32nd ANNUAL WINTER MEETING OF THE MINERAL DEPOSIT STUDIES GROUP / APPLIED MINERALOGY GROUP

This year, the Applied Mineralogy Group of the Mineralogical Society co-convened the annual winter meeting of the Mineral Deposit Studies Group. Camborne School of Mines (University of Exeter) hosted the meeting on the newly built Combined Universities in Cornwall campus near Falmouth. It attracted 120 delegates from universities and industry with ~50% being postgraduate students. Following established tradition, the meeting was generously supported by industry (Barrick, Anglo American, Rio Tinto, Golder Associates, SRK Consulting, Helio Resources, and Boliden). The highlights of the meeting included two field excursions, two special sessions, and a workshop entitled 'The Application of Mineralogical Characterization to Processing and Exploration'. The conference dinner was held at the National Maritime Museum Cornwall in Falmouth.

The programme started with an excursion to the classical mining districts of West Cornwall, led by Robin Shail and Peter Scott. This trip visited some of the most impressive locations within a landscape that is now protected under the Cornish Mining World Heritage Site. After a visit to Cape Cornwall, Botallack and Levant, the delegates enjoyed a Cornish pasty lunch at Geevor mine, which was one of the last operating tin mines in Cornwall. The afternoon offered an opportunity to go underground at Rosevale mine near Zennor.

Tony Clarke demonstrating the flotation of sulphides to workshop participants

The highlights of the academic programme were the two special sessions. Robert Schouwstra (Anglo Research, South Africa) gave the keynote address in the 'Mineralogy in Mineral Processing' session. His presentation explored the need for mineralogical characterization in the extractive industries, with particular examples from the South African platinum industry. The other presentations served to highlight the profound significance of automated mineral characterization (via QEMSCAN® or MLA) in modern mining operations (ore and waste characterization, as well as process optimization). In the 'Ore Deposits Related to Acid Magmatism' special session, Michel Cuney (CNRS, France) presented the keynote address on uranium deposits related to granitoids. His talk highlighted the significance of granite petrogenesis for uranium exploration. The session reflected the broad spectrum of ore deposits related to acid magmatism. The general sessions included presentations on a wide variety of mineral deposit types and locations, from the traditional sulphide-related resources to laterite ores and non-sulphide zinc deposits. Elizabeth Sharman (McGill University) received the prize for the best student poster (sponsored by Anglo American) for her study of multiple sulphur isotopes in the investigation of volcanogenic massive sulphides. Rob Thorne (Southampton University) earned the prize for the best student oral presentation (sponsored by Rio Tinto and presented by Barry Stoffell) on the Çaldağnickel laterite deposit in Turkey.

Elizabeth Sharman receiving the Anglo American prize for the best student poster from Chris Carlon

The main sessions of the meeting were followed by a workshop on the application of mineralogical characterization to processing and exploration. The workshop offered an opportunity to visit the laboratories for mineral processing and analysis at Camborne School of Mines. Richard Pascoe (Camborne School of Mines) opened the workshop with a general introduction to mineral processing. This was followed by a presentation by Sarah Prout (SGS, Lakefield) on the use of mineralogical characterization for exploration and processing at SGS. The practical programme included demonstrations of the major industrial mineral processing technologies (sensor-based sorting, shaking tables, hydrocyclones, dense-media separation, magnetic and electrostatic separation, flotation), as well as an introduction to modern technologies for mineralogical characterization (including the QEMSCAN®) and analysis (electron microprobe and chemical analysis).

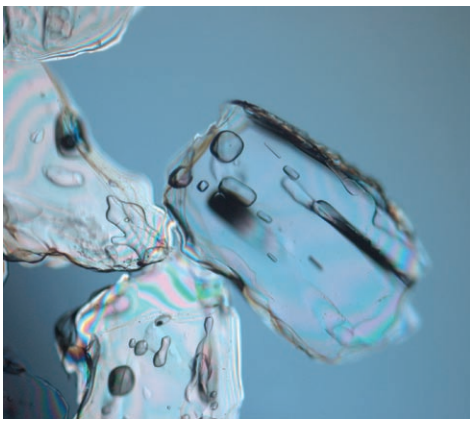
The final day offered a joint excursion with the Ussher Society, led by Richard Scrivener (British Geological Survey) and John Cowley (Wolf Minerals), to the Hemerdon Ball tungsten mine on the edge of Dartmoor in South Devon. The mine site is under licence to Wolf Minerals and scheduled to resume production of tungsten and tin in 2010. It was in production up until 1944 and is considered to contain one of the largest unexploited tungsten deposits in the world.

Jens C. Andersen
Member of the Organizing Committee

MINERALS, INCLUSIONS AND VOLCANIC PROCESSES

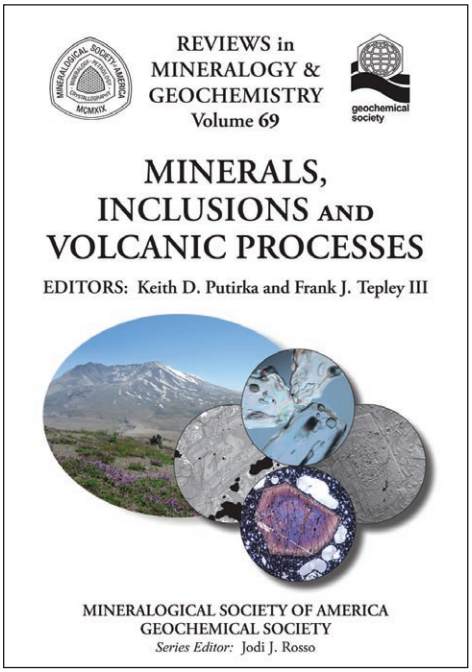
MINERALOGICAL SOCIETY OF AMERICA AND GEOCHEMICAL SOCIETY SHORT COURSE

Minerals and their inclusions have long been used to understand magmatic systems (Sorby 1858; Roedder 1965). New interest relative to volcanic systems was sparked by Anderson and Wright (1972), Eichelberger (1975), Anderson (1976), and Dungan and Rhodes (1978), among others. Recent advances in microanalytical techniques (e.g. Davidson et al. 1990) have greatly accelerated this work, highlighting the potential for improved views of magma plumbing systems (Marsh 1996). The short course "Minerals, Inclusions and Volcanic Processes", was organized by us to summarize where these earlier strands of research have branched, with the hope of initiating new collaborations based on an alliance of complementary techniques. The prospects for such were perhaps indicated by the broad range of backgrounds of the 207 attendees at the short course held on December 13–14, 2008, in San Francisco.



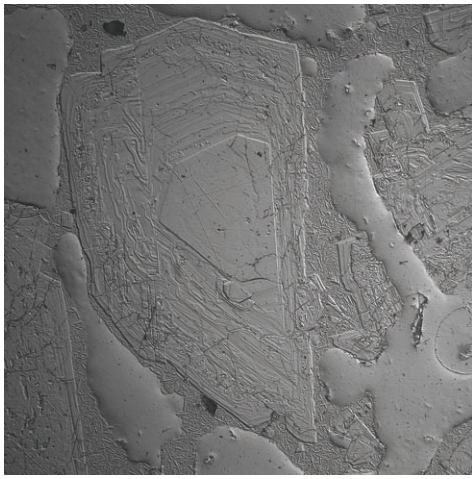
Fluid inclusions in quartz. Photo C. Schnyder and O. Bachman

Julia Hammer began the session with a review of crystal kinetics. She illustrated the importance of undercooling in forming various mineral textures—including melt inclusions. She also noted that crystal growth rates decrease with time as crystals and liquid approach equilibrium, implying that true instantaneous growth rates are perhaps only captured in the earliest moments of dynamic experiments. Keith Putirka discussed mineral–melt-based thermometers and barometers, with an emphasis on tests of equilibrium. Putirka showed that dynamic experiments can be used to test our "tests of equilibrium" and that independent tests or, better yet, independent *P*–*T* estimates, are crucial to narrowing uncertainty. Lawford Anderson showed applications of thermobarometry to granitoids in California. In some plutons, Ti-in-zircon thermometry yields temperatures ranging from the granite solidus to the liquidus, but Anderson warned that though these *T* ranges may be real, the activities of trace components are sensitive to mineralogy and liquid composition and new experiments are needed. Thor Hansteen and Andreas Klügel reviewed methods to estimate pressures from fluid inclusions. These estimates can be very precise if inclusions are homogeneous and isochoric, and if they remain closed ("Roedder's Rules"). But even where closure is violated, Hansteen and Klügel showed that frequency plots of *P* estimates yield peaks that can be correlated to depths of magma storage. An additional promising result is that fluid inclusions and mineral–melt equilibria in some instances yield similar pressure ranges.



Jon Blundy presented a multifaceted study of Mount St. Helens, performed in collaboration with Katherine Cashman. There, mineral textures, melt inclusions, and several thermometers and barometers yield an internally consistent picture of the magma plumbing system and degassing rates. Blundy also showed a *P*–*T* diagram illustrating gradients in crystallinity and volatile saturation, emphasizing that minerals may record this variability, with *T* being a proxy for proximity to a chamber wall. Malcolm Rutherford summarized magma ascent rates as determined by experimental investigations. Magma ascent rates from amphibole-breakdown reactions are similar to those from decompression-induced crystallization (ca. 0.2 m/s at Mount St. Helens), and within an order of magnitude of estimates derived from seismicity (0.6 m/s at Mount St. Helens). Ascent rates are also correlated with explosivity, indicating an important petrologic forensic tool.

Nicole Métrich and Paul Wallace examined volatile contents and showed that fluid inclusions yield higher pressures than melt inclusions



Plagioclase from Arenal Volcano, Costa Rica. Nomarski image from M. Streck

and that inclusions from one sample can yield a range of saturation pressures. This implies that inclusion capture is concurrent with magma rise and that melt inclusions record shallower-level degassing and crystallization. Gordon Moore showed that CO_2 and H_2O solubilities are sensitive to melt composition and are interdependent, and he noted that saturation models thus should not be extrapolated. The models of Newman and Lowenstern (2002) (VolatileCalc) and Papale et al. (2006) account for compositional variations in mixed CO_2–H_2O-bearing melts. Both work well for rhyolites, while the Papale et al. model is better for mafic systems.

Adam Kent began the second day discussing how melt inclusions capture a wider range of complexity than revealed by whole rocks. He showed how Ca/Al ratios can differentiate whether melt inclusions trap far-field or near-field melts (Faure and Schiano 2005), and he concluded that most trap far-field compositions. Frank Ramos and Frank Tepley summarized isotopic microsampling procedures. They showed examples where individual crystals yield cores in isotopic disequilibrium and rims in equilibrium with adjacent glass. Intergrain heterogeneity may result from age differences and/or mixing between two components. Ilya Bindeman surveyed oxygen isotopes from single crystals and demonstrated how O isotopes are especially powerful for identifying hydrothermally altered components in magmatic systems. And because O diffuses slowly, heterogeneity is preserved over long timescales. Kari Cooper and Mary Reid reviewed timescales from U-series crystal ages. At Lacher See, some flows yield identical mineral and whole-rock eruption ages, but early evolved flows (presumably from the top of the magma chamber) host minerals that are 17 ky older than recorded by the whole-rock system—perhaps indicating a minimum subterranean life span of the eruptive system. Fidel Costa provided an overview of timescales from diffusion profiles. Diffusion profiles yield much shorter timescales than U-series methods; very young ages (mostly <100 y) reflect entrainment of

older crystals and periods of crystal overgrowth. The Bishop Tuff, for example, yields diffusive timescales of ~100 y, reflecting late-stage reheating and overgrowth.

Martin Streck reviewed mineral textures and emphasized that genetic terms like"xenocryst" and "antecryst" lose meaning when individual crystals are composites of multiple growth (and dissolution) events. Optical methods reveal different types of zoning and, at Arenal, yield a precise enumeration of five magmatic events. The following discussion, however, indicated that fewer students are being trained to use a petrographic microscope. Pietro Armienti reviewed crystal size distributions (CSDs); he showed that, properly measured, CSDs are independent of sampling scale (from 7 cm^2 to >800 cm^2 at Mt. Etna). At Mt. Etna, near-vent samples have CSDs identical to downstream samples, indicating that crystallization occurred prior to eruption. Armienti also showed that peaks in CSDs may indicate degassing.

George Bergantz presented work done in collaboration with Olivier Bachman on the physical mechanisms of magma mixing. Bergantz noted that the "Daly gap" in SiO_2 is found in some arcs, while others are strikingly homogeneous (monotonous intermediates of Hildreth 1981). Sluggish convection can create heterogeneities as plumes produce thermal/chemical gradients, especially if the Reynolds number is low (Re <1). At high Re (>10^4), heterogeneities can also be produced if convection is limited to a single overturn. Monotonous intermediates may reflect multiple overturn events, despite their being SiO_2- and crystal-rich (and so resistant to convection).

Although recent advancements spurred the organization of the short course and publication of the accompanying volume, there remains a clear need for additional work. New experimental data are needed to better understand volatile saturation, equations of state for mixed fluids, and crystal growth. Many current lines of investigation are complementary and can be used to great effect in concert: U-series ages appear to indicate the earliest stages of magma generation, while diffusion-profile ages inform us of later transport. Mineral–melt barometers inform us about the deeper parts of volcanic systems, and volatile-saturated equilibria inform us of the shallower part; fluid inclusions appear to record both, perhaps with higher precision. An alliance of methods can provide key tests of our assumptions and interpretations. To the extent that such tests yield a coherent picture of a volcanic system, the advances outlined at the short course and in the volume illustrate the promise of petrology and mineralogy for affording fundamental tests of the evolution of magma storage, transport, and eruption.

CHECK *GEOCHEMICAL NEWS* JULY 2009 FOR A LONGER VERSION OF THIS REPORT.

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ELEMENTS IN THE CLASSROOM

I am an associate professor of geochemistry in a geological engineering school in France, the Institut Polytechnique LaSalle Beauvais. I enjoy reading *Elements* magazine and have used it in my geochemistry class. This semester, I decided to make further use of *Elements* in my hydrogeochemistry (master 1) class. I chose four themes, arsenic, phosphates, nanoparticles, and uranium, that have been covered by *Elements* issues "Arsenic", "The Nuclear Fuel Cycle", "Energy", "The Critical Zone", "Phosphates and Global Sustainability", "Carbon Dioxide Sequestration" and "Nanogeoscience." Each student was partnered with a classmate and asked to read an article and make a short presentation (10 minutes) about it to the whole class.

Students were very pleased with the selected subjects and enjoyed reading and listening about each broad theme. Even if most of my students will specialize in Environment and Development, they have realized how chemistry and even physics are intimately linked with geology and how they need to be familiar with field geology. Thus, the subjects of phosphate and arsenic were more amenable to them, and the nanoparticle theme required a little more preparation. In the future, I hope to expand such presentations to the entire master 1 level and involve students from the "Energy and Minerals" program. I have enclosed a photograph of my class.

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