A Global Dataset of Noble Gas Concentrations And Their Isotopic Ratios in Active Tectonic and Volcanic Settings

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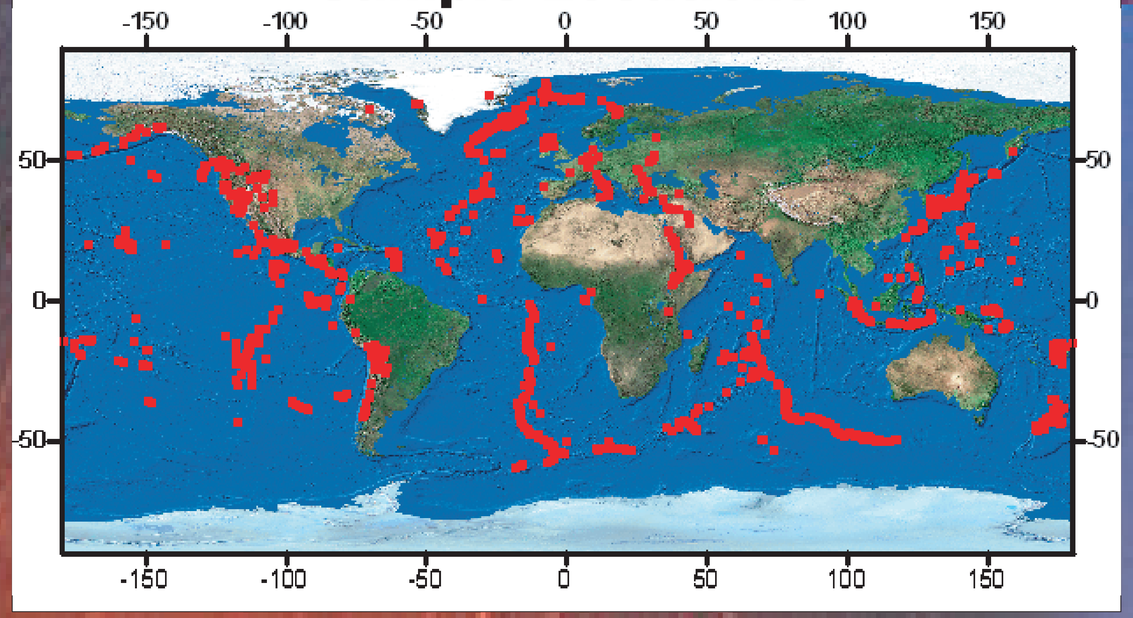
1. INTRODUCTION

The extent to which ocean islands are derived from the deep mantle (mantle plumes), or from chemical heterogeneities embedded within the mantle convective flow has long been debated. Noble gases have unique properties that enable them to provide significant information regarding this debate and make them important geodynamic tracers. The study of noble gas isotopic compositions in active tectonic and volcanic areas is central to understanding the origins of major volcanic anomalies on Earth's surface.

We have created a large database that contains information on noble gas concentrations and isotopic values from volcanic system in Mid-Ocean ridges, ocean islands, seamounts, and oceanic and continental arcs. Where it was available we also included the isotopic ratios of strontium, neodymium, and carbon. Overall, there are more than 5,000 entries in the database, which is sub-divided both into material sampled (e.g., volcanic glass, different minerals, fumarole, spring), and into different tectonic settings (MOR, ocean islands, volcanic arcs). The database extends previous compilations by Farley and Neroda (1998) and Graham (2002).

2. Sample Locations

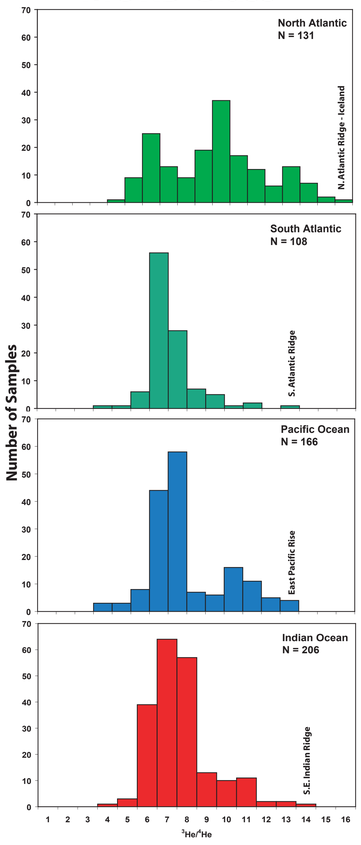


3. The distribution of samples in the database

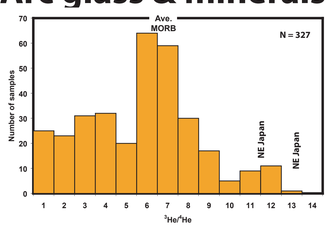
Sample Type	Number
Glass	1320
Olivine	1172
Pyroxene	218
Whole rock & other minerals	178
Springs	681
Fumaroles	865
Seafloor hydrothermal vents	423

4. $^3He/^4He$ (R_C/R_A) in volcanic rocks and minerals

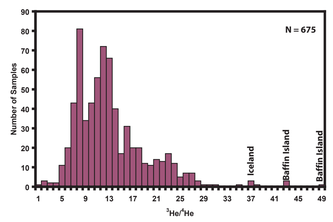
MORB Glass



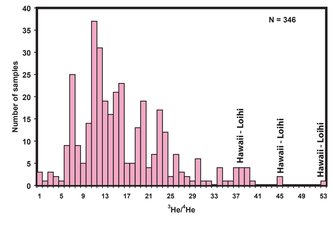
Arc glass & minerals



OIB olivine & CPX



OIB Glass



5. Correlation between Seismic Tomography and Helium isotopes

Name	Tomography Observations	Max $^3He/^4He$
Afar	May be a deep Plume	17.0
Azores	Lack of Mid-mantle resolution	15.3
Canary	Robust	6.6
Easter	Robust	11.7
Eifel	Robust	5.9
Etna	Strong in upper mantle	8
Solomon	Near a robustly resolved plume	9.3
Galapagos	Strong in upper mantle	27.4
Hawaii	Not enough constraints on depth	53
Iceland	Strong in upper mantle	37.7
Indian Ocean	Not well resolved	14
Juan de Fuca	Strong in upper mantle	11.5
Juan Fernandez	Lack of resolution below 2350 km	18
Kerguelen	Robust	20.2
Reunion	May be a deep plume	14.9
Samoa	Robust , except between 1000 to 1450 km	23.9
South of Java	Does not reach surface – stops at 1450 km	8.8
Tahiti	Robust , except between 1000 and 1450 km	10.4

- Tomography from Montelli et al., Science, V. 303, 2004
- Table only includes sites where He isotopes are available.

6. MAJOR OBSERVATIONS

- There is a statistically distinct difference in the helium isotope composition between OIB Vs. MORB and volcanic arcs
- The helium isotope composition in glass and mineral samples supports previous studies that suggested an undegassed mantle as a source for oceanic island basalt (OIB), and a degassed mantle source for MORB and arcs.
- OIB samples display a very large range in He isotope composition in comparison to MORB and volcanic arc samples.
- The maximum ratio in fumaroles and hot spring samples is usually lower than in rocks from the same locality.

When completed, the database will be available to the scientific community through the World Wide Web, and will allow examination of some unresolved scientific problems, for example, the database can help identify the chemical characteristics of the mantle at most volcanic systems on Earth.