Calcareous and Ultramafic Rocks

Reading: Winter Chapter 29

Calcareous Metamorphic Rocks

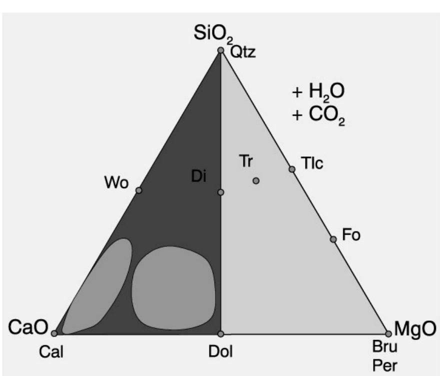
- Calcareous rocks are predominantly carbonates, usually limestone or dolostone
- Typically form in a stable continental shelf environment along a passive margin
- They may be pure carbonate, or they may contain variable amounts of other precipitates (such as chert or hematite) or detrital material (sand, clays, etc.)
- Result when the passive margin becomes part of an orogenic belt

Types of Calcareous Rocks

- Metacarbonates
  - Carbonate component predominates
- Marbles
  - Nearly pure carbonate
- Calc-silicates
  - Carbonate is subordinate
  - They may contain Ca-Mg-Fe-Al silicate minerals
  - Diopside, grossular, Ca-amphiboles, vesuvianite, epidote, wollastonite, etc.

Skarns

- Calc-silicate rocks formed by metasomatism
- Interaction between carbonates and silicate-rich rocks or fluids
- Contact between sedimentary layers
- Contact between carbonate country rocks and a hot, hydrous, silicate intrusion, such as a granite



Chemographics in the CaO-MgO-SiO_2-CO_2-H_2O system. The green shaded areas represent common compositions of limestones and dolostones. Both calcite and dolomite can coexist in carbonate rocks. The left half of the triangle represents metacarbonates. Carbonated ultramafics occupy the right half of the triangle. Winter (2001)

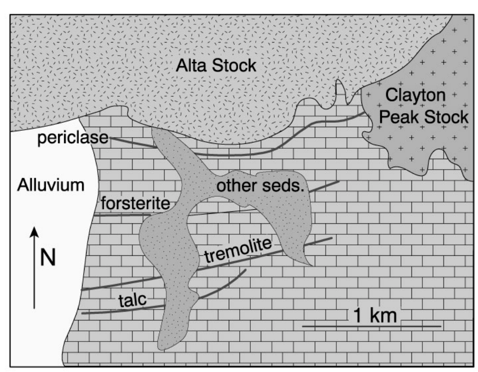
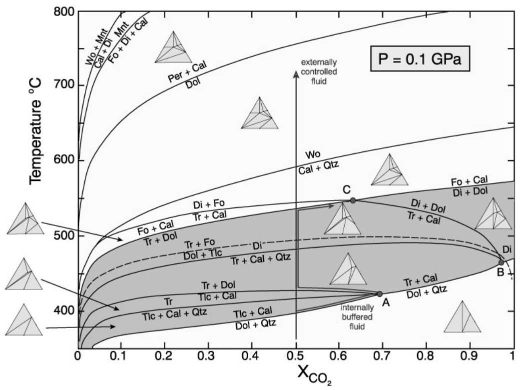
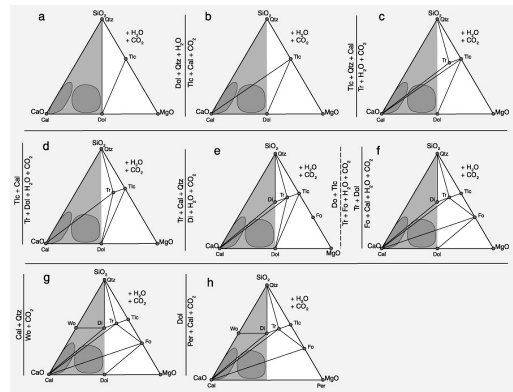


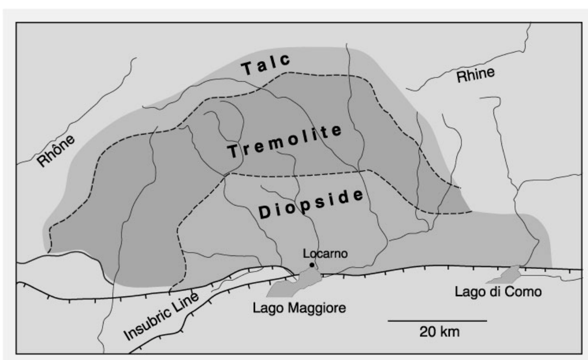
Figure 29-2. A portion of the Alta aureole in Little Cottonwood Canyon, SE of Salt Lake City, UT, where talc, tremolite, forsterite, and periclase isograds were mapped in metacarbonates by Moore and Kerrick (1976) *Amer. J. Sci.*, 276, 502-524.



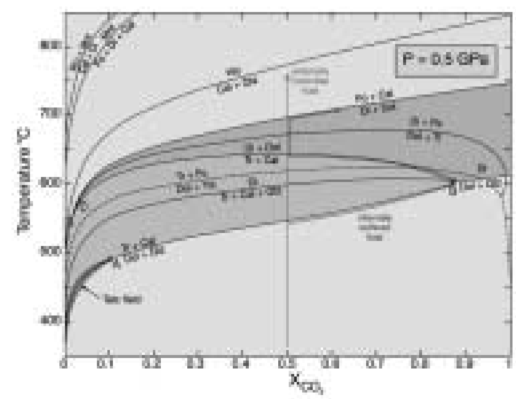
T-X_{CO2} phase diagram for siliceous carbonates at P = 0.1 GPa. The green area is the field in which tremolite is stable, the redish area is the field in which dolomite + diopside is stable, and the blue area is for dolomite + talc. Winter (2001).



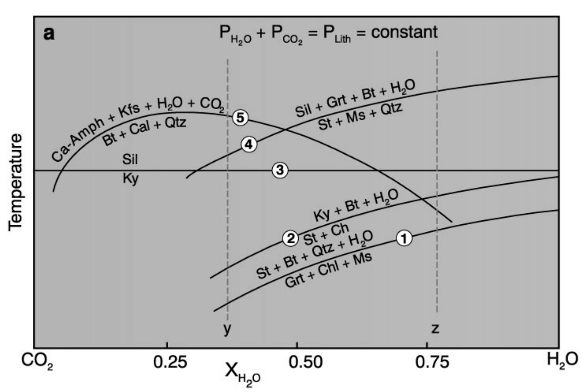
The sequence of CaO-MgO-SiO_2-H_2O-CO_2 compatibility diagrams for metamorphosed siliceous carbonates (shaded half) up metamorphic grade. The dashed isograd requires that tremolite is more abundant than either calcite or quartz. After Spear (1993)



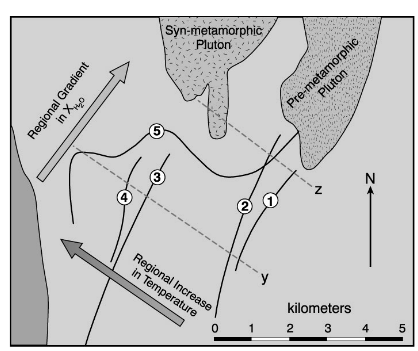
Metamorphic zones developed in regionally metamorphosed dolomitic rocks of the Lepontine Alps, along the Swiss-Italian border. After Trommsdorff (1966). Winter (2001).



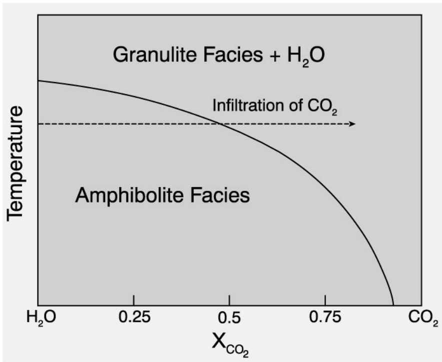
T-X_{CO2} phase diagram for siliceous carbonates at P = 0.5 Gpa. The light-shaded area is the field in which tremolite is stable, the darker shaded areas are the fields in which talc or diopside are stable. Winter (2001).



T-X_{H2O} diagram illustrating the shapes and relative locations of the reactions for the isograds mapped in the Whetstone Lake area. After Carmichael (1970) *J. Petrol.*, 11:147-181.

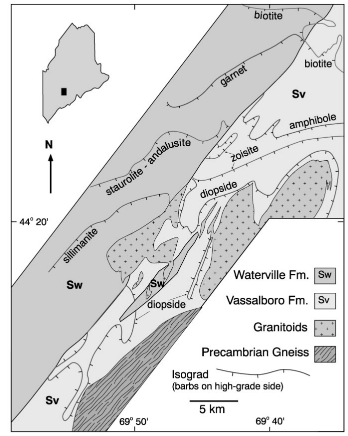


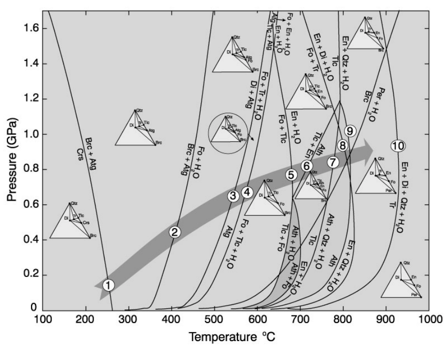
Isograds mapped in the field. Note that isograd (5) crosses the others. This behavior is attributed to infiltration of H_2O from the syn-metamorphic pluton in the area, creating a gradient in X_{H2O} across the area at a high angle to the regional temperature gradient, equivalent to the T-X diagram. After Carmichael (1970) *J. Petrol.*, 11, 147-181.



Schematic T-X_{CO2} diagram illustrating the characteristic shape of typical dehydration reactions, such as those that generate orthopyroxene from hornblende or biotite. Notice that the amphibolite facies to granulite facies can be accomplished by either an increase in temperature or infiltration of CO_2 at a constant temperature. Winter (2001)

Map of isograds in the pelitic Waterville and calcareous Vassalboro formations of south-central Maine. After Ferry (1983) *J. Petrol.*, 24, 343-376.





Petrogenetic grid for water-saturated ultramafic rocks in the system CaO-MgO-SiO_2-H_2O. The green arrow represents a typical medium P/T metamorphic field gradient. The dark blue area represents the stability range of anthophyllite in "normal" ultramafic compositions. The lighter blue area represents the overall stability range of anthophyllite, including more siliceous ultramafic rocks. After Spear (1993).

Ultramafic Metamorphic Rocks

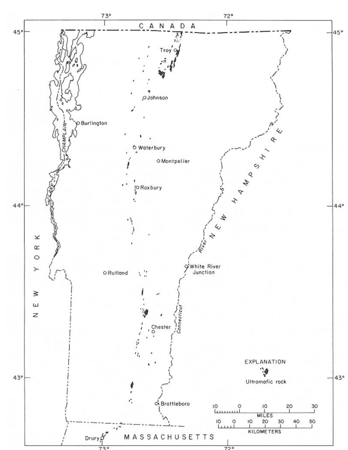
- Alpine peridotites
  - Uppermost mantle = base of slivers of oceanic lithosphere that become incorporated into the continental crust along subduction zones
- Dismembered portions of ophiolites
  - Pieces of oceanic crust and mantle that either separate from the subducting slab and become incorporated into the accretionary wedge of the subduction zone,
  - Or (more commonly) get trapped between two terranes during an accretion event

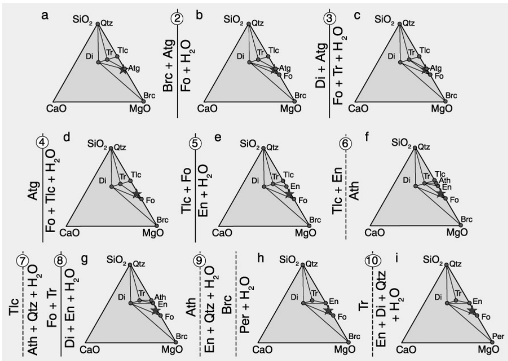
Associations

- Strings of ultramafic bodies in orogens follow major fault zones separating contrasting rock bodies. Interpreted as remnants of oceanic crust + mantle that once separated collisional terranes, and thus mark the suture zone
- Association of blueschist facies rocks with the ultramafics further supports a subduction-related origin

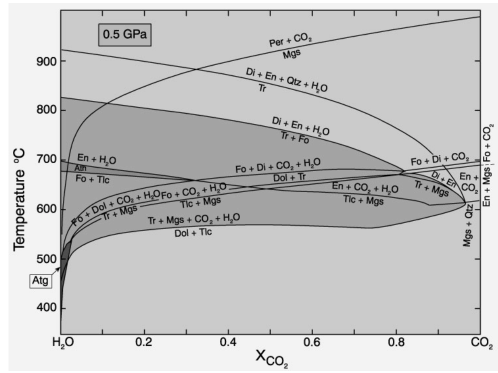
Ultramafic Bodies in Vermont

Chain indicating a suture zone of the Ordovician Taconic Orogeny. The ultramafics mark a closed oceanic basin between North American rocks and an accreted island arc terrane. From Chidester, (1968) in Zen et al., *Studies in Appalachian Geology, Northern and Maritime.* Wiley Interscience.





Chemographics of ultramafic rocks in the CMS-H system (projected from H_2O) showing the stable mineral assemblages (in the presence of excess H_2O) and changes in topology due to reactions along a medium P/T metamorphic field gradient. The star represents the composition of a typical mantle lherzolite. After Spear (1993).



T-X_{CO2} phase diagram for the system CaO-MgO-SiO_2-H_2O-CO_2 at 0.5 Gpa. Focuses on ultramafic-carbonate rocks. Shaded fields represent the stability ranges of serpentine-antigorite (purple), anthophyllite in low-SiO_2 ultramafics (blue), and tremolite in low-SiO_2 ultramafics (green). Winter (2001).