Dating The Movements Of The Denali Fault

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Introduction

The Denali fault system is one of the most prominent and seismically active strike-slip faults in North America, extending over 2,000 km across Interior Alaska and into Western Canada. Understanding the timing and rates of displacement along this fault is critical for reconstructing the tectonic evolution of the northern Cordillera and assessing ongoing seismic hazards in the region. However, the exact timing of fault motion has remained difficult to constrain due to the remote nature of the terrain and the complexity of deformation histories recorded in adjacent units. $^{40}Ar/^{39}Ar$ thermochronology addresses these challenges, as it can directly date the cooling histories of rocks that record fault activity. By applying $^{40}Ar/^{39}Ar$ geochronology to samples collected along key segments of the Denali fault such as the Schist Creek and Foraker plutons, this study aims to establish a timeline of vertical fault movement and contribute to the understanding of how large-scale strike-slip systems accommodate plate motion in convergent continental margins.

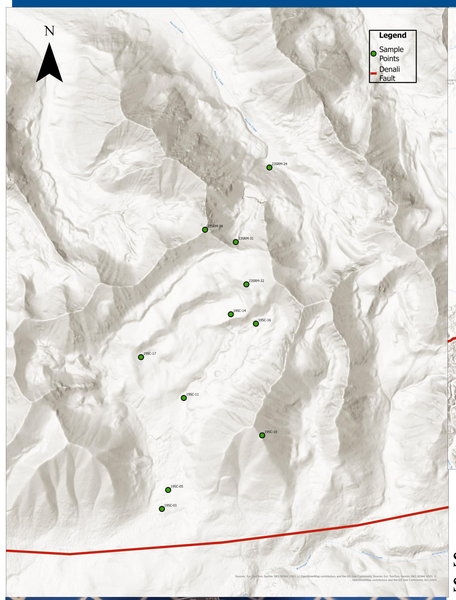
Methods

Research began by gathering samples used by Regan, Benewitz, and Holland in their previous research of the Denali fault. We chose samples that had been taken at the Schist Creek and Foraker locations. We crushed each sample down and sieved out grain sizes between 250-500 um.

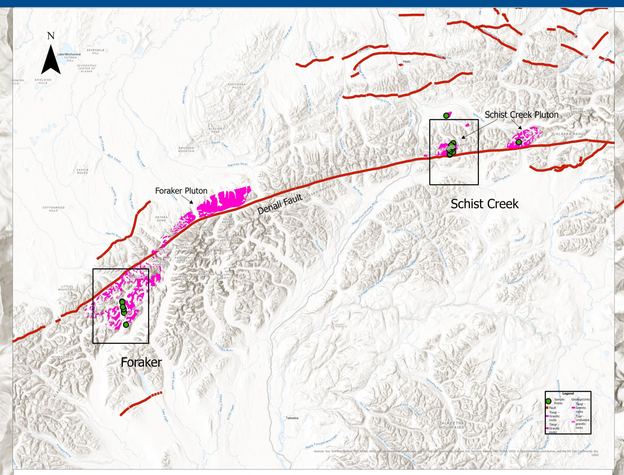
After sieving, the samples were picked for both biotite and feldspar. Biotite and feldspar have different closure temperatures. Getting data from both the biotite and the feldspar allowed us to see the thermal cooling history in staggered stages.

Once picked, the minerals were put through irradiation to induce nuclear reactions. This reaction converts the stable ^{39}K to ^{39}Ar for the next step of the process. We then put the irradiated materials through a NGX mass spectrometer to measure the ratio of $^{40}Ar/^{39}Ar$. Measurement of this ratio gives the closure dates of each mineral (biotite and feldspar) which allows us to see if or when the faults were moving.

Findings

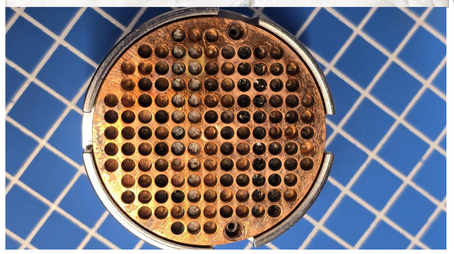


Schist Creek Sample Sites



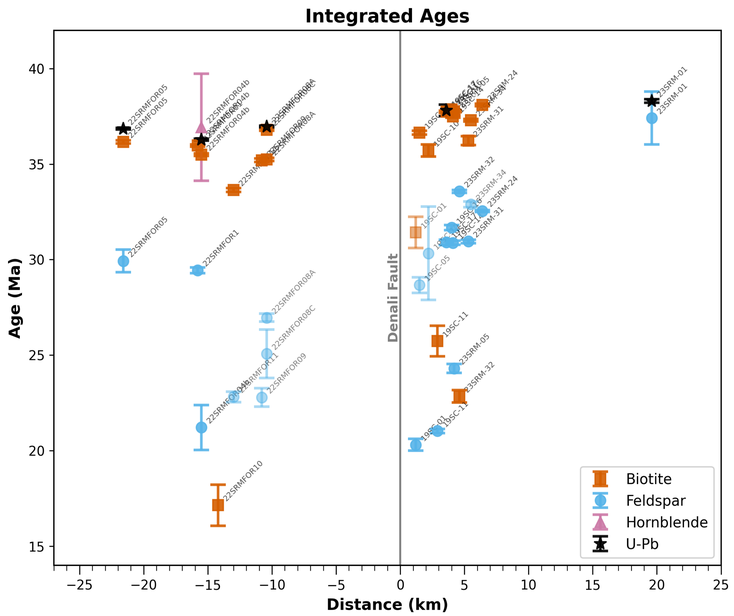
Denali Fault with sample locations for both Schist Creek and Foraker

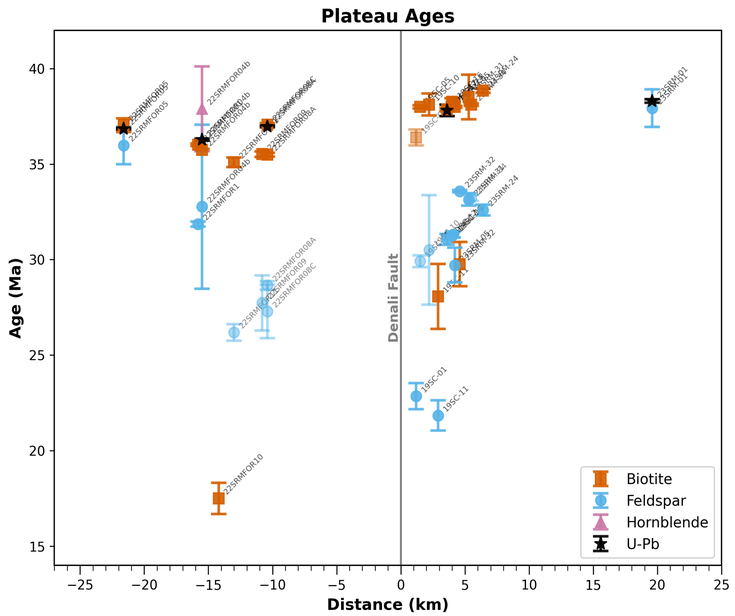
Foraker Samples Sites



Irradiated mineral grains being loaded into the mass spectrometer by Alex Patton in the Goechronology lab

Ages vs Distance - Denali Fault (with recalculated ages)





Future Research

Future research efforts should integrate thermal modeling with the $^{40}Ar/^{39}Ar$ dataset to produce continuous time-temperature paths and constrain exhumation rates along the Denali fault system. Coupling these data with lower-temperature thermochronometers such as zircon and apatite fission track and U-Th/He systems would extend thermal histories to shallower crustal levels and broader time intervals. Thermokinematic modeling can also resolve slip rates and strain partitioning between fault segments by simulating the thermal evolution of fault-adjacent rocks through time. In the Alaska Range, models must account for glacial unloading as a significant driver of exhumation alongside tectonic processes, as failure to do so risks misattributing surface erosion to fault activity. With the current data provided and future thermal modeling, these approaches would produce an even more complete history of the Denali fault across a range of crustal depths and timescales.

References

Regan, S.P., Benowitz, J.A., and Holland, M.E., 2020, A plutonic brother from another magma mother: Disproving the Eocene Foraker–McGonagall pluton piercing point and implications for long-term slip on the Denali Fault: Terra Nova, v. 32, p. 66–74, https://doi.org/10.1111/ter.12437.

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Rojas, A., Cooperdock, E.H.G., Hofmann, F., and Lackey, J.S., 2025, Plutonic piercing points as recorders of continental transform fault evolution: Chronologic insights from the transpressive southern San Andreas Fault: Tectonics, v. 44, e2024TC008727, https://doi.org/10.1029/2024TC008727