EXPLORATION OF VOLCANISM ALONG The PACIFIC "SUBMARINE RING OF FIRE"

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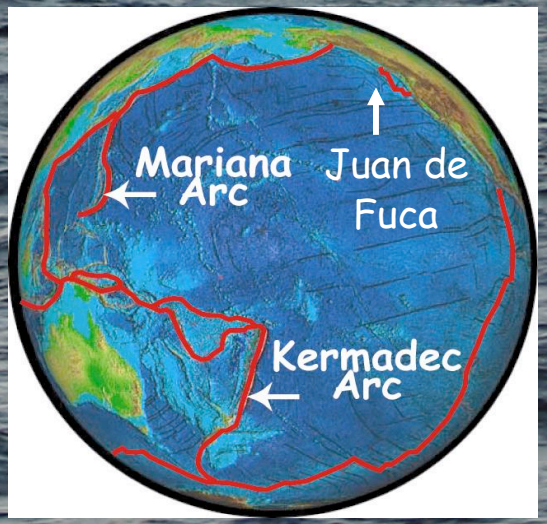
- NOAA Office of Ocean Exploration
- PMEL VENTS Program
- Natural Science & Engineering Research Council of Canada (2004)
- NZ GNS Science (2005)
- NZ NIWA (2005)
- ALSO: 2003/2004 Collaboration with Archaean Park Program (Japan)

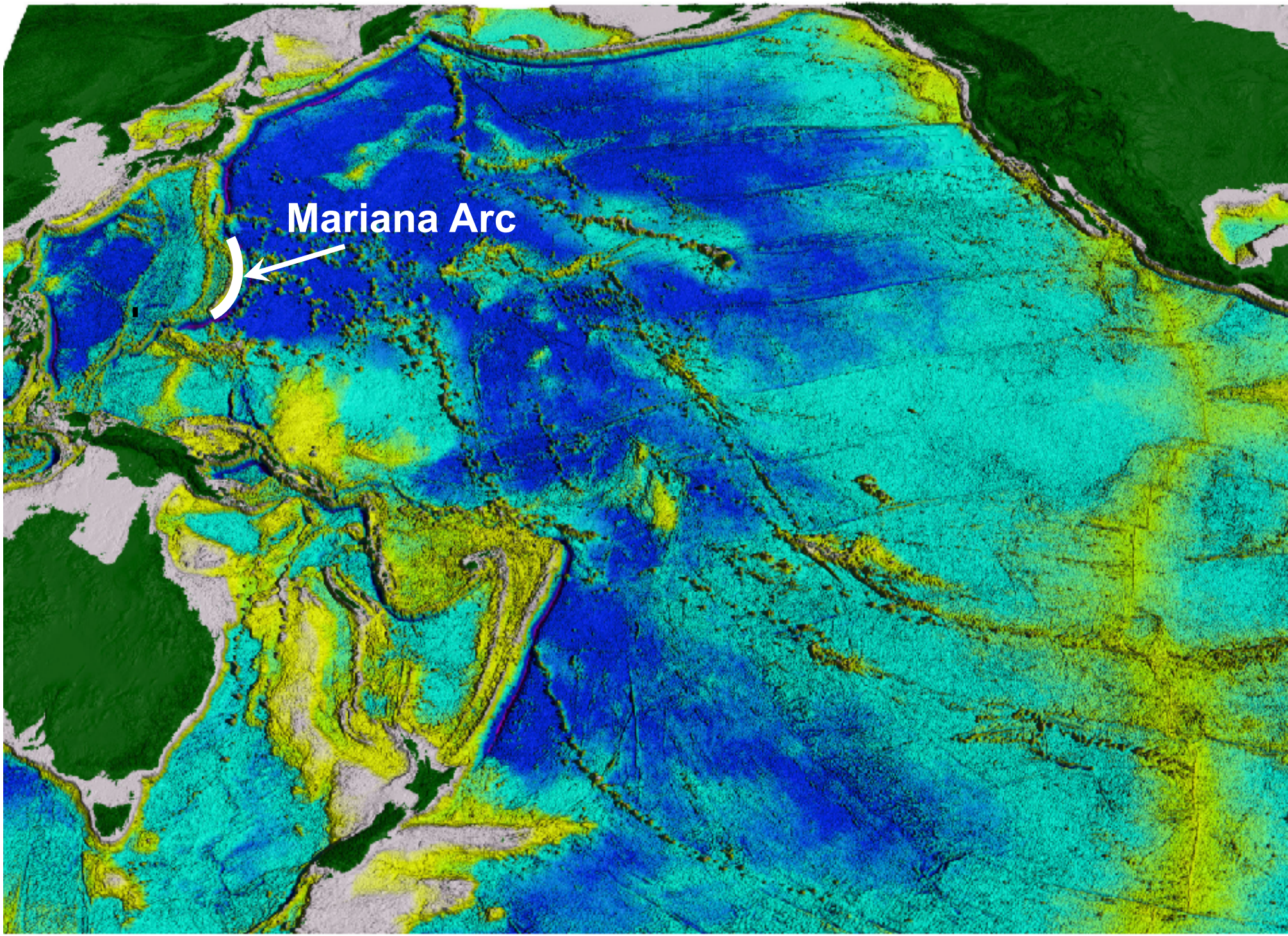


Goal, Science

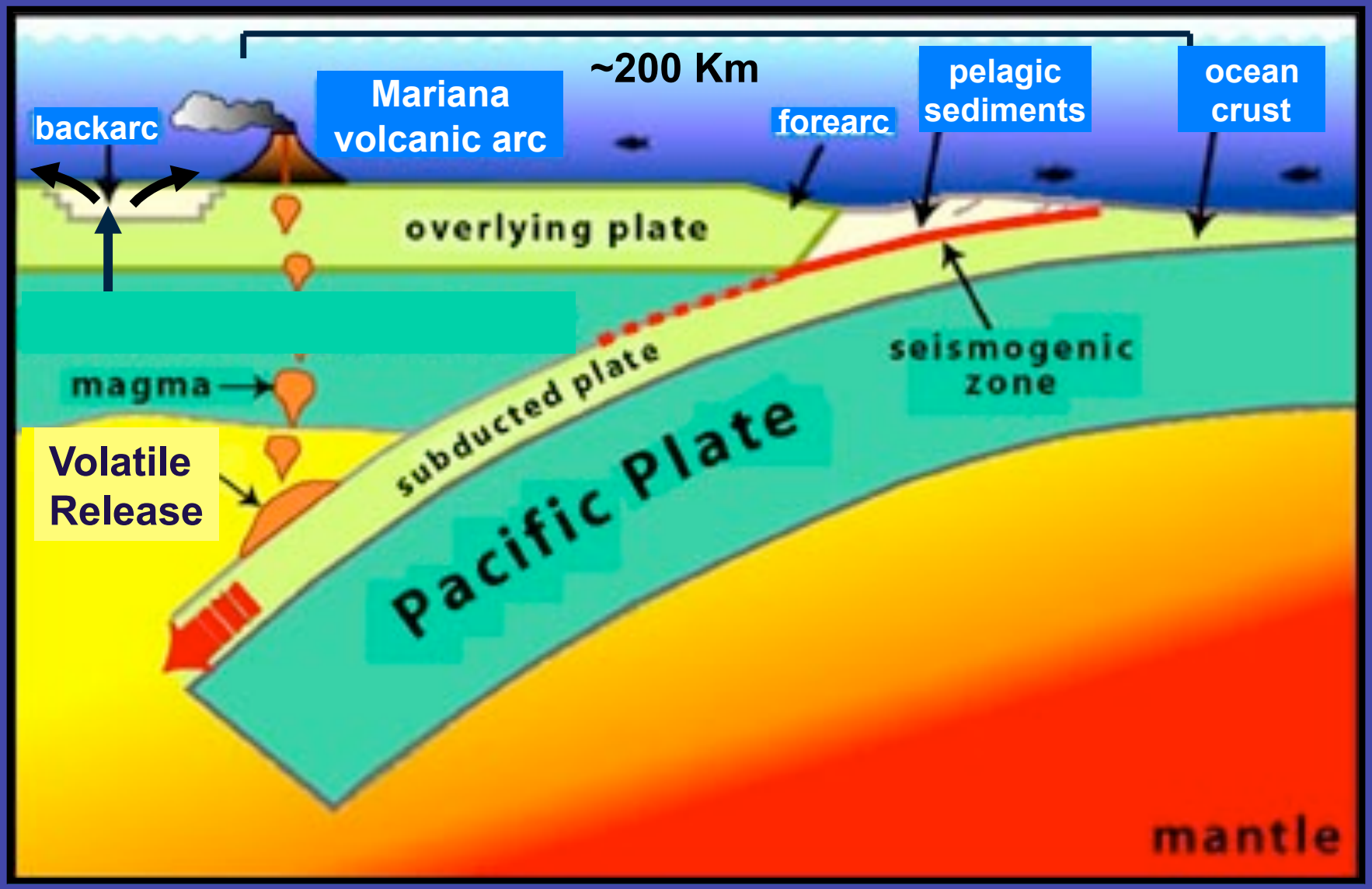
Systematic, interdisciplinary exploration of submarine magmatic arcs and diverse ecosystems

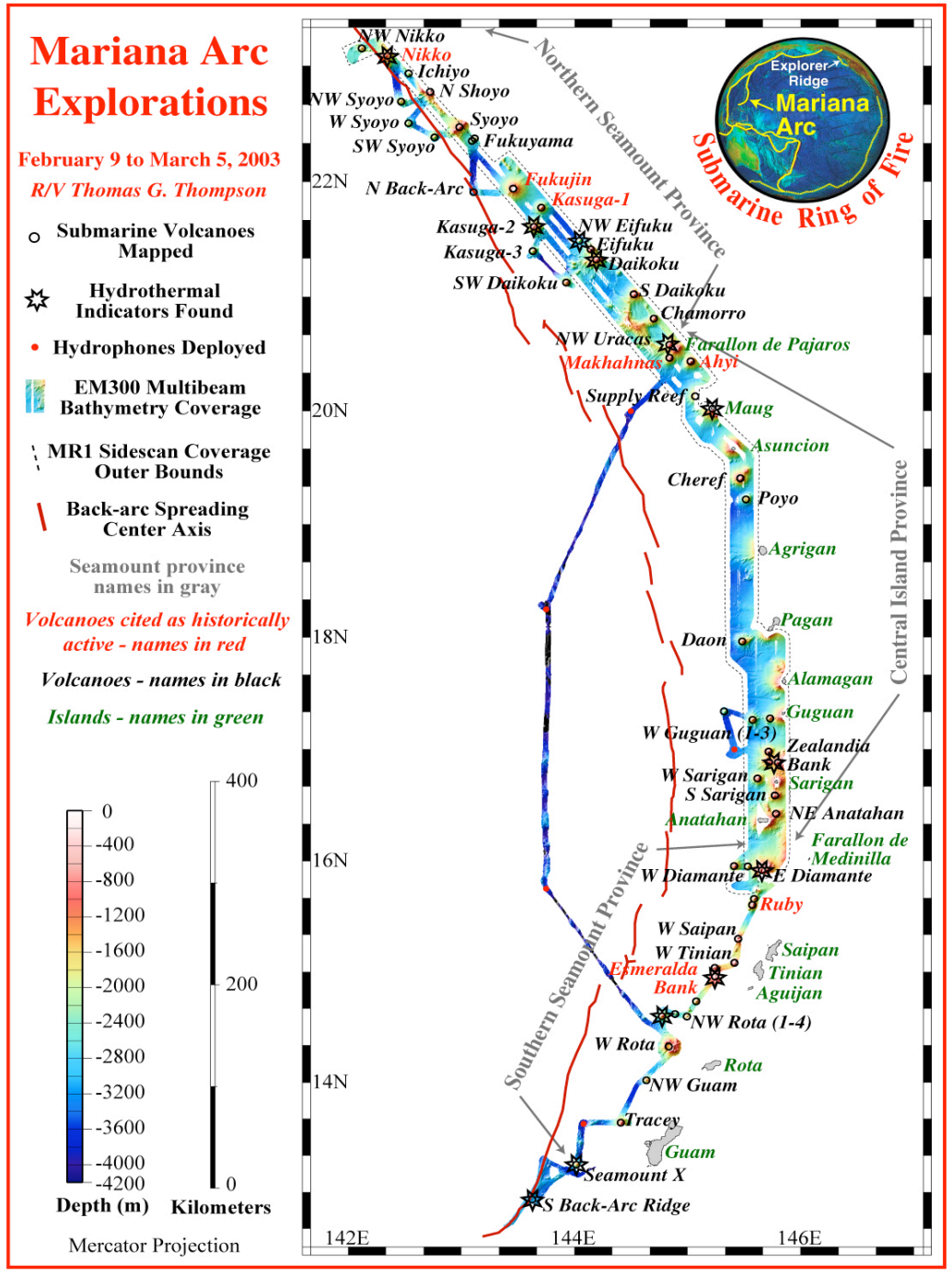
- Spatial & temporal patterns of volcanic/hydrothermal activity along arcs vs. MOR

- 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





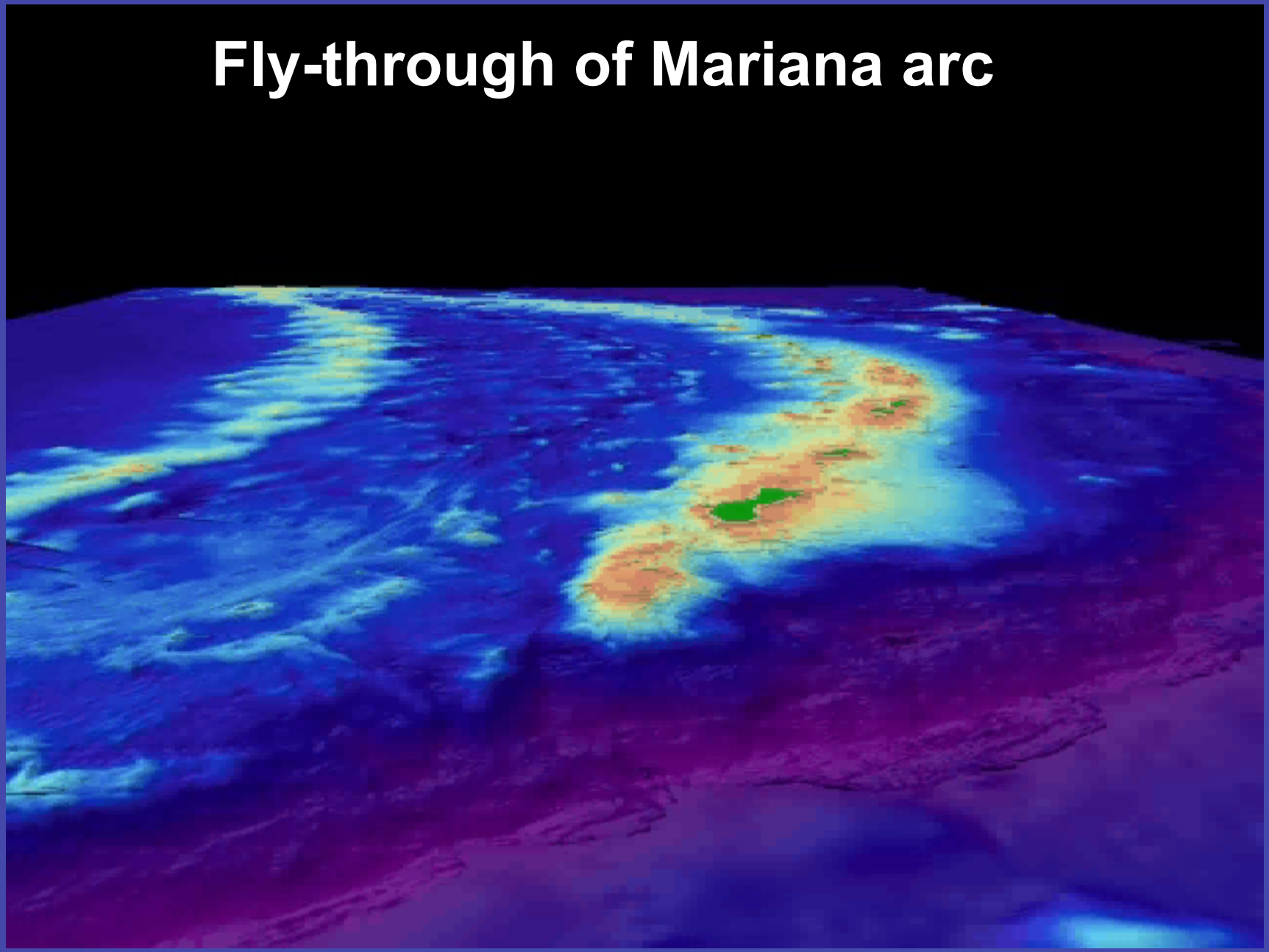
2003, 04, 06 Programs

- 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**

Brimstone Pit, NW Rota-
530 m depth

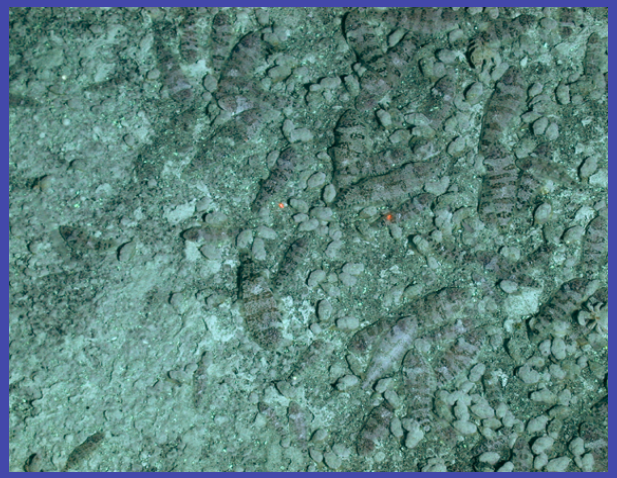
Boiling and free gas phase is common on the shallow, gas-rich Arc volcanoes

While animal diversity at any one site is not high, the Arc provides numerous settings of hydrothermalism and many habitats that increase overall diversity

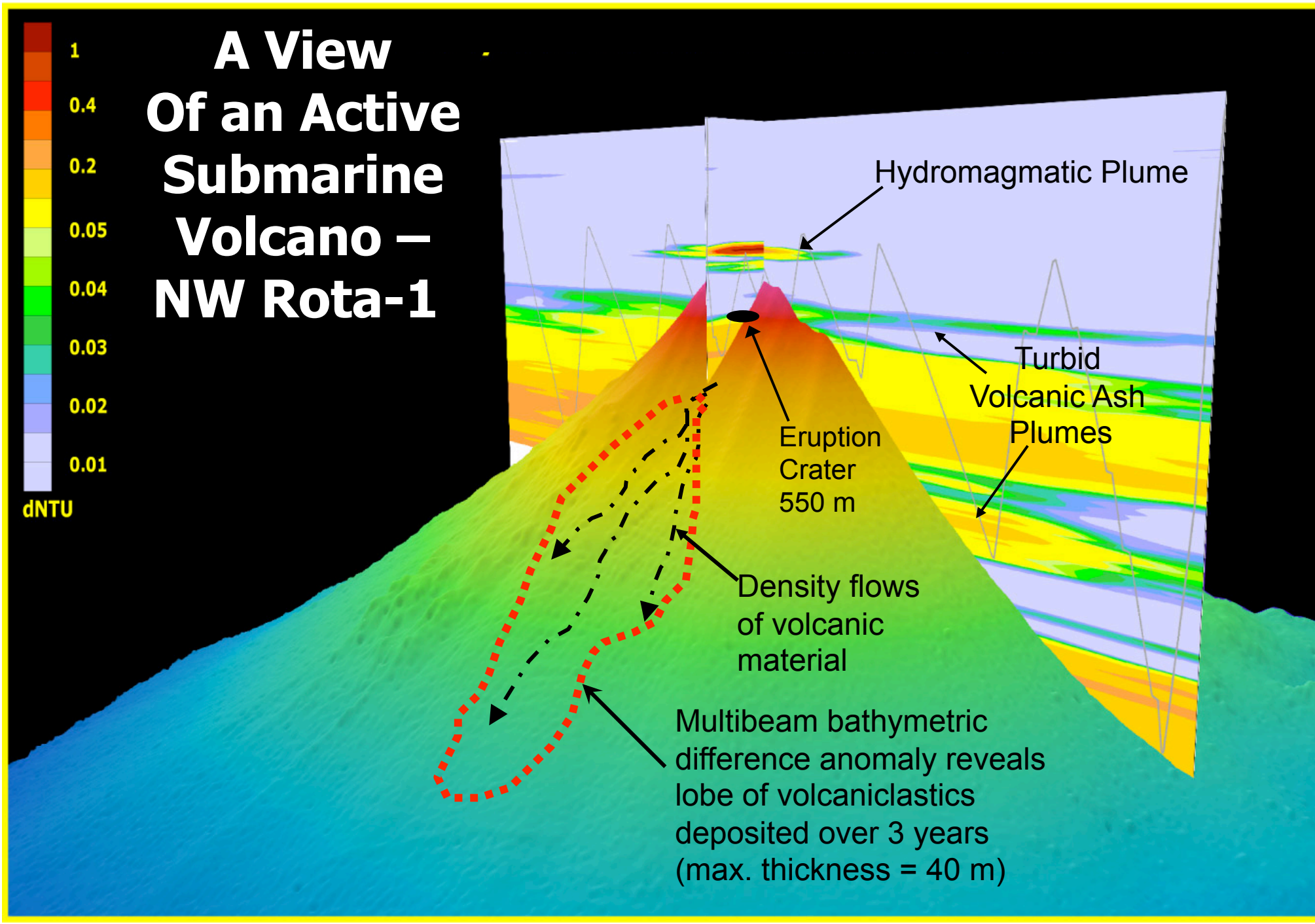
Unstable volcanism i.e. NW Rota

Shallow high temperature i.e. E. Diamante

High CO_2 deep venting i.e. NW Eifuku

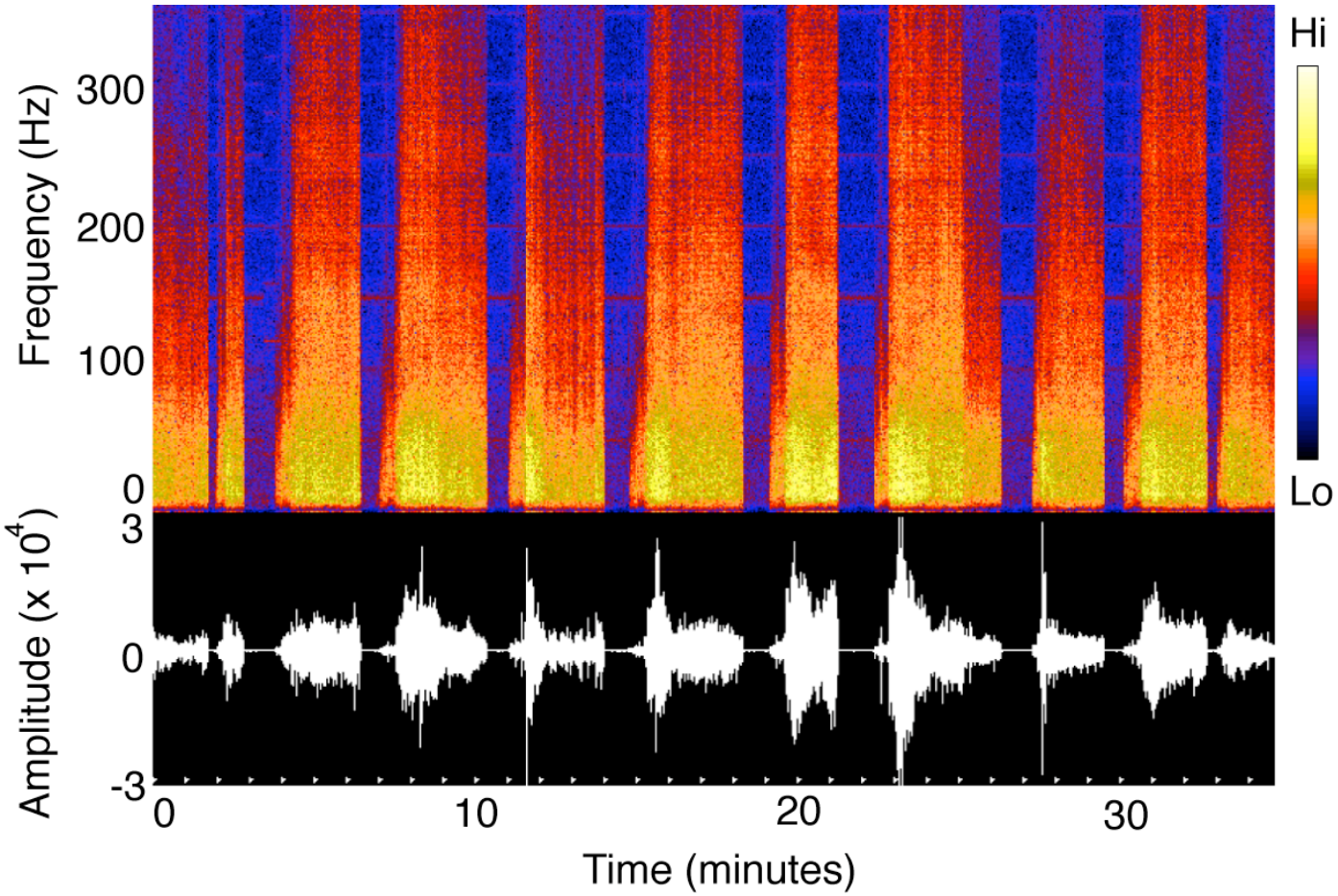


Sedimented slopes above sulphur ponds i.e. Daikoku, Kasuga-2


A View
Of an Active
Submarine
Volcano –
NW Rota-1
1
0.4
0.2
0.05
0.04
0.03
0.02
0.01
dNTU
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

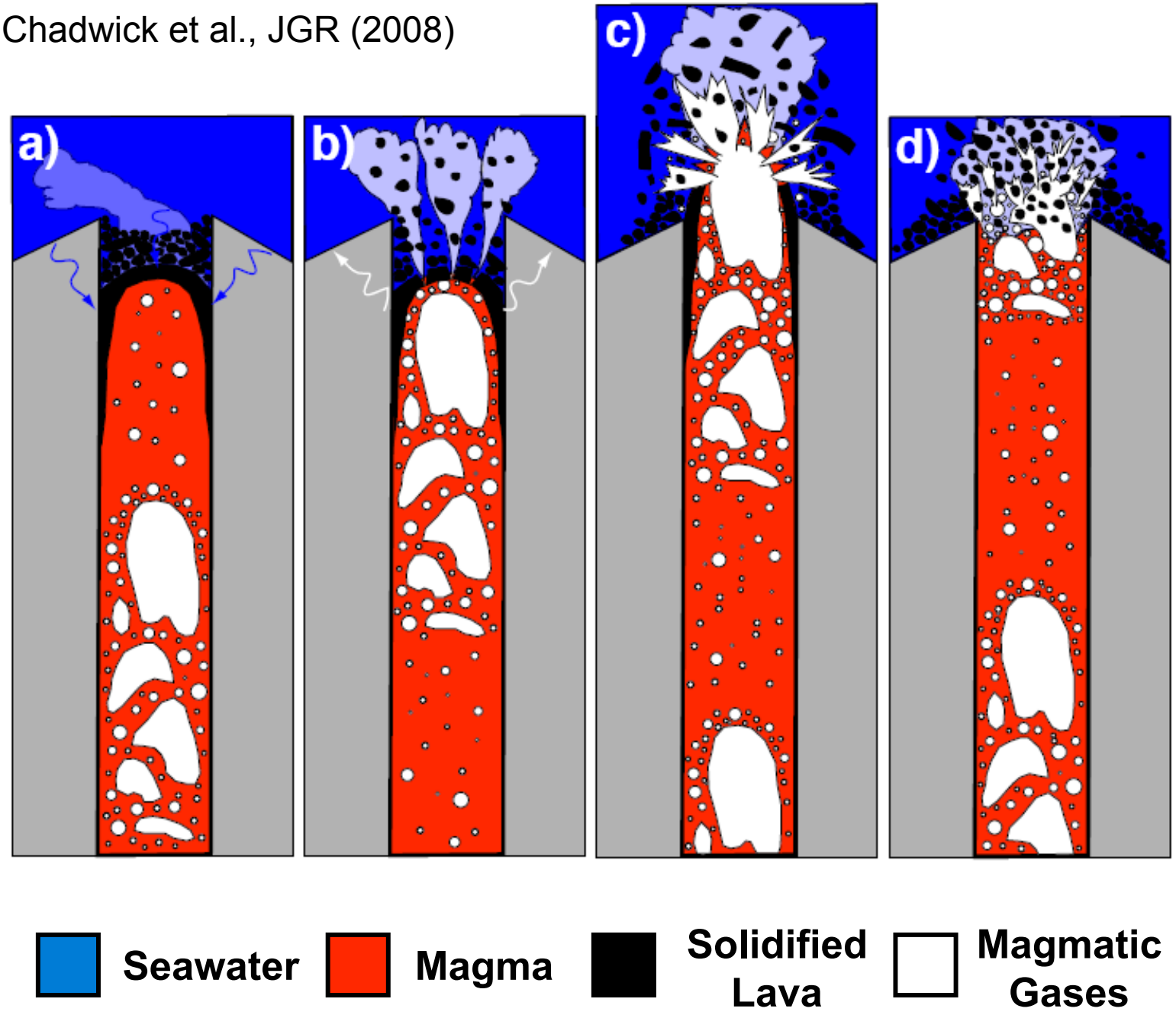
First simultaneous hydrophone and visual observations of submarine volcanism



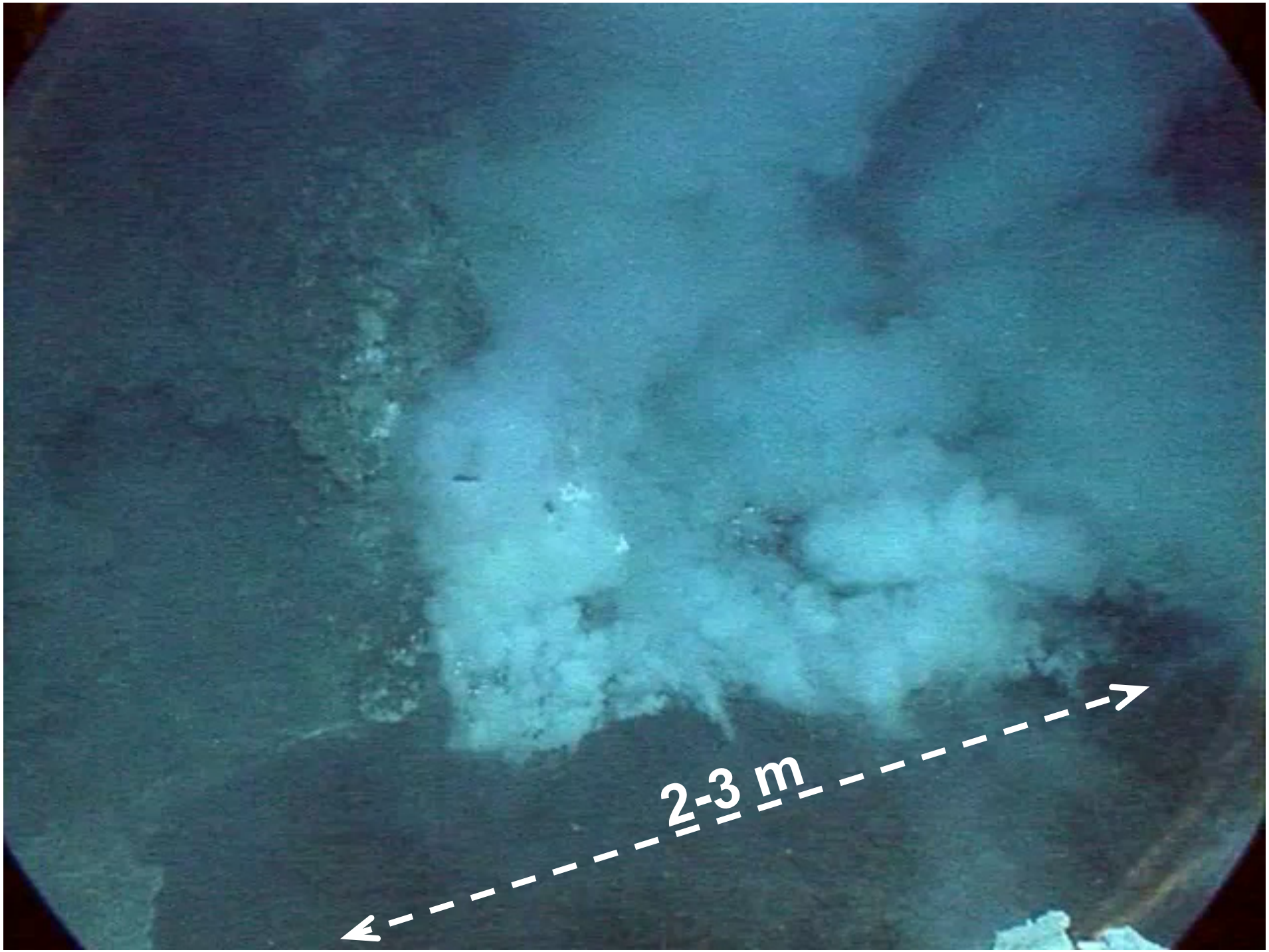
From Chadwick et al., JGR (2008)

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"

Chadwick et al., JGR (2008)



From death comes life:
Deadfalls from toxic volcanic plume provide food

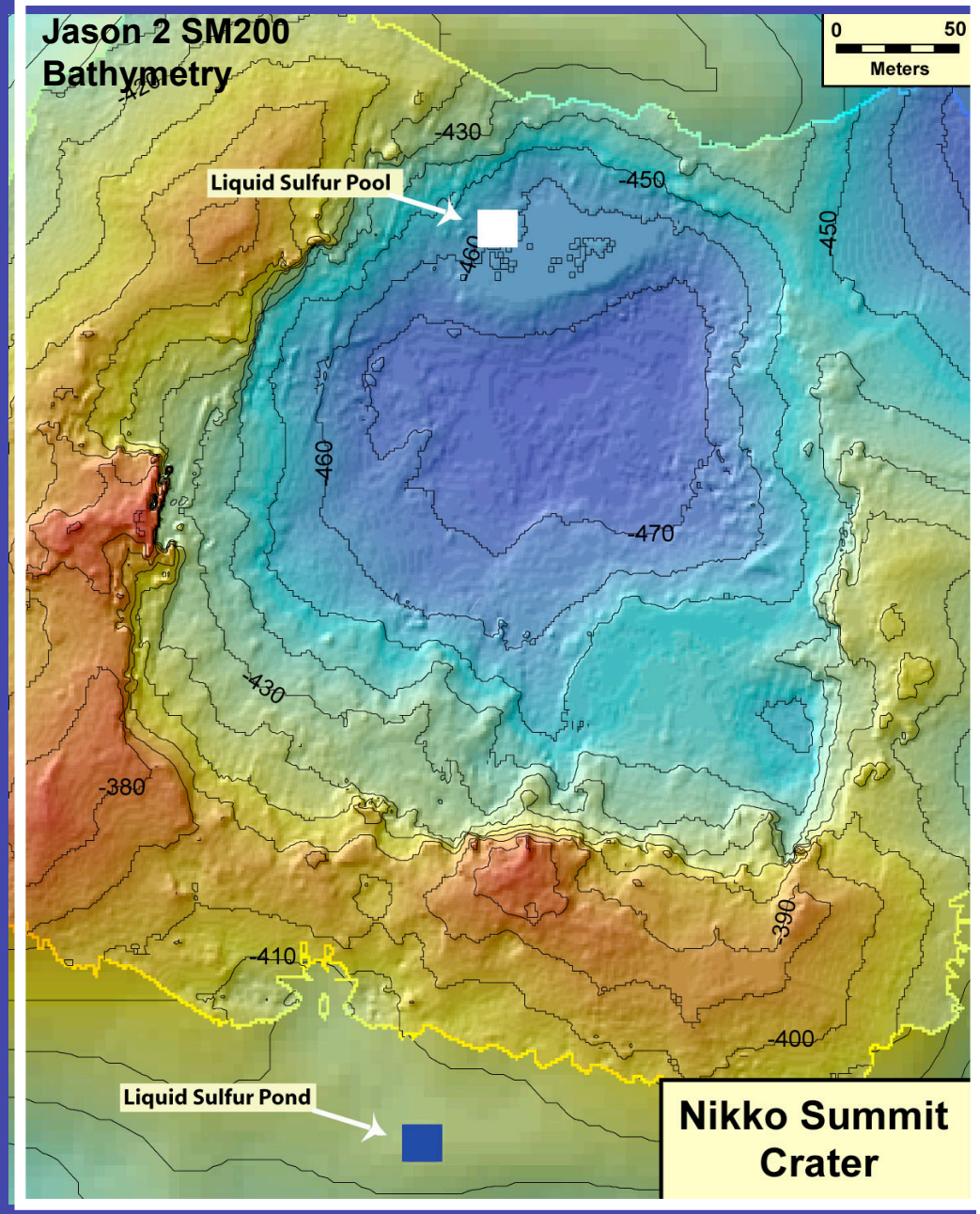

2-3 m


Depth range: -380 to -2611 m
2 X VE
~2000 m foreground
Nikko
North
Summit Crater
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)




J2-199 2006/05/08 16:55:37 H=353 D=0458
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