SOCIETAL RELEVANCE OF SCIENTFIC OCEAN DRILLING

U.S. Advisory Committee for Scientific Ocean Drilling
September 2009

INTRODUCTION

Humans have long depended on vital resources extracted from the Earth and endured devastating natural disasters. More recently, we have become aware of the challenges of global environmental change. Both above and below the seafloor, the oceans are an integral part of the cycles that control global climate, hazards, and resources. Scientific ocean drilling provides access to an archive of past history as well as a window on active processes below the seafloor.

This white paper provides examples of where scientific ocean drilling contributes to the welfare and prosperity of future generations. These examples are grouped under the interrelated themes of global change, natural hazards, and resources. The list is not exhaustive, nor does it prescribe specific drilling plans. This document is intended as a starting point to spur creative thinking about societal relevance during and following the INVEST conference.

GLOBAL CHANGE

The atmospheric concentration of CO_2 is now higher than experienced on Earth for at least the past 800,000 years and probably over the past 20 million years, and it is expected to continue to rise at an increasing rate. As a consequence, the Earth is expected to warm by ~3°C over the next century and continue to remain warm for many centuries afterward. The amount of warming and length of time that global temperature will remain high are not well constrained, and it is poorly understood how this warming will impact Earth systems. The record of environmental change obtained by scientific ocean drilling uniquely helps to understand and assess the magnitude and direction of this change. Scientific ocean drilling provides insight into the stability of ice sheets, the history of past sea-level rise, changes in ocean circulation and chemistry, and climate oscillations on the scale of decades to hundreds of thousands of years.

Ocean Acidification: The overarching scientific questions that need to be answered to understand the fate of CO_2 entering the ocean are: how much can be absorbed, where is it absorbed, and how fast is it neutralized? Scientific ocean drilling provides the requisite time series of environmental and biotic changes (preserved in proxy records such as corals and marine sediments) needed to answer these questions. Past drilling has yielded a remarkable archive of material, but it is critical to acquire additional material from different locations, different time intervals, and using improved drilling and analytical techniques.

Past Warm Periods: Studies of past warm climates, although outside the temperature range envisaged for current climate change, will allow us to understand better how greenhouse gases control Earth surface temperatures. The Paleocene–Eocene Thermal Maximum (PETM) occurred 55 million years ago, when an abrupt increase in atmospheric CO_2 caused massive dissolution of shallow carbonate sediments and the extinction of calcifying organisms. In particular, study of the PETM will provide much needed insight on the rate at which biogeochemical feedbacks will restore the ocean to its pre-anthropogenic state.

Sea-Level Change: Sea-level change is one consequence of climate change. As global temperatures increase, continental glaciers melt and water volume increases. Current warming has been projected to increase sea level by up to 1 meter by the end of the 21^{st} century, threatening coastal areas with submergence. This is an especially great problem on continental margins with low coastal gradients and large populations living at or near sea level. Understanding past patterns and rates of sea-level change is necessary to decipher the complex feedback between climate change and ice-sheet dynamics.

NATURAL HAZARDS

As a tectonically and volcanically active planet, Earth continues to undergo natural changes that impact human life. Scientific ocean drilling provides invaluable information on the mechanisms and consequences of earthquakes, submarine landslides, and bolide impacts, and such information is vital for planning disaster prevention and mitigation.

Earthquakes and Tsunami**:** Subduction zones occur where one oceanic plate descends beneath another oceanic or continental plate. This process generates earthquakes, including the largest known to mankind, “great earthquakes” with magnitudes ≥ 8. The destructive power of subduction zone earthquakes was demonstrated vividly by the 2004 Sumatra earthquake and associated tsunami. Scientific ocean drilling allows access to sediment records of past fault slip and related slope failures, collection of fault-zone samples for laboratory studies, and installation of equipment to monitor the relationship between earthquakes, strain, and fluid pressures through time.

Landslides**:** Submarine landslides can destroy offshore infrastructure, including platforms, pipelines, and cables, and produce huge tsunamis. Landslides can be triggered by volcanic slope failure, earthquakes, and subseafloor fluid flow and elevated fluid pressures. Ocean drilling can delineate the past history of slope failures and help to understand the conditions that cause failure, including the relationship between volcanic growth and collapse. Ocean drilling also provides information on subseafloor fluid pressures, sedimentation rates, and the fluid-flow properties of sediments. These observations are then used to validate numerical models of fluid flow and slope stability.

Volcanism: Volcanism is important both as a natural hazard and in global climate. It links the vast reservoir of greenhouses gases (H_2O, CO_2, S, CH_4) stored in the solid Earth with surface processes. Large volcanic eruptions can devastate local communities. Ash released into the atmosphere can block sunlight, lower global temperatures, and result in famine and invariably economic loss. Carbon dioxide released by volcanism may have accelerated the recovery from past glaciations, aided by the lower albedo of ice sheets covered with volcanic ash. Episodes of extensive volcanism may have altered ocean circulation and ocean chemistry, caused the extinction of species, and contributed to the formation of a hot, ice-free world by recycling of seafloor carbonates. The volcanic record on the seafloor is accessible through scientific ocean drilling and is vital to determining when and how volcanism impacted the Earth’s habitable environment in concert with other pacers of environmental change.

Bolide Impacts**:** The Earth remains exposed to extraterrestrial bombardment as revealed by impact structures in the recent geological past. Scientific drilling offers the only direct means to investigate the internal structure and associated deposits generated by such an event. By directly sampling ejecta near to and far from known impact sites, we can understand the effects of impacts of varying size. Additionally, scientific drilling is necessary to document changes in past biological diversity, both locally and globally, critical in preparation for future impacts. Finally, drilling-obtained constraints on impact structure and distribution of deposits can be used to calibrate models of future impact scenarios.

RESOURCES

The demands on the Earth's natural resources will only increase in the future. The oceans contain important resources that have barely been explored. Ocean drilling provides vital information on the economic potential and future exploitation of natural resources.

Energy Resources and the Carbon Cycle: Scientific drilling contributes to exploration for conventional energy resources. In offshore frontier areas, ODP/IODP drilling may offer the only solid evidence of what rock types are present in the region and their age. This type of information is critical for finding reservoirs, estimating their size and potential, and assessing the feasibility of exploitation. Through better understanding of subseafloor sediment behavior and slope stability, scientific drilling allows better site selection for infrastructure needed for both traditional and renewable energy.

Scientific ocean drilling has played a leading role in assessing the location, origin, and stability of vast gas-hydrate deposits that reside in continental shelf and slope sediments. These deposits store carbon in the form of methane trapped in ice. Dissociation of gas hydrates may play a role in initiating landslides. In turn, sudden unloading by landslides may destabilize gas hydrates, releasing methane to the atmosphere and leading to past rapid warming events. Ocean drilling can help test this hypothesis through examining the past record preserved in seafloor sediments.

Hydrocarbons are only one component of the global carbon cycle. Carbon is also stored naturally beneath the seafloor as organic matter, in carbonate sediments, and within other minerals. Subseafloor microbes play a key role in the carbon cycle. The vast subseafloor biosphere may contain 50% of the Earth's biomass and holds major implications for climate, energy, and perhaps even human health. The carbon cycle is also impacted by fluid flow within ocean sediments and crust, which redistributes chemicals, microbes, and heat. Investigations through scientific drilling and subseafloor observatories are a vital component for examining the sub-seafloor biosphere and fluid flow, and their impact on global elemental cycles.

As anthropogenic CO_2 emissions increase, scientists have begun searching for rock formations in which to capture and store the excess atmospheric CO_2. Basalt and peridotite, two rock types that occur abundantly in the ocean basins, have shown high potential as long-term reservoirs. Scientific ocean drilling plays a leading role in assessing and identifying shallow subsea sites suitable for carbon sequestration.

Hydrologic Cycle: Although some consider water to be the gold of the 21st century, the effects of global climate change on the hydrologic cycle are poorly understood. Data on hydrologic response to past climate changes are vitally important for predicting the future. Furthermore, groundwater systems can have long residence times and thus are affected by past hydrologic regimes. Some aquifers today contain water that was recharged during the last ice age, and the freshwater–seawater interface of some coastal aquifers is still adjusting to sea-level rise following the last glacial maximum. Ocean sediments provide an archive of past hydrologic change that can be used to better understand feedbacks between climate change, evapotranspiration, and surface and groundwater flow.

Workforce Development: The challenges of the 21st century—global climate change, energy and water resources, and geohazards—require a culturally competent workforce able to function in interdisciplinary and international settings. IODP and its predecessor, ODP, are widely recognized as hallmarks of international collaboration, bringing together international scientists and engineers who work together to select research ideas, to organize and implement expeditions, and to conduct and disseminate research obtained through scientific ocean drilling. The drilling programs have always included early career scientists, as well as undergraduate and graduate students, on research expeditions and in shore-based projects. This unique experience has fostered collaborations among international scientists who have become mentors, colleagues, and employers. In this way, scientific ocean drilling serves as an important training ground for scientists who work in academia, industry, and government.