

# Science and Human Society II

(Geology, Mineralogy and Environment)

## Chapter 10 Gold, Platinum and Copper

I introduce production countries, deposits types, use, and price on gold, platinum (PGM), and copper.

**Gold production increased by a factor of seven since 1900.**

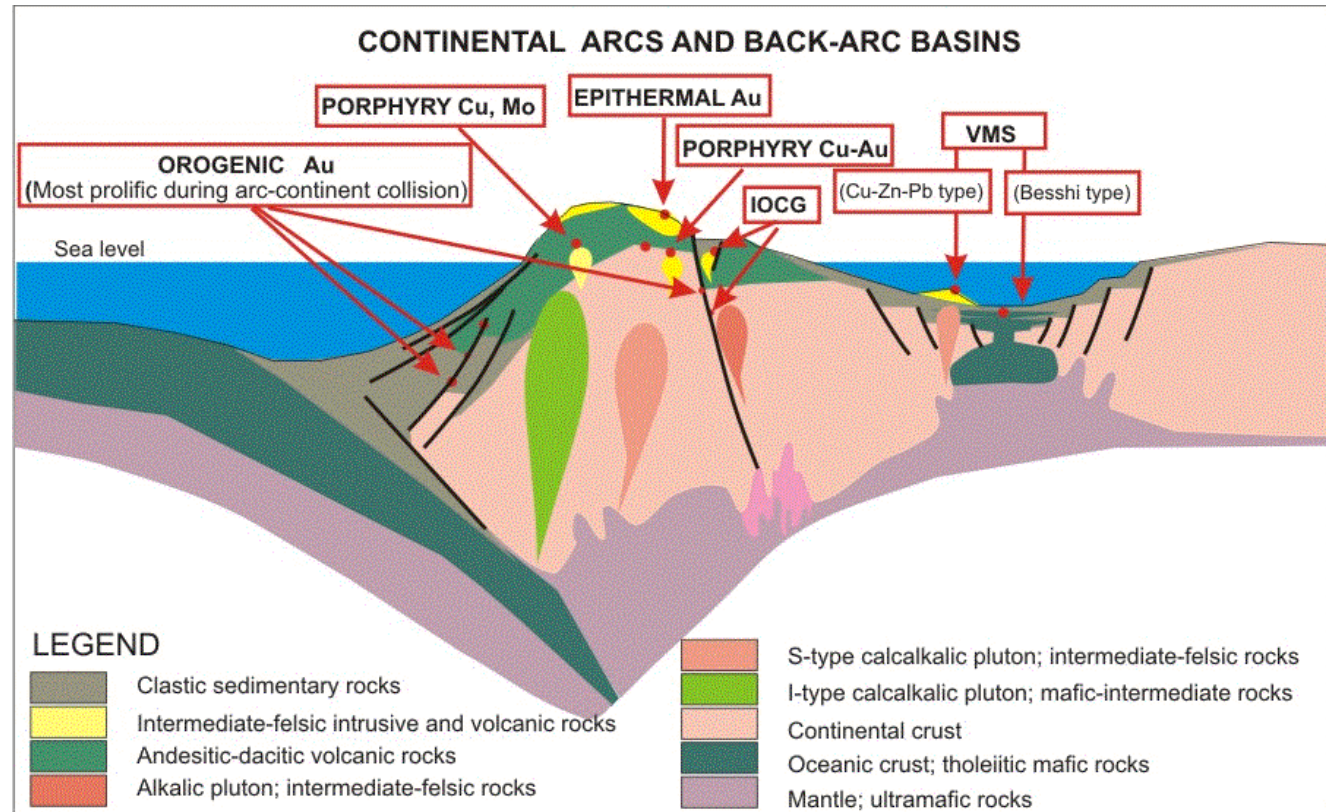
**Most of PGM (Platinum group) are produced in only three countries, South Africa, Zimbabwe and Russia.**

**Copper production has increased by a factor of 38 since 1900.**

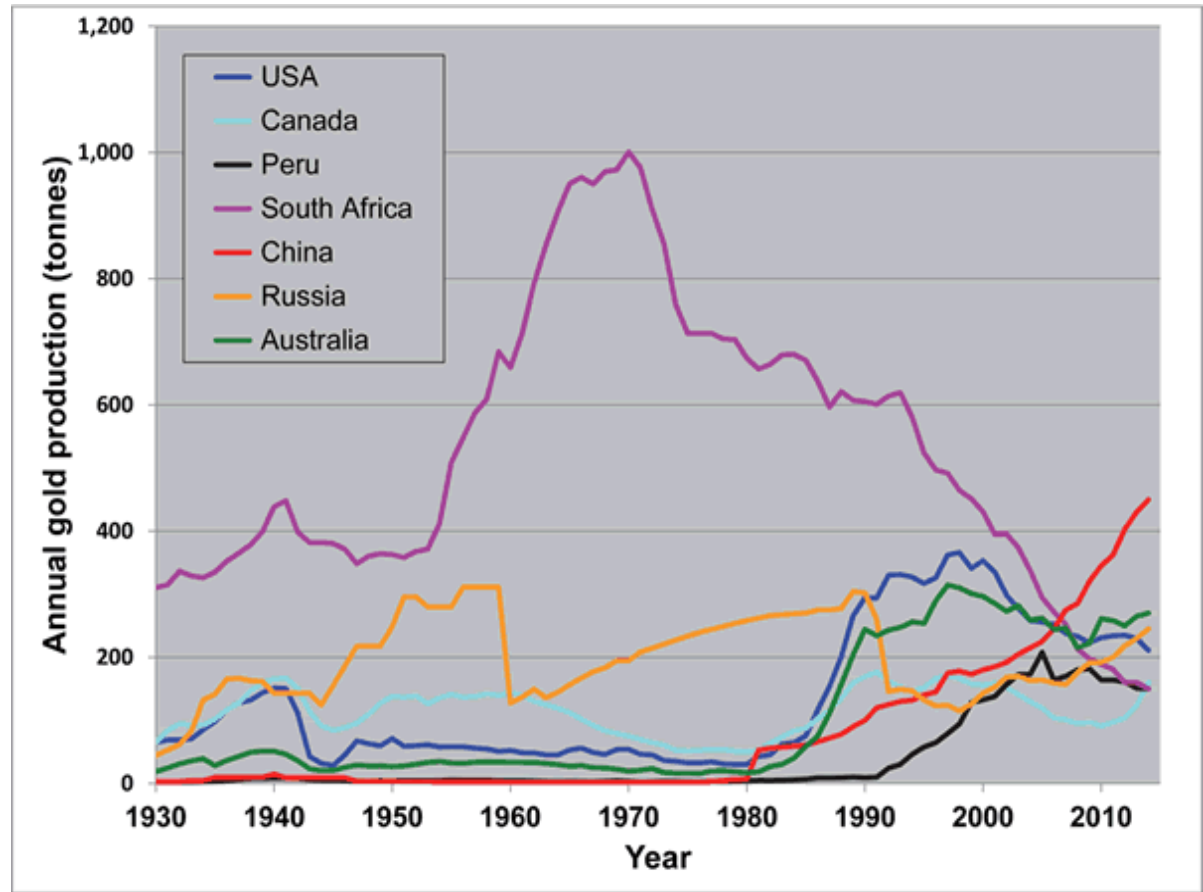
# Mineral deposits in continental arcs and back-arc basin

Porphyry type;  
Continental Arcs or Continental Margin (Au, Cu, Mo)

Volcanic Massive Sulfide type;  
Back-Arc Basins (Cu, Pb, Zn)



- The world of gold mining has changed.
- For decades the Witwatersrand in South Africa dominated global gold production.
- In 2007, China overtook South Africa to become the number one producer.



### Gold-mining boom

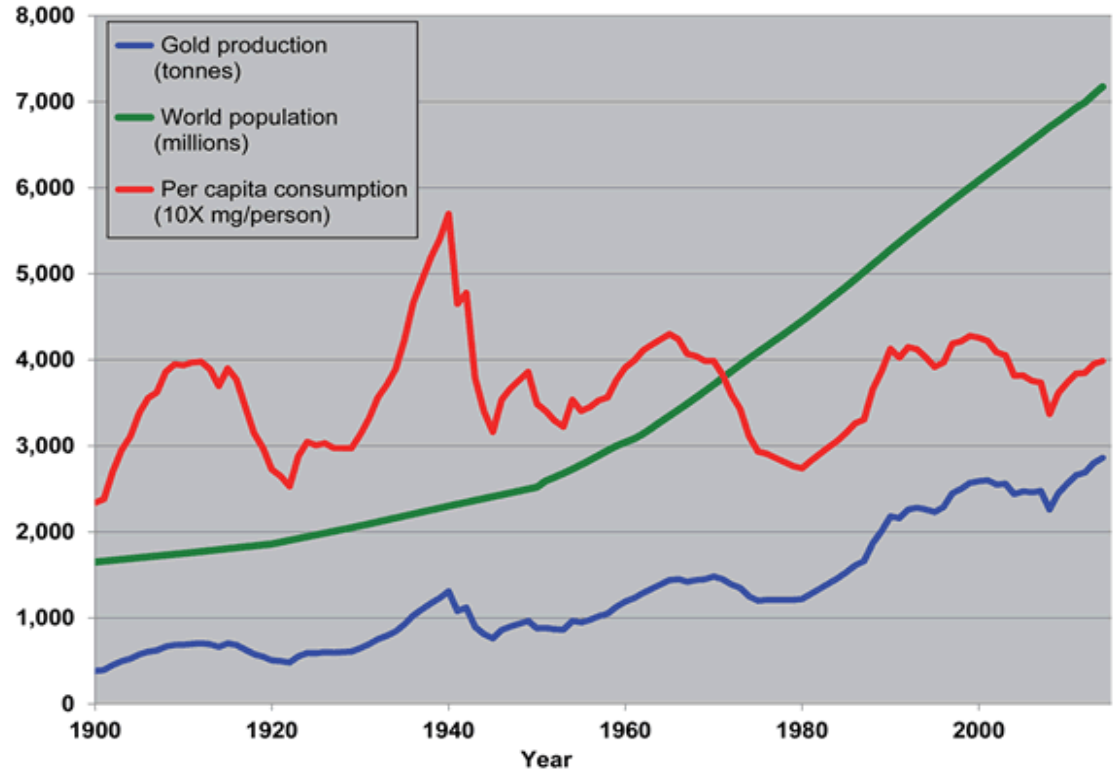
2023 (ton) (USGS)

1 China	370
2 Australia	310
2 Russia	310
4 Canada	200
5 USA	170

Price (2016) The world is changing. GSA Today, 26, 4-10.

## Annual global gold production, 1900 – 2014

- Gold production increased by a factor of seven.
- Per capita consumption increased by a factor of about two.



Recent production  
2019; 3300 ton  
2021; 3000 ton  
2023; 3000 ton

# PGM (Platinum Group Metal)

Zientek et al. (2014): USGS Scientific Investigations Report 2010–5090–Q, pp. 126.

- PGM: Ruthenium (Ru), Rhodium (Rh), Palladium (Pd), Osmium (Os), Iridium (Ir), Platinum (Pt)
- They show resistance to chemical attack

周期 /族	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1H																		He
2Li	Be												B	C	N	O	F	Ne
3Na	Mg												Al	Si	P	S	Cl	Ar
4K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6Cs	Ba	La *	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7Fr	Ra	Ac **	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og	

- Use : Autocatalysis, Jewelry, Electronics

- Price (2023):

Platinum US\$1000/Oz

Palladium US\$1500/Oz

- Production:

Platinum 186 ton (2019), 180 ton (2021), 180 ton (2023)

Palladium 227 ton (2019), 200 ton (2021), 210 ton (2023)





## PGM resources in South Africa and Zimbabwe

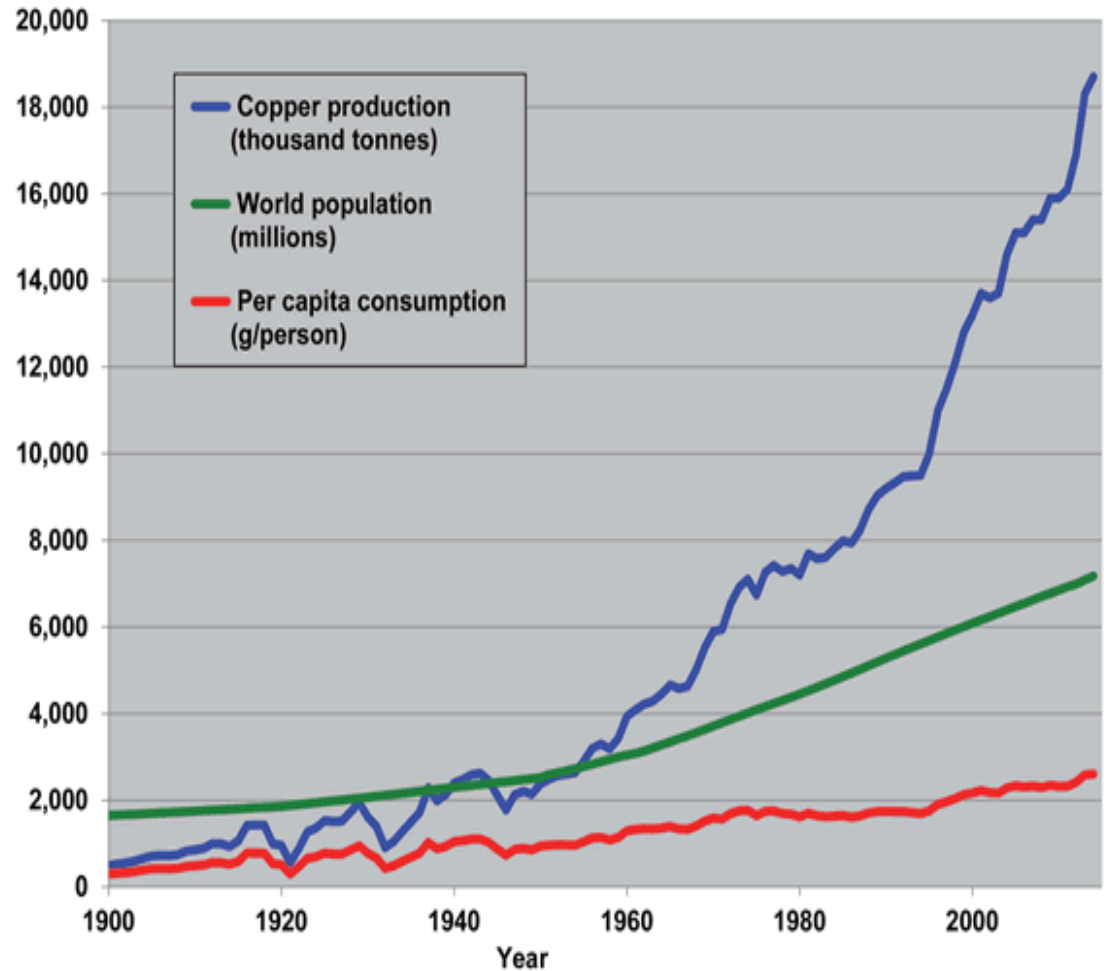
Undeveloped PGM resources of 75,000 tons are known mostly in Bushveld complex of South Africa.



South Africa and Zimbabwe

# Annual global copper production, 1900 – 2014

- World population has increased four-fold.
- Copper production has increased by a factor of 38.
- Per capita consumption has risen nine-fold.



Recent production x 1000 ton  
2019; 20,400  
2021; 21,000  
2023, 22,000

# Copper Resources in the world

Porphyry copper deposits account for about 60 % and Sediment-hosted strata-bound copper deposits for 20 %.

Copper ore deposits are concentration of sulfide, oxide and carbonate copper minerals. Previously Japan has many copper mineral deposits. After around 1960, smelting technology has developed and low-grade ores have been much processed.



Distribution of porphyry copper deposits (USGS, 2005)

# Copper is used in every modern life

Used in almost every aspect of modern life such as plumbing, electrical wiring, cars, cell phones, and energy systems (e.g., wind turbines).

U.S. consumption is about 2 million metric tons of copper per years whereas world consumption is about 22 million metric tons per year.

✘ In addition to identified copper resources of 2100 Mt, a mean of 3500 Mt of undiscovered copper is expected in 11 regions spanning six continents.

Video on Sado Gold Mine and Copper mining in Chile are introduced.

Sado Gold Mine

Sado Mine in Edo Epoch has been rebuilt for tourism.

<https://www.youtube.com/watch?v=tFy6qI60YsI>

Copper mining in Chile by Marubeni. 4' 31".

(2024/03/12)

[https://www.youtube.com/watch?v=3IkEAHb3\\_eA](https://www.youtube.com/watch?v=3IkEAHb3_eA)