Comparing Metamorphic Conditions of Catalina Schist Rocks with Zirconium-in-Rutile Thermometry

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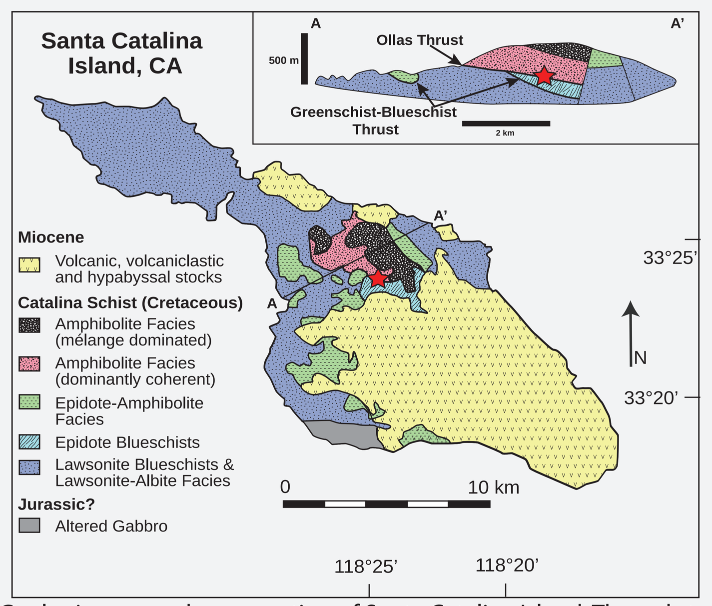
Introduction



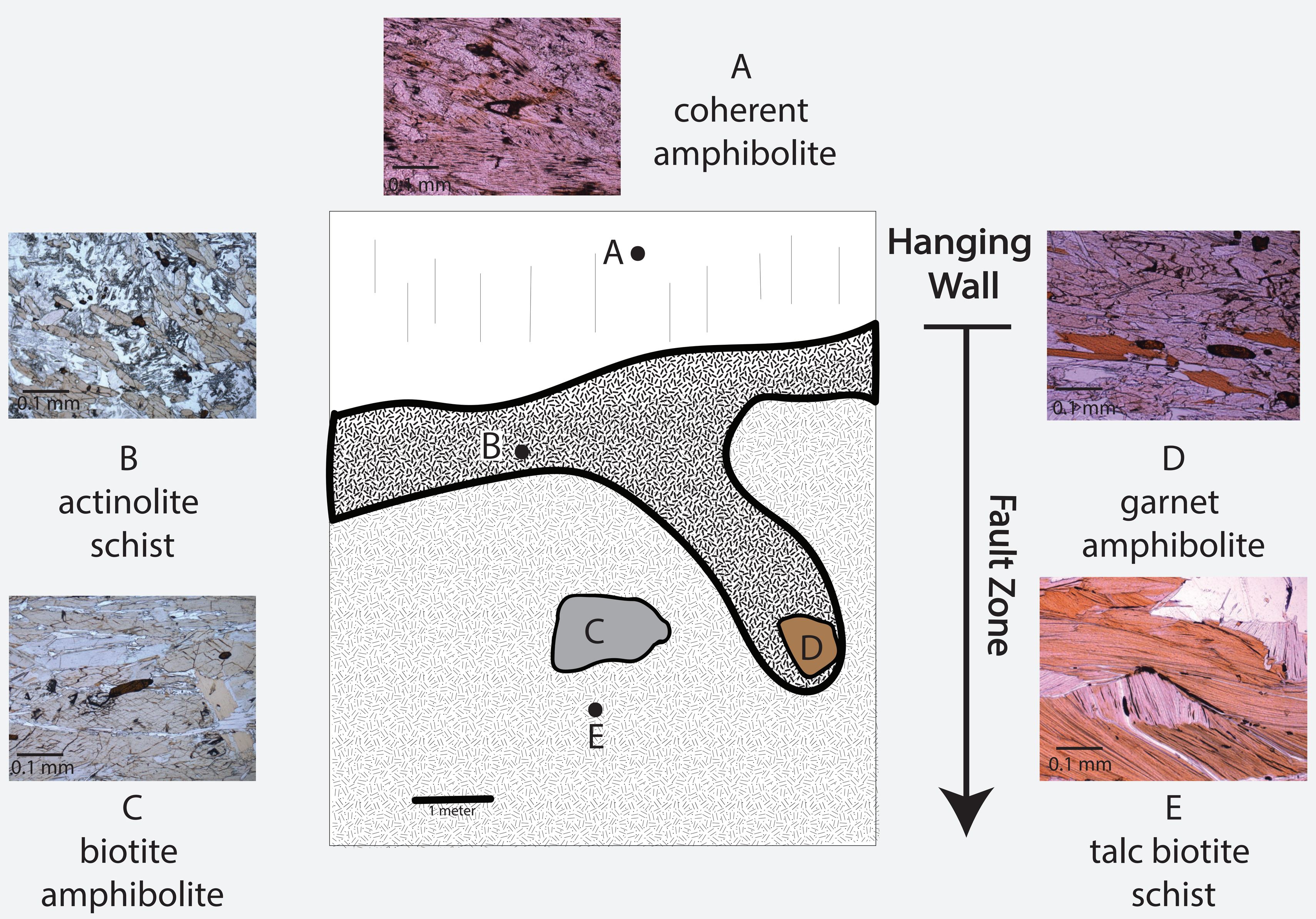
Geologic map and cross section of Santa Catalina Island. The red star represents the locality where samples were collected. Adapted from Penniston-Dorland et al. (2018)

- Catalina Schist is an exhumed paleosubduction zone located on Santa Catalina Island, California
- A previous study from a several kilometers-wide amphibolite facies mélange zone of the Catalina Schist supports the idea that blocks move independently of each other during subduction (Penniston-Dorland et al. 2018)
- Ollas fault zone is narrower than the amphibolite mélange of the Catalina Schist with an upper estimated width of 138 meters

- Material is broken off from subducting slab and overriding plate during subduction and carried further down into the subduction zone
- Material is subducted and uplifted, having recorded some information in the form of metamorphic changes about the convoluted path it took
- Grade of metamorphism experienced depends on how deep material was subducted
- Paleosubduction zones provide a chance to analyze samples that have been uplifted in old subduction zones.

Block-in-matrix structure of Ollas fault zone.

Samples

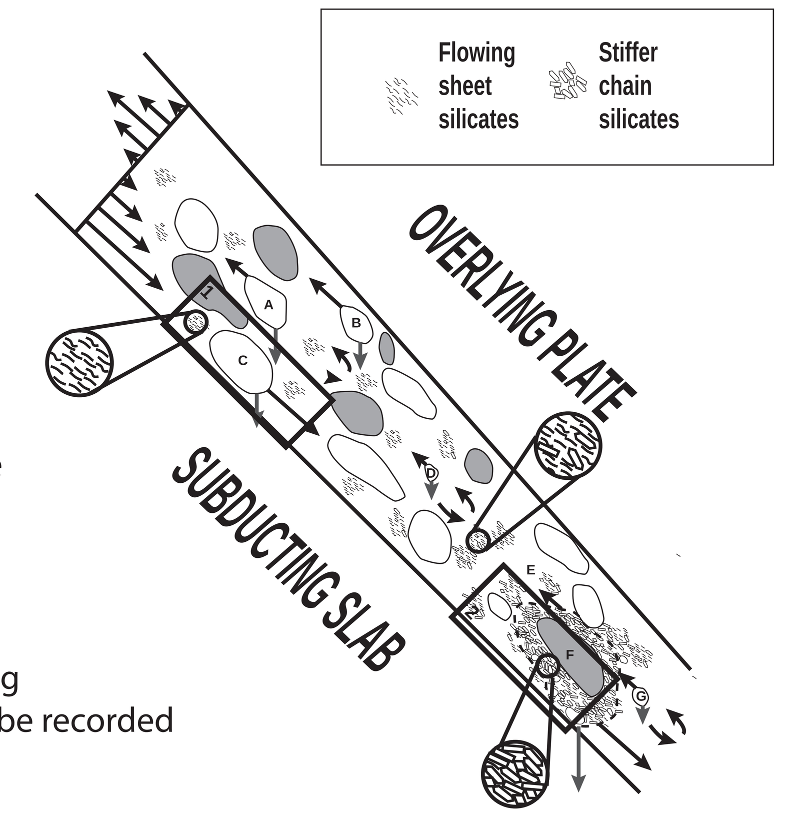


The location of the samples from above and within the fault zones, represented by photomicrographs in plane polarized light with 10x magnification

Hypothesis

- Two possible models for block movement: everything moves togeher or blocks experience differential transport
- If everything moves together, blocks could have similar peak temperatures, indicating all samples were metamorphosed at the same depth
- If blocks experience differential transport, blocks could have different peak temperatures, indicating that blocks reached different depths

- I predict tectonic mixing occurred with samples experiencing differential transport; therefore, different temperatures will be recorded

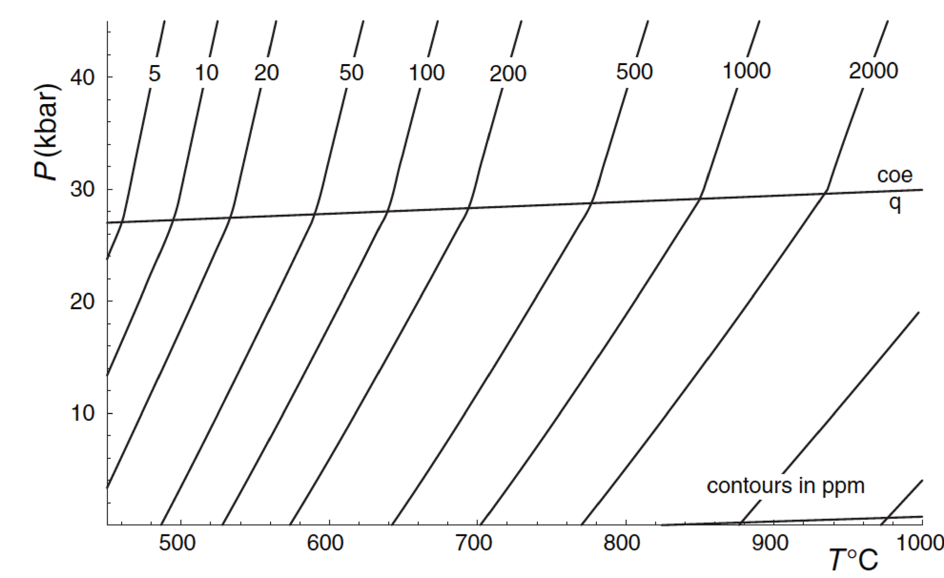


A model of mixing in a fault zone
Adapted from Penniston-Dorland et al. (2018)

Methods

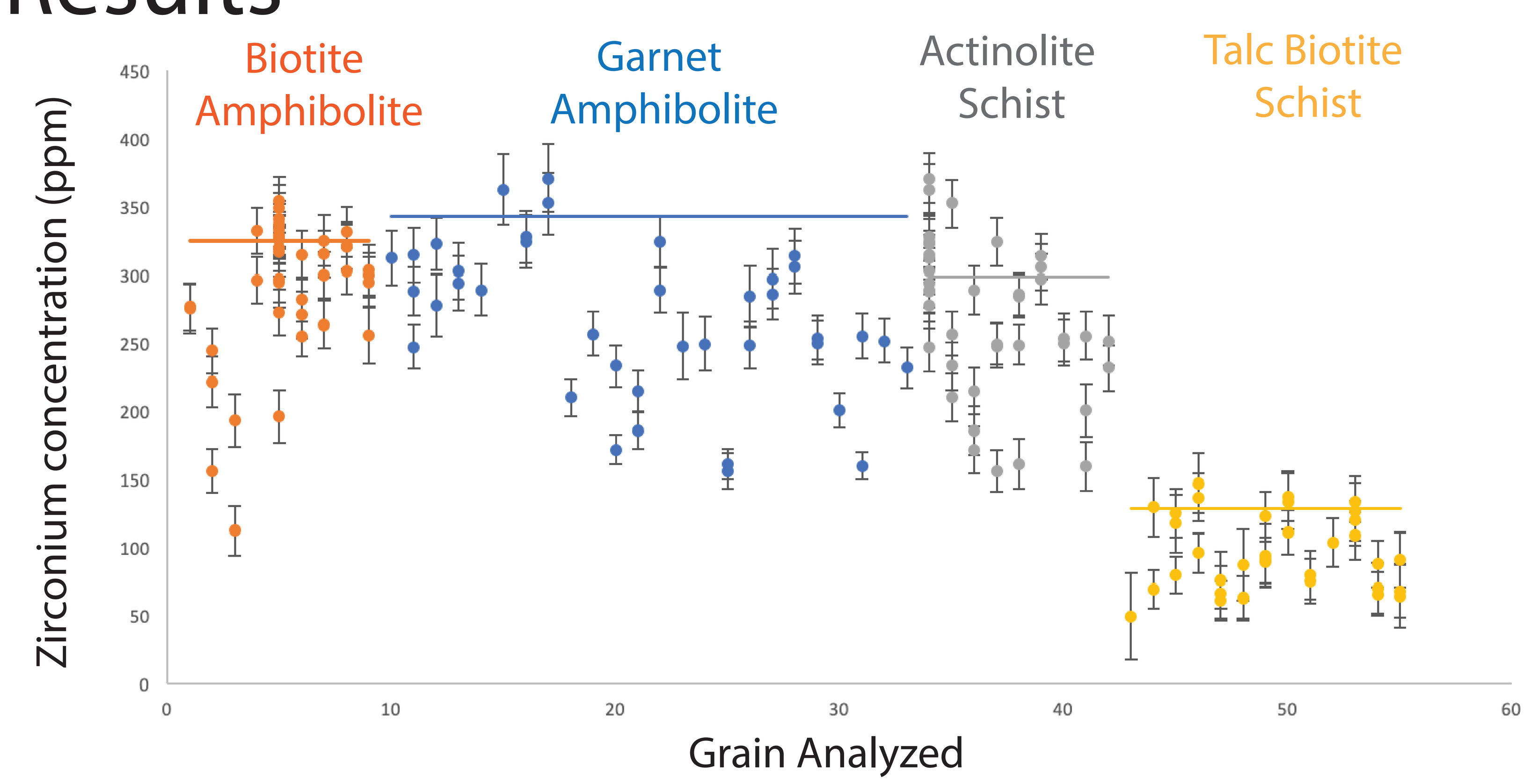
- Used EPMA to analyze samples with rutile (coherent amphibolite, actinolite schist, biotite amphibolite, garnet amphibolite, talc biotite schist)
- Coherent amphibolite, quartzite, and grayschist samples did not contain rutile

Zr-in-Rutile Thermometer (Tomkins et al. 2007)



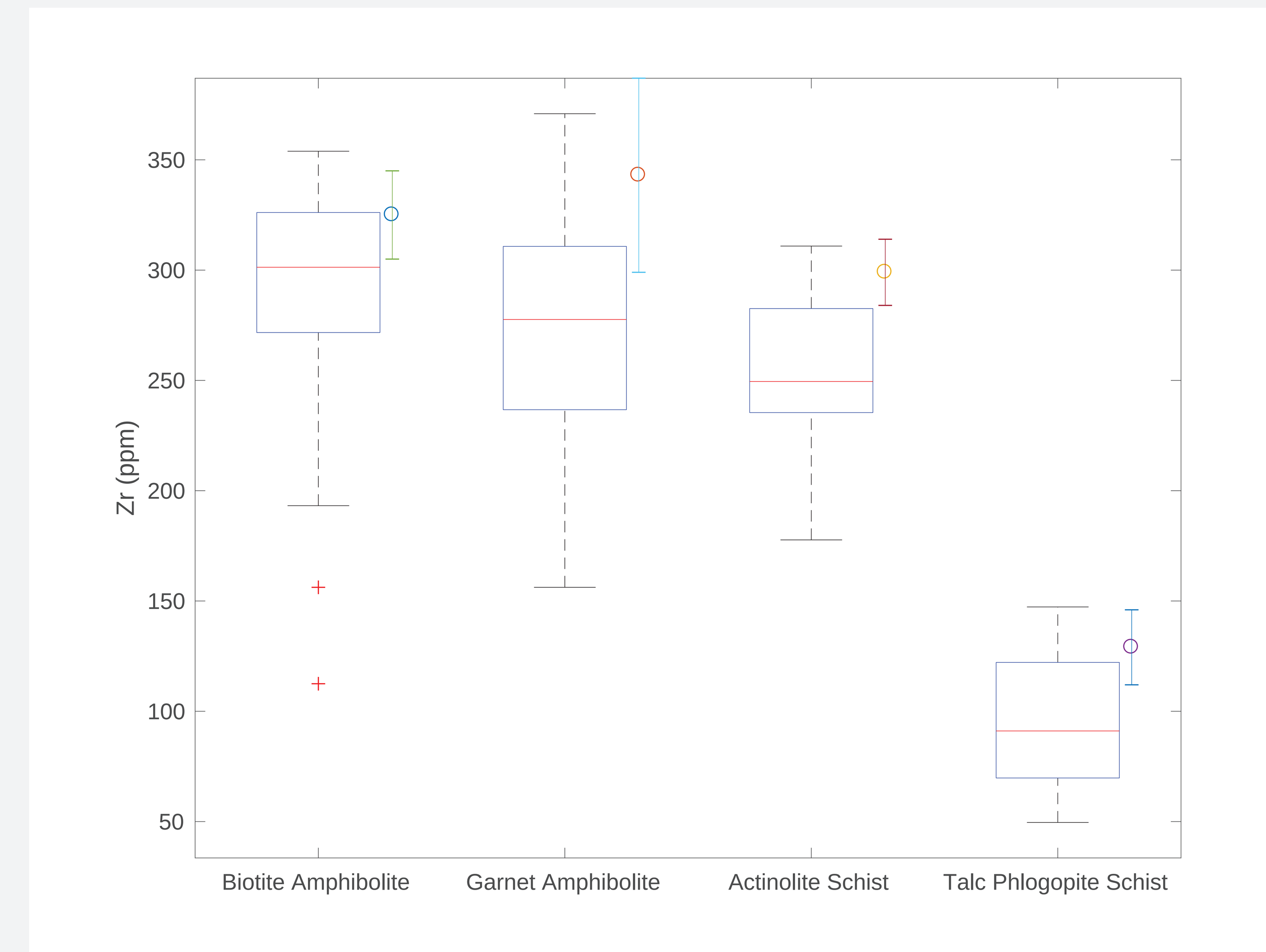
The calibration of the Zirconium-in-Rutile geothermometer by Tomkins et al. 2007. The geothermometer has a pressure dependence of about 4 degrees C per 0.1 GPa (Penniston-Dorland et al. 2018).

Results



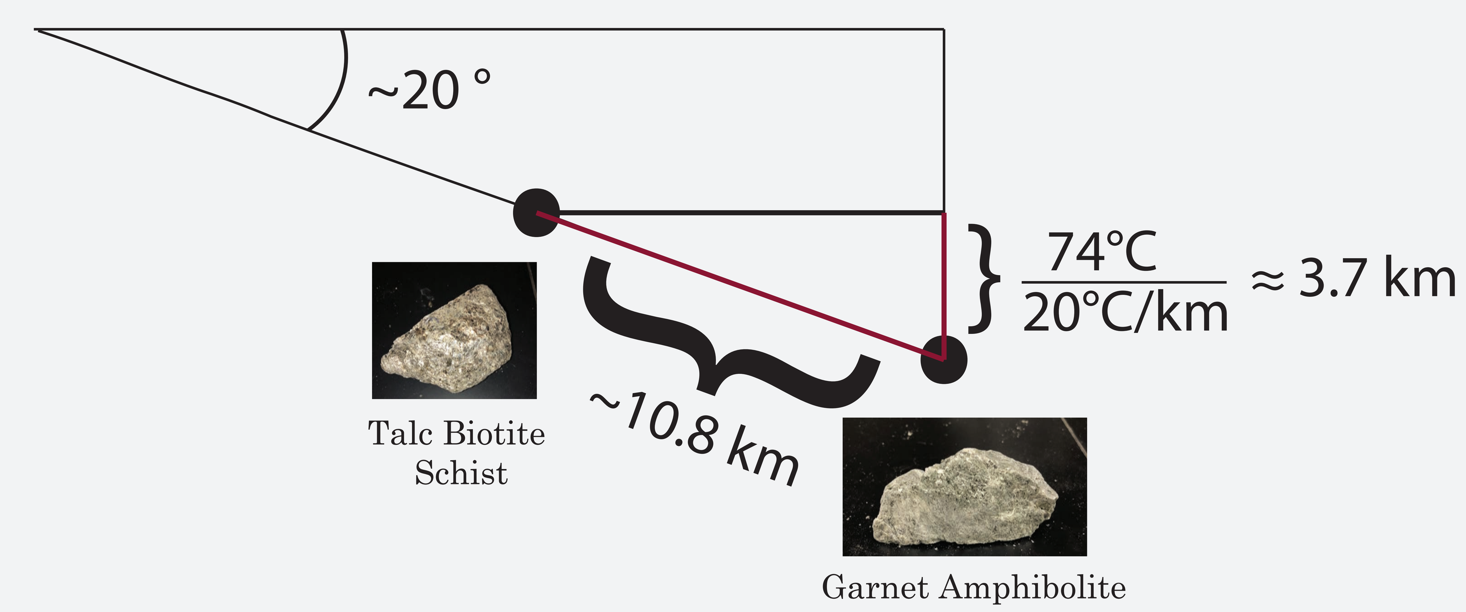
Graph with concentrations of zirconium for each grain plotted. Horizontal bars indicate the mean-maximum zirconium concetration for each sample. Error bars represent 2 sigma uncertainty.

Results



Box and whisker plot displaying the range of zirconium-in-rutile concentrations for each sample. Circles represent the mean-maximum zirconium concentration for each sample with 2 sigma uncertainty.

Discussion



The scale of mixing between two samples from the Ollas fault zone displaying a difference in peak metamorphic temperatures of 74°C , assuming a subduction angle of approximately 20 degrees (Penniston-Dorland 2018), a temperature gradient of 20 Celsius per kilometer (Sorensen and Barton 1987), and a pressure of 1 GPa.

- In the km-scale mélange zone the scale of mixing was 11.7 kilometers (Penniston-Dorland et al. 2018)
- The Ollas fault zone is an order of magnitude smaller, but still displays a similar scale of mixing
- The samples experienced differential transport, supporting my hypothesis

References

Penniston-Dorland, S.C; Kohn, M. J; and Piccoli, P. M. 2018. A mélange of subduction temperatures: Evidence from Zr-in-rutile thermometry for strengthening of the subduction interface, Earth and Planetary Science Letters, 482, 525-535. 10.1016/j.epsl.2017.11.005
Sorenson, S.S., and Barton, M.D., 1987. Metasomatism and partial melting in a subduction complex: Catalina Schist, southern California. Geology, 15:115-118.
Tomkins, H. S., Powell, R. and Ellis, D. J. 2007. The pressure dependence of the zirconium-in-rutile thermometer. Journal of Metamorphic Geology, 25: 703-713. doi:10.1111/j.1525-1314.2007.00724.x