Patterns in Global Hydrothermal Activity

Presenter: Edward T. Baker
Earth--the water planet
Earth--the dynamic planet
Volcanic environments created by plate creation and plate consumption

The NE Pacific

NOAA’s Mission for global exploration

NOAA Research Plan Areas:
- Advance our understanding of ecosystems
- Explore our oceans

Global vision

Global partners & customers

Global exploration program

Global resources & stewardship
Key science questions for a global vision

What factors can be used to predict the distribution of hydrothermal vent sites at scales from global to local?

Heat supply? Permeability? Do arcs differ from ridges?

How can hydrothermal processes be quantified?

How many sites? Chemical budgets? Temporal variability?
Global partners & customers
Surveys by/with VENTS

International and national collaborations since 2004

- U of Hawaii
- U of Rhode Island
- Lamont-Doherty Earth Obs.
- WHOI
- Brown Univ
- U California Santa Barbara
- Scripps Inst Oceanography
- U South Carolina
- Duke
- U Texas
- U Washington

- NSF FUNDING

- IFM-GEOMAR, Germany
- Univ of Kiel, Germany
- University of Bremen, Germany
- National Oceanography Centre, UK
- Durham University, UK
- Peking Univ, China
- 2nd Inst. of Oceanography, Hangzhou, China
- Australian National Univ.
- CSIRO, Australia
- National Institute of Oceanography, India
- GSN Science, NZ
- Inst. Nazionale di Geofisica e Vulcanologia, Italy
- Inst. per l’Ambiente Marino Costiero, Italy
- AIST Tsukuba, Japan
- Nautilus Minerals Inc, Canada
Global exploration

- First black smokers on the GSC
- First vents discovered in the S Atl.
- Eruption discovered at 10°N
- Discovery of ISS sites on the ELSC
- Submarine venting on the Aeolian Arc
- Comprehensive surveys of T-K Arc & Lau Basin
- Comprehensive survey of Mariana Arc
- First hi-T vents discovered on ultra-slow ridge
- First megaplume on a slow ridge

Midocean ridge vent sites = 280 [136 (48%) involved NOAA/VENTS]
Recent highlights, 2004-2008

Arc vent sites = 65 [39 (60%) involved NOAA/VENTS]
Global resources & stewardship

Discover and analyze the potential of marine natural products for biomedical and commercial applications.

from the Ecosystem Mission Res. Plan

- Biomedical and chemical engineering products from chemosynthetic ecosystems.

2010, offshore PNG

- High value metals (Au, Ag, Cu) mined from inactive hydrothermal deposits.

We provide information for informed decisions.
Using exploration data to quantify hydrothermal processes

- **Global inventory and spatial distribution**
  Biogeographic and mineral distributions

- **Thermal and chemical fluxes**
  Ecosystem production and mineral deposition

- **Temporal variability**
  Ecological diversity and mineral accumulation
Global inventory prediction

Total with arcs ~1300 active chemosynthetic sites
only ~160 so far observed or sampled

\( \sum = 1049 \) (95% CI=937-1167)
Thermal and chemical fluxes

Brothers Volcano, 2007
Kermadec arc

Autonomous Benthic Explorer (ABE)

ABE tracks
Thermal and chemical fluxes

\[ \Delta T \]
- High = hydrothermal discharge
- Low = increased reduced chemicals (H\(_2\)S, Fe\(^{+2}\))

**ORP**
- Low = active or inactive discharge sites

**Magnetics**
- Low = active or inactive discharge sites

B. Davy, GNS NZ

High-T vents
Temporal variability

How continuous is vent field discharge?

Heat available: $H_a$

Heat output: $H_o$
Temporal variability

For steady discharge,

$$\frac{\text{Heat output (} H_0 \text{)}}{\text{Heat available (} H_a \cdot L \text{)}} = 1$$

$$H_0 \frac{2000 \text{ MW}}{(1 \text{ MW/km})(200 \text{ km})}$$

axial cooling length for steady discharge

if $L_c$ (true cooling length) is known

then, duty cycle $= \left( \frac{L_c}{L} \right) \times 100$

Baker, 2007
Temporal variability: punctuated cooling

\[
\left(\frac{L_c}{L}\right) \times 100 = \text{duty cycle}
\]

\[
\left(\frac{7 \text{ km}}{333-196 \text{ km}}\right) \times 100 = 2-4\%
\]

Singh et al. 2006

Baker, 2007
Future Directions

Quantify processes:
• Employ or develop new technologies (AUVs, solid-state chemical sensors).

Temporal variability:
• Establish seafloor observatories.
• Expand acoustic monitoring networks.