



Water Speciation Around Vesicles within Obsidian Fragments from Mono Craters, CA: Testing the 'Bubble Geobarometer'

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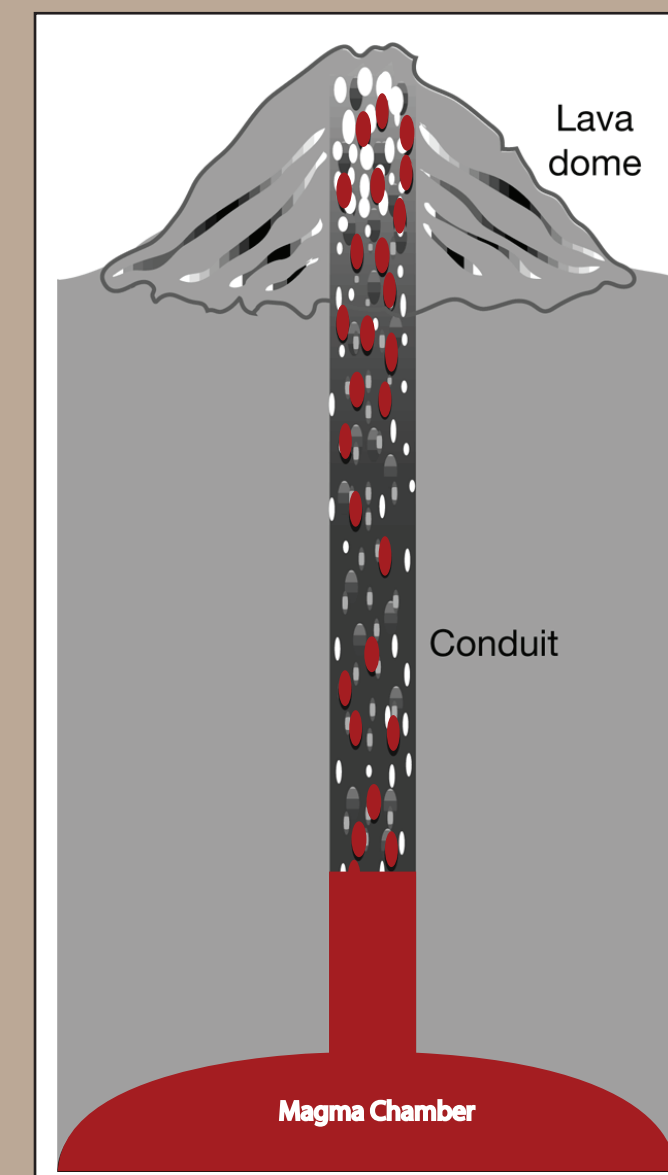
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Abstract

Obsidian glasses preserve textural evidence that multiple cycles of fragmentation and annealing occurred within magmatic conduits prior to eruption. The nature and timescales of these processes are poorly understood. Dissolved volatile concentrations provide valuable insights into eruption dynamics, as solubility and speciation are sensitive indicators to changing pressures and temperatures. Recently, Watkins et al. (2012) postulated a 'bubble geobarometry' technique utilizing water diffusion profiles around vesicles in obsidian fragments collected from tephra deposits of Mono Craters, California. They suggested that the gradients in water content were the product of volatile resorption following pressure increases of 5-30 MPa prior to eruption. To test this intriguing hypothesis, we present infrared spectroscopic measurements of dissolved water and carbon dioxide contents in Mono Craters obsidian fragments. The relative abundance of the two dissolved water species (hydroxyl and molecular water) measured in silicate glasses is a direct function of the total water content and the cooling rate of the melt. Hydration occurring at temperatures below the glass transition can thus be readily identified. We examine the variation in abundance of hydroxyl and molecular water species along hydration gradients near large vesicles to determine whether hydration occurred at magmatic or sub-magmatic temperatures.

Supervolcanoes: Why We Care

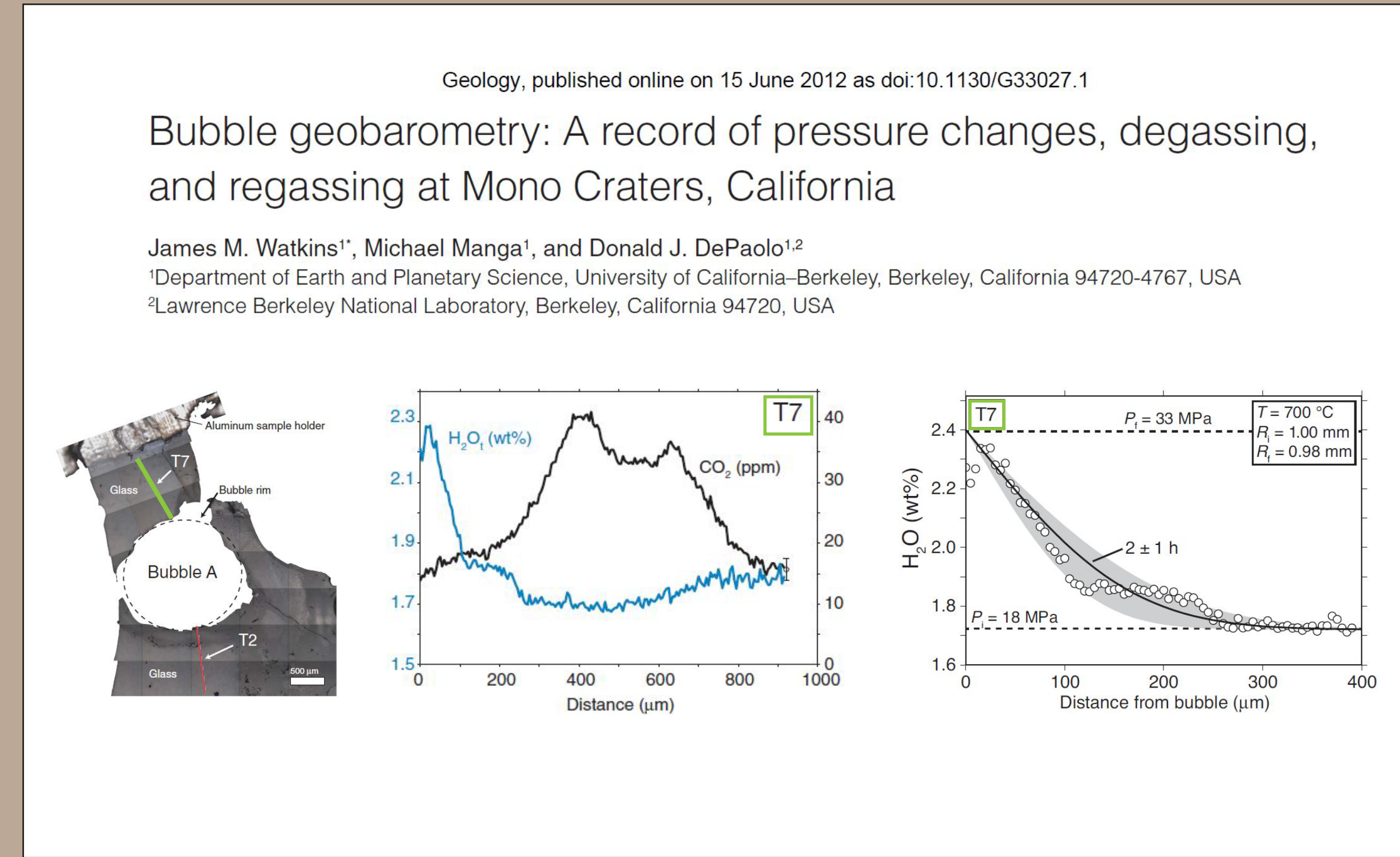
Supervolcano eruptions have dramatic impacts on Earth's environment. Major eruptions from these volcanos can decimate the global population. Dissolved volatile species control the physical properties of magma, and hence, the nature of its eruption. Detailed study of quenched volatile concentrations in eruptive glasses provides insights into the dynamics of supervolcano eruptions.



Motivation

New Insights into Rhyolite Magma Chamber Dynamics

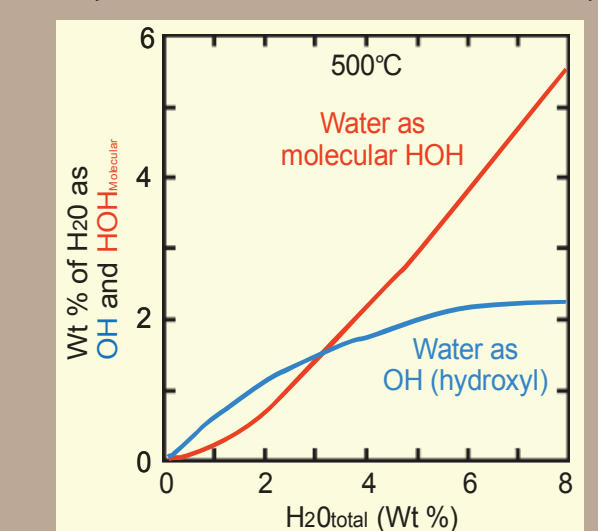
Recent studies have shown that water concentration gradients around large bubbles (>1 mm) in volcanic clasts record pressure changes occurring within the parent magma chamber just prior to eruption (Watkins et al., 2012). The measured gradients in water content provide insights into the timing of pressure and temperature changes associated with the triggering of the eruption.



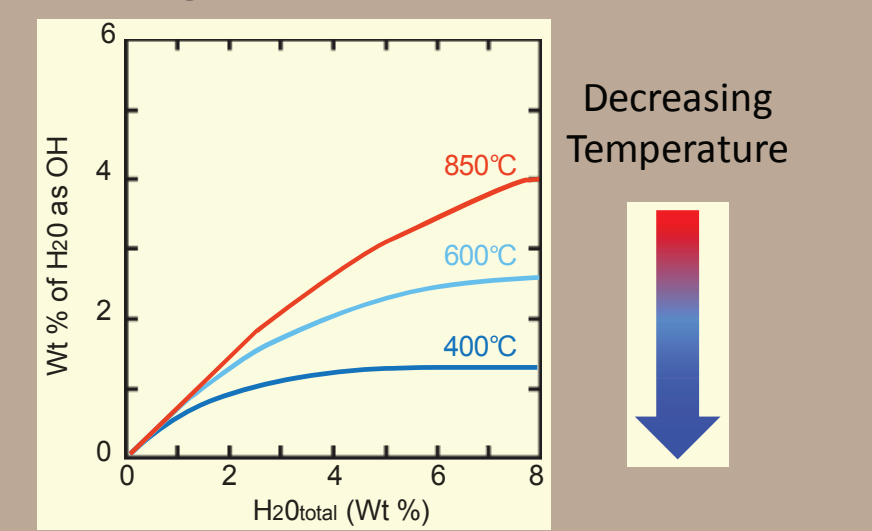
What We Can Offer: A Test of the new 'Bubble Geobarometer'

Infrared spectroscopy allows for the measurement of individual hydrous species in silicate melt (Stolper, 1982). The relative abundance of the two species (molecular and hydroxyl) records the glass transition temperature on quench during eruption (Ihinger et al., 1999).

Two Hydrous Species in Rhyolite



Fraction of Dissolved Water as OH Changes with Temperature



Sample Locality



Panum Crater
http://volcanoes.usgs.gov/volcanoes/mono_inyo_craters/

FT-IR Technique

Infrared photons can be used to detect trace constituents in obsidian. The energy of the absorbed photon correlates with the energy of the chemical bond of the trace constituents. By measuring absorbance in the IR, the total number of chemical bonds related to a particular trace species can be determined.



Sample Preparation

Obsidian clasts were mounted in graphite powder and pressed into cylindrical pucks. The pucks were sectioned using a diamond-tipped wafer blade and doubly-polished to ~300 microns thick. Large bubbles (>1 mm) were selected and analyzed using the micro-FTIR facility at UW-Eau Claire.



Results

Obsidian Clast One: Traverses 1 and 2

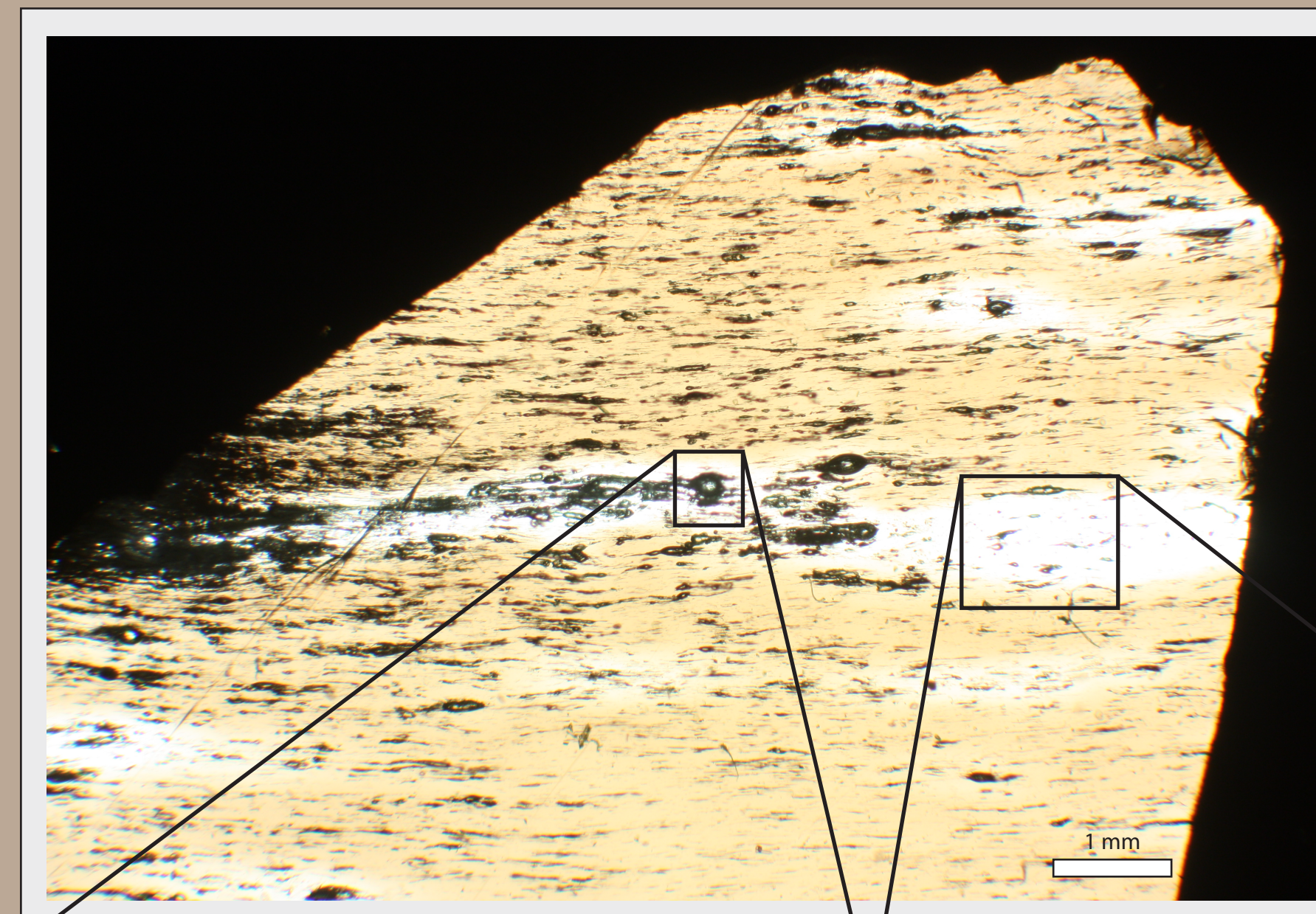


Figure 1 Polished thin section of Mono Craters obsidian clast

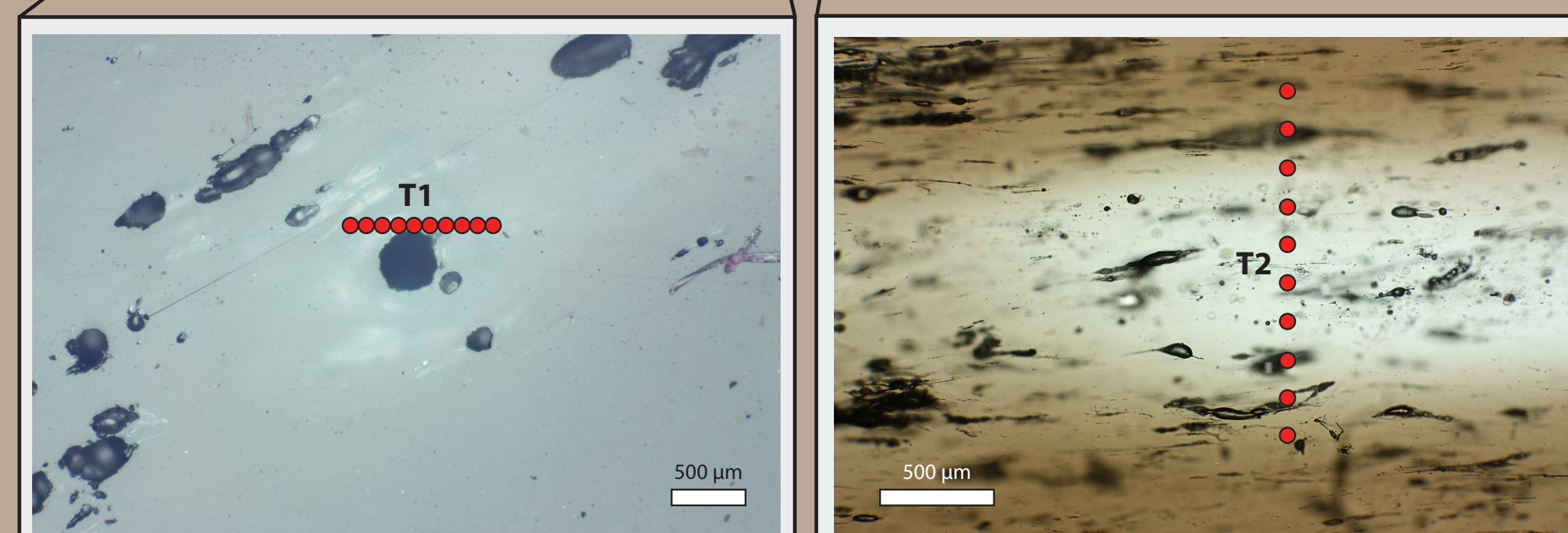


Figure 2 Analytical traverse tangent to large bubble Figure 3 Analytical traverse across light and dark banding

Obsidian Clast Two: Traverses 3 and 4

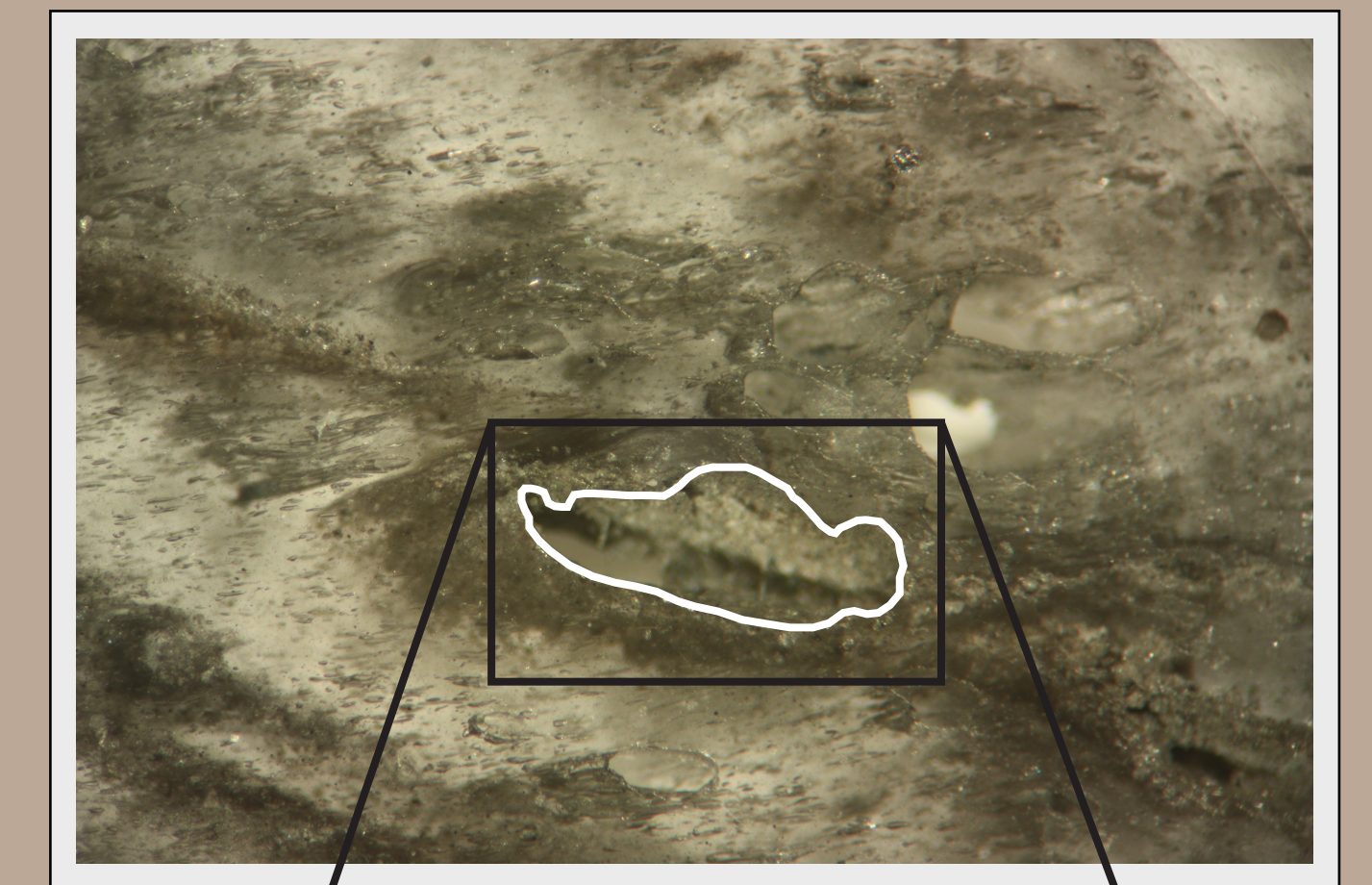


Figure 4 1.25 mm deformed bubble in doubly-polished obsidian clast

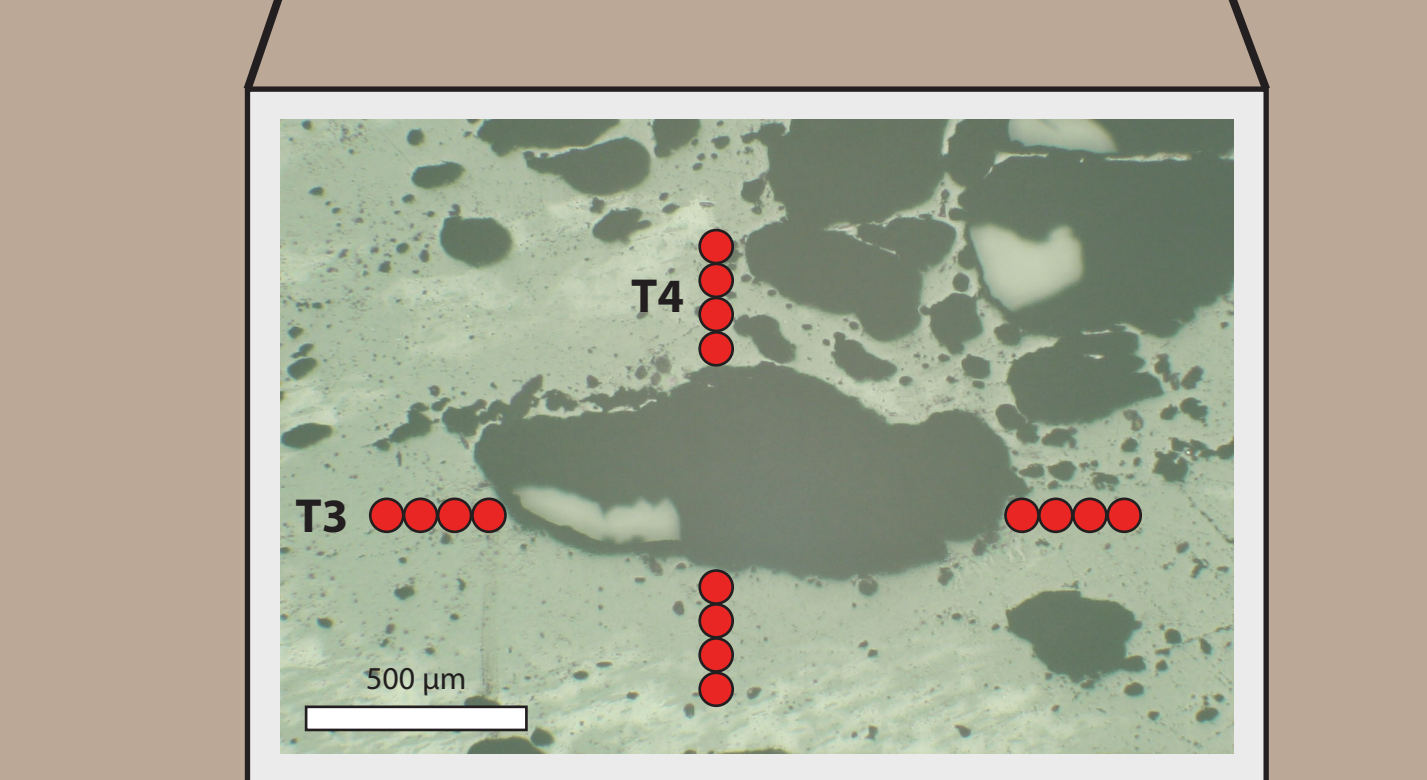
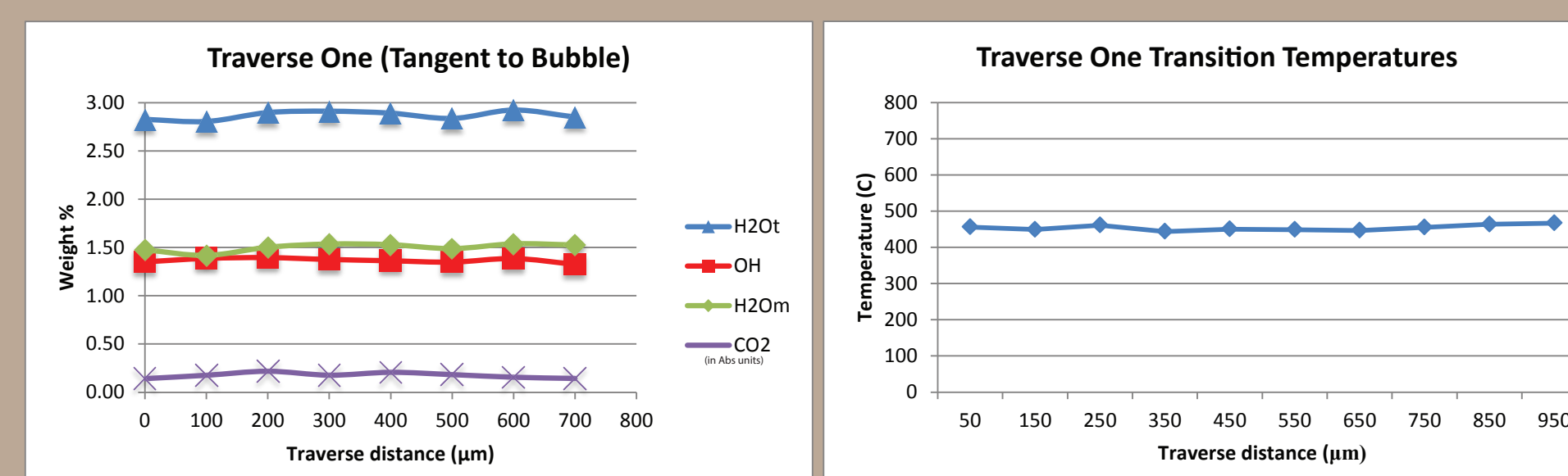
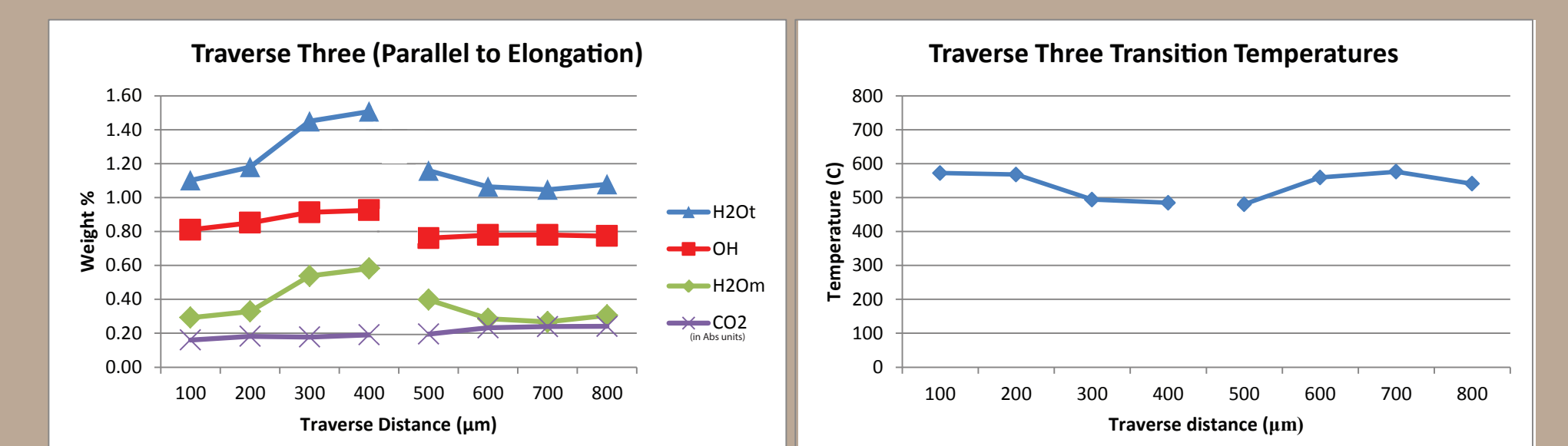


Figure 5 Vertical and horizontal traverses radial to bubble

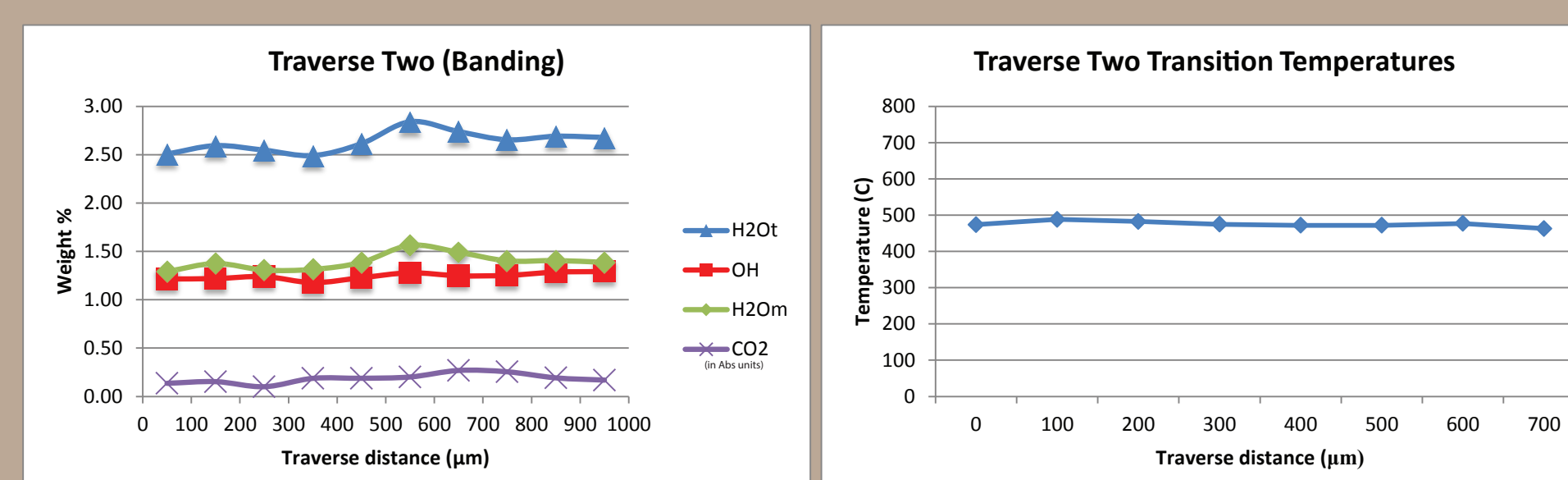
Traverse to determine variations tangential to bubble



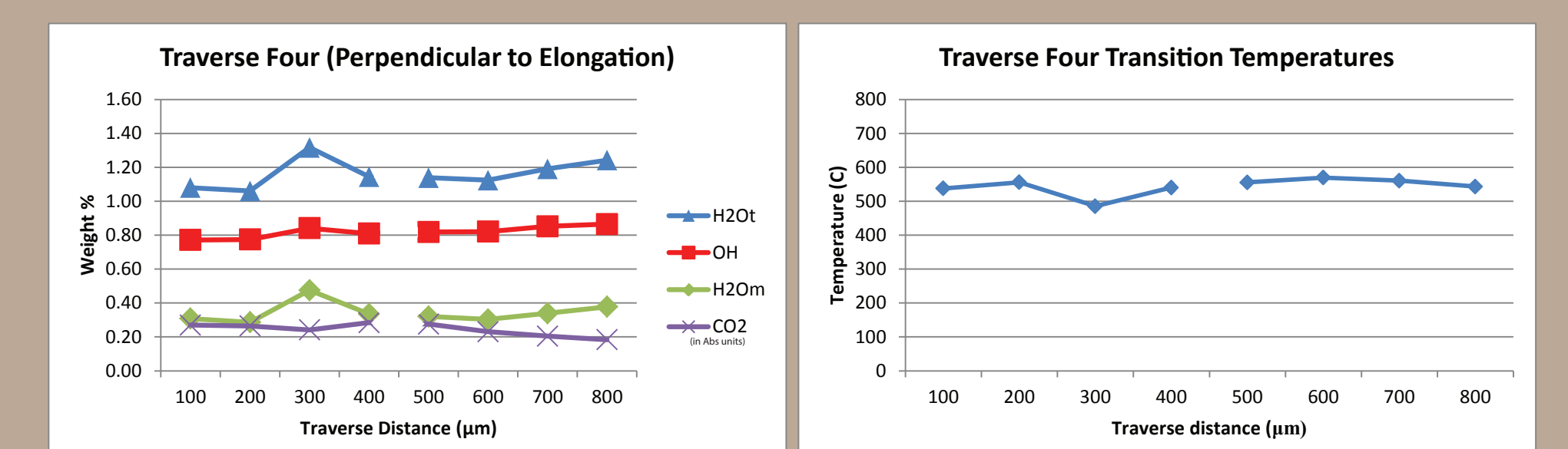
Traverse parallel to bubble elongation



Traverse to determine possible causes in dark and light banding across sample



Traverse perpendicular to bubble elongation



What's Next

We aim to examine more obsidian clasts using our sample preparation method in pursuit of large (>1 mm), isolated resorbed bubbles. Traverses exceeding several mm will be conducted away from the bubbles, with the hope of measuring glass transition temperatures that correlate with gradients in total water content.

Acknowledgements

We thank Dr. James Watkins, University of Oregon, for introducing his bubble geobarometer theory to us and for providing the samples used in our study. We also thank Professor Matthew Jewell and the Material Science Center for access to their new sample preparation facilities.

References

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Conclusions

- Hydrous species concentrations can be used to measure glass transition temperatures within glass fragments from Mono Craters, CA. We thus can set constraints on the temperature of bubble resorption used in the Bubble Geobarometer of Watkins et al., 2012;
- No water or carbon dioxide resorption was observed around the two bubbles from Mono Craters obsidian clasts that we investigated;
- No apparent relationship between water speciation, water content, carbon dioxide content, and glass transition temperature is observed across light and dark bands within obsidian clasts.