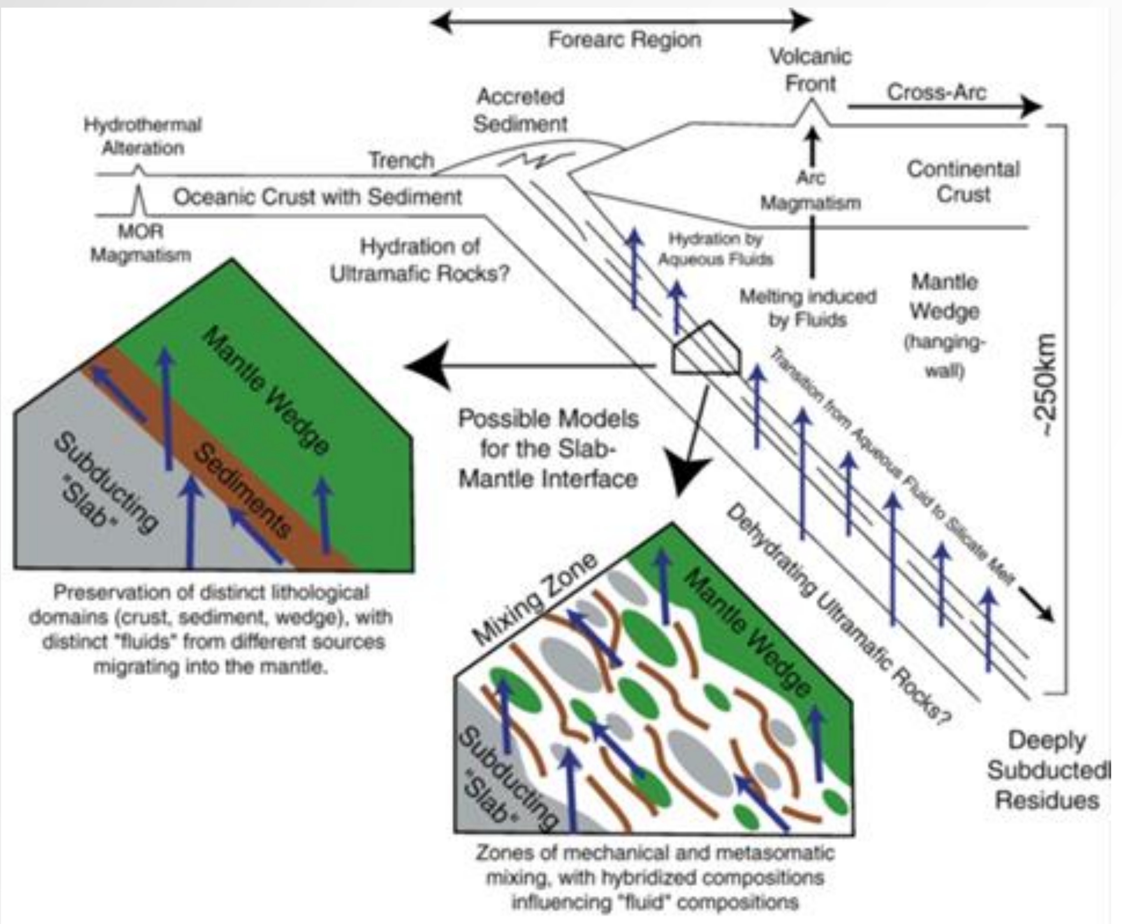
Zirconium in Rutile Geothermometry: Peak Temperature Determination in the Catalina Schist

Geol 394 By Steven Noll Advisors: Dr. Sarah Penniston-Dorland and Dr. Phil Piccoli

Background



Bebout (2007)

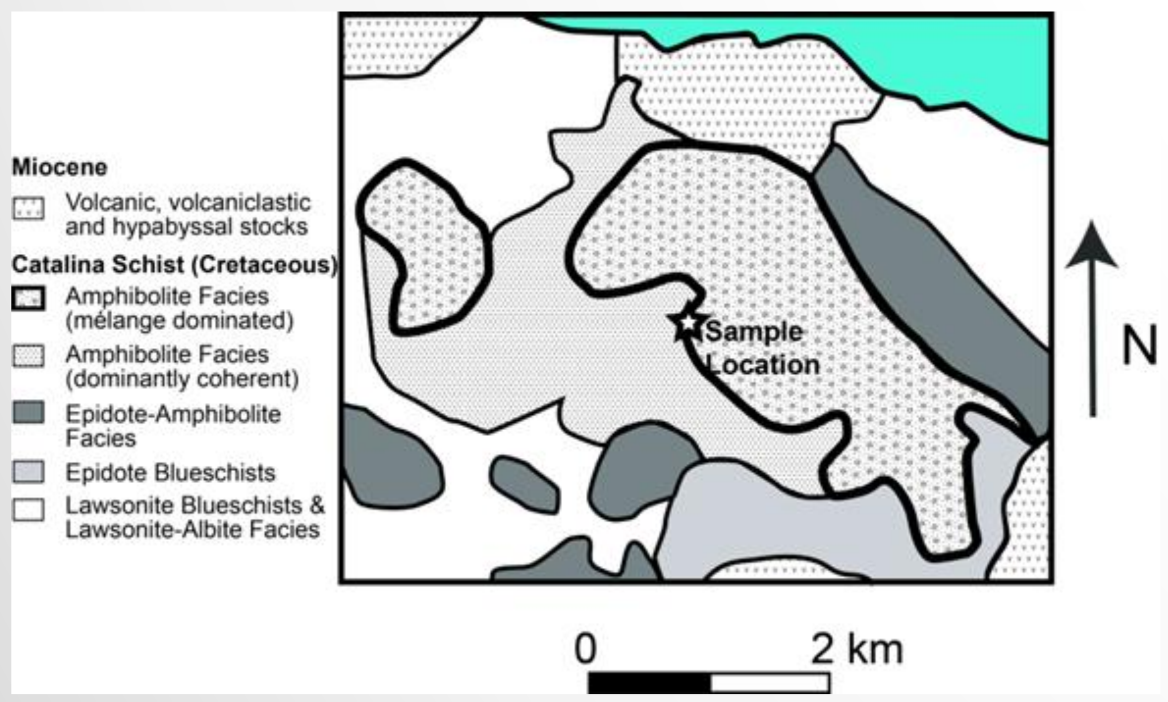
- Two models for subduction zones are illustrated
- Rocks can move as a coherent package (left) or as a mixed package (right)
- Using zirconium in rutile geothermometer to approximate temperatures of formation for rocks to support endmember model

Primary Goals

- Determining peak zirconium concentrations in rutile
- Calculating peak temperatures of formation based off of the zirconium concentrations in rutile
- Comparing zirconium concentrations between rock samples to determine if there is differences in zirconium concentrations outside of uncertainty

Hypothesis:

- Zirconium content of samples will be significantly different from each other (outside of uncertainty)

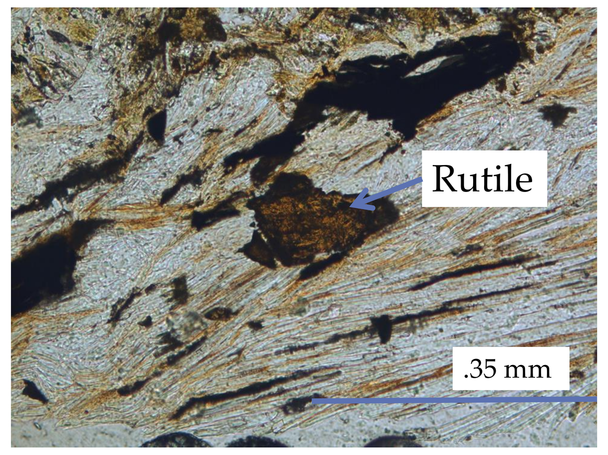


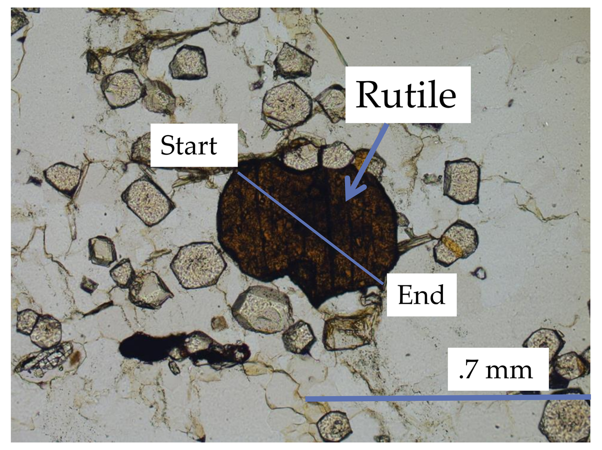
Location of samples in the Catalina Schist marked by a star. (Dr. Sarah Penniston-Dorland)

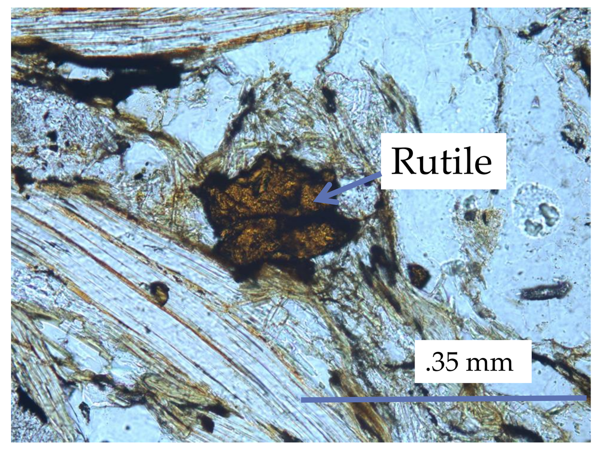
Methods

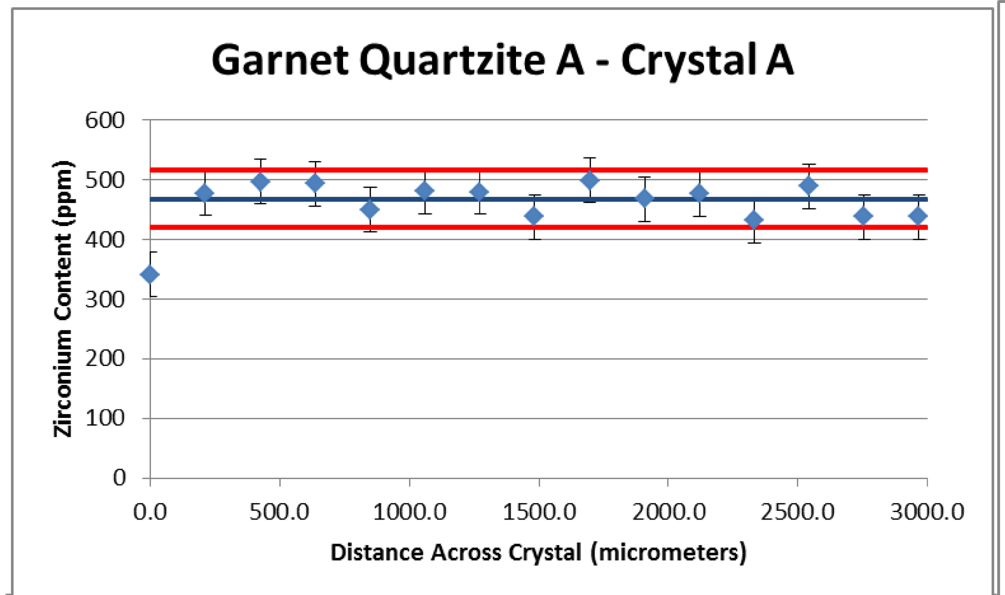
- Used petrographic microscope to map rutiles
- Used Electron Probe Microanalyzer to determine zirconium concentrations
- Used zirconium in rutile geothermometer as calibrated by Tomkins et al (2007)
- Used 10 kbar calibration for temperature calculations

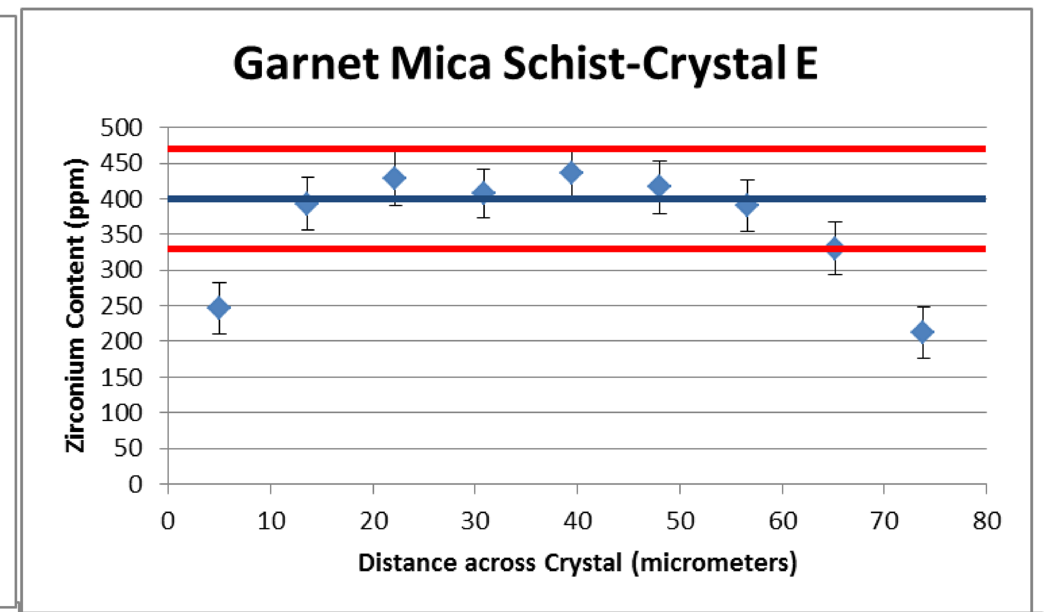
Data and Results

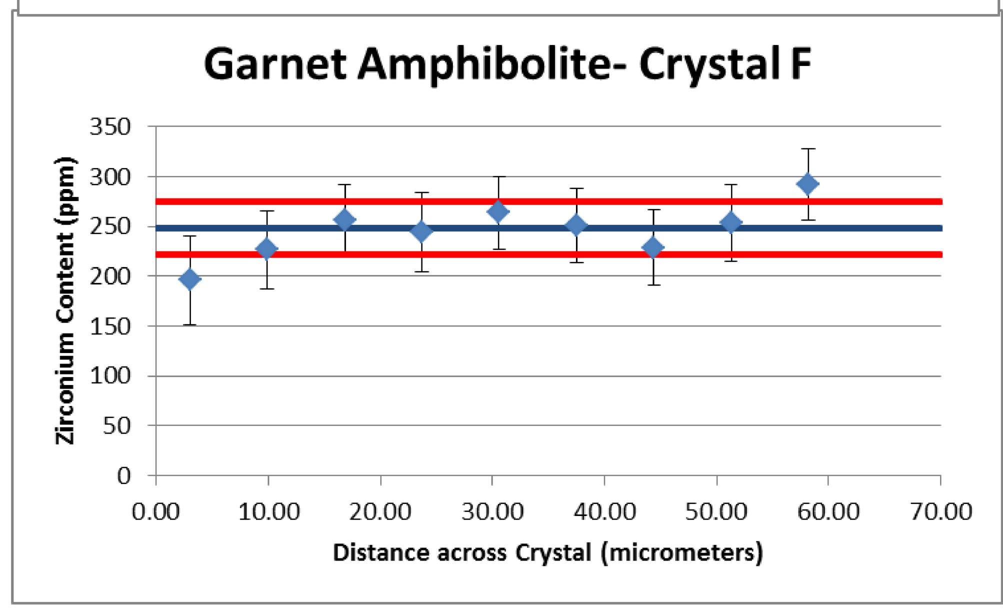


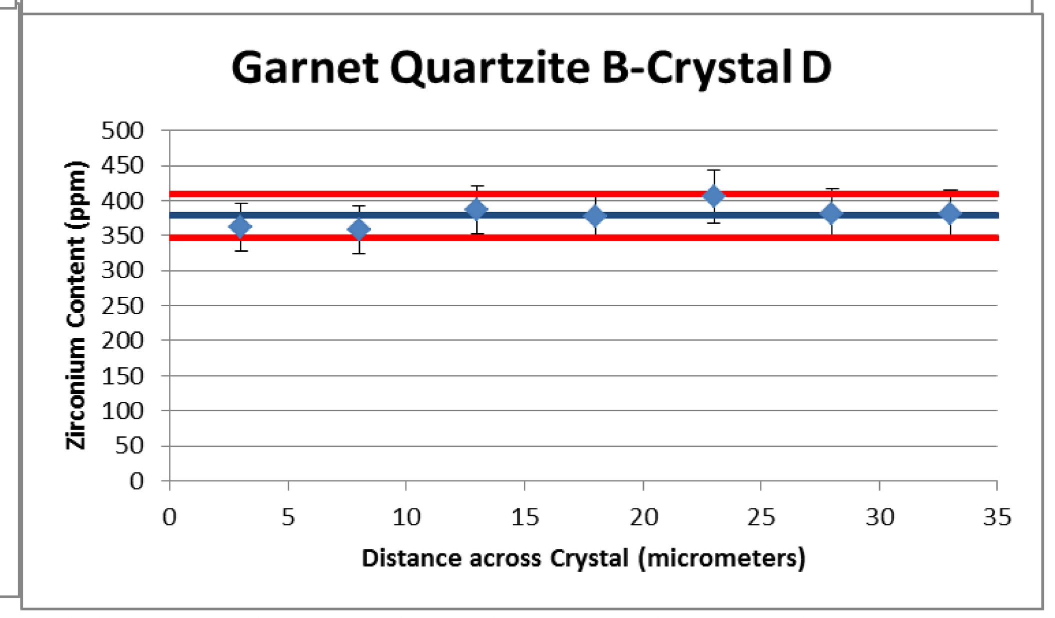












Representative charts depicting zirconium content in a crystal from each sample. The error bars indicate 2 sigma uncertainty due to counting statistics of the electron probe microanalyzer, the blue line indicates the average zirconium content based off of usable data (within uncertainty and less than 300 ppm silicon content), and the red lines indicate 2 sigma uncertainty from standard deviation of mean (SDOM).

Garnet Quartzite A		
Crystal	AverageZr Content	Uncertainty
A	468	49
B	457	46
C	465	11
D	458	76
E	473	36
F	453	40
Average	462	
Uncertainty	86	

	Garnet Amphibolite	
Crystal	Average Zr Content	Uncertainty
B	338	37
C	280	89
F	249	26
Average	289	
SDOM	91	

	Garnet Mica Schist	
Crystal	Average Zr Content	Uncertainty
A	328	40
B	351	50
C	305	97
D	185	49
E	400	70
Average	346	
SDOM	81	

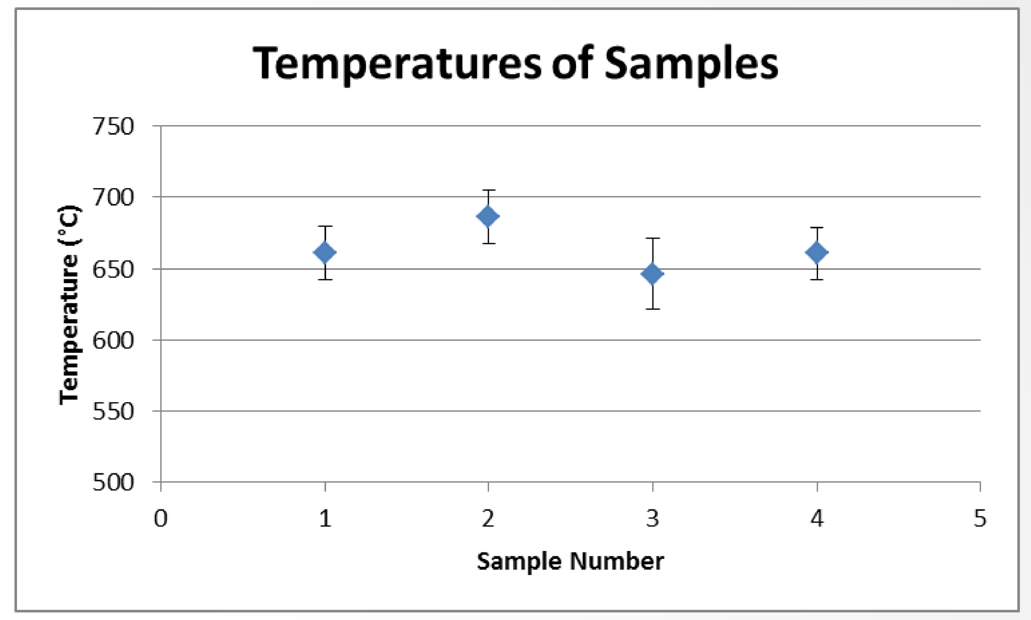
	Garnet Quartzite B	
Crystal	Average Zr Content	Uncertainty
A	357	56
B	289	56
C	314	62
D	379	31
E	387	45
Average	345	
SDOM	84	

All temperatures are in °C and zirconium content is in ppm

Summary

Sample	Zirconium Content	SDOM	Temperature	SDOM
Garnet Mica Schist	346	81	661	19
Garnet Quartzite A	462	86	686	19
Garnet Amphibolite	289	91	646	25
Garnet Quartzite B	345	84	661	18

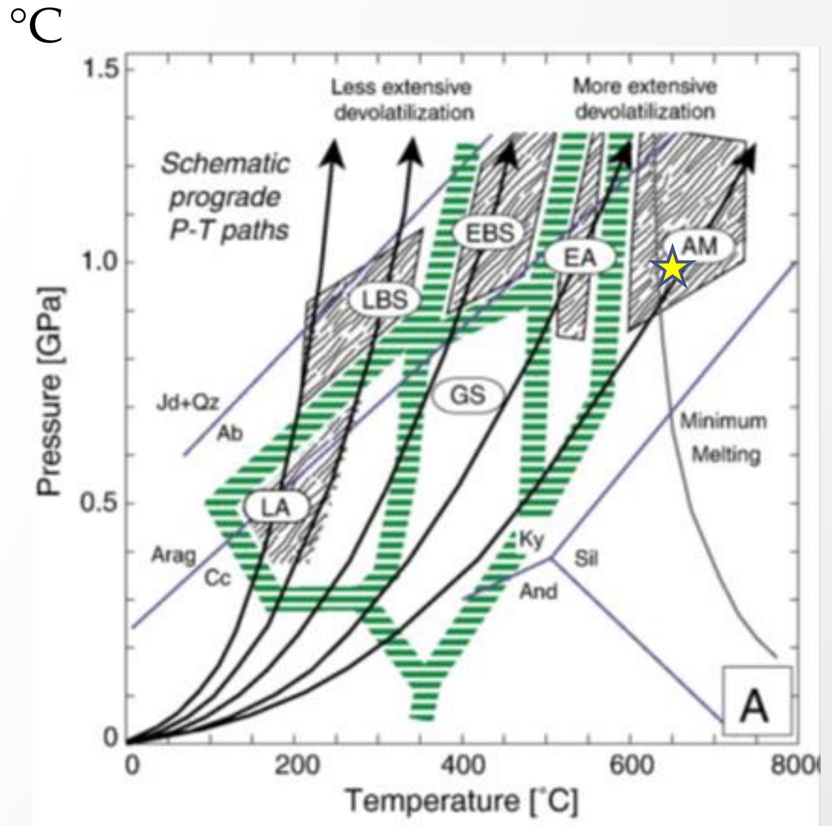
All temperatures are in °C and zirconium content is in ppm



- Final temperatures range from 646 to 686 °C
- All temperatures fall within uncertainty of each other
- Zirconium content is the same within uncertainty
- Does not support my hypothesis of significantly different zirconium contents
- Supports single package end member theory

Comparison to Other Results

- Temperatures calculated by McBride (2013) were 630-708 °C



PT diagram illustrating P-T conditions specific to the amphibolite facies rocks, labeled AM, of the Catalina Schist (Bebout, 2007). Yellow star indicates T calculated from this study.

References

Bebout, G. E., Metamorphic chemical geodynamics of subduction zones, Earth and Planetary Science Letters 260, 2007, p 373-393

McBride, H., 2013, Zirconium in Rutile Thermometry: Temperature Estimates for Metamorphic Rocks of the Catalina Schist

Tomkins, H.S., Powell, R., Ellis, D.J., 2007, The pressure dependence of the zirconium-in-rutile thermometer, J. metamorphic Geol., 2007, 25, 703–713