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# FIGURES

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1. The first offshore wells in the United States
2. A permeable rock allows hydrocarbons to flow from pore to pore within the rock.
3. In an anticlinal trap, hydrocarbons migrate into a porous and permeable layer and are trapped there by an overlying impervious layer.
4. In a fault trap, an impervious layer moves opposite a porous and permeable layer, thereby trapping hydrocarbons.
5. In an unconformity trap, an impervious layer is deposited on top of a hydrocarbon-bearing layer.
6. Hydrocarbons can be trapped around and above a salt dome.
7. A change in permeability within a single rock layer can trap hydrocarbons.
8. A combination of folding, faulting, and an unconformity can trap hydrocarbons.
9. A positive gravity anomaly over an igneous uplift can indicate the presence of a hydrocarbon accumulation.
10. A negative gravity anomaly can indicate the presence of a salt dome with associated hydrocarbon accumulations.
11. A special air gun produces sound that is reflected from rock layers. Detectors pick up the sound reflections.
12. A seismic section, color-enhanced by a computer in this example, gives a view of the subsurface and thus the possibility of traps.
13. Bright spots, shown in red on this color-enhanced seismic section, may indicate accumulations of natural gas.
14. A mobile offshore drilling unit (MODU)
15. Four types of mobile offshore drilling units. (A) jackup; (B) drill ship; (C) submersible; (D) semisubmersible
16. This jackup working in Indonesian waters is one type of bottom-supported unit. Each of its legs is in contact with the seafloor.
17. Four boats tow a jackup as it floats on the water's surface.
18. The first MODU was a submersible designed to drill in shallow waters.
19. When flooded, the bottles cause a bottle-type submersible to submerge to the seafloor.
20. A concrete island drilling system (CIDS) features a reinforced concrete caisson with a steel base.
21. Jackups may have either open-truss legs (A) or columnar legs (B).
22. A special ship carries a semisubmersible rig.
23. A mobile offshore drilling unit (MODU)
24. A rack and pinion consists of a rack and two pinions that mesh with the rack.
25. A rack on each leg of a jackup allows the pinions to raise or lower the leg.
26. The mat on a mat-supported jackup rests on the seafloor and prevents the legs from penetrating the ooze.
27. Spud cans on the end of each leg of a jackup penetrate a short distance into the seabed and stabilize the rig.
28. The derrick package on this cantilevered jackup is supported by large steel beams that extend from the platform deck.
29. The derrick on this jackup rests over a slot (keyway) in the platform deck.
30. A drill ship

31. In this dynamic positioning system, hydrophones on the vessel's hull receive signals from a subsea beacon. The signals and information from a taut wire and a wind sensor are transmitted to onboard computers. The computers process all data and activate the thrusters to maintain the floating unit on station.
32. Several spread mooring patterns are available for anchoring a floater. The pattern used depends on, among other things, the shape of the unit and weather and sea conditions.
33. Riser pipe connects the stationary subsea well equipment to the surface equipment on a floating rig.
34. On a bottle-type semisubmersible, partially flooded bottles submerge the rig below the water's surface but above the seafloor.
35. A semisubmersible at work
36. A column-stabilized semisubmersible rests below the waterline when in the drilling mode.
37. A drill bit has teeth to penetrate a formation to make hole.
38. Drilling mud is a special liquid essential to the drilling process.
39. Drilling mud jets out of the bit nozzles to lift cuttings off the bottom of the hole.
40. The mud pump picks up drilling mud from steel mud tanks and sends it down the kelly (or topdrive), drill pipe, drill collars, and bit. Mud and cuttings return to the surface up the annulus.
41. A heavy-duty mud pump
42. Mud and cuttings return to the surface via the annulus, the space between the pipe and sides of the hole.
43. A shale shaker screens drilled cuttings from the mud.
44. Hydrocyclones remove solids from mud.
45. A centrifuge spins mud at high speeds to remove solids.
46. A top drive (power swivel) is used to rotate the bit.
47. The kelly mates with the kelly drive bushing, which fits into the master bushing of the rotary table.
48. The kelly is made up on the swivel.
49. A horizontal well begins vertically and is deflected to horizontal.
50. A bent sub has a 1° to 3° bend in it to begin deflecting the hole from vertical.
51. A downhole motor laid out on a land rig's pipe rack
52. Several large diesel engines provide power for an offshore rig.
53. This generator, attached directly to an engine, makes electric power.
54. An electric motor provides power to a mud pump.
55. The driller controls rig power from a station on the rig floor.
56. Crown block, wire rope drilling line, traveling block, derrick, and drawworks are the basic hoisting system parts.
57. Drill collars are heavy pipe that put weight on the bit.
58. Racked in the derrick, this drill pipe is ready to be run back into the hole.
59. A typical drill stem assembly
60. A large hook, attached to the traveling block, supports the weight of the drill string.
61. Wire rope drilling line reeved through the traveling block's sheaves
62. The crown block at the top of a mast
63. The derrick on this drill ship supports the crown and traveling blocks and the drill stem.
64. Several lines reeved between the traveling block and the crown block increase hoisting capacity.
65. The drawworks is a large hoist.
66. Drilling line is wrapped around the spool (drum) of the drawworks.
67. A driller works at his station on the rig floor.
68. Standing on a small platform high in the derrick (the monkeyboard), a derrickhand guides the top of a stand of drill pipe. Note the safety harness to prevent a fall.
69. Three rotary helpers make up a joint of drill pipe.
70. A roustabout attaches a lifting sling to a crane's hoist line.
71. Usually, the roustabout foreman also operates the large cranes on the rig.
72. A ballast-control specialist stands at the ballast-control panel of a semisubmersible. The layout gives him a visual indication of the location and amount of ballast in the rig's pontoons.

73. Helicopter and boat companies transport personnel and supplies. *Left*, personnel transfer from the rig to the boat; *right*, a helicopter lands on the rig's helipad.
74. This station bill tells rig personnel how to recognize emergency alarms, and gives duty and station assignments.
75. Underway during a rig abandonment drill, personnel steer an escape capsule away from the rig.
76. An artificial gravel island and its drilling rig loom out of the fog in Alaska's Beaufort Sea. The sea is completely frozen and thus shows up as white behind the island.
77. Two joints of casing lie on a ramp, ready to be picked up and run into the hole.
78. A worker stands on the conductor casing that extends upward from the hole in the seafloor.
79. Cemented conductor casing lines the top part of the hole. More hole has been drilled out below the casing.
80. Several casing strings are run and cemented as the well reaches total depth. Note the names given to each string.
81. These blowout preventers are mounted on the casing.
82. Floating rigs are subjected to six motions caused by the wind, current, and wave action of the sea.
83. The temporary guide base is landed on the seafloor by drill pipe. Note the four guidelines running up to the rig.
84. A hole opener enlarges the hole made by the regular bit.
85. The guide frame centers the bit and hole opener into the opening in the temporary guide base.
86. A Squinch Joint™, a threadless connector used to make up large-diameter joints of casing
87. The permanent guide structure attached to the top of the foundation-pile housing is lowered on the guidelines. The foundation-pile casing enters the drilled hole, and the permanent guide structure seats on the temporary guide base.
88. The subsea BOP stack is lowered onto the permanent guide structure.
89. This marine riser system is connected to the top of the subsea BOP stack.
90. A riser tensioning system provides upward tension on the riser system.
91. These three piston-and-cylinder assemblies are part of the riser tensioning system.
92. Buoyant devices attached to riser joints augment the riser tensioner system.
93. This heave compensator assembly is attached to the traveling block. Note the two pistons and cylinders that offset heave motion.
94. The heave compensator keeps weight on the bit at a constant value in spite of the floater's up-and-down movement.
95. The curves on this well log can reveal information about the formation penetrated by the hole.
96. When made up on a core barrel, the core bit (*left*) cuts a long cylindrical sample of the formation, which is called a core (*right*). Only a short portion of the core is shown.
97. Several cores are laid out for analysis at an onshore laboratory.
98. Special burners flare gas harmlessly into the atmosphere on this unit in the North Sea.
99. A platform tender is anchored next to a relatively small platform.
100. A self-contained platform houses all the drilling and production equipment, crew quarters, galley, offices, and recreation rooms.
101. A platform jacket is so tall, it is usually built and transported on its side.
102. A large crane hoists a deck section onto the jacket.
103. Five boats tow a concrete platform to a site in the North Sea.
104. Concrete cylinders arranged around the base of a concrete gravity platform provide storage space for oil.
105. A caisson-type platform rests in the ice-free waters of early summer in the Cook Inlet of Alaska.
106. The relatively lightweight jacket of a guyed-tower platform is supported by several guywires and clump weights.
107. A buoyant tension-leg platform is held on station by several tensioned tubes attached to the seafloor.
108. A jackup drills development wells on a small jacket (*right*).
109. Two relatively small platforms replace a single large platform.

110. A subsea template allows several wells to be drilled, completed, and produced from a relatively small area on the seafloor.
111. Several directionally drilled wells tap an offshore reservoir.
112. A perforating gun is lowered into the wellbore and fired. Shaped charges perforate the casing, cement, and formation.
113. When a packer is set, it forms a seal between the outside of the tubing and the inside of the casing, causing reservoir fluids to flow into the tubing.
114. In a surface completion, equipment that controls the flow of hydrocarbons from the well is placed on a deck of the platform.
115. A wet subsea Christmas tree installed on the seafloor
116. This dry subsea Christmas tree is isolated from the water by a protective dome.
117. In a dissolved-gas drive reservoir, gas comes out of solution from the oil and drives oil to the surface.
118. In a gas-cap drive, the gas cap expands to lift oil to the surface.
119. In a water drive, water moves oil to the well and up to the surface.
120. In a combination drive, expanding gas and water lift oil to the surface.
121. This production platform retains the derrick used in drilling the wells.
122. In this subsea production system, oil flows from wells on the template, up the production riser, and to a special mooring buoy, where a tanker loads the oil.
123. A free-water knockout removes free water from produced fluids.
124. A photomicrograph of a water-in-oil emulsion reveals the small droplets of water that are dispersed through the oil.
125. A horizontal treater is used to remove most of the emulsified water from oil.
126. A glycol dehydration system removes most of the water from natural gas.
127. Two horizontal separators installed on this platform separate oil and gas.
128. Gas lift involves the injection of gas into a well to lower pressure at the bottom of the well. (A) Since the well is not producing, no liquids are flowing; (B) injected gas forces liquid out through tubing; (C) gas enters top valve and lightens liquid in tubing, causing liquid level to fall further; (D) well is producing fluids from the reservoir.
129. When water is used for pressure maintenance, it is injected into the reservoir to drive oil to producing wells. Some of the oil will be left behind, however.
130. Injecting a surfactant can recover additional amounts of oil from a reservoir.
131. Alternating injections of CO<sub>2</sub> and water can recover additional oil.
132. A mobile jackup rig services a well.
133. A wireline unit is used to make well repairs.
134. Gas-lift valves installed in side-pocket mandrels can be run and pulled with wireline.
135. A tie-in pipeline joins a trunk line running to a shore facility.
136. This lay barge is at work in the North Sea.
137. Protruding from the stern of this semisubmersible lay barge is the stinger, which supports the pipe as it enters the water.
138. Pipeline is wound onto the reel of this reel ship.
139. By using high-pressure jets of water, a bury barge digs a trench for a pipeline.
140. A single-point buoy mooring system loads oil into a tanker.