From Magma to Mudpool: Linking Arc Volatiles and Active Geothermal Systems with Implications for Gold Exploration

Isabelle Chambefort,[1*] Markus Wälle,[2] Chris Heinrich,[2] and John Dilles[3]

[1]GNS Science, Wairakei Research Centre, Taupo, New Zealand
[2]ETH-Zurich, Switzerland
[3]College of Earth, Atmospheric and Oceanic Sciences, Oregon State University, Oregon USA

*E-mail, i.chambefort@gns.cri.nz

The Taupo Volcanic Zone (TVZ) offers an excellent location to track the evolution of volatiles and fluid mobile elements from mafic to felsic melts, as well as their fractionation into the hydrothermal fluids and resultant alteration minerals. Deep melt and alteration compositions can be compared to the chemistry of surface fluids in active geothermal systems, and used as a proxy to refine our understanding of hydrothermal processes associated with Au deposition.

TVZ geothermal fluids are divided into two groups: (1) low-gas (CO_2-poor), high Cl and Li, low B and Li/Cs ratio systems, having chemical affinities with basaltic (and rhyolitic) magmas, and (2) high-gas (H_2S, CO_2), low Cl and Li, high B and Li/Cs ratio systems, having chemical affinities with andesitic magmas. Variation in F and total sulfur are also distinct between geothermal field types.

Melt inclusion data and measurements of gas emissions both are indirect estimates of the magmatic volatile content. They represent the "left over" after degassing or hydrothermal scrubbing. New direct in situ analyses of trapped fluid inclusions in phenocrysts and hydrothermal veins associated with magmatic degassing and deep meteoric water circulation provide a way to assess the composition of exsolved magmatic fluids and deep dilute near-neutral geothermal waters. Hypersaline fluid inclusions and associated vapors, halite-bearing, intermediate density and dilute fluid inclusions (fluid and steam) interpreted to represent the last composition of the fluid exsolving from magma crystallizing in subsolidus conditions represent the fluid evolution composition toward the surface in the hydrothermal system. Hypersaline fluid inclusions trapped in rhyolite skeletal phenocrysts are enriched in B, Cs, and Li compared to hydrothermal fluids trapped in inclusions in veins hosted in diorite. Dilute meteoric-dominated chloride fluids are enriched in Li, Cl, as well as K and Ca, but are depleted in B. Preliminary results on chlorine and bromine content of the fluid inclusions show that fractionation of these elements occurs during phase separation at the magmatic-hydrothermal interface and heterogeneous trapping in this deep environment. They may also surprisingly fractionate during steam-liquid separation during boiling events in the shallow active geothermal system likely at sub-supercritical conditions.

High-density fluid inclusions are enriched in metals compared to dilute ones. Hypersaline fluids exsolving from a diorite are enriched in Pb, Cu, and Zn compared to rhyolite fluid inclusions but the latest appear to be enriched in Ag. Positive correlation between Pb, Zn, Ag, As and Cs, B, and Li is interpreted to be linked to vapor loss.