

Matthew Wong¹, E. Troy Rasbury², Jason Kirk³, Kevin Hatton², Karol Faehnrich⁴, William McClelland⁵, Justin V. Strauss⁴, Margaret Odlum⁶, Erin Donaghy⁴

¹Mark Keppel High School, ²Stony Brook University, ³University of Arizona, ⁴Dartmouth College, ⁵University of Iowa, ⁶Scripps Institution of Oceanography

Background

Figure 1: Terrane map showing the Porcupine Fault System, taken from a grant proposal by Strauss et al., 2024

Figure 2: Map showing locations of collected rock samples, green pins show very favorable U/Pb ratios, yellow pins show favorable, white pins are untested, red pins show unfavorable. *If multiple samples were collected from one location, only one pin shows up

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- The Porcupine Fault System is a major tectonic boundary, separating the Western Laurentian terranes from the North Slope Subterranean (Figure 1)
- Mesozoic sinistral displacement has been proposed to accommodate the opening of the Canadian basin
- Calcite, a mineral that precipitates in fault and fracture zones can help constrain timing of different faults
- We develop a modified isotope dilution technique in order to date and better understand the calcite veins within the Porcupine Fault System

Methods

Crush and clean fragments under a microscope to select samples without evidence of alteration

Hand-pick fragments under a microscope to select samples without evidence of alteration

Weigh 5 mg of a sample into five pre-cleaned centrifuge, dissolving in 2% nitric acid

Run samples on Agilent 7500 cx quadrupole mass spectrometer, measuring U and Pb isotopes, major and trace elements

Spike the samples with a mixed tracer of enriched ^{208}Pb and enriched ^{235}U

Figure 3: Equations that allow us to calculate the isotope ratios or other variables within after analyzing the mass spectrometer data, such as the $^{207}\text{Pb}/^{206}\text{Pb}$ or $^{238}\text{U}/^{206}\text{Pb}$ ratios

$$\frac{^{208}\text{Pb}}{^{206}\text{Pb}} = R = \frac{\text{moles } ^{208}_N + \text{moles } ^{208}_S}{\text{moles } ^{206}_N + \text{moles } ^{206}_S}$$

$$R = \frac{M_N \cdot \% ^{208}_N + M_S \cdot \% ^{208}_S}{M_N \cdot \% ^{206}_N + M_S \cdot \% ^{206}_S}$$

where N denotes natural, and S denotes spiked

Results

Vein Analysis

Prior Data

Modified Isotope Dilution

Figure 4: Models showing different types of calcite veins and their movement (Roberts & Holdsworth, 2022)

Figure 4a: Rock sample TR-24-057 showing a single phase opening mode fracture-filled vein

Figure 4b: Rock sample TR-24-014 showing a filled pull-apart/jog vein

Figure 4c: Rock sample TR-24-017 showing an implosion breccia type vein

Figure 4d: Rock sample K1907A showing a filled pull-apart/jog vein

Figure 5a and 5b were generated from Iolite (Paton et al., 2011), and figures 5c and 5d were generated from IsoplotR (Vermeesch, 2018)

Figure 5b: Parts of the rock sample I selected using the monocle function (Petrus et al., 2017) as Drost et al. (2018) did

Figure 5c: Isochron generated that shows the age of the calcite veins in K1907A (red), and the entire rock (green) from laser ablation data

Figure 5d: Isochron generated that shows the age of sample K1907A using data collected from a multi-collector

Figure 6: Isochrons of samples 14, 15, 17A, 17B, 32, 57, K1907A, and WC-1 reference material using the standard Tera-Wasserburg concordia diagram and Parrish $^{208}\text{Pb}/^{206}\text{Pb}$ Technique; figures generated from IsoplotR (Vermeesch, 2018)

For the isochron with all samples, the numbers on color bar on the right corresponds to samples; 1 - Sample 14, 2 - Sample 15, 3 - Sample 17A, 4 - Sample 17B, 5 - Sample 1907A, 6 - Sample 32, 7 - Sample 57

Discussion

Omitting one data point makes the generated ages more in-line with previously collected data, showing the weight each data point has

This limitation can be mitigated with more data points collected from the same sample

Figure 10: Sample K1907A from the modified isotope dilution using the standard Tera-Wasserburg isochron plot (left) and Parrish $^{208}\text{Pb}/^{206}\text{Pb}$ Technique (right) through IsoplotR (Vermeesch, 2018)

Figure 9: Sample K1907A Plotted with data points using the modified isotope dilution technique (blue) with the data from laser ablation (red; left) and multi collector (red; right) using a Tera-Wasserburg isochron plot through IsoplotR (Vermeesch, 2018)

The modified isotope dilution data points plot in-line with data collected from laser ablation and multi collector

The spread for the modified isotope dilution is much less, but could be mitigated with more data points

Rare Earth Element Plots normalized to values of PAAS, separated to highlight Europium anomalies

Some of the samples analyzed show a Europium anomaly

REE concentrations are estimated from counts

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