Hydrological evolution and chemical structure of a hyper-acidic spring-lake system at White Island, NZ

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White Island has a long and varied history of acid spring discharge and shallow ephemeral lake formation on the Main Crater floor. In the 12 months prior to the 1976-2000 eruptive episode, mass discharge from the spring system increased ca. 10-fold, pointing to a strong coupling of the hydrothermal environment to the evolving magmatic system. However, between 1976-1978, numerous eruption vents to 200 m depth periodically formed in the Western Sub-crater, and these abruptly changed the hydrostatic regime of the volcano, resulting in the reversal of groundwater flow in the massif towards the newly-formed crater(s). This affected not only the style of volcanic activity (leading to phreatic-phreatomagmatic-magmatic eruption cycles), but also led to the demise of the spring system, with total flow from the crater declining by a factor > 100 by 1979. Eruptive activity came to a close soon after moderate Strombolian activity in mid-2000, by which time ephemeral lakes had already started to form in the eruption crater complex.

Since 2003 there have been two complete lake filling and evaporative cycles, reflecting varying heat flow through the conduit system beneath the lake. Over these cycles, lake water concentrations of Cl and SO_4 varied between ca. 35-150 and 5-45 g/l respectively, with pH values ranging between +1.5 and -1. Springs reappeared on the Main Crater floor in 2004, and their discharges have varied with lake level, pointing to the lake seepage being a primary control over the piezometric surface in the crater area. Springs closest to the crater complex show direct evidence of crater lake water infiltration into the crater floor aquifer, whereas distal spring discharges show compositional variations reflecting vertical displacement of the interface between shallow, dilute condensate and an underlying acidic brine fluid. Evidence suggests that this acid brine presently contains a significant component of altered seawater.