Determination of Metamorphic Temperatures of the Raspas Complex, Ecuador, Using Zr-in-Rutile Thermometry

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Background

Subduction Zones

- Convergent plate boundary where more dense oceanic crust sinks below less dense continental crust
- High pressure metamorphism
- Highly volcanically and seismically active
- Lower temperature conditions than other tectonic settings
- Discrepancy in temperatures estimated by numerical models and estimated based on geothermobarometry
- Understanding true temperature conditions of subduction zones creates better understanding of tectonic processes occuring there

Raspas Complex, Southwestern Ecuador

- Late Jurassic-Early Cretaceous accretionary wedge
- Formed due to Andean Orogeny
- Subduction zone metamorphic rocks: eclogites and blueschists
- Protoliths both OIB and MORB
- 9 samples taken from boulders along Rio Raspas

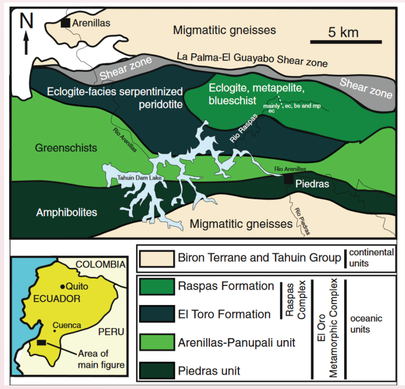

Figure 1: Geologic map showing an overview of the major formations and rock types found in the Raspas Complex and surrounding units (John et al., 2010)

The Zr-in-Rutile Thermometer

- $SiO_2 + ZrO_2 = ZrSiO_4$
- Quartz + rutile with Zr = zircon
- Less prone to reset during uplift than other thermometers

Hypotheses

Null: Temperatures determined through Zr-in-rutile thermometry will be consistent with those estimated by John et al. (2010) within uncertainty.

Alternative: Temperatures determined using Zr-in-rutile will be significantly higher or lower than previous estimates.

Secondary Null: The temperature estimates determined through Zr-in-rutile geothermometry for both eclogites and blueschists will be the same within uncertainty.

Secondary Alternative: The eclogite samples will display higher temperatures than the blueschists.

Methods

Petrography

- Identify main mineral phases
- Determine lithology
- Locate and map rutile locations

EPMA

- WDS data for major elements and ZrO2 wt%
- Zr detection limit of 25 ppm
- EDS spectra obtained for zircon and quartz to demonstrate equilibrium

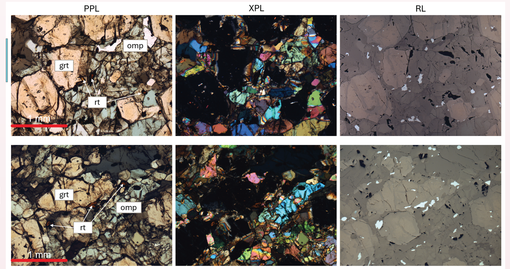

Figure 2: Photomicrographs in plane-polarized, cross-polarized, and reflected light of two locations in sample SEC 43-03 showing the presence of rutile (rt) grains along with garnet (grt) and omphacite (omp).

Equation

T = Temperature in °C
P = Pressure in bars
C = Zr concentration in ppm
R = Ideal gas constant

$$T = \frac{71360 + 0.378 \times P - 0.130 \times C}{130.66 - R \times \ln(C)} - 273.1$$

Figure 3: Zr-in-rutile thermometer equation from Kohn (2020)

Results

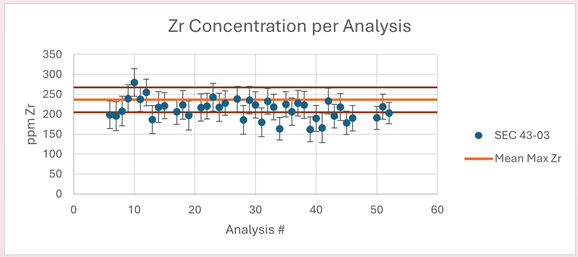

Figure 4: Zr concentration for each analysis shown with 2 sigma uncertainty. Mean max Zr shown as orange line.

Mean Max Zr: 236 ±31 ppm

Compare to upper quartile value: 241 ppm

Mean max Zr value used to calculate temperature range from 1.4-2.0 GPa

Pressure estimates based on John et al. (2010) geobarometric estimates

Temperature range of 626° to 653°C ±12°C

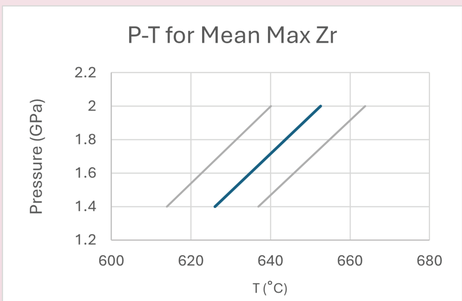

Figure 5: Estimated P-T conditions for sample SEC 43-03 based on the calculated mean max Zr concentration

Discussion

Zr-in-rutile estimates are consistent with previous estimates of 550-650°C for 1.6-1.8 GPa

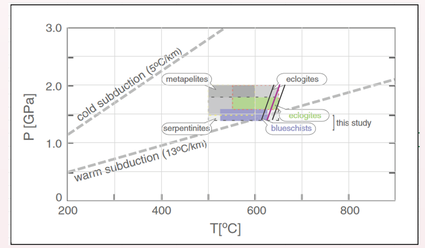

Figure 6: Estimated P-T conditions for SEC 43-03 overlaid on John et al. (2010) results

Estimates by Srinidhi Guruvayurappan:
SEC 27-1
539°-555° ± 29°C
SEC 43-1
639°-657° ± 10°C
SEC 50-1
554°-570° ± 19°C

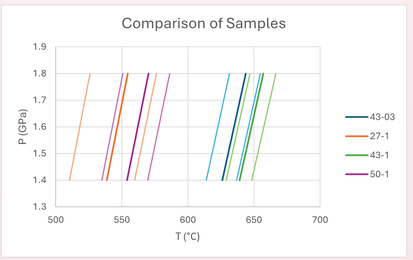

Figure 7: Comparison of the estimated temperatures for samples SEC 43-03 (blue), SEC 27-1 (orange), SEC 43-1 (green), SEC 50-1 (purple)

Estimates for SEC 43-03 are most consistent with those of SEC 43-1

Future Work

- Repeat process for three more samples (two blueschists, one eclogite)
- Reevaluate past data on additional samples
- Compare results between rocks and between geothermometers

References

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