Model 24a	Mafic extrusive VAMS Cu-Zn-Ag-Au-Co
Alternative Model Name	Ophiolite hosted Volcanic Massive Sulphide; Cuperous pyrite.
Commodities	Cu, Zn, Co, Ag, Au
% Global Production	Minor: 10^{th} quantile has > 418 650 tonnes Cu-Pb-Zn-Au-As (1998)
% Australian Production	
World Class Deposit Size	>5 Mt @ >1.5% Cu or >1% Zn; Mavrovouni, Cyprus - 15 Mt
World Class Deposit Examples	Mavrovouni, Tilt Cove, Beatson, Vuonos, Skorovass, Hyal As Safil, Lasail, Skouriotissa
Geological Setting	Oceanic spreading zones; fore-arc and mature and immature back-arc extensional zones; Obducted Ophiolites in collisional setting
Age	Archaean(?) to Tertiary (most often of Ordovician to Cretaceous)
Components:	
Source	Metal: sub-seafloor ophiolites Fluids: sea water mixed with variable amounts of magmatic water. Energy: magma chambers under the spreading axis.
Transport/Pathway	Large faults, parallel to axis of the fossil ridge, controlling the rift system; convection in porous medium driven by anomalous heat flow along rifts
Trap	Interaction with seawater at or just below the seawater-rock interface; For stockwork mineralisation – fractures and breccia zone
Other	Water depth > 2000 m. Rapid burial after mineralisation
Critical Elements	• Spreading centres that have undergone alternating periods of fast (evidenced by the presence of large gabbroic magma chambers, thick sheeted dyke complex, overlapping spreading centres) to intermediate rates of spreading (evidenced by well developed volcanic stratigraphy and the presence of pelagic Fe-Mn rich sediments). (1) • Association with basaltic volcanism (3) • Extensional structures that allow fluid circulation (1) • Significant deposits are associated with hydrothermal/pelagic Fe-Mn rich sediments at the contact between volcanic units of differing composition. Sediments indicate periods of quiescence between magmatic events (2) • Interaction with seawater at or just below ocean floor (1) • Deep water depth > 2000 m (2) • Rapid burial to allow preservation (2)
Other Comments	Basaltic source rocks limit possible metals; these deposits are generally small and are probably not of much interest.
Key References	Franklin, J.M., Sangster, D.M. & Lydon, J.W., 1981. Volcanic-associated massive sulfide deposits. Economic Geology 75th Anniversary Volume, 485-627. Galley, A.G. & Koski, R.A., 1999. Setting and characteristics of ophiolite-hosted volcanogenic massive sulfide deposits. Reviews in Economic Geology 8, 221-246.

Significant factors for forming large deposits: (Sawkins, 1990)

- The backarc and forearc related to underlying subduction zone (ie. suprasubduction setting) more favourable than typical mid oceanic spreading zones
- In mid oceanic spreading zones the supply of heat doesn't last long and the heat is used up before the critical time to form a large deposits is reached
- In most vigorous seafloor systems the metals are dispersed over a wider area
- Large massive sulphide deposit require setting that favours felsic magmatism
- Important are geochemical signatures which can show arc related setting of the ophiolites
- The spacing of deposits within ophiolite complexes are probably related to the size of the convective system.

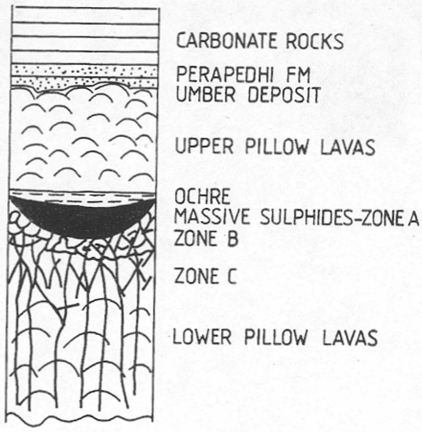
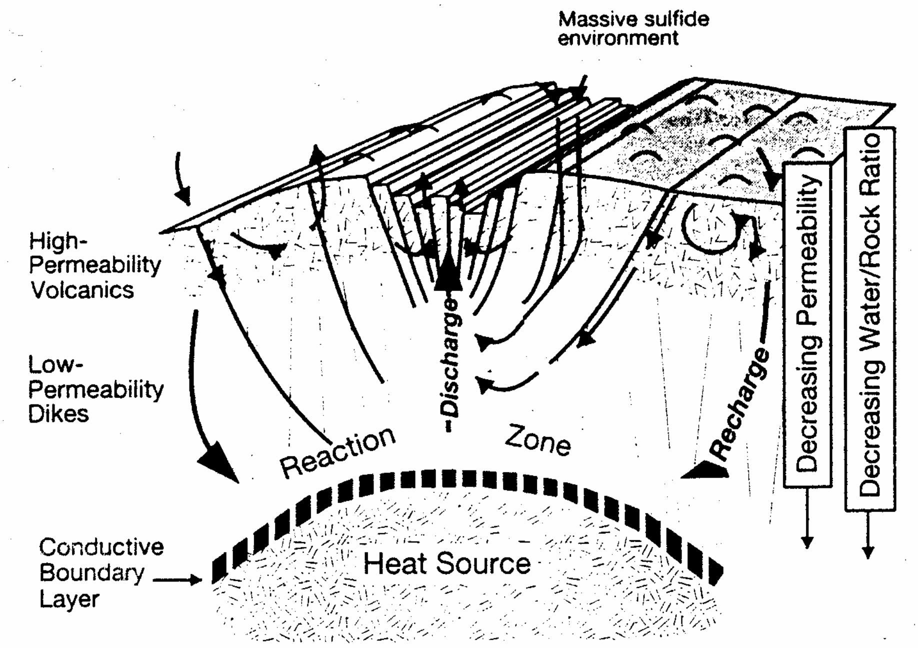


Fig. 12.16. Schematic section through a typical Cyprus-type sulphide deposit and its relationship to overlying lithologies (After Hadjistavrinou and Constantinou 1982)


Massive sulfide environment
High-Permeability Volcanics
Low-Permeability Dikes
Discharge
Recharge
Reaction
Zone
Decreasing Permeability
Decreasing Water/Rock Ratio
Conductive Boundary Layer
Heat Source

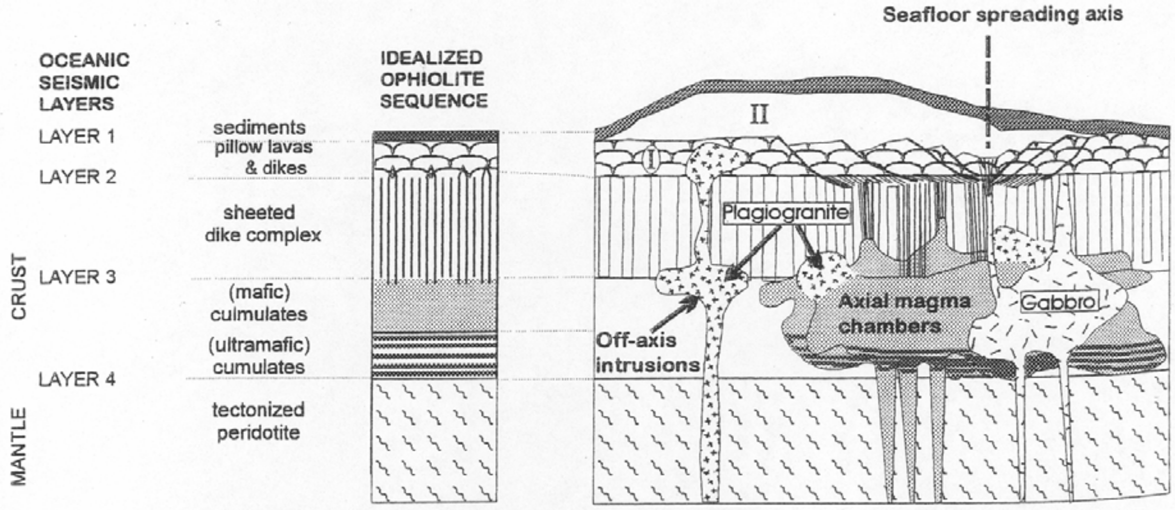


FIG. 2. A composite schematic comparing a section through an idealized ophiolite sequence with a more realistic section through an ophiolite formed above a subducting plate margin. Lower lavas (I) consist of either N-MORB or arc tholeiite. In a fore-arc environment, the upper lavas (II) would contain boninitic units, whereas in back-arc environment, picrites and fractionated tholeiitic suites would be included in the upper part of the extrusive sequence. The idealized section is also compared to an idealized oceanic seismic profile. Modified from Malpas et al. (1989) and Robertson and Xenophontos (1993).