- **Classification of ore deposits: why bother?**

- **Major basis for classification:**

Different methods for classification of ore deposits:

- **Niggli classification:** Grouped the *epigenetic* ores into ***Volcanic***, or near surface and ***plutonic*** or deep seated. The plutonic deposits were divided into hydrothermal, pegmatitic-peneumatolytic and orthomagmatic subgroups.

- **Schneiderhohn classification:** classified ore deposits according to 1- the nature of the fluid, 2- mineral association, 3- a distinction between deep seated and near surface deposition and 4- the type of deposition, host, or gangue.

The classification of ore deposits by **Schneiderhohn as bellow:**

1- Intrusive and liquid-magmatic deposits, 2- Pneumatolytic deposits, 3- Hydrothermal deposits,

4- Exhalative deposits

❖ Lindgren classification:

1- Magmatic ores

2- Hydrothermal ores

(hypothermal, mesothermal, epithermal, telethermal, xenothermal)

3- Metamorphic ores

4- Ores in water bodies

5- Mechanical concentrations

❖ Meyer classification:

Mafic igneous

- Volcanogenic massive sulfides
- Sediment-hosted ores

  eg. (iron formation, MVT, bedded Cu)
- Stratabound deposits

  eg. (U deposits, Au conglomerates, Au in iron formation)
- Hydrothermal porphyry-related

  eg. (Cu, Mo, Sn/W porphyries & epithermal veins)
- Tectonic classification:

Convergent/divergent plate boundaries

Collisional vs extensional tectonic environment

Discordant Ore bodies

Regularly shaped bodies

- Tabular – veins, faults. Divides footwall and hanging wall
- Tubular – pipes or chimneys (vertical) and mantos (horizontal)

❖ *Irregularly shaped bodies*

- Disseminated deposits eg diamonds in kimberlites, closely spaced veins called a stockwork
- Irregular replacement deposits eg. magnesite replacement of limestone, skarn (Fig1)

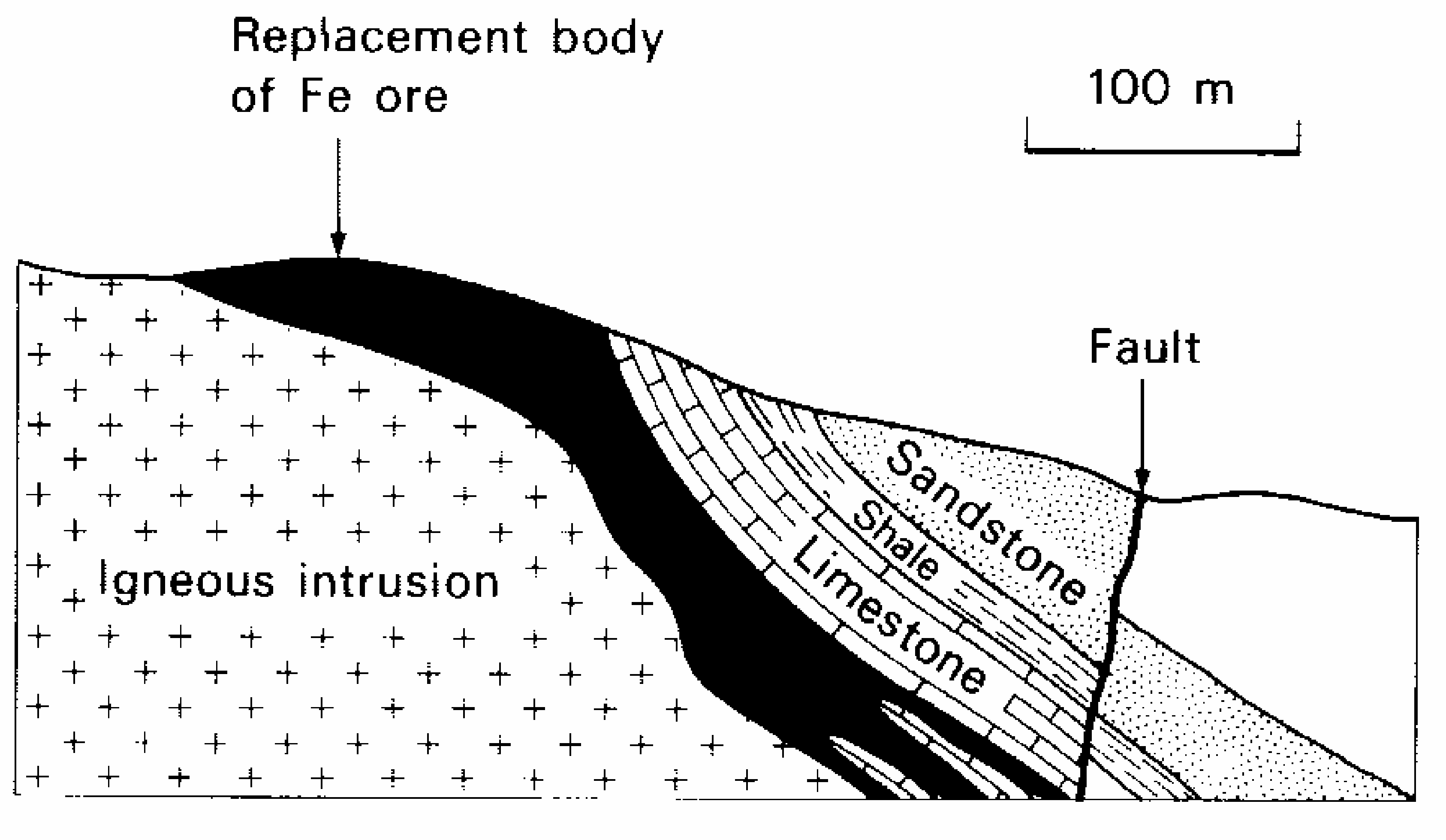
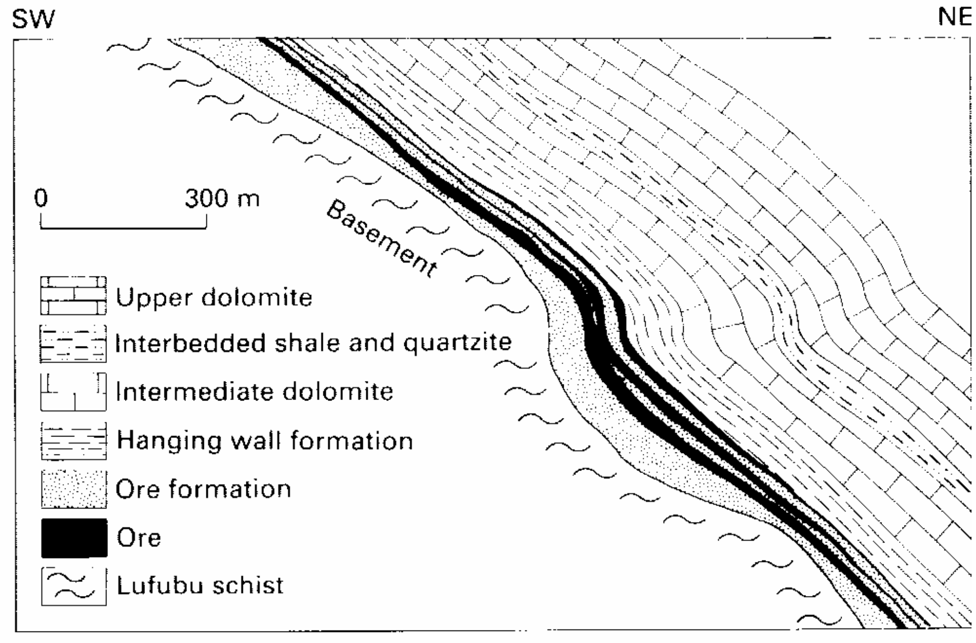


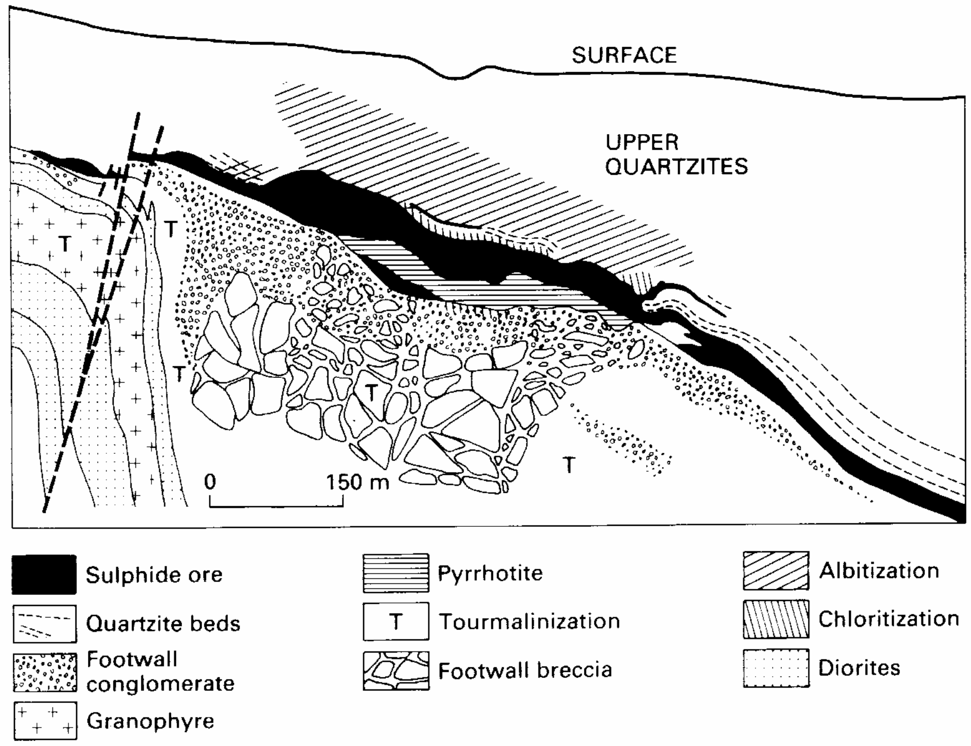
Fig. 1 magnesite replacement of limestone, skarn

❖ *Concordant Ore bodies*

- Sedimentary host rocks
  - particularly important for base metals and iron.
  - Parallel to bedding and limited development perpendicular to it, thus strataform (Fig. 2). Not to be confused with strata bound, which refers to type of ore body, concordant or discordant, which is restricted to a particular part of the stratigraphic colomn

- Fig. 2 Stratiform Deposits





- **Sedimentary host rocks**
  - Limestone hosts
    - Very common host for base metal sulfide deposits
    - Due to their solubility and reactivity they become favourable horizons for mineralisation
  - Argillaceous hosts
    - Shale, mudstone, argillite and slates
    - Eg. copper bearing shale,
    - Arenaceous hosts – Fig. 4
  - Rudaceous hosts
    - Alluvial gravels and conglomerates often host placer deposits of gold, PGE's and Uranium
  - Chemical sediments
    - Iron, manganese, evaporite and phosphorite formations

Arenaceous Hosts

- Heavy minerals in beach sands eg. Amij Formation (type section in Wadi Amij 50 Km ENE of Rutba W. of Iraq)

- It comprises a lower clastic unit and upper carbonate unit, the lower clastic unit consist of 20-30 m of cross bedded cross laminated fine grained qurtizitic sandstone and siltstone with lamination produced by concentration of heavy minerals such as Zircon, ilmenite
- Unconsolidated, easy to process using gravity settling techniques

- Formed in a marginal marine coastal lagoon and marsh environment.

- ***Volcanic hosts***

Volcanic-associated massive sulfide (VMS) deposits. Important source of base metals comprising mainly pyrite > 90 %, chalcopyrite, sphalerite is located at the ocean floor interface and generally stratiform bodies. The section bellow showing the characteristics of VMS deposits. Associated volcanic may be intermediate or felsic in composition. The lens of massive sulfide ore formed on the ocean floor, underlain by a stockwork zone of disseminated sulfide and intensely altered volcanic rocks, is typical of VMS deposits in general

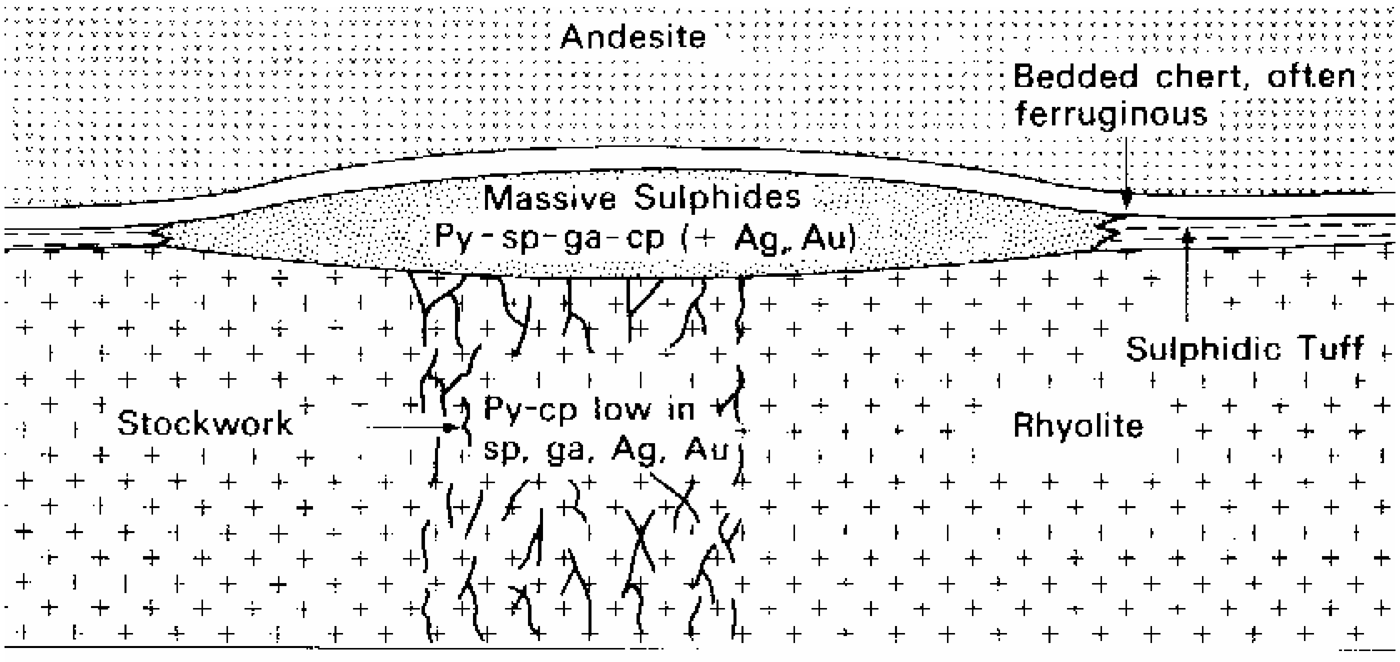


Fig. 4.10 Schematic cross section through an idealized volcanic-associated massive sulphide deposit showing the underlying feeder stockwork and typical mineralogy. Py, pyrite; sp, sphalerite; ga, galena; cp, chalcopyrite.

(After large, 1992)

- ***Igneous Host Rocks***
- Plutonic hosts
  - Layered mafic intrusions
    - Rythmic layering in the form of alternating bands of mafic and felsic minerals
    - Host to chromite, magnetite, ilmenite and PGE's
    - Stratiform, great lateral extent eg. Bushveld
  - Komatiites
    - Nickel-copper sulfide ores formed by the sinking of an immiscible sulfide liquid to the bottom of a magma chamber or lava flow. Liquation deposits.
    - Sulfides usually accumulate in hollows at the base of the magma forming conformable sheets or lenses

- ***Residual Deposits***
- Formed by the removal of non-ore material from proto-ore.
- Eg leaching of silica and alkalis from a nepheline syenite may leave behind a surface capping of hydrous aluminum oxides, called bauxite.
- Eg weathering granite – kaolinite
- Eg laterite can enrich nickel from peridotites

❖ Supergene Enrichment

- Groundwater circulation can lead to redistribution of metals above the water table

- ***Theories of Ore Genesis***
- Internal Processes
  - Magmatic crystallisation
    - Diamonds in kimberlites, feldspar in pegmatites
  - Magmatic segregation
    - Fractional crystallisation
    - Liquation
  - Hydrothermal processes
    - Sources of the solutions and their contents
      - Meteoric water
      - Sea water
      - Deeply penetrating ground water
      - Metamorphic water
      - Magmatic water
    - Means of transport (ligands)
  - Lateral secretion
  - Metamorphic processes

Fluid Sources

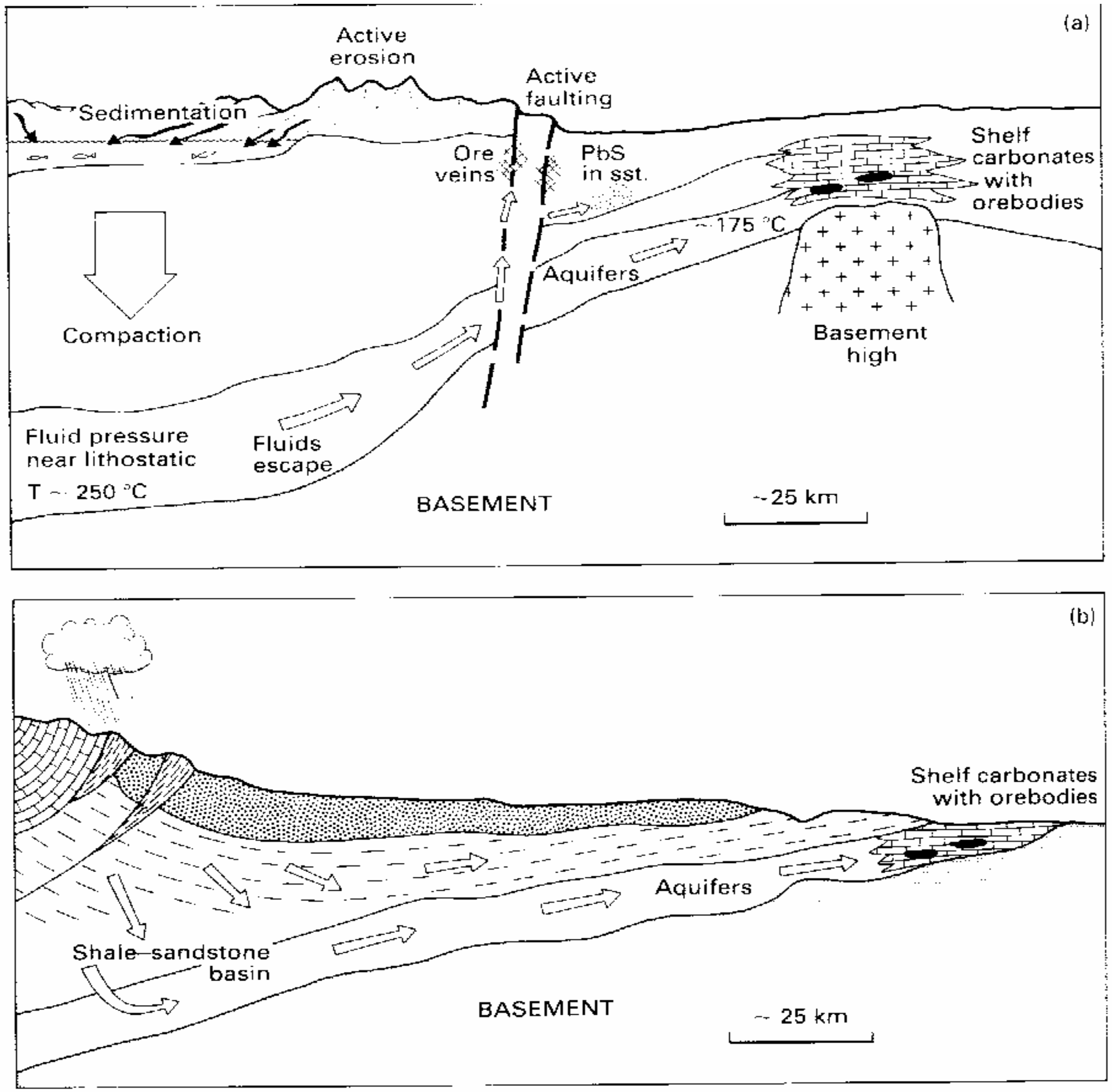


Fig. 6.3 Schemata for the formation of Mississippi Valley-type deposits. (a) Overpressured, hot pore fluids escape from a shale basin (perhaps aided by hydraulic fracturing) and move up aquifers to form deposits in cooler strata, filling fractures or forming other types of orebody. (b) Gravity-driven fluids flowing from a hydraulic head in a highland area flush through a basin driving out and replenishing the formation waters.

- **Lateral Secretion**

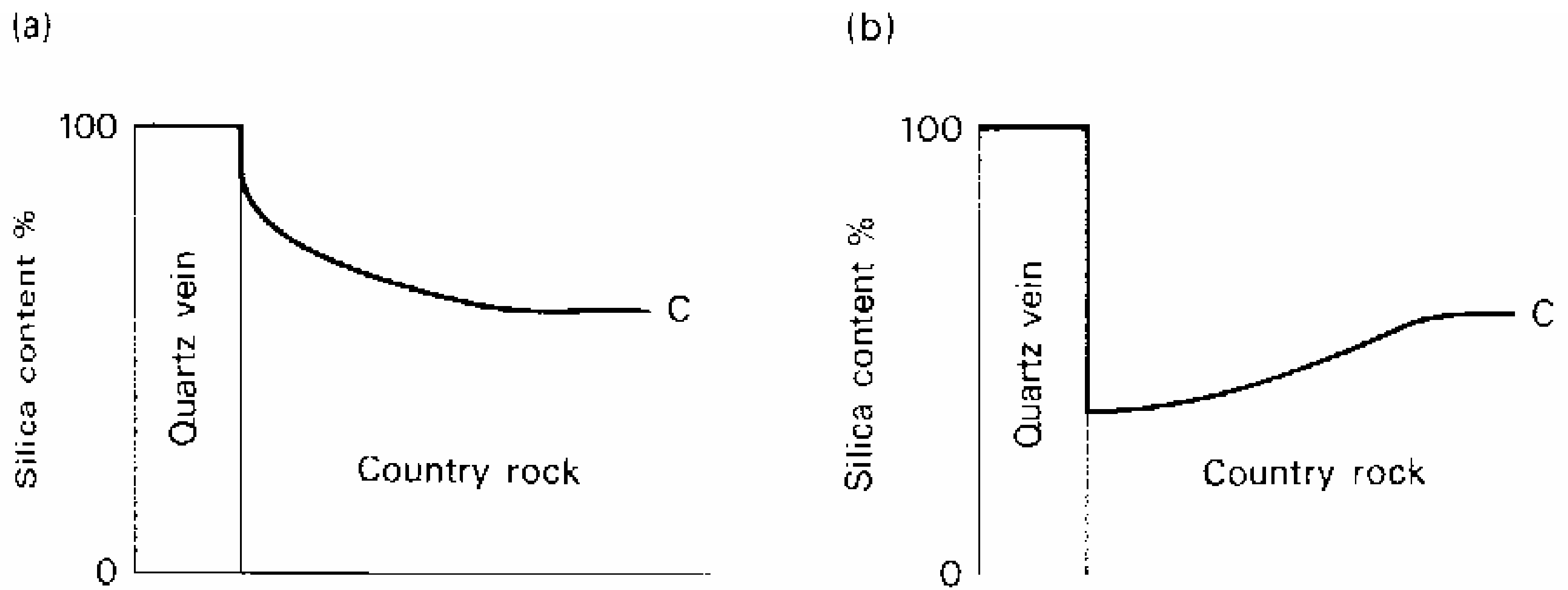


Fig. 6.5 Comparison of hypothetical profiles of silica. In (a) silica is added to the wall rocks from the hydrothermal solution, which is depositing quartz in the vein. In (b) silica is abstracted from the wall rocks and deposited as quartz in the vein. C indicates the normal level of silica in the country rocks.

- ***Metamorphic Processes***

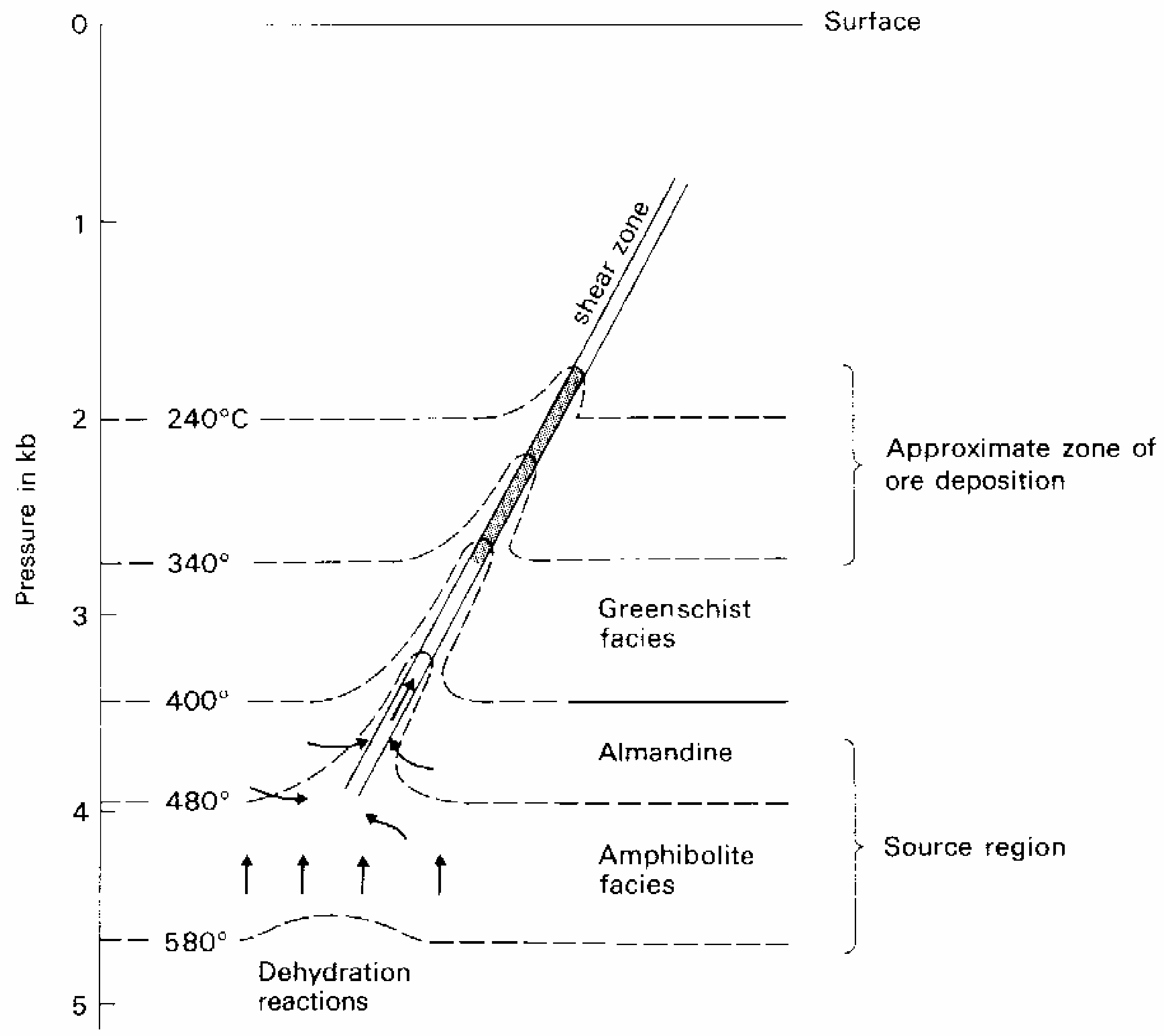


Fig. 6.6 Diagram of a shear zone where metamorphic water from a large volume of rock is rising to higher levels.

- ***Origin Due to Surface Processes***
- Exhalative processes (volcanic and sedimentary) – exhalites

Eg. Volcanic massive sulphide **(VMS) Formation**

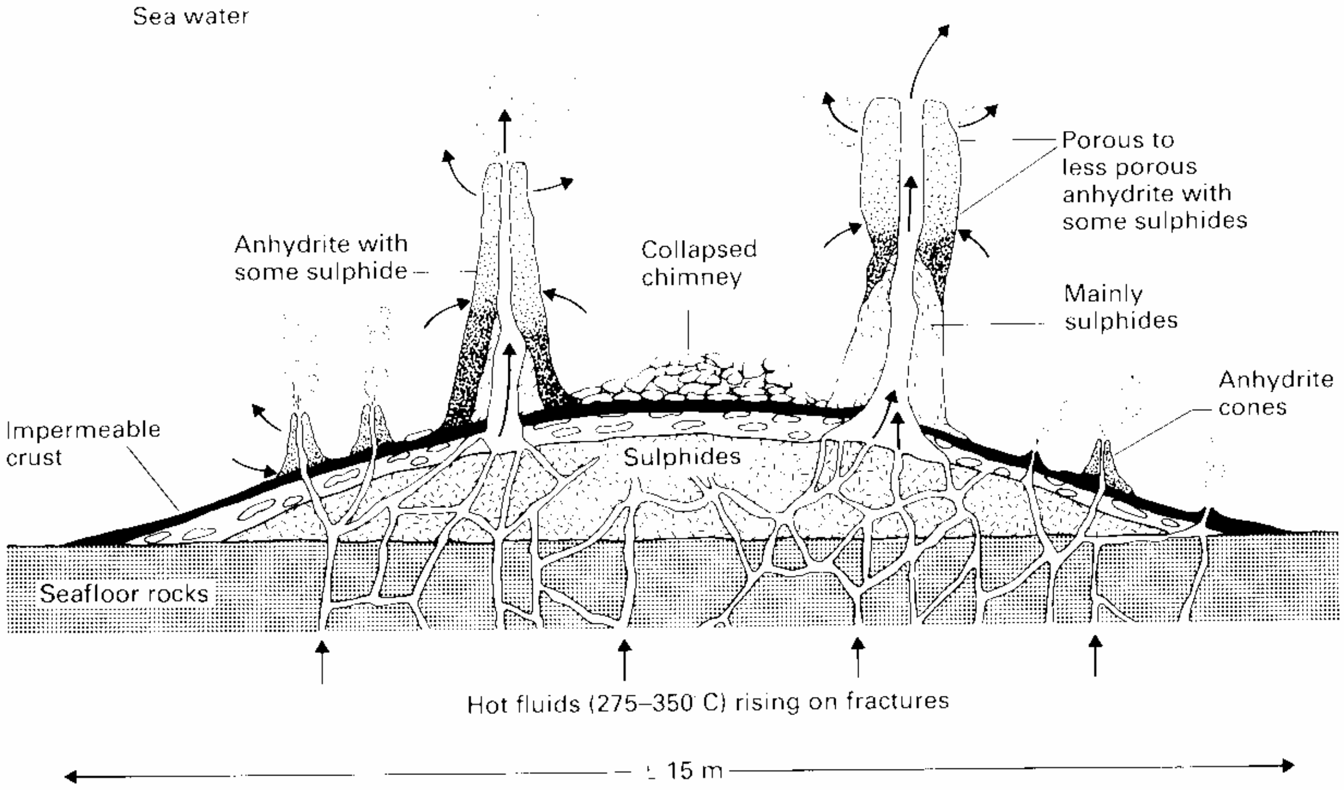


Fig. 6.8 Formation of chimneys and sulphide mounds on the sea floor. (After Barnes, 1988, *Ores and Minerals*, Open University Press, with permission.)

- ***VMS Fluid Circulation***

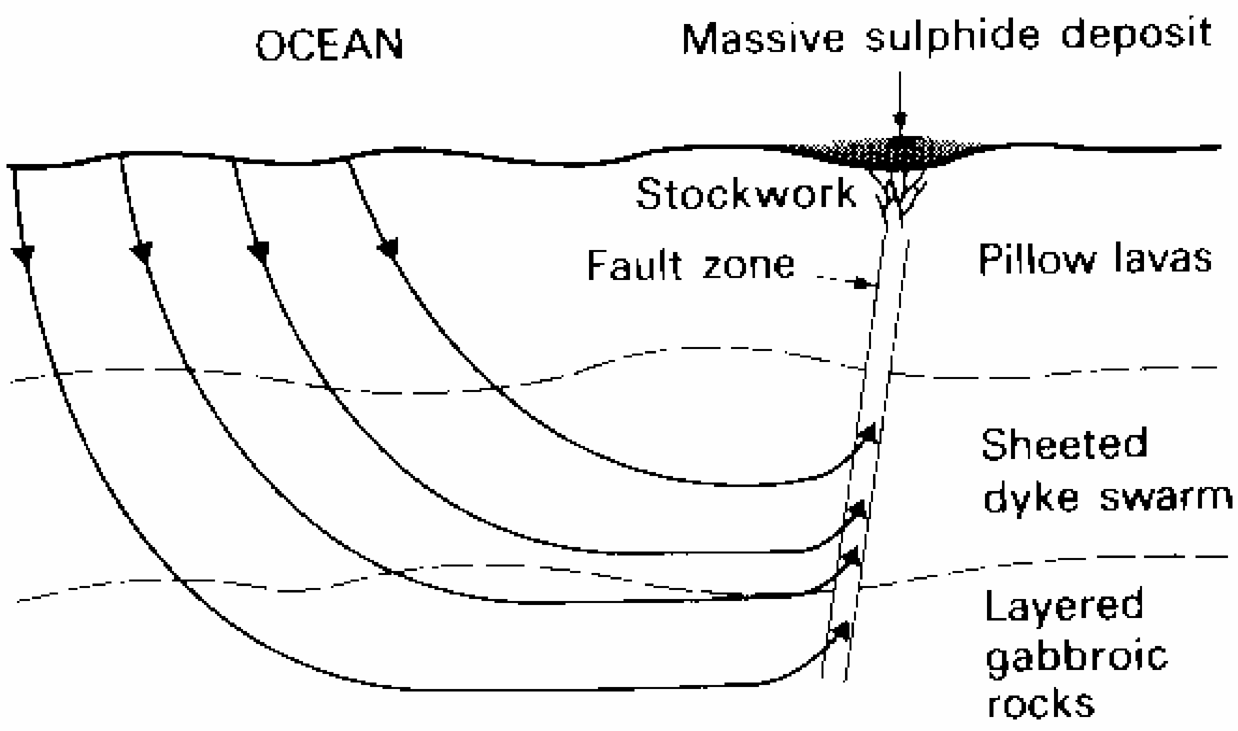


Fig. 6.7 Diagram showing how sea water circulation through oceanic crust might give rise to the formation of an exhalative volcanic-associated massive sulphide deposit.

- ***Stages of VMS Development & Zoning***

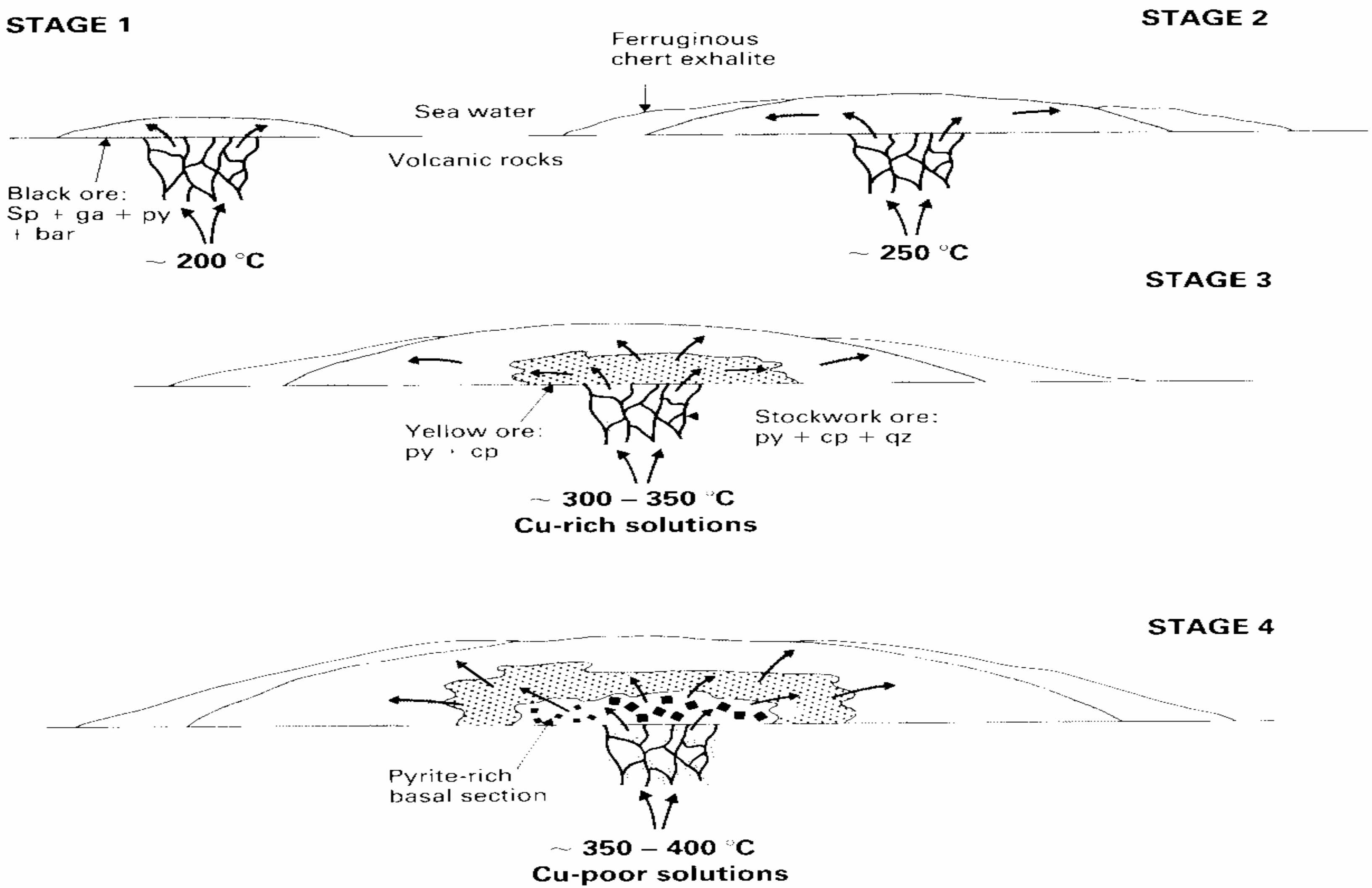


Fig. 6.9 Diagrams to illustrate the first four stages during the formation of volcanic-associated massive sulphide deposits as described in the text; bar = baryte, cp = chalcopyrite, ga = galena, py = pyrite, qz = quartz, and sp = sphalerite.

- ***Hydraulic Fracturing***
- Fracturing of rock by water under high pressure
- Increases permeability
- Transport and deposition of ores

Fracturing

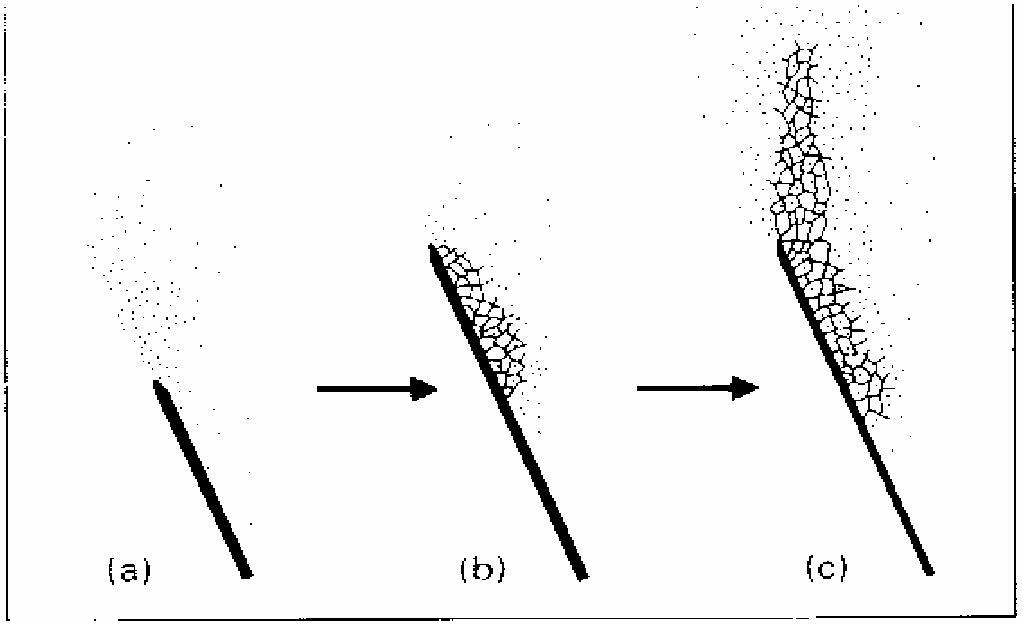


Fig. 6.10 Propagation of normal faults and accompanying development of breccia zones. (a) Hydrothermal solution saturates fault zone and permeates into the hanging wall. (b) Sudden fracturing extends fault upwards and a breccia zone forms in the hanging wall; with further similar extensions and brecciation a large breccia zone may form. (c) Vertical hydraulic fracturing may occur above the fault zone.

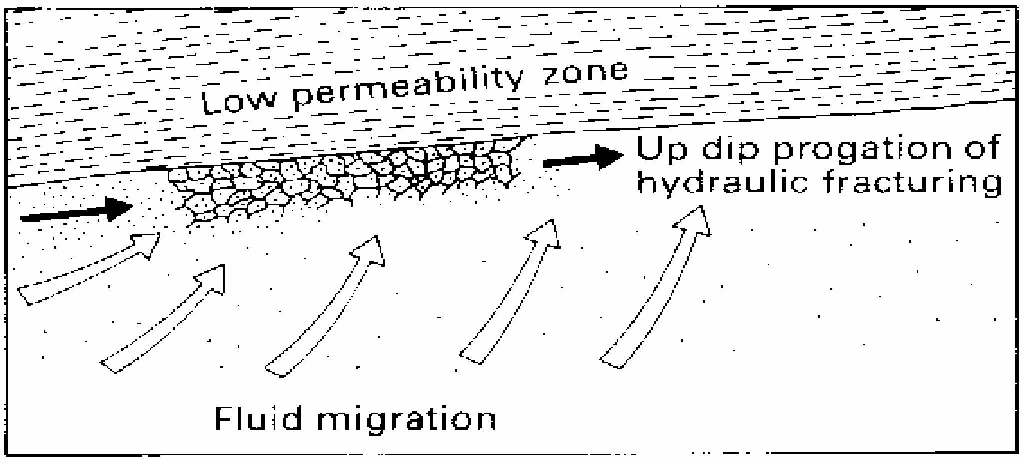


Fig. 6.11 Development of hydraulic fracturing in a sedimentary basin. Fluids accumulate beneath an impermeable zone, e.g. shale or evaporite sequence, pore pressure builds up and hydraulic fracturing is initiated and propagated up dip.