

Field-Portable Helium Isotope Detector for Continuous Monitoring of Large Earthquakes and Volcanic Unrest

Gary M. McMurtry¹, James R. DeLuze², David R. Hilton³, and James E. Blessing⁴

¹*SOEST, University of Hawaii, Honolulu, Hawaii 96822 USA and Pacific Environmental Technologies, LLC (Pace Tech Hawaii)*

²*Fusion Energy Solutions of Hawaii, 611 University Avenue, Apt. 301, Honolulu, HI 96826*

³*Scripps Institution of Oceanography, Univ. of California, San Diego, California 92037*

⁴*MKS Instruments, Inc., San Jose, California 95134*

The $^3\text{He}/^4\text{He}$ ratio in volcanic emissions and dissolved gas in groundwater is often co-seismic with, and sometimes precursory to, volcanic unrest and earthquake activity. Because of the extremely low abundance of primordial ^3He to radiogenic ^4He , and difficulties in resolving ^3He in the presence of hydrogen isobars such as HD, the measurement of this ratio has so far been confined to the laboratory. A field-portable He isotope instrument must overcome these analytical hurdles and be small, compact, lightweight and low enough in power consumption to deploy in critical locations. We use two compact mass spectrometers, an MKS ion trap and a frequency-modified quadrupole MS, with a full-range pressure gauge and waste pumps based upon noble diode ion or turbo-rough pumping. These are coupled to a high-purity quartz glass port that is heated under high vacuum. Gas samples can be separated from waters or directly analyzed by pumped circulation through a sample chamber. We monitor vacuum quality with the ion trap and use the quadrupole MS to obtain sensitive determination of hydrogen and helium isotopes. Two methods of isobaric separation are utilized: a statistical mass-2 vs. mass-3 regression intercept, and an adjusted (threshold) ionization mass spectrometry (AIMS) technique. Comparison of these two independent methods for 44 data pairs in a “blind collection” after heat ramps to a predetermined maximum temperature are complete yields a significant correlation ($r = 0.89$). Results on laboratory air are within a factor of 2 of the accepted ratio of 1.40×10^{-6} (R_a). We can obtain the exact air ratio ($R/R_a = 1.0$) if we continuously monitor the MS scans during the heat ramps, allowing for differences in the diffusion rates of ^3He and ^4He . With an established power level, keeping to a constant scan time allows precise $^3\text{He}/^4\text{He}$ ratios to be obtained to within $0.1 R/R_a$.