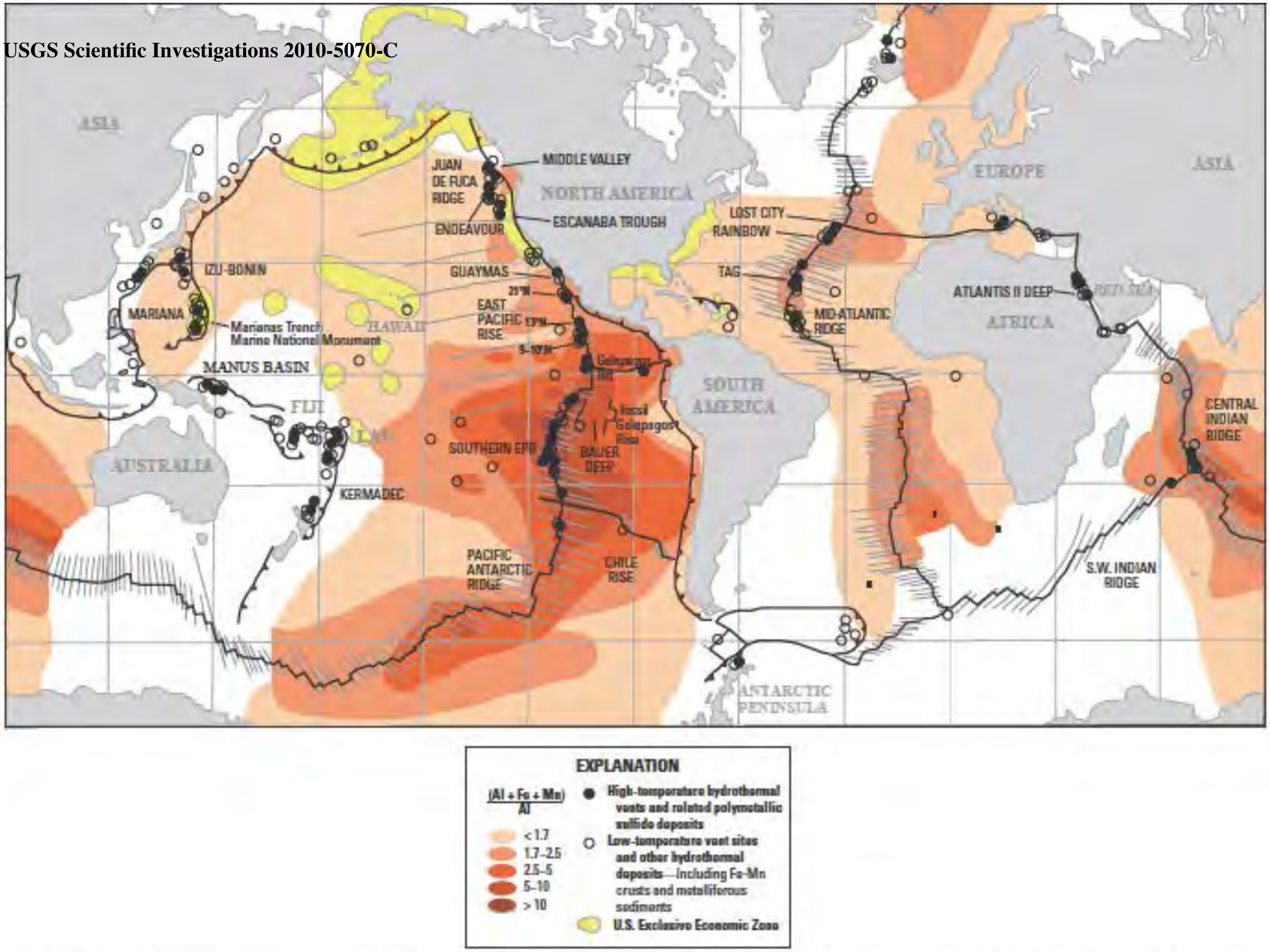
WHOI Hydrothermal Vents Video

USGS Scientific Investigations 2010-5070-C

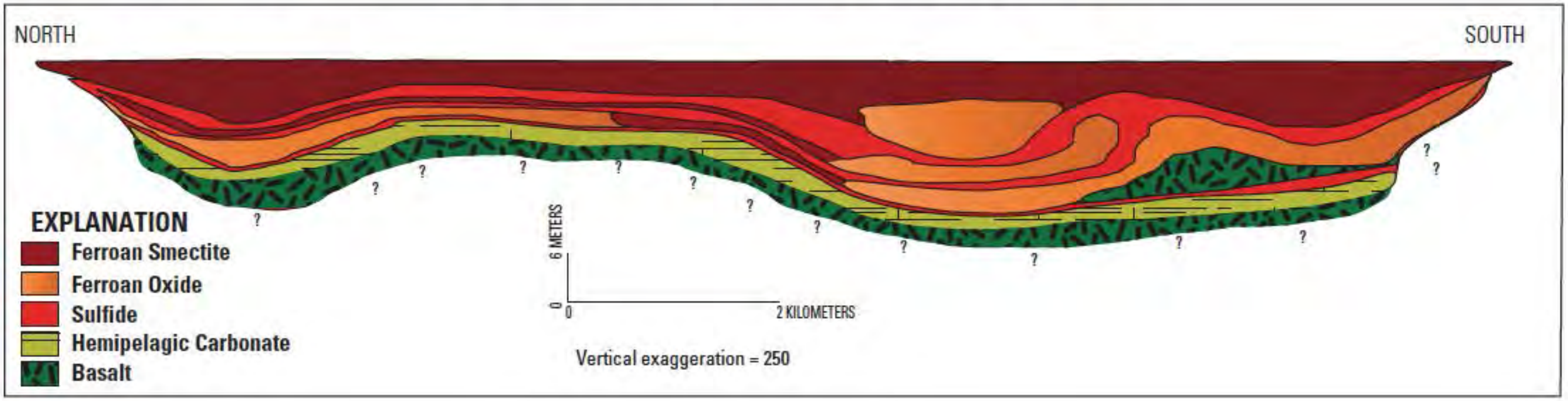


Distribution of Seafloor Metalliferous Sediment, Massive Sulfide Deposits, and Hydrothermal Vents

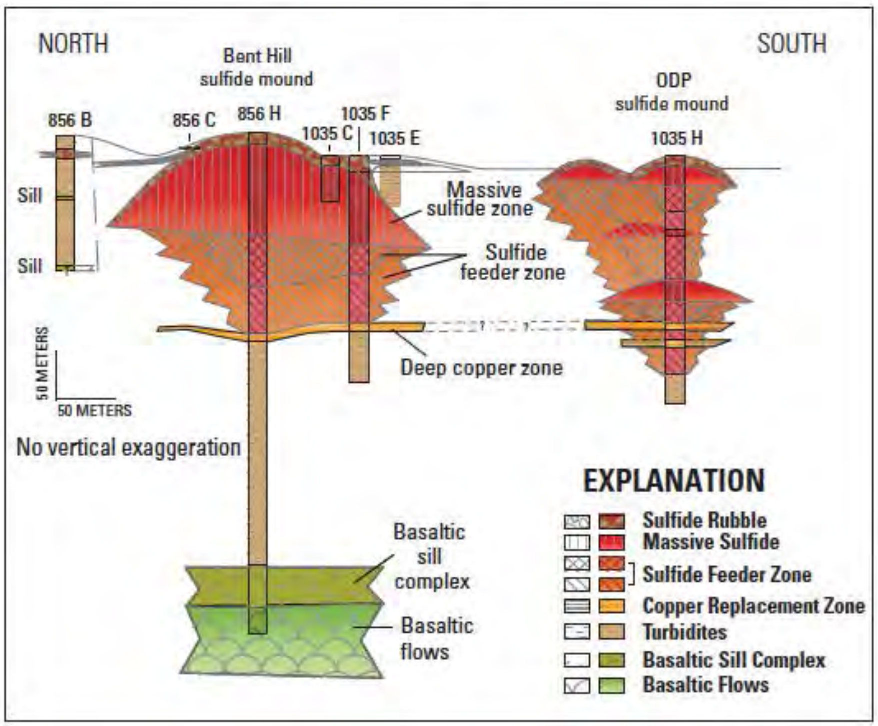
Modified after Hannington and others (2007) and Bostrom and others (1969)

Figure 3–1. Map of seafloor tectonic boundaries, metalliferous sediment distribution (modified from Boström and Peterson, 1966), locations of seafloor hydrothermal vents and deposits (modified from Hannington and others, 2005), and distribution of U.S. Exclusive Economic Zones. [Al, aluminum; Fe, iron; Mn, manganese]

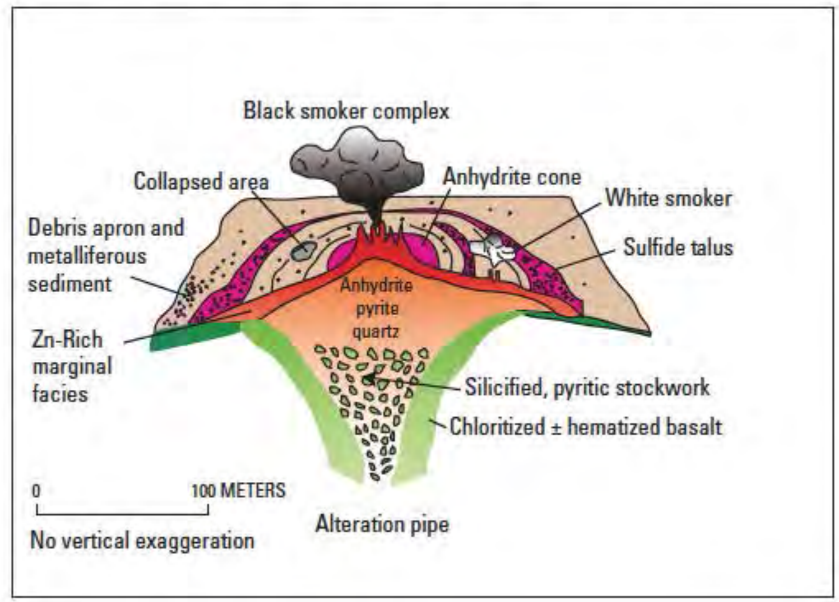
A. Mineralogic Facies of Metalliferous Sediment beneath the Atlantis II Deep Brine Pool, Red Sea



B. Middle Valley Massive Sulfide System



C. TAG Sulfide-Sulfate Mound, Mid-Atlantic Ridge



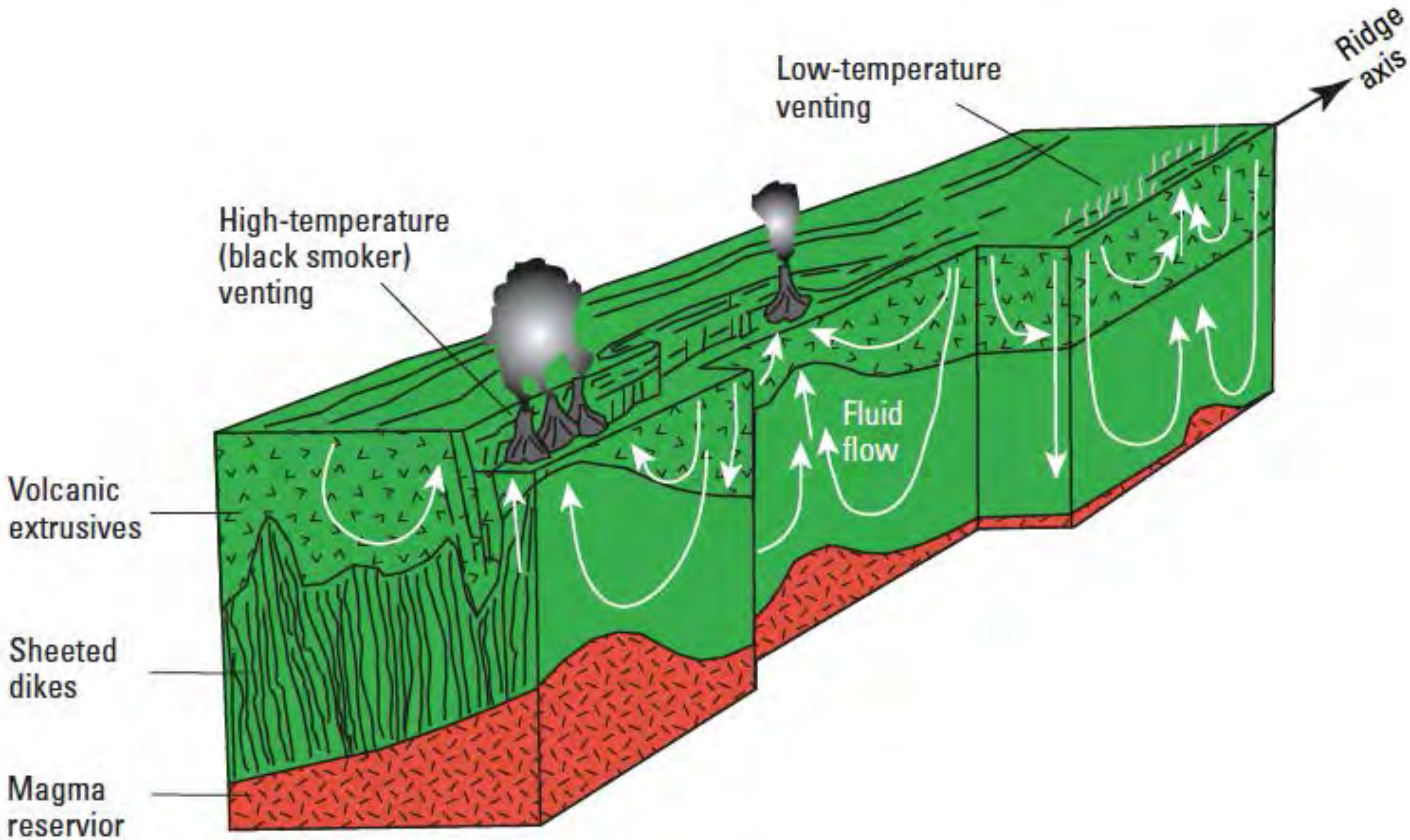


Figure 4–2. Schematic diagram showing proposed hydrothermal fluid flow at a fast-spreading ridge (for example, East Pacific Rise). Note that high-temperature (black smoker) vents occur above shallower segments of the axial magma reservoir. Modified from Haymon and others (1991).

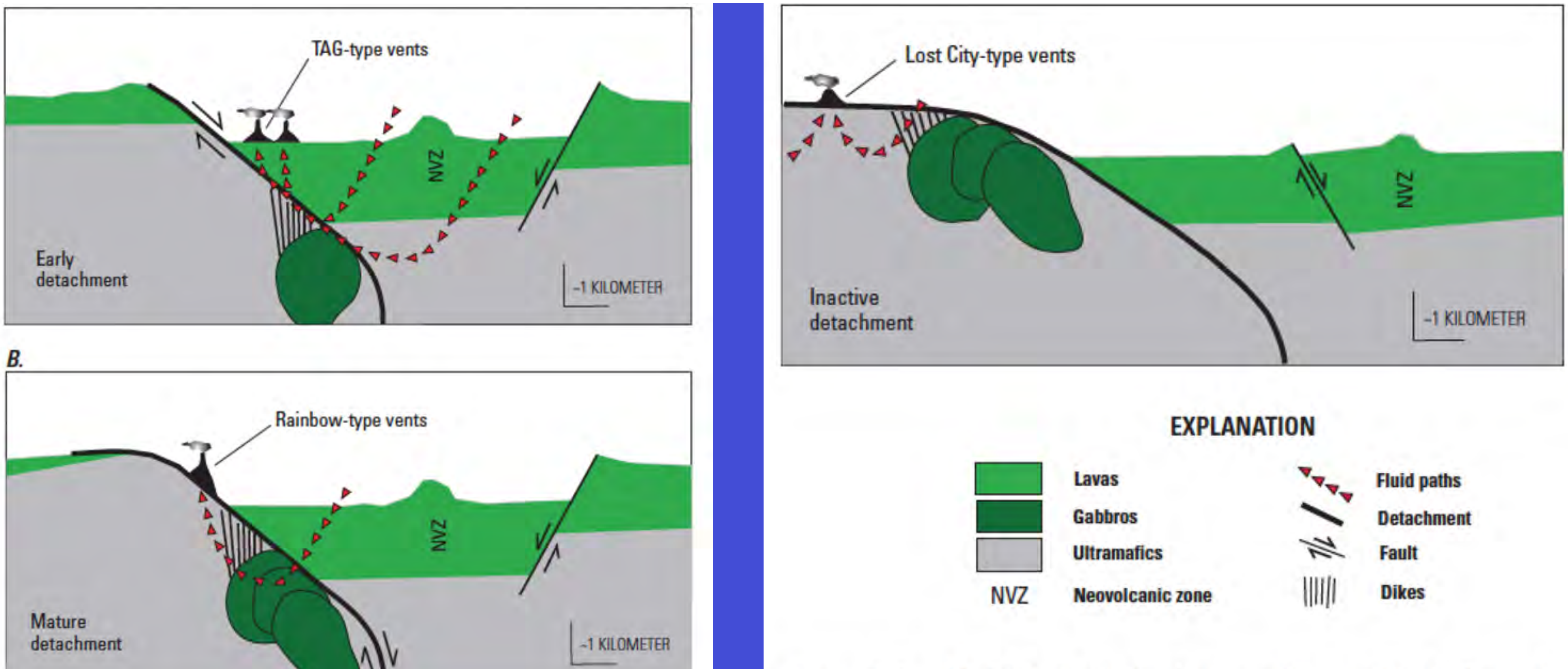


Figure 4–6. Model for fluid circulation and types of hydrothermal

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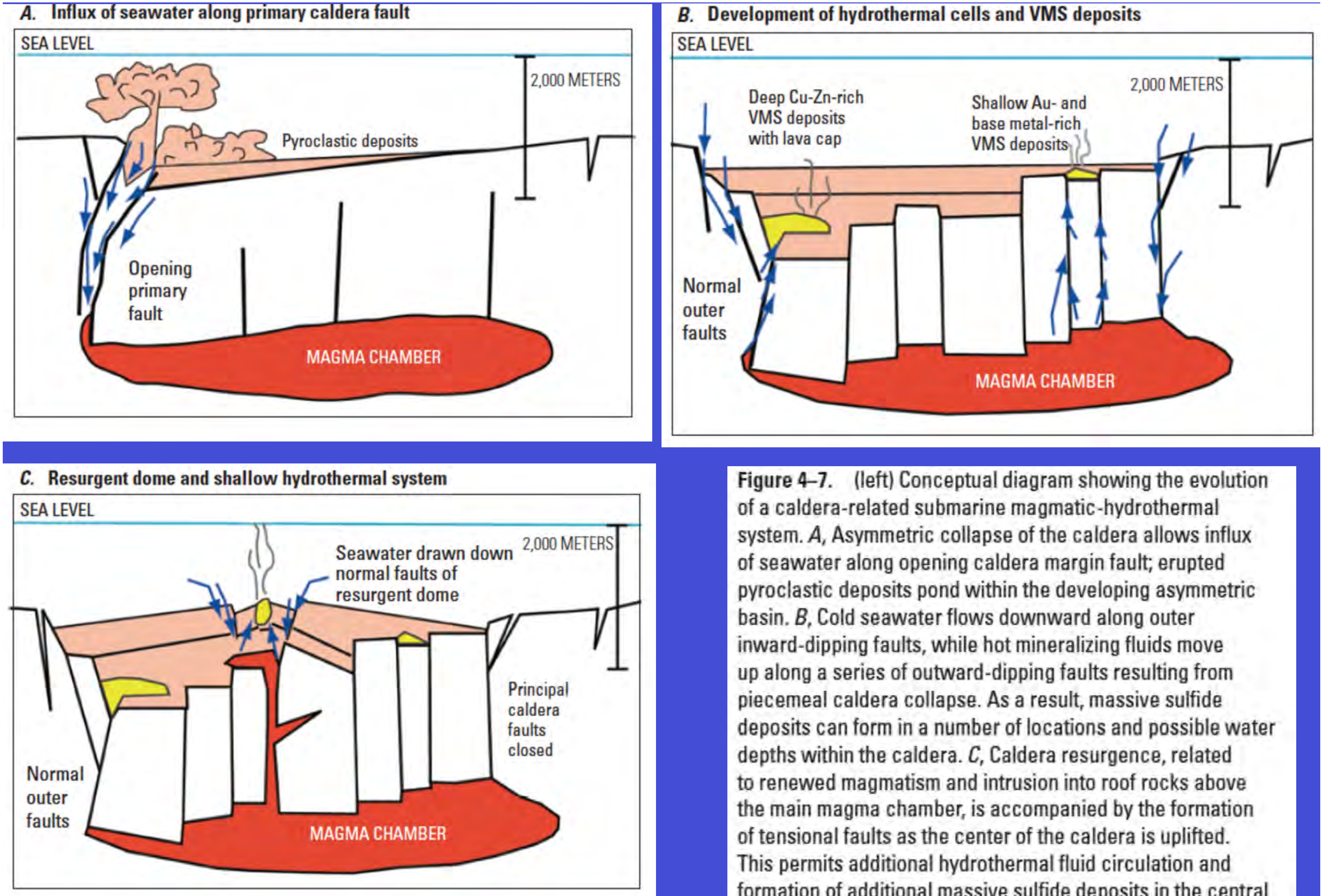

Figure 4–7. (left) Conceptual diagram showing the evolution of a caldera-related submarine magmatic-hydrothermal system. *A*, Asymmetric collapse of the caldera allows influx of seawater along opening caldera margin fault; erupted pyroclastic deposits pond within the developing asymmetric basin. *B*, Cold seawater flows downward along outer inward-dipping faults, while hot mineralizing fluids move up along a series of outward-dipping faults resulting from piecemeal caldera collapse. As a result, massive sulfide deposits can form in a number of locations and possible water depths within the caldera. *C*, Caldera resurgence, related to renewed magmatism and intrusion into roof rocks above the main magma chamber, is accompanied by the formation of tensional faults as the center of the caldera is uplifted. This permits additional hydrothermal fluid circulation and formation of additional massive sulfide deposits in the central parts of the caldera. Modified from Stix and others (2003). [VMS, volcanogenic massive sulfide; Au, gold; Cu, copper; Zn, zinc]

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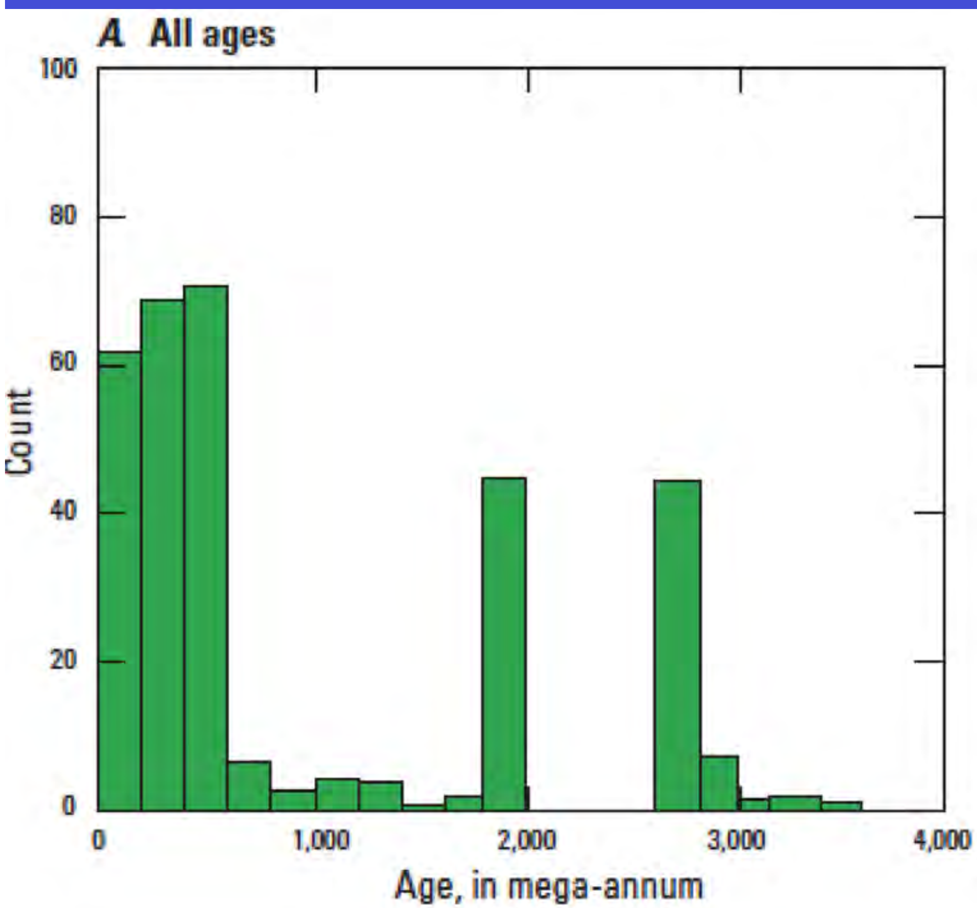

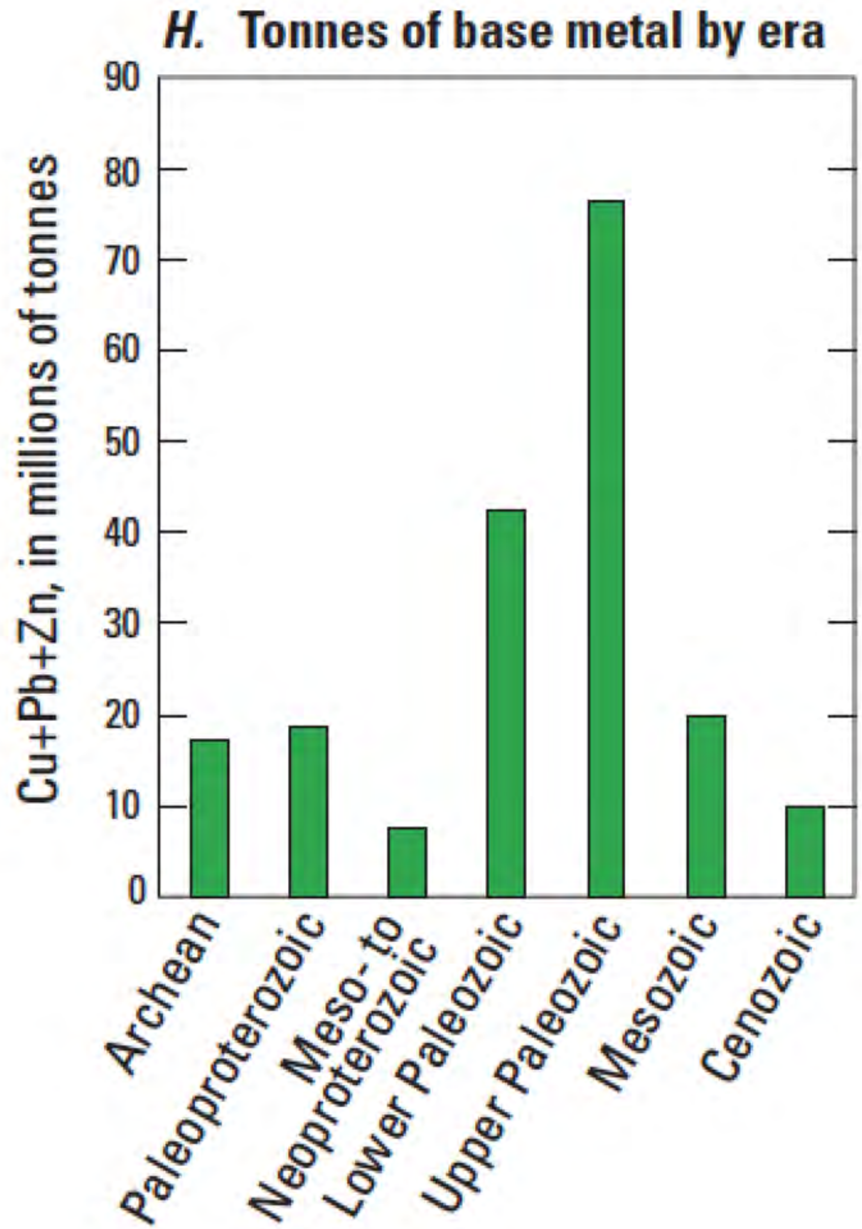

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Some Ore Models

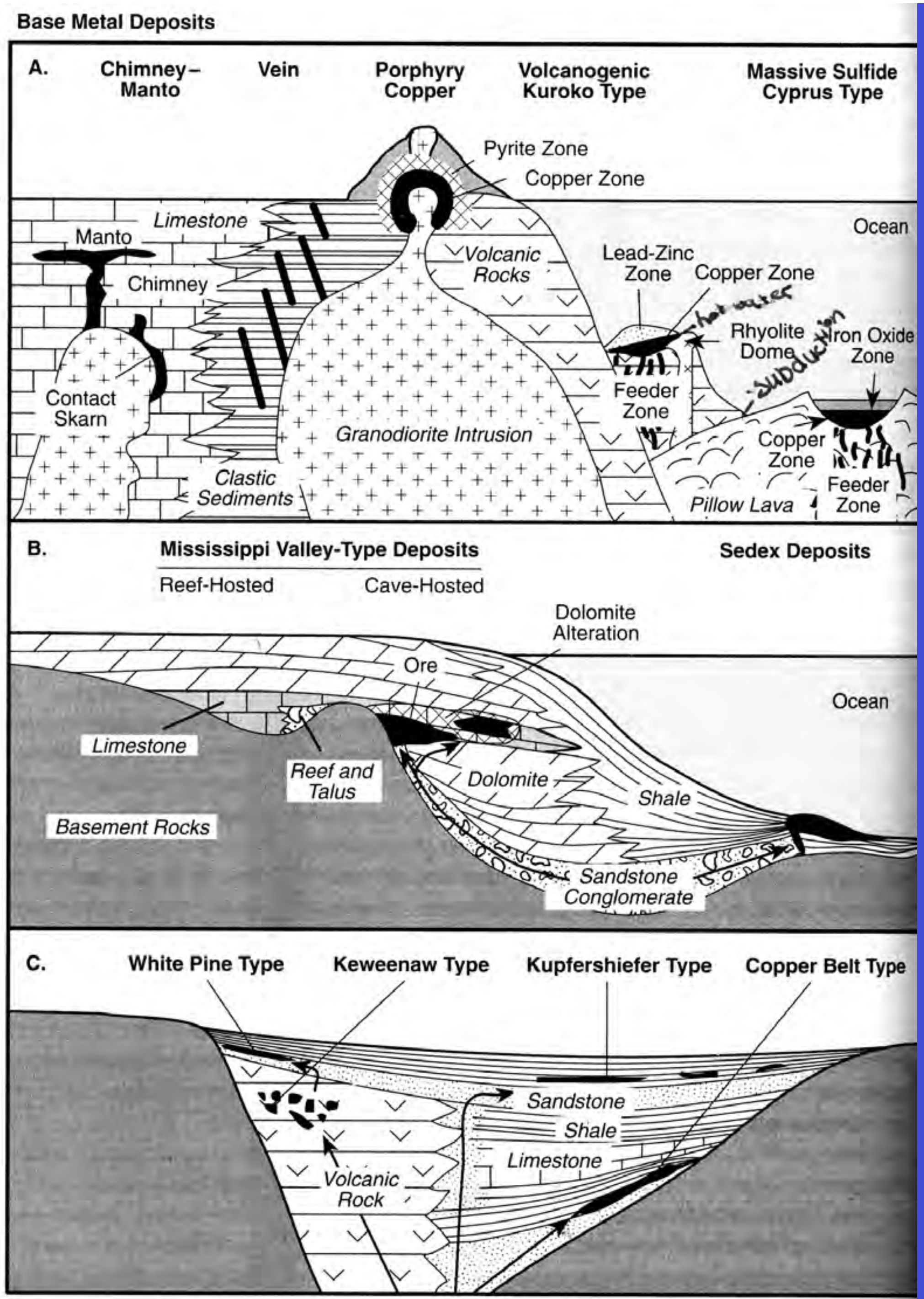
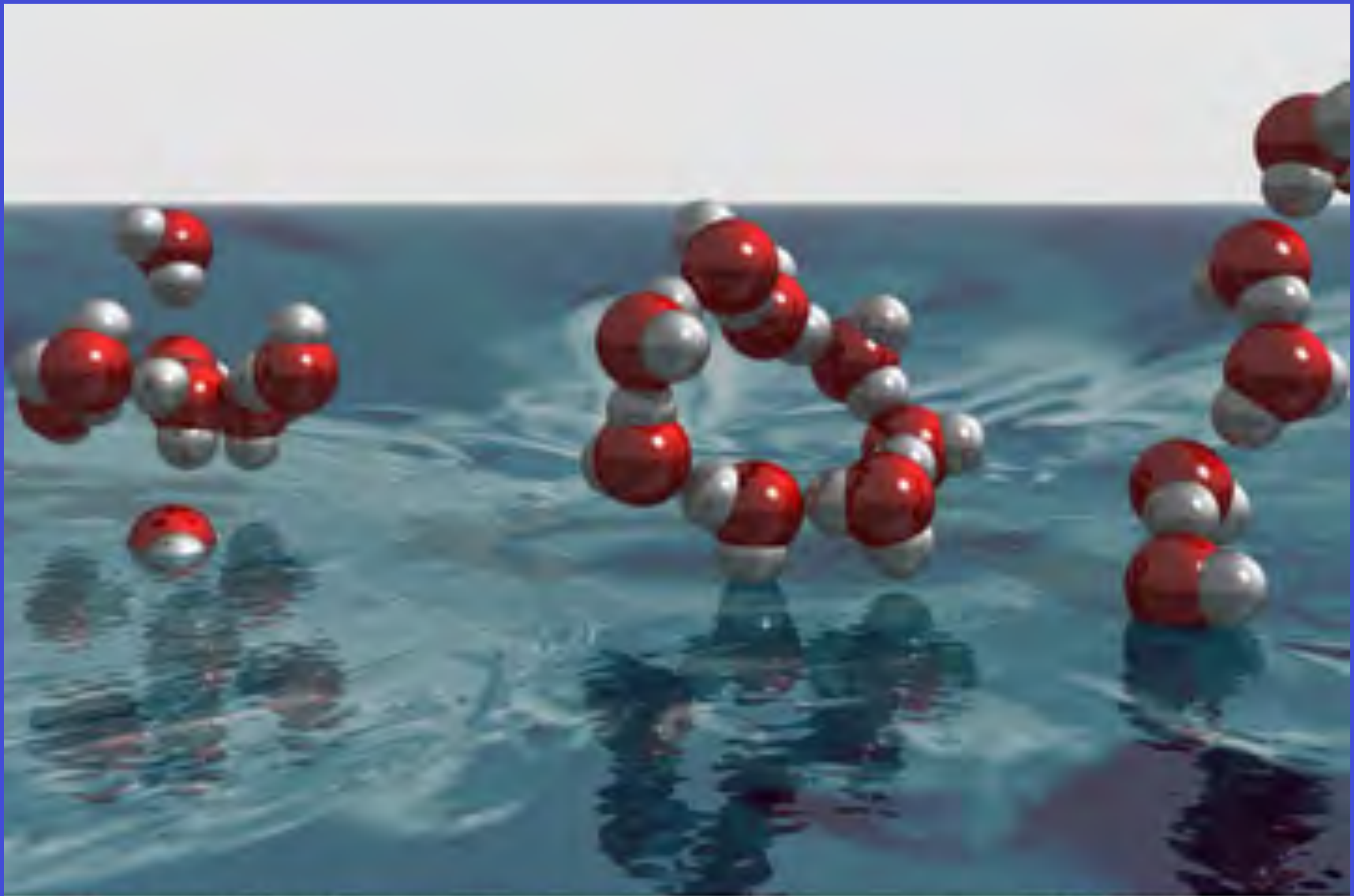


Figure 9-11 Kessler (1994) Mineral Resources, Economics, And the Environment

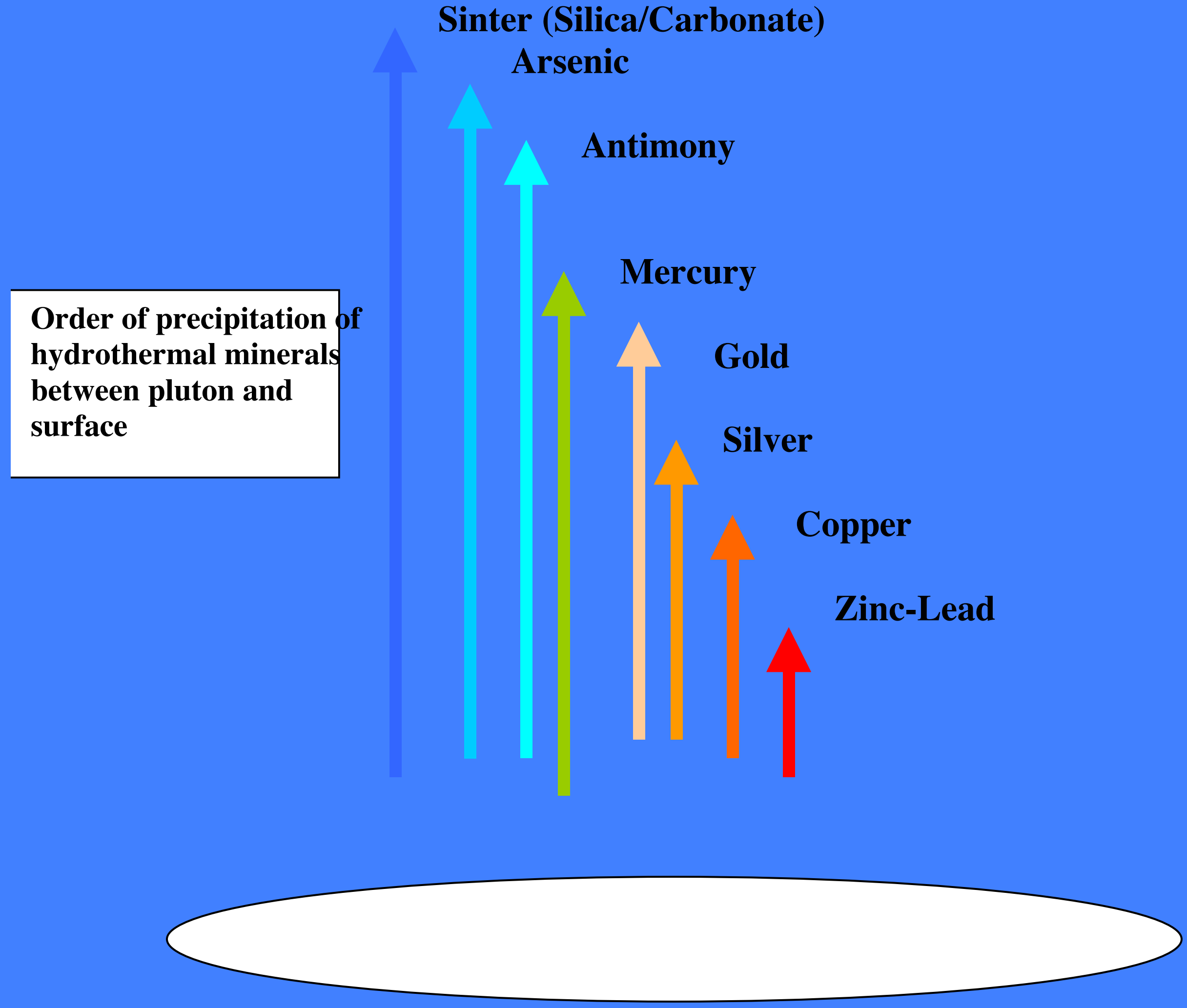
Water: polar, high dialectric constant, high heat capacity, high surface tension, maximum density above 32°F



The Structure of the First Coordination Shell in Liquid Water — Illustration by Hirohito Ogasawara

3. Hydrothermal settings- as magmas crystallize, the water present in the liquid magma is driven off into fractures or permeable beds within the host rock. Minerals species that are water-soluble will thus be carried away from the parent magma body. As the water encounters lower temperatures and pressures, it may boil. Sulfide ores will precipitate in the order shown in this diagram, beginning with zinc or lead if present, and ending with a sinter of silica and or carbonate. The host rock may thus become host to hydrothermal deposits. Hydrothermal waters may also be derived from the circulation of ground water in deep basins. If the resulting brines ascend to shallow depths, the same order of precipitation of dissolved sulfides may occur.

Hydrothermal settings



SEDEX Model

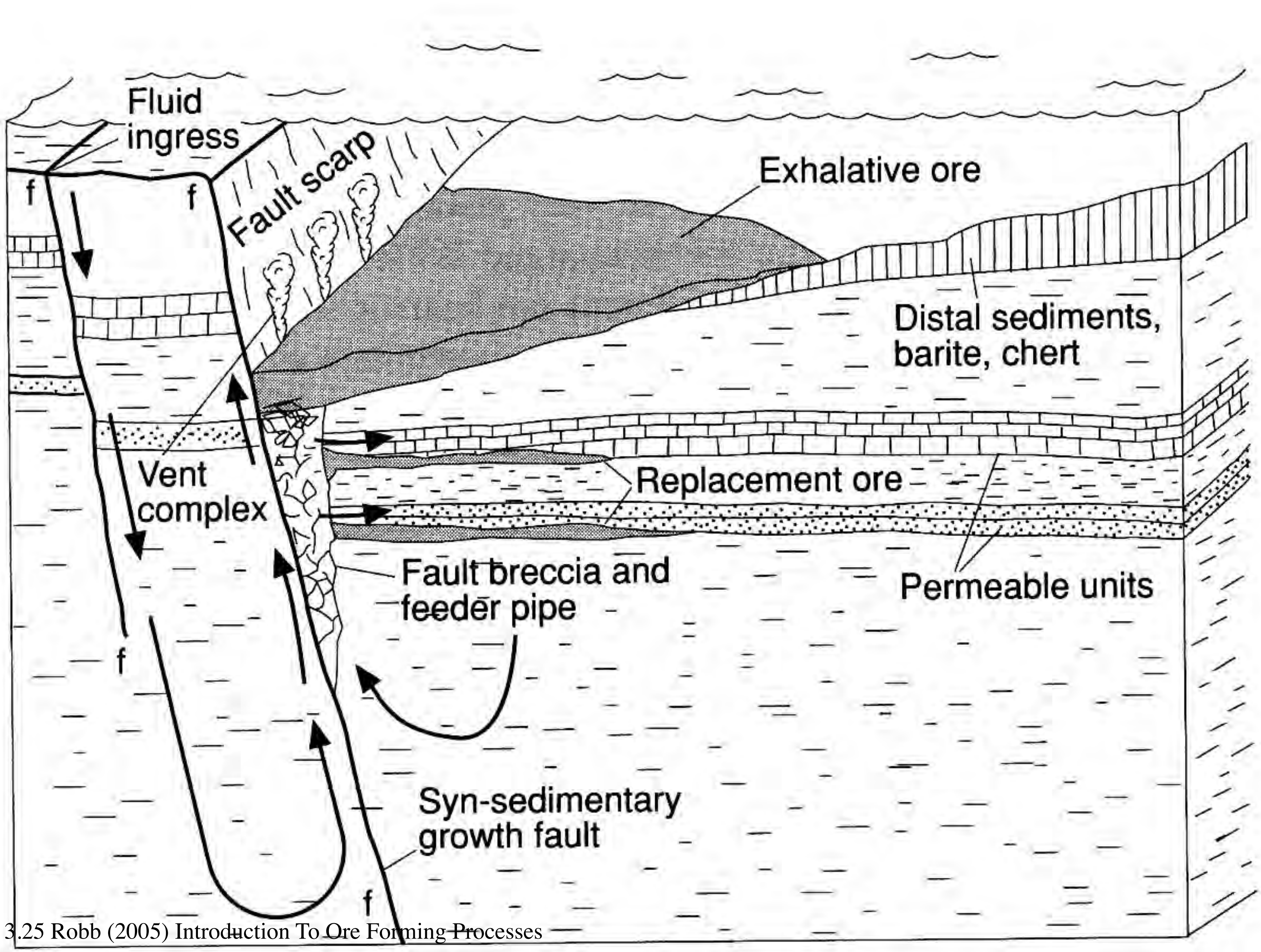
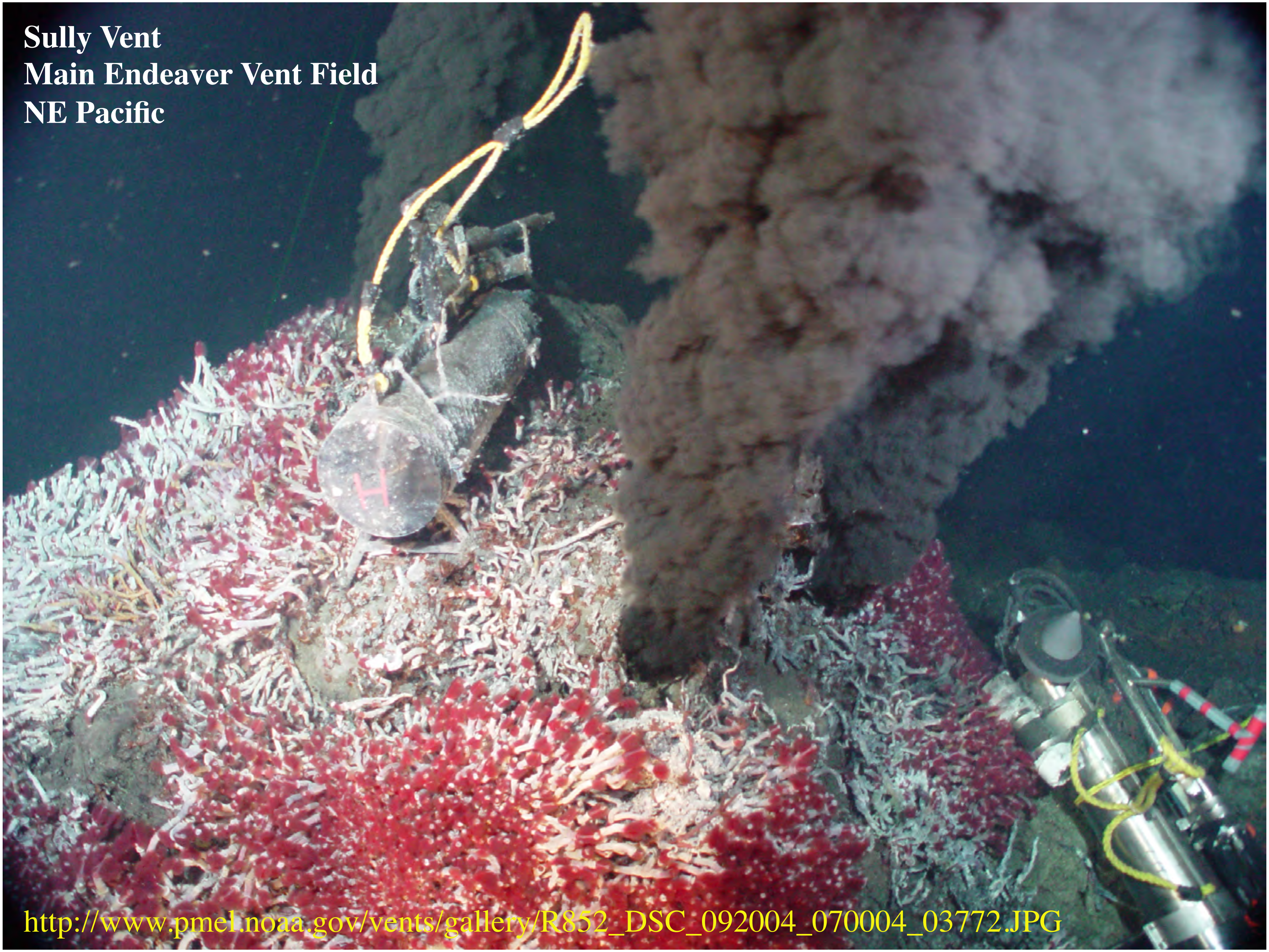
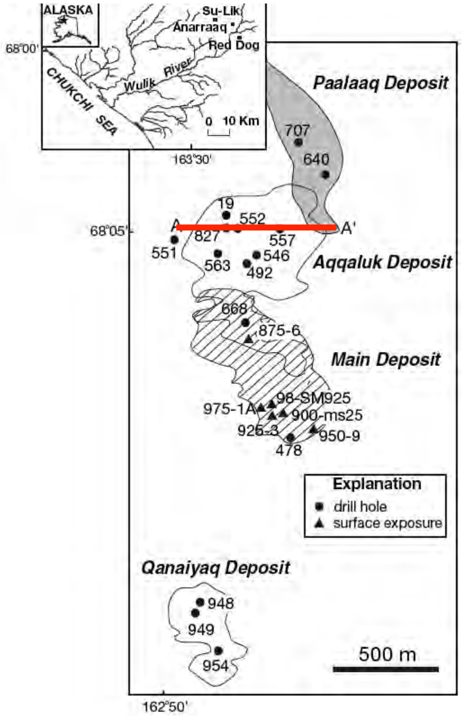


Figure 3.25 Robb (2005) Introduction To Ore Forming Processes


Sully Vent
Main Endeaver Vent Field
NE Pacific
http://www.pmel.noaa.gov/vents/gallery/R852_DSC_092004_070004_03772.JPG

Red Dog Mine: world's largest zinc producer

Red Dog Mine Pit



http://m.ammoth.us/blog/wp-content/uploads/2010/03/red-dog-pit-mine_2.jpg

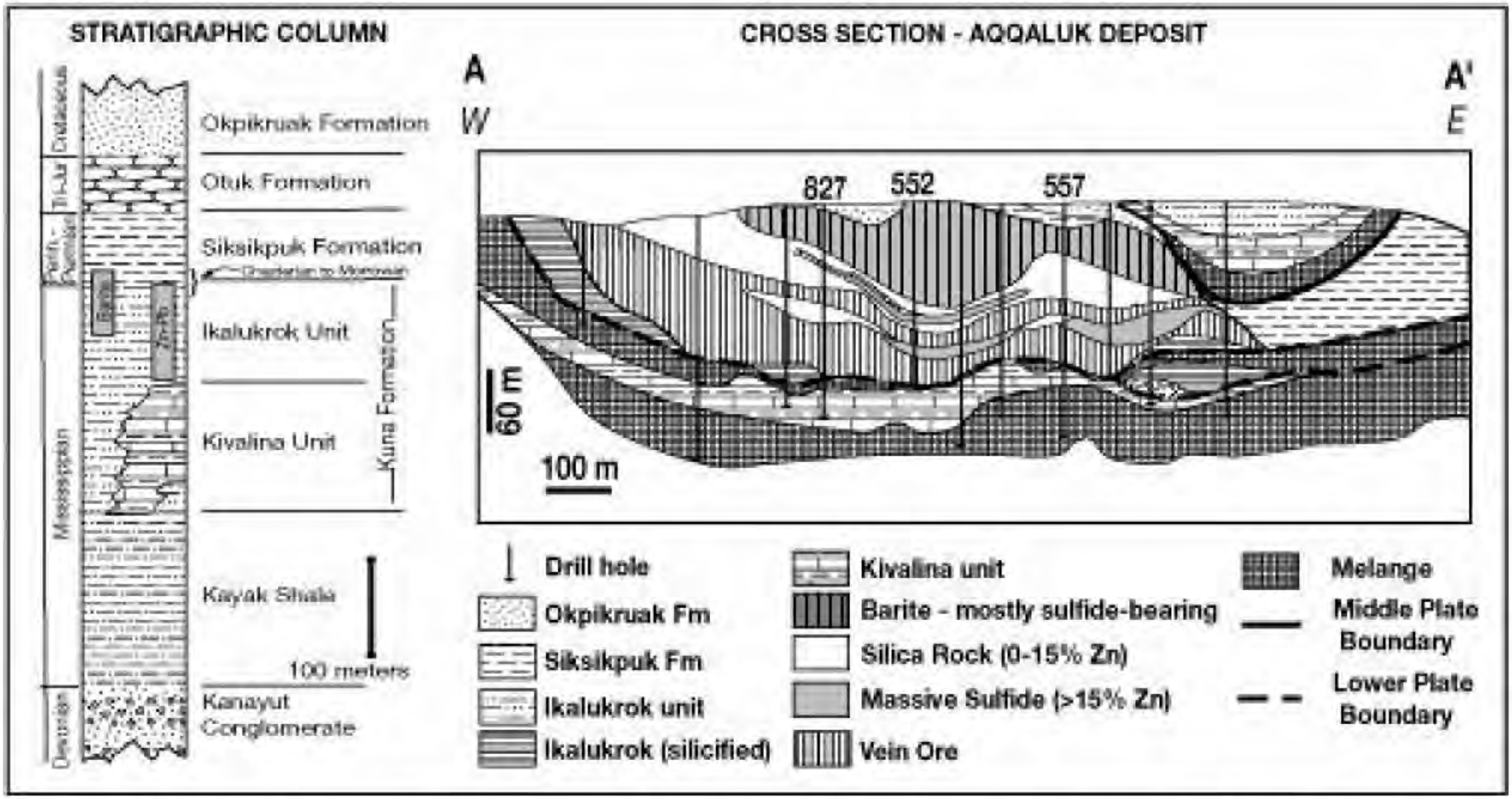
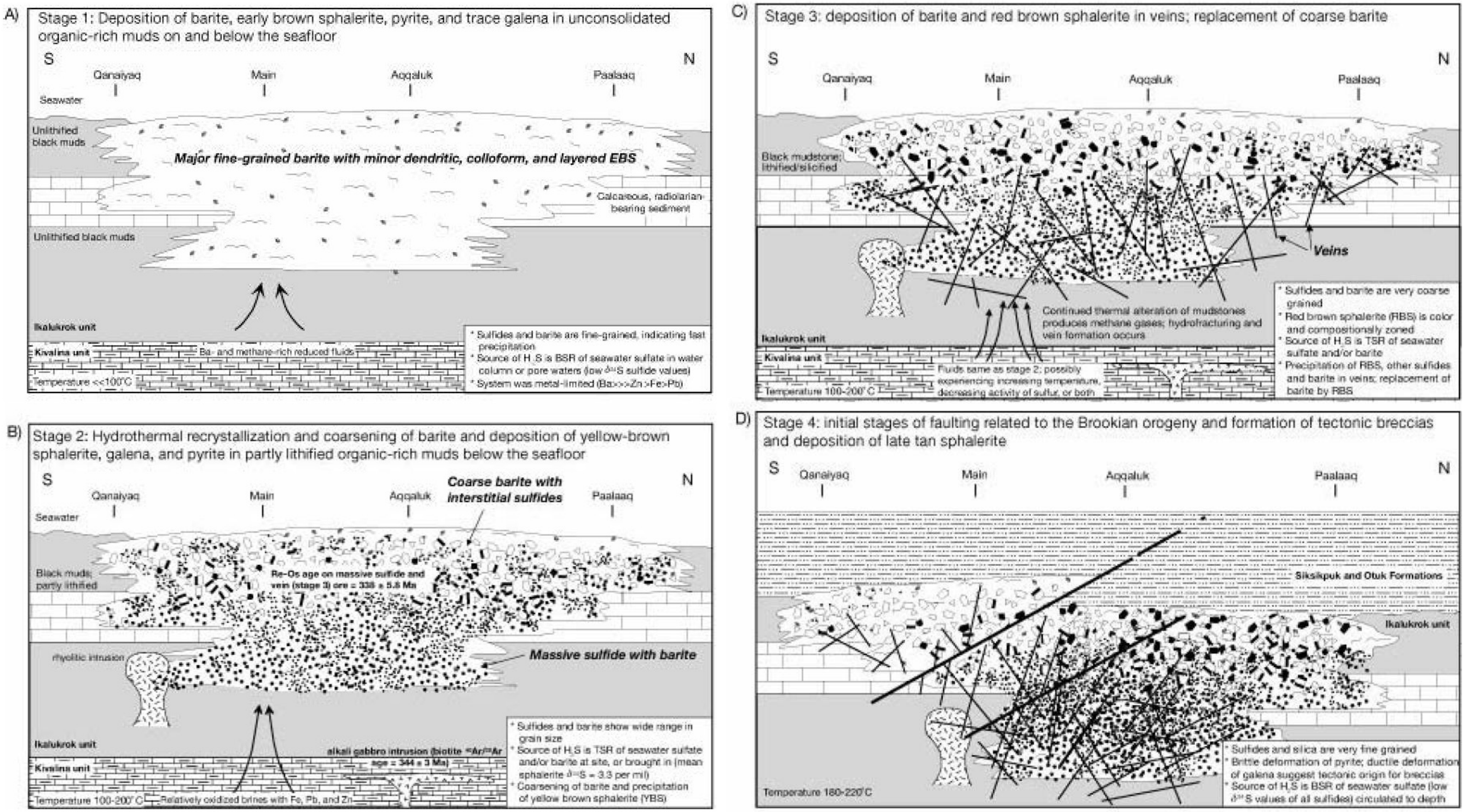
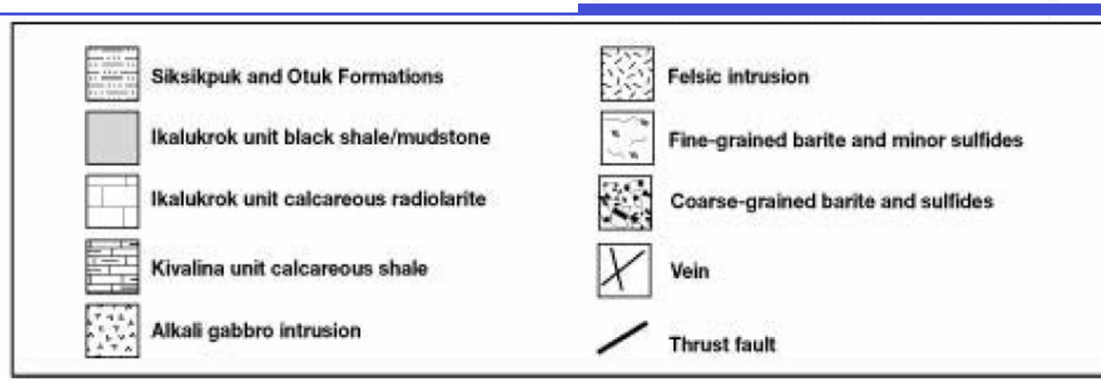


FIG. 3. Generalized stratigraphic column (modified from Young, 2004) and cross section across the Aqqaluk deposit. Note the stratigraphic position of the orebody and typical thickness of barite and Zn-Pb mineralized zones. Okpikruak Formation comprises micaceous sandstone and mudstone, Otuk and Siksikpuk Formations comprise dominantly chert and shale, Ikalukrok unit comprises shale and mudstone with interbedded carbonate, Kivalina unit comprises calcareous shale, Kayak Shale comprises sandstone, shale, and limestone, and Kanayut Conglomerate comprises conglomerate, sandstone and minor shale.

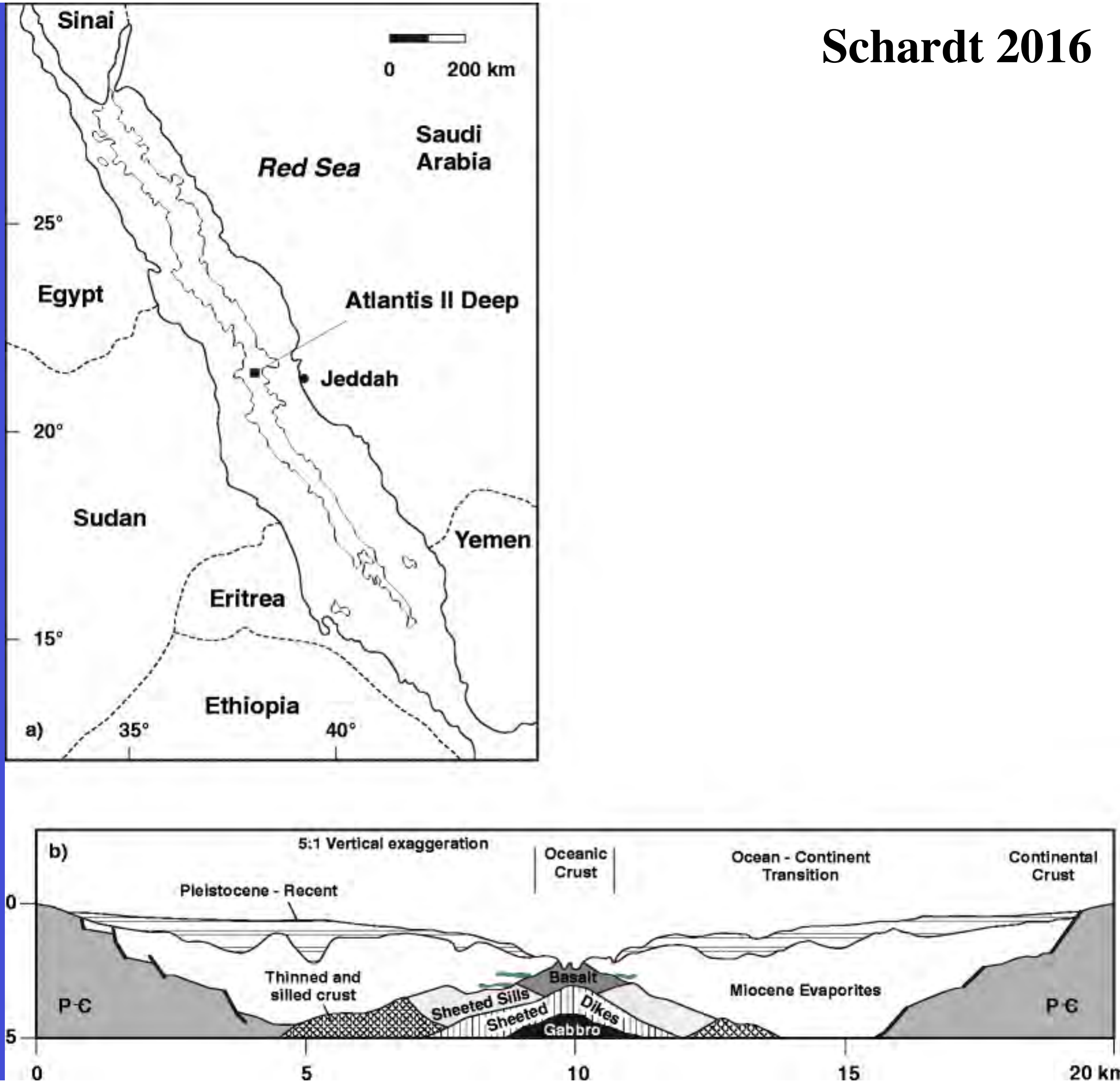
Kelley et al 2004

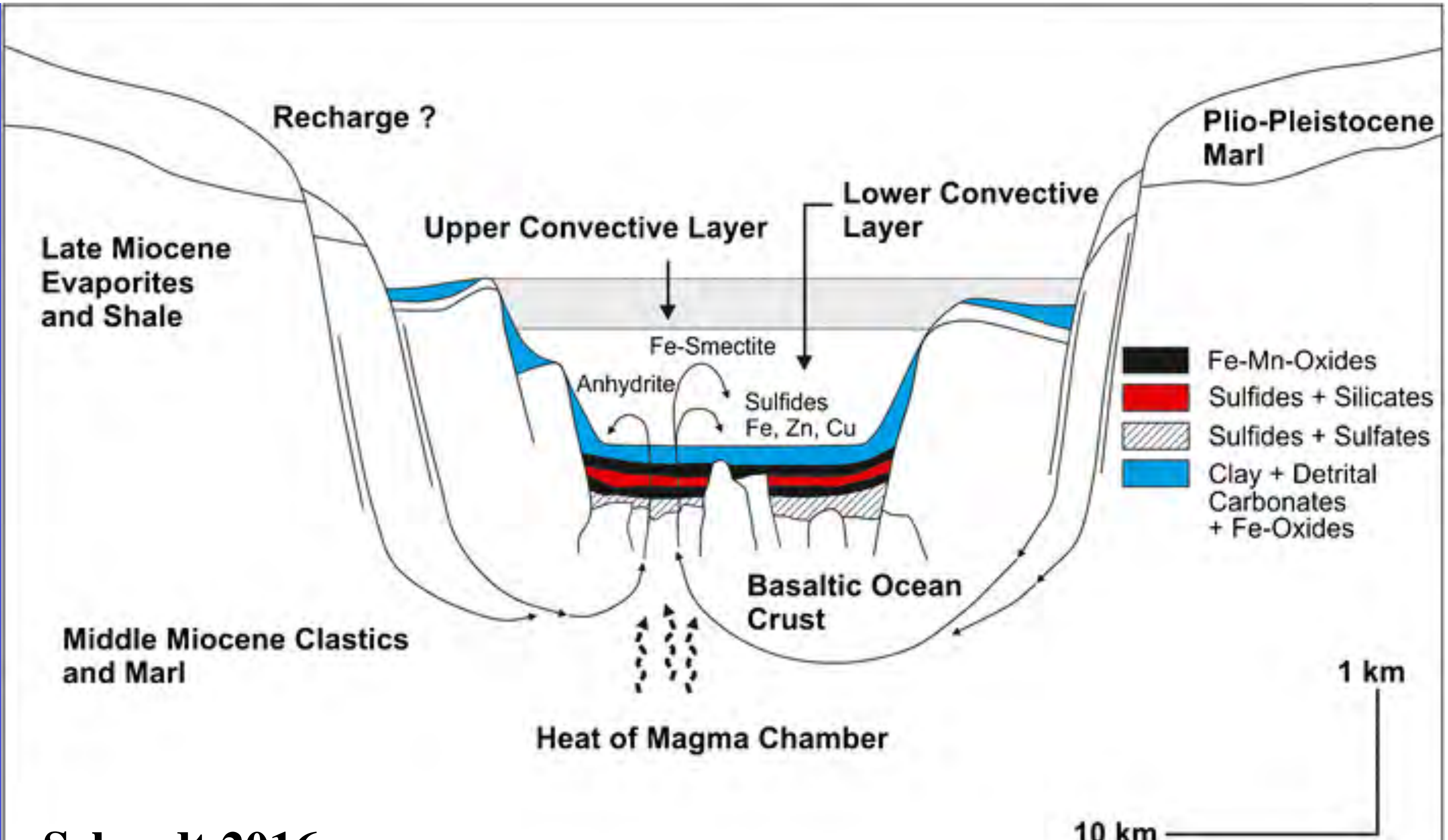




Kelley et al 2004

Schardt 2016





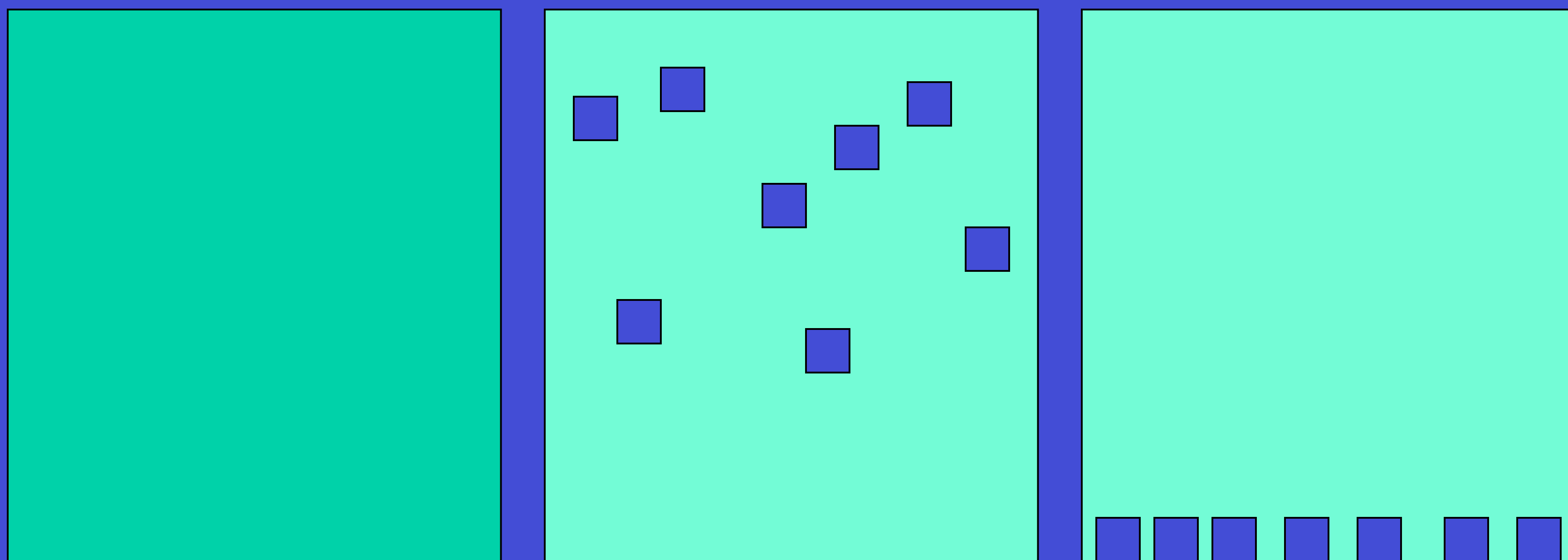
Schardt 2016

Magmatic Processes

- Within the magma chamber
- During magmatic ascent
- During volcanic venting
- The role of water
  - Magmatic water
  - Ground water

What goes on within the magma chamber?

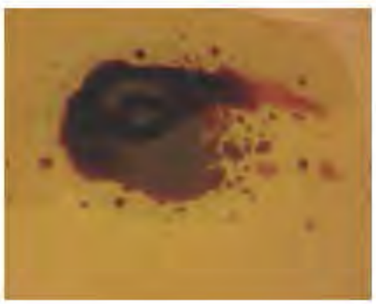
1. Magma Chamber **2. Early Minerals** **3. Gravity Settling**

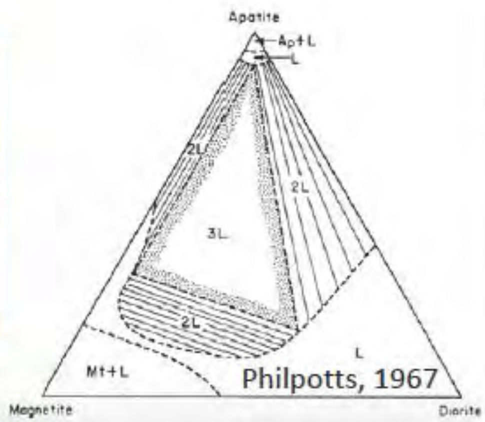


Examples: Chromite($FeCr_2O_4$), Ilmenite ($FeTiO_3$) in a mafic magma body. Both are oxides, which crystallize early in a magma's solidification.

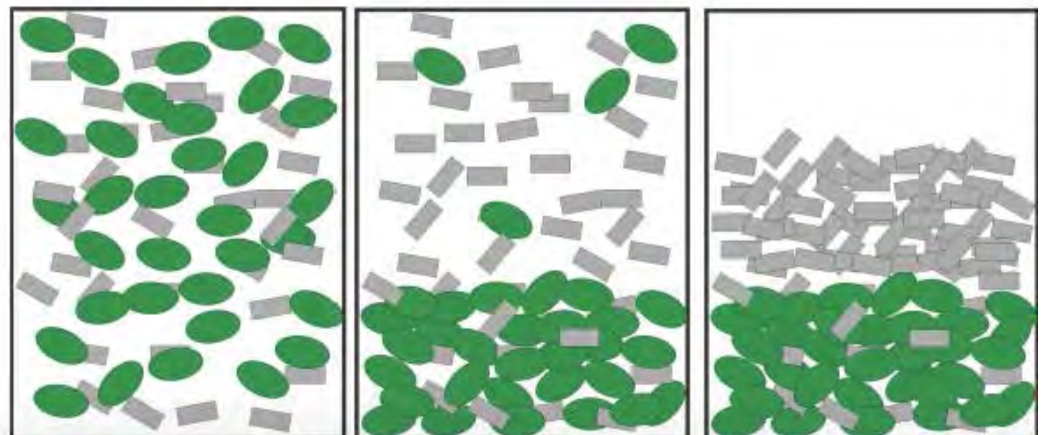
1. Philpotts (1967) experiments: immiscible Fe-O-P (no Ti) liquid at T = 1400°C but ~25 years of experiment have never succeeded in lowering the T or having Ti in the immiscible high-Fe liquid (Lindsley 2003)

2. Fractional crystallization that enriches the magma in Fe and Ti and accumulation of the oxides by density (ilmenite density = 4.72, plagioclase density = 2.6, magmas parental or residual to anorthosite density = 2.65 to 2.9, Scoates 2000)





Philpotts, 1967



Josephine Ophiolite, Klamath Mtns, near Weed, CA

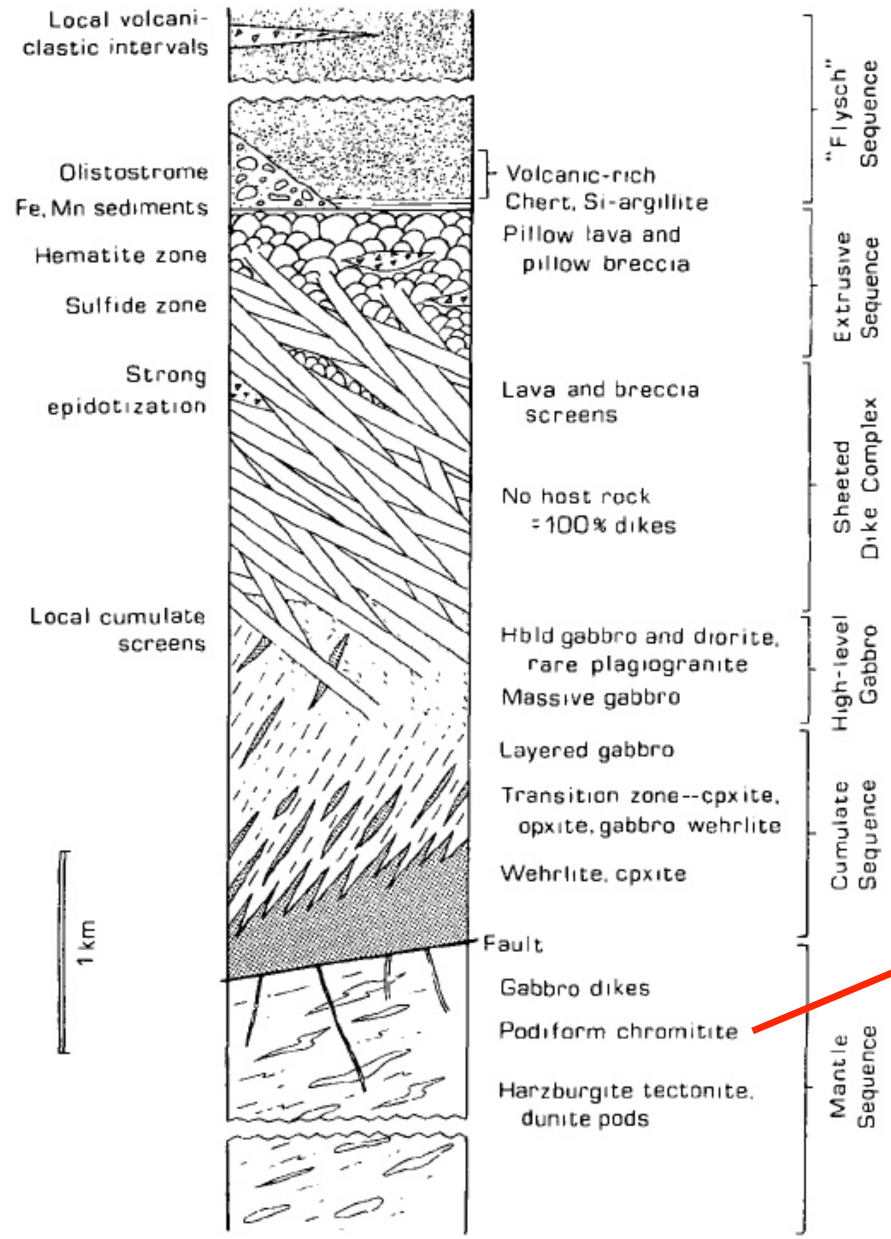
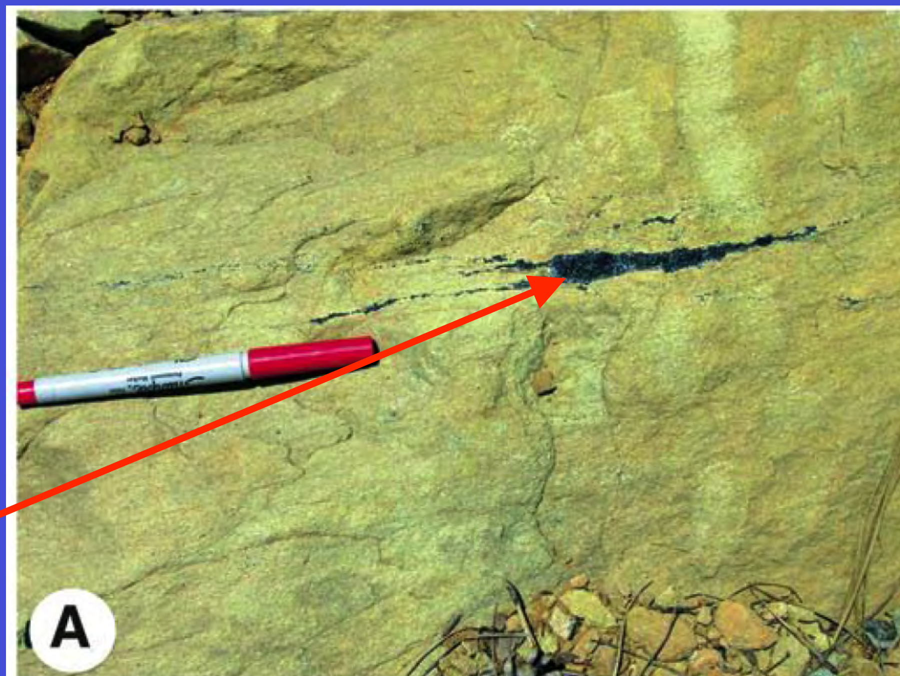


Figure 1. Idealized columnar section of the Josephine ophiolite.

Harper 1984



Chromite within dunnite

Garick et al 2009

Illmenite/Anorthosite deposit Tellnes, Norway (World's largest Titanium mine)