

MINERAL ASSEMBLAGES, ISOGRADS, AND CONTACT METAMORPHISM

Objective

As we have discussed in class and in lab, equilibrium mineral assemblages (coexisting minerals) in metamorphic rocks reveal important information about the pressure, temperature, and fluid conditions under which metamorphism took place. Data from numerous sets of related rocks can be used to determine the tectonic and deformational history of a region. The purpose of this exercise is to use simplified field data to map metamorphic isograds, determine mineral assemblages, and estimate conditions of metamorphism. This activity was adapted from *An Isograd and Mixed-Volatile Exercise using data from the Ubehebe Peak Contact Aureole* by William H. Peck and Gregory T. Roselle, and is available at:

http://serc.carleton.edu/NAGTWorkshops/petrology/teaching_examples/2331.html.

Contact Metamorphism - Introduction

Contact metamorphism occurs when heat and/or fluids from an igneous body alter the surrounding rock. Under the right conditions, an **aureole** of metamorphosed country rock surrounds the igneous intrusion, with metamorphic grade increasing toward the igneous body. The assemblages of minerals that develop in the metamorphosed country rock depend on the rock's starting composition as well as the heat and/or fluid conditions.

In this problem set you will be looking at contact metamorphism of siliceous dolomites caused by intrusion of the 173 Ma Ubehebe Peak quartz monzonite in Death Valley National Park. The aureole has affected three rock units (the Paleozoic-aged Lost Burro Formation, Hidden Valley Dolomite, and the Ely Springs Formation), providing an ideal situation in which to examine the role of fluids and temperature during contact metamorphism. Although metasomatic fluids played an important role during metamorphosis, we will concentrate on understanding the changes in mineral assemblages resulting from heating by the magmatic intrusion.

Problems

1. On the geologic map, draw in the isograds that represent changes between mineral assemblages. Do this by noting the first appearance of new minerals as you approach the intrusion. You should end up with three isograds separating four distinct zones of metamorphism. [Hint: lump together the open and closed circles into a single zone; also lump together the open and closed triangles into a single zone].
2. On the page of phase diagrams, draw tie lines between coexisting mineral phases for each of the four zones (A-D). Color in the area represented by the equilibrium assemblage for each phase.
3. On the bottom phase diagram, determine the bulk composition of the source rock. [Hint: identify a region in which all four equilibrium assemblages A-D overlap]. Note that to do this, we have to assume that there is no exchange of fluids (metasomatism) between the igneous intrusion and country rock.

4. Write a general reaction for each of the isograds that distinguishes changes in the mineral assemblage between metamorphic zones. Think about which minerals are consumed and produced during the reaction, and how the tie lines are changing on the phase diagrams.

Mineral Reaction Zone A to Zone B:

Mineral Reaction Zone B to Zone C:

Mineral Reaction Zone C to Zone D:

5. Use the attached petrogenetic grid for carbonate rocks to determine the approximate temperatures at which the mineral reactions that characterize the transition between each zone took place. Assume that the depth of the intrusion is shallow, so therefore the pressure is around 1 Kb. Note that the reactions in the grid include the mineral Di (Diopside) rather than tremolite. Since we do not have any diopside in our rocks, and since these minerals plot close to one another on the ternary diagram, you can substitute tremolite for diopside on the graph.

Approx. Temperature Zone A to Zone B:

Approx. Temperature Zone B to Zone C:

Approx. Temperature Zone C to Zone D:

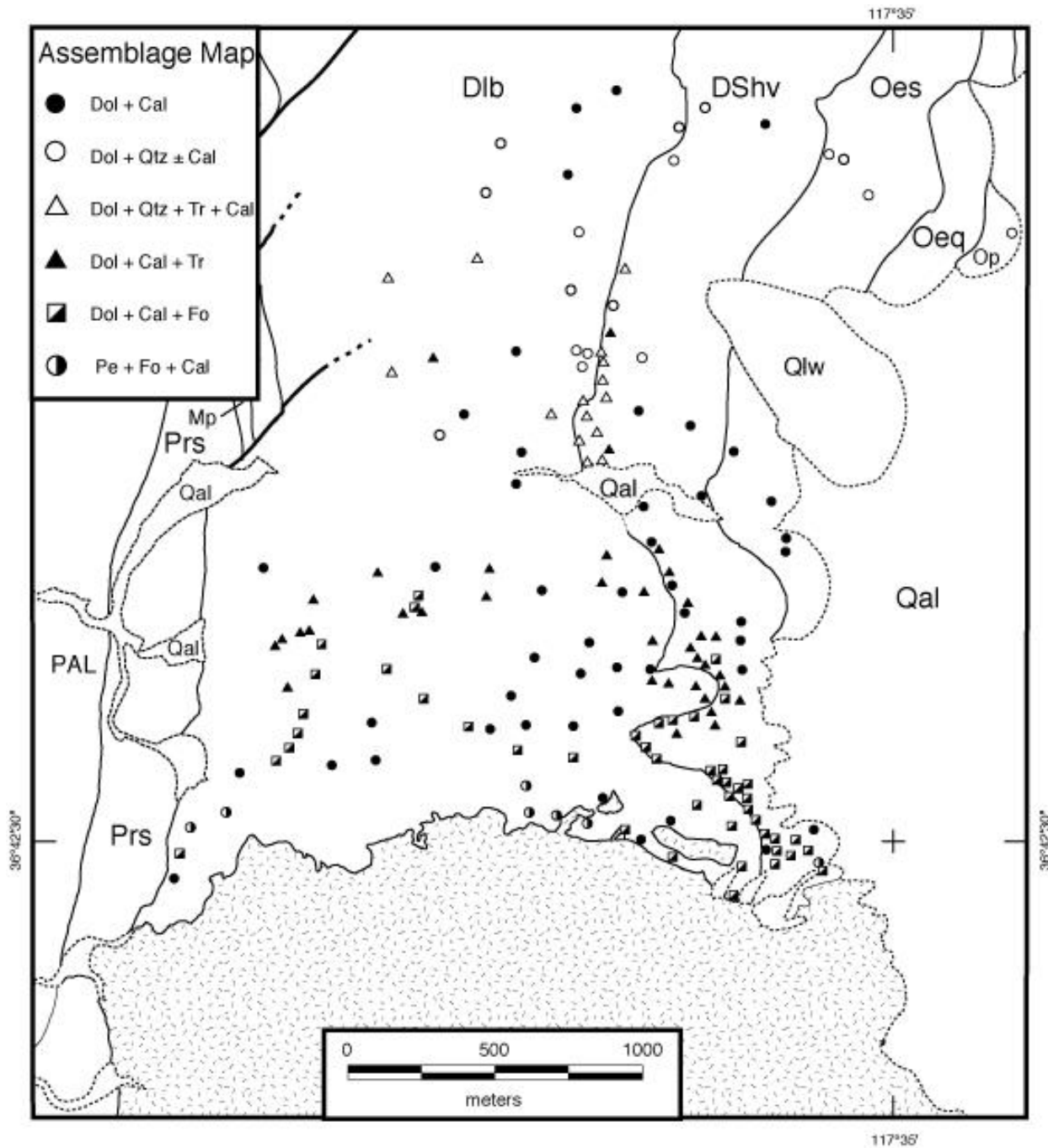
6. Use the metamorphic facies diagram to determine the facies to which each of the zones in the contact aureole belongs.

Facies of Zone A:

Facies of Zone B:

Facies of Zone C:

Facies of Zone D:



Simplified from Roselle, 1997

Abbreviations:

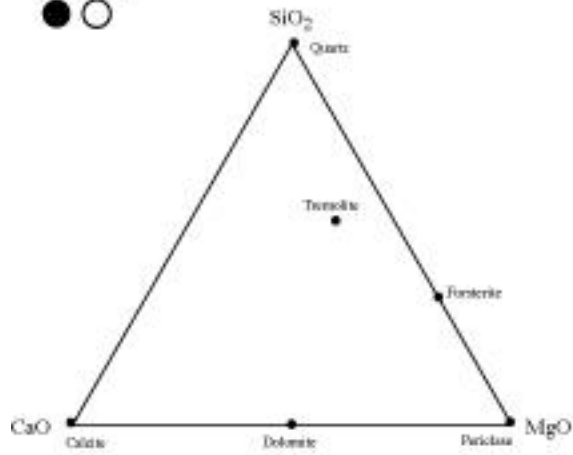
Rock Units affected by contact metamorphism:

- Dlb = Lost Burro Formation
- DShv = Hidden Valley Dolomite
- Oes = Ely Springs Formation

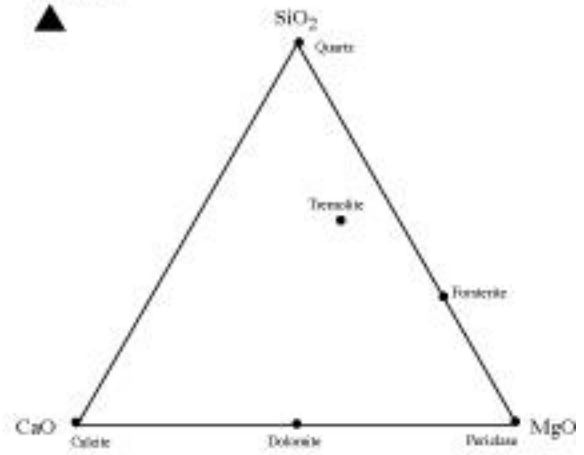
Minerals:

- Dol = dolomite
- Cal = calcite
- Qtz = quartz
- Tr = tremolite (amphibole)
- Fo = forsterite (olivine)
- Pe = periclase (MgO)

Zone A.



Zone B.



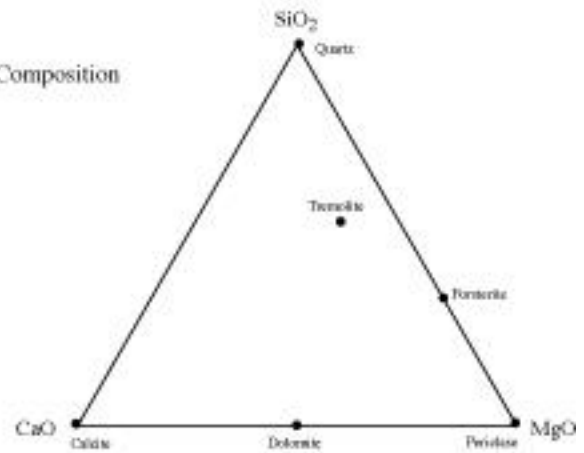
Zone C.

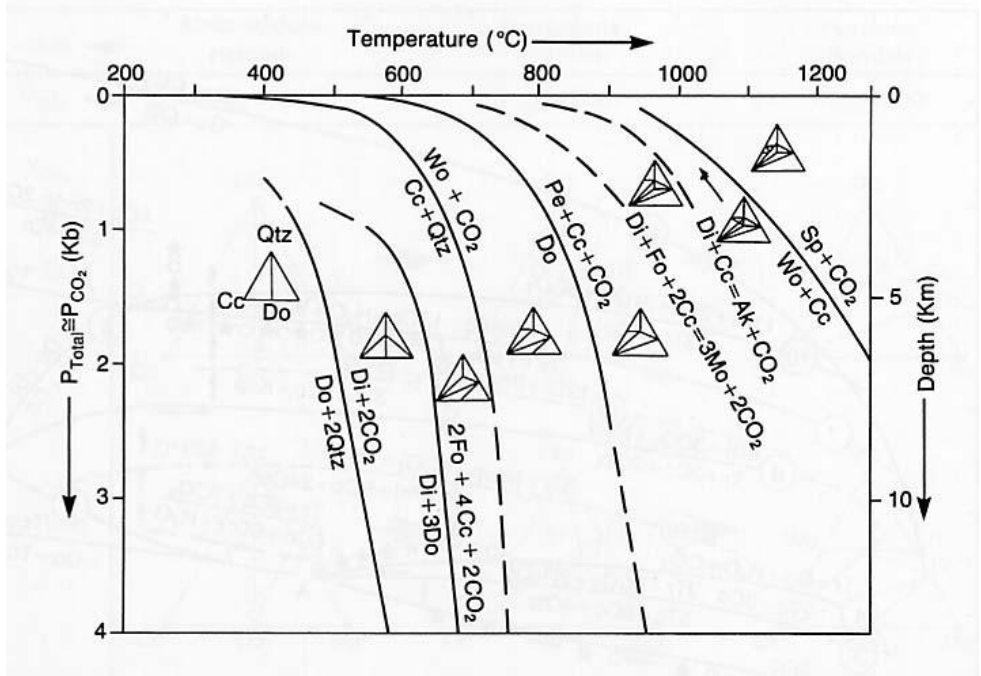


Zone D.



Bulk Composition





From Raymond, 1995, p. 541

Abbreviations:

- | | | |
|--------------------------------------|-------------------|-----------------|
| Qtz = quartz | Cc = calcite | Do = dolomite |
| Di = diopside (substitute tremolite) | Pe = periclase | Fo = forsterite |
| Wo = wollastonite | Mo = monticellite | |
| Ak = akermanite | Sp = spurrite | |

