

# Origins of thin, hot and weak mantle beneath the North American Plate in British Columbia

Holly Sparks



Supervised by Dr. Dante Canil and Dr. Rebecca Morris

School of Earth and Ocean Sciences

March 2025

## 1. Objectives and Overview

- Mantle lithosphere is the solid, uppermost section of mantle which composes a significant portion of tectonic plates.
- There are three proposed models for lithospheric mantle age/origin below the Canadian Cordillera.
- One proposed model is that the lithosphere delaminated/foundered in the past 50 Myr. This would be associated with high cooling rates (>10C/Myr).

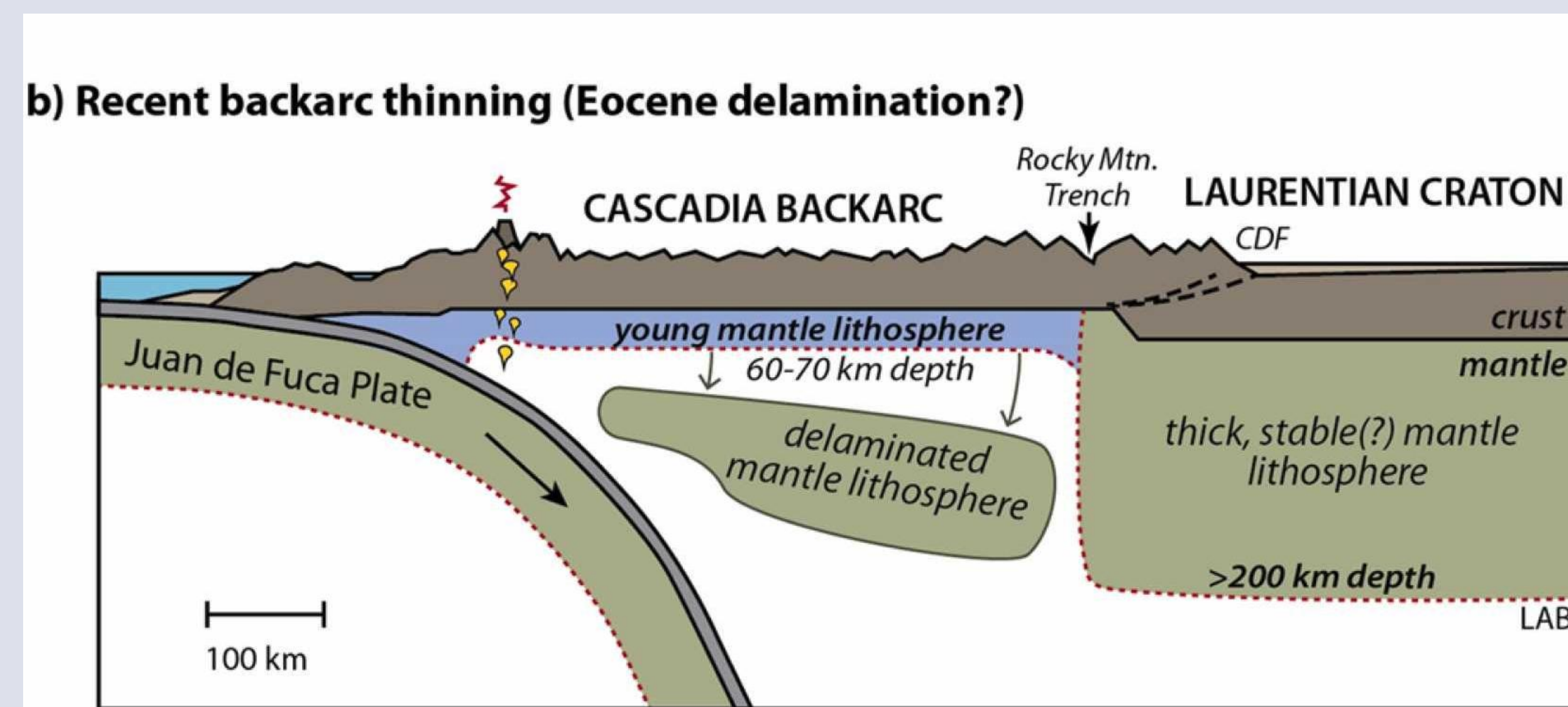


Figure 1. Schematic showing mantle delamination of the Cordillera modified from Currie et al. (2022)

- To test these models, we can use the cooling history of mantle xenoliths derived by the grain size dependence of temperatures recorded by cation exchanges amongst minerals.

## 2. Background

Three spinel peridotite mantle xenoliths were studied from Mount Timothy (MT), south central BC.

Xenoliths were mostly hosted in massive basanite to nephelinite lavas, with eruption ages of less than 400 k. y. ago.

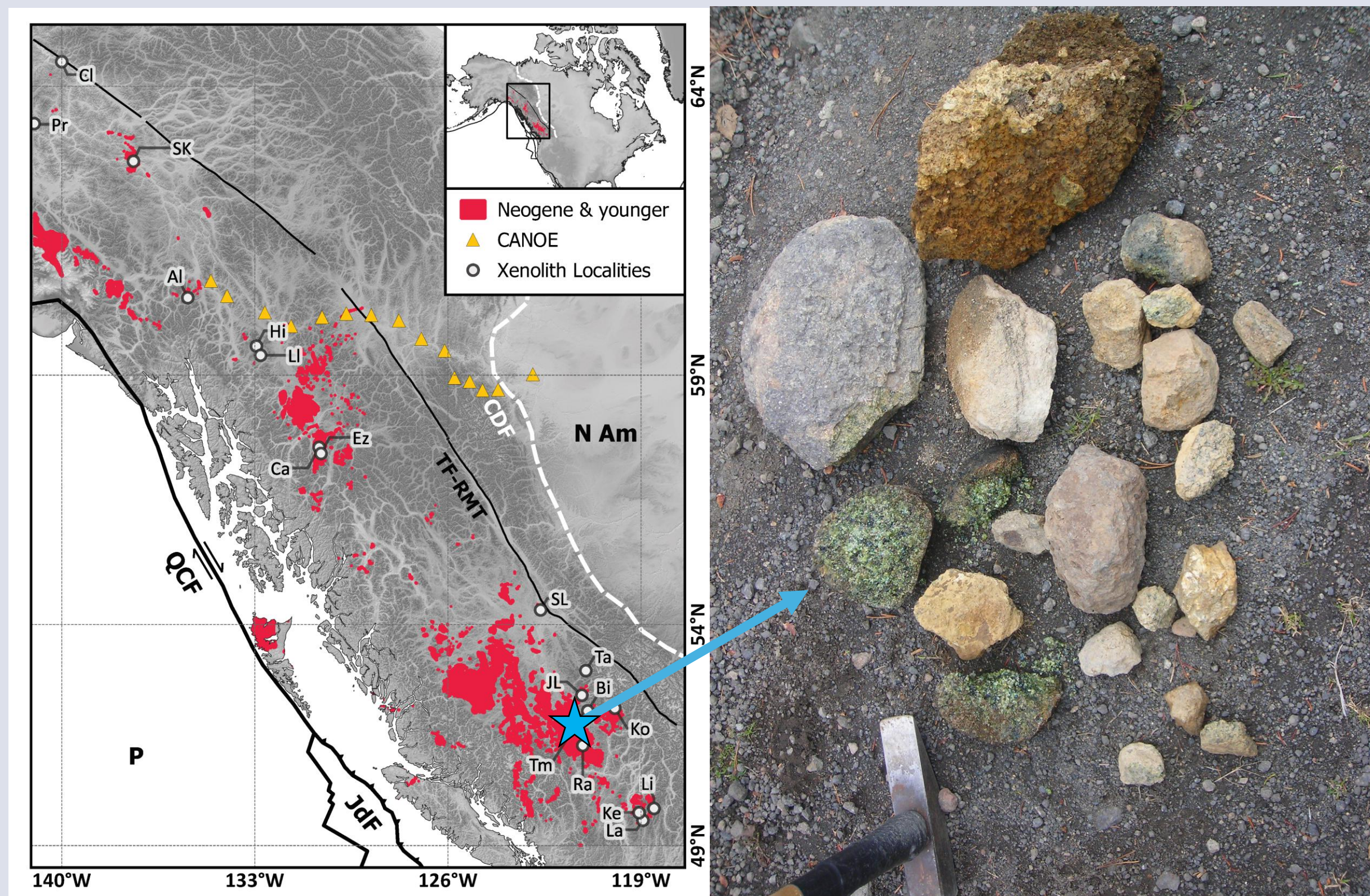


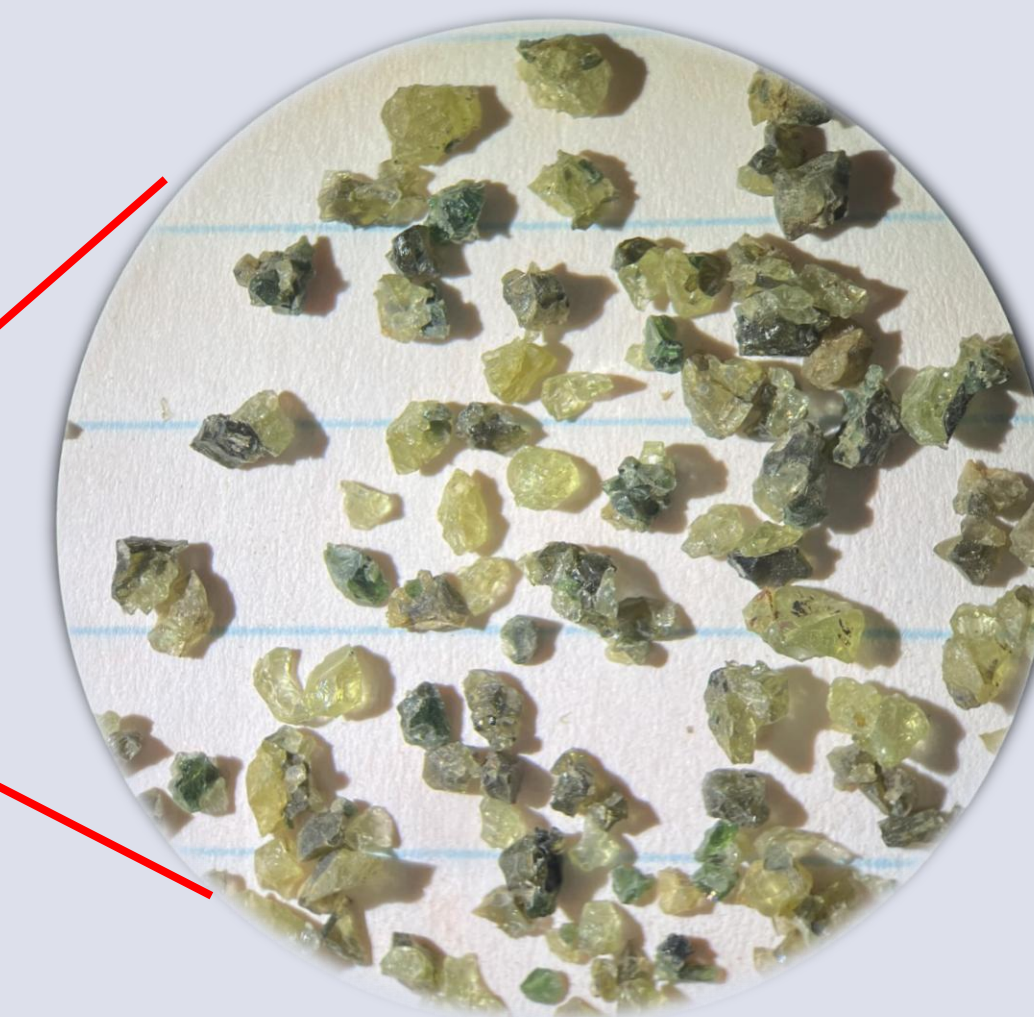
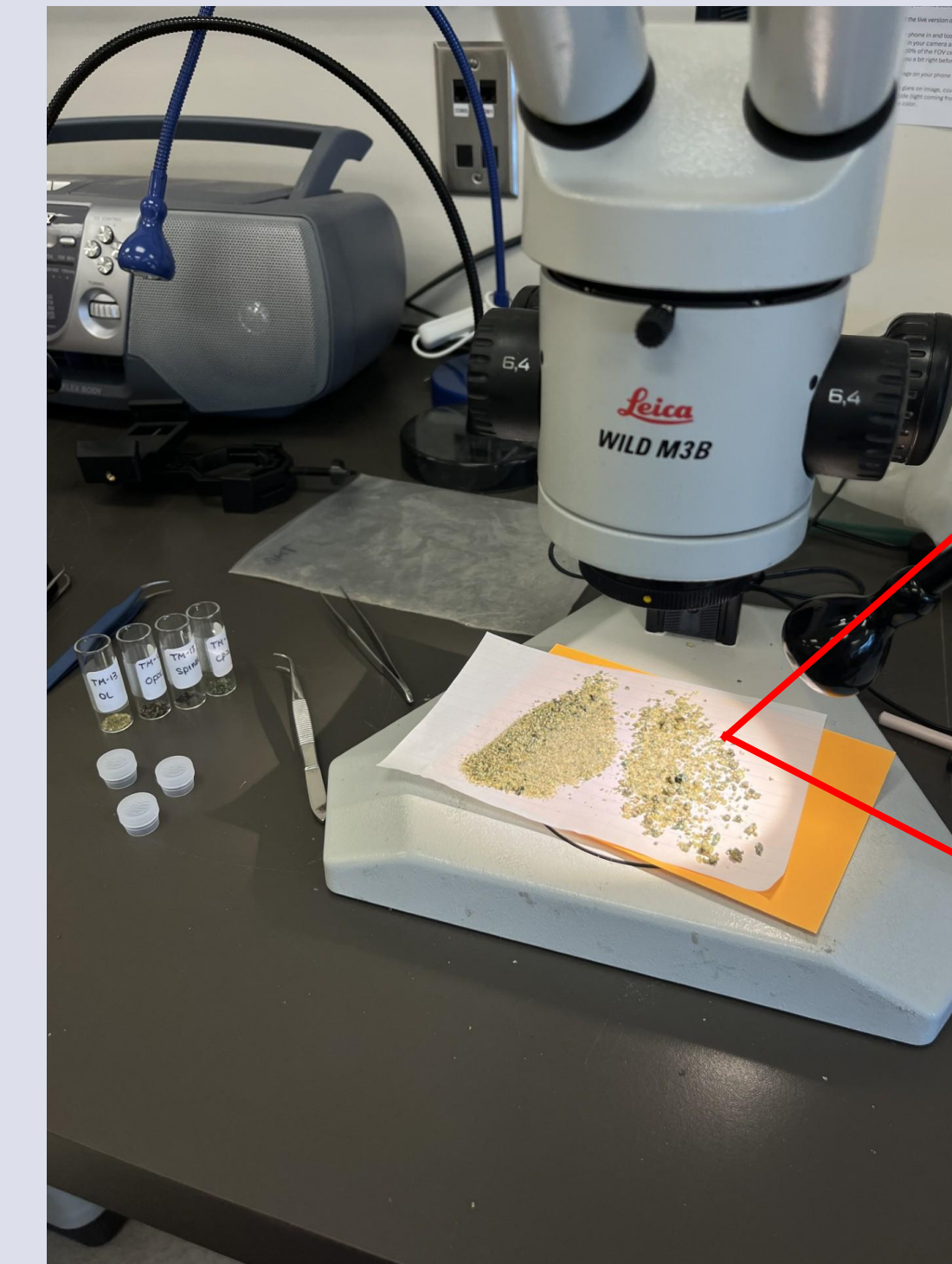
Figure 2. Left shows a map of the Canadian Cordillera from Canil et al. (2021), right is of xenolith samples from Mount Timothy taken by Dante Canil, some broken/crumbling showing their friable nature.

## References

- Bao, X., Eaton, D. W., & Guest, B. (2014). Plateau uplift in western Canada caused by lithospheric delamination along a craton edge. *Nature Geoscience*, 7(11), 830–833. <https://doi.org/10.1038/ngeo2270>
- Canil, D., Russell, J. K., & Fode, D. (2021). A test of models for recent lithosphere foundering or replacement in the Canadian Cordillera using peridotite xenolith geothermometry. *Lithos*, 398–399, 106329. <https://doi.org/10.1016/j.lithos.2021.106329>
- Currie, C. A., Mallyon, D. A., Yu, T., Chen, Y., Schaeffer, A. J., Audet, P., & Gu, Y. J. (2022). Mantle structure and dynamics at the eastern boundary of the northern Cascadia backarc. *Journal of Geodynamics*, 155, 101958. <https://doi.org/10.1016/j.jog.2022.101958>
- Dodson, M. H. (1973). Closure temperature in cooling geochronological and petrological systems. *Contributions to Mineralogy and Petrology*, 40(3), 259–274. <https://doi.org/10.1007/bf00373790>
- Putirka, K. (2008). Thermometers and Barometers for Volcanic Systems. In: Putirka, K., Tepley, F. (Eds.), *Minerals, Inclusions and Volcanic Processes, Reviews in Mineralogy and Geochemistry*, Mineralogical Soc. Am., v. 69, pp. 61–120.

## 3. Methods

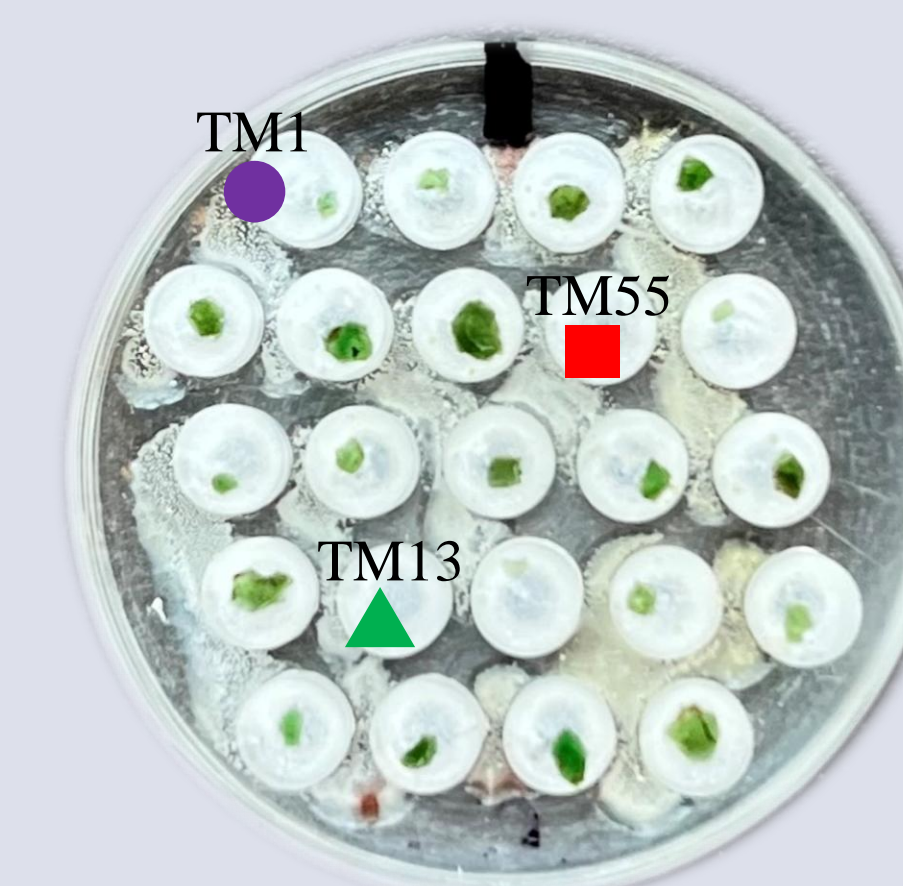
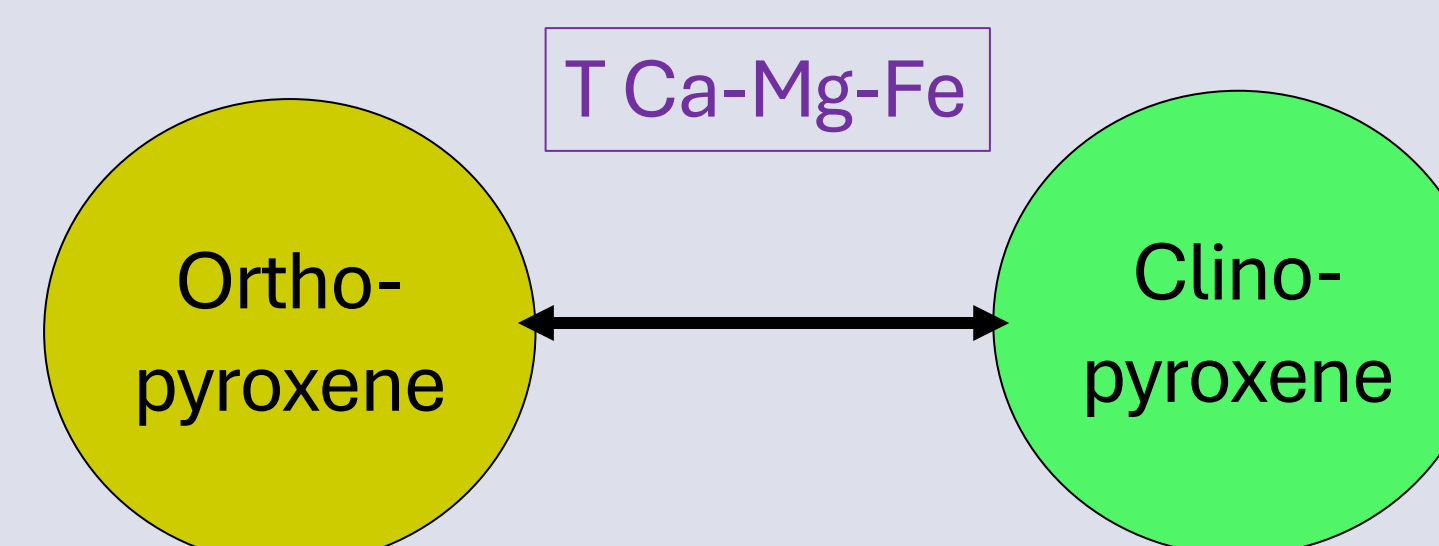
Samples are optimally unique as they are highly friable allowing for crystal separation from the bulk xenolith and subsequent analysis under a stereo microscope. Grain size was estimated by measuring grain weight and using the assumption that grains are roughly spherical



Picked grains were mounted, polished and analyzed using LA-ICPMS to obtain major and trace element concentrations. Closure temperatures for different cations in different minerals were calculated. Expected temperatures were then compared with grain size to deduce cooling rates using Dodson's relationship for closure temperatures.

## 4. Results

Exchange of Ca, Mg and Fe between orthopyroxene and clinopyroxene was measured to obtain closure temperatures.



Mounted clinopyroxene grains representing the data points on adjacent plot.

Closure temperatures generally increase with grain size following Dodson's closure temperature relationship and range from ~930°C-1040°C.

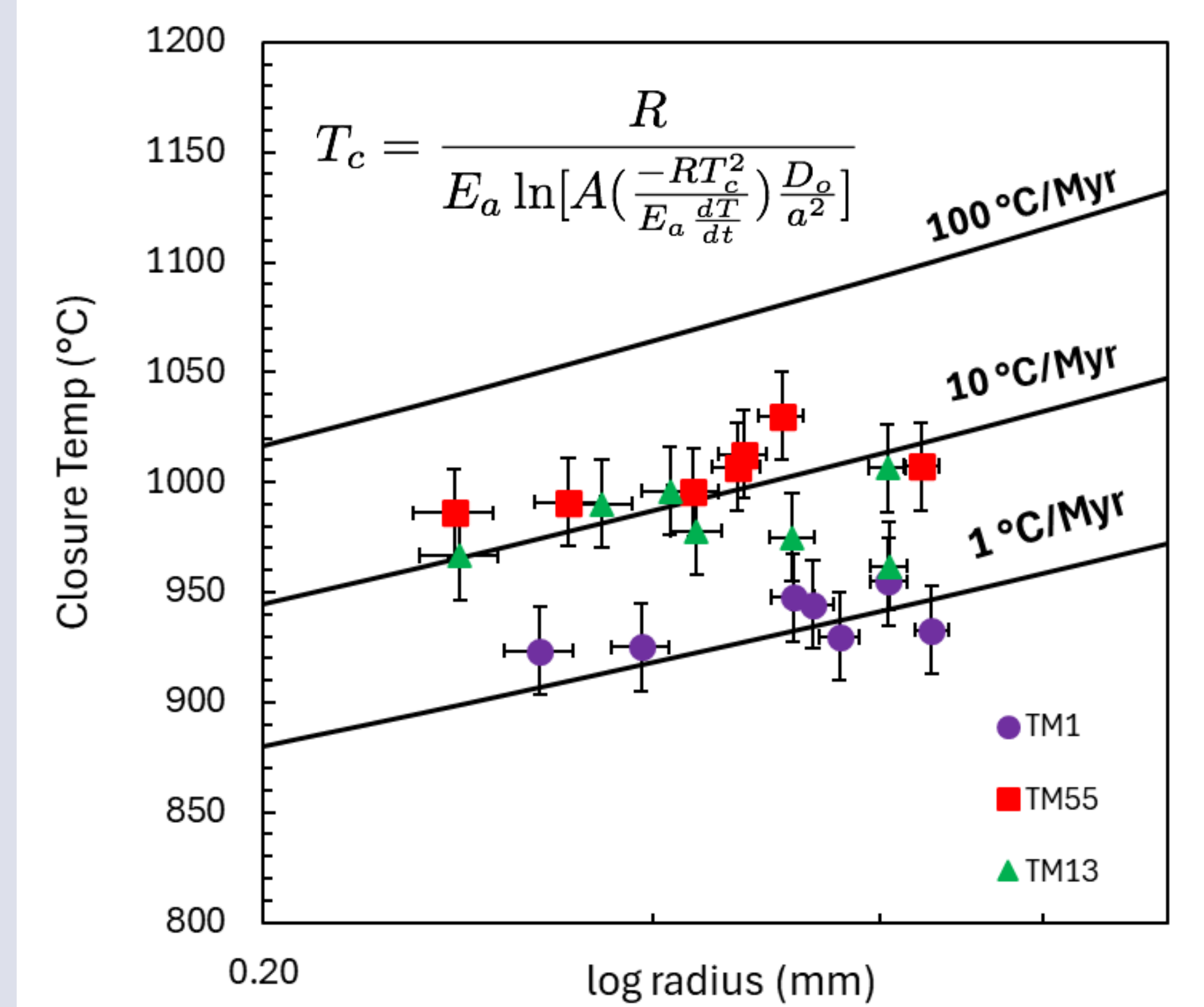


Figure 3. Cooling rate curves calculated using Dodson's closure temperature relationship (1973) plotted alongside TBKN temperatures (Putirka, 2008) calculated using the exchange of Ca, Mg and Fe between orthopyroxene and clinopyroxene

## 5. Conclusions

- Cooling rates of 1°C-10°C/Myr were calculated from MT samples.
- Assuming a typical mantle solidus of 1250 °C, mantle delamination would have had to occur upwards of 125 million years ago to represent these cooling rates.
- Mineral handpicking and subsequent analysis could be applied to other xenolith localities in BC to further investigate mantle age/origin.

\*Acknowledgement: This research was supported by the Jamie Cassels Undergraduate Research Awards, University of Victoria.