



Drilling hazard assessment for hydrate bearing sediments including drilling through the bottom-simulating reflectors



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ABSTRACT

To achieve the scientific goals of the NGHP Expedition 01 project, it was necessary as a preliminary step to examine the available marine 2-D seismic data covering then-proposed investigation drilling sites for potential drilling geohazards. A total of 19 potential drilling sites, located in offshore areas of the northern Indian Ocean: the Krishna–Godavari Basin, the Kerala–Konkan Basin, the Mahanadi Basin, and the Andaman Islands, were investigated. The NGHP Expedition 01 staff identified several potential drilling hazards to be investigated at each site, including, but not limited to, the common drilling hazards of seafloor slopes and failure conditions, complex seafloor topography and anomalous amplitude response, shallow gas hydrates, shallow free gas, shallow water-flow, and faults/fractures. Specific proposed drilling sites were investigated over a depth range beginning at the seafloor and extending to 350–700 m below the seafloor, depending upon the specific planned depth at each site. These investigations resulted in some sites being interpreted to be clear of potential drilling geohazards, while other sites were determined to have potentials for specific geohazards significant enough for reconsideration. These reconsiderations consisted of moving specific sites to more favorable locations interpreted to be relatively unsusceptible or less susceptible to a specific identified geohazard, and/or reducing the planned depth of drilling, or removing a potential site at least temporarily from consideration. This work contributed to favorable results from the NGHP Expedition 01 in that no drilling geohazards were reportedly encountered.

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1. Introduction

The primary goal of NGHP Expedition 01 (NGHP01) was to conduct scientific ocean drilling/coring, logging, and analytical activities to assess the geologic occurrence, regional context, and characteristics of gas hydrate deposits along the continental margins of India in order to meet the long term goal of exploiting gas hydrates as a potential energy resource for India. During NGHP01, dedicated gas hydrate coring, drilling, and downhole logging operations were conducted from 28 April, 2006 to the 19 August, 2006.

Based on analysis of geological and geophysical data, the Expedition was planned to visit ten sites in four areas: the Kerala–Konkan Basin in the Arabian Sea – western continental shelf of

India; the petroliferous Krishna–Godavari Basin and Mahanadi Basin in the Bay of Bengal – eastern continental shelf of India; and the previously unexplored Andaman Islands (Fig. 1). During its 113.5-day voyage, the expedition cored or drilled 39 holes at 21 sites (one site in the Kerala–Konkan Basin, 15 sites in the Krishna–Godavari Basin, four sites in the Mahanadi Basin and one site in the Andaman deep offshore areas), penetrated more than 9250 m of sedimentary section, and recovered nearly 2850 m of core. Twelve holes were logged with logging-while-drilling (LWD) tools and an additional 13 holes were wireline logged (Collett et al., 2008a, 2008b).

Offshore drilling operations, and especially those in deepwater, are characteristically complex, expensive, and exhibit potentially challenging conditions. This is true of drilling operations for scientific and engineering purposes as well as for petroleum exploration and production. The challenges come not only from failures of operational systems and plans, but also from geologic hazards. The geologic hazards would mostly affect the operations and objective of projects, by causing delays, or by damaging equipment or the borehole. Less frequently, such hazards could affect the

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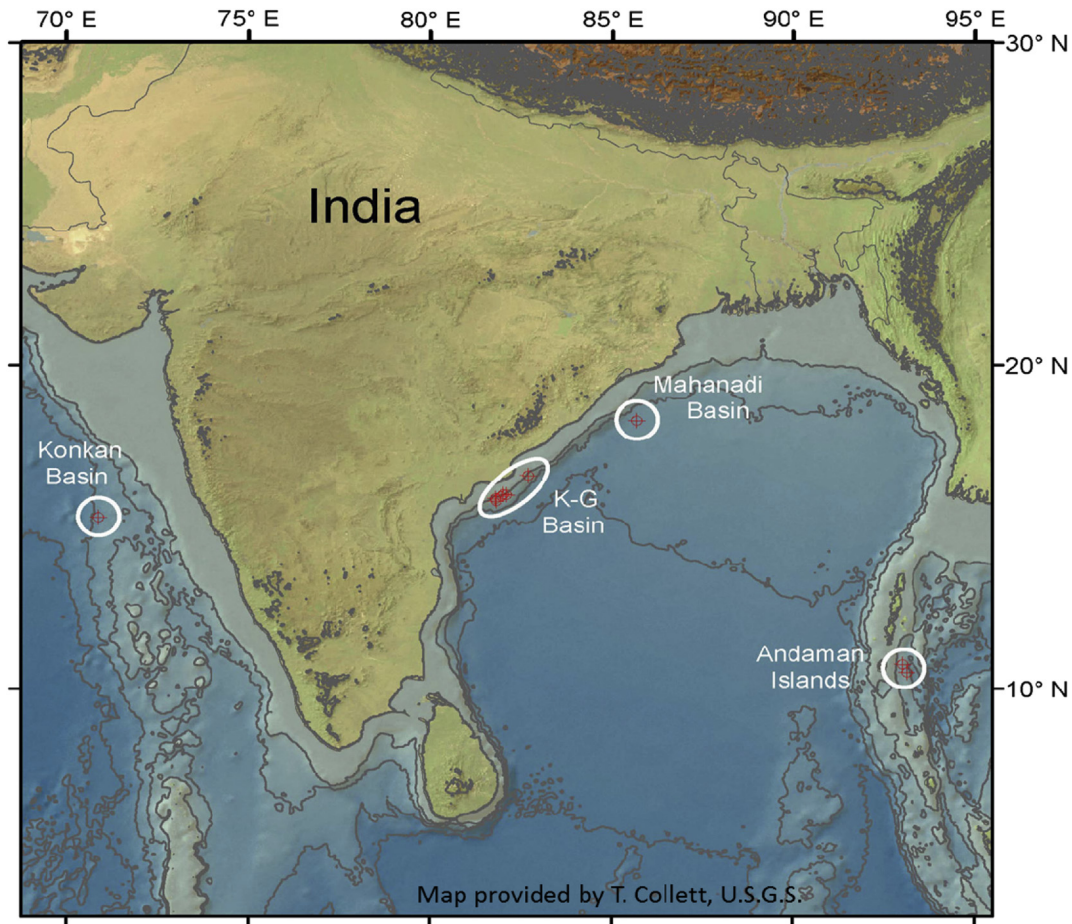


Figure 1. Regional location map showing locations of offshore basins targeted by NGHP01 2006 activities.

health and safety of those at the worksite, through such incidents as blowouts.

Fortunately, the most significant potential shallow geologic drilling hazards typically can be detected and assessed by using marine seismic reflection data. The hazard assessment methodology has evolved and been refined somewhat by trial-and-error. However, by the early-to mid-2000s, the use of marine seismic data to identify potential drilling hazards and assist with the design of mitigation measures had become standard practice in the offshore drilling industry. Largely because of the confidence in this approach to geohazard assessments, the NGHP02 drilling program was able to be executed successfully with respect to effectively dealing with shallow drilling hazards (Collett et al., 2008a, 2008b).

Boswell et al. (2012), Collett and Boswell (2012), and McConnell et al. (2012) discuss the latest thinking about drilling hazards associated with gas hydrates. Hadley et al. (2008) discuss hazards to petroleum production facilities and operations that can result from gas hydrates.

The purpose of this report is to provide an understanding of how standard industry 2-D seismic data is interpreted to assess shallow geohazards and review the methods used to assess the specific geohazards associated with the proposed NGHP01 drilling sites. The reader will note that some discussion of site selection related to optimizing the potential for encountering gas hydrates is also included. Because gas hydrates represent the goal of the overall field expedition, as well as a possible drilling hazard, site-specific assessments on the preferable occurrence of gas hydrates naturally follow from their consideration as a potential hazard by the shallow geohazard specialist.

The geohazard assessment work was performed using the available seismic data sets, which consisted of 2-D survey lines. The majority of the originally proposed 19 drill sites were located along the eastern coast of India, with 15 sites located in the Krishna–Godavari Basin, one in the Kerala–Konkan Basin, two in the Mahanadi Basin, and one in the Andaman Islands area. Of the 19 sites investigated, seven sites were moved to avoid specific hazards or to optimize the chance of sampling gas hydrate. One site was recommended against drilling because of steep slopes, and one site was recommended against drilling in favor of another planned site.

The proposed drilling depths at the individual drilling sites generally ranged from 350 m to 700 m below seafloor (mbsf). However, not all sites were drilled to the depths considered within the shallow hazards assessment; some boreholes were terminated at shallower depths.

The following sections of this report describe: (1) the seismic data used for the NGHP01 pre-drill identification and assessment of shallow geologic drilling hazards; (2) the types of hazards that may be identified using the seismic data made available for this review; (3) the potential impact of the identified hazards on drilling and recommended mitigation steps; (4) our pre-drill geohazard prognoses for the proposed drilling sites; (5) the drilling results with respect to the geologic hazards that were reported; and (6) a summary.

Detailed descriptions of the drilling operations and on-board scientific activities are provided in Collett et al., (2008a, 2008b, 2014). However, a summary of drilling operations between 5 May to 30 May 2006, and 1 June to 4 June 2006, is included in Table 1 as an example of NGHP01 operations.

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