Fluid-Rock Interactions and the Sub-Seaﬂoor Biosphere

Figure E.1. Subseaﬂoor ﬂuid ﬂow regimes (from JOIDES Hydrogeology PPC Report, 2001, http://posiden.paleoz.geomer.de/panels/reports.html). Black arrows indicate water movement. Red blobs are rising melt; red stars are earthquake locations. Half arrows below the red stars indicate the relative direction of movement of the subducting lithosphere and overriding plate.
BACKGROUND DATA

• Examples of Key Scientific Questions (OOI Science Plan)

• Scientific Priorities (San Juan Meeting)

• Example ORION Experiments (San Juan Meeting)
Examples of Key Scientific Questions (OOI Science Plan)

• What is the extent, abundance, distribution, and diversity of the sub-seafloor biosphere?

• How do submarine hydrothermal systems and their associated biological communities vary over time?

• What processes control the formation and destabilization of gas hydrates? What role do gas hydrates play in catastrophic slope failure?
Overarching Question to Answer in 20 Years

How do subseafloor processes impact life on our planet?

How?
Characterize the mass and energy exchange among the lithosphere, the subsurface ecosystem, and the ocean, and how its influence on our planet.

Why?
The deep biosphere may be host more biomass than any other ecosystem, and it is virtually unknown.
What is the extent, abundance, distribution, and diversity of the sub-seafloor biosphere?

1. *How can the CND be enhanced to better address this science theme?*

**Priority Sites:**

1. MOR (beyond RCO sites); 1 Subduction Zone site; Near-ridge CORKed sites; Coastal sedimented site.

**Global:** Phase I sites: none in dynamic environments
   Phase II sites: 1 MOR & 1 Subduction Zone -- BOTH HIGH PRIORITY (but a long way off).

**RCO:** Will provide data in shorter-term. Connection between RCO and NW coastal array could have benthic capability.

**Coastal:** Important areas along coast (gas hydrates, freshwater aquifers) -- could include seafloor access on (some) Endurance Array moorings.
What is the extent, abundance, distribution, and diversity of the sub-seafloor biosphere?

2. What other approaches could be combined with the observatory elements to better address the science questions across the range of temporal/spatial scales?

Phase I Approach:

1) Make use of IODP holes to gather data in crust and sediments to show **global connectiveness** and address extent question.

2) Make use of DART buoys to emplace seafloor and subseafloor sensors

3) Design cheap experiments -- piston cores, sensors

4) Feasibility study of use of FLIP as spar buoy -- test platform and possible permanent buoy? 2-year phase of testing -- may decrease time to data.

Goal of Phase I -- Constrain the geochemical variations (as signatures of microbial activity and develop microsensors for use in Phase II.
Funding exists for deployment of additional DART Buoys, as shown in Green (planned) and Blue (approximate locations - discussion could influence final locations). For more info contact <gerard.fryer@noaa.gov>
What is the extent, abundance, distribution, and diversity of the sub-seafloor biosphere?

3. What experiments, observations, or activities are likely to yield early success for the ORION program? How can ORION facilitate that success?

- Connect RCO cable to ridge flank CORKed holes to provide real-time off-axis data -- hydrogeology and microbial communities
- RCO ridge sites -- real-time data

Other Recommendations

- ORION, IODP, NOAA, DoE Workshop to establish a joint planning process to address this question.

- Sensors are unreliable -- need to advance technology in preparation for long-term deployments.
How do submarine hydrothermal systems and their associated biological communities vary over time?

1. How can the CND be enhanced to better address this science theme?

Priority Sites: **Global**: 1 Mid-Ocean Ridge (MAR or EPR); 1 Non-Accretionary Margin (e.g. Mariana -- intraoceanic)

**RCO**: MOR sites + Accretionary Margin.

Priorities: 1) Constrain geochemical fluxes -- NEED SENSOR DEVELOPMENT
2) Include experiments to address connectivity to the open ocean -- moorings, sensors, etc.

2. What other approaches could be combined with the observatory elements to better address the science questions across the range of temporal/spatial scales?

Evolution of Crustal Hydrogeology/Permeability:
Priority Sites: RCO links to ODP CORKED flank holes.

3. What experiments, observations, or activities are likely to yield early success for the ORION program? How can ORION facilitate that success?

Real-time data from NEPTUNE Canada -- ensure success in investigating hydrothermal systems.
What processes control the formation and destabilization of gas hydrates? What role do gas hydrates play in catastrophic slope failure?

1. **How can the CND be enhanced to better address this science theme?**

Priority Sites:
- Barkley Canyon node; connection between Newport Coastal line and RCO to access Hydrate Ridge
- Hydroacoustic network at RCO to monitor slope failure
- Hydrate Ridge -- cable with geophones for subsurface variability in hydrate distribution

2. **What other approaches could be combined with the observatory elements to better address the science questions across the range of temporal/spatial scales?**

- AUV surveys with sensors to determine seafloor equipment locations (discharge varies in location)
- Sensors on coastal Pioneer arrays -- positioning??
- IODP holes to investigate porosity in slope sites.
What processes control the formation and destabilization of gas hydrates? What role do gas hydrates play in catastrophic slope failure?

3. What experiments, observations, or activities are likely to yield early success for the ORION program? How can ORION facilitate that success?

- Instrument node at Barkley Canyon to get real-time data combined with planned AUV survey and other Canadian studies (benthic rover, imagery, etc.) to determine hydrate distribution.
Examples of Key Scientific Questions (OOI Science Plan)

• What is the extent, abundance, distribution, and diversity of the sub-seafloor biosphere?

• How do submarine hydrothermal systems and their associated biological communities vary over time?

• What processes control the formation and destabilization of gas hydrates? What role do gas hydrates play in catastrophic slope failure?
Scientific Priorities (San Juan Meeting)

1. Determine the influences of fluid (water, gas, magma) migration and water-column hydrodynamics on chemical & biological systems at and near seafloor spreading centers.

2. Determine the processes that lead to continental margin slope failure, & their consequences.

3. Estimate the mass & energy fluxes between the crust/lithosphere/asthenosphere & the ocean, document how they are distributed in space and time, & determine their consequences.

4. Characterize the composition & activity of subsurface microbes within the oceanic lithosphere & adjacent continental margins, & identify their biogeochemical processes & influences.
Example ORION Experiments (San Juan Meeting)

• How are ridge-crest hydrothermal systems, & the biological communities that they support, affected by volcanic & tectonic events?

• What are the dominant processes controlling gas hydrate dynamics & what are their environmental, climatological, & geological consequences?

• Are most submarine slope scars formed by catastrophic slope failure from hydrate-related gas venting or by slow creep and/or numerous smaller slope-failure events?

• What are the abundance, diversity, & metabolic activity of microbes within young oceanic lithosphere & how does this biosphere vary in space and time?
Cross-Cutting Science Theme Breakout Group Questions

1. How can the CND be enhanced to better address this science theme?

2. What other approaches could be combined with the observatory elements to better address the science questions across the range of temporal/spatial scales?

3. What experiments, observations, or activities are likely to yield early success for the ORION program? How can ORION facilitated that success?