

Analysis of Decrepitate Mounds as a Compliment to Fluid Inclusion Thermometric Data: Case Studies from Granitic environments in Nova Scotia and Peru¹

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Introduction

Thermometric analyses, that is ice melting temperatures, of fluid inclusions is a rapid method of obtaining bulk chemical compositions (i.e., wt. % equiv. NaCl) and, as such, is a valuable non-destructive means of estimating fluid chemistry. In addition, integration of carefully measured phase changes (i.e., eutectic measurements) during low-temperature runs with known phase changes in the chemically appropriate binary (e.g., MgCl₂-H₂O, CaCl₂-H₂O) and ternary (e.g., CaCl₂-NaCl-H₂O) systems allows more precise estimates of the solute chemistry of fluid inclusions. However, the difficulty of discriminating between low- to moderate-salinity fluids dominated by NaCl or KCl, as well as limited data for more complex multi-component systems (e.g., Fe, Mn, Sr, Ba) limits estimates of the fluid chemistry. Although a variety of nondestructive and destructive methods are available for determining the major, trace and minor element solute chemistry of fluid inclusions, a relatively simple and efficient method underutilized is analysis of fluid inclusion decrepitate mounds. Although the method was first discussed and applied by Eadington (1974), it was the work of Haynes et al. (1988) on synthetic inclusions that demonstrated that this was a reliable semi-quantitative method to obtain cation and anion analysis of fluid inclusions. Subsequently, Haynes and Kesler (1987) successfully applied decrepitate analysis to the study of MVT-style mineralization in the East Tennessee and Pine Point districts and recognized the importance of reduced S in these systems. More recently, Savard and Chi (1998) used similar methods to analyze mineralizing fluids that formed the MVT deposits in Maritimes of eastern Canada. In another successful study, Chryssoulis and Wilkinson (1983) applied decrepitate analysis to show that quartz megacrysts in mineralized granite of San Luis Potosi, Mexico, contains fluid inclusions with several wt. % each of Na, K, Ca, Mn, Fe and Ag.

The present study focuses on integrating decrepitate analysis with standard thermometric measurements in order to determine the cation chemistry of fluids in a variety of granitic settings. These examples include greisen Sn-base metal mineralization at East Kemptville, Nova Scotia, a pegmatite-aplite system in the South Mountain Batholith, Nova Scotia, and the San Rafael tin-base metal vein system in Peru. Samples were decrepitated on the fluid inclusion stage (U.S.G.S.-type gas flow) and subsequently imaged and analyzed with an electron microprobe at Dalhousie University, Halifax, using an EDS technique. The decrepitate analysis suggest a distinct fluid chemistry for mineralized versus barren systems that may have implications for exploration.

Environments

East Kemptville, Nova Scotia: The host topaz-muscovite leucogranite occurs as the chemical fractionate of

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the zoned Davis Lake biotite monzogranite, itself part of the large, peraluminous 370 Ma South Mountain Batholith of southern Nova Scotia. The upper contact of the granite, proximal metasedimentary rocks, is marked by a chilled zoned and layered aplite-pegmatites with unidirectional solidification textures (UST's) occur. Mineralization occurs as zoned cassiterite-topaz-sulphide greisens and sulphide veins. Fluid inclusion studies of altered granite, pegmatites, greisens and veins indicates the mineralizing fluids exsolved from an evolved granitic melt at $\leq 550\text{--}600^\circ\text{C}$ with bulk composition of 20-40 wt. % equiv. NaCl. Decrepitate analysis were obtained for quartz and cassiterite from two pegmatites, quartz from a cassiterite-bearing miarolitic cavity, and quartz in a sulphide vein. The data indicate the common cations, in descending order, are Na, K, Fe, Mn, Ca, Sr and Ba; Zn and P were mainly detected in the vein sample. The dominant anion is Cl and minor S occurs. Although discrete phases of halite and sylvite occur, most mounds are mixed Na-K-Fe-Mn-Ca salts. The striking feature of the mounds at East Kemptville is the abundance of cations other than Na and K, in particular those elements that would otherwise go undetected.

Peggys Cove, Nova Scotia: Biotite monzogranite of the 370 Ma South Mountain Batholith occurs in close proximity to the Lower Paleozoic Meguma Group, a thick sequence of metaturbiditic rocks locally enriched in carbonate. The monzogranite is cut by abundant, undulating sheets of zoned aplite-pegmatite. The pegmatites contain comb K-feldspar layers, the aplites have well-developed line-rock texture, and coarse quartz-muscovite-tourmaline pods core pegmatites. Fluid inclusions in pegmatitic quartz are both aqueous (L-V, L-V-Halite) and mixed aqueous-carbonic types. The former are interpreted to be exsolved magmatic brines, whereas the later are considered to involve influx of exocontact fluids derived from Meguma Group sedimentary rocks. Low-temperature measurements (i.e., freezing runs) and projection of results into the NaCl-CaCl₂-H₂O ternary indicate three compositional groups of fluid inclusions: (1) a Na(-K) fluid; (2) a Na-Ca fluid; and (3) a Ca-rich fluid. Analysis of decrepitate mounds confirms the three compositional groups in terms of the cationic proportions of Na-K-Ca. The chemistry of the fluid is considered to trace the evolution of a magmatic fluid from early K-rich to one of Na-rich nature that reflects fluid:rock interaction at declining temperatures. The Ca-signature, along with trace amounts of S, reflects the incursion of an exotic fluid equilibrated with the Meguma Group metasedimentary rocks. The chemistry contrasts markedly with that at East Kemptville in that Fe and other cations were not detected.

San Rafael, Peru: In southern Peru, an epizonal, 25 Ma biotite-cordierite monzogranite stock intruding Lower Paleozoic metasandstones and metasilstones contains a high-grade lode tin deposit (ca. 36,685 t tin concentrate in 2000). The mineralization occurs as vertically-zoned, high-grade Sn-Cu chloritic lodes. Abundant, secondary fluid inclusions sporadically distributed in the quartz megacrysts contain moderate- to hypersaline fluid inclusions and record a system that first boiled and then underwent dilution due to incursion of meteoric water. A similar fluid evolution is recorded by fluid inclusions hosted by vein quartz and cassiterite. Decrepitate analysis of fluid inclusions in the quartz megacrysts indicate three distinct fluid compositions, these being Na-, K- and Ca-rich with the Na-rich fluid most abundant. These fluids are also enriched in other cations, most notably Fe with minor to trace Mn and Mg also present.

Discussion

Analysis of decrepitate mounds is a relatively easy and rapid method for providing additional information on the chemistry of fluid inclusions. An interesting result of this study is that the two tin-base metal mineralized systems are also characterized by the presence of Fe ($\pm\text{Mn}\pm\text{Sr}\pm\text{Ba}$). Given the relative ease of acquiring such data, it is suggested that it become a more routine method of characterizing the chemistry of fluids during fluid inclusion work. With time, the implications of the Fe-enrichment in mineralized systems may be realized and its implications applied.

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