Understanding Magma Production in the Central Taupo Volcanic Zone, New Zealand using Quartz Crystal Clusters

Karina Graeter, 2014

The central Taupo Volcanic Zone (TVZ), New Zealand is one of the most productive volcanic regions on earth. This zone is composed of 8 calderas, caldron-like volcanic features which result from land collapse following the eruption of large volumes of magmatic material. The eruptions from the central TVZ calderas have produced over 10,000 km$^3$ of material in the last 1.6 Ma (Wilson et al., 1995). However, no voluminous eruptions have occurred from TVZ calderas in documented history. This lack of current activity in the central TVZ and in many caldera systems around the world means there is limited direct evidence of caldera magma dynamics. Rhyolite, a particular type of magma typical to caldera systems, is hypothesized to form at shallow depths through the separation of developing crystals and interstitial molten magma. Without direct evidence from active eruptions, my research tests this hypothesis by examining the textural evidence recorded in quartz crystals found in deposits from a large caldera eruption in the central TVZ. Through my research, I contribute to our understanding of the processes that form eruptible magma that eventually will help scientists to predict future activity of the TVZ calderas and to create models for hazard mitigation.

My research project focuses on fragments from plutons, rocks formed by magma cooling and solidifying at depth, found in the volcanic deposits of the 0.7 ka Kaharoa eruption in the central TVZ. Previous research suggests that the Kaharoa plutonic fragments were part of a solid sub-chamber or carapace at the top of a larger magma chamber that solidified at shallow depths and was then intercepted and erupted during the Kaharoa eruption event (Deering et al. 2012, Shane et al., 2012). My goal is to interpret the texture of these samples and relate the texture to the processes occurring within the magma chamber. Magma consists of primarily melt (the liquid rock), gas, and crystals. As the magma rises and cools, we hypothesize that crystals that form from the melt may cluster together. If crystals are accumulating and solidifying into plutons at a shallow depth, the Kaharoa plutonic fragments may record the dynamic processes affecting the formation of rhyolite magma.

This summer I examined quartz crystal clusters using petrographic microscopy, cathodoluminescence imaging, and electron backscatter diffraction methods to interpret the growth history of the quartz crystals accumulating in the shallow magma chamber. The grains are highly fractured, sometimes with portions of what was once a single grain separated by other crystals (Figure 1). Many quartz grains also have growth patterns that indicate they remelted slightly and then further crystallized. These details suggest that the Kaharoa plutons solidified through intermittent periods of cooling and melting. Quartz orientations, as analyzed using electron backscatter diffraction, show many crystals are oriented with their large dipyramidal faces attached (Figure 2). This attachment is interpreted to have occurred in the magma chamber through gravity -influenced settling and crystal compaction (Beane and Wiebe, 2012). Based on the data I have collected so far, I interpret that the Kaharoa plutonic lithics were directly influenced by the larger magma system throughout their formation, rather than being isolated during the cooling process. Therefore, these rocks may be further studied to understand the dynamic processes affecting magma chambers at shallow depths and how these processes might relate to the formation of rhyolite magma. I intend to continue my research through the coming year to contribute to ongoing research on the central TVZ calderas and the dynamics and 'state' of their magma chambers. Understanding the 'state' of caldera magma chambers is critically important for hazard mitigation. Eruptions from calderas can rapidly deposit high volumes of high temperature material >100km from the source. Therefore, it is imperative that scientists develop methods for determining how much magma remains in the chamber, and how likely it is for an eruption to occur. Only through developing a clearer picture of the 'state' of an underlying magmatic system can hazard mitigation models be improved.
Faculty Mentor: Rachel Beane

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References


