Fluid alteration processes and base metal sulphides at Spirit Lake Pluton, Mt. St. Helens, WA

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The emplacement of an early Miocene, epizonal granitic pluton is thought to mark the culmination of the major period of mid-Tertiary magmatism in the Mount St. Helens area [1]. The pluton was mapped as three major, texturally and compositionally heterogeneous bodies, broadly composed of feldspars + pyroxenes + oxides + quartz ± amphibole ± mica ± zircon ± apatite and other accessory minerals [1].

Recent EMPA mapping and LA-ICP-MS data have allowed us to define a likely continuum of patchy autometasomatic fluid alteration of the primary pyroxenes to high-halogen, fluoro-magnesiohornblende (up to 2.5 wt.% fluorine), accompanied by phlogopite crystallisation. This was followed by low-temperature hydrothermal ± deuteric alteration of the secondary amphibole to actinolite-tremolite compositions, and disseminated Cu-Zn-Fe sulphide mineralisation of the amphiboles and oxide phases (Fig. 1).

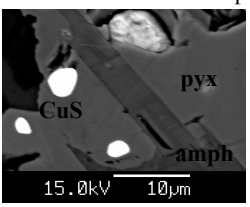

Figure 0: Cu-sulphide inclusions in altered pyroxene.

Al-geobarometry, combined with marked negative Sr, Eu and Ba anomalies, and low Zr, for the amphibole-bearing patches indicates shallow, late-stage formation at ≤1.5 kbars (~5 km), following significant crystal fractionation. The increasing oxidation state and halogen enrichment of the residual fluid is reflected in the high Mg# of the phlogopites (~80) and these changes likely stabilised their formation at lower P and T. Whilst the origin of the sulphides is still uncertain, high but variable Zn contents (up to 500 ppm) in the amphiboles and phlogopites appear primary, whilst high Cu contents (up to 400 ppm) are likely derived from metal-bearing fluids.

Ongoing experimental investigations should provide constraints on the source of the mineralising fluids, the partitioning of these ore metals between evolved calc-akaline melts, exsolved volatiles and crystallising assemblages, and the effects of sulphur on these alteration processes.

[1] Evarts *et al* (1987) *J. Geophys. Res.* **92**, 10155-10169