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Volatile characteristics of Hikurangi Subduction Zone thermal fluids and gases

PETER H BARRY[1], DAVID J BYRNE[2], ERY C HUGHES[3], MATTHEW B STOTT[4], CYNTHIA A. WERNER[5], AROLA MORERAS MARTI[6], MURRY CAVE[7], MICHAEL W. BROADLEY[8], MATTHIJS C VAN SOEST[2], UWE MORGENSTERN[2], BRUCE CHRISTENSON[9], LUANA ALVES[10], ALAN M. SELTZER[11], REBECCA TYNE[12], MAARTEN DE MOOR[13], DEBORAH BASTONI[14], JOSHUA CURTICE[1], JULIANN PANEHAL[15], GERDHARD JESSEN[16], DONATO GIOVANNELLI[17] AND KAREN G. LLOYD[18]

[1]Woods Hole Oceanographic Institution
[2]New Zealand Institute of Earth Sciences
[3]UCL
[4]University of Canterbury
[5]Research Geologist (contractor)
[6]Auckland University of Technology
[7]Gisborne District Council
[8]University of Manchester
[9]Earth Sciences New Zealand
[10]Earth Sciences New Zealand (GNS Science)
[11]University College Dublin
[12]The University of Manchester
[13]National University
[14]University of Naples Federico II
[15]USC
[16]Austral University of Chile
[17]CNR-IRBIM, National Research Council
[18]University of Southern California

At convergent margins, plate tectonics control the exchange of volatile elements between Earth's deep and shallow reservoirs. The efficiency of this transfer plays a critical role in regulating mantle heterogeneities and redox conditions. Over geological-timescales, the balance between volcanic outgassing and subduction-related recycling determines the distribution of terrestrial volatiles.

The active Hikurangi Subduction Zone (HSZ) extends off the east coast of New Zealand's North Island, where the Pacific and Australian plates obliquely collide. Subduction of the Pacific plate westward beneath the eastern North Island drives volcanism, which is largely concentrated within the Taupō Volcanic Zone (TVZ), resulting in thousands of thermal springs. The ~200km wide Hikurangi Forearc (HF) is located on the east coast of the North Island and consists of turbidites, sediments and greywacke basement. Fluids are discharged along the shallow portion of the HF margin through springs and mud volcanoes. However, the magnitudes of volatile fluxes, their relative contributions from slab-derived versus mantle sources, and their sinks remain poorly constrained, particularly in the HF region.

Here, we present unpublished noble gas, stable isotope, tritium and radiocarbon data from thermal springs across the HF and TVZ. Isotope and abundance data are reported for 70 thermal spring sites. All fluid samples are non-modern, with apparent radiocarbon ages between 11.1k-46k years before present. Tritium data (0 to 1.1 TU) help constrain water residence times and mixing of shallow fluids. Helium isotopes (3He/4He) vary from 0.3 to 7.5 RA, dominated by radiogenic contributions in the HF and increasing to typical volcanic arc values in the TVZ. Argon isotopes (40Ar/36Ar) vary from atmospheric up to 420, with the elevated Ar isotope values co-occurring with radiogenic He values in the HF. Carbon isotope compositions of CO2 vary from -14.1‰ to +16.8‰, suggesting a variety of sources and fractionation processes in this complex region. Nitrogen isotope compositions range from -4.8 to +1.7‰, suggesting a mix between slab and mantle contributions. Source mixing models and fractionation models will be further explored, with the goal of better constraining volatile fluxes, sources and sinks across the HSZ.