Addressing Caribbean Geophysical Hazards through the Continuously Operating Caribbean GPS Observational Network (COCONet) and International Ocean Drilling Program (IODP)

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The Illinois State Geological Survey (ISGS) contributes to the International Ocean Drilling Geo Hazard Program (IODP) by developing the Coastal Zone Geo Hazard Geophysical Observation System based on off shore drilling platforms. As was dramatically shown by the Sumatra earthquake and associated tsunami of late 2004, the oceans are the source of some of the most severe geophysical hazards. Large tsunamigenic earthquakes tend to occur several times per century, commonly near coastal areas, with devastating impacts on communities and coastlines both near to and far from the source. Smaller earthquakes also can generate significant tsunamis, often much larger than predicted by the earthquake magnitudes. Global examples are well known and include seismically active plate boundaries of all types. Oceanic hazards are generated in many other settings as well. These settings include passive margins in which rapid sedimentation, fluid overpressure, or gas hydrate dissociation can cause slope failure. Explosive eruptions and sudden flank deformation on coastal or island volcanoes can induce sector collapse and catastrophic landslides and have the potential to generate devastating tsunami and related coastal damage.

The mechanisms and controls on tsunamigenic deformation are still incompletely understood, as are their distribution in time and space. Because of their oceanic setting, tsunamigenic events are often preserved in the marine sedimentary record. Thus, ocean drilling provides several new opportunities to extract and read this geologic record and to monitor physical and chemical processes and changes in material properties associated with dangerous geologic phenomena. Developing a sound scientific understanding of the geological and physical processes underlying these hazards is crucial to efforts to evaluate their distributions, to produce predictive models, and to mitigate their risks.

Presently, the characterization and understanding of the causes and consequences of oceanic geologic hazards is an under realized element of the IODP Initial Science Plan http://www.iodp.org/geohazards/

Coastal, shelf and continental slope areas of the Caribbean region are quickly becoming new major areas of industrial technological development owing to vast natural resources such as oil and gas available in these areas. We hold that the best approach to complex monitoring and investigation of processes accompanying drilling and oil/gas production on the coastal zone and continental shelf is by way of bottom cable systems of continuous observation - in other words – bottom observatories located in the vicinity of a drilling platform and cable connected with a data processing centre (Figure 1). Operation of such systems is to be combined with GPS and satellite survey as well as with scientific cruise investigations.

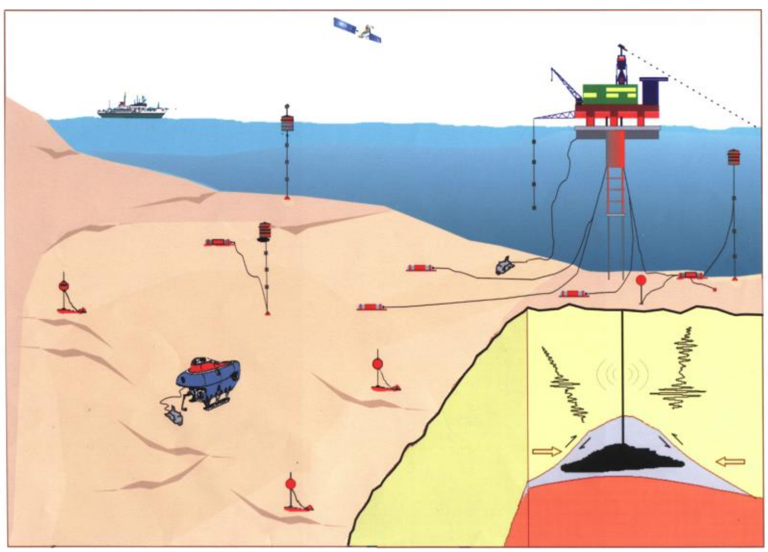

Figure 1. A general structure of the coastal zone geophysical hazard observation system based on drilling platforms

It was over 15 years ago that the international programs for creation and development of bottom cable observatories were adopted in Japan (POSEIDON) and Europe (GEOSCOP). In 2001 the USA NSF called the program for creation of long term ocean systems priority for nearest decades. Unfortunately implementation of the above programs is hindered by some technical problems, particularly the expensiveness of bottom cables (over 1 million dollars per 10 km), and difficulties associated with cable laying in surf zones etc. If marine monitoring systems on continental slopes are constructed in the traditional way, that is by connecting them to a coastal lab, it means hundreds km long cables and hence tens of million dollars. Thus the total cost of world cable monitoring for drilling platforms on the shelf and continental slopes of Caribbean region, South America and other continental margins can amount to several billion dollars. Such expenses can be hardly incurred even by leading industrial countries.

On the other hand if highly technological drilling platform infrastructure serves to collect and process information the total cable length will be orders shorter. Consequently the cost of such systems is going to be one order lower. We estimate the cost of such systems to amount to 1% of marine drilling platform cost. Therefore oil companies can easily provide for a development of such systems in the framework of investment projects aimed at construction and safe operation of marine drilling platforms. Another important feature of the above approach is its ability to be coordinated in time with all stages of industrial development starting from exploration, through construction, operation and liquidation. In this way the above system of environmental monitoring integrated in drilling platform infrastructure will be an important tool of environmental protection in the world ocean.

Marine drilling platforms can bear a set of special equipment and give a start for development of bottom cable observatories, which allow automatic or semiautomatic control of oceanic environment. All ecologically important characteristics of seawaters and bottom suffering from anthropogenic impact can be grouped as technological, physical, geophysical, chemical, and biological. Technical equipment required for geoecological monitoring include: bottom cable observatories designated for measuring hydrophysical and some hydrochemical characteristics of bottom sediments and water mass; bottom cable seismographs to register natural and induced seismic activity; multifunctional laser measuring complex for monitoring of phytoplankton and of oil pollution of seawater, submersible probes, measuring fluorescence and light conditions meant for express control of superficial waters polluted by hydrocarbons and other organic matter, they can also be used to determine chlorophyll concentration in phytoplankton; optical type probes with integrated digital cameras for evaluation of dimension-quantitative characteristics of mesozooplankton. To determine the content of various dimensional groups of zooplankton, and macroplankton content a submersible camera is necessary. To determine the amount of macrophytes and zoobentos a submarine remote control camera is required. In addition corers for liquid and soft fractions, intended for sampling both on the bottom and within the water mass and subsequent transportation to platform-mounted lab are required. Submersibles are required for installation and subsequent examination of bottom cable stations, change of sensors, and installation of optional equipment. Similar vehicles are supposed to be used for underwater examination of the drilling platforms and pipe columns.

Some principal benefits to be obtained by realization of suggested program of complex geophysical monitoring in the Caribbean region are as follows:

1. Presented system of complex monitoring combines' high tech potential and developed infrastructure facilities of oil/gas companies, and latest scientific achievements to secure environmental protection.
2. Suggested monitoring system could provide reliable control of ecological situation in drilling areas and adjacent zones in the Caribbean region and forecast of possible hazardous changes, and also helps to protect the coastline zone from possible pollution.
3. It enhances drilling safety thanks to stress state monitoring of hydrocarbon reservoirs and surrounding rock massif.
4. It diminishes the risk of penalty in case of pollution by exterior carriers.
5. It provides new fundamental knowledge of processes occurring on coastal zone and continental shelf of the Caribbean region.
6. This monitoring system will help to protect the coastal zone and continental shelf ecological systems.

The COCONet Workshop could establish the current state of community knowledge and activity in Caribbean region in the area of submarine geophysical hazards and to address a series of focused questions. In particular, investigations of geophysical hazards through scientific ocean drilling still face many obstacles. The understanding of the necessary conditions and triggers for catastrophic geologic events (e.g., landslides,

earthquakes, and tsunami) is incomplete, and instruments for making in situ or remote measurements of the geotechnical and other material properties of the rocks and sediments involved are limited. Moreover, there is a need to define tractable scientific questions and to design realistic science and engineering plans that can actually answer them. A few of the key goals of the scientific discussion during the workshop could be to define outstanding research questions that can be addressed through scientific ocean drilling, establish scientific priorities, identify potential drilling targets, evaluate existing technologies and scientific approaches, and formulate strategies to overcome anticipated scientific and engineering challenges. The workshop could enhance international collaborations and stimulate teams of proponents who are expected to develop competitive COCONet - IODP proposals addressing Caribbean geologic hazards.
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