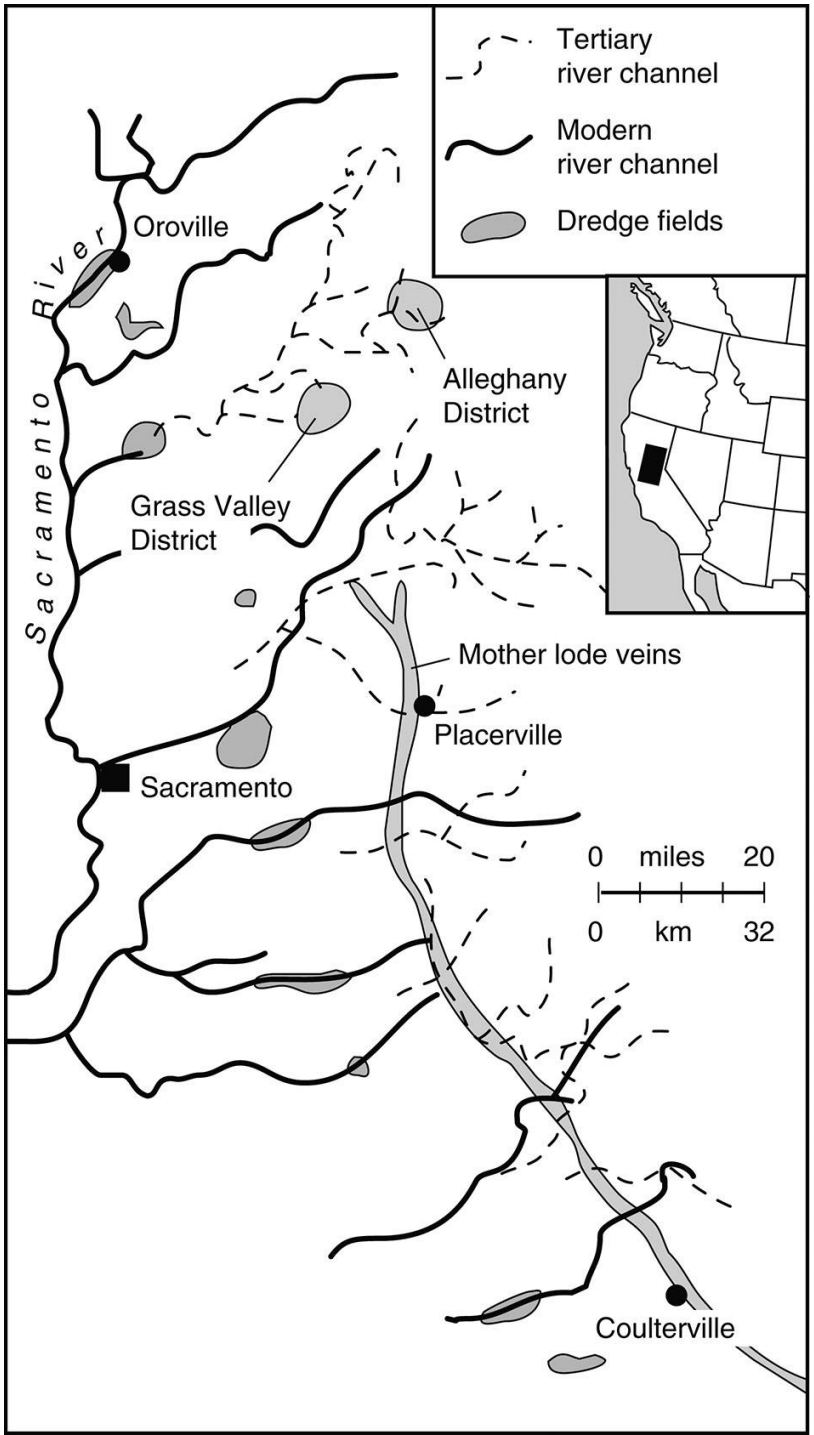

Crevasse splay
Floodplain
Cut bank
Levee
Point bar
Overbank deposits
Channel deposit
Lateral accretion


Gold in quartz veins is liberated by weathering and eroded into streams
"Mother Lode"
Heavy gold grains settle out of water when it slows down over rough areas in the stream bottom and as it goes around bends
Origin of placer gold

Metal	Density (lb/in^3)	Specific Gravity
Magnesium	.064	1.77
Aluminum	.098	2.70
Titanium	.161	4.51
Chromium	.250	6.92
Zinc	.258	7.14
Tin	.264	7.30
Stainless Steel (Type 410)	.278	7.70
Iron/Steel	.284	7.87
Stainless Steel (Type 304)	.285	7.90
Muntz Metal	.303	8.39
Cartridge Brass	.308	8.53
Commercial Bronze	.318	8.80
Monel	.319	8.83
Nickel	.321	8.90
Nickel Silver	.323	8.95
Copper	.323	8.96
Silver	.379	10.49
Lead	.409	11.34
Gold	.687	19.32


Tertiary
river channel
Modern
river channel
Dredge fields
Oroville
Sacramento River
Alleghany
District
Grass Valley
District
Mother lode veins
Placerville
Sacramento
0 miles 20
0 km 32
Coulterville


USGS Photo, ~1875


Tertiary
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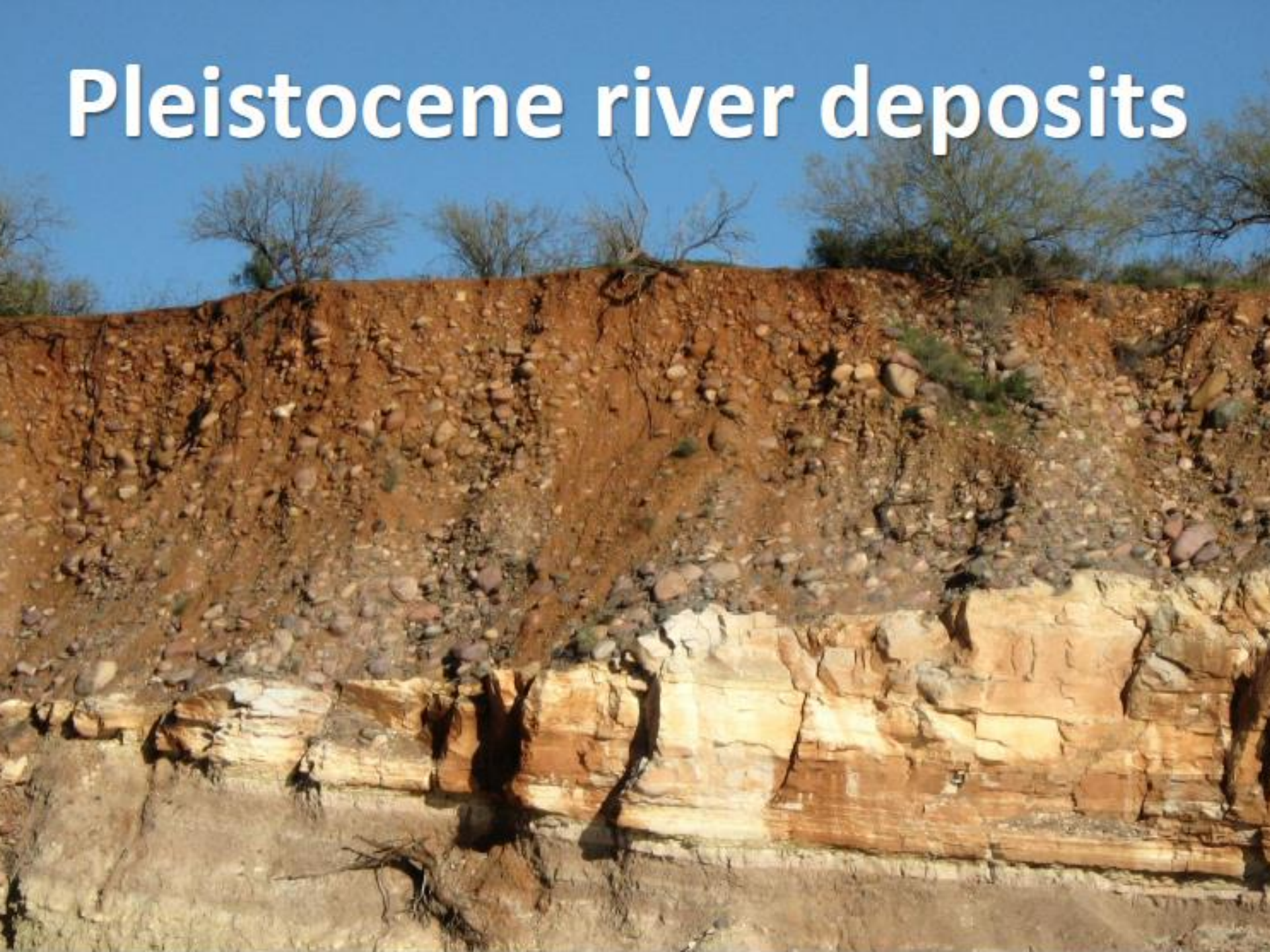
Sacramento River
Oroville
Alleghany
District
Grass Valley
District
Mother lode veins
Placerville
Sacramento
0 miles 20
0 km 32
Coulterville

Panning for gold

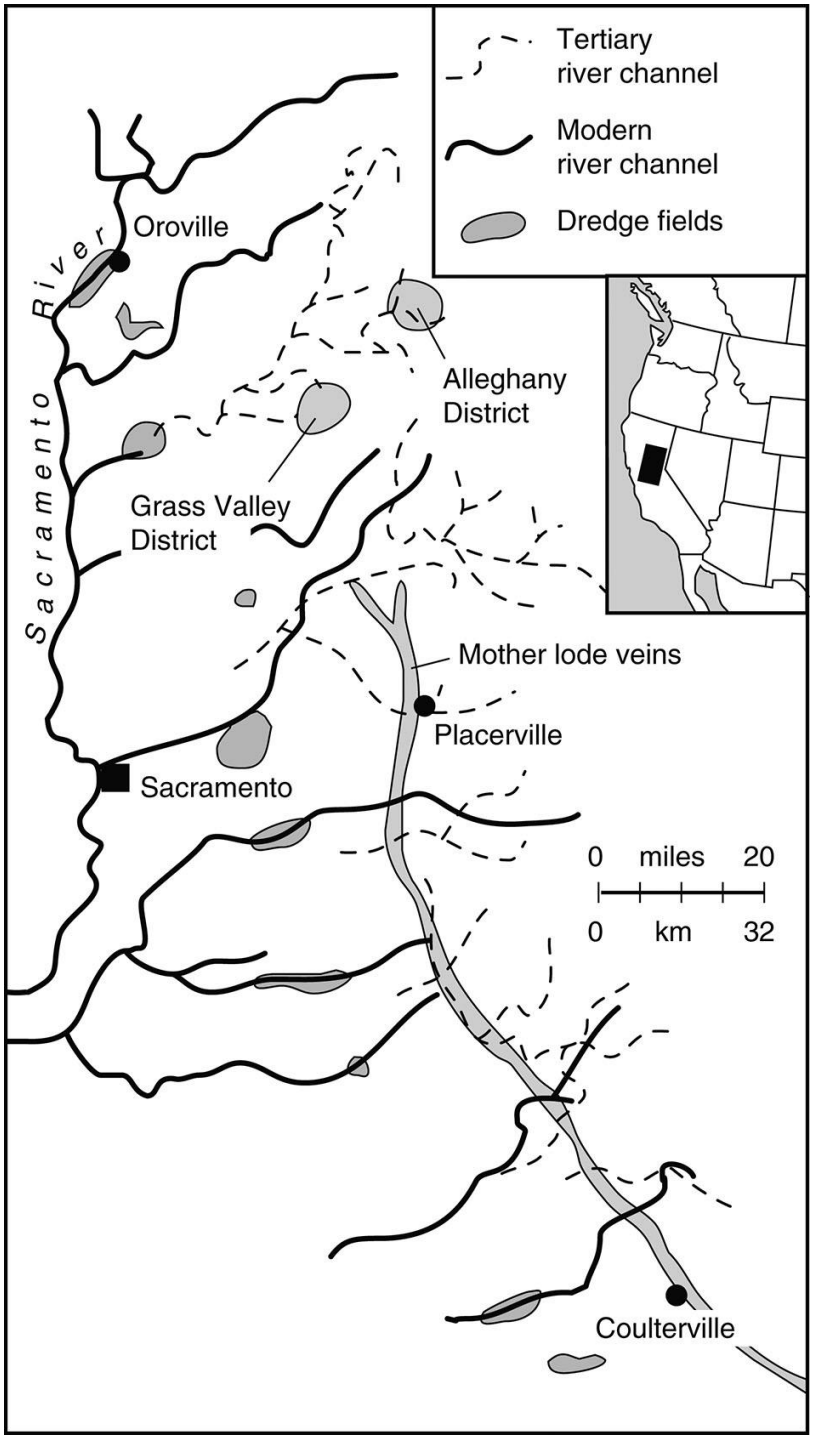
Hydraulic Mining

Pleistocene river deposits



Panning for gold

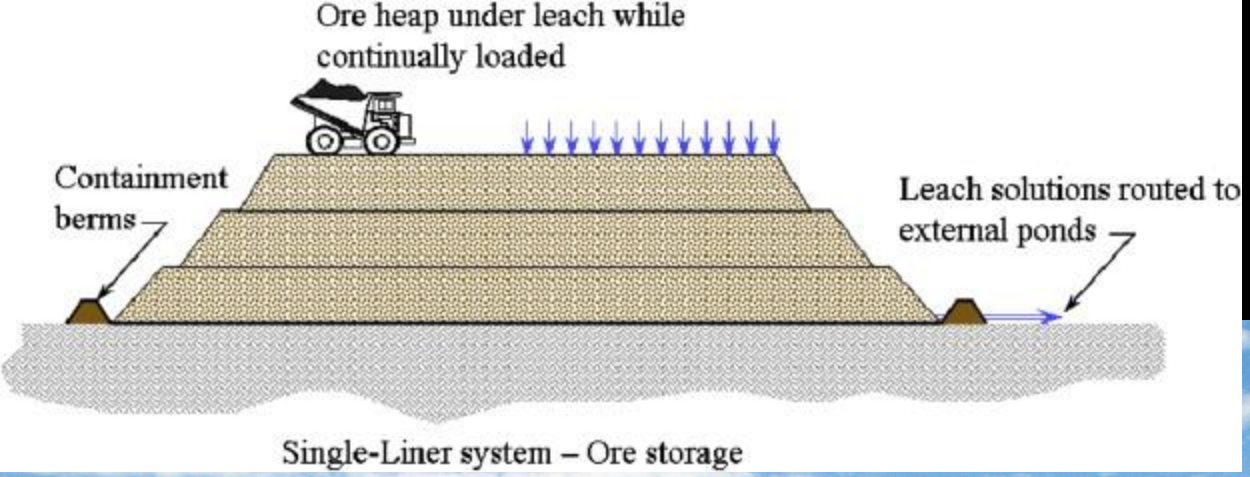
Mercury Amalgamation



Amalgamation:

- “Patio Process” mix ore with mercury (Hg) to dissolve gold, then heat to vaporize Hg, leaving behind gold
- Mercury bioaccumulates in fish (and the environment)
- 1883 California Debris Commission Act
- Still used by 10-15 million “artisanal” miners in Brazil, Ghana, Thailand, etc, releasing 100 million tonnes into the environment annually

Heap Leach Pads



(a)

Heap Leach Pads

(a)

Heap Leach Pads

Cyanide Process:

- Cyanide dissolves gold from ore, forming “pregnant solution”
- Later add zinc which causes gold and silver to precipitate
- International Cyanide Management Code developed after a dam failure in a Romanian gold mine released 100 tonnes of cyanide into the Tisza River
- Some states and countries now ban its use