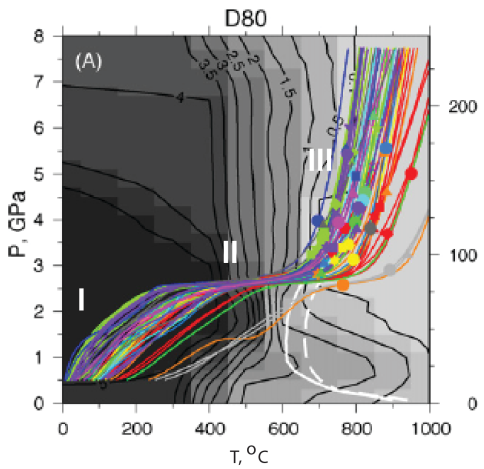
# What P-T conditions do rocks experience inside a subduction zone?

This exercise allows students to examine the pressure-temperature conditions predicted by thermal modeling in a scientific study funded by the NSF-MARGINS initiative (Syracuse et al., 2010) in order to understand the factors that affect the predicted pressures and temperatures within a subduction zone. The exercise allows students to compare the P-T paths predicted by thermal modeling with P-T paths determined from thermodynamic constraints provided by subduction-related metamorphic rocks in another scientific study (Page et al., 2007).

**Instructions:**

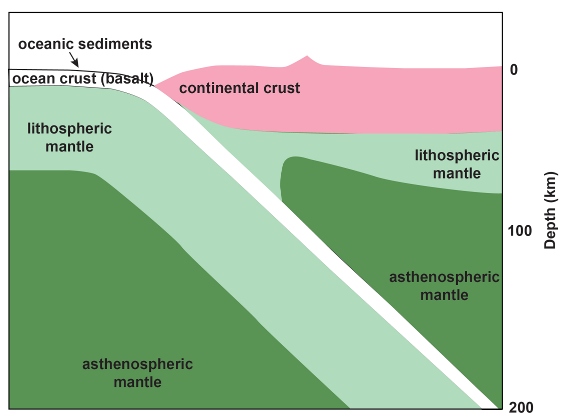
**A. P-T PATHS PREDICTED BY MODELING** - Read Syracuse et al. (2010) focusing on the "Introduction" and "Case descriptions" in the "Results" sections. Answer the following questions. Note: 1 GPa corresponds to a depth of about 33 km.



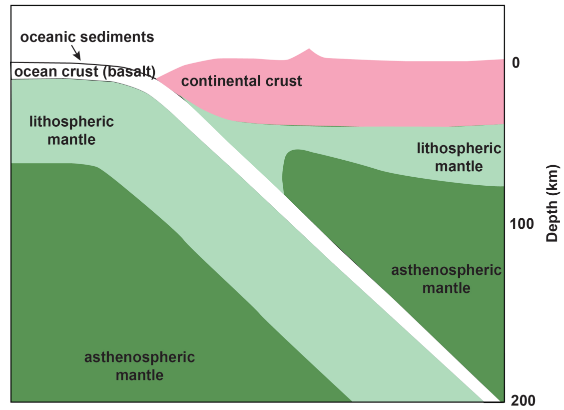

Look at Figure 6a, "D80" from Syracuse et al. (2010) which is reproduced to the left.

The curves in this diagram represent P-T conditions modeled for rocks on the top of a subducting slab. Each curve can be divided into three different parts. Part I is the left-most part of the curves where P < 2.5 GPa. Part II is the middle part of the curve that is relatively flat. Part III is the right-most part of the curves where P > 2.5 GPa.

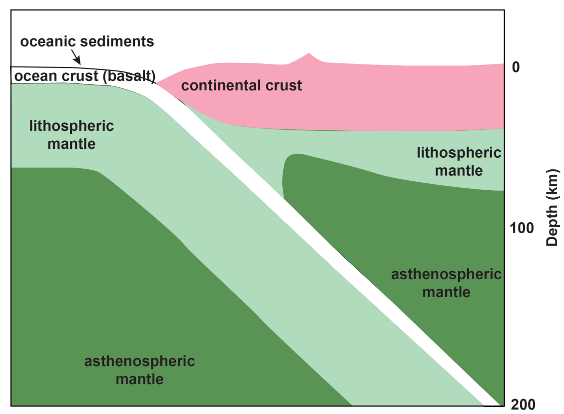
1. Which part of a subducting slab does Part I of the curve correspond to? On the subduction cross-section to the right, color in the region on the subducting slab that you think corresponds to Part I. What is happening in the subducting slab that results in the somewhat steep slopes in Part I of the curve?

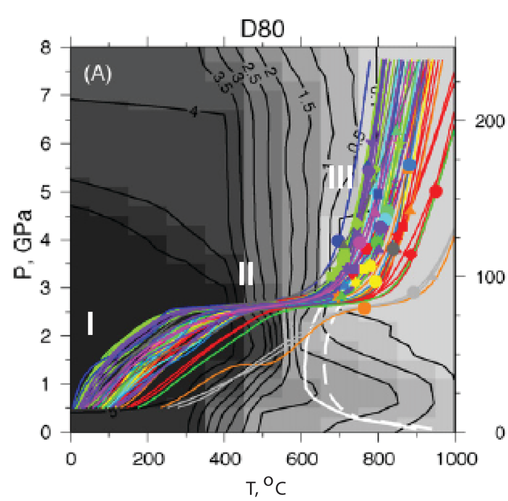


2. Which part of a subducting slab does Part II of the curve correspond to? On the subduction cross-section to the right, color in the region on the subducting slab that you think corresponds to Part II. What is happening in the subducting slab that results in the flat slopes in Part II of the curve?




3. Which part of a subducting slab does Part III of the curve correspond to? On the subduction cross-section to the right, color in the region on the subducting slab that you think corresponds to Part III. What is happening in the subducting slab that results in the steep slopes in Part III of the curve?




4a. The different colored curves represent the P-T conditions predicted for different subduction zones. Compare the P-T conditions predicted for the Izu subduction zone (yellow-green with the diamond symbol) to the P-T conditions predicted for Central Cascadia (gray circle) on Figure 6a (to the left). How are they different?

4b. How are the input parameters used for the modeling of these two subduction zones in Table 2 of Syracuse et al. (2010) different?

4c. Speculate about which parameters might be responsible for producing the differences in P-T conditions predicted for these two subduction systems.

**B. P-T CONDITIONS RECORDED BY ROCKS** - Read Page et al. (2007) focusing on the "Thermobarometry" section.

5. What mineral reactions in Page et al. (2007) are used to constrain the P-T path of the Junction School eclogite? There are four mineral reactions involved in Figure 9a – what are they?

| | Write out mineral reaction |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

6. For each reaction above determine whether it is a continuous or discontinuous reaction. Also determine whether it more closely resembles a geobarometer or geothermometer.

| | Continuous/discontinuous? | Geobarometer/thermometer? |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

7. In Figure 9b the data points are in pairs connected by dashed lines. Why are there pairs of data points? What does each pair represent?

8. What other mineral reactions in Page et al. (2007) are used to constrain the P-T path of the Junction School eclogite? There are three mineral reactions involved in Figure 9b (one is the same reaction as used in Figure 9a) – what are they?

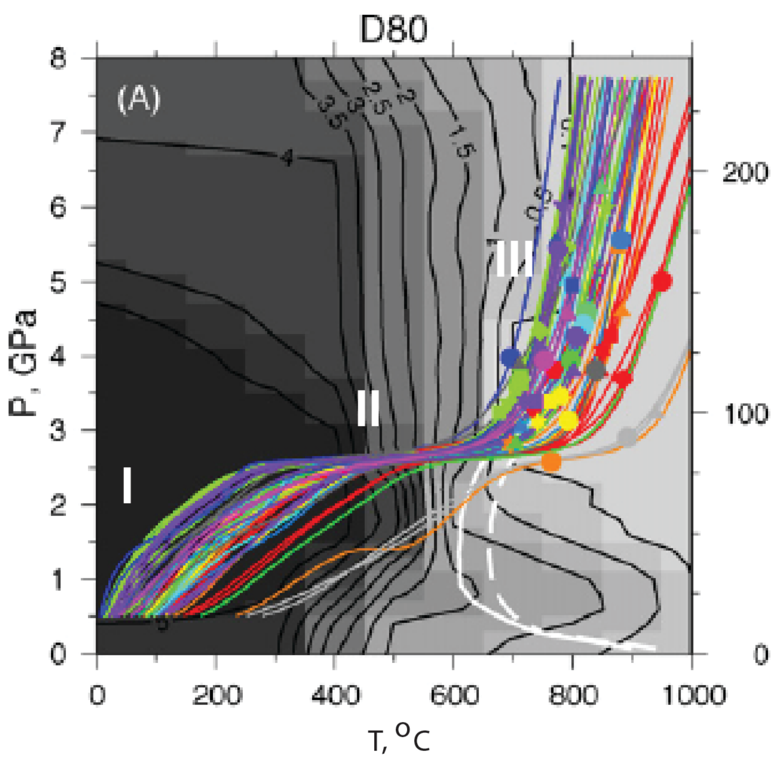
| | Write out mineral reaction |
|---|---|
| 1 | |
| 2 | |
| 3 | |

9. For each reaction above determine whether it is a continuous or discontinuous reaction. Also determine whether it more closely resembles a geobarometer or geothermometer.

| | Continuous/discontinuous? | Geobarometer/thermometer? |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

10. The authors use mineral compositions obtained from garnet cores, mantles and rims in Figure 9b as a proxy for time. Which would represent the earliest? middle? latest? Why?

11. The authors put their geothermobarometry estimates together in Figure 10. The thick gray arrow represents their interpretation for the P-T path the Junction School eclogite experienced while in the subduction zone. Sketch this P-T path on top of the P-T paths predicted in Syracuse et al. (2010), Figure 6a below.



12. Answer the following questions about this comparison.
a) Do the P-T conditions estimated by Page et al. (2007) for the ancient subduction zone associated with the Franciscan Complex overlap with any of those predicted by the thermal modeling in Syracuse et al. (2010)?

b) If they do, which of the subduction zones modeled most closely match the P-T conditions estimated for this rock. If they don't why do you think they do not?

c) What inferences can you make about the ancient subduction zone associated with the Franciscan Complex? Can you make any inferences about the age of the subducting slab? Its descent rate? Its slab dip? Are there any other factors that you think might affect the P-T history of rocks inside a subduction zone?

Resources:
Page, F.Z., Armstrong, L.S., Essene, E.J., and Mukasa, S.B, 2007, Prograde and retrograde history of the Junction School eclogite, California, and an evaluation of garnet-phengite-clinopyroxene thermobarometry, Contributions to Mineralogy and Petrology, 153, 533-555.

Syracuse, E.M., van Keken, P.E., and Abers, G.A., 2010, The global range of subduction zone thermal models, Physics of the Earth and Planetary Interiors, 183, 73-90.