The Source to Surface Project: what are geochemical proxies really telling us about magmatic-hydrothermal systems in the Taupo Volcanic Zone, New Zealand?

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The uses of geochemical proxies both to describe and quantify heat and mass fluxes are important tools in understanding hydrothermal systems globally. Information derived from these proxies is crucial for geothermal resource characterization and management, studying ore-forming processes, understanding geochemical cycling, and the assessment for both hydrothermal and volcanogenic hazards. Over the past half-century, hydrothermal systems in the Taupo Volcanic Zone, New Zealand (TVZ) have been extensively studied to which numerous inferences have been presented describing the origin, flow paths, and heat and mass flux through fluid geochemistry. In this study, we have compiled and compared published, unpublished, and our own data for liquid, gas, and soil-gas surveys in the TVZ hydrothermal systems. We describe here an updated model for the origin, flow paths, and heat and mass transport for fluids in the TVZ. Numerous relationships between elements and compounds show evidence for a geochemically distinct single-parent fluid. However, the ultimate origin(s) or end-member(s) for the elements and compounds comprising this fluid is not known. New interpretations are presented regarding three unique groupings based on B/Cl relationships. Where these groupings occur, they do not spatially correlate with any particular tectonomagmatic setting, as inferred by previous authors. We propose these relationships to be the result of water-rock interaction and phase separation and not from multiple fluid sources. We also show from soil-gas surveys, that 'blind' structural components are a significant factor in detecting upflow zones that are not readily apparent from either structural mapping or temperature profiles. Spatial correlations also exist between geophysical data and our soil-gas surveys demonstrating a powerful new combined method in the identification of upflow. Finally, from our soil CO_2 studies we demonstrate that for high-resolution surveys, a CO_2-based method incorporating the carbon isotopic signature of CO2 may provide a more accurate heat flux value than existing chloride models which may not always be reliable throughout the TVZ (Bibby et al., 1995). This has implications for reassessing the heat flux for the entire TVZ (currently accepted to be 4500 MW) and ultimately the scale of modern crustal magmatism. Our findings are of particular interest for similar arc- and rift-type systems alike and our methods are likely applicable outside the TVZ for both assessment and monitoring of magmatic-geothermal systems.