Summary of Bokan Mtn Fluid Inclusion Work

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The first week or two I was here I spent largely reading about fluid inclusions (primarily in the *Fluid Inclusions: Analysis and Interpretation* book that Al gave me). I also spent some time organizing and doing inventory on samples from Alaska that Cliff Taylor and John Philpotts had collected in the early '90's. Only a few of these samples were actually from Bokan, most were from surrounding areas, including Dora Bay.

Petrography

Once I had a decent understanding of fluid inclusions, I began to look at the Bokan Mountain thick sections that Al had made (DR25B1, DR25E, DR26B1, DR28C, DR28F, DR28G, DR255A1, DR255B, 10BM05-1, 10BM06 and 10BMAG). All of the samples that begin with DR were collected by Doug Stoesser from buckets essentially filled with rock from prospect pits at Bokan Mountain. The 10BM samples were collected by Brad Van Gosen.

All of samples had quartz grains that were full of inclusions, many of which belonged to indiscernible assemblages. Basically it is a big mess of cross-cutting inclusion trails that appear to be secondary, possibly healed fractures. The majority of the inclusions observed petrographically are small (< 15 microns), about half irregularly shaped and half negative crystals, and generally 3 phase inclusions (aqueous phase, liquid CO2 and vapor CO2). Some of the inclusions appear to be 2 phase at room temperature, but upon microthermometric analyses, these inclusions were shown to be H2O-NaCl-CO2 inclusions with a CO2 homogenization temperature below room temperature. It also appears that there are some mineral inclusions in the quartz.

Quartz CL

In an attempt to classify the inclusions as primary or relate them directly to REE mineralization, I spent 3 days on the SEM taking CL images of the inclusion-rich quartz. This work was largely done in vain as virtually none of the quartz in any of the samples showed any texture whatsoever (other than radiation haloes), with the exception of 10BMAG, which has some oscillatory zoning present (no inclusion assemblages could be related to this zoning though). After collecting the CL images, I spent some time taking photomicrographs of the same grains in an attempt to correlate inclusions with CL signatures. I created PDF and Powerpoint files of all of the areas that CL imaging was done on.

We also spent 1 afternoon on the newer SEM using the color CL detector to see if it could show us anything that the old SEM black and white CL didn't. This was also unsuccessful as we found no additional textures to speak of.

Microthermometry

The majority of the analyses I conducted on the Bokan Mountain samples were on microthermometry. As mentioned above, almost all of the inclusions looked at are H2O-CO2-NaCl. The CO2 gas phase was confirmed by a CO2 melting temperature of -56.6°C in nearly all of the inclusions, with the exception 3 inclusions in sample DR28F chip #3. These inclusions were analyzed on the Raman and found to have only CO2 in the gas phase, which implies that the anomalous CO2 melting temperatures must have been the result of a glitch with the heating stage.

Overall, there appeared to be two main classes of inclusions, at least in terms of microthermometric behavior. Both classes are H2O-CO2-NaCl inclusions, but one class behaved under Q2 melting conditions, that is, the clathrate melt occurred in the presence of both a liquid and vapor CO2 phase. The other class did not follow Q2 melting conditions, and the CO2 homogenization temperature had to be determined in the metastable absence of a clathrate. Clathrate melting temperatures for the Q2 class range from 3.5 to 8.2°C and CO2 homogenization temperatures range from 18.4 to 29.7°C. Clathrate melting temperatures of the non-Q2 class range from 5.4 to 8.7°C and CO2 homogenization temperatures range from -12.9 to 4.9°C.

Once CO2 melting, clathrate melting and CO2 homogenization temperatures had been determined, I continued with total homogenization microthermometry. The first few chips I did total homogenization on need to be taken with a grain of salt, because I did not know about the phenomenon of fluid inclusion stretching during heating, leading to anomalously high total homogenization temperatures. These chips include: DR25E chip #5, DR25E chip #1, and DR28F chip #1. Once I realized that stretching was occurring, I was able to perform more competent analyses on the remaining samples, which include: DR28F chip #5, DR28F chip #4 and 10BMAG chip #4. Overall, a large percentage of the inclusions either stretched or decrepitated fully upon heating, anywhere from 175 to 321°C.

I took all of the microthermometry data and plugged it into the appropriate Bakker program to determine bulk properties and calculate isochores. Homogenization temperatures of the ‘competent’ analyses range from about 230 to 300°C and homogenization pressures range from about 1.2 to 2.8 kbar. An independent measure of pressure or temperature is needed in order to determine the trapping conditions.

Carbon Isotope Analyses

The final week of my internship we began a carbon isotope analysis in an attempt to compare the carbon isotope signature of the fluid inclusions to that of the REE fluorocarbonate minerals. Al and I extracted CO2 from inclusions in samples DR25E and DR28F, while Craig and I extracted CO2 from powdered whole rock samples that contained the fluorocarbonate minerals (DR25A, DR25C, DR28D and DR28F). However, the yield of the fluorocarbonate samples was much less than expected for 3 of the samples, suggesting that perhaps the fluorocarbonate minerals were not actually reacting with the acid and the only sample that did produce the expected amount of CO2 is rich in calcite (DR28D). This analysis was not quite complete by the time I left.