Mineral Systems

Q3 Fluid reservoirs

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Key Parameter → Mineral System → Exploration

is reflected in

scale-dependent translation

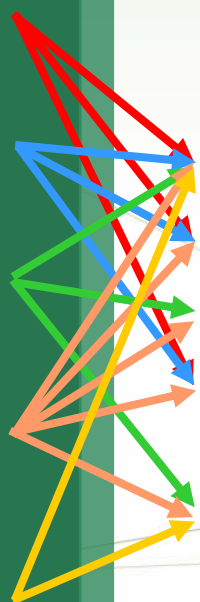
A. Gradient in hydraulic potential

B. Permeability

C. Solubility sensitivity to P, T, C

D. Spatial gradient of P, T, C

E. Time (duration)



5 Questions

1. Geodynamics
2. Architecture
3. Fluid reservoirs
4. Flow drivers & pathways
5. Deposition

Terrain Selection

Area Selection

Drill Targeting

Slide after: A. Barnicoat

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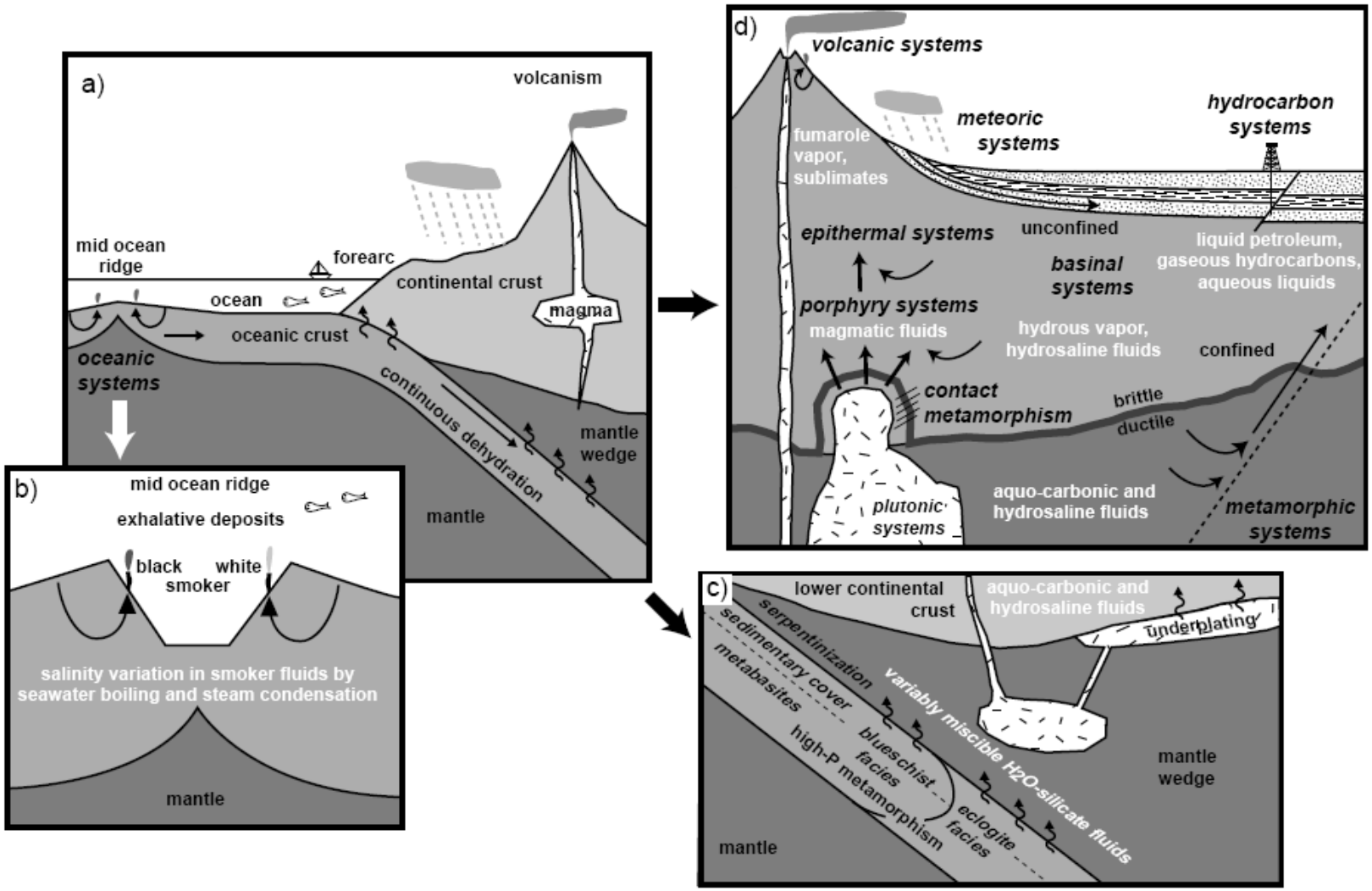
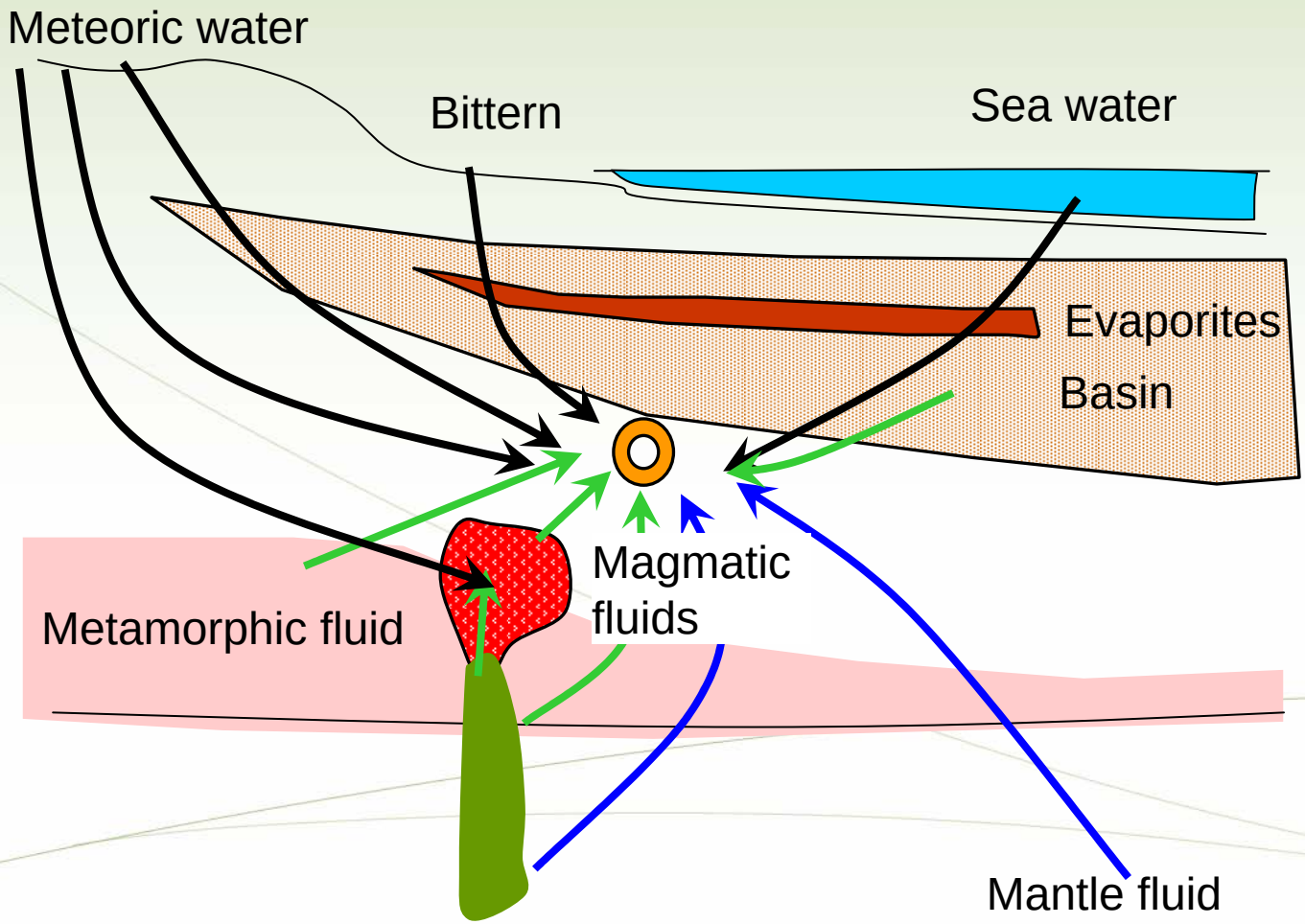


Liebscher&Heinrich 2007

Potential fluid sources (basins?)



Meteoric fluids

Surface derived
needs rainfall and topography

wide range of chemistries
anions: sulphate, bicarbonate, chloride or acetate

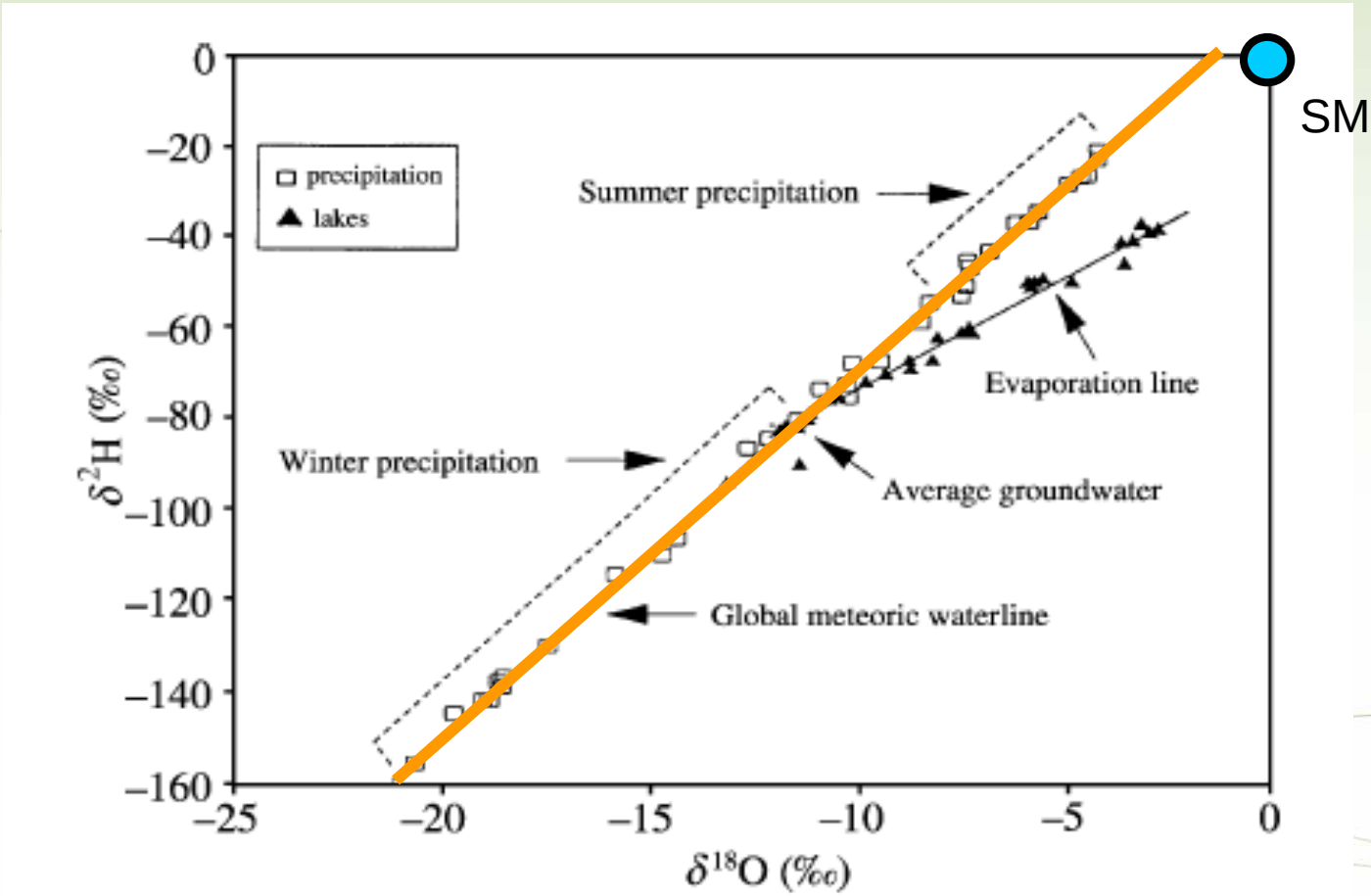
Sulphate: most important in shallow groundwaters

Bicarbonate: increases with depth

Acetate: may dominate in groundwaters at T ≈ 80-120 °C

Meteoric waters may be (largely) unmodified, may contribute to basinal waters or to magmatic fluids.

Meteoric fluids



Basinal fluids

formation water

water present in pores and fractures immediately prior to drilling

Connate water

water trapped with the sediment and subsequently unmodified (meteoric or seawater)

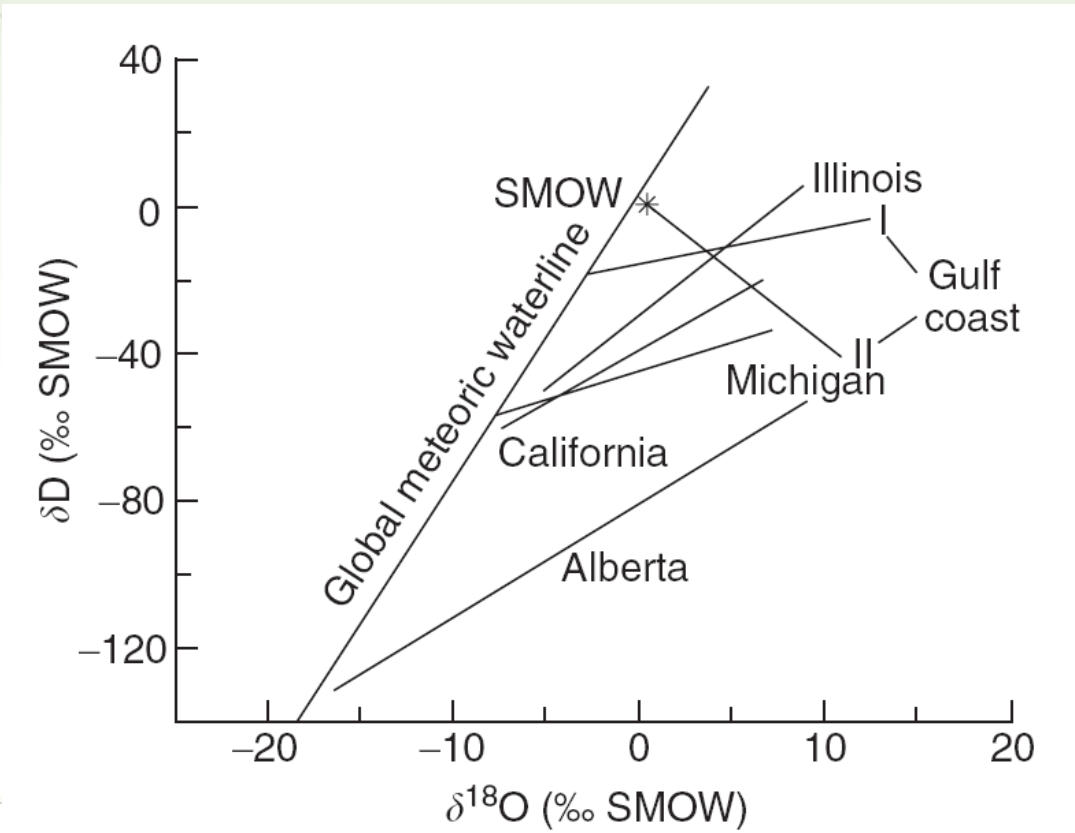
modified meteoric water

Many basinal waters are of mixed origin with marine, meteoric and bittern components

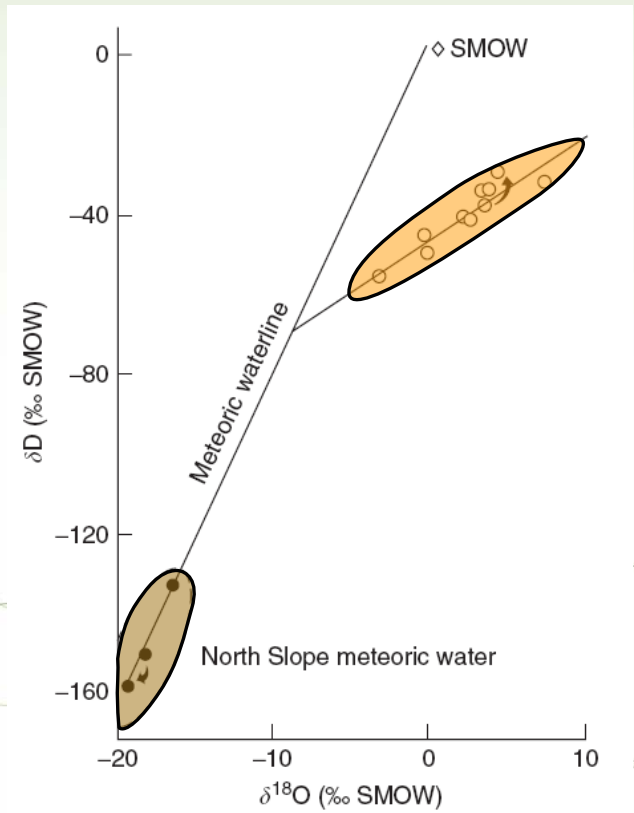
Basinal fluids - origins

Meteoric origin

recent



not recent



Basinal fluids

Chemistry

major cations Na, K, Ca and Mg increase in general with increasing salinity (total dissolved solids)

The concentration of many cations is controlled by reaction with mineral phases including carbonates, feldspar, illite and chlorite

SiO2 is controlled by equilibration with metastable silica polymorphs such as opal at low temperatures, and with quartz at temperatures above about 80°C

pH increases with increasing salinity , a function of fluid rock interaction as exemplified by the reaction

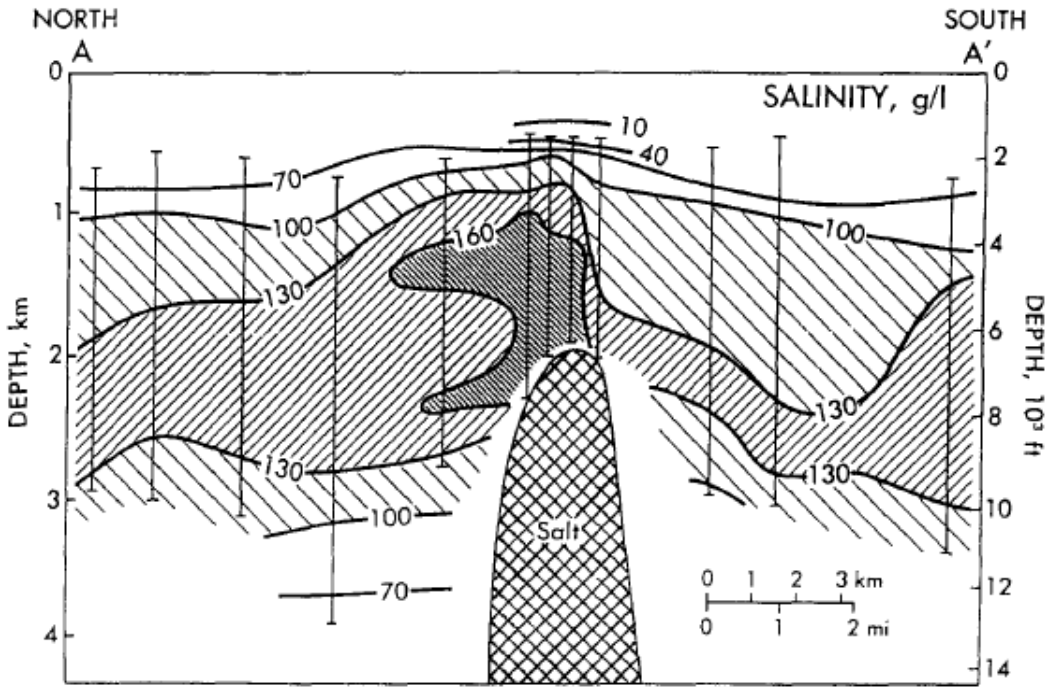
$$NaAl_3Si_3O_{10}(OH)_2 + 6SiO_2 + 2NaCl = 3NaAlSi_3O_8 + 2H^+ + 2Cl^-$$

Chloride is the dominant anion in waters of seawater salinity and above

Basinal fluids - salinity

Salinity sources

- **Dissolution of evaporites**
- **Descent of bittern brines from surface**



Metamorphic fluids

'Metamorphic' fluids have mixed origin

- **Devolatilisation**
- **External fluids reacting with metamorphic rocks**

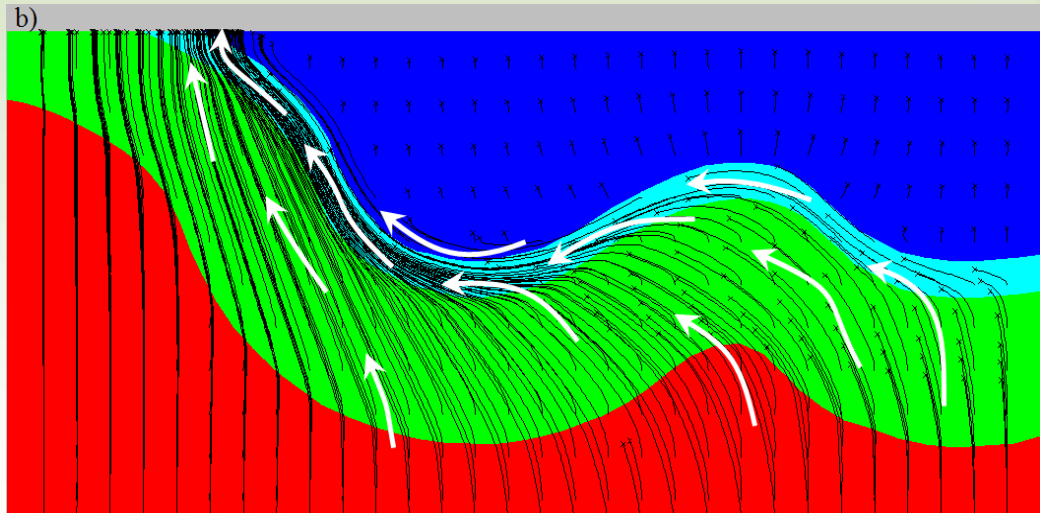
Devolatilisation

- **During heating, volatiles released**
- **Constant temperature leads to no fluid generation**
- **Decrease in temperature leads to resorption of residual fluid by retrogression**

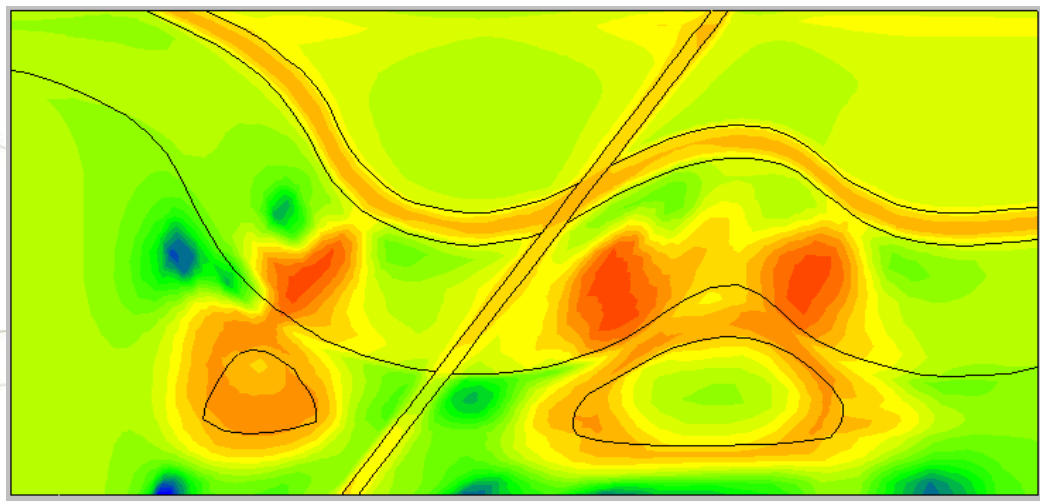
Metamorphic fluids

Devolatilisation

upflow & fluid focussing

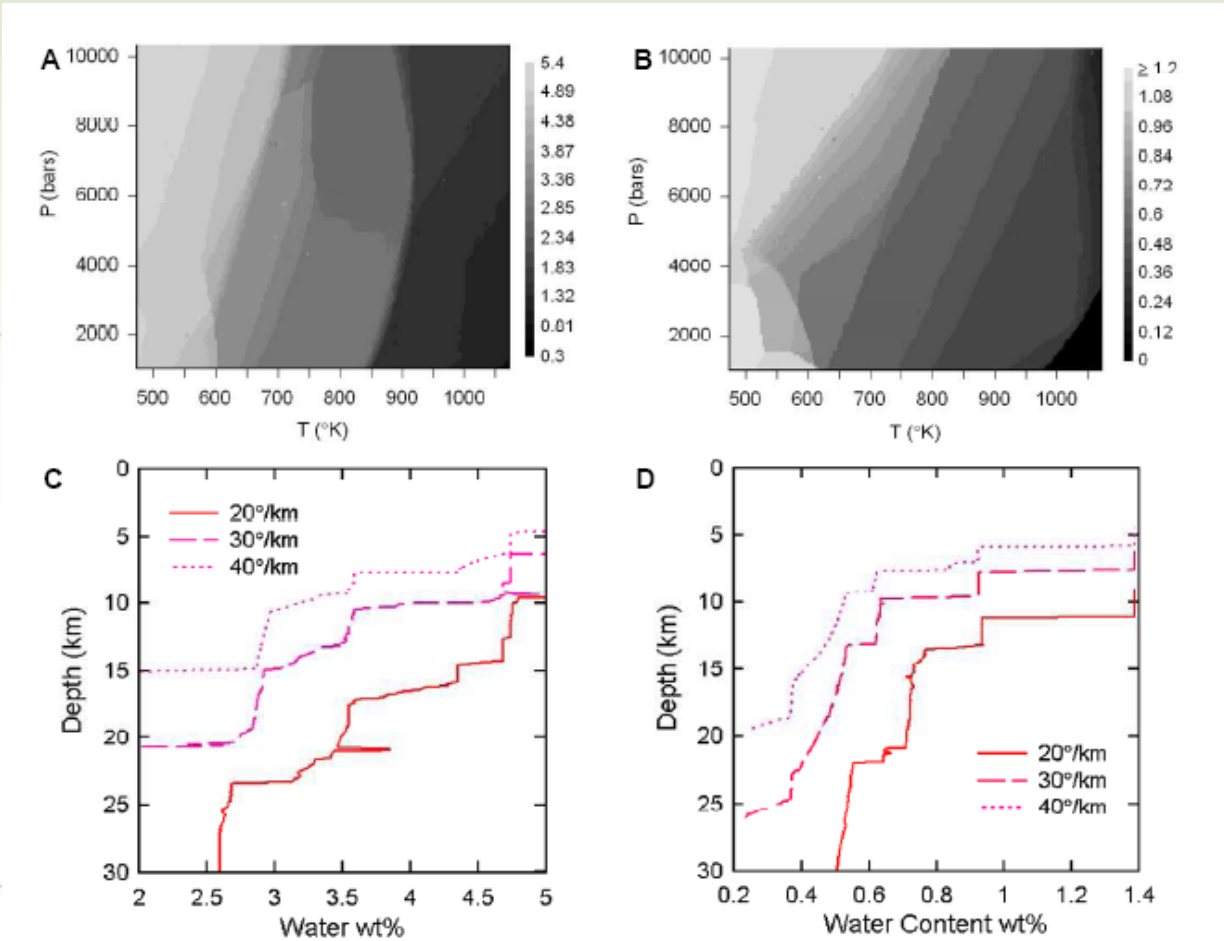


increase in permeability



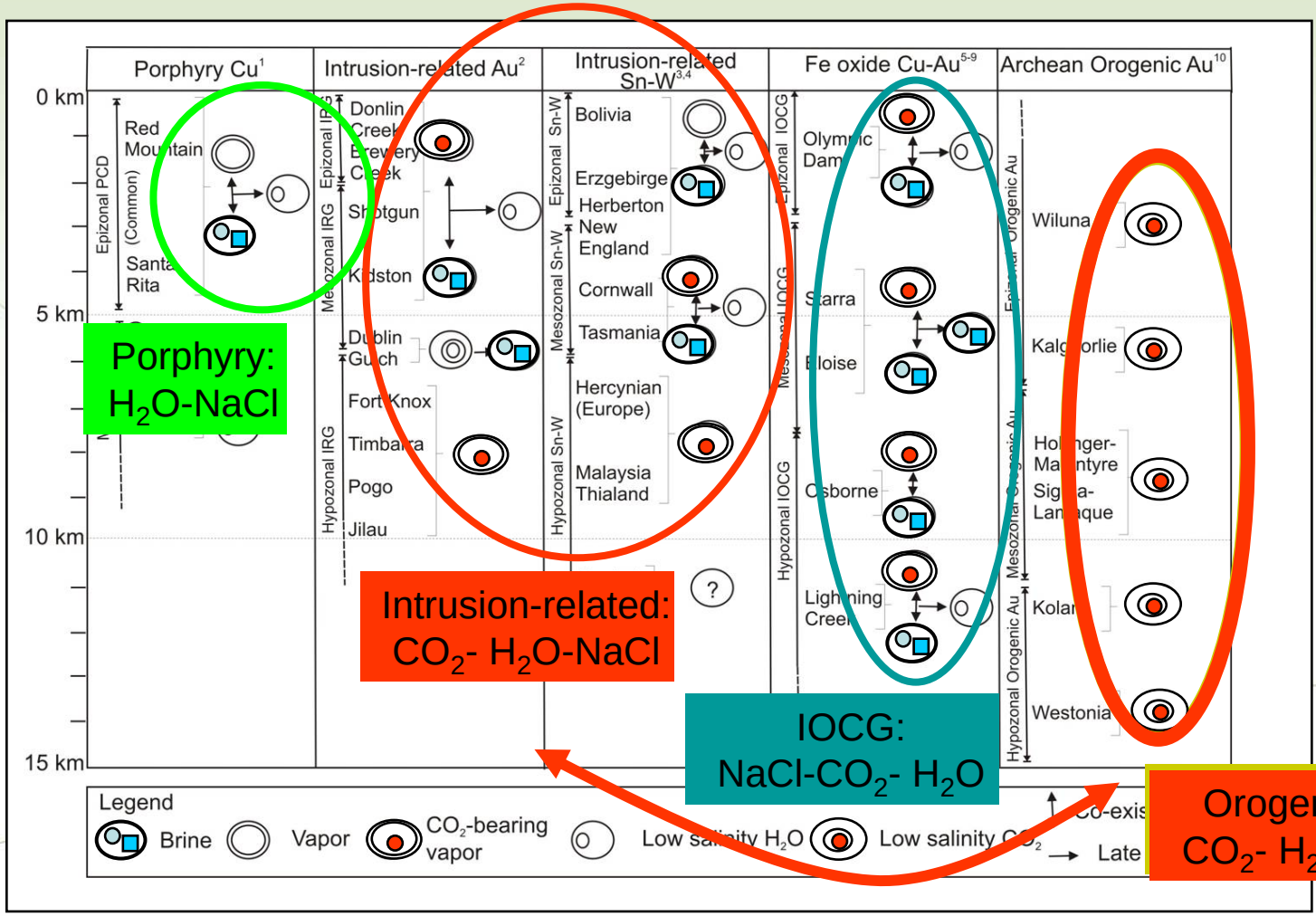
Metamorphic fluids

tholeiitic basalt



high-Ca granlite

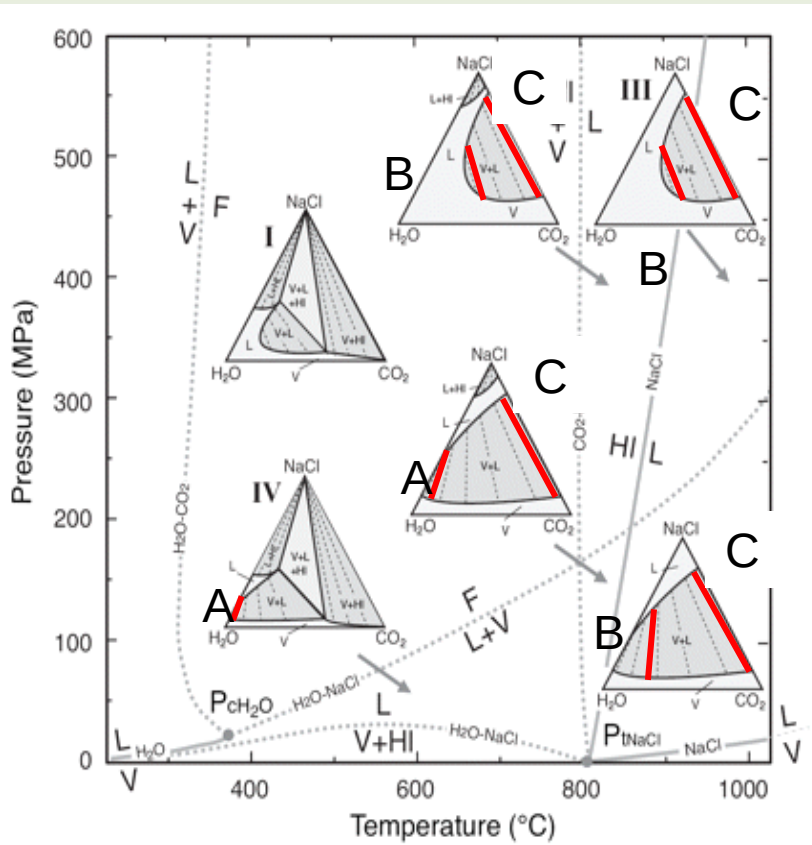
Magmatic fluids



Magmatic fluids

Ore deposits associated with magmatic-hydrothermal fluids:

- **Porphyry Cu, Au and Mo deposits (A)**
- **High-sulphidation epithermal deposits associated with porphyries**
- **Intrusion-related gold and other metal deposits, linked to reduced intrusions (B)**
- **Iron oxide – copper –gold (IOCG) deposits (C)**



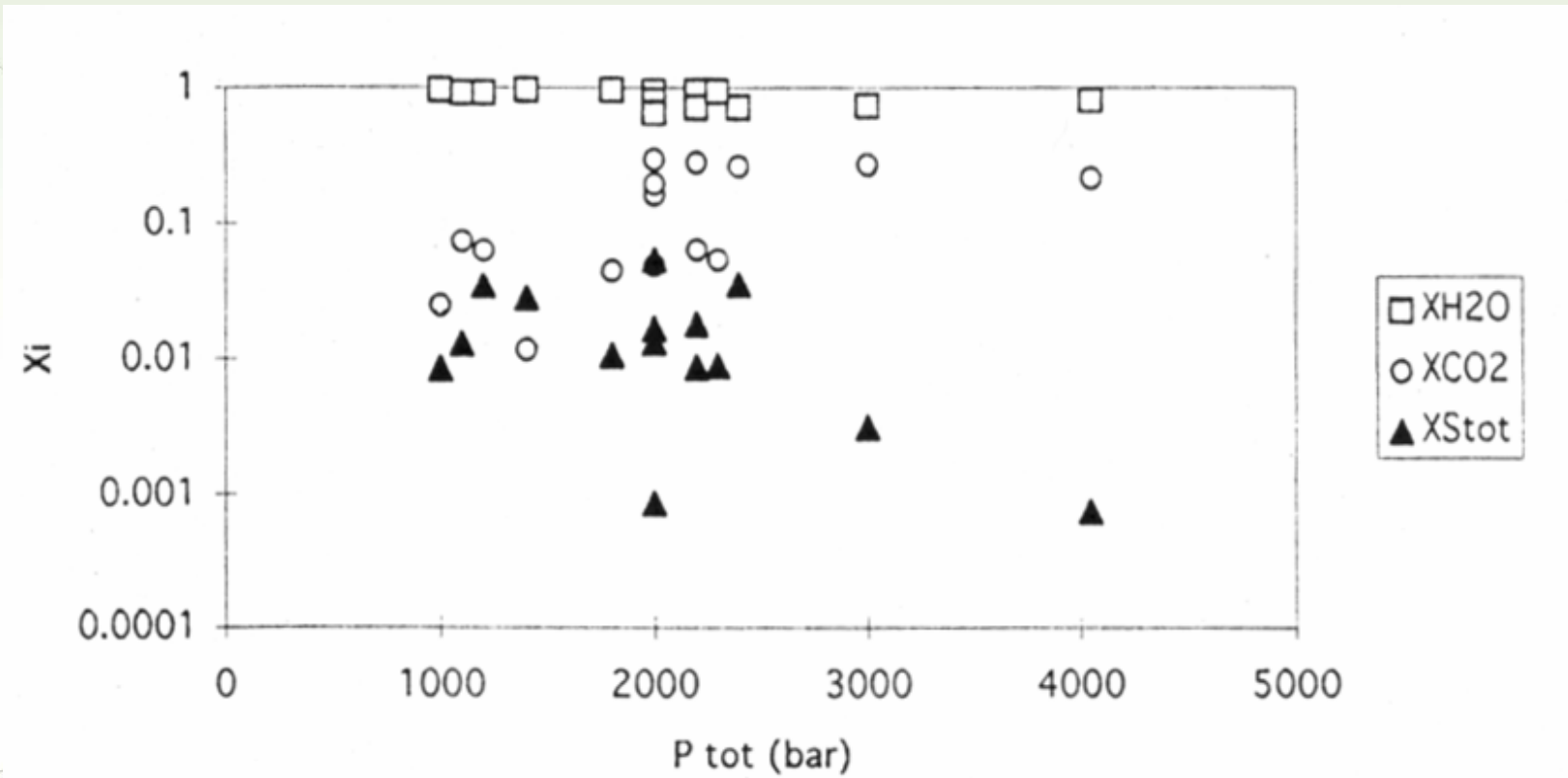
Magmatic fluids – volatiles

Porphyries are characterised by H2O-NaCl fluids that are high in sulphur

Intrusion-related systems are associated with CO2-H2O fluids with limited NaCl contents; sulphur contents of the deposits and by inference the fluids are relatively low.

IOCG systems are dominated by NaCl-rich melts and CO2-rich fluids. Sulphur contents of the fluids are relatively low.

Magmatic fluids – volatiles



Mantle fluids

Possible source of reduced components

Subduction-related processes

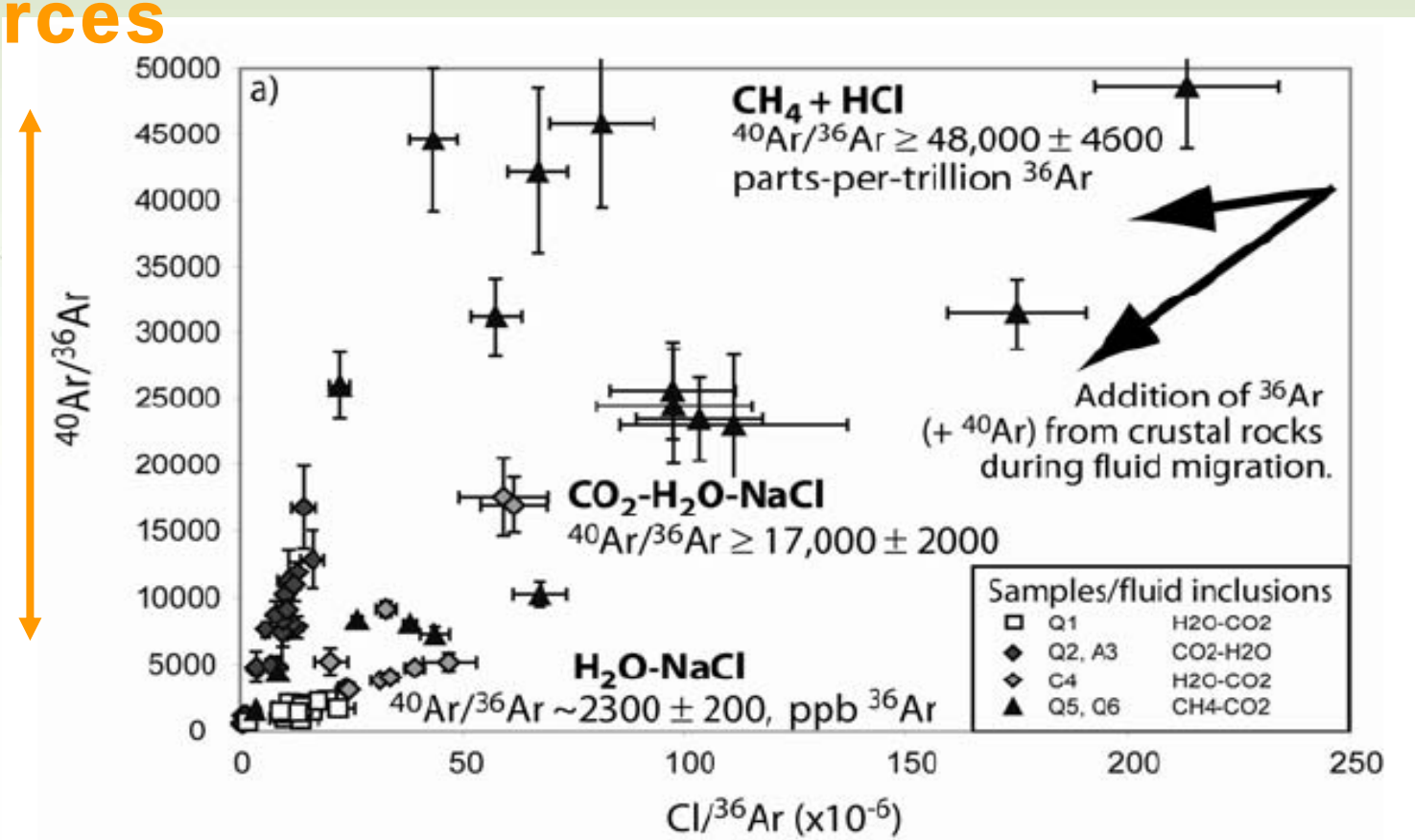
CO_2 used to be often considered to be mantle derived

Mantle redox more variable than initially envisaged

- **Possible source of (very) reduced fluid**

$^{40}Ar/^{36}Ar$ Constraints On Crust/Mantle Sources

Mantle



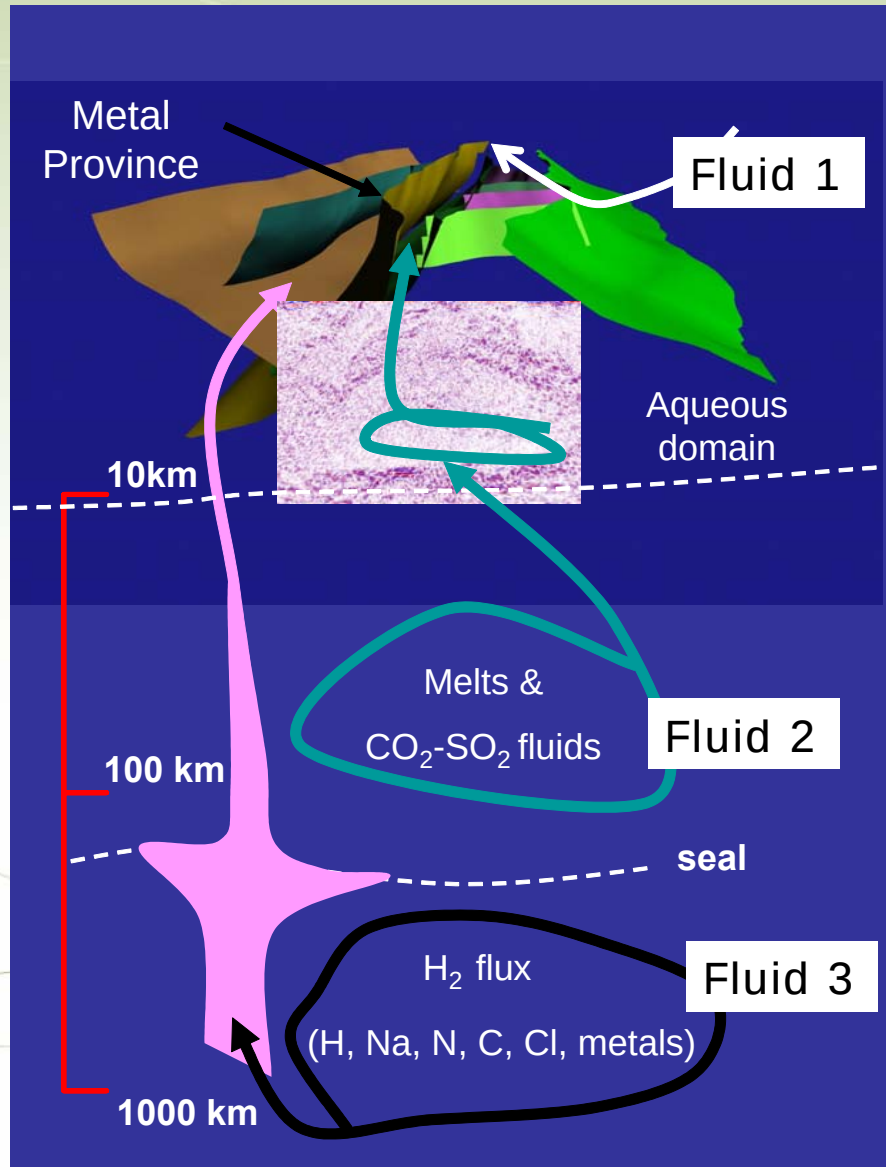
Chlorine (HCl, NaCl)

Kendrick et al., 2008

Fluid reservoirs

3 end-member fluids:

1) ambient crustal aqueous fluid, with low concentrations of salt and volatiles
2) magmatic, dominated by CO2 and SO2
3) 'deep-earth', highly reduced CH4 - N2 - H2 - fluid
   - acid volatiles (H2S, HCl ±HF),
   - noble gases (Ne and Ar) of mantle origin,
   - possibly metal hydrides (e.g. NaH, MgH2, AlH3 and SiH4)
   - and probably Au



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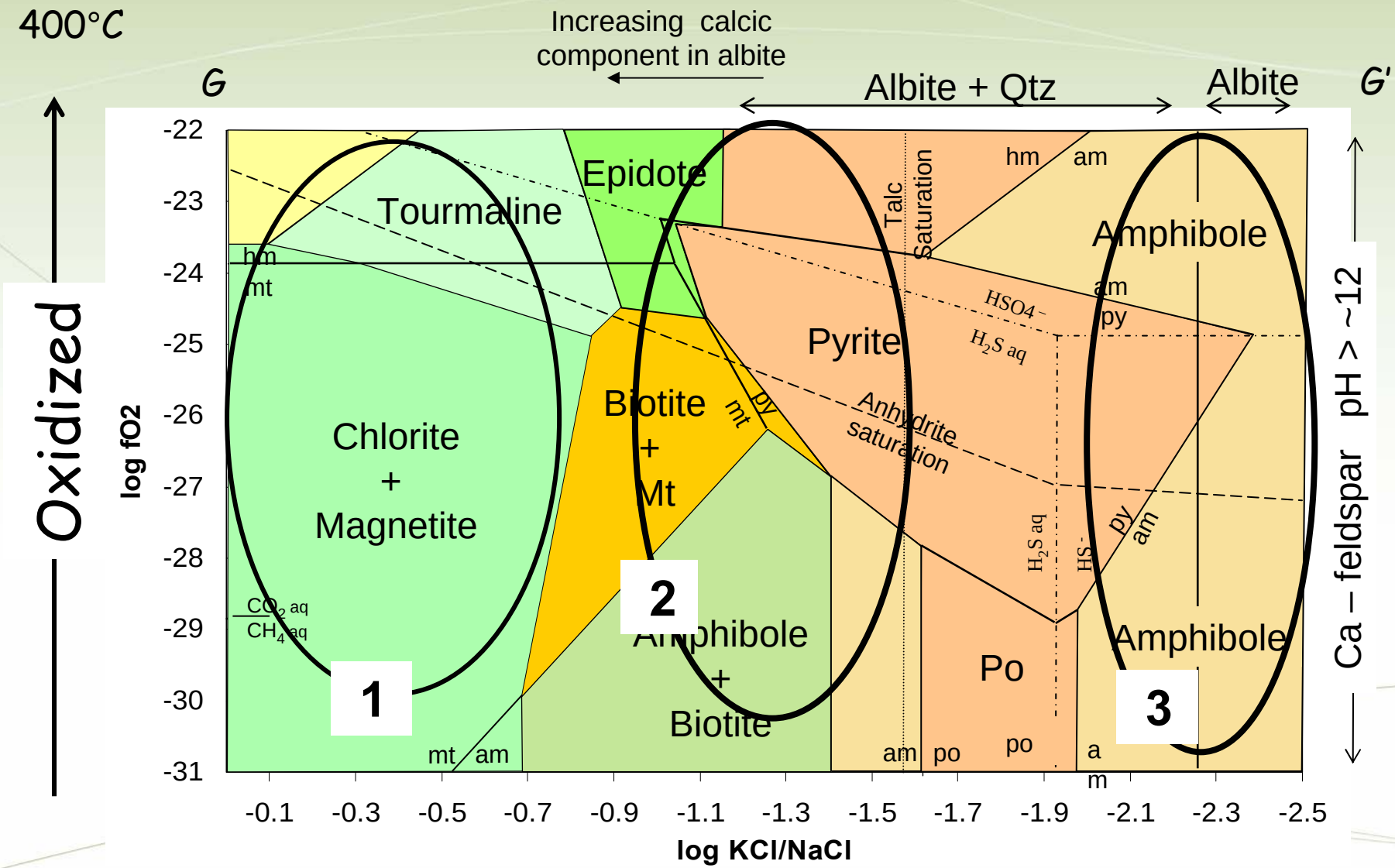

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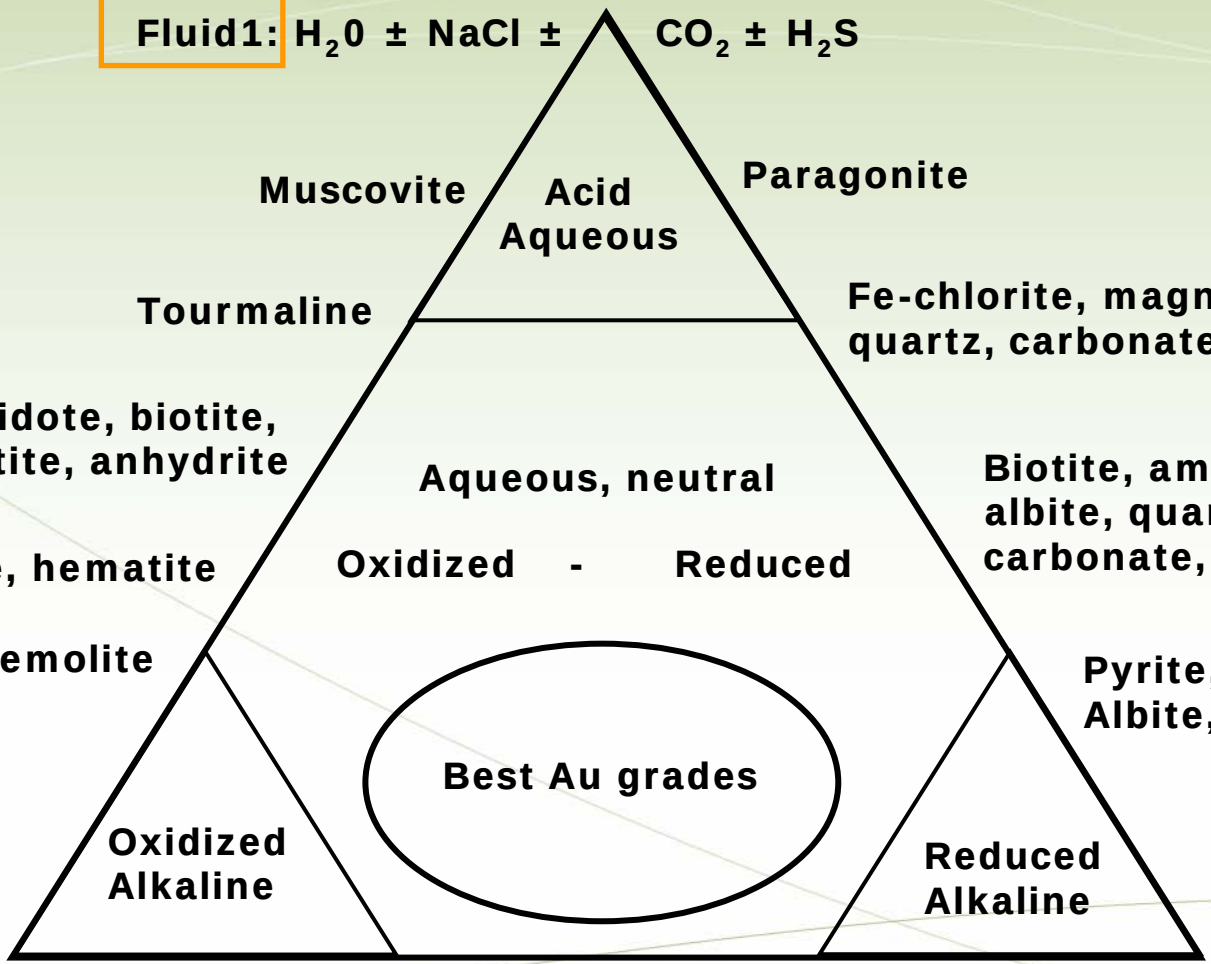

Fluid 2: CO_2 - SO_2 – volatiles; potassic

← Anhydrous Volatiles →

Fluid 3: H_2,H_2S, CH_4, N_2, HCl, HF sodic

*predictive mineral discovery*Cooperative Research Centre*

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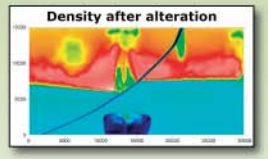

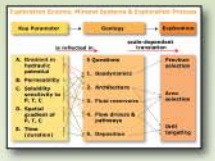

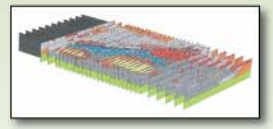

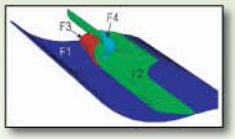

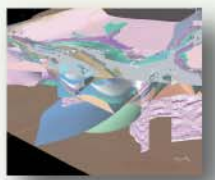

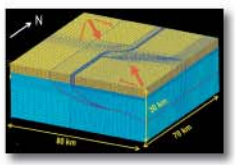

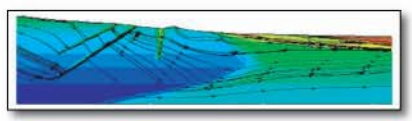

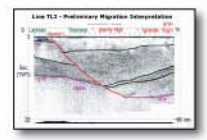

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