Final Project Report: Noble gas tracers at the Mid-Cayman Spreading Center
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Helium is a unique tracer for mantle/volcanic inputs at the sea floor because it is the most inert element and is therefore not influenced by chemical reactions. The light isotope, ^{3}He, is extremely rare in the atmosphere and in seawater but is enriched in magmatic liquids, making it extremely sensitive to deep ocean mantle inputs. One goal of this project was to initiate a new collaboration between the WHOI noble gas lab and researchers interested in sea floor hydrothermal chemistry. Specifically, we were able to make new helium measurements in hydrothermal fluids collected by Chris German and Jeff Seewald from the Mid-Cayman Rise in a 2009 cruise. The new helium measurements provided documentation that the unusual fluid chemistry found in the Mid-Cayman Rise seawater samples were related to seafloor volcanic inputs. The helium data were critical to demonstrating that the Mid-Cayman Rise not only hosts the deepest hydrothermal vents, at 5000 meters below sea level, but is unique in the diversity of the fluids, suggesting several inputs with distinct chemistry. Correlations between helium, methane, manganese, and iron concentrations helped to demonstrate the diversity of fluid inputs, i.e. via differing ratios between these elements. These results were published in 2010 in a high profile journal (German et al., 2010) and the collaborations are continuing.

A related goal of the project was to make new helium, neon, and argon measurements in ocean crust samples from the Mid-Cayman Rise. Previous measurements have focused on seawater and volcanic rocks, and the distribution and abundance of noble gases within the ocean crust itself is poorly understood. Crustal noble gas inventories are important to models of mantle evolution, atmosphere formation, and the global carbon cycle. For example, the $^{3}He/C$ ratio is widely used to calculate global carbon fluxes, in both mid-ocean ridge and subduction zone settings; it is therefore important to determine the relationships between carbon and helium. Although appropriate seafloor rock samples for these studies were not recovered on the Mid-Cayman Rise cruise, we were able to make preliminary measurements in a suite of crustal gabbro samples from the East Pacific Rise. The results were surprising in showing roughly ten times higher helium concentrations than in previous studies, which were all from slower spreading ridges. We are now exploring the reasons for this difference. The preliminary interpretation is that deformation within the crust influences noble gas abundances, and that the East Pacific Rise has been less influenced by deformation. In addition, we made the first measurements of noble gases in amphibole, a mineral that requires hydrous melting that probably relate to hydrothermal influences. These new data showed that amphibole has extremely high noble gas concentrations and may be a key residence site within the crust. The preliminary measurements led to new funding for this work by the National Science Foundation, so the project is ongoing.

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C. R. German, A. Bowen, M. L. Coleman, D. L. Honig, J. A. Huber, M. V. Jakuba, J. C. Kinsey, M. D. Kurz, S. Leroy, J. M. McDermott, B. Mercier de Lépinay, K. Nakamura, J. S. Seewald, J. L. Smith, S. P. Sylva, C. L. Van Dover, L. L. Whitcomb, and D. R. Yoerger (2010) Diverse styles of submarine venting on the ultraslow spreading Mid-Cayman Rise. Proceedings of the National Academy of Sciences of the U.S.A. 107, 14020-14025.

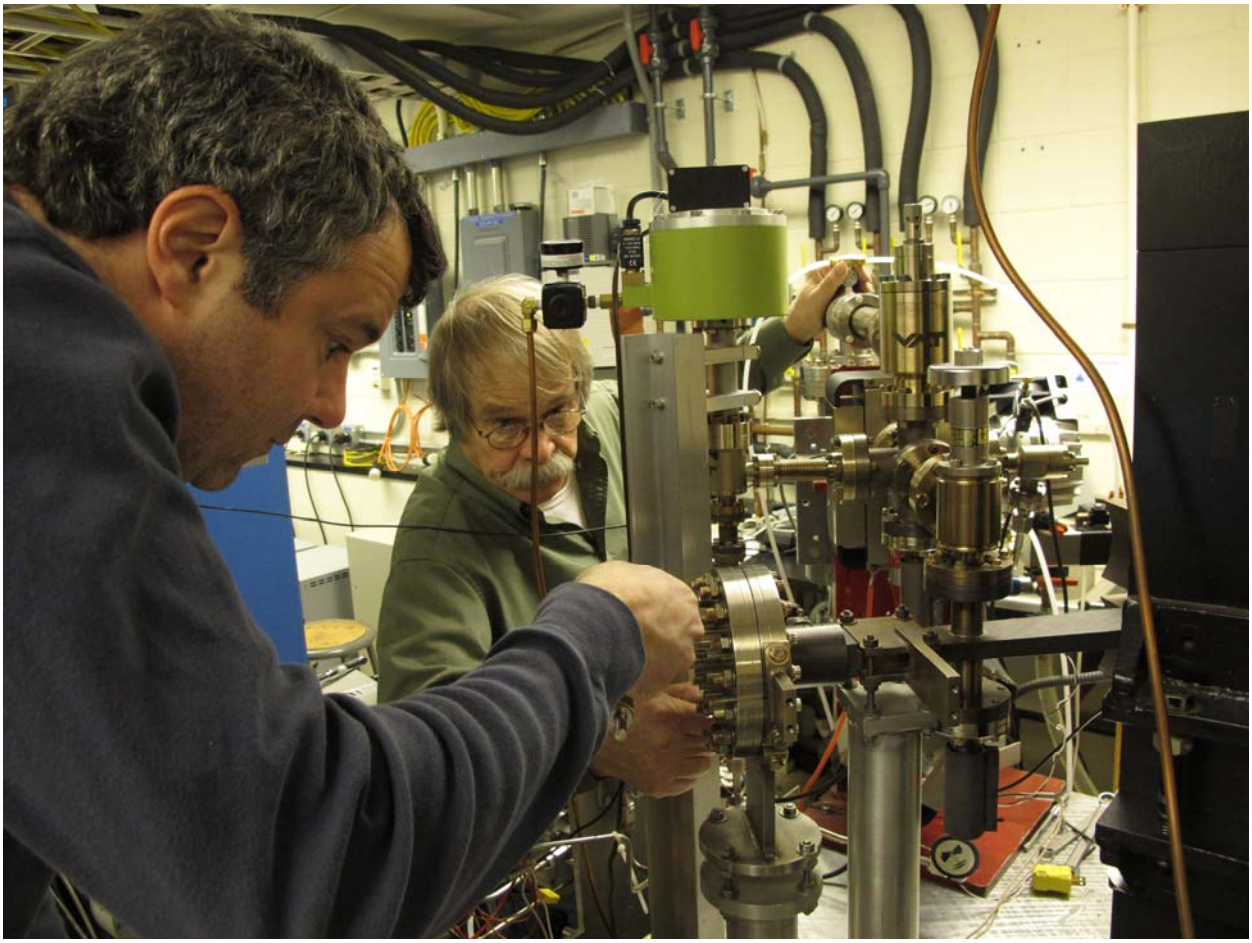

Photo caption: WHOI technical staff members Joshua Curtice (left) and Dempsey Lott working on part of the Noble Gas Mass Spectrometer, which is within the Isotope Geochemistry Facility; this mass spectrometer was used for the Mid Cayman Rise helium measurements. Measurement of helium isotopes requires specialized ultra-high-vacuum extraction lines and mass spectrometry, a long-term strength of the Department of Marine Chemistry and Geochemistry.