DEEPWATER GEOHAZARDS AND ENGINEERING GEOLOGY: MEETING TOUGH CHALLENGES

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Petroleum exploration and development are now being carried out in water depths of 5,000 feet and more. Investments for these offshore activities are huge: rates for some deepwater drilling rigs alone are currently \$100,000 per day or more, and total investment in some deepwater developments has been as much as \$1.2 billion.

To complicate matters, shallow geologic and soil conditions at deepwater sites are often complex and difficult compared with conditions typically found on the continental shelves. These complex conditions present serious engineering and safety challenges that require careful application of geoscience techniques as a basis for avoiding or reducing hazards and to help minimize the cost of deepwater development. Reliable engineering-geologic characterization of site conditions, being increasingly based on 3-D seismic data, is essential to optimize siting, design, and operation of facilities and to thus maximize value to investors.

Complete characterization of offshore sites includes defining water depths and seafloor topography, determining soil geotechnical properties and relationships among soil strata, and making an engineering assessment of geologic conditions. Geophysical data define geologic features and general stratigraphy, whereas borehole data define detailed stratigraphy and soil geotechnical properties at specific points; alone, neither completely characterizes a site. Among the activities requiring offshore site characterization, including geohazards assessment, are well planning and exploratory drilling, pipeline routing and design, and facilities siting and design.

Complex deepwater (water depths > 600 feet) conditions in the Gulf of Mexico that can cause engineering difficulties include 1) steep and potentially unstable slopes of 10 degrees or more; 2) irregular, commonly rocky, topography with sharp relief ranging from a few feet to several tens of feet; 3) faults, many of which appear to be active, with seafloor scarps ranging up to more than 200 feet high; 4) both modern and ancient landslides covering large areas; 5) gas hydrates (solid, ice-like mixtures of gas and water found in water depths > 1,500 feet) that may be subject to reduced shear strength and thaw settlement when heated; 6) overpressured sands at relatively shallow depths; 7) erosion of tens of feet of seafloor sediments; and 8) soil conditions ranging from weak, underconsolidated soils to rock. Similar difficult conditions are found in many other deepwater areas outside the Gulf of Mexico as well.

Several geophysical tools are typically used to help characterize offshore sites: a narrow-beam water-depth recorder with velocimeter calibration and/or a swath-mapping bathymetric system; a side-scan sonar to show a plan view of the seafloor and features on it; a shallow-penetration subbottom profiler (3.5 kHz) to show geologic conditions to penetrations of up to about 200 feet; an intermediate-penetration profiler (minisparker or small air guns, as examples) to show conditions within the foundation zone (to penetrations of about 500 feet); and a deep-penetration profiler (air-gun array with multi-channel digital recording, for example) to show deep-seated faults, buried landslides, and gassy sediments (to penetrations up to 4000 feet).

Results of marine engineering geophysical site surveys include a variety of color graphics such as water-depth map and 3-D perspective views of the seafloor, seafloor gradient map, seafloor soil and soil province maps, soil cross sections, geologic structure and features maps, and hazards maps, including drilling risk and development favorability maps. Results 1) are presented using simple, straight-forward terminology and not in technical jargon the end-user (engineers) may not be familiar with; 2) focus on the important engineering issues and not on survey documentation and methodologies; 3) are presented as quantitatively as possible; and 4) are integrated with geotechnical data for a reliable definition and engineering assessment of both soil and geologic conditions.

Developing trends include increasing use of 3-D seismic data and workstation analysis; site-survey data increasingly being recorded in digital format; integration of site-survey results in GIS data bases; and application of exploration and development techniques (including attribute analysis and geostatistics for direct characterization of materials using seismic data) to shallow engineering concerns.

Characterizing deepwater sites around the world, and developing new techniques and technologies for doing so quantitatively, will continue to provide marine engineering geoscientists with tough challenges into the next century.

Biographical Sketch

Kerry J. Campbell is Manager, Geoscience Projects, at Fugro-McClellan Marine Geosciences, Inc., in Houston, and has been with Fugro-McClelland and predecessor companies for more than 20 years.

Mr. Campbell has been involved in applying 3-D seismic exploration data to drilling hazards and regional engineering-geologic assessments at various deepwater sites around the world. Mr. Campbell holds B.S. and M.S. degrees in geology from the University of Massachusetts, Amherst. He is a Registered Geologist and a Certified Engineering Geologist in California, and a Certified Professional Geologist.■

Note: The reservation code for this meeting is 5-0-2.