Deformation conditions of mantle xenoliths from Siberian kimberlites constrained by REE thermobarometry and grain size piezometry

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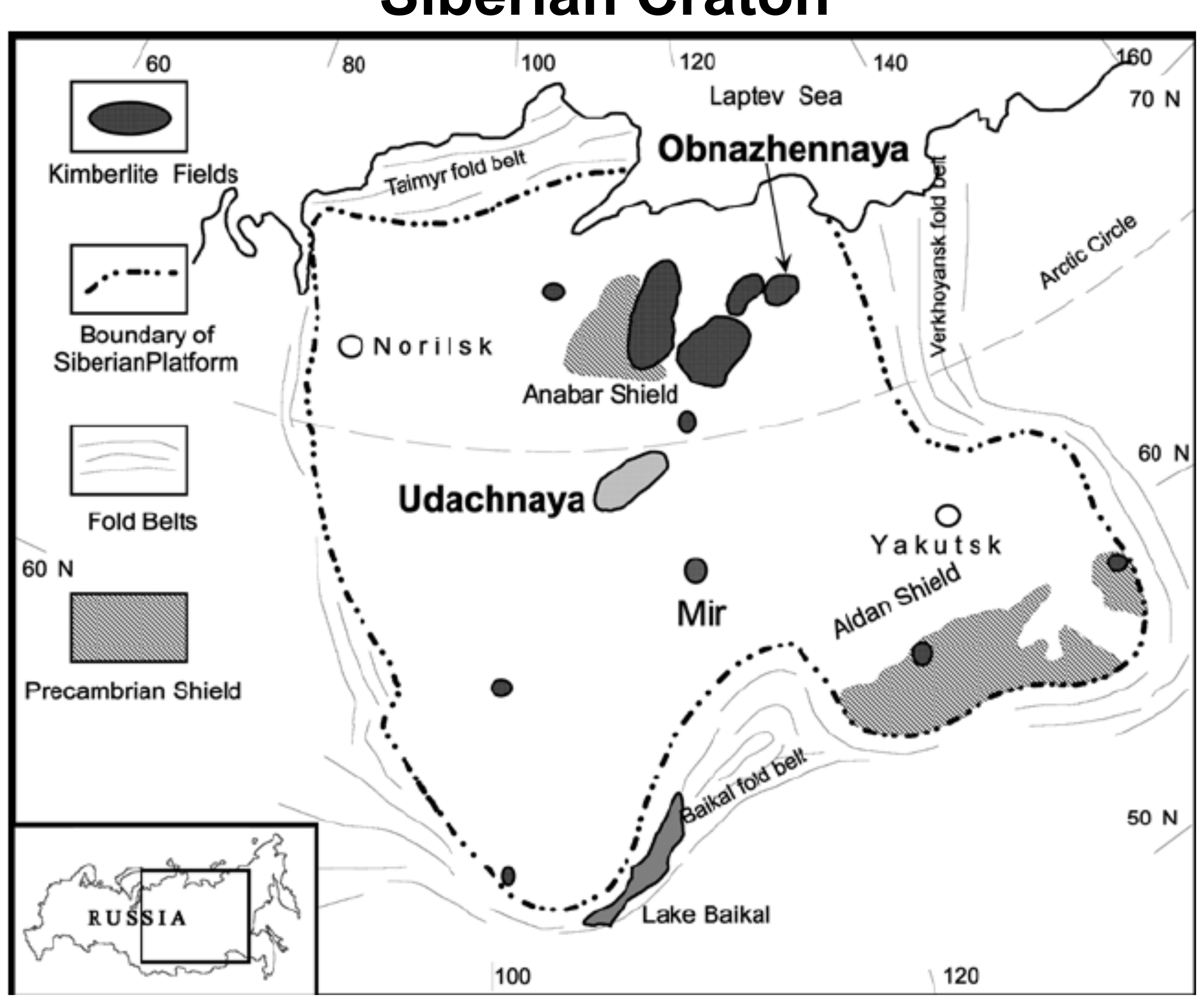
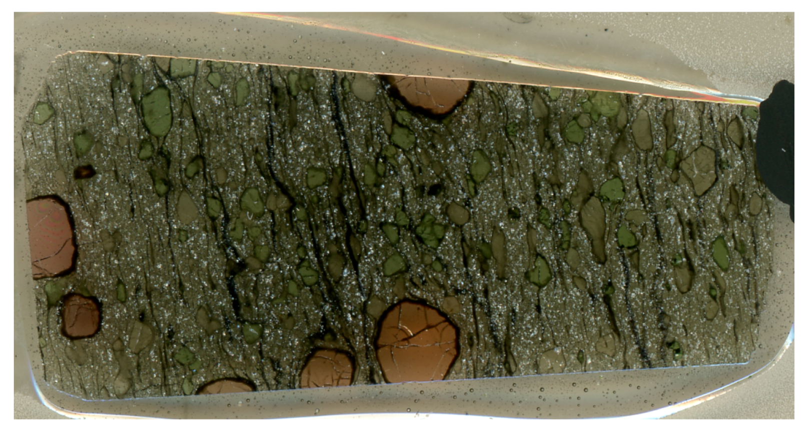
Introduction

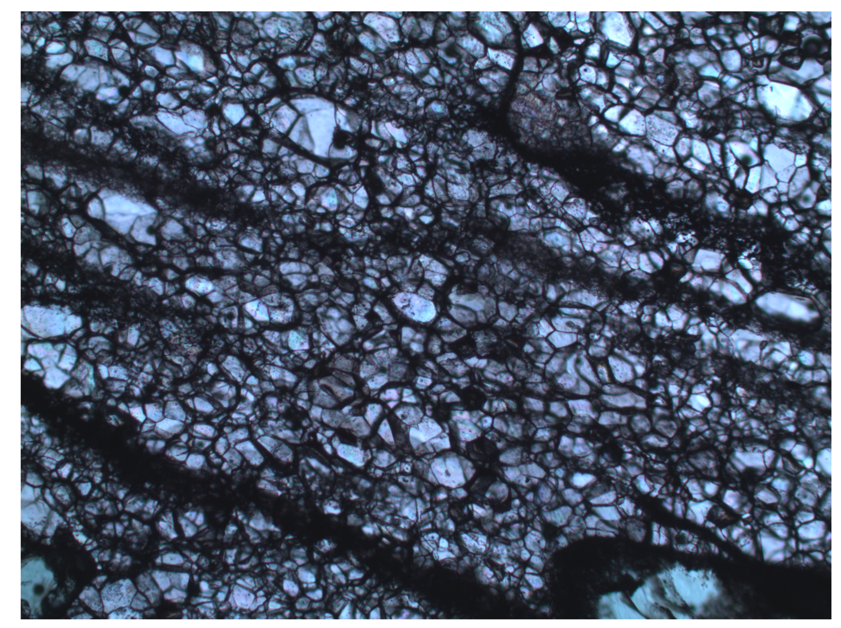
Kimberlite eruptions occur in the asthenosphere at depths exceeding 90 miles from the Earth's surface. These volcanic eruptions rise at speeds approaching 800 mph and this rapid uplift carries along mantle xenoliths from great depths resulting in greater amounts of strain. We examined grain deformation and measured recrystallized olivine grain sizes to better understand these conditions. Using major and trace element data from peridotite xenoliths, we approximated deformation temperatures and pressures with several thermobarometers. Our samples from two different kimberlite structures showed grain size and deformation conditions congruent with estimated temperatures and pressures. Samples with strain from an older, hotter kimberlite pipe showed a higher amount of pressure reported when used in a REE thermobarometer. The kimberlite structures examined are the older than 350 Ma Udachnaya pipe and the estimated 168 Ma Obnazhennaya pipe. A noticeable difference in deformation temperatures, pressures, and olivine grain sizes were shown indicating much different mantle activity between the two structures.

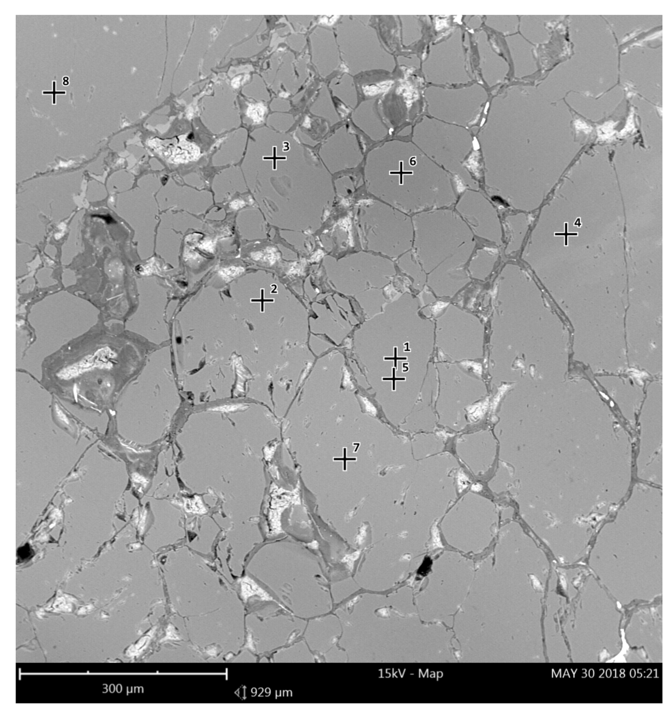
Siberian Craton



Samples and Methods

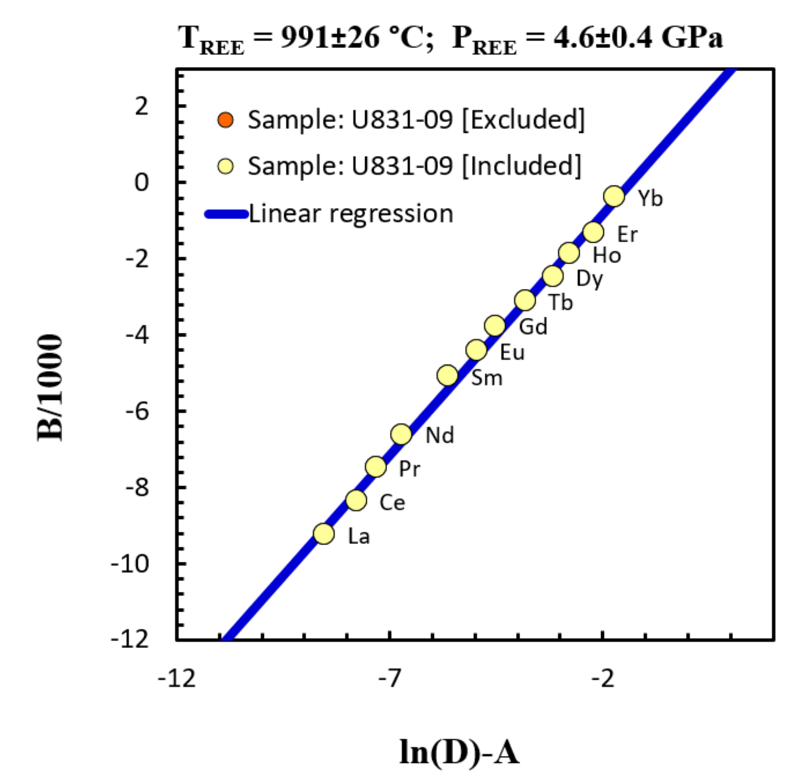


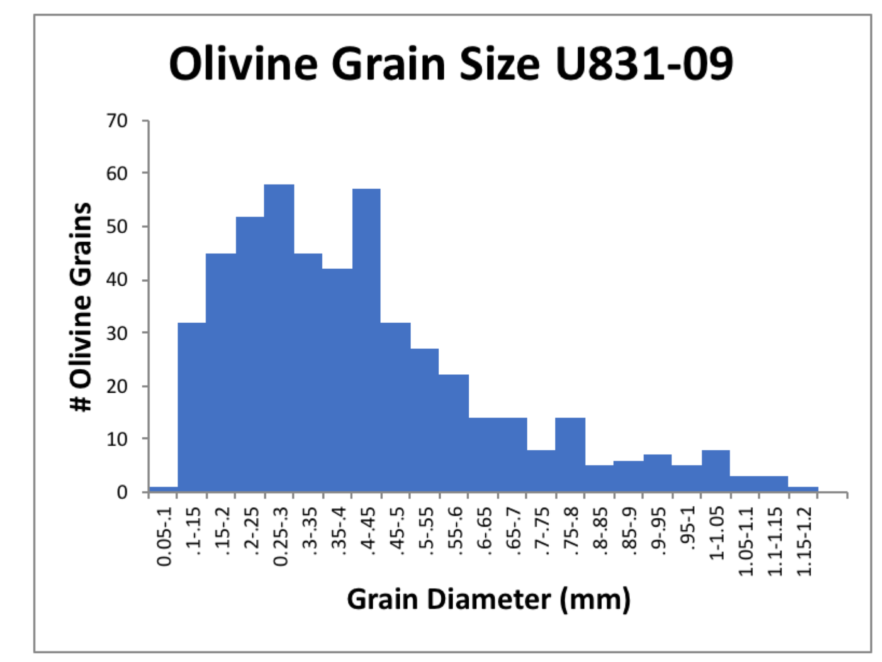




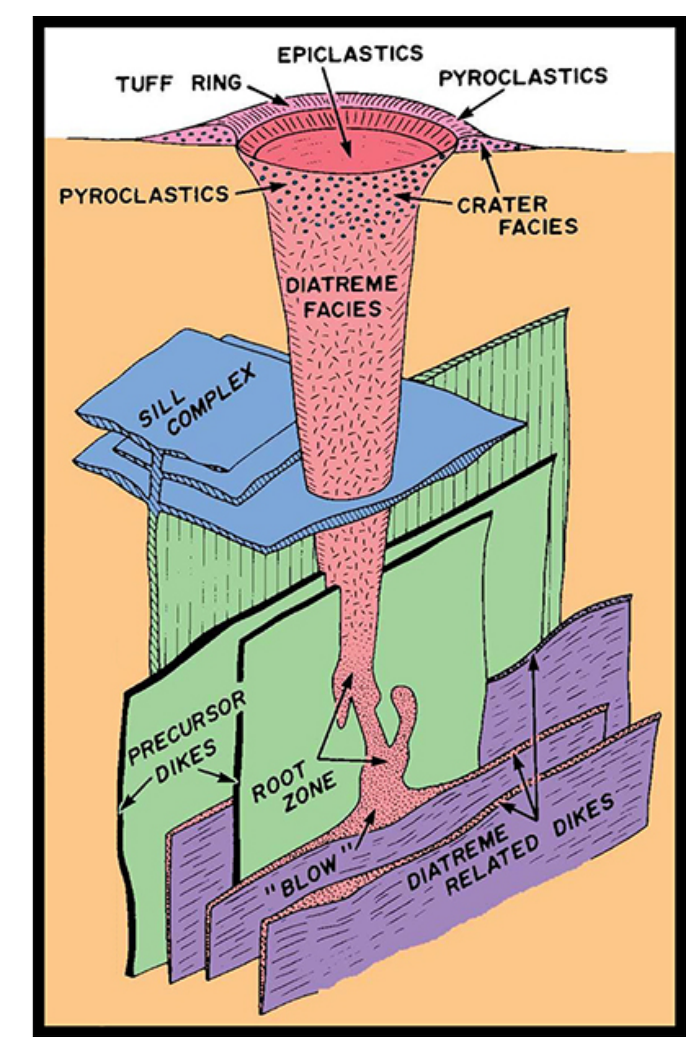
Sample U831-09 from the Udachnaya kimberlite structure. Top left is an image of the thin section clearly showing a mylonitic pattern with olivine sheared into striations. Above is the sample zoomed in on a petrographic microscope showing individual olivine grains and banding. On the left is an image from the SEM of individual olivine grains with a scale of 300 micrometers.

Results

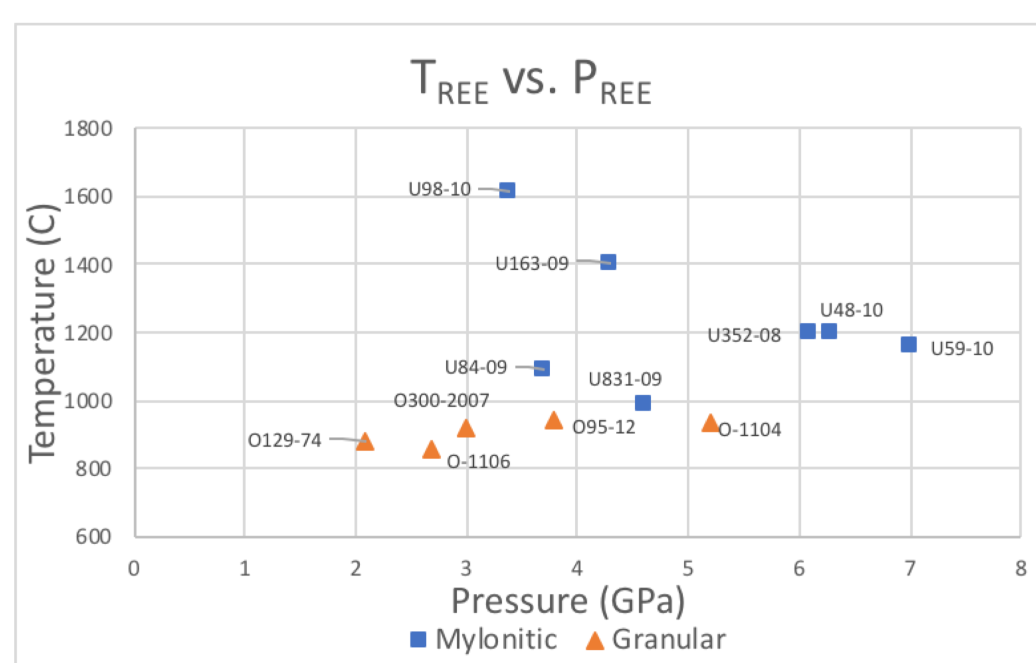


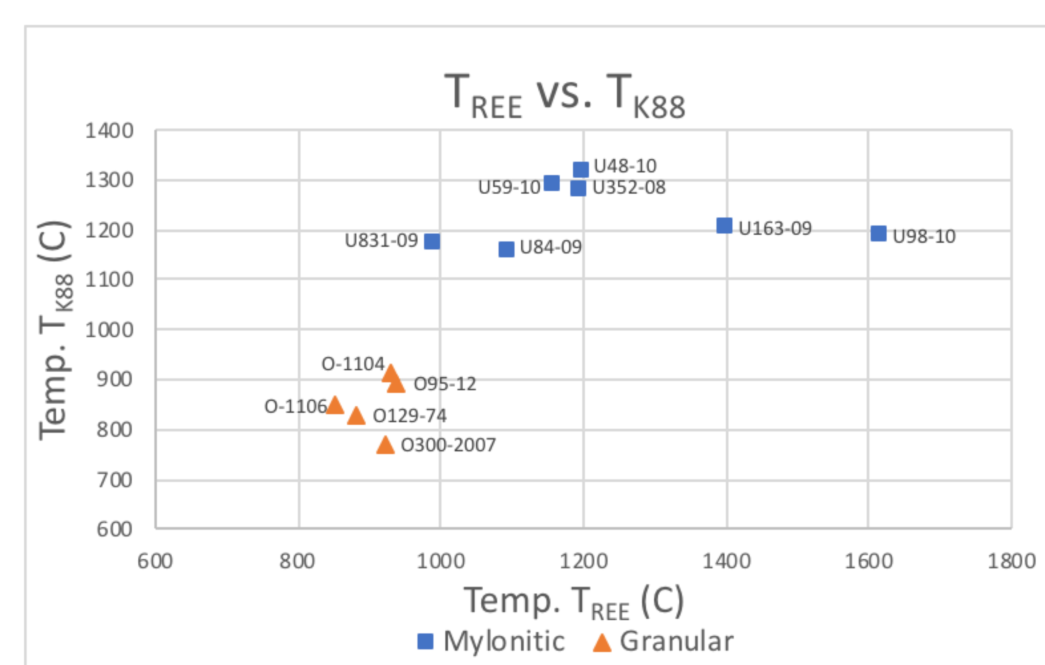


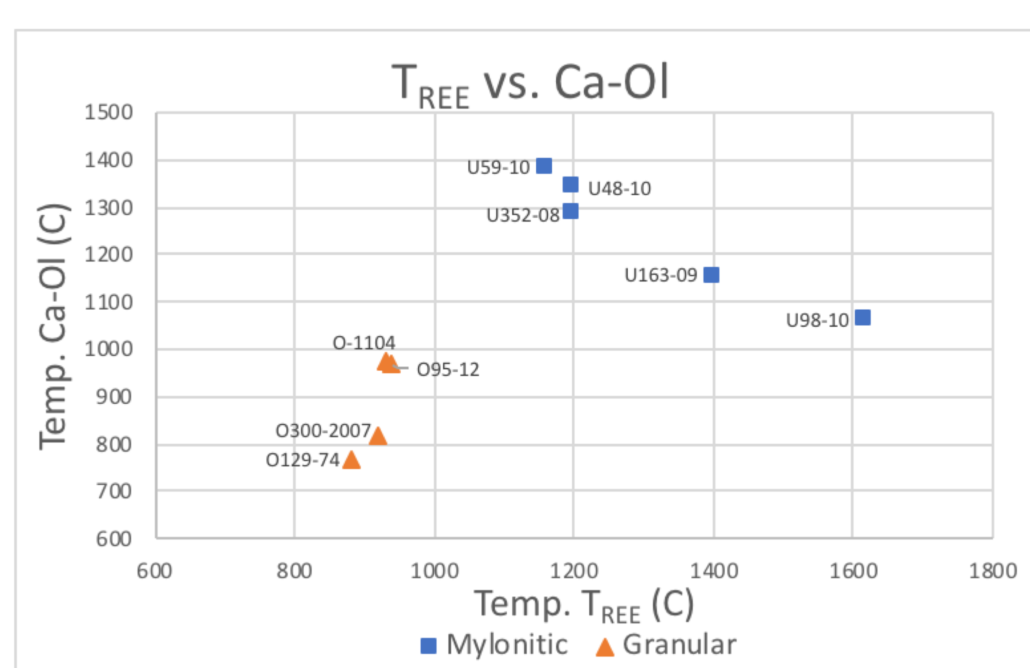
Sample	GS (mm)	St. Dev.	Intensity (Mpa)
U831-09	0.039	0.258	88.167
U59-10	0.054	0.444	68.384
U367-08	0.029	0.206	111.186
U98-10	0.046	0.333	77.449
U352-08	0.041	0.217	84.898
U84-09	0.053	0.365	69.345

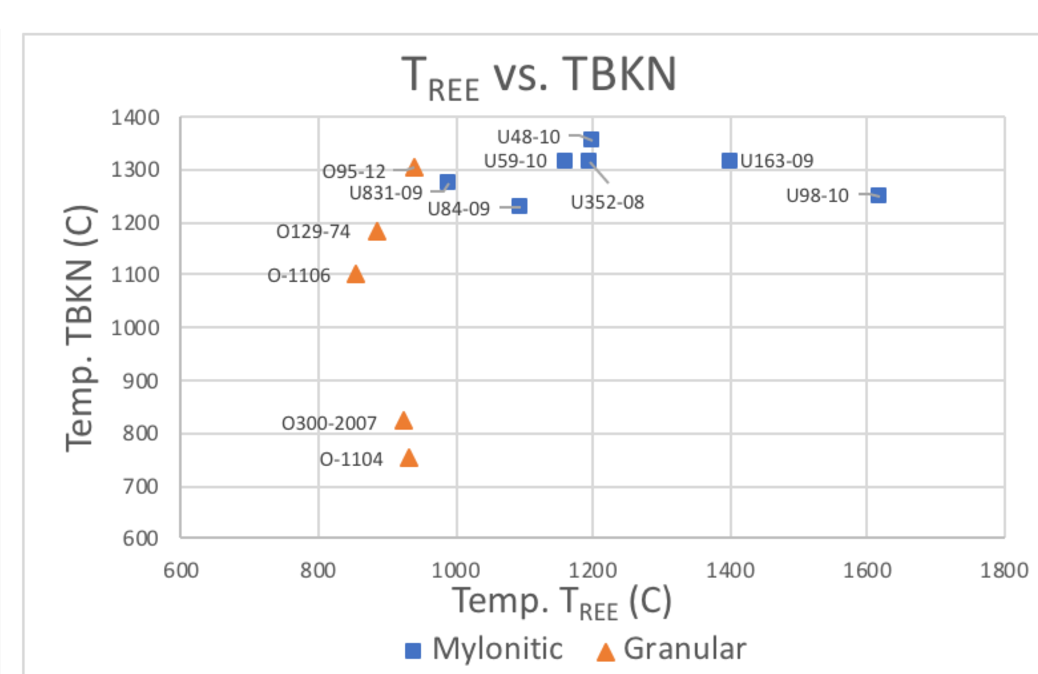


Results









Future Work

By better understanding this process of strain in these sample rocks, these same processes could possibly be used to predict mantle viscosities for other terrestrial bodies in our solar system and may ultimately reveal how cracks can propagate through the lithospheres of planetary mantles.

References

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