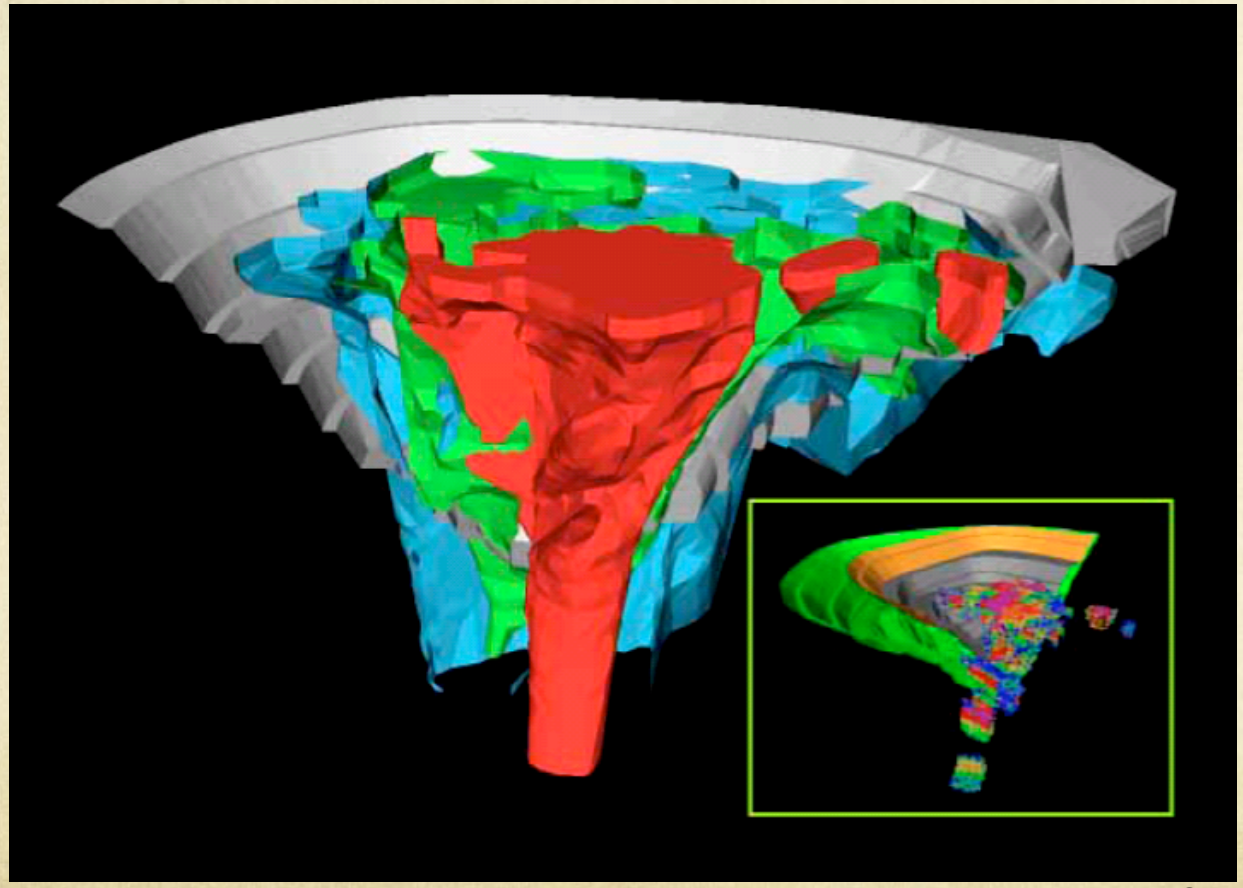
MI4100: Fundamentos de Metalurgia Extractiva

Objetivos Clase No 1

- Proceso minero
- Definicion de hidrometalurgia (scope)
- Contexto mundial/desafios
- Hidrometalurgia/participacion en el mercado mundial
- Hidrometalurgia vs pirometalurgia
- Flowsheet
- Termodinamica: Diagramas E_h-pH/Equilibrio quimico
- Cinetica: homogenea/heterogenea
  - Heterogenea:
  - Control difusivo/Control cinetico

I. Introduccion

- Paso 1. Identificacion de riquezas - Geologia



Evaluacion Tecnica

Explotacion

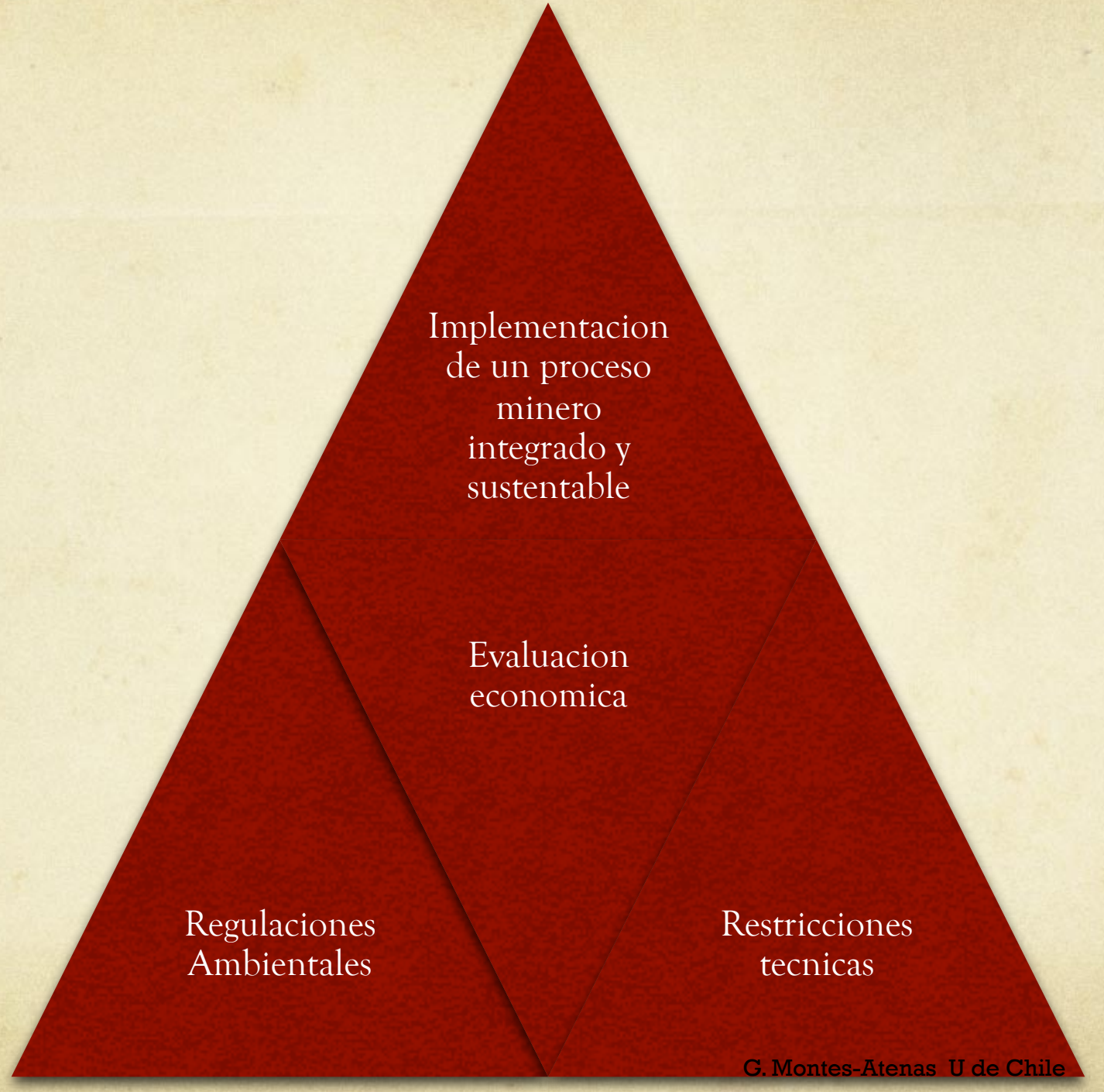
Uso de tecnologias:
-Explotacion minera
-Metalurgia Extractiva

I. Introduccion

- Paso 2. Explotacion minera
  - Conminucion
    - Seca: chancado
    - Humeda: molienda
  - Concentracion
    - Flotacion (fisico-quimica)
    - Gravitacional (fisico)
    - Magnetico (fisico)

Consecuencia de Explotacion Minera

- Aumento de superficie para Rx quimicas entre minerales, agua, aire, microorganismos, etc.
- Effecto negativo en el medio ambiente (aguas acidas, residuos solidos, residuos liquidos con y sin reactivos, residuos particulados, gases, particulas en suspension)


Implementacion de un proceso minero integrado y sustentable
Evaluacion economica
Regulaciones Ambientales
Restricciones tecnicas

Definicion de Proceso Minero

"Conjunto de procedimientos y metodos tecnologicos mediante las cuales, a partir de un yacimiento de interes geologico y economico, se pueden obtener determinados metales y/o productos no metalicos, de pureza y calidad comercial, de manera rentable y con un impacto ambiental aceptable", (Domic 1998)

Consideraciones adicionales

- Tendencias Modernas/Uso de economia de escala.
- Planificar la vida util de un proyecto (10-15 anos)
- Variacion de precios de mercado de los materiales
- Estabilidad politica y economica del pais receptor de la inversion

Hydrometallurgy

G. Montes-Atenas U de Chile

HYDROMETALLURGY

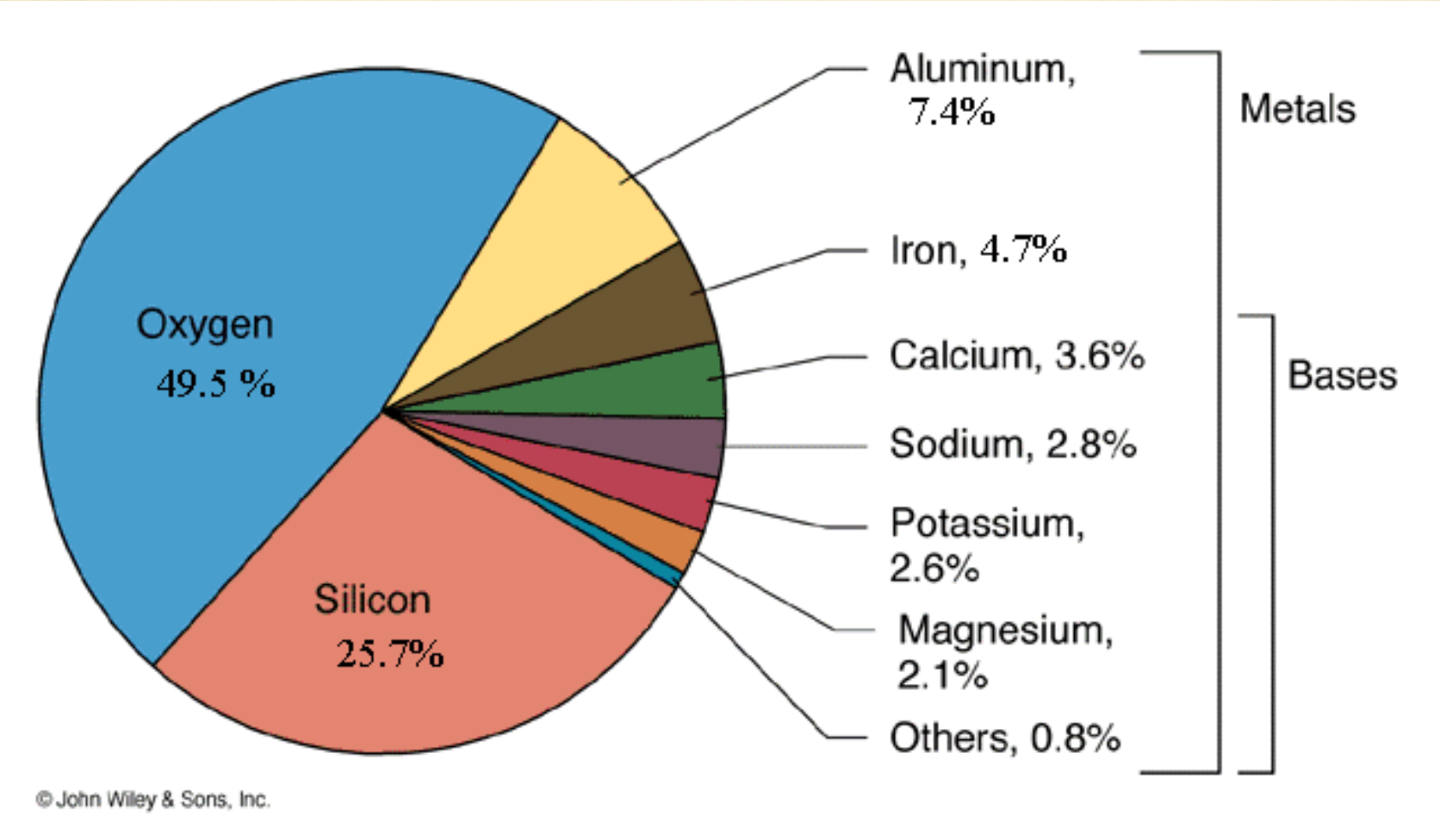
… is a discipline of extractive metallurgy, which for recovering of metals from ores, concentrates, by-products, wastes or for purification of solutions, and for production of metals utilizes chemical processes in aqueous solutions. Temperatures 25 to 250°C and pressures ranging from a few kPa up to 5000 kPa.

HYDROMETALLURGY...

... is a interdisciplinary technique, applying the knowledge of geology, mineralogy, chemistry, physics, engineering, ecology and economy...

In the Earth's Crust

- Metals account for 25% of the earth's crust



Occurrence and Distribution of Metals

Minerals

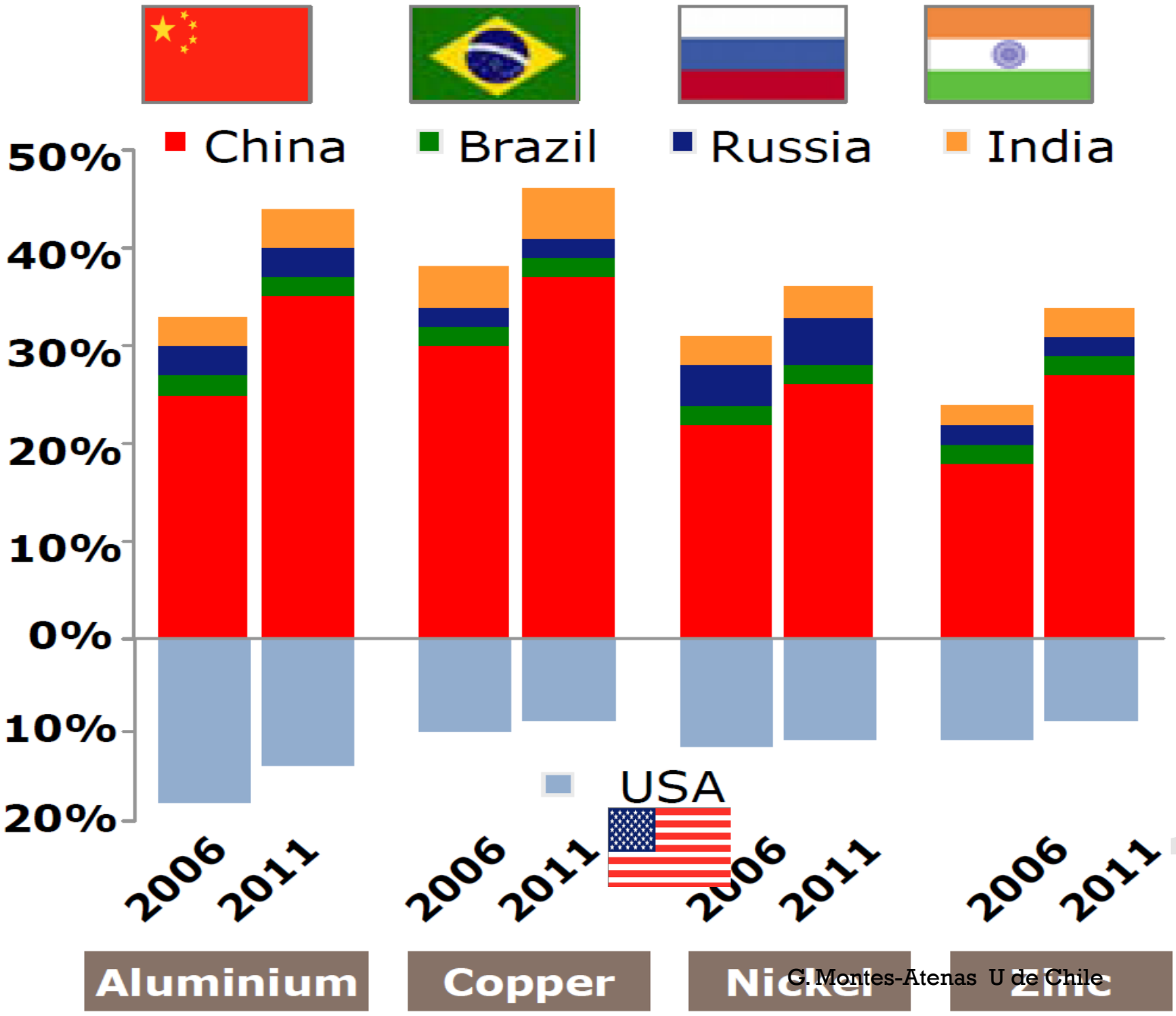
PRINCIPAL MINERAL SOURCES OF SOME COMMON METALS

Metal	Mineral	Composition
Aluminum	Bauxite	Al_2O_3
Chromium	Chromite	$FeCr_2O_4$
Copper	Chalcocite	Cu_2S
	Chalcopyrite	$CuFeS_2$
	Malachite	$Cu_2CO_3(OH)_2$
Iron	Hematite	Fe_2O_3
	Magnetite	Fe_3O_4
Lead	Galena	PbS
Manganese	Pyrolusite	MnO_2
Mercury	Cinnabar	HgS
Molybdenum	Molybdenite	MoS_2
Tin	Cassiterite	SnO_2
Titanium	Rutile	TiO_2
	Ilmenite	$FeTiO_3$
Zinc	Sphalerite	ZnS

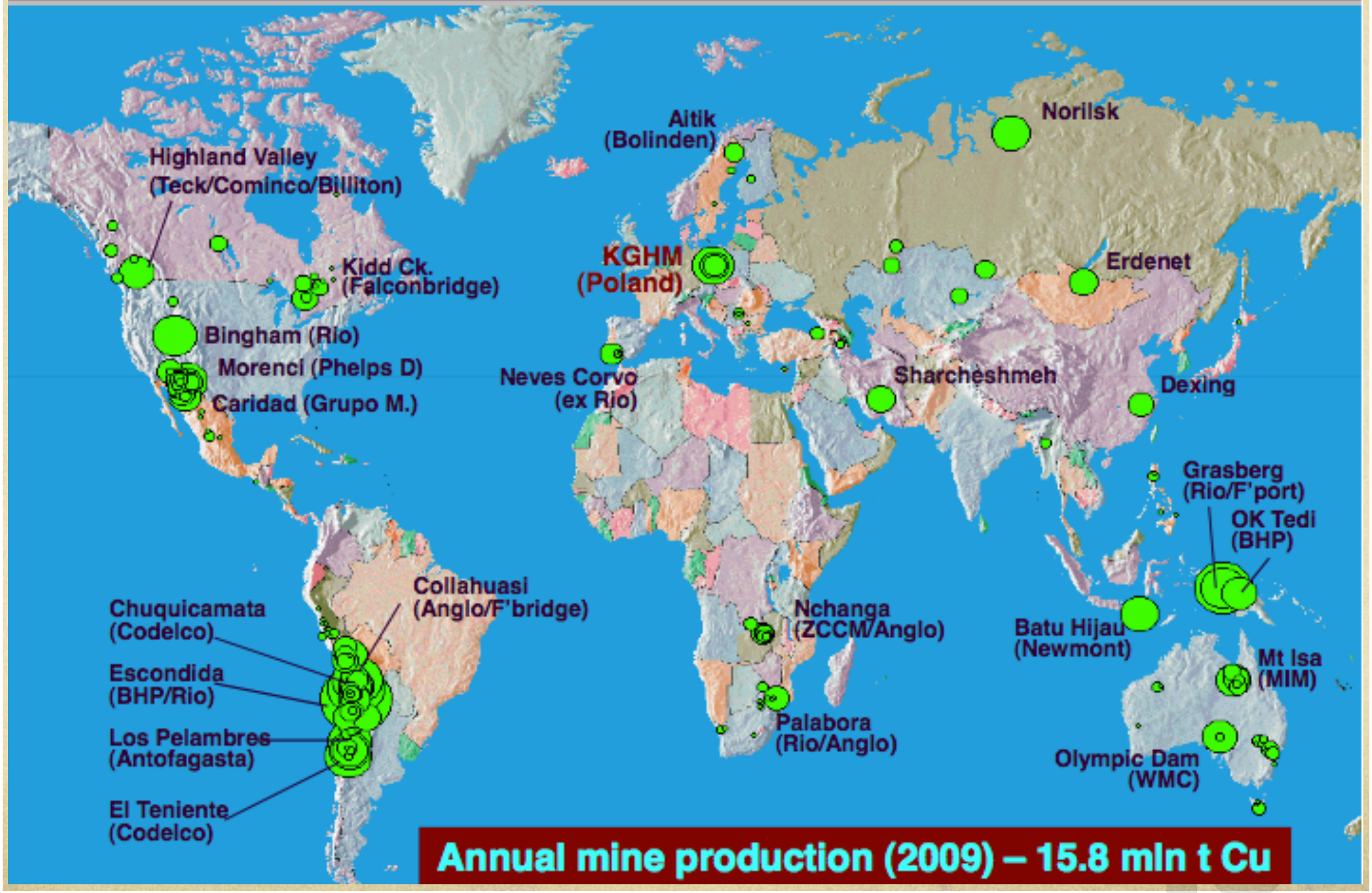
History of Hydrometallurgy

- Cementation & Aqua Regia - 8th Century
- Cyanidation - 1887
- Bayer Process - 1887
- Copper Electrowinning - 1912
- Zinc Electrolytic Process - 1916
- Manhattan Project (IX/SX) - 1940's
- Biooxidation of Sulphide Concentrates - 1960's
- Pressure Leaching
  - Sherrit Gordon Nickel Process - 1954
  - Pressure Acid Leaching of Ni Laterites - 1955
- Large Scale Copper SX/EW - 1960's
- Concentrate pressure leaching

Consumption of global commodities

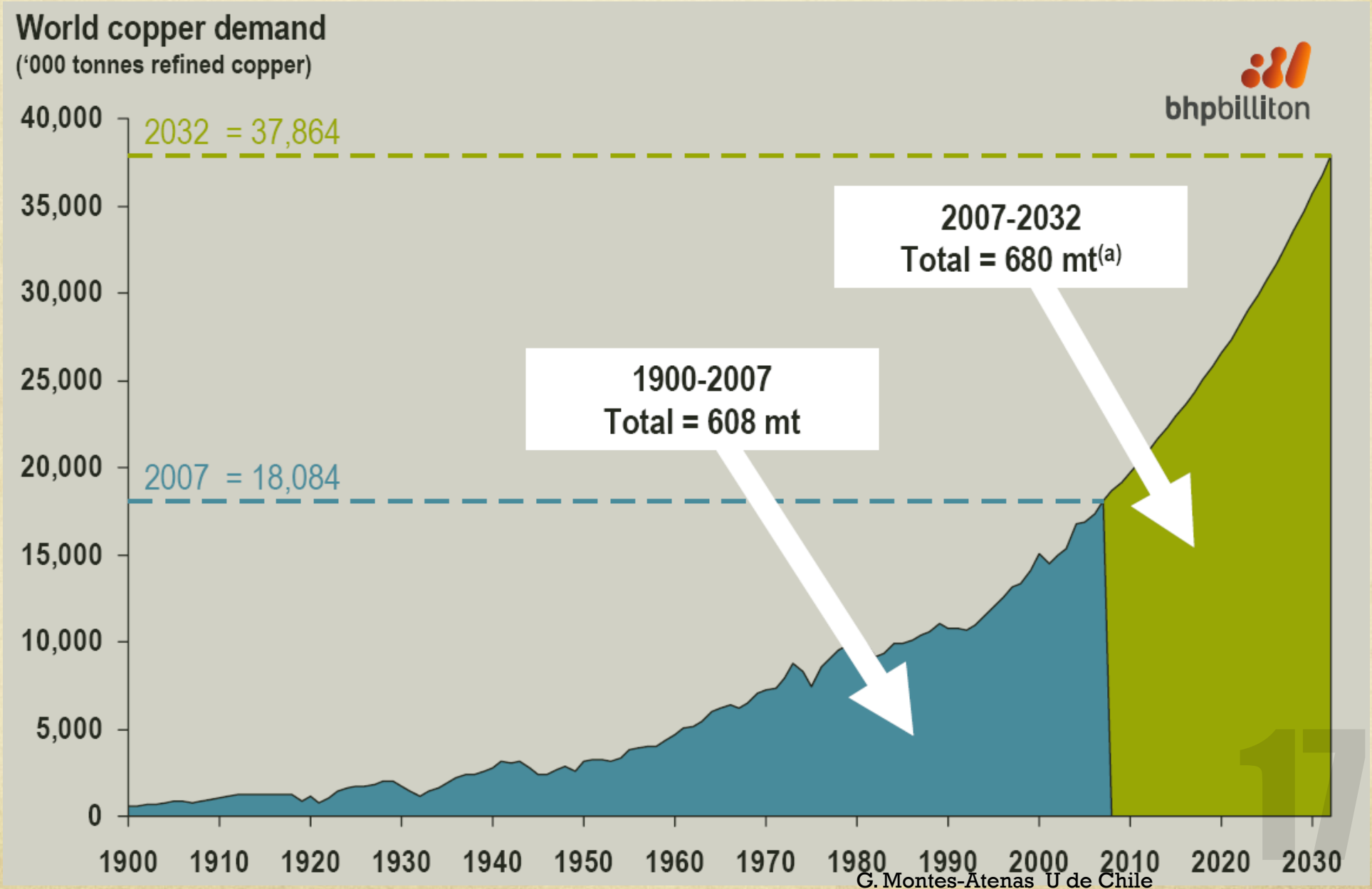


World copper producers



Annual mine production (2009) – 15.8 mln t Cu

To satisfy demand the world may need to mine as much copper over the next 25 years as throughout history



Significance of copper hydrometallurgy (2008)

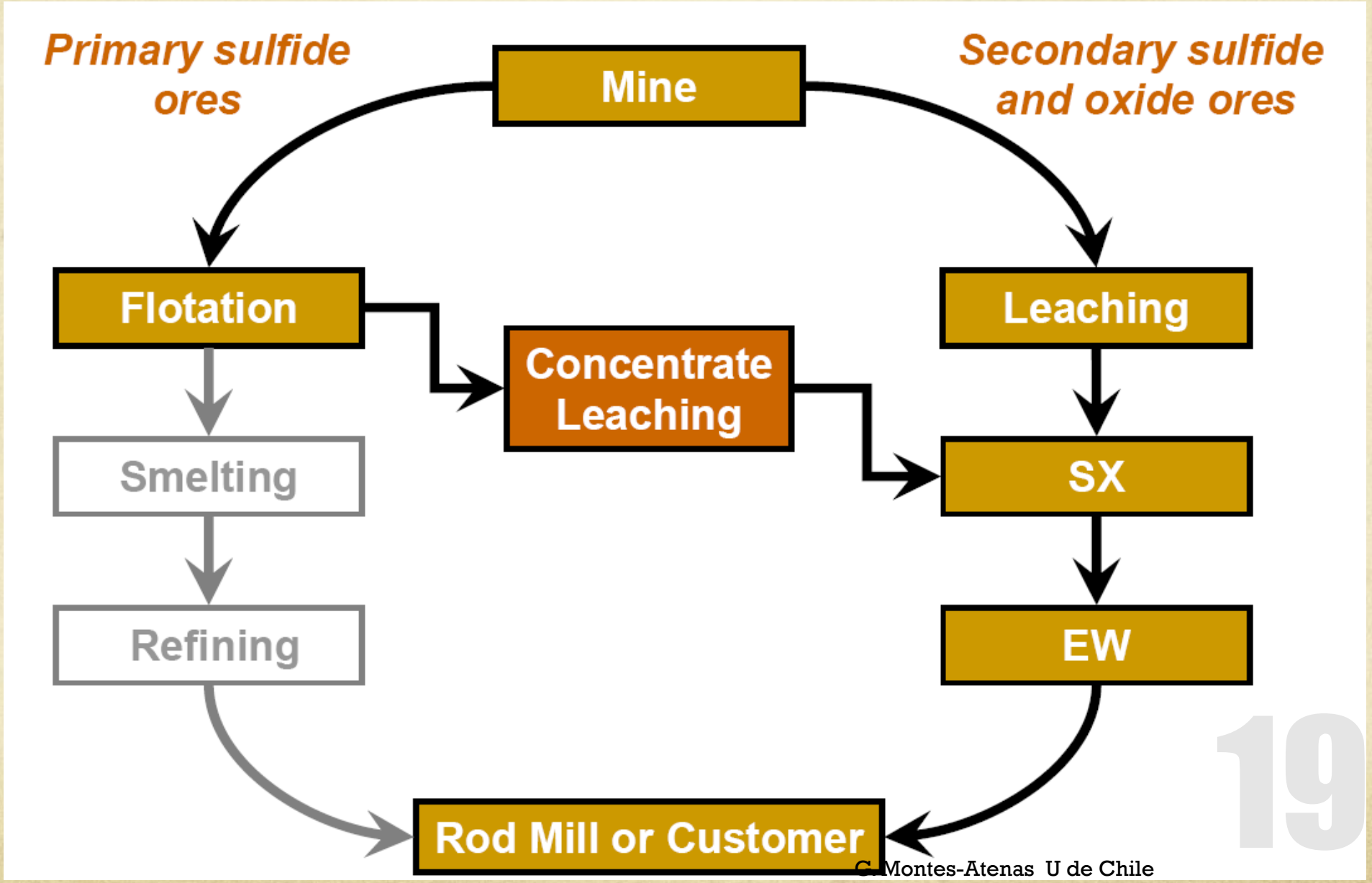
MINE PRODUCTION 15.5 mln tonnes

Smelting – 70 - 75 %

Hydrometallurgy 25 - 30 %

+ Cu scrap – 5.7 mln ton

Concentrate leaching technology



Hydrometallurgy vs. Pyrometallurgy

	Hydrometalurgy	Pyrometallurgy
Treat high grade ore?	Less economic	More economic
Treat low grade ore?	Possible with selective leaching	Unsuitable
Treat sulphide ore	No SO_2; otherwise S^o or SO_4^{2-} are generated	SO_2 generated (can be converted to H_2SO_4)
Separate similar metal, such as Ni and Co	Possible with certain method	Not possible
Pollutant	Waste water, solid/ slurry residues	Gases and dust
Reaction rates	Slower	Rapid

Hydrometallurgy vs. Pyrometallurgy

	Hydrometalurgy	Pyrometallurgy
Scale of operation?	Possibly economic to be done at small scale operation and expansion is easier	Unconomic at smale scale operation
Capital cost	Generally lower than pyrometallurgy	Higher
Energy cost	Lower	Higher
Materials Handling	Slurry Easy to be Pumped and Transported	Handle Molten Metal, Slag, Matte
Residues	Residues – Fine and Less Stable	Slags – Coarse and Stable

Strategy and concepts of hydrometallurgy development

- **1960-80th:** Elimination or reduction of SO_2 release to the atmosphere (elemental or sulphate sulphur is the product of sulphidic sulphur oxidation). Dust reduction by replacing the smelting processes with hydrometallurgical leaching (concentrates),

- **1980-90th:** Novel strategy of hydrometallurgy: leaching operation are complementary to smelting (specific feed materials, low grade and polymetallic ores, remote and small ore deposits, costs reduction for small scale production).

Unit Processes in Hydrometallurgy

- In general, hydrometallurgy involves 2 (two) main steps:

1. **Leaching**

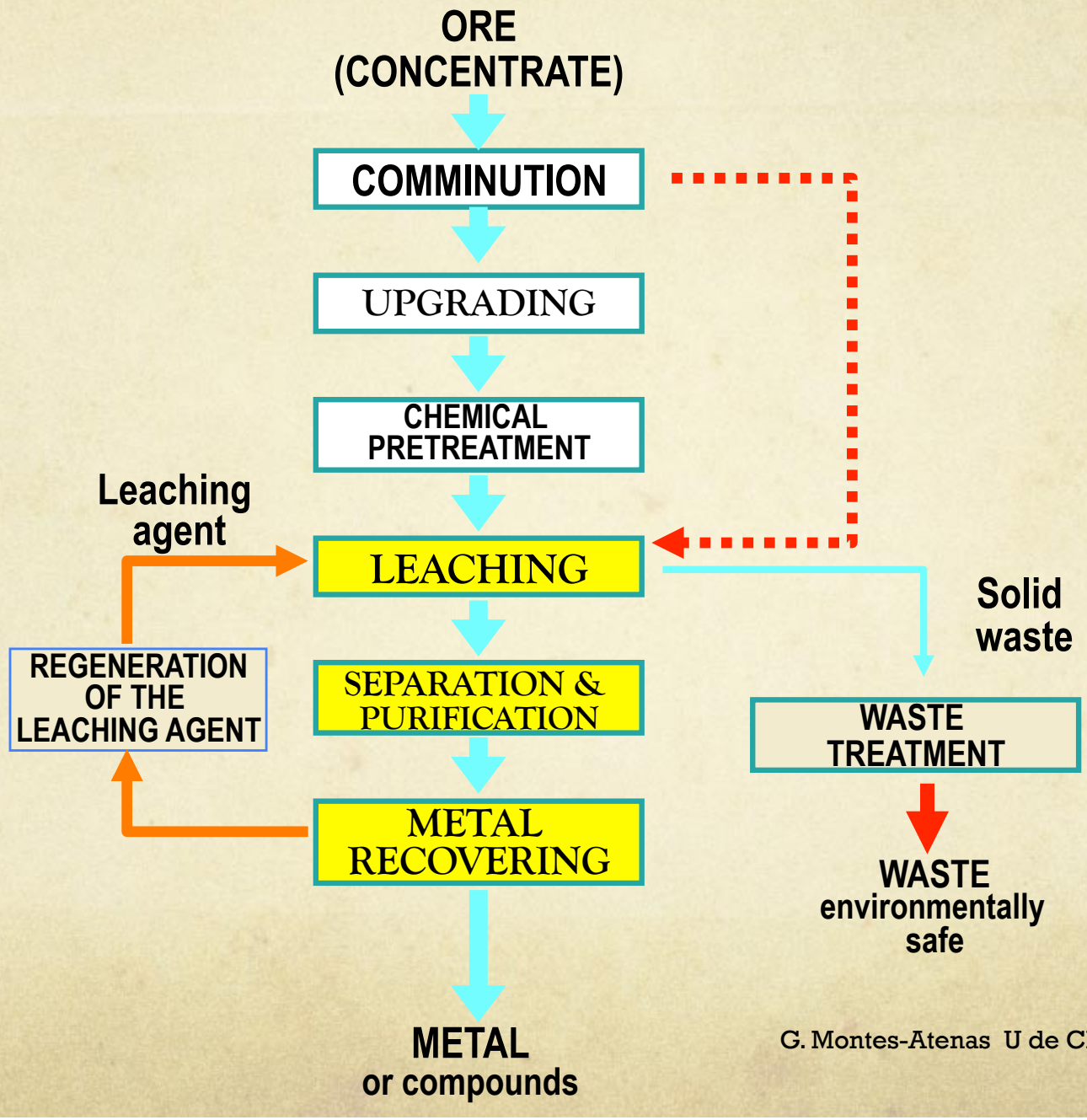
   Selective dissolution of valuable metals from ore.

2. **Recovery**

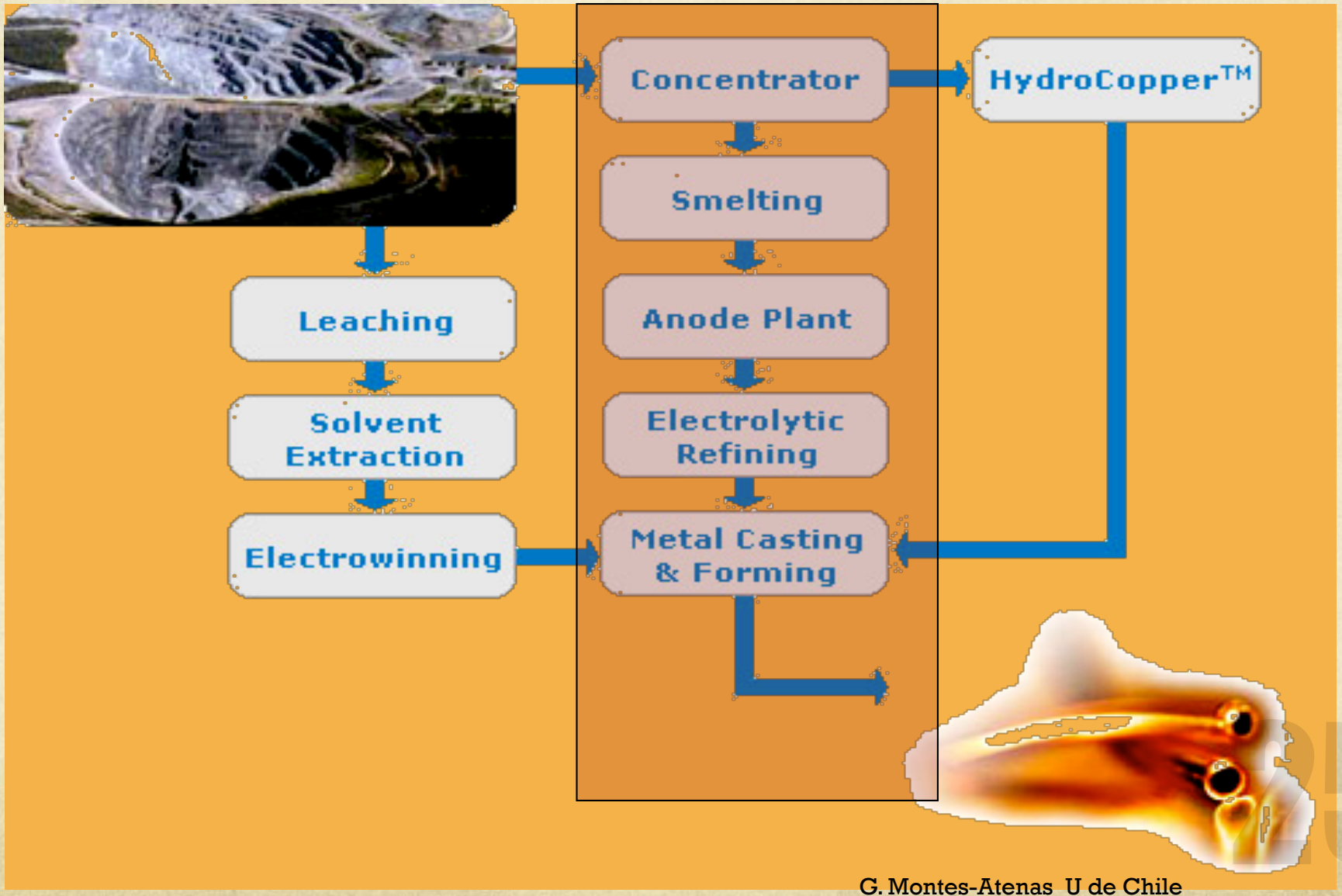
   Selective precipitation of the desired metals from a pregnant-leach solution.

General flowsheet of a hydrometallurgical process

Key unit operations



Copper metallurgy



Leaching agents in hydrometallurgy – characteristics

- Selective for one metal or a group of recovered metals (can not react with barren minerals),
- Well and fast dissolves in water at ambient temperatures, low viscosity of aqueous solutions,
- High concentration of metal (metals) in aqueous solutions,
- Easy for regeneration,
- Non-volatile, non-toxic (some exceptions), non-flammable, non-corrosive, environmental-friendly….
- Easy accessible, chemically, stable, not expensive

E-pH equilibrium diagrams

(Pourbaix diagrams)