EXPLORATION OF VOLCANISM
ALONG The PACIFIC “SUBMARINE RING OF FIRE”

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- NOAA Office of Ocean Exploration
- PMEL VENTS Program
- NZ GNS Science (2005)
- NZ NIWA (2005)
- ALSO: 2003/2004 Collaboration with Archaean Park Program (Japan)
Goal, **Science**

Systematic, interdisciplinary exploration of submarine magmatic arcs and diverse ecosystems

- Spatial & temporal patterns of volcanic/hydrothermal activity along arcs vs. MOR

- How do geologic variables relate to chemical and ecosystem variables, e.g., depth, gas content, rock types etc.
Mariana Arc
Hundreds of submarine volcanoes are generated within subduction zones.

Volatile Release

~200 Km

Mariana volcanic arc

overlying plate

forearc

pelagic sediments

ocean crust

backarc

magma

subducted plate

seismogenic zone

Pacific Plate

mantle

Volatile Release
2003, 04, 06 Programs

- Mapped 1400 km of arc
- CTDO surveys of 50 volcanoes
- Identified 20 active systems
- Dives with remotely operated vehicle on 15 volcanoes
Fly-through of Mariana arc
Relevance

• **Scientific community**
  - Has inspired several follow-on expeditions (Japan, NSF)

• **General Public and educators**
  - Material incorporated into Smithsonian “Hall of the Oceans”
  - One of most popular OE websites
  - >50,000 hits YouTube 2007-08

• **Policy planners (GO and NGO)**
  - Northern area proposed for new marine national monument
  - Effect of increased ocean acidification on marine ecosystems
  - Effect of natural perturbations on ecosystems
Some First Order Discoveries

• Long-term, observable submarine volcanic eruption

• “Super” CO$_2$ vent with liquid phase (Lupton Presentation)

• Liquid Sulfur vents & high density chemosynthesis
Boiling and free gas phase is common on the shallow, gas-rich Arc volcanoes.
While animal diversity at any one site is not high, the Arc provides numerous settings of hydrothermalism and many habitats that increase overall diversity.
A View Of an Active Submarine Volcano – NW Rota-1

- Hydromagmatic Plume
- Turbid Volcanic Ash Plumes
- Eruption Crater 550 m
- Density flows of volcanic material
- Multibeam bathymetric difference anomaly reveals lobe of volcaniclastics deposited over 3 years (max. thickness = 40 m)
Use of co-located hydrophone, when combined with seafloor observations, enabled quantification of volcanic activity—A surprising result is that observation of submarine eruptions can be easier than subaerial ones.
Deployment of a hydrophone near the NW Rota-1 eruption site provided data to quantify intensity of eruptive episodes. This was the ‘first time a submarine volcanic eruption was both visually observed and “heard”'
From death comes life:
Deadfalls from toxic volcanic plume provide food
Several Mariana volcanoes have intense magmatic degassing & extensive precipitation of elemental sulfur.
• Nikko 250 m diam. crater is floored with extensive sulfur flows,

• Venting of >100° gas-rich fluid trapped in the crater creates “VOG” & supports an extensive community of tubeworms, crabs, flatfish, bivalves etc.,
(Possibly the highest single-site Biomass known associated with hydrothermal venting)

• First find of **LIQUID S** in 2005 (HD-496) and by 2006 discovery of large pool of it on southern flank (J2-199)
Extensive chemosynthesis is associated with sulfur volcanoes.
Summary

• Initial explorations of submarine arcs:

  - Found some of most diverse and extreme systems since the discovery of hydrothermal vents

  - They are dominated by high volatile throughput (S, CO$_2$), and, in one case, with a superimposed long-term volcanic eruption

• Several of these are natural laboratories for studying the effects of submarine volcanism on the ocean and ecology of extreme hydro-magmatic systems
Future Directions

• Long-term monitoring of several of the known sites
  - NW Rota-1
  - NW Eifuku
  - Daikoku?

• Additional exploration of arc environments in the western Pacific, Antarctic and other regions
Submarine Ring of Fire 2004 Science Team