Geospatial variation in magmatic and volatile fluxes to the oceans and atmosphere from active subaerial/submarine volcanism in the New Zealand Primary Site

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This proposed project is aimed at constraining magmatic and volatile fluxes from active New Zealand primary site volcanoes (subaerial and submarine) as functions of space and time through the site. Such an observational data set, covering the past century of volcanic activity, would provide a means to investigate several overarching questions as functions of structural and tectonic gradients throughout the greater NZ focus site magmatic system (e.g., crustal thickness, convergence rate, suducted sediment type/amount). These overarching questions include: (a) the underlying petrological and tectonic controls on the magnitude and extent of arc/backarc magmatism per unit time; (b) differences between fluxes from marine and subaerial volcanic systems; and (c) the relative influences of deep and shallow magmatic processes upon magmas and gases that erupt at the surface. By studying current and recently active systems along the Hikurangi, Taupo, and Kermadec arcs, the Havre Trough, and with possible extension to compositionally extreme juvenile volcanoes of the Tonga arc and Lau back-arc, this proposed project aims to explore multiple aspects of the GeoPRISMS Science and Implementation Plans (e.g., the broad themes "Fluids, Magmas and Their Interactions", "Geochemical Cycles", "Origin and Evolution of Continental Crust") as well as NZ specific science questions outlined in the GeoPRISMS Implementation Plan (see last paragraph).

This proposed project would require an inventory and sampling of all active and recently active volcanoes in the NZ site and surrounding areas to the north, followed by geochemical analysis of lavas, pyroclasts, gasses, and fluids sampled at each site (petrology, geochronology, water chemistry, etc..). Importantly, the project would require the same amount of attention be devoted to submarine and subaerial volcanoes in order to fully characterize the range of processes, compositions, and fluxes that control subduction cycles. Although we know less, globally speaking, about the numbers of submarine volcanic eruptions in the recent past and their size, frequency or duration (see review by Rubin et al., 2012), we know that today and through most of geological history submarine volcanic eruptions have had substantial integrated compositional, thermal and ecological impacts on the world's exosphere. Submarine eruptions are more difficult to detect and observe than subaerial eruptions, but strides in eruption detection, response speed, and observational detail over the past 25 years suggest that a comprehensive study of submarine volcanoes within a small focused area such as the NZ Focus Site (see Fig. 2) should be achievable. Active monitoring would be required, which for the submarine sites means hydrophone arrays, seismometers on land, repeat bathymetric surveys and water column monitoring (e.g., Resing et al., 2011; Chadwick et al., 2008; Watts et al., 2012), along with the aforementioned sampling at active volcanoes.

There is some data available already to jump start this process (see Fig. 1), plus observations at recently active submarine volcanoes in the area such as Rumble III (35.75S), Brothers (34.9S), Havre (31.1S), and Monowai (24.9S). Combined existing and new geochemical data from the subaerial and submarine volcanos will provide a detailed snapshot of the material fluxes exiting this system across the entire arc/backarc. Because of strong gradients along the arc these will allow a nearly unique investigation of the interplay of variable subduction parameters (e.g., sediment type and amount, Plank in press) and crustal structure on magmatic cycling in the arc. Furthermore, a comprehensive submarine/subaerial program would provide for the first quantitative assessment of the differences between compositions and magnitudes of magmatic products entering earth's exosphere across the water line from a single arc. An even greater understanding would arise from incorporation of existing data along the Tonga Arc and Lau Backarc (and perhaps new sampling as needed) because it extends the arc system at recently active volcanoes further in tectonic and compositional space (e.g., boninites at W. Mata).

This is clearly a project that could not be accomplished by just a few researchers. Rather, the data set envisioned by this project would require multiple research teams and collaboration with NZ partners to accomplish. Analysis and modeling of resulting data would likely significantly improve understanding of several SCD (Subduction Cycles and Deformation) themes as described in the science plan (e.g., 4.4. How are volatiles, fluids, and melts stored, transferred, and released through the subduction system? 4.5. What are the geochemical products of subduction zones…? and 4.6. What are the physical and chemical conditions that control subduction zone initiation and the development of mature arc systems?). Furthermore, the project addresses multiple NZ-specific science questions from GeoPRISMS Implementation Plan: D. What are the … respective contributions of subducted sediments and crustal assimilation along- and across-strike of the arc? and E. How does … the spatial and temporal variation of magmatism relate to the nature of slab-derived fluid-to-melt?, as well as comparative/thematic theme 3: Fore-arc to back-arc volatile fluxes. It is therefore clearly aligned with the goals of the GeoPRISMS initiative.

References:

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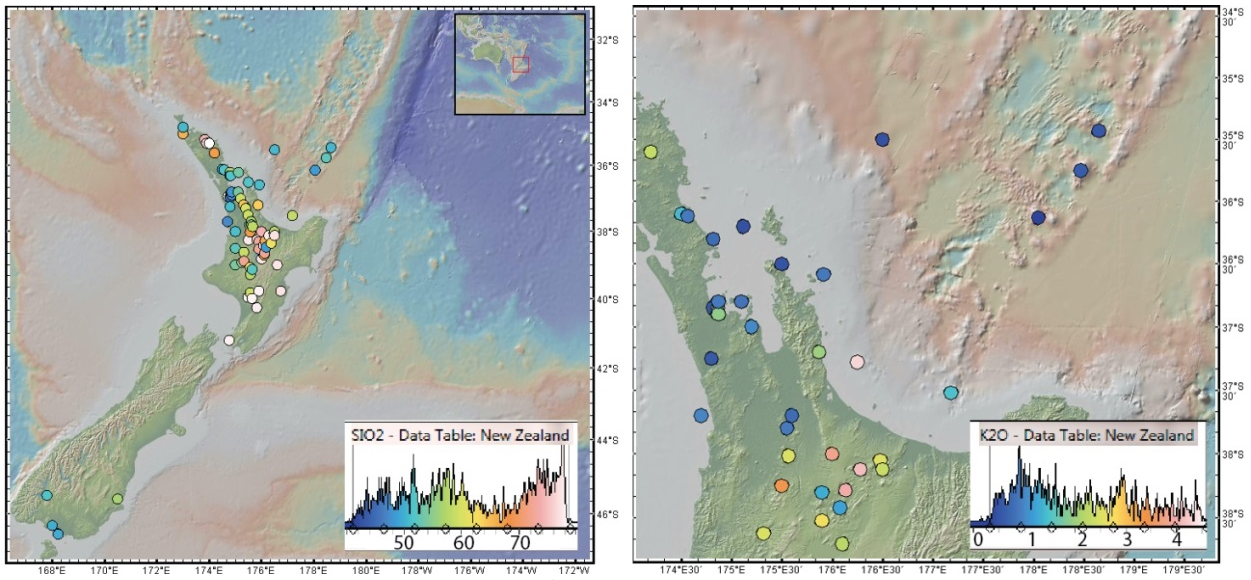

Figure 1. Map with samples available from PetDB/EarthChem in the NZ Focus Site. Panel A on the left shows SiO_2 data and panel B on the right is a zoomed-in view of K_2O data in the northern part of North Island and the southern Kermadec/Harve submarine system. Importantly, this is all available data, not filtered for eruption age. There would undoubtedly be substantially fewer samples if only historical or dated samples from the last 100 yrs were shown, although the data to make such a distinction are not presently available in the EarthChem databases.

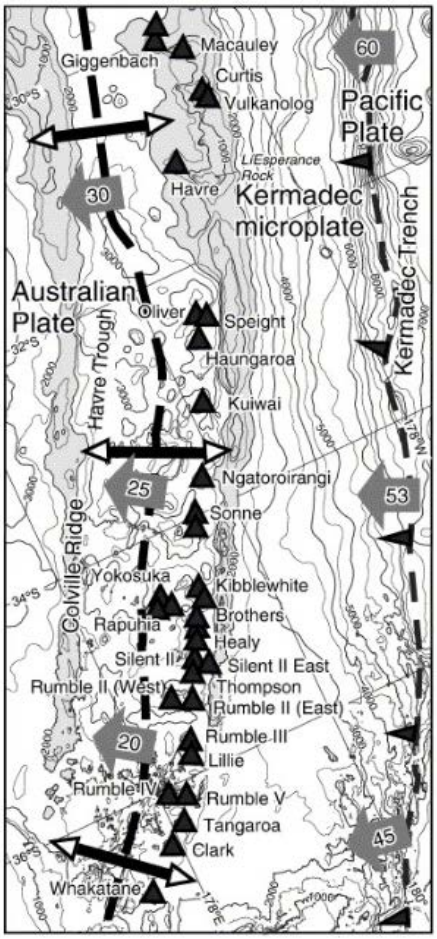

Figure 2. recently discovered volcanoes of the southern and central Kermadec arc (Wright et al., 2006).