Submarine Hydrothermal Activity on the Aeolian Arc: New Evidence from Helium Isotopes

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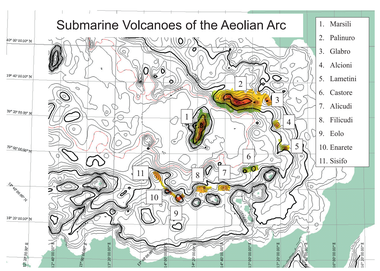
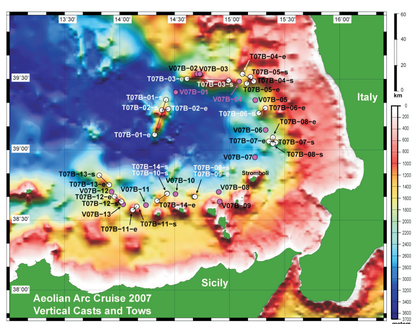
Abstract

In November 2007 we conducted a water-column and seafloor mapping study of the submarine volcanoes of the Aeolian Arc in the southern Tyrrhenian Sea aboard the R/V Urania. A total of 26 CTD casts were completed, 13 vertical casts and 13 tows. In addition to in situ measurements of temperature, conductivity, pressure and suspended particles, we also collected discrete samples for helium isotopes, methane, and trace metals. The helium isotope ratio, which is known to be an unambiguous indicator of hydrothermal input, showed a clear excess above background at 5 out of the 10 submarine volcanoes surveyed. We found the strongest helium anomaly over Marsili seamount, where the $^3He/^4He$ ratio reached maximum values of δ^3He = 23% at 610 m depth compared with background values of ~7%. We also found smaller but distinct δ^3He anomalies over Enarete, Eolo, Palinuro, and Secca del Capo. We interpret these results as indicating the presence of hydrothermal activity on these 5 seamounts. Hydrothermal venting has been documented at subsea vents offshore of the islands of Panarea, Stromboli, and Vulcano (Dando et al., 1999; Di Roberto et al., 2008), and hydrothermal deposits have been sampled on many of the submarine volcanoes of the Aeolian Arc (Dekov and Savelli, 2004). However, as far as we know this is the first evidence of present day hydrothermal activity on Marsili, Enarete, and Eolo. Samples collected over Filicudi, Glabro, Lamentini, Sisifo, and Alcioni had δ^3He very close to the regional background values, suggesting either absence of or very weak hydrothermal activity on these seamounts.

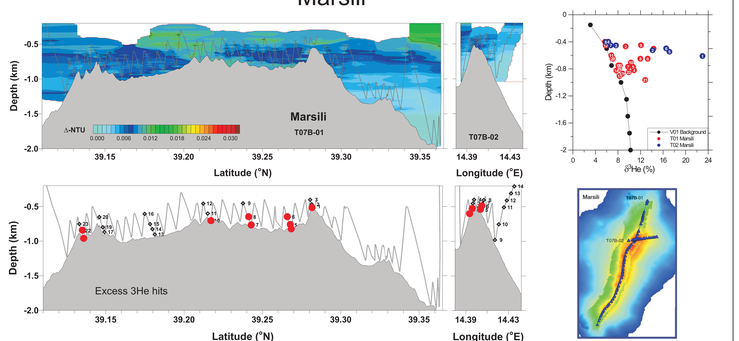
Helium isotope measurements from the background hydrocasts positioned between the volcanoes revealed the presence of an excess in 3He throughout the SE Tyrrhenian Sea. These background profiles reach a consistent maximum of about δ^3He = 11% at 2300 m depth. Historical helium profiles collected in the central and northern Tyrrhenian Sea in 1987 and 1997 do not show this deep ^3He maximum (W. Roether and B. Klein, private comm.). Furthermore, the maximum is too deep to be attributed to the volcanoes of the Aeolian Arc, which are active at <1000 m depth. We are currently conducting additional measurements to determine whether this deep ^3He maximum is from a local hydrothermal source or is somehow related to the deep water mass transient which occurred in the eastern Mediterranean in the 1990's.





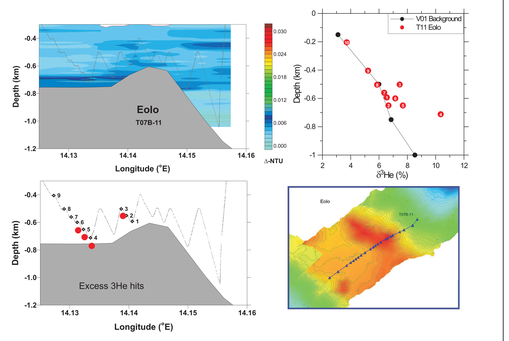
Map showing the location of the 13 vertical casts and 13 tows that we completed over the submarine volcanoes of the Aeolian Arc in November of 2007.

Marsili



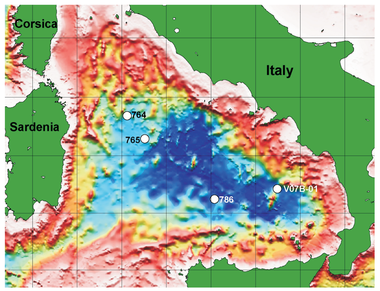
Detailed results from two tows over Marsili Seamount, showing suspended particle signals (upper panel) and bottles with excess ^3He (lower panel). The graph in the upper right shows that some samples had excess ^3He up to δ^3He = 23%. These results indicate that several separate sites of hydrothermal activity exist on Marsili.

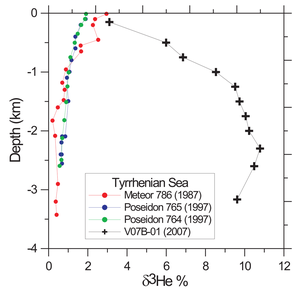
Eolo



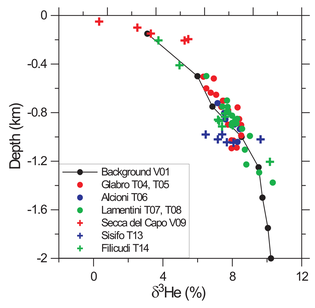
Results from a single tow over Eolo Seamount, showing suspended particle signals (upper panel) and excess ^3He hits from single bottle samples (lower panel). The helium data indicate that the hydrothermal activity is located southwest of the volcano summit.

Mysterious Deep ^3He signal in the Tyrrhenian Sea



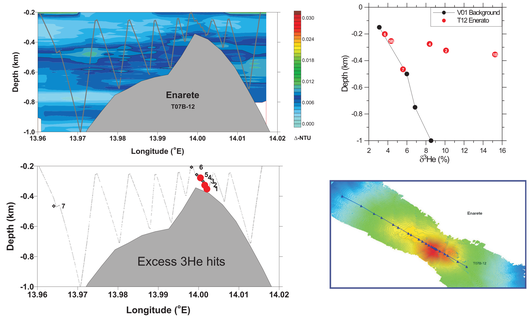


Our background station V07B-01 shows ^3He increasing with depth reaching a maximum of δ^3He = 11% at ~2500 m depth. This is in contrast to historical profiles collected in 1987 and 1997, which show δ^3He < 1% at 2500 m. The somewhat higher values at shallow depths in these historical profiles are due to ^3He production by tritium decay. The source of this deep ^3He excess in our 2007 background cast is unknown. It is too deep to be the result of activity from the submarine volcanoes of the Aeolian Arc, which are active at depths <1000 m. One possibility is that there has been a major water mass change in the deep Tyrrhenian Sea since 1997. (The 1987 and 1997 data courtesy of W. Roether and B Klein).



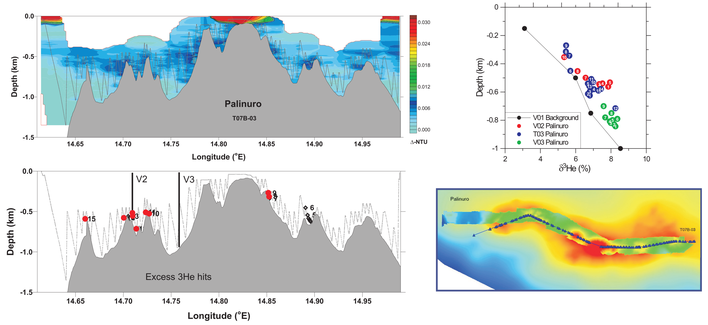
Composite graph of δ^3He values for water column samples over 6 different Aeolian Arc volcanoes. With the exception of the cast over Secca del Capo, which is known to be hydrothermally active, all of these δ^3He values are close to the background curve. This indicates either absence of or very weak hydrothermal activity on Filicudi, Glabro, Lamentini, Sisifo, and Alcioni.

Enarete



Results from a single tow over Enarete, showing suspended particle signals (upper panel), and ^4He hits from discrete bottle samples (lower panel). The graph in the upper right shows that δ^3He reached values up to 15% over the volcano summit.

Palinuro



Results from two vertical casts and one long tow over Palinuro Seamount, showing suspended particle signals (upper panel) and excess ^3He hits from discrete bottle samples (lower panel). The helium data suggest weak hydrothermal venting at several sites along the axis of the seamount.