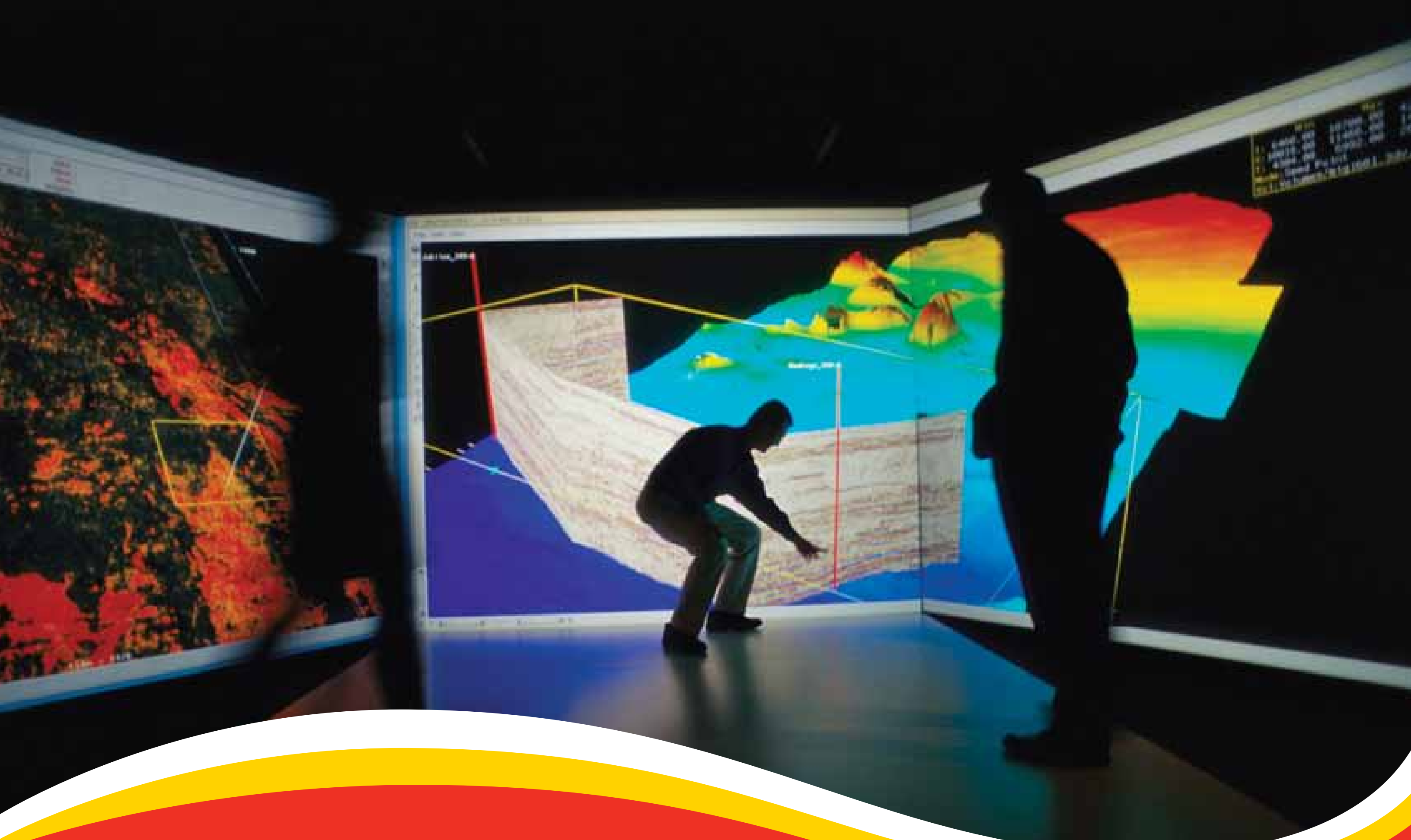

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CHAPTER TWO:

OIL AND GAS OFFSHORE EXPLORATION

Offshore Exploration

Understanding how oil and gas* are formed gives us important information for the first stage of petroleum development: exploration. Knowing the geological age, rock compositions and other details of potential reservoir systems gives us some hint about where to look geographically. Finding them, however, is a long and complicated process. It can take years of research, survey work and exploration drilling before a single drop of oil or gas is produced. And even if they are discovered, the quantity or quality of the hydrocarbons may not be sufficient for production. Exploration is also expensive, but while it may take five to 15 years to find and develop an oil and gas field, it can produce for as long as 50 years. Even if oil or gas is not found in a specific area, the information gained from these operations enhances our understanding and allows us to improve our future decisions. Today, technological advances allow us to find hydrocarbons more quickly and economically than ever, while reducing the environmental impact of exploration operations.

Early Explorers

Oil was once produced only from places that were easy to identify and access. In the 1850s, Canadian entrepreneur Charles Tripp found "black goo" seeping into the water well he was digging for his factory. That hole near Black Creek, now called Oil Springs, became the first commercial oil well in North America, marking the beginning of the petroleum age. The oil rush that followed prompted explorers to start looking beyond the "easy" oil sources, searching deeper below the Earth's surface and farther around the globe. Some of the most promising areas for petroleum development today are also in the most remote corners of the world, with challenging geographic and climate conditions.

Leasing

To begin any exploration, developers must obtain the rights from the owner whose land or waters it wants to search. In the United States, most offshore drilling takes place in state waters or in the federal Outer Continental Shelf (OCS). State and sometimes local governments typically have authority over operations within three miles of shore. The federal government controls the rights beyond that to about 200 miles offshore, where they are administered by the Department of Interior's Minerals Management Service (MMS).

Companies obtain these rights by bidding on blocks of OCS territory that the MMS auctions at various times of the year. A lease block is typically nine square miles. The lease terms are usually granted for five, eight or 10 years, depending on the anticipated time needed to explore and develop the potential oil and gas resources. If development is established during the initial term of the lease, the rights are extended until production stops. The rights are returned to the MMS when the lease expires.

* The terms "petroleum," "hydrocarbons" and "oil and gas" are often used interchangeably throughout this text. For definitions and distinctions, refer to the glossary at the end of this chapter.

KULLUK
THE *KULLUK* IS PREPARING TO BE WINTERED IN HERSCHEL BASIN (OFFSHORE YUKON TERRITORIES, CANADA) WITH HELP FROM SUPPORT VESSELS: THE BLUE AND WHITE *FENNICA* (AT LEFT), AND THE SMALLER *KN10* BARGE (AT RIGHT).

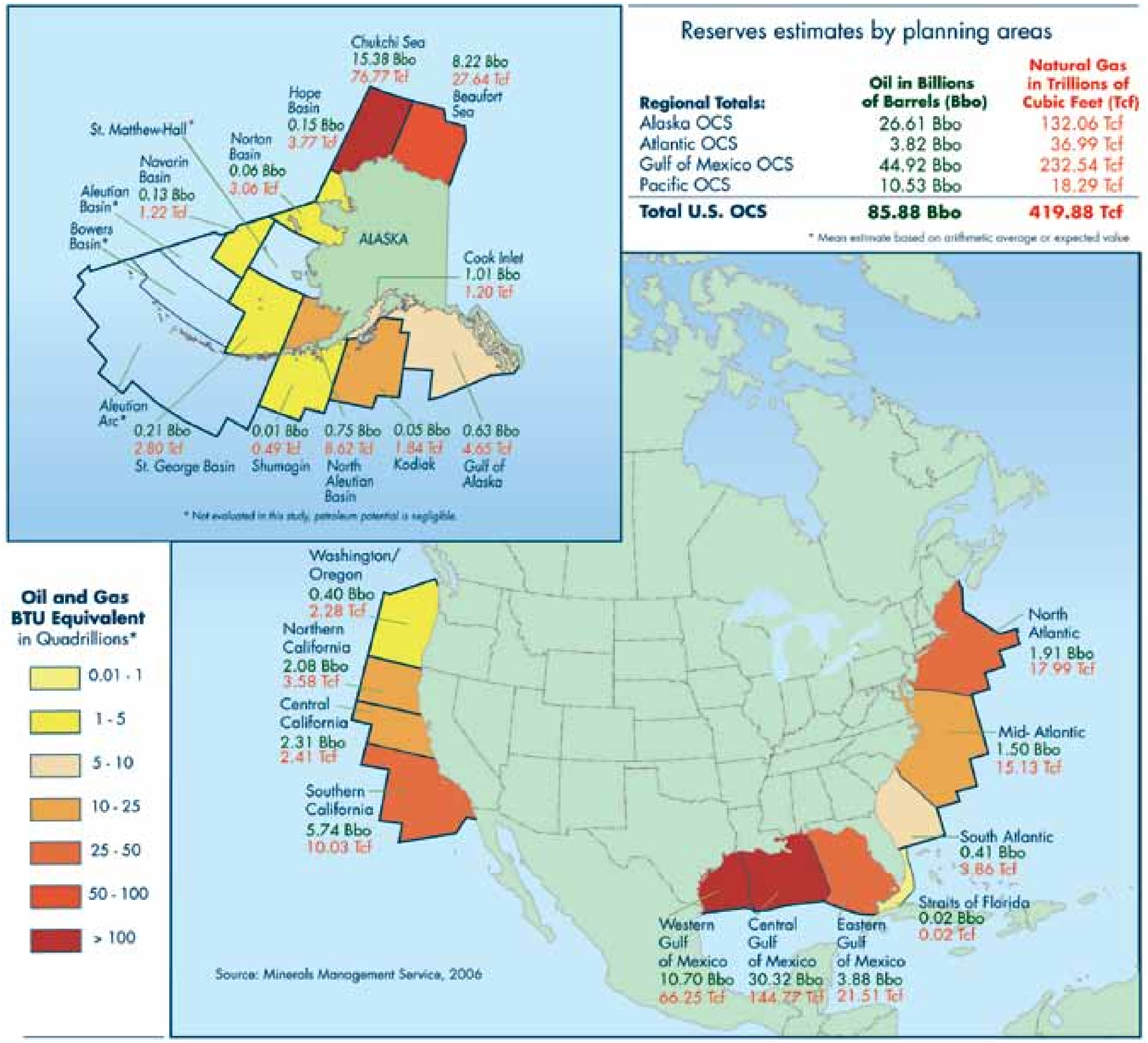
Jeffery Loman, assistant director for the U.S. Minerals Management Service, announces bids for the offshore petroleum leases in the Chukchi Sea in Anchorage, Alaska on Feb. 6, 2008. The U.S. Minerals Management Service opened bids within 29 million acres of the Arctic Ocean for oil exploration.

A company may delay or decide against exploration drilling on its blocks for a variety of reasons. Sometimes there are long waiting lists for the workers and equipment the company needs to contract for the operations. In other cases, information gathered after the lease sale may indicate that a block is not as promising as previously believed. The new data may suggest that there are not enough hydrocarbons for development, or that other conditions make production economically unfeasible. Because companies must make annual payments on leased blocks, they have an economic incentive to move forward with exploration operations or relinquish their rights to the MMS.

Tools of the Trade: Survey Technology

The more challenging oil and gas reservoirs we search for today do not usually give us any visible clues about where to find them. Instead, explorers must use indirect survey methods to determine the best places to drill exploratory wells. These methods look for the kinds of geological formations that are most likely to contain petroleum. Measuring the magnetic properties of subsurface rocks can reveal the presence of granite, or other types of rocks that might push petroleum upward into subsurface traps. In magnetic surveys, a boat tows a "magnetometer" that can record magnetic distortions in the Earth's crust. Another device called a "gravimeter" indirectly "weighs" the rocks. It can detect rocks that seal reservoirs, the porous materials in which petroleum can lie, and formations like salt-domes that can trap hydrocarbons. Another test, called geochemistry, involves taking soil samples and testing them for faint traces of hydrocarbons that have seeped to the surface from underlying reservoirs.

Assessment of Technically Recoverable Oil and Gas from America's Outer Continental Shelf, 2006



Reserves estimates by planning areas

Regional Totals:	Oil in Billions of Barrels (Bbo)	Natural Gas in Trillions of Cubic Feet (Tcf)
Alaska OCS	26.61 Bbo	132.06 Tcf
Atlantic OCS	3.82 Bbo	36.99 Tcf
Gulf of Mexico OCS	44.92 Bbo	232.54 Tcf
Pacific OCS	10.53 Bbo	18.29 Tcf
Total U.S. OCS	**85.88 Bbo**	**419.88 Tcf**

* Mean estimate based on arithmetic average or expected value

Seismic Surveys

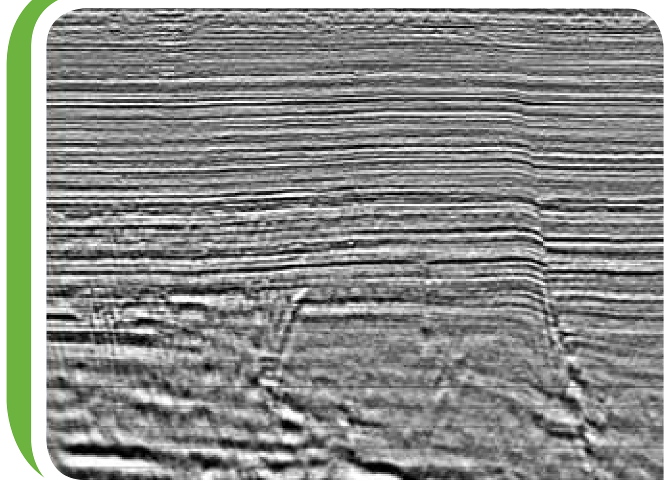
The best method of indirect exploration is the seismic survey. This tool enables explorers to see through solid matter in the same way an ultrasound can see a baby inside its mother. The process works by sending sound waves into the seafloor and measuring how long it takes for the rocks underneath to reflect the waves back to the surface. That time period can indicate the varying characteristics of the rocks, just like a ball bounced on a hard floor will jump back more quickly than on a carpet. Seismic waves reflecting off dense rock layers will behave much differently than if they hit the porous materials. The surveys are conducted with pulses of sound sent from air-guns on a ship toward the bottom of the ocean. A very sensitive recording device called a "hydrophone" is trailed from the stern to record the echoes that bounce back.

3-D Seismic Surveys

Three-dimensional (3-D) seismic surveys use several lines of hydrophones in a grid to record the signals. Sophisticated computer software can then translate those signals into a "virtual reality," revealing the thicknesses and densities of the sub-surface rocks, including those that have been stressed into the types of folds or faults that might trap petroleum. Seismic surveys produce the best data available about petroleum potential short of actually drilling an exploration well.

Avoiding Seafloor Hazards

Surveys used in early exploration work can also identify potential hazards to vessels or seafloor conditions that may be unsafe for the placement of exploration drilling rigs. "Shallow hazard" surveys look for underwater peaks and valleys (topography) or man-made dangers like shipwrecks. In the Arctic, special surveys on conditions such as ice gouges and strudel scours may be conducted to gather data for potential future oil and gas production activities. (See page 10 for more details.)



3-D Seismic Survey Imaging

The Real Test: Drilling

Though surveys and models might indicate that oil and gas could be present, the only sure way to find out is to drill an exploration well, sometimes called a "wildcat" well. As with all oil and gas industry technology, drilling methods have grown in leaps and bounds from its humble beginnings. The idea of digging below the sea for petroleum began early in the 1800s, but it took nearly a century before it produced any real results. One of the earliest offshore oil rigs was built in 1887 by H.L. Williams, who erected a derrick on a 300-foot-long wharf off Summerland, California. Soon many wells were built this way, moving further and further from the coastline. The first offshore rig out of sight of land came in 1947 off the Louisiana coast. Even though the well was drilled in just 16 feet of water, it marked a major breakthrough in the industry. With the use of modern technology pioneered by Shell, we are currently exploring in water depths of more than 10,000 feet.

Choosing a Rig

Water depth, weather, seafloor conditions, operational safety and efficiency all determine what kind of vessels or platforms will be used for drilling. In exploration drilling, the rigs are usually mobile so they can move, with crew, from one site to another. Some of these moveable rigs are floating units, such as drillships or partially submerged platforms. Others are bottom-supported, using legs to stand on the seafloor or hulls that rest on the bottom.

Floating Rigs

There are two main types of floating rigs: drillships and semi-submersibles. All mobile offshore rigs float when moving from one location to the next, but these vessels are labeled floating rigs because they remain buoyant while the well is drilled.

Drillships

Drillships are the most mobile drilling units because they are shaped like ships and can rapidly move under their own power. This type of rig can operate in remote, deep waters. A walled hole in the middle of the ship, called a "moon pool," is open to the water's surface so that the drill bit and other equipment can be lowered to the seafloor. The rig holds its position over the top of a well either by being moored (using wire or chain attached to anchors or piles in the seafloor) or by thrusters (directional propellers mounted in the bottom of the ship's hull) that counteract the forces of wind, waves and ocean currents.

Semi-Submersibles

A semi-submersible rig consists of a platform on top of columns, which are connected to pontoons. These pontoons can be partially filled with water, or ballasted, so that the lower portion is submerged. This helps to stabilize the "semi," which is held in position by huge anchors, allowing it to operate in ocean conditions that may be too challenging for drillships. Because it does not sit directly on the seafloor, a semi can drill in deeper waters than bottom-supported rigs. Once the drilling is complete, water is pumped from the hull to re-float the vessel so that it can be self-propelled or towed away.

Bottom-Supported Rigs

There are two types of bottom-supported rigs: submersibles and jack-ups. Fully submersible rigs operate much like semis, except that they rest on the bottom and are most suitable for shallow water. Some submerge the hull completely so that it rests on the bottom with the main deck supported above the surface on rigid columns. Others, called "jack-ups," are floated out to the drilling area and have "legs" lowered down to the seafloor. Sometimes the legs are filled with water for extra stability so they can work in open-ocean areas. Jack-ups can drill in slightly deeper water than submersibles and are very portable. When its job is done, the legs are raised up out of the water so that the rig once again becomes a floating barge that can be towed away or placed upon a large transport ship.

Exploration and Appraisal Wells

Oil and gas wells are drilled for two general purposes: to explore for hydrocarbons and to produce them. Exploration wells are drilled to determine whether enough hydrocarbons exist for a sound economic investment in production operations. Additional appraisal wells may be drilled around the site to determine the size of the reservoir, and how the quality and quantity of the hydrocarbons may vary throughout the field. These wells have a relatively short life cycle as the time required for drilling, evaluating and abandoning them is typically on the order of days or months. Production wells are usually drilled to last for years, and even decades, until the reservoir is depleted.

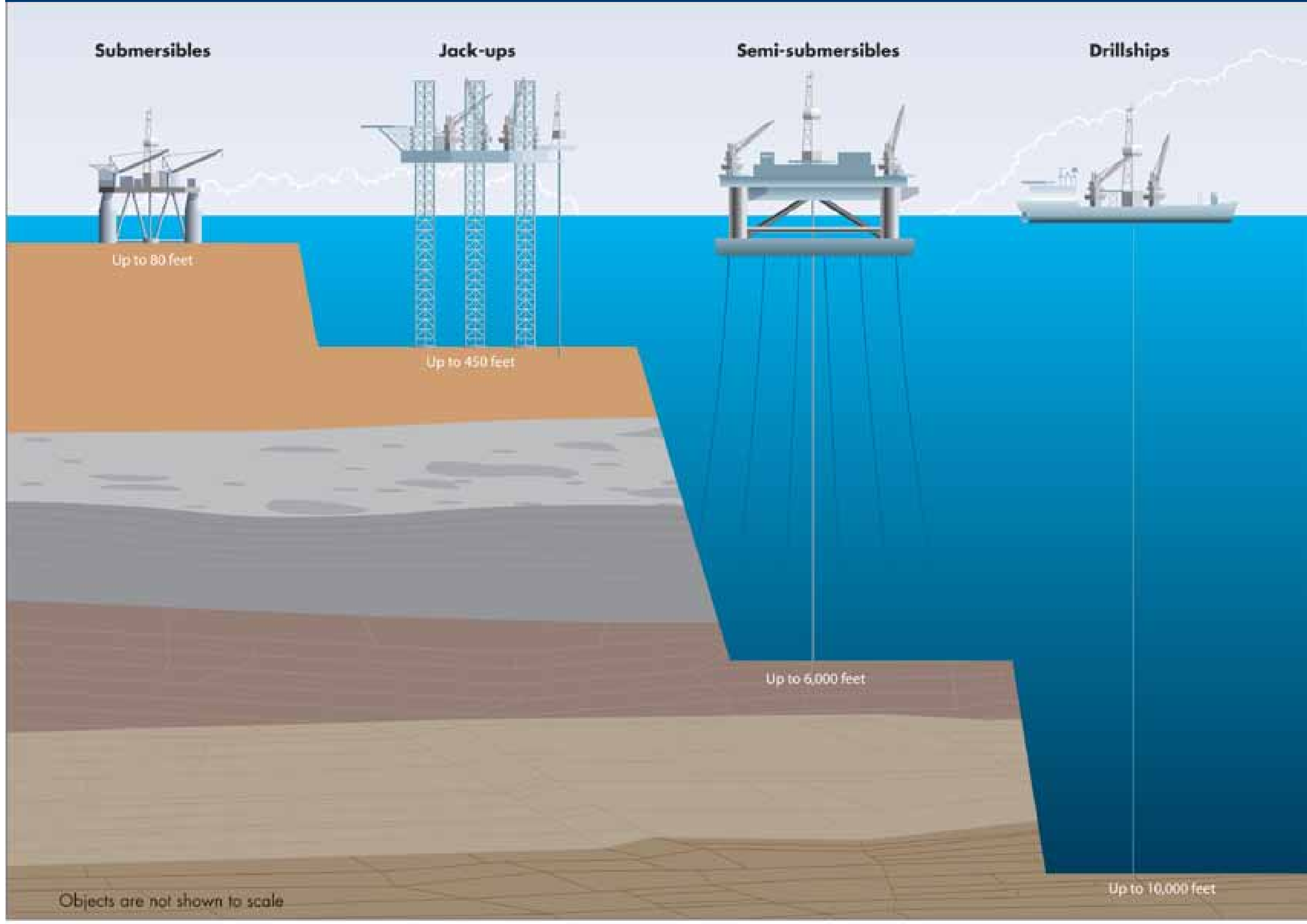
Drilling

The same basic drilling methods and technology are used for both exploration and production wells. For a full description of how wells are drilled, refer to Chapter 3, Offshore Oil and Gas Production.

WELL LOGGING

After a well has been drilled, recording devices are lowered into the well to evaluate the rock and fluid properties. These devices are called logging tools and the findings (or "well logs") are evaluated to help make future decisions about drilling operations. This information includes fluid type (water, oil or natural gas), rock porosity and thickness of the rock layers.

CONVENTIONAL EXPLORATION RIGS



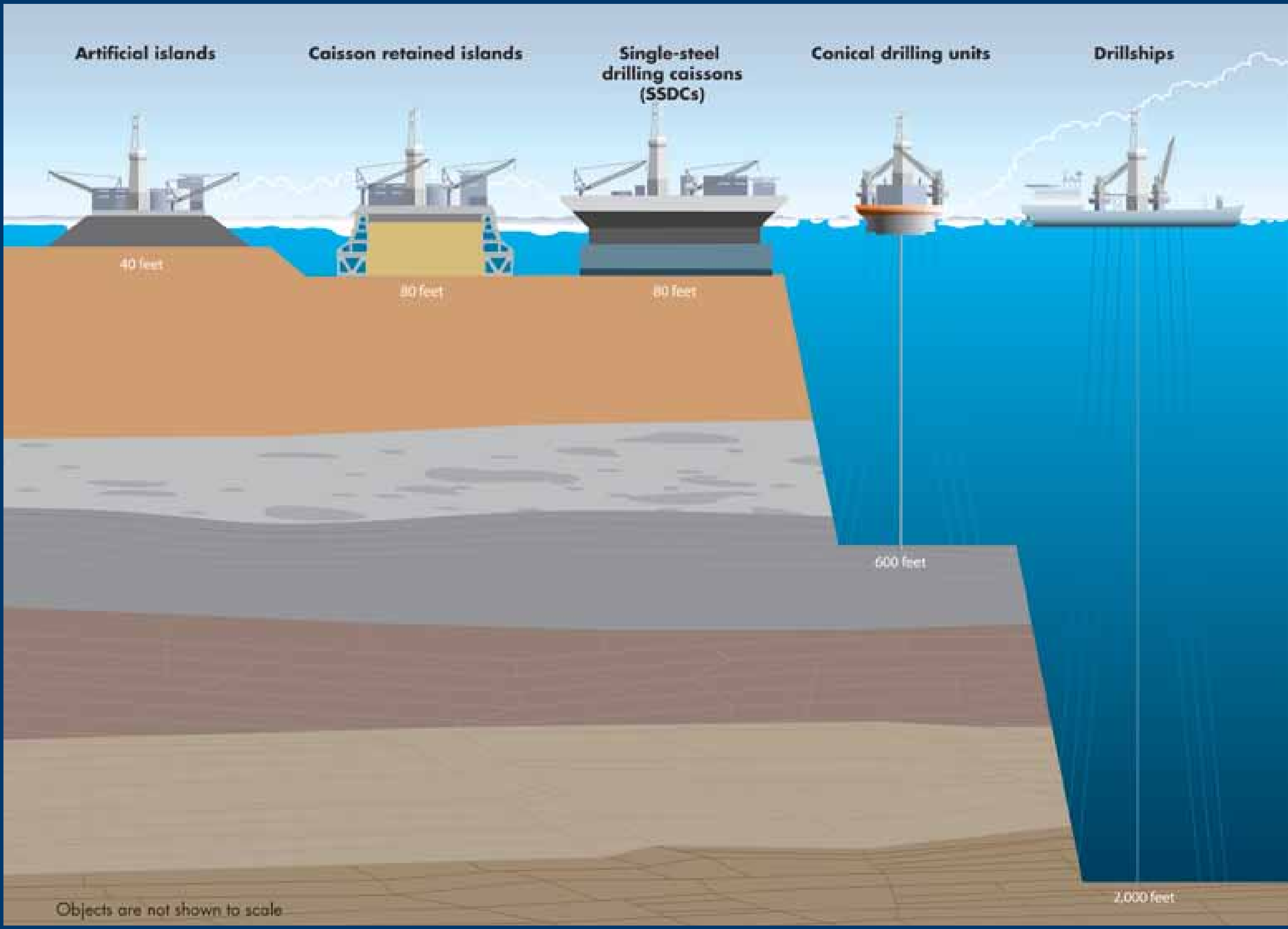
DRILLING SAFELY

Exploration wells also require additional devices to control and monitor the hydrocarbons. One key mechanism, called a "blowout preventer" (BOP), is installed on the top of the casing, or "wellhead." The BOP monitors the balance of the well pressure, which is what prevents the hydrocarbons from flowing out of the reservoir during drilling. (See Chapter 3 for more on BOPs.)

WELL ABANDONMENT

Most exploration wells are abandoned. This is typically because they do not contain oil or gas or they may not be designed for production operations. When a prospective site turns out to be void of oil or gas or contains too little to be worth developing, it is labeled as a "dry hole" and abandoned. Plugs are installed in the wellbore at various depths to seal it off and to ensure there is no seepage. After the well has been plugged, the equipment and debris are removed from the site.

EXPLORATION RIGS IN ARCTIC CONDITIONS



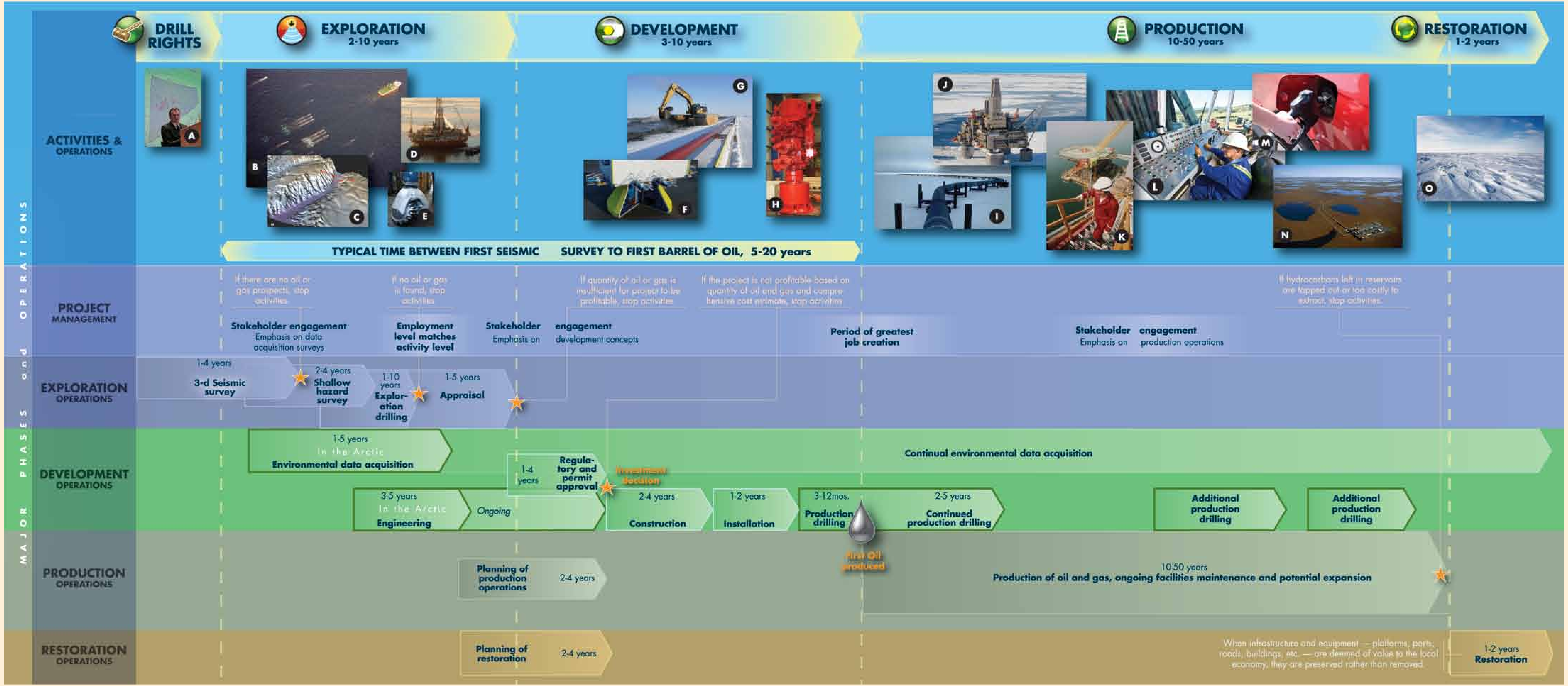
ARCTIC OFFSHORE

The readily accessible sources of conventional oil and gas are depleting as global demand is rising for energy and a multitude of other petroleum-based products. The oil and gas industry must explore in ever-more remote and challenging regions to meet these needs. Such regions include offshore Alaska, Canada, Russia, Greenland and Norway, areas where terrain and weather conditions can be some of the most extreme on Earth.

ARCTIC EXPLORATION

For near-shore, shallow water locations, drilling typically occurs during the winter. In deeper water, heavy ice conditions mean Arctic exploration must be conducted mostly during the summer and autumn "open water season." Even then, weather and ice conditions are constantly monitored for operational safety. Much of the equipment used is conventional but has been modified for arctic conditions. Extra staff is required to limit the impact of the operations on the sensitive environment. For example, marine mammal observers and environmental scientists are employed to monitor and safeguard the wildlife. Seismic

EXPLORATION AND PRODUCTION AT A GLANCE



A: Lease announcement
B: Seismic survey
C: Seismic data imaging
D: Exploration platform
E: Drill bit close-up
F: Gravity-based structure concept
G: Pipeline trenching
H: Blow-out preventer
I: Trans-Alaska Pipeline System
J: Production drill rig
K: Offshore platform
L: Platform control room
M: Gas station pump
N: Onshore production facility
O: Restored arctic landscape

* Timeline may differ based on project location.

BEAUFORT SEA, ALASKA
DUE TO HEAVY ICE, ARCTIC EXPLORATION MUST BE CONDUCTED MOSTLY DURING THE SUMMER AND AUTUMN "OPEN WATER SEASON." EVEN THEN, WEATHER AND ICE CONDITIONS ARE CONSTANTLY MONITORED FOR OPERATIONAL SAFETY.

survey work includes special sound evaluations to minimize any disturbance to marine mammals. Work is also scheduled to minimize any impact on regional activities such as subsistence hunting.

SURVEYING THE ARCTIC SEAFLOOR

In addition to the conventional seafloor surveys to avoid hazards for exploration drilling activities and vessels, arctic operations must identify ice-related conditions such as ice gouge marks and strudel scours for potential future production activities, such as pipeline installation. Ice gouges are formed by "ice keels" (the undersides of ice ridges) hitting the seafloor. Strudel scours are formed during the spring melt, when rivers overflow existing ice. Cracks and seal breathing holes allow the water to flow through the ice, causing a circular draining action that can scour the seafloor. Helicopters first check for the drain locations, and then bottom surveys determine whether the drains resulted in scours. Because weather conditions change these formations from year to year, the surveys must be conducted annually to calculate how deep pipelines must be buried to protect them.

DRILLING

Bottom founded or floating rigs are generally used for offshore exploration in the Arctic, but they are modified so they can operate safely in extreme conditions. These drill rigs are constructed with specific types of steel that will not become brittle in low temperatures. Special structural additions are made to reinforce the rig's integrity so that it can resist heavy ice and weather conditions. The rig's work areas are either fully or partially enclosed, and they are heated to ensure worker safety and comfort. The blowout preventer (the BOP, or well control equipment) is placed below the well's mud line rather than on the drill rig at the surface to protect it from the ice. Ice breaking vessels support floating operations to improve efficiency, lengthen the short drilling season and to escort the rigs to different locations. Upgraded radar systems are used to monitor ice movements, while satellites and other weather tracking systems are used for forecasting.

Glossary

Blow Out Preventer (BOP) – a series of large valves placed at or near the surface of an oil or gas well to prevent the uncontrolled release of hydrocarbons.

Dry Hole – a well that has been drilled but does not contain enough hydrocarbons to be developed for extraction.

Geochemistry – soil sample surveys that test for faint traces of hydrocarbons that have seeped to the surface from underlying reservoirs.

Gravimeter (Gravity survey) – a device used to explore for petroleum by "weighing" the rocks under the surface. It can detect impermeable rocks that seal reservoirs, the porous materials in which petroleum can lie, and formations like salt-domes that can trap hydrocarbons.

Hydrocarbons – organic chemical compounds of hydrogen and carbon atoms forming the basis of all petroleum products. They may exist as gases, liquids or solids. An example of each is methane, hexane and asphalt. For this document the terms "hydrocarbons," "petroleum" and "oil and gas" are interchangeable.

Hydrophone – the recording device used to measure the sound waves in seismic surveys.

Ice Keel – the undersides of ice ridges, which can strike the seafloor and leave gouges.

Magnetic Survey – an exploration method which measures the magnetic properties of subsurface rocks that may reveal the characteristics of petroleum reservoirs.

Petroleum – a substance occurring naturally in the earth in solid, liquid, or gaseous state and composed mainly of mixtures of chemical compounds of carbon and hydrogen, with or without other nonmetallic elements such as sulfur, oxygen and nitrogen. In some cases, especially in the measurement of oil and gas, petroleum refers only to oil — a liquid hydrocarbon — and does not include natural gas or gas liquids such as propane and butane. For this document the terms "hydrocarbons," "petroleum" and "oil and gas" are interchangeable.

Porosity – The gaps in rocks that are capable of storing fluid, like a sponge.

Rig (Drill) – the derrick or mast, draw works and equipment used in drilling oil wells.

Salt Dome – a geological structure where very deep layers of salt flowed upward through the bedrock from pressure of the overlying rock and sediment. The salt can break through the sediment and protrude in a dome-like shape and sometimes pierce completely to the surface.

Seismic Survey – an exploration tool which sends pulses of sound into the seafloor to identify sub-surface rock characteristics and the possible presence of hydrocarbons.

Strudel Scour – a shallow hole in the seafloor caused during the spring melt, when rivers overflow existing ice. Cracks and seal breathing holes allow the water to flow through the ice, causing a circular draining action that can scour the seafloor and create unsafe conditions for pipelines.

Well Abandonment – the process of capping an exploration well that has been evaluated, or a production well which has been determined to contain insufficient amounts of hydrocarbons for production.

Well Log – data collected from recording devices lowered into a well to evaluate the rock and fluid properties. The findings are evaluated to help make future decisions about drilling operations.

Wildcat Well – an exploratory well drilled in an area where no oil or gas production exists.

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Shell in Alaska

TO FIND AND DEVELOP COMMERCIAL HYDROCARBON RESOURCES IN THE CHUKCHI AND BEAUFORT OUTER CONTINENTAL SHELF. TO SUPPORT COMMUNITIES WHERE WE OPERATE IN BENEFITING FROM ANY POTENTIAL OFFSHORE ACTIVITIES ECONOMICALLY AND SOCIALLY. TO RESPECT THE WAY OF LIFE OF THE RESIDENTS OF ALASKA.