



Site Characterization

Geochemical Characterization Methods

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Geochemical Characterization Methods

Outline

- Whole Rock Analysis
- Mineralogical Methods
- Calculating Modal Abundance

Whole Rock Analysis

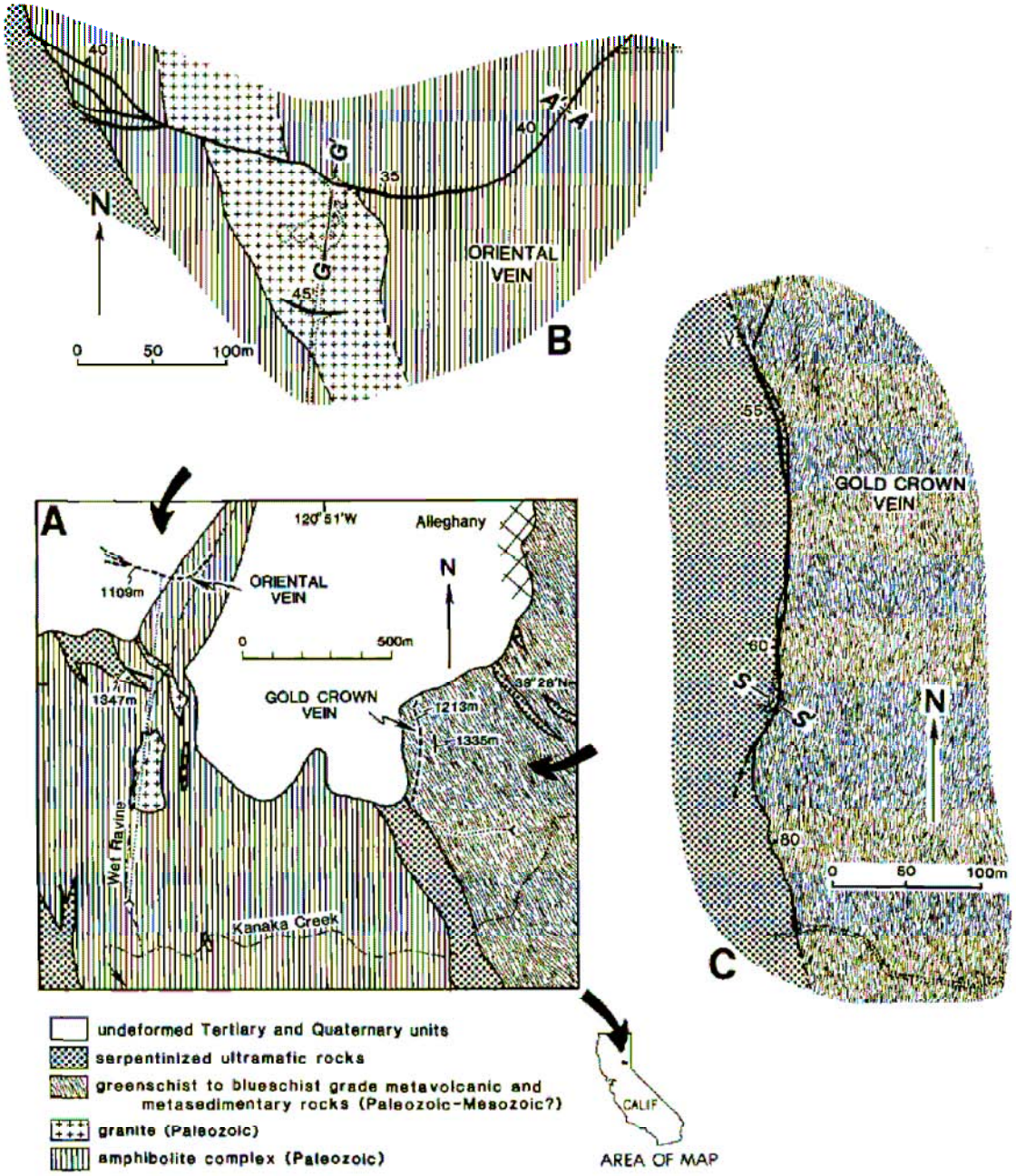
- Chemical Methods
  - X-Ray Fluorescence
  - Inductively Coupled Plasma (ICP, -AES, -MS)
  - Emission Spectroscopy
  - Neutron Activation
  - Atomic Absorption (Graphite Furnace)
  - Atomic Fluorescence (mercury)
- Each method has strengths and weaknesses
  - Detection limits, precision, accuracy, cost

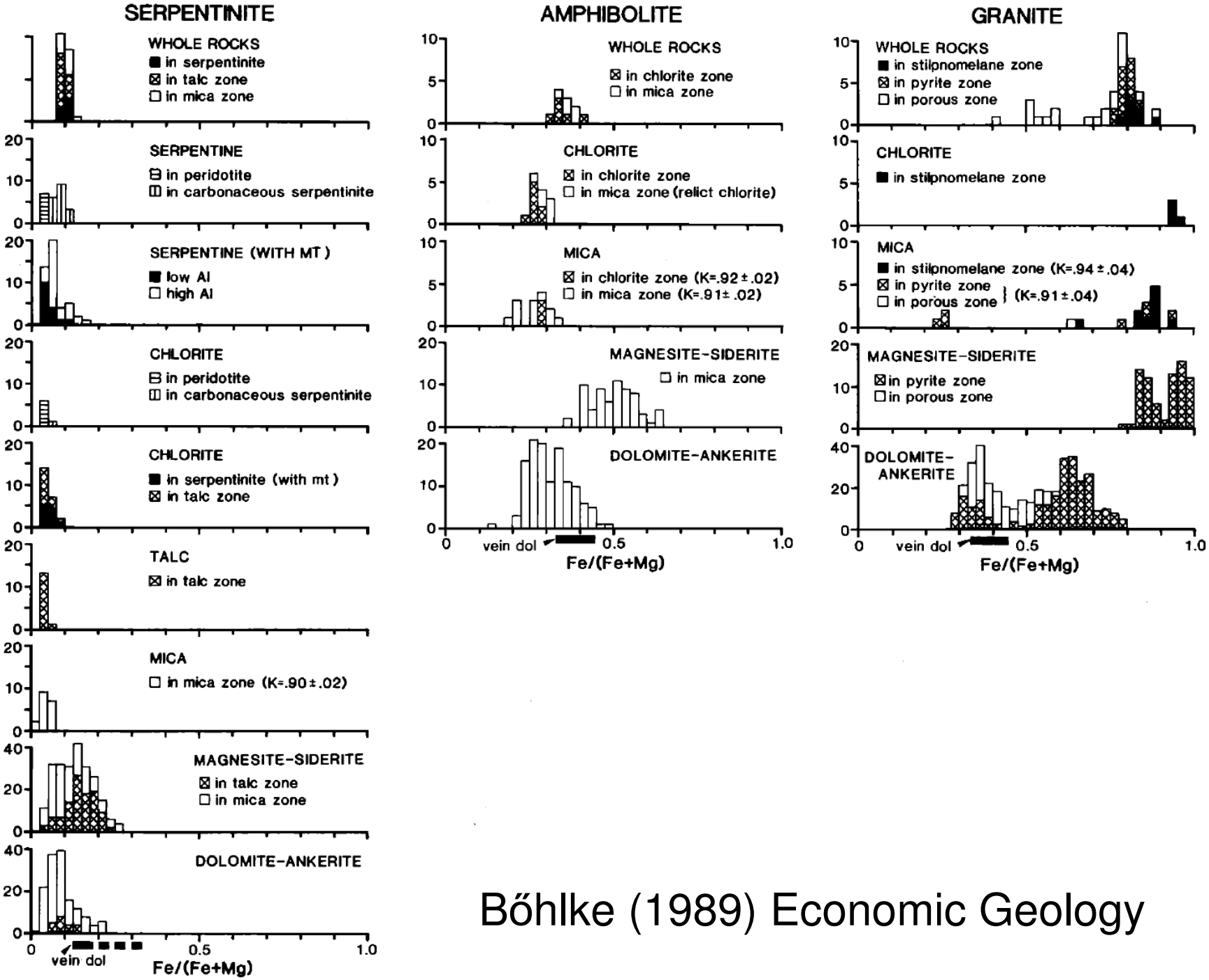
Mineralogical Methods

- Field ID, Petrography
- X-Ray Diffraction (qualitative, quantitative)
- Electron Microprobe
- Electron Microscopy (SEM, TEM, HR-TEM)
- Synchrotron methods
  - XAS, EXAFS, XANES – speciation
  - µXRF, µXRD
- VNIR Reflectance Spectroscopy
  - AVIRIS
  - Field instruments

Mariposite with quartz veins – altered serpentinite

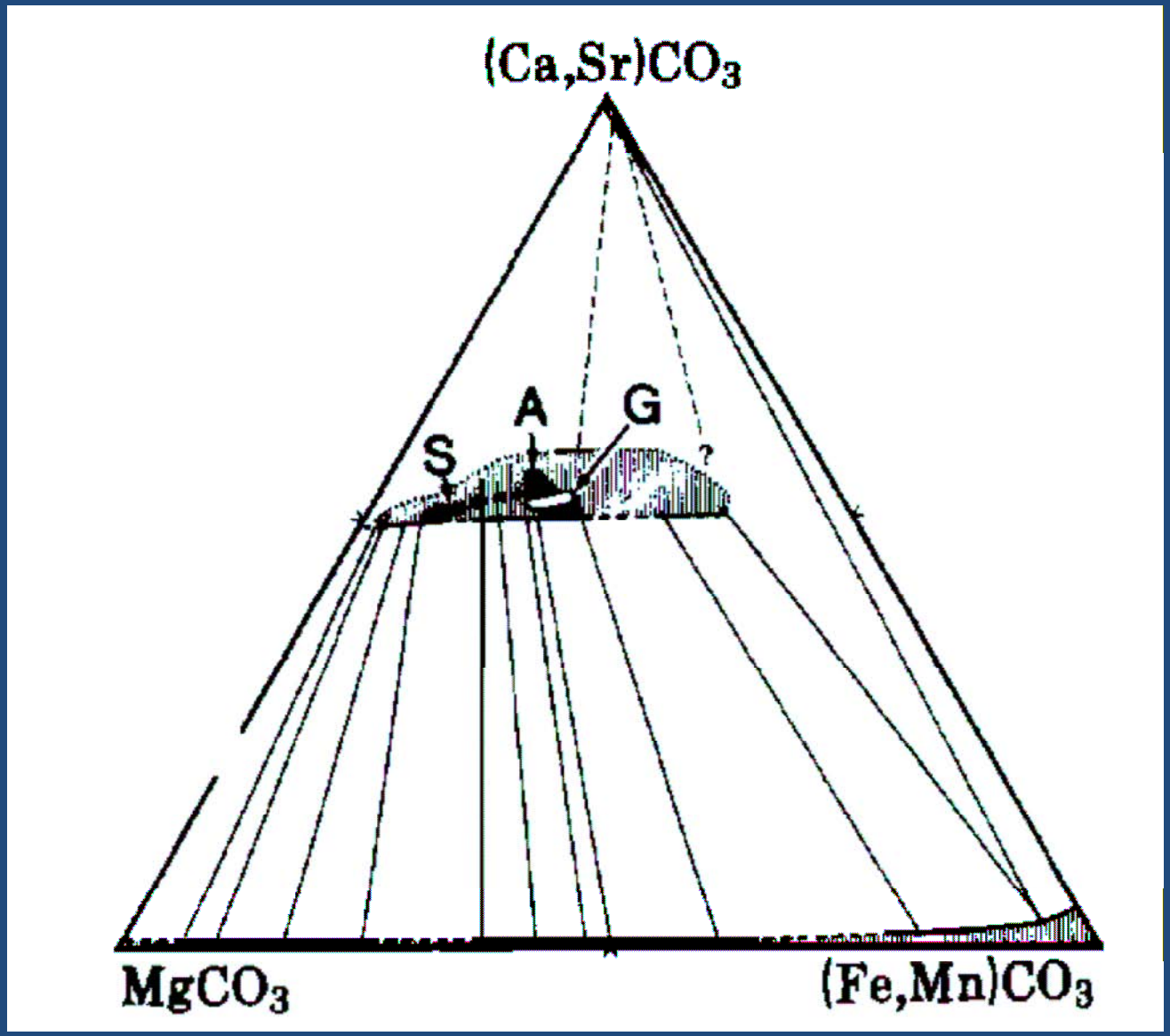
Bőhlke (1989) Economic Geology





Bőhlke (1989) Economic Geology

Carbonate compositions in 3 rock types, Alleghany mining district



Bőhlke (1989) Economic Geology

Solving for modal abundance of minerals (x) given mineral formulas (A) and whole rock composition (b)

$$A \times x \approx b, \tag{7}$$

for example,

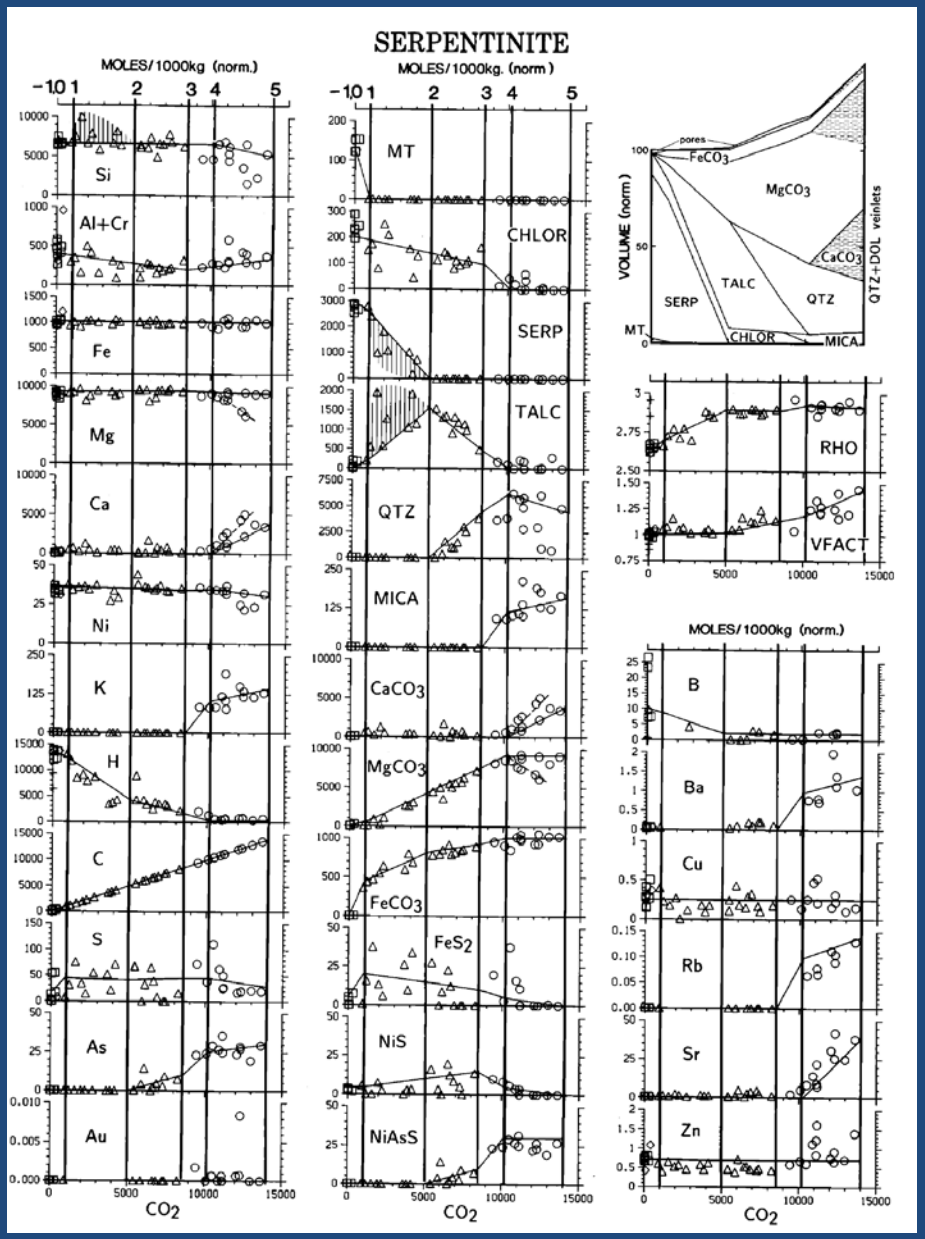
$$\begin{bmatrix} \frac{\text{moles Si}}{\text{mole albite}} & \frac{\text{moles Si}}{\text{mole muscovite}} & \cdots \\ \frac{\text{moles Al}}{\text{mole albite}} & \frac{\text{moles Al}}{\text{mole muscovite}} & \cdots \\ \vdots & \vdots & \vdots \end{bmatrix} \times \begin{bmatrix} \frac{\text{moles albite}}{\text{1,000 kg rock}} \\ \frac{\text{moles musc}}{\text{1,000 kg rock}} \\ \vdots \end{bmatrix} \approx \begin{bmatrix} \frac{\text{moles Si}}{\text{1,000 kg rock}} \\ \frac{\text{moles Al}}{\text{1,000 kg rock}} \\ \vdots \end{bmatrix}. \tag{7A}$$

Bőhlke (1989)
Economic Geology

Qualitative mineralogy of alteration zones in serpentinite

Zone	S0 □	S1 △	S2 △	S3 △	S4 ○	S5 ○	Veinlets
Chromite	X	X	X	x	x		
Magnetite	XX						
Serpentine	XX	XX					
Chlorite	XX	XX	XX	XX			
Talc		X	XX	X	x		
Quartz				XX	XX	XX	XX
Mica					XX	XX	X
Calcite	x	x	x	x	x	x	x
Magnesite		X	XX	XX	XX	XX	x
Dolomite	x	x	x	x	x	XX	XX
Pentlandite	X	X					
Pyrite	X	X	X	X	x		
Millerite	x	x	X	X	x		
Gersdorffite				X	X	X	
Arsenopyrite							x
Gold						x	x
Graphite	x	x	x	x	x	x	x

Bőhlke (1989) Economic Geology



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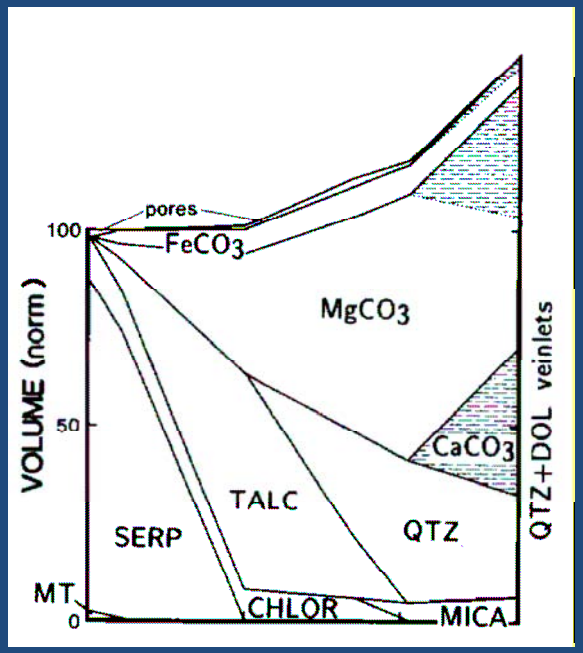
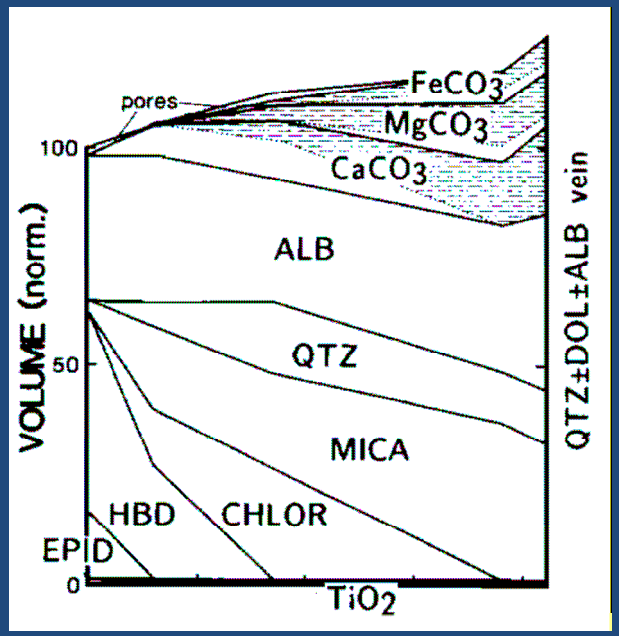
Calculated abundance of minerals in alteration halos around quartz veins

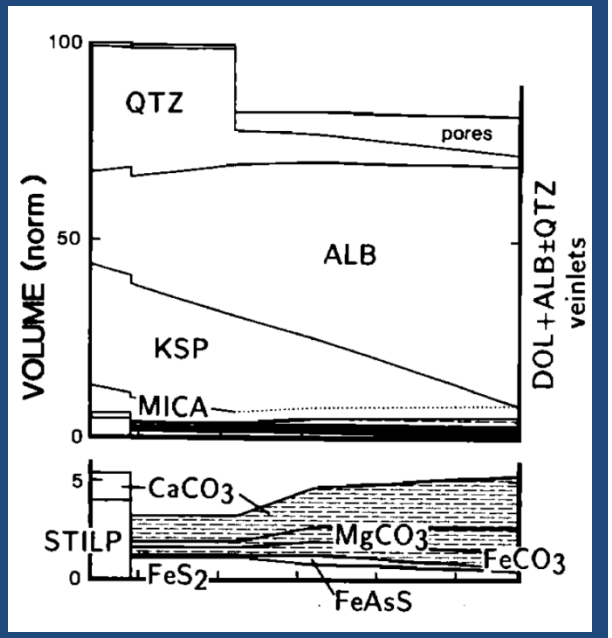
Serpentinite



Amphibolite



Granite



Increasing carbonate metasomatism →

Bőhlke (1989) Economic Geology

Quantitative mineralogy from powder X-ray diffraction (XRD) using whole-pattern matching

Eberl (2003)

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USER'S GUIDE TO ROCKJOCK -- A PROGRAM FOR DETERMINING QUANTITATIVE MINERALOGY FROM POWDER X-RAY DIFFRACTION DATA

Open-File Report 03-78

U.S. Department of the Interior
U.S. Geological Survey

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Combining quantitative mineralogy (XRD) with whole rock chemical data (XRF) to get information on mineral chemistry

Eberl (2008)