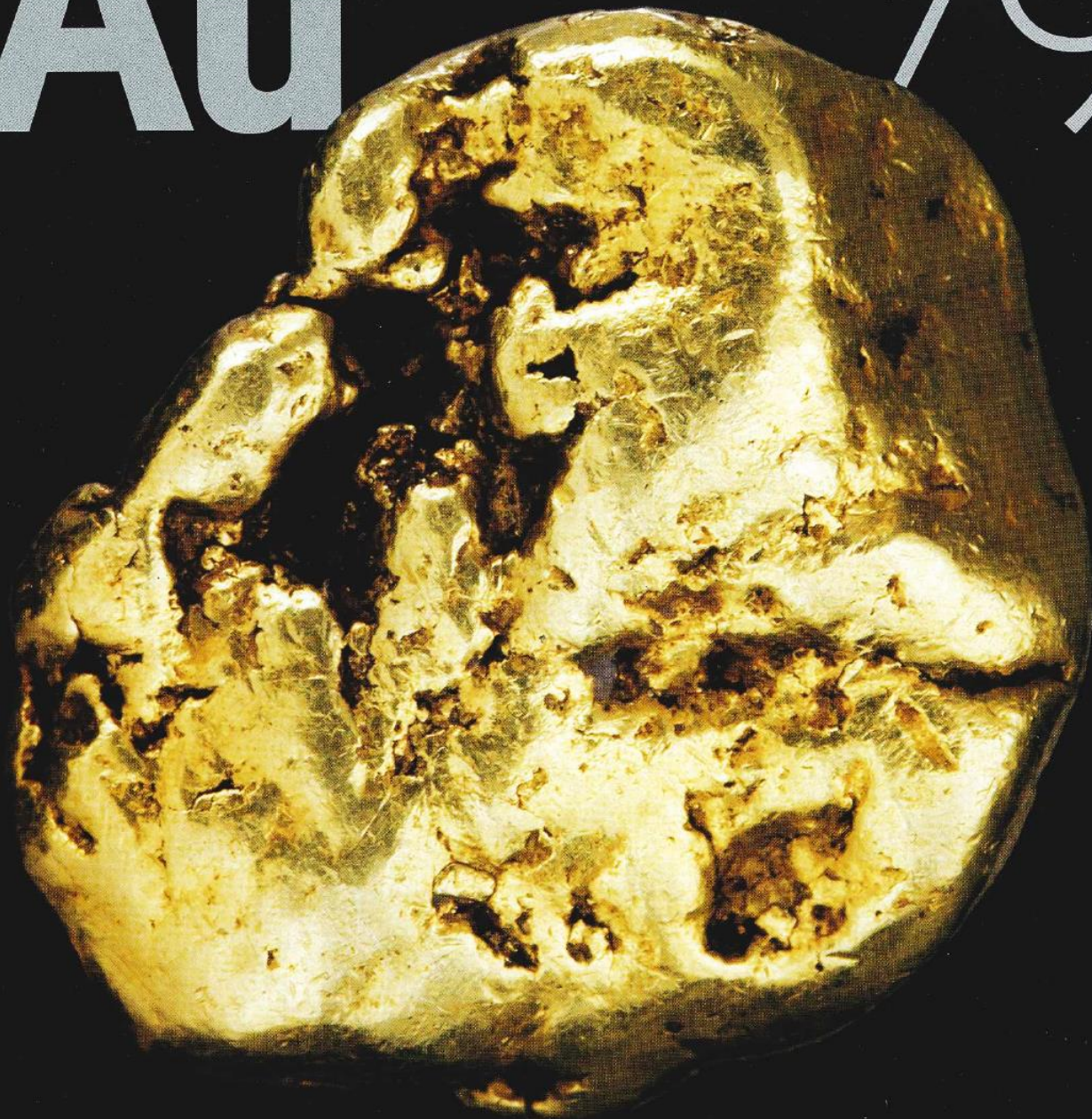


Gold

Au

79





# Gold

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.

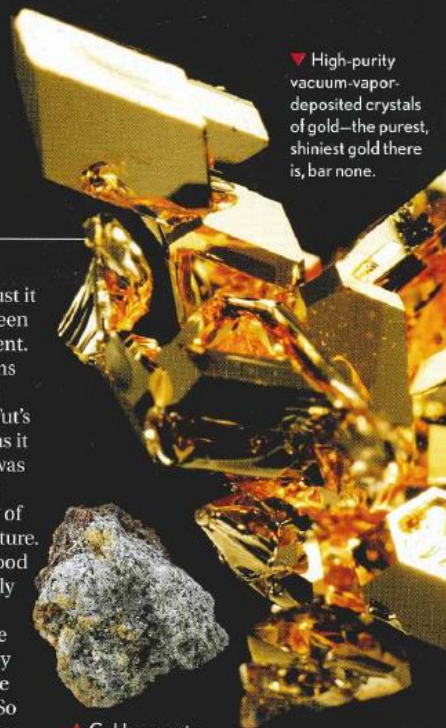
▼ "Healey gold" is made with a plating process that uses uranium, but no radioactivity is left in the final article.



► 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.

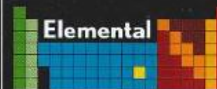


▼ High-purity vacuum-vapor-deposited crystals of gold—the purest, shiniest gold there is, bar none.

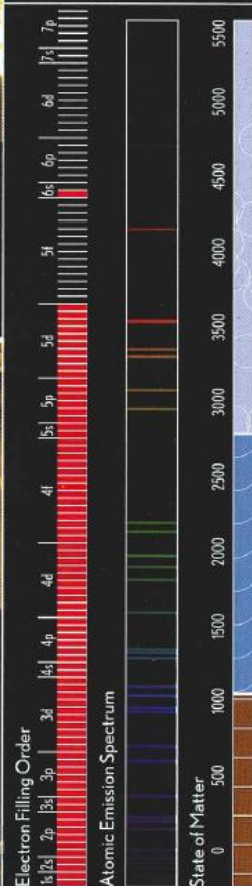
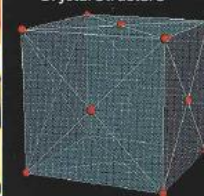


▲ Gold on quartz

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

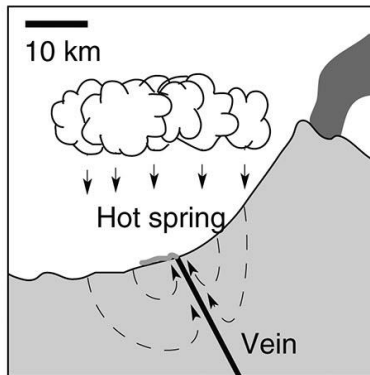


Atomic Weight  
196.96655  
Density  
19.3  
Atomic Radius  
174pm  
Crystal Structure

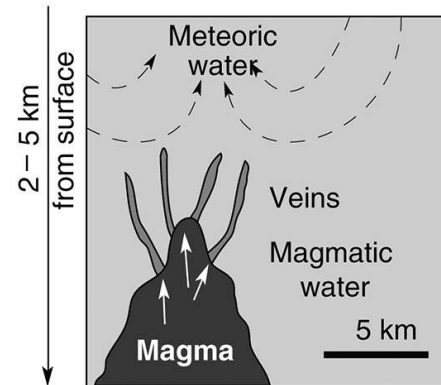
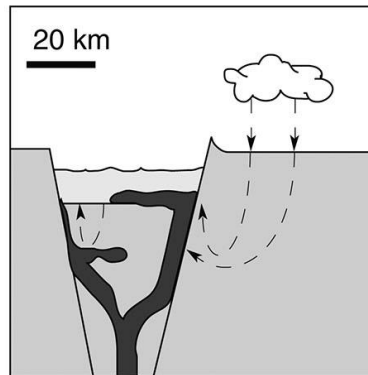


# Hydrothermal systems

Volcanic terrain

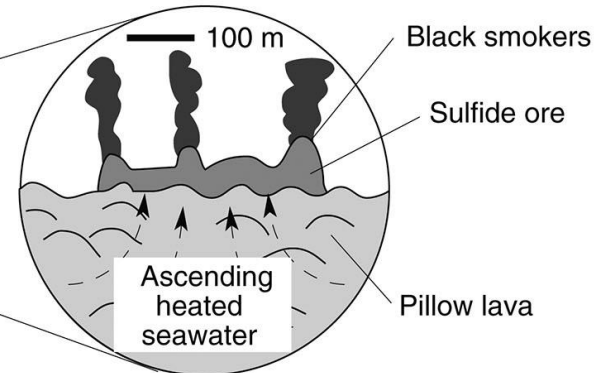
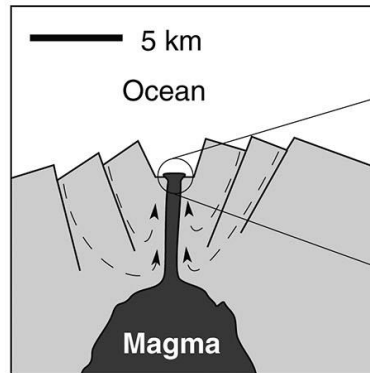


Rift zone

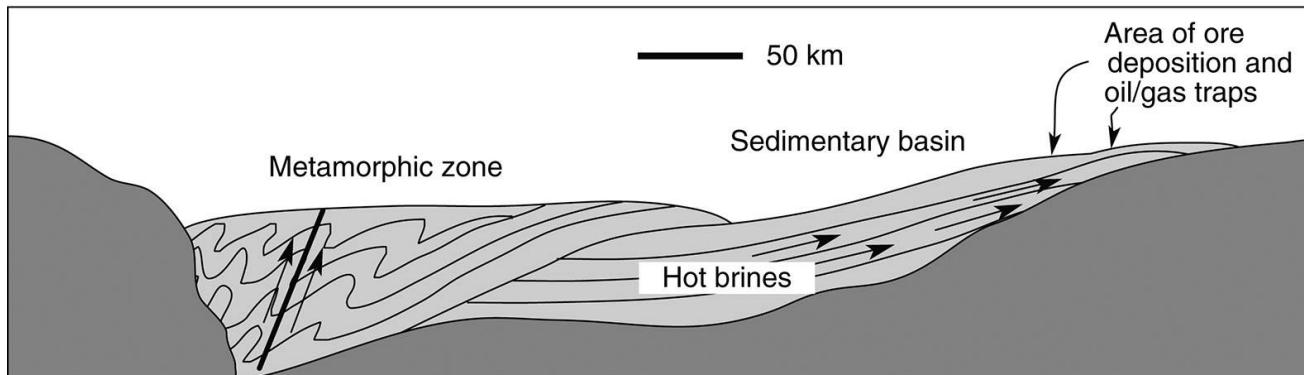


Meteoric water systems

Magmatic water system



Seawater system

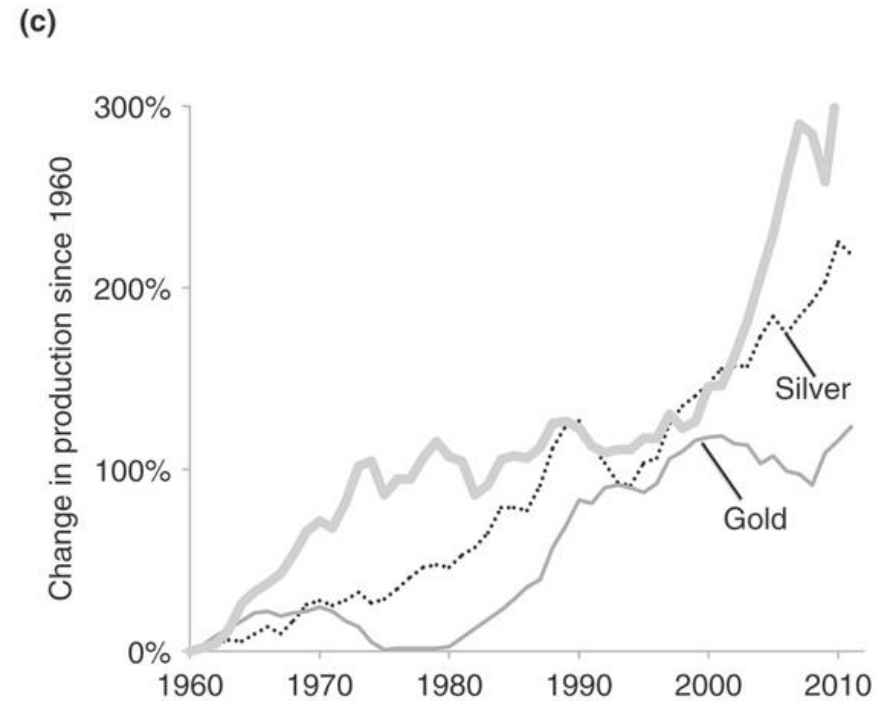
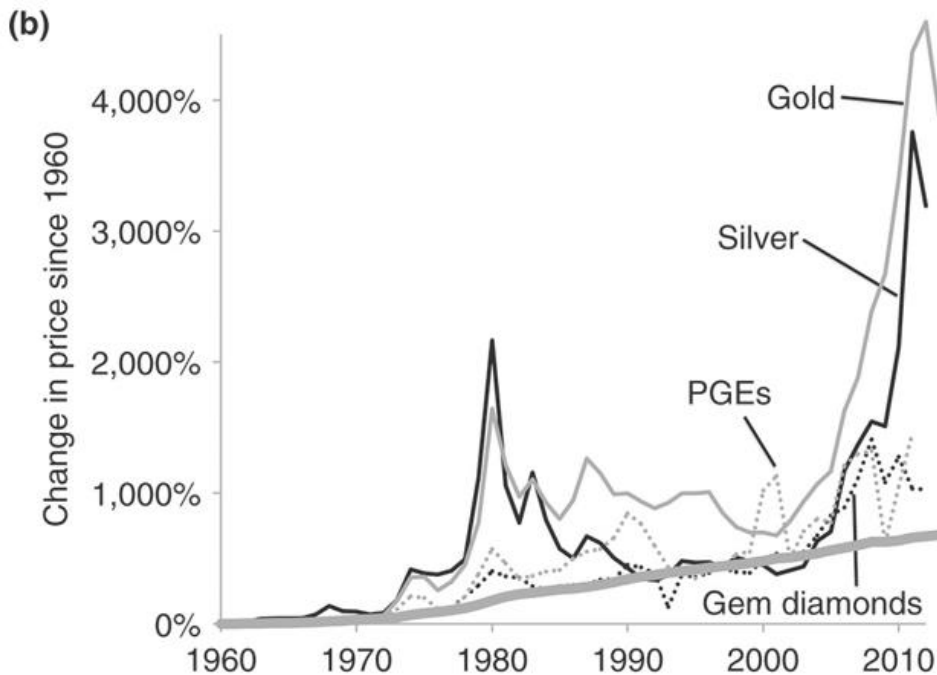


Metamorphic water system

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 vs Silver (2000-2025) - Dual Axis





## Gold Occurrence:

- Native Gold (Au)
- Electrum
- Telluride Minerals

## Geologic Setting:

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



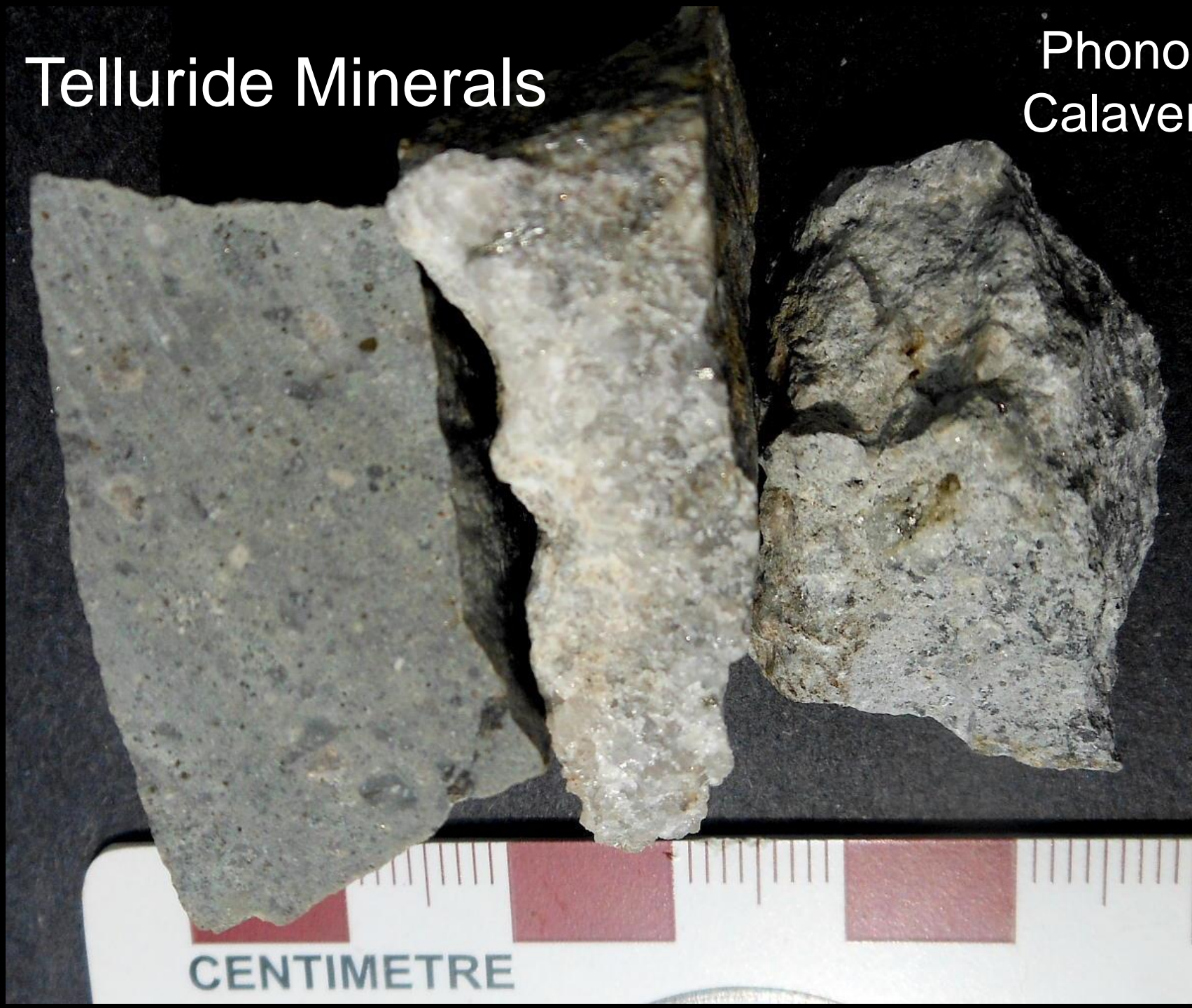
Electrum: Natural alloy of silver and gold





Telluride Minerals

Phonolite  
Calaverite

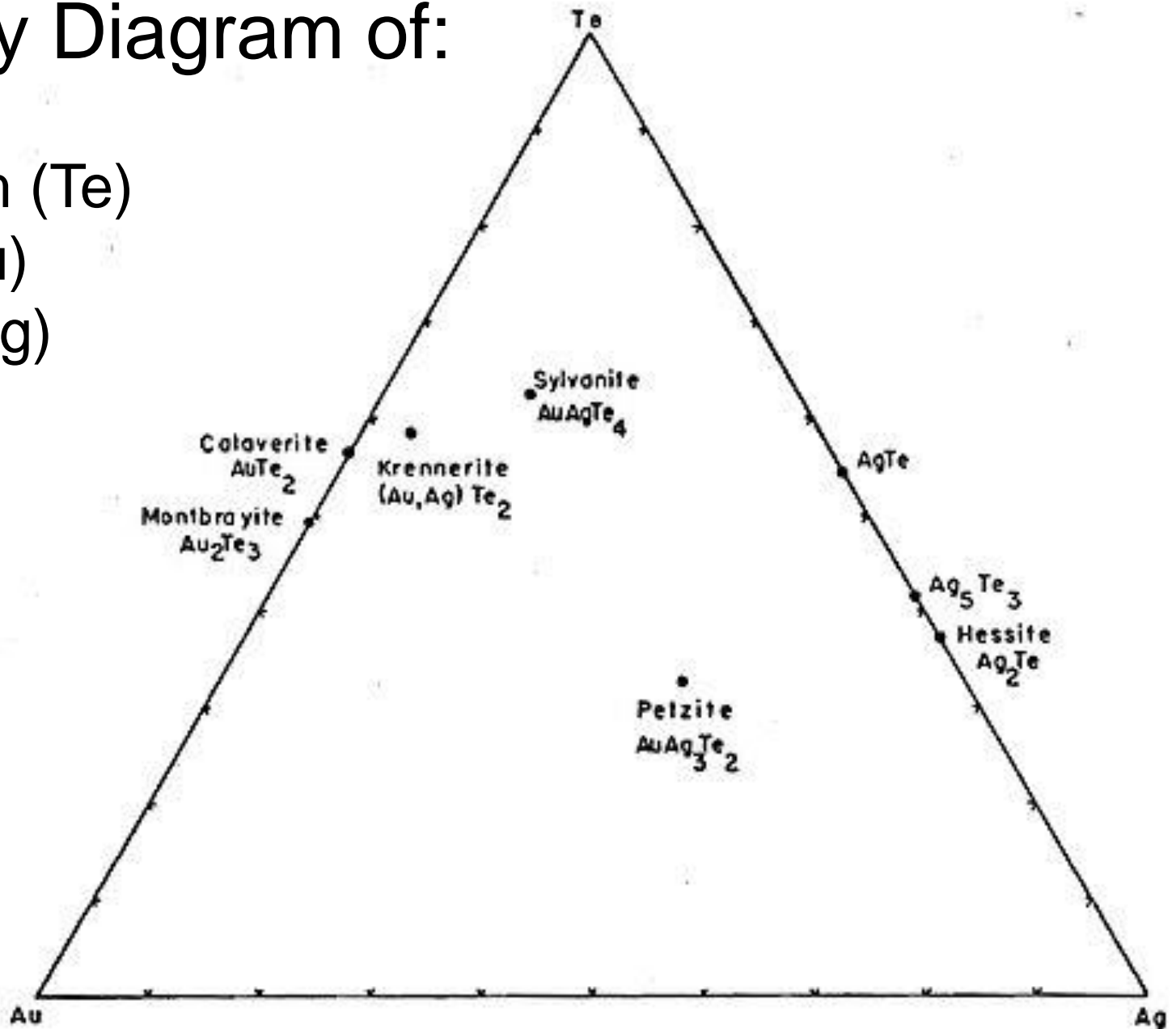


# Ternary Diagram of:

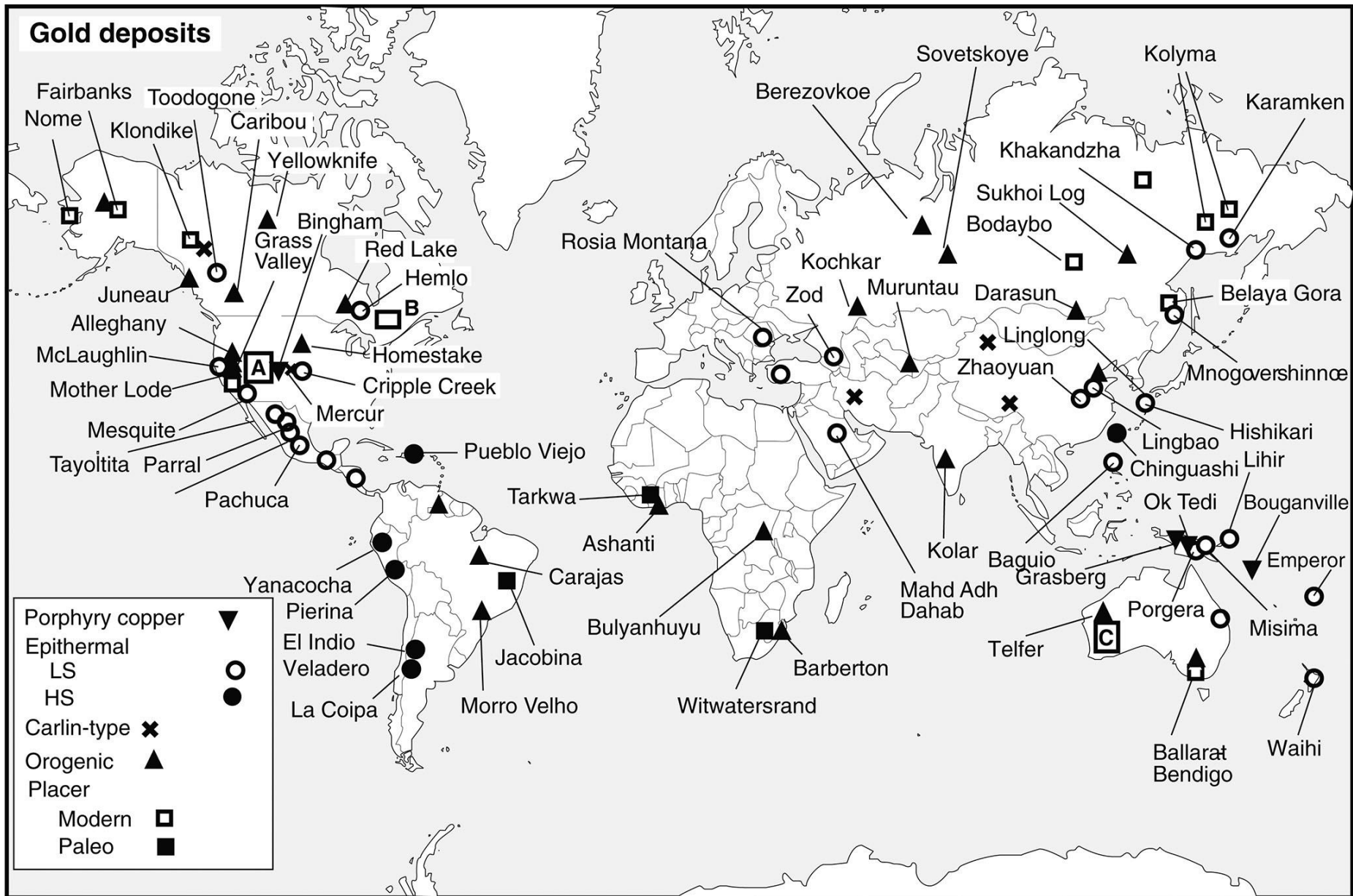
Tellurium (Te)

Gold (Au)

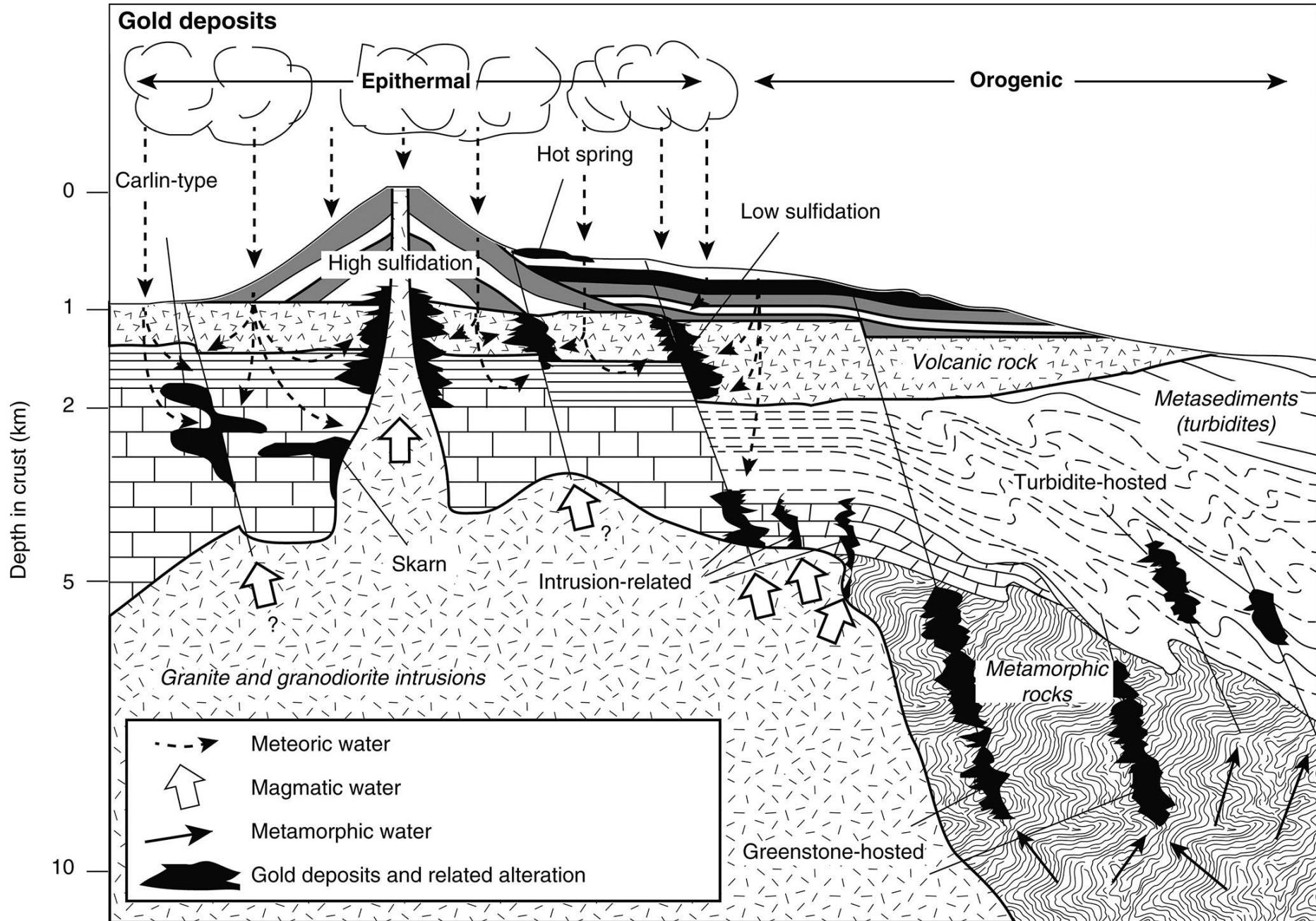
Silver (Ag)



# Gold deposits







# Epithermal Gold Deposits

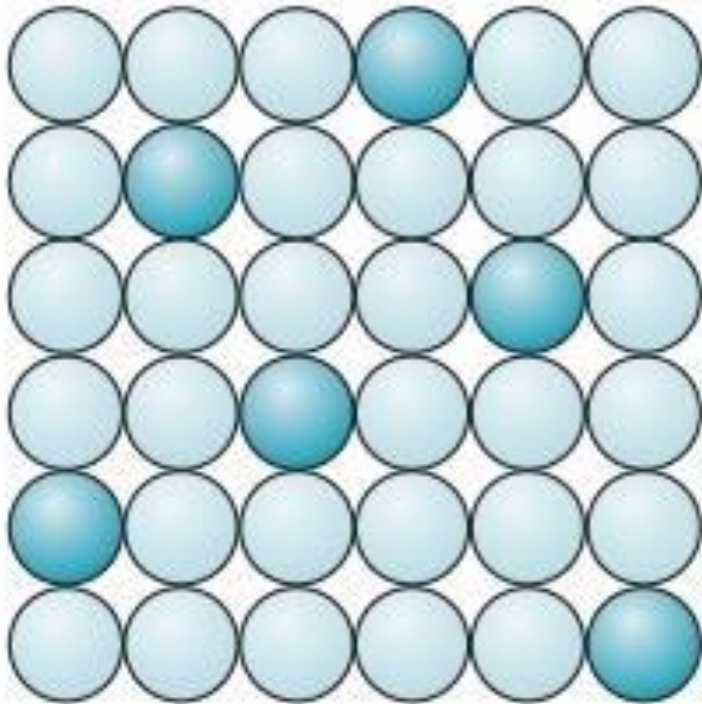
- “Low” temperature (200-300°C)
- ~1km depth (3,280 ft) Geothermal gradient is ~25°C / km
- Three main types:
  1. Magmatic fluid derived so acidic ( $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{HCl}$ )
  2. Meteoric water influenced (further from magma)
  3. “Carlin-type”: Au is in solid solution within a form of pyrite (fool’s gold!)



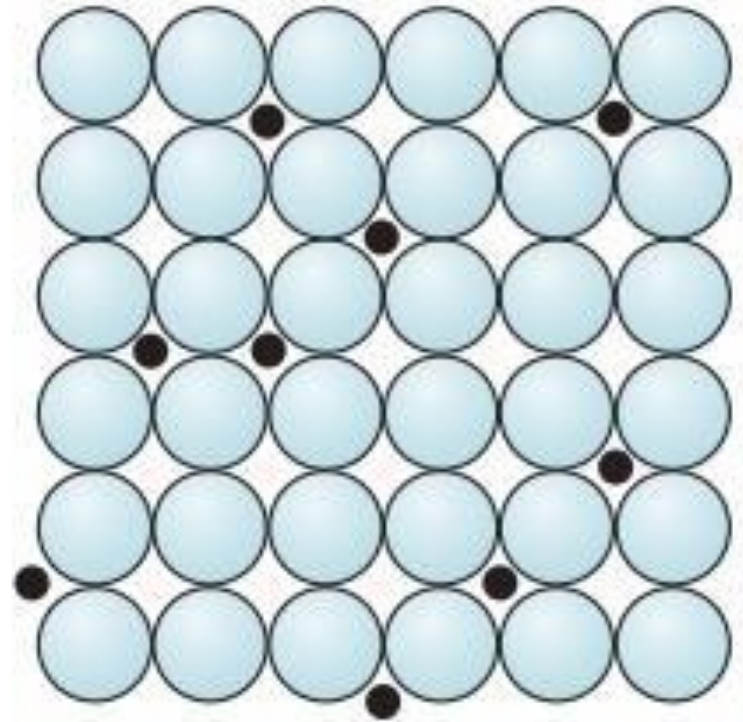
# Solid Solution

a) Substitutional

b) Interstitial



(a)



(b)







Rock solid resources.  
Proven advice.™

## **BARRICK GOLD CORPORATION**

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# **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.**

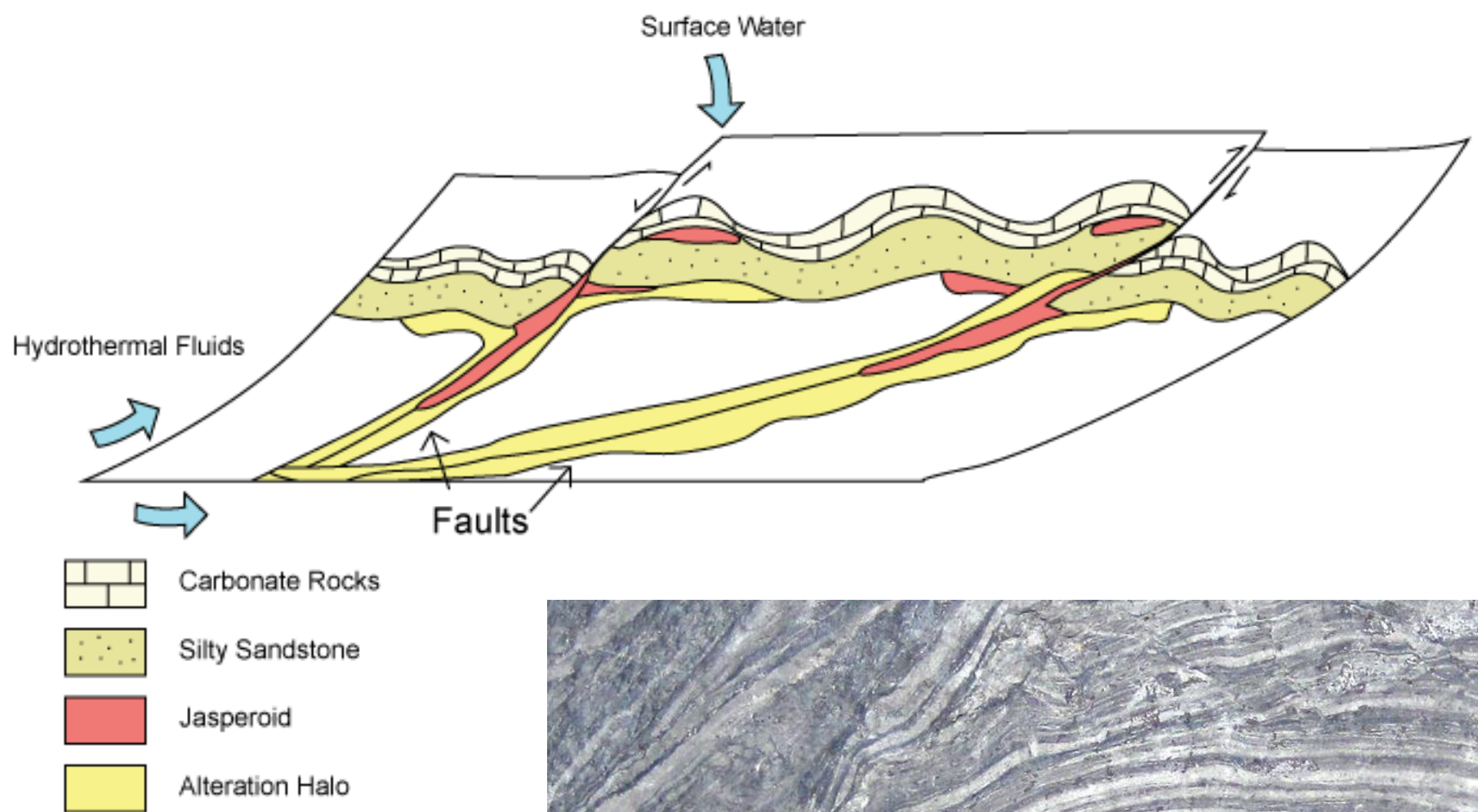
**Philip A. Geusebroek, P.Geo.**

**Wayne W. Valliant, P.Geo.**

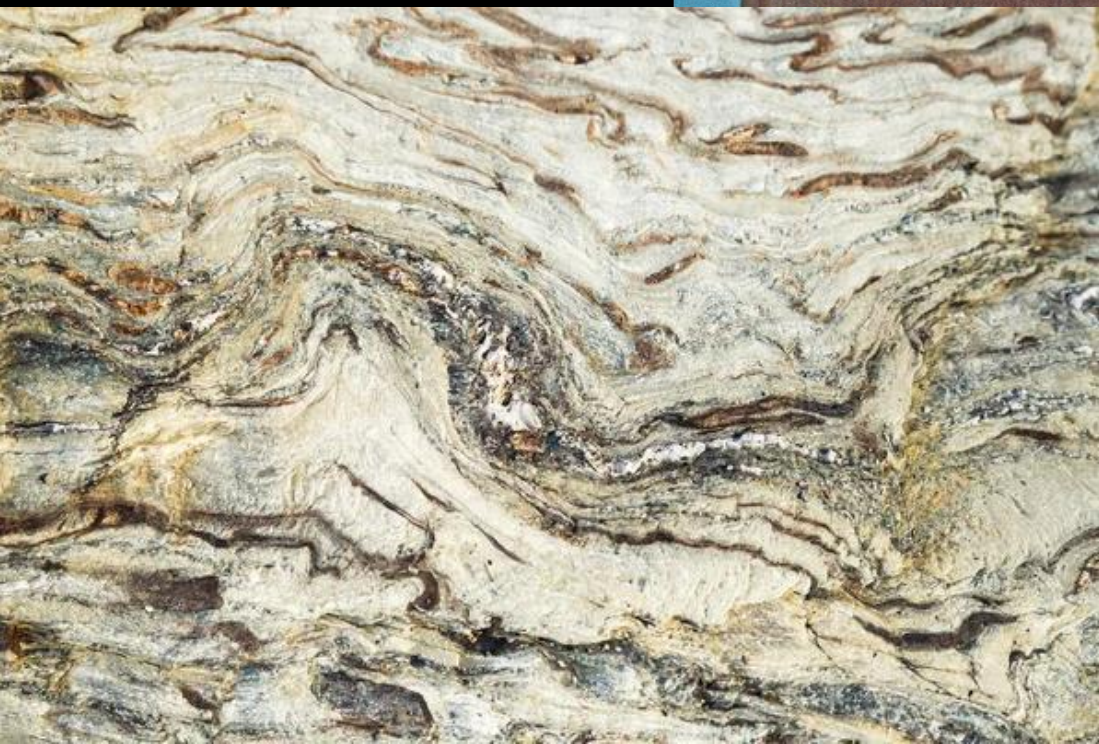
**Steve Haggarty, P.Eng.**

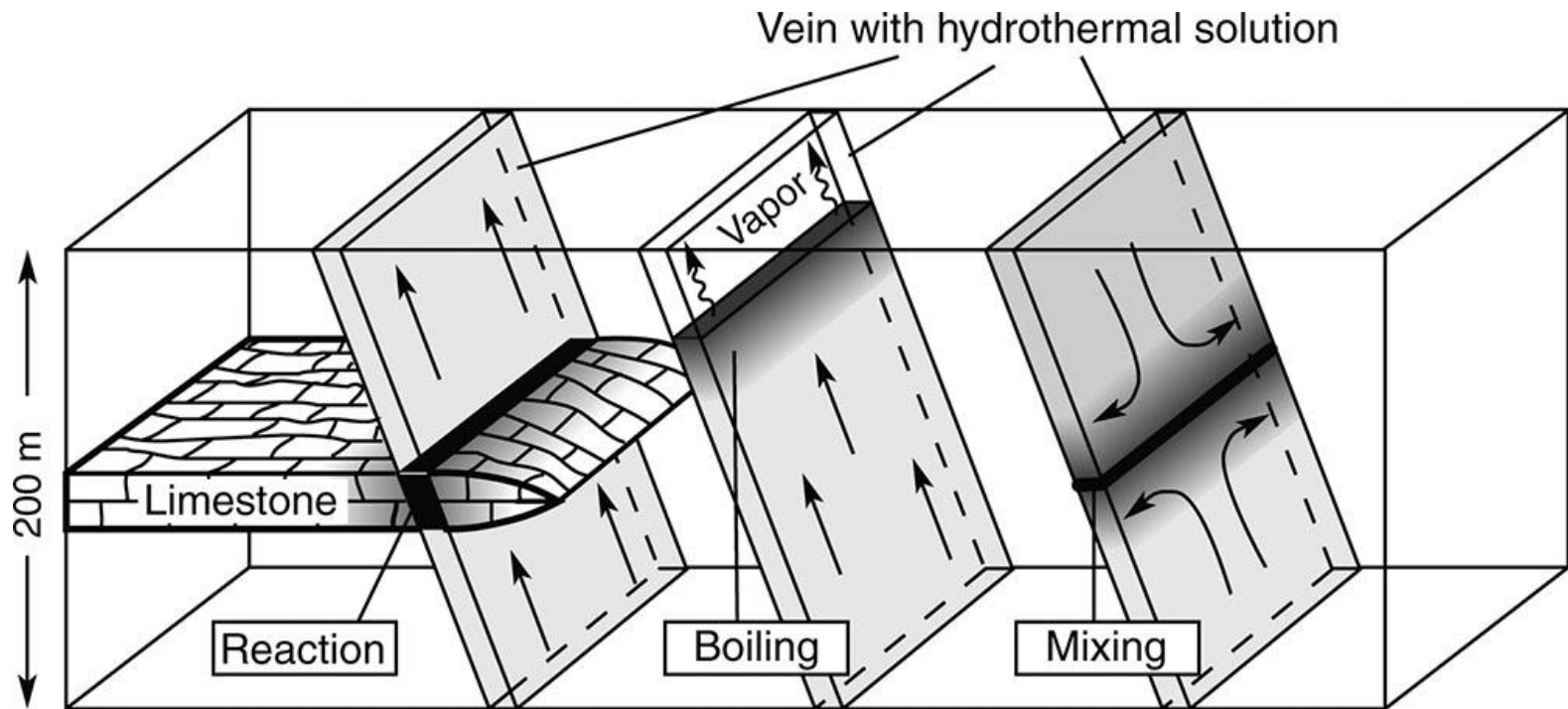
For Geology, see Pg. 47



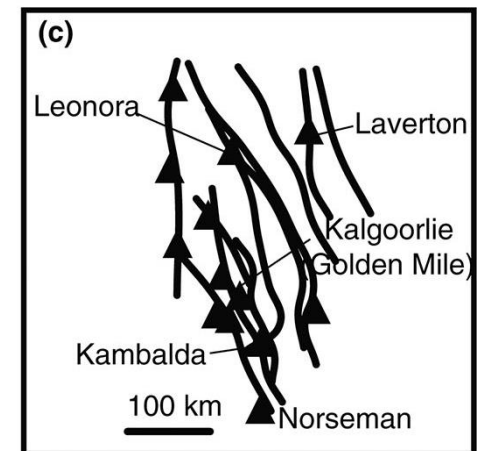
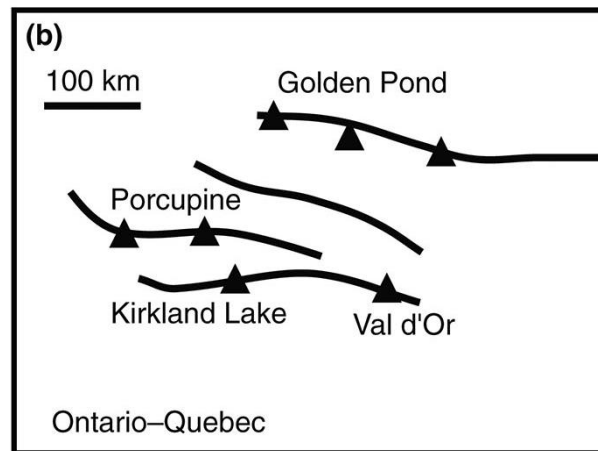
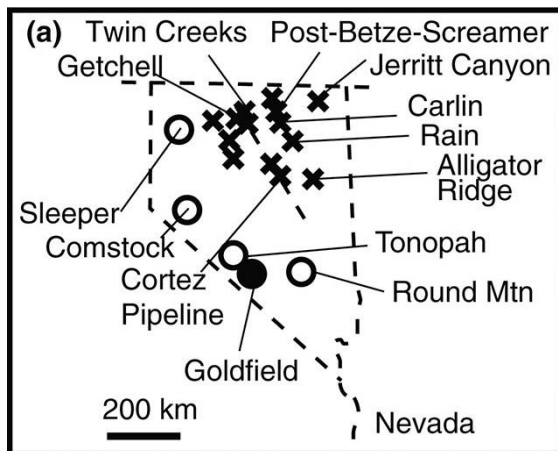








**Depositional mechanisms in hydrothermal solutions**





# 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



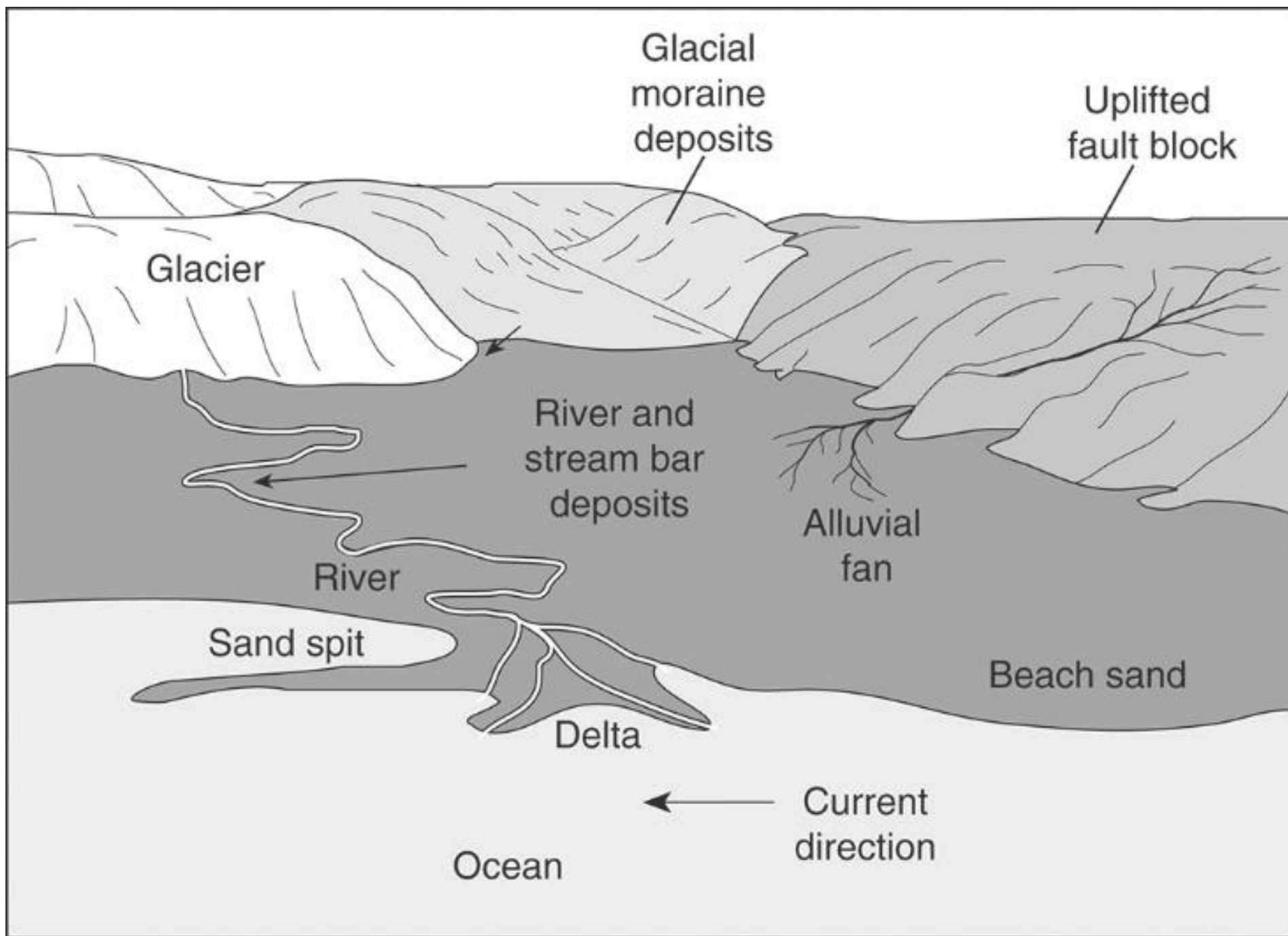
# Gold Mining Wages and Production

Witwatersrand miners make ~\$15,600 / person / year  
...this is ~10% the average wage of American miners

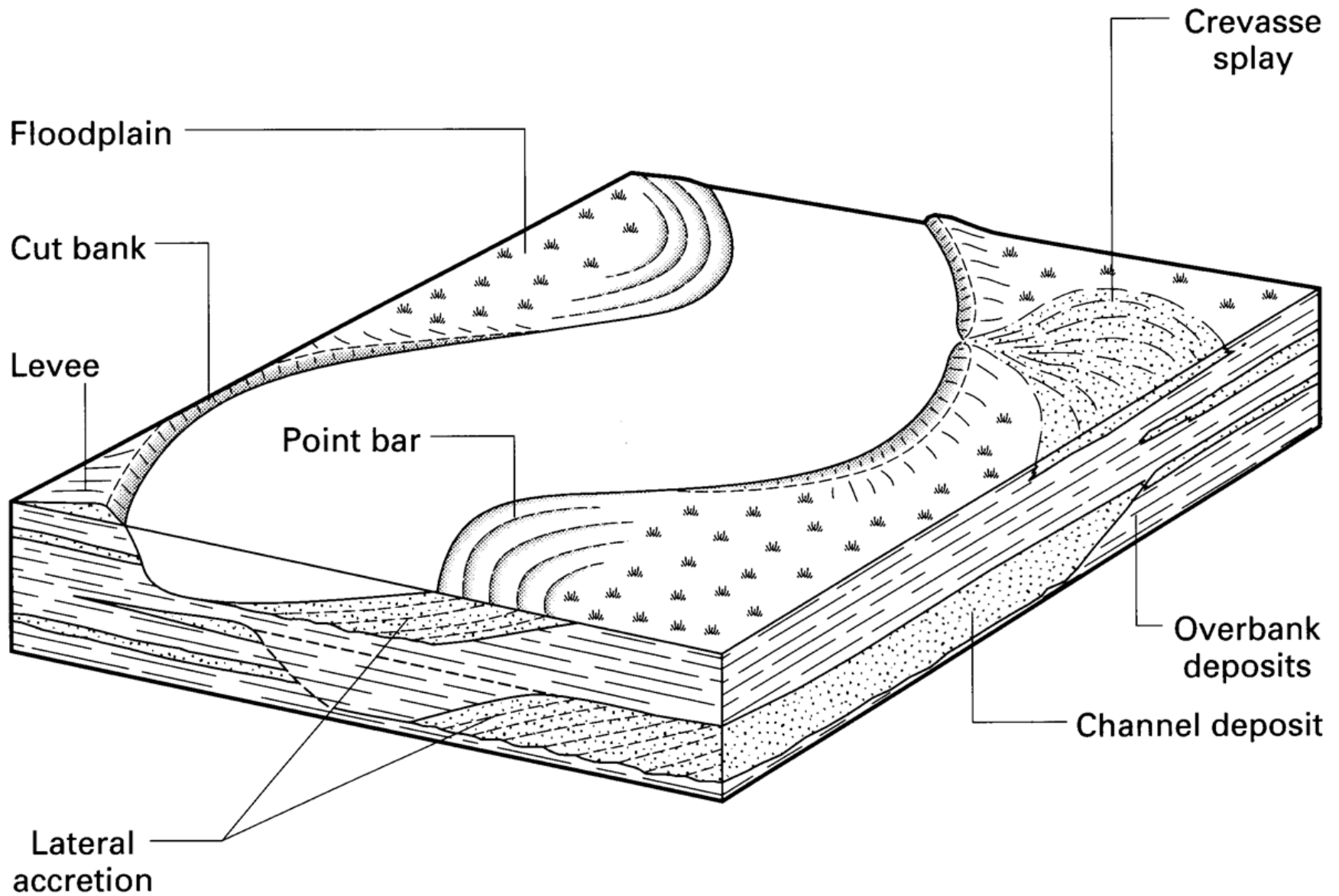
<i>Company</i>	<i>Gold production (ounces)*</i>	<i>Fraction of gold produced in South Africa<sup>#</sup> (%)</i>	<i>Employees</i>	<i>Ounces per employee</i>
Agnico–Eagle	1,100,000	0	3,250	338.5
Newmont	5,100,000	0	15,100	337.7
Kinross	2,600,000	0	8,230	315.9
Barrick	7,160,000	0	23,000	311.3
Goldcorp	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.

<sup>#</sup> No other African country is a major producer of gold for these countries.





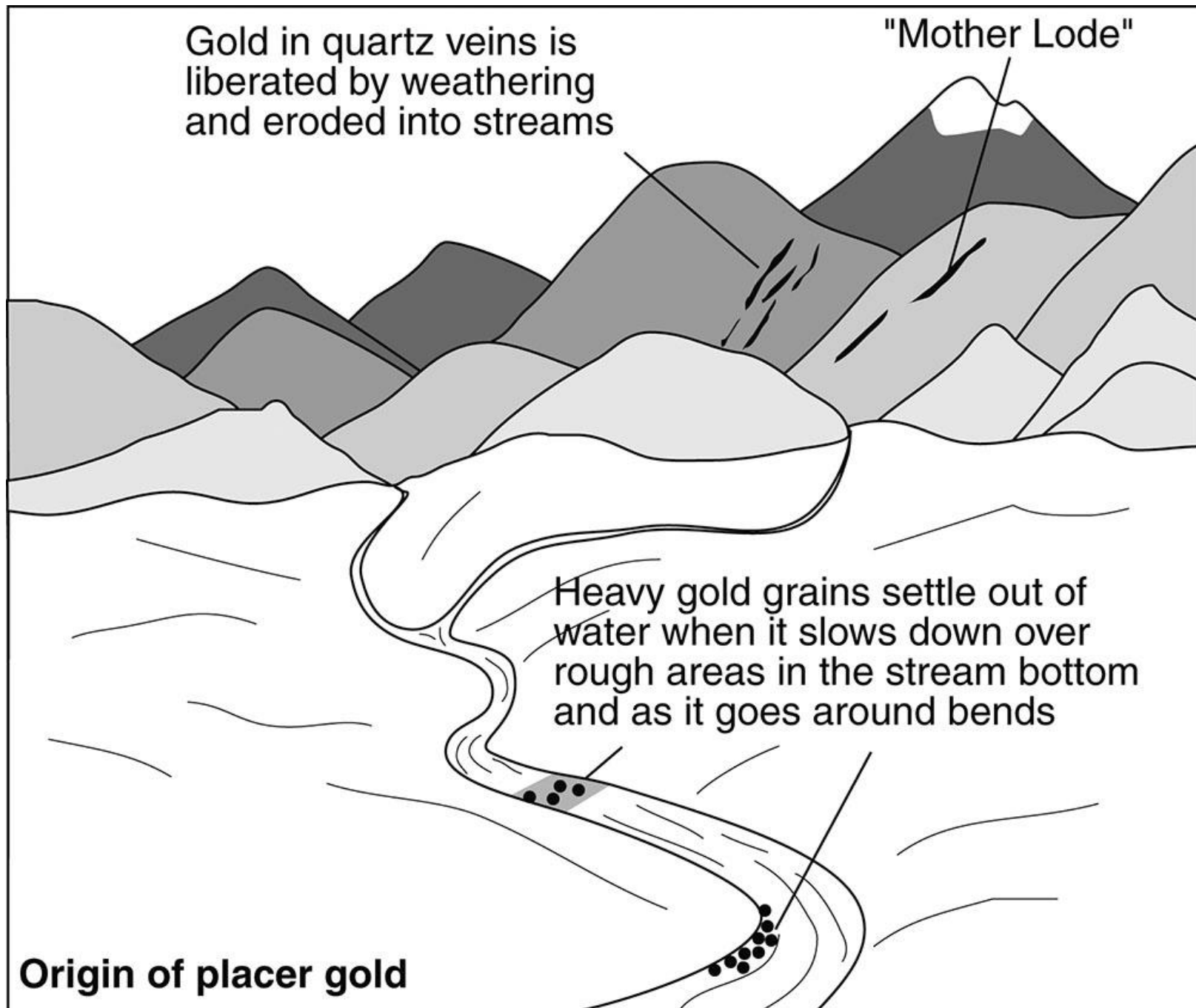


Gold in quartz veins is  
liberated by weathering  
and eroded into streams

"Mother Lode"

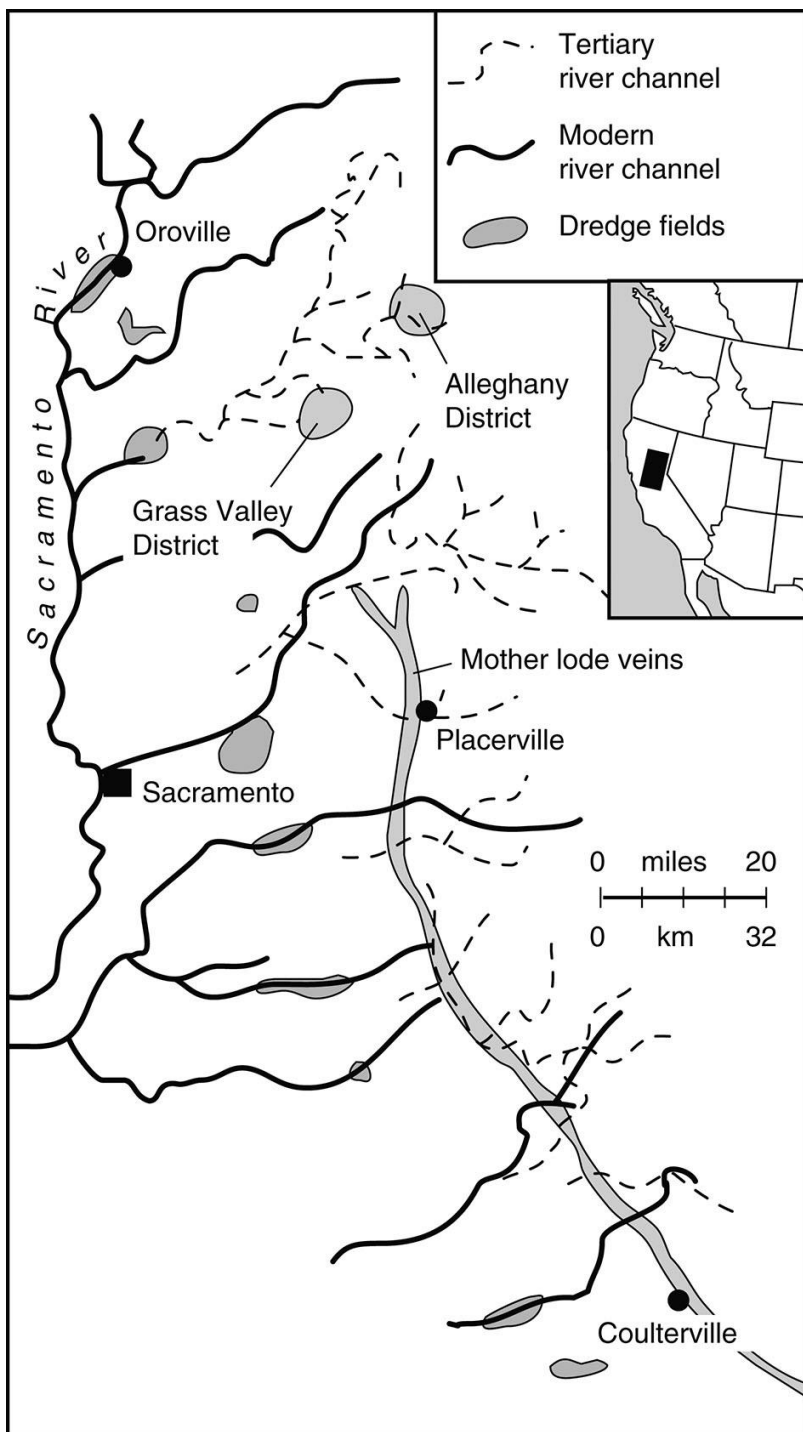
Heavy gold grains settle out of  
water when it slows down over  
rough areas in the stream bottom  
and as it goes around bends

Origin of placer gold

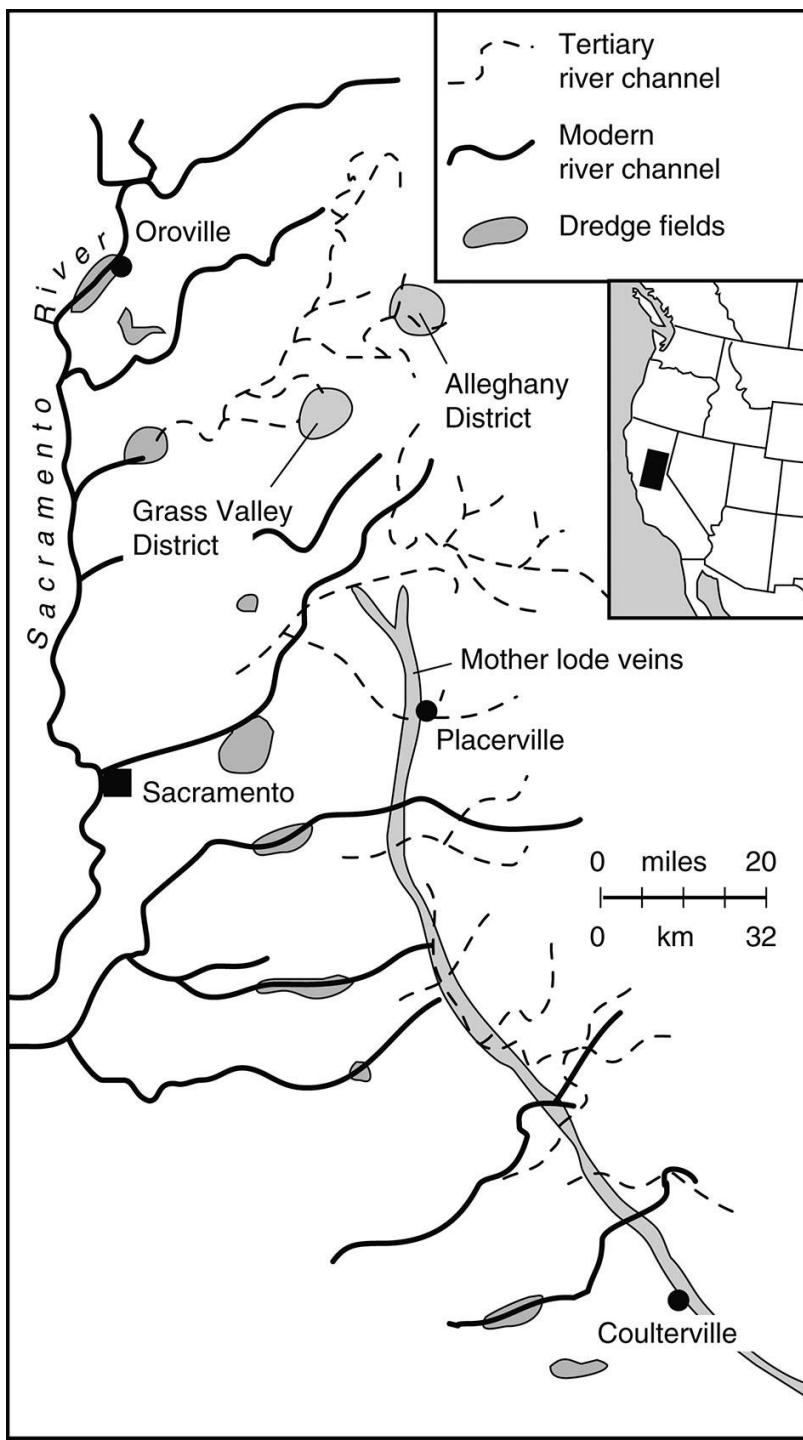


Metal	Density (lb/in <sup>3</sup> )	Specific Gravity
Magnesium	.064	1.77
Aluminum	.098	2.70
Titanium	.161	4.51
Chromium	.250	6.92
Zinc	.258	7.14
Tin	.264	7.30
Stainless Steel (Type 410)	.278	7.70
Iron/Steel	.284	7.87
Stainless Steel (Type 304)	.285	7.90
Muntz Metal	.303	8.39
Cartridge Brass	.308	8.53
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





USGS Photo, ~1875





Panning for gold

Hydraulic Mining





# Pleistocene river deposits



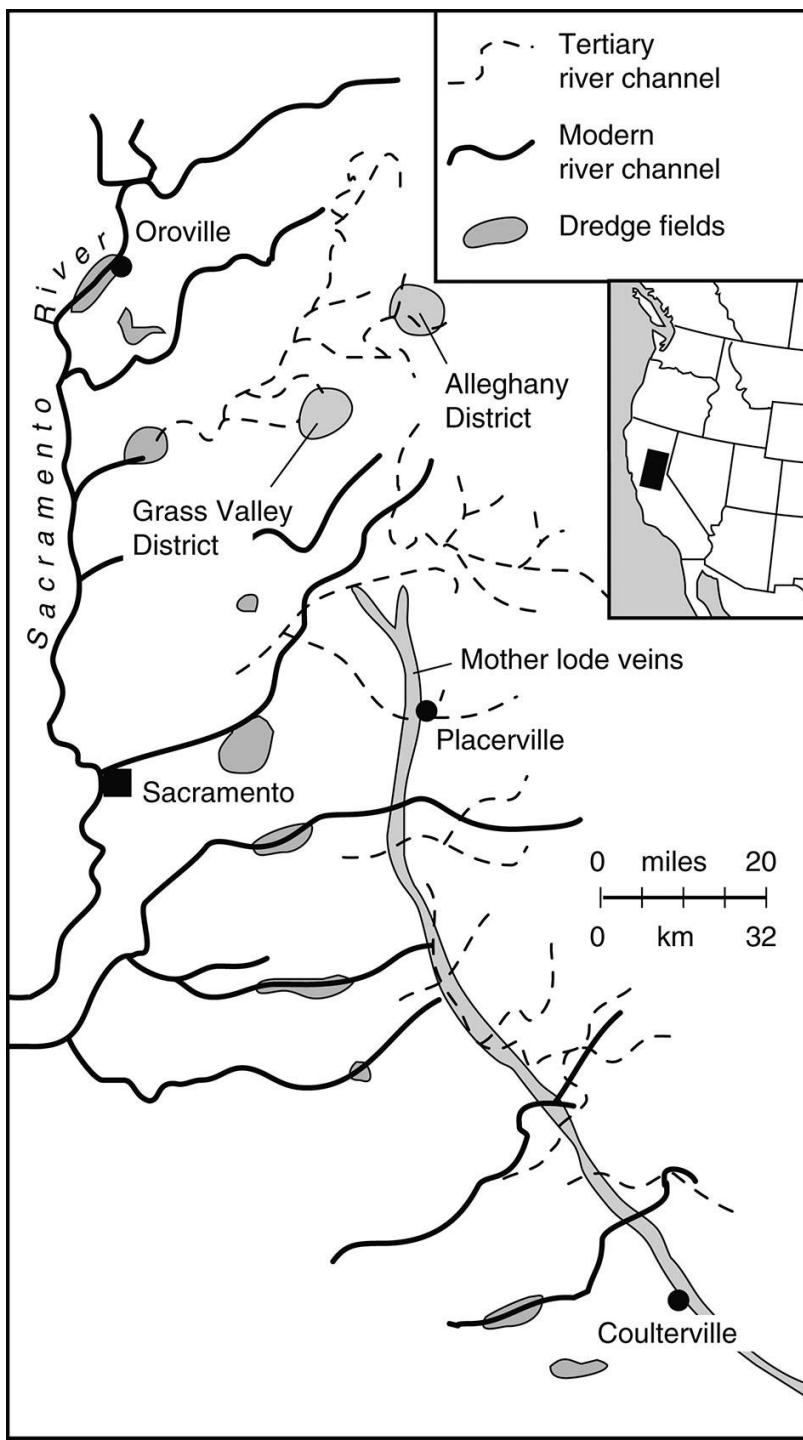




Panning for gold

Mercury Amalgamation

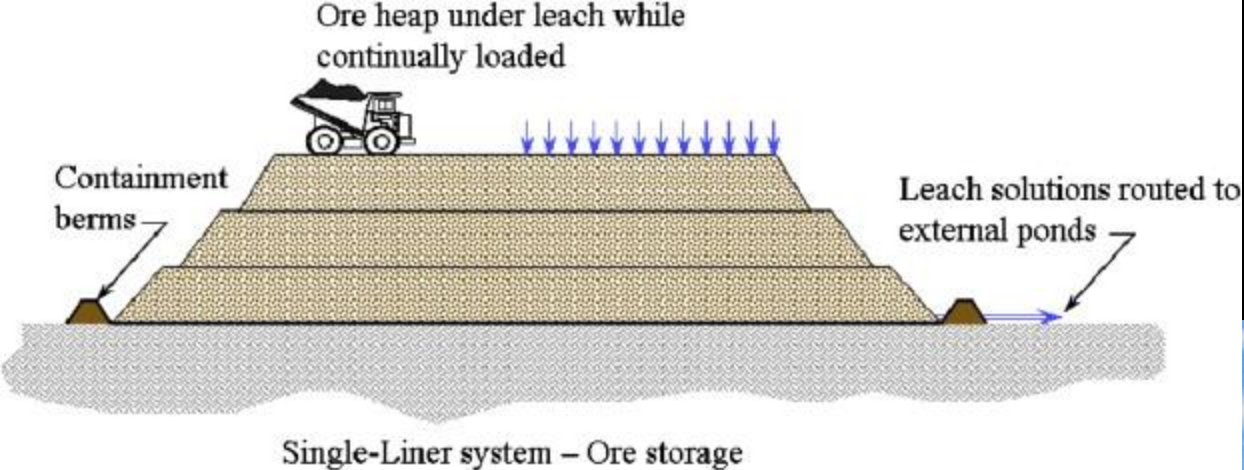




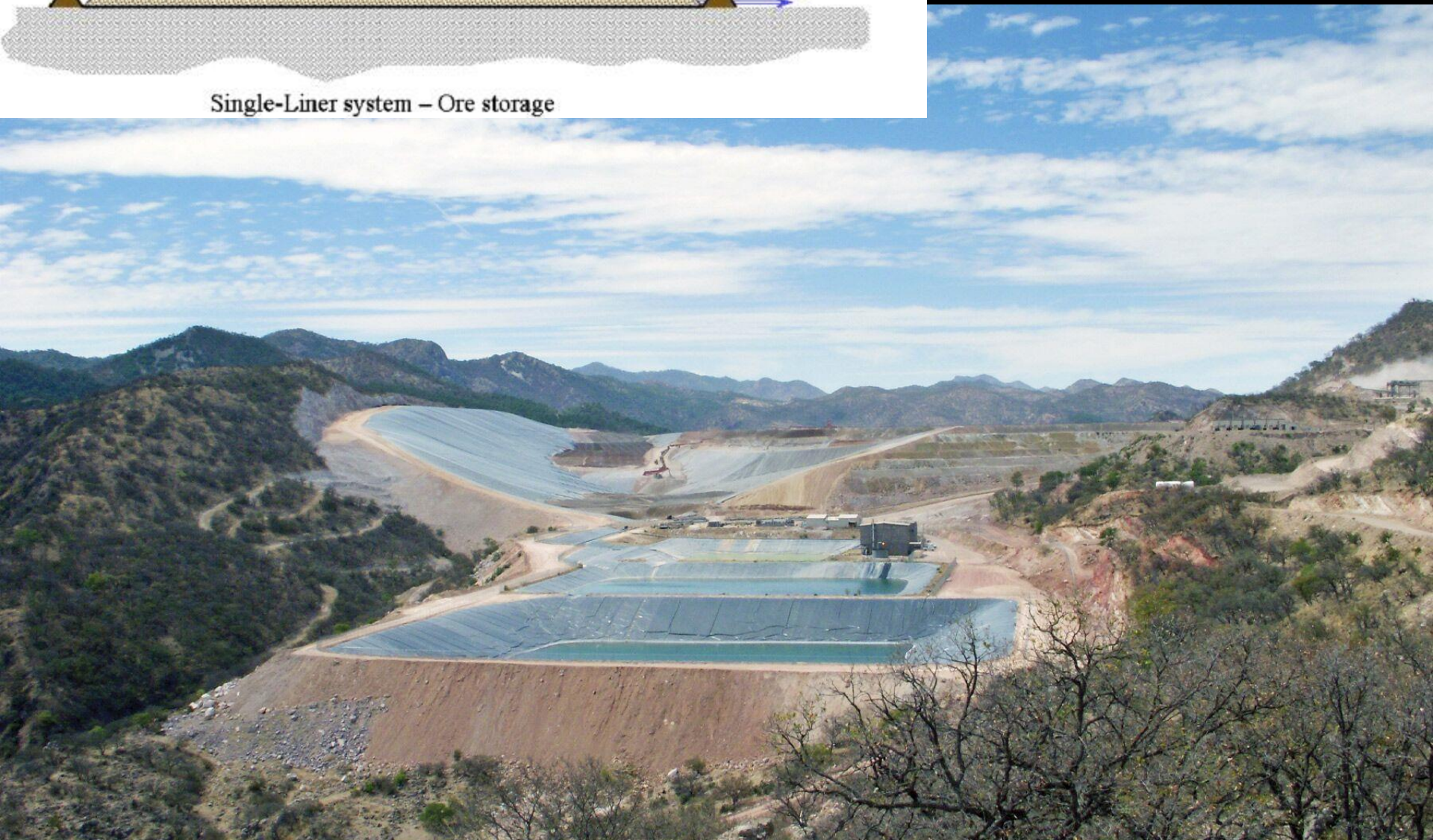
## Amalgamation:

- “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

