CHAPTER II

Notions de base de la gîtologie des gisements métallifères et des substances utiles et minéraux industriels.

GLOBAL DISTRIBUTION OF DEPOSITS

Introduction

Organic deposits are not evenly distributed across the globe. Vast areas of land lack viable deposits, while other territories, known as "metal provinces," contain an unusual proportion of deposits of one or more types. Notable examples include the alignments of enormous copper deposits along the American Cordillera, from Alaska to Chile; the clusters of lead-zinc deposits in limestones in the central United States; and the tin deposits in the granites of Southeast Asia. For both geological and economic reasons, it is important to understand some key features of deposit distribution. From a geological perspective, the distribution of deposits provides important clues about mineralization processes; from an economic perspective, uneven distribution strongly influences metal prices and global trade; it is a significant factor influencing international relations and sometimes explaining alliances and conflicts.

• In plate tectonics-related deposit classifications, the emphasis is quite naturally placed on the tectonic context in which the deposit is located, but many deposits form in sedimentary contexts or by surface processes (weathering/erosion); for these examples, geomorphology, relief, and current and past climates exert additional controls on the location of deposits.

II.1 processus génétiques:

A- Processes Related to Internal Mechanisms

1- Magmatic Segregation (Magmatic Separation)
  - ➢ Fractional Crystallization: Solid-Liquid Separation
  - ➢ Immiscibility: Separation of two magmatic liquids

2- Hydrothermal Processes

3- Metamorphic Processes

B- Processes Related to External Mechanisms

1. **Residual Processes:** The weathering of rocks forms residual deposits concentrated in minerals such as bauxite.
2. **Detrital Processes**: Minerals are transported and concentrated in deposits by physical forces, such as water, forming alluvial deposits.
3. **Supergene Enrichment Processes:** The oxidation and leaching of minerals at the Earth's surface can concentrate certain metallic minerals in deposits.

II.2 The relationship between plate tectonics, geodynamics, and deposits

Plate tectonics and geodynamics dictate the formation and location of economic mineral deposits by driving magmatic, hydrothermal, and metamorphic processes at plate boundaries. Convergent, divergent, and transform settings concentrate specific resources (e.g., porphyry Cu-Au, VMS) through magma generation, crustal deformation, and heat flow over millions of years

II.2.1 Key Aspects of the Relationship:

Convergent Boundaries (Subduction Zones): These are the primary drivers of metal enrichment. Subduction drives magma generation, forming porphyry copper-gold-molybdenum deposits, as well as epithermal gold-silver, and VMS (volcanogenic massive sulphide) deposits.

Divergent Boundaries (Mid-Ocean Ridges): Magma rises to fill gaps, driving the formation of massive sulfide deposits on the seafloor.

Transform Boundaries & Continental Collision: These settings are often characterized by intense shear, metamorphism, and mountain building, which can localize mineral deposits.

Geodynamic Processes: The movement of plates on the asthenosphere (mantle convection) causes high heat flow and deformation, concentrating minerals.

Temporal Evolution: The transition from early Earth (mantle plume-dominated) to modern plate tectonics shifted the types of ore deposits formed and preserved, with older deposits often found in thicker, more buoyant continental crust.

II.2.2 Deposit Types Linked to Tectonics:

Porphyry Cu-Au-Mo: Associated with continental/intra-oceanic arcs.

VMS (Volcanogenic Massive Sulphide): Form at spreading ridges.

Ni-Cu-PGE: Form in mafic-ultramafic intrusions, often within specific tectonic settings.

Diamonds: Often associated with stable continental cratons.

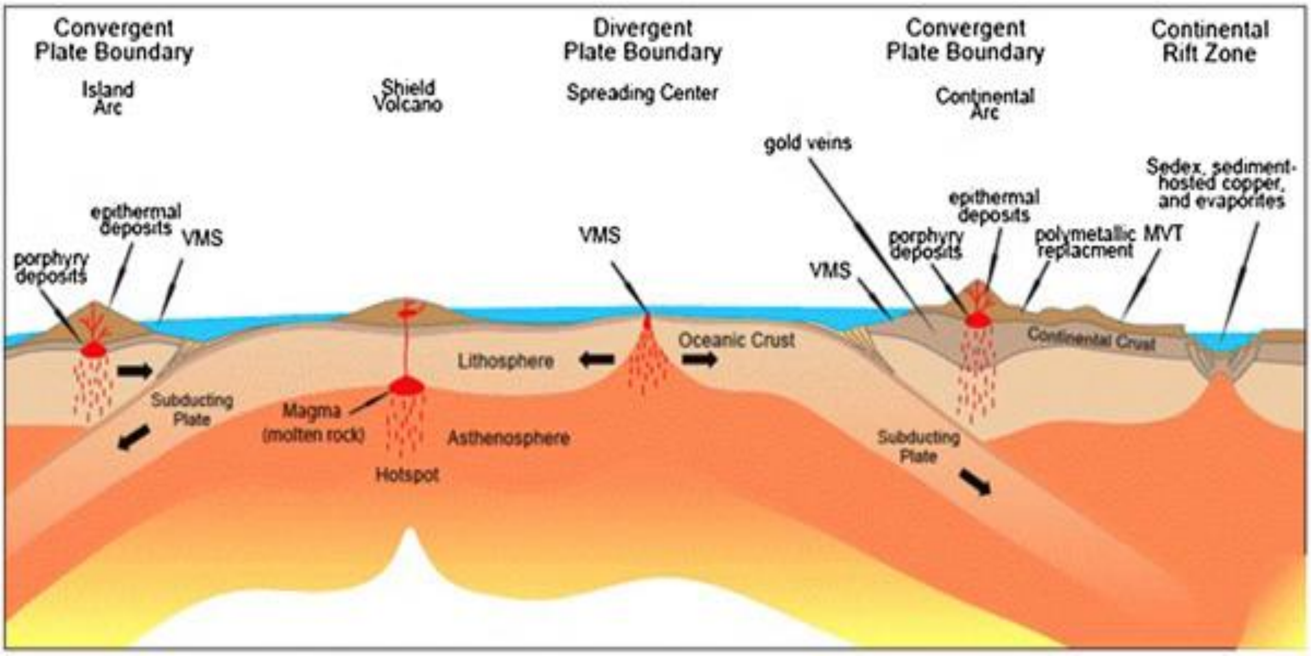


Figure: The plate-tectonic settings of common types of volcanism. Composite volcanoes form at subduction zones, either on ocean-ocean convergent boundaries (left) or ocean-continent convergent boundaries (right). Both shield volcanoes and cinder cones form in areas of continental rifting. Shield volcanoes form above mantle plumes, but can also form at other tectonic settings. Sea-floor volcanism can take place at divergent boundaries, mantle plumes and ocean-ocean-convergent boundaries. [SE, after USGS (http://pubs.usgs.gov/gip/dynamic/Vigil.html)]

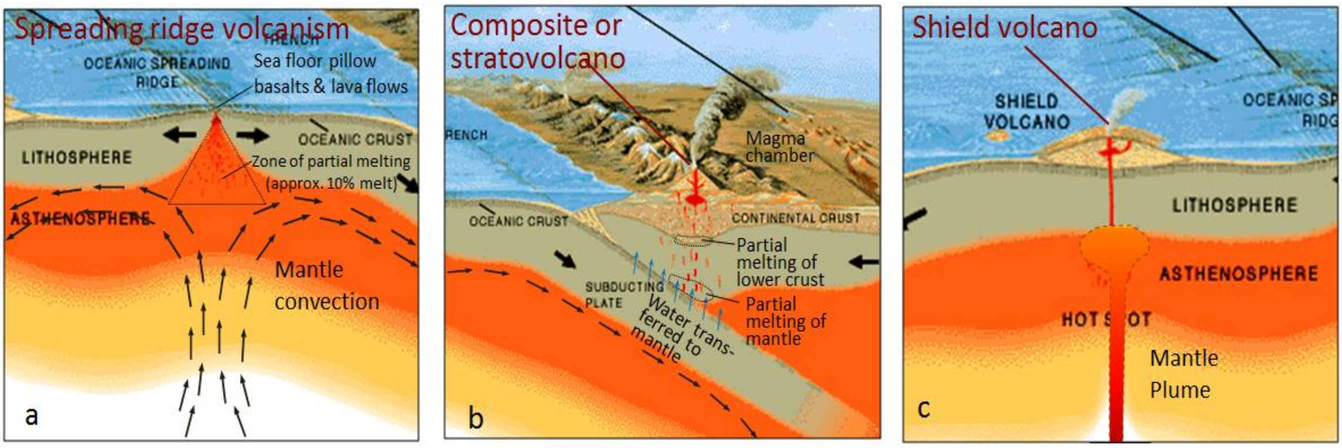


Figure: The processes that lead to volcanism in the three main volcanic settings on Earth: (a) volcanism related to plate divergence, (b) volcanism at an ocean-continent boundary, and (c) volcanism related to a mantle plume. [SE, after USGS*

II.3 Formation of a mineral deposit تكوين رواسب معدنية

Mineral deposits driven by geological processes like **magmatic crystallization**, **hydrothermal fluid circulation**, or **sedimentary deposition**. These deposits develop when favorable conditions allow metals to be sourced, transported, and deposited in specific crustal locations

The existence of a mineral deposit depends on the following four factors:

a) **A source of the mineral** **Une source du minéral**, regardless of its origin.

b) **Transport of the mineral** **Un transport du minéral**, either magmatic in origin or secondary by reworking from a pre-existing deposit, by mechanical transport (via streams, rivers) in solution by water in combined or free form.

c) **A reservoir** **Magasin** where the physicochemical conditions favorable to concentration are met (i.e., a "sponge" effect).

d) **A trap** **Un piège**, that is, a blockage preventing the mineralizing solution from leaving the "sponge" reservoir (this is the plug).

The relationships between "trap" and "reservoir" are called **METALLOTECTS**.

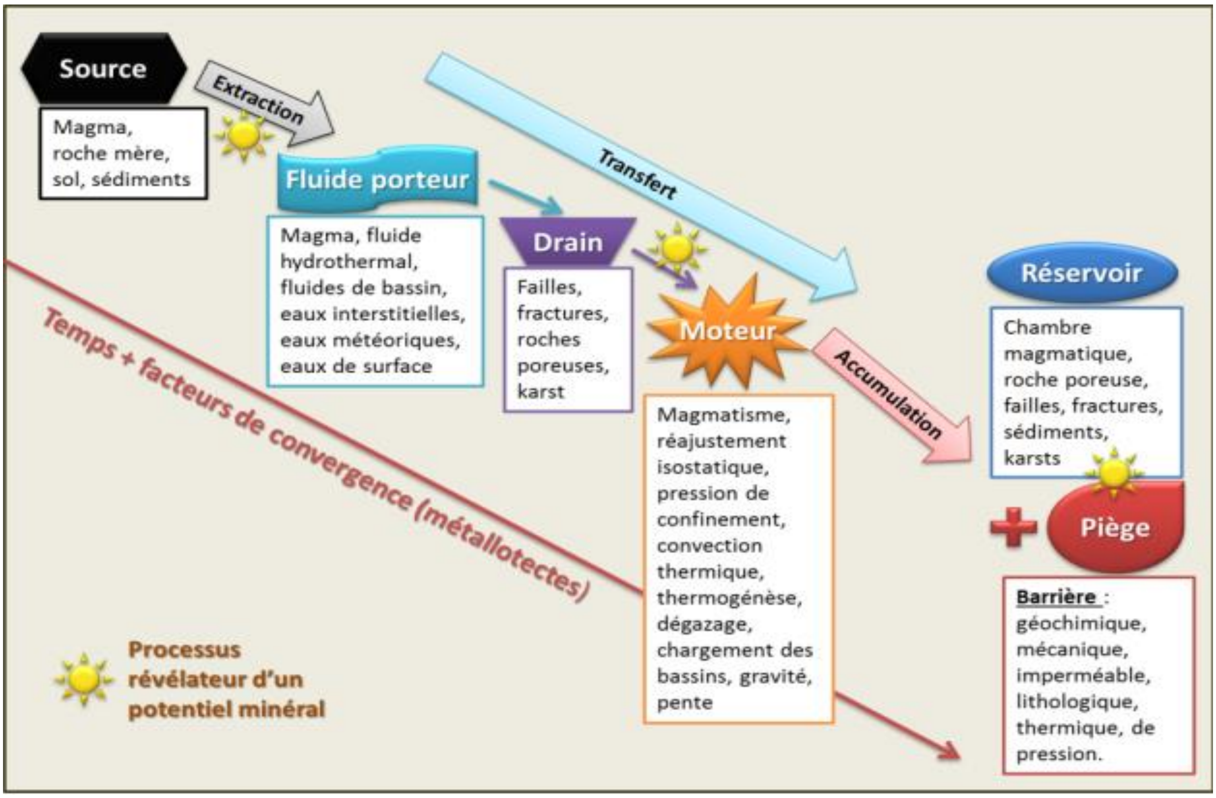
Metallotects are specific geological, structural, lithological, or geochemical features (such as rock types, faults, or alteration zones) that control the localization, formation, and concentration of ore deposits. They act as "ore guides" by creating favorable conditions for mineral deposition, helping to pinpoint potential economic mineral occurrences.

Mineral deposit formation requires a geological source, followed by **extraction**, **transport**, and **accumulation** of ore-forming elements. Essential stages include liberating minerals from host rock, moving them via fluids or magma, accumulating them, and trapping them in a, often geological, trap, resulting in concentrated mineral deposits

Extraction (Liberation): Ore-forming elements are removed from their source, often dissolved by hot fluids passing through rock (hydrothermal processes) or released from cooling magma.

Transfer (Transportation): The dissolved metals or minerals travel through fractures, fissures, and permeable rocks.

Accumulation & Trapping: The mineral-rich fluid cools, causing the material to precipitate and accumulate in traps (e.g., veins or specific sedimentary layers) to form a deposit.



Rappel : processus de formation des gisements

II.4 Methods for analyzing mineral deposits

1. Surface, Underground, and Borehole Surveys:

• Surface: 1) Regional mapping; 2) Local mapping (deposit grid); 3) Detailed mapping (outcrop); Age of mineralization.

• Underground: Mapping of gallery roofs.

• Boreholes: Continuous coring in the mineralized zone.

2. Structural Analysis:

Understanding the relationship between structural evolution and mineralization. Cross-cutting relationships with deformation episodes allow for constraints on the relative age of mineralization.

3. Mineralogy, texture, and structure.

4. Hydrothermal alteration

5. Chemical composition (calculations of indices)

6. Fluid inclusions

7. Stable and radiogenic isotopes

8. Geochronology