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Goldstein Award Summary Report
September 28, 2017

My Joseph Goldstein Scholar Award was used to purchase 24 hours of analytical time on the Cameca IMS-1280 secondary ion mass spectrometer (SIMS) at the Northeast National Ion Microprobe Facility (NENIMF) at Woods Hole Oceanographic Institute (WHOI). I visited WHOI on July 31, 2017 to spend the day collecting trace element measurements of natural and synthetic quartz crystals. Given my past experiences running the SIMS, which enabled me to maximize time efficiency during my visit, combined with the clear and concise objectives of my project, I was able to use the funds provided by the Goldstein Award to support an immensely productive day of data collection that provided all of the measurements necessary to complete my outlined research project.

I submitted a proposal for a Goldstein Award to support a project I have been working on to develop microanalytical reference materials for trace element analysis of quartz. This work originated as a "side project" that began after realizing the need amongst the analytical community for reference materials to evaluate the accuracy and precision of quartz trace element measurements. Specifically, trace-level Ti and Al concentrations in quartz have been shown to be indicative of pressures and temperatures of crystallization, and therefore could be useful for constraining petrologic formation conditions. However, to apply these techniques it is necessary to measure parts per million-level variations in concentration from micron-scale features in minerals, and this challenging analytical task has introduced error into measurements that has limited the accuracy of petrologic reconstructions. To improve on the confidence of trace element measurements, it is necessary to verify the precision and accuracy of an analytical routine by analyzing reference materials, but to date there does not exist a widely-available suite of quartz reference materials suitable for trace element analysis. For this reason, I began running high pressure-temperature crystallization experiments to grow quartz crystals with consistent and homogeneous trace element contents (Fig. 1). Having access to the electron probe that I manage at Syracuse University enabled me to test my synthetic quartz crystals with EPMA, but in order to fully characterize these materials prior to distribution and publication, it was necessary to conduct ion probe analyses using SIMS to improve the precision of analytical measurements. For this reason, I sought out a Goldstein Award to support my visit to use the ion probe at WHOI.

During my visit to the SIMS, I was able to measure (at 15 minutes per analysis) a total of 68 different crystals grown in several different crystallization experiments. SIMS results demonstrate excellent consistency between crystals from the same experiment, and measurements of samples from different experiments with different concentrations were used to generate a SIMS working curve (Fig. 2). This working curve improves on past analytical working curves that were generated with fewer crystals or with glasses. Results obtained from this research were presented in an invited talk at the Microscopy and Microanalysis 2017 meeting in the session *"Standards, Reference Materials, and Their Applications in Quantitative Microanalysis"*. Following exposure generated from my talk at M&M, I have already begun distributing these materials to a handful of different labs, with more to come. This experience enabled me to network with researchers at WHOI that will foster future collaborations with this facility. Finally, and most importantly, I am currently preparing this work for publication (in collaboration with scientists at WHOI) to disseminate this research and the associated reference materials. Thank you to the *Microanalysis Society*, the *Meteoritical Society*, and *Springer* for supporting my Goldstein Scholar Award that enabled me to design and undertake an independent research project that will serve to benefit my career and the wider microanalytical community.

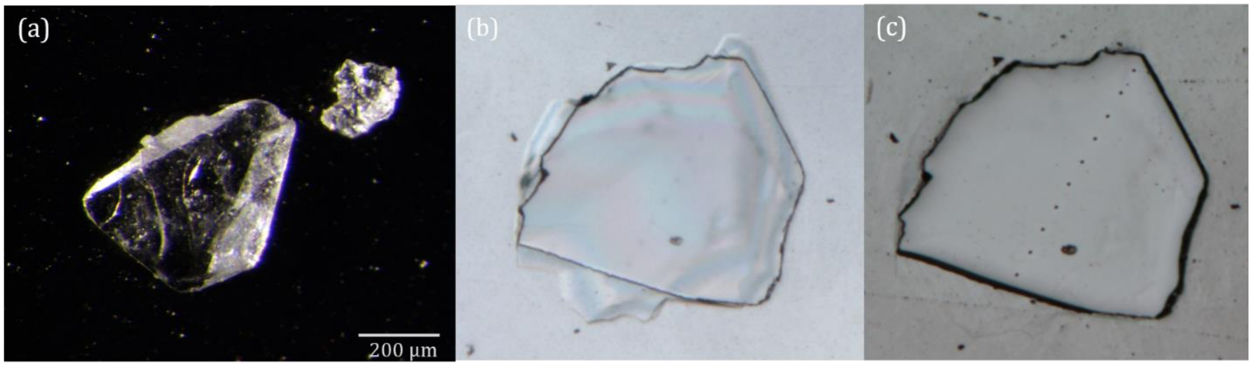

Figure 1. Photographs of an experimentally-grown quartz crystal prior to mounting (a), after mounting and polishing (b), and after analysis with EPMA (c).

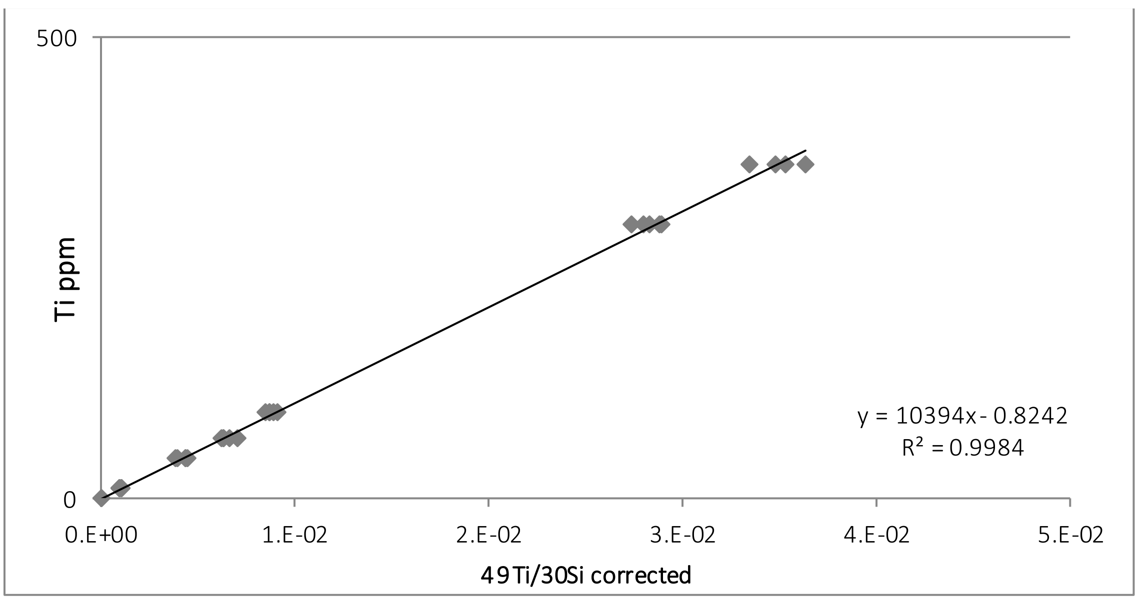

Figure 2. Working curve generated for SIMS analysis of Ti concentrations in quartz, showing the expected Ti concentration (in ppm Ti) for a given isotope ratio measured with SIMS ($^{49}Ti/^{30}Si$). This plot contains SIMS data from six experimental quartz samples and one natural sample and spans the Ti concentrations expected for quartz crystallization in nearly all geologic settings. By synthesizing quartz with a wide range of Ti concentrations (10-360 ppm) and using natural quartz with a nearly "blank" Ti concentration (0.003 ppm), it is possible to obtain accurate and precise SIMS measurements at all concentrations expected for natural rocks.