U.S. Department of the Interior
Minerals Management Service
Atlantic OCS Region

SPECIAL INFORMATION

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Descriptions of Geological and Geophysical Activities

Regulatory authority for geological and geophysical (G&G) surveys are authorized by the Outer Continental Shelf Lands Act (OCS Lands Act); (Title 43, Chapter 29, Subchapter III, §1340); 30 CFR 250 Subpart B (onlease); 30 CFR 251(exploration); and 30 CFR 280 (minerals other than oil, gas, and sulphur).

The following are descriptions of potential G&G activities associated with oil and gas, as well as non-mineral resources (sand and gravel), and alternative energy activities. These activities include the various G&G exploration techniques currently being used in other areas and expected to be employed in the future by operators in the Atlantic OCS. Particular attention is paid to seismic techniques, especially the role of seismic sources (e.g., airguns).

Seismic surveys have historically covered large areas of the OCS each year and have the potential for “significant” impacts on the environment, unless mitigation and monitoring measures to reduce or eliminate impacts to the environment are applied. Further, there are increasing concerns in the regulatory and scientific communities regarding acoustic impacts on marine life, including marine mammals, turtles, and fishes. Therefore, seismic surveys are described first, followed by the other techniques.

High-Resolution Seismic Data. High-resolution site surveys collect data using electrically generated acoustic sources from 140 to 210 decibels (dB) that are reflected from sediments near the seafloor surface to several kilometers or more below the seafloor. They are used for various reasons – to investigate potential geohazards and soil conditions, to identify potential benthic biological communities (or habitats) and archaeological resources, or to a lesser degree for exploration purposes. Such high-resolution data may be used for initial site evaluation for drilling rig emplacement and for platform or pipeline design and emplacement. They can also be used for the identification of potential sand resources for coastal restoration. High-resolution site survey data obtained at greater depths below the seafloor can be used for exploration purposes.

Deep-Penetration Seismic Surveys. Deep-penetration seismic exploration and development surveys are conducted to obtain data on geological formations from the sediment near-surface to several thousand meters deep (below the sediment surface). A survey vessel will tow a low-frequency acoustic source (usually high-pressure airgun arrays) that penetrates several thousand feet in the earth’s subsurface and are then refracted to surface receivers, either towed in the water column or placed on the ocean bottom. These acoustic sources are generated by airguns, generating compressed air bubbles, and are generally in the 225- to 260-dB range for airgun arrays. This information enables industry to accurately assess potential hydrocarbon reservoirs and helps to optimally locate exploration and development wells, maximizing extraction and production from a reservoir. In two-dimensional or three-dimensional seismic surveys, the receivers (hydrophones) are on streamer cables towed behind the survey vessel at a depth of 5 to 10 meters (m) below the surface of the water. Individual streamers can be up to 12 kilometers (km) in length or, on rare occasions, even longer. Tail buoys with radar reflectors and strobe lights are used to mark the end of the streamers and make them more visible and/or detectable to other vessels. Alternatively, receivers may be deployed on the seafloor as bottom cable surveys or remotely-operated vehicle positioned "nodes." When conventional 3D ship surveys or bottom cable surveys are repeated at the same location over time, these are referred to as 4D or time-lapse surveys. Another method of determining downhole seismic through the wellbore involves vertical cables with receivers suspended within wellbores and an external source used in the water column, usually by another vessel or a source hung over the rig.

Deep-Tow, Sidescan-Sonar Surveys. Deep-tow, sidescan-sonar surveys are conducted in the Gulf of Mexico primarily for engineering studies involving the placement of production facilities and pipelines. These surveys provide information on the presence of sand flows, hydrates, and seeps, as well as bottom topography (e.g., hard bottom).

Operations are conducted from ships towing cables up to 7 km long, which enables operations in water depths up to 3,000 m deep. Close to the end of the cable is a 30- to 45-m long section of chain to keep the sensor package (fish) tracking at approximately 25-30 m above the bottom. To do this requires the chain to be dragged along the seafloor, causing an approximately 10 centimeter (cm) wide by 15 cm deep (4 inch wide by 6 inch deep) trench to be cut in the seafloor. In situations where the chain can become entangled in shipwrecks, well heads, or other obstructions or where reef colonies live, the chain is removed, and the sensor package is kept above the seafloor by adjusting the length of the tow cable. Maintaining a constant elevation above the seafloor by adjusting the cable length is very difficult, and the elevation above the seafloor is somewhat greater in this case.

Electromagnetic Surveys. Electromagnetic surveys are used to help delineate potential oil and gas reservoirs. Many geological processes in the crust and upper mantle of the seafloor involve the interaction of fluid phases with surrounding rock. The conductivities of hydrothermal phases are different from those of host rock, and collectively they offer distinct profiles of electrical conductivity/resistivity depending on the specific geological process involved. Magnetotelluric surveys are passive measurement of the earth's electromagnetic fields. Additionally, controlled source electromagnetic surveys, sometimes referred to as seabed logging, induce very low-frequency (typically less than 2 hertz) electromagnetic signals into the upper layers of the seafloor via a towed dipole. The signals are propagated laterally to an array of receivers kilometers away. The variations in the electromagnetic field relative to the geometry of the receiver arrays and distance provide a conductivity/resistivity profile of the seafloor. From the profile, hydrocarbon reservoirs can be differentiated from water reservoirs and surrounding rock.

Geological and Geochemical Sampling. Geological and geochemical sampling is conducted to obtain samples of the seafloor for physical and/or chemical analyses. Physical analyses are used in engineering studies for the placement of structures such as platforms and pipelines. Chemical analyses (surface geochemical prospecting) are based on the premise that upward migrated petroleum from deep source rocks and reservoirs can be detected in near-surface sediments and are used to evaluate exploration potential.

Bottom sampling involves devices that penetrate only a few centimeters to several meters below the seafloor. Samples of near surface sediments are typically obtained by dropping a piston core or gravity core ("dart"), essentially a weighted tube, to the ocean floor and recovering it with an attached wire line. Samples can also be obtained using a grab, which is a device with a jaw-like mechanism, or with a dredge, which is a wire cage dragged along the seafloor. Shallow coring is done by conventional rotary drilling equipment from a drilling barge or boat. Penetration is usually limited to the recovery of several feet of consolidated rock. Usually, a program of bottom sampling and shallow coring is conducted simultaneously using a small marine drilling vessel.

Surface geochemical prospecting is a petroleum exploration technique based on the premise that upward migrated petroleum from deep source rocks and reservoirs can be detected in near-surface sediments and used to evaluate exploration potential. In deepwater exploration, a crucial and arguably the most critical single issue is whether oil has been generated and, if it has, what can be determined, before making costly decisions, regarding the quality, maturity, and age of the source succession. Fortunately, since oil and gas accumulations are invariably leaky, surface geochemical exploration can be used to recover and type migrant hydrocarbons in the initial exploration phases.

Remote Sensing. Radar imaging is currently used to detect oil slicks on the sea surface. This is possible because, when the oil molecules reach the sea surface, they form a thin layer that dampens the ocean surface capillary waves. The detection of oil slicks requires quiet water conditions and consequently is limited by sea state as well as by satellite position and frequency of coverage.

Aeromagnetic Surveys. Aeromagnetic surveys are conducted in the Gulf of Mexico to look for deep crustal structure, salt-related structure, and intrasedimentary anomalies. The surveys are flown by twin-engine, fixed-wing aircraft, typically Cessna 404 or 208, Piper Aerostar, or Navajos. The flight lines are on the order of 400 km long, are at a height of 75-150 m above the surface, and are flown at speeds of about 220 km/hour.

Gravity Surveys. Marine gravity data can be collected with instruments on the seafloor, in boreholes, in ships, or in helicopters. Data were originally collected on the seafloor, but modern technology has moved the collection point to ships. Marine gravity meters have, in some cases, been housed in a ship while it is conducting a seismic survey. However, the preferred method has been to use dedicated ships (about 50 m long) in order to acquire more precise data. With the advent of global positioning systems navigation systems and larger, more stable seismic ships, it is now possible to achieve the same order of accuracy with meters placed in seismic ships as in dedicated ships. Data grids for gravity surveys range from 1.6 km by 8 km to 9.7 km by 32 km.

Marine Magnetic Surveys. Marine magnetic surveys measure the earth's magnetic field for the purpose of determining structure and sedimentary properties of subsurface horizons. These surveys are usually conducted in conjunction with a seismic survey, allowing the navigation information to be used for both surveys. The development of low-power digital sensors has allowed the sensor package to be towed behind the seismic source array, which has greatly improved the operational efficiency of magnetic surveys.