geoconvention
Virtual Event
September 21-23
2020
CSPG • CSEG • CWLS • GAC • MAC • IAH

Application of cathodoluminescence to tracking metasomatism in intrusion-related ore settings

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Summary

The role of metasomatism, herein considered as chemical change (i.e., ΔC) in a unit volume of material (i.e., mineral or rock), in various hydrothermal ore settings has long been appreciated, but the scale and imprint of the process varies widely - from cryptic to intense and local to pervasive. Recognizing the development and scale of ΔC is important, as in some cases it is accompanied by textural preservation such that it masks the important chemical processes and hence ΔC is neither recognized nor appreciated in terms of fluid:rock interactions which can also affect other chemical parameters (e.g., isotopic signatures). The latter is well illustrated in felsic intrusive settings, particularly those related to mineralization, by the commonly observed albitization of primary plagioclase (An20-30) or orthoclase (Or100) replacing primary sanidine (Or70Ab30). In both these cases, the products of ΔC, neomorphic feldspar phases, are inundated with fluid inclusions which attests to coupled dissolution precipitation (CDP) accompanying the reactions. Despite such observations, many such rocks are described in the literature as "fresh" or at best "least altered". Cathodoluminescence (CL) provides the means to detect subtle chemical and textural variation in mineral phases and thus has been widely used for example in the study of carbonate rocks and magmatic and hydrothermal quartz. Here we apply CL to trace how multiple mineral phases react to fluid ingress by using an instrument capable of capturing high-quality, polychromatic (i.e., true colour) CL images at low magnification (e.g., 1.5x), hence whole rocks are examined rather than single mineral phases. Examples from a variety of mineralized intrusive settings have been examined and will be used to illustrate the power of CL to illuminate such features as: 1) preservation of magmatic features, including textures and mineral zoning, at various scales in variably altered rocks; 2) the cryptic nature and development of metasomatism; 3) formation of new mineral phases (e.g., carbonates, apatite, feldspars), from micro- to macro scales, due to metasomatism; and 4) define an alteration paragenesis to constrain mineralization. This study shows that the extent of fluid-mediated alteration is likely more extensive and pervasive than generally considered since the scale of observation with modern SEM-based CL detectors is at much higher magnification and in many cases monochromatic (i.e., grey scale).