deposits that might provide stratigraphic traps, such as pinchouts, barrier islands, and channels. Drapes over basement highs might trap petroleum. The seaward part of the Blake Plateau Basin contains a thick (14 km), landward-dipping section, probably composed mainly of carbonate platform deposits. Carbonate banks and an Albian-Aptian rudist reef might provide traps, although the seaward part of the platform has been breached by erosion.

In the Carolina trough, flow of Jurassic(?) salt has formed diapirs, and withdrawal of salt has caused a large growth fault complex to form along the landward side of the trough. Because the block of sedimentary rock (12 km thick) above the salt is subsiding almost vertically, structures at the fault may include compressional features. The diapirs and faults may provide traps. A large shelf-edge anticline exists more than 150 km long and with a closure of as much as 500 m. Other possible traps might result from stratigraphic features of the onlapping sedimentary wedge landward of the Carolina trough and the eroded and buried paleoslope on the seaward side of the trough.

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North Sea Petroleum Province: A Failed Rift Basin

The North Sea oil and gas province is primarily a Mesozoic failed rift basin developed in response to the break-up of the Pangean supercontinent. The associated tectonism controlled deposition of reservoirs, source, and seals and development of structures and thus was the important factor in the generation, migration, and trapping of hydrocarbons.

The tectonic history of the basin can be divided into three major phases: (1) initiation of subsidence as a broad intracontinental downwarping during Permian, (2) tension induced normal faulting and half graben development from Triassic to Early Cretaceous, and (3) a return to broad basinwide subsidence from Late Cretaceous to the present.

The primary reservoirs include Lower Permian eolian sands, Upper Triassic to Middle Jurassic shallow to marginal marine sands, Upper Jurassic and Paleocene deep marine sands, and Danian and Maestrichtian chalks. Primary source rocks are Middle to Upper Jurassic marine shales and Carboniferous coals. The main structures include buried rotated fault blocks and halokinetic features.

Of the approximate 1,400 exploration wells, 490 have been oil and gas discoveries representing a 1:3.5 success rate. Total proved recoverable reserves are over 32 billion bbl oil equivalent with total potential recoverable reserves estimated at 46 to 70 billion bbl oil equivalent. Nine fields contain more than one billion bbl oil equivalent.

More than 53 billion dollars have been invested in the North Sea since 1965. Average cost to find and totally develop fields is approximately 2 billion dollars. At present, at least 100 million bbl recoverable reserves are usually needed for a field to be economic.

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Facies and Porosity Distribution, Swan Hills Reef Complex, Snipe Lake Oil Field, Alberta, Canada

All of the 11,700 ft (3,566 m) of core in this 130-well limestone reef oil pool was logged for a proposed miscible flood enhanced recovery scheme. The textures, fauna, porosity types, cements, and exposure surfaces are well preserved. Selected examples of each are presented by colored slides.

Nine sedimentary facies and eight porosity types are noted. The porosity is facies selective, but is modified by solution and cementation. Submarine, blocky calcite cement is common. Vadose pendular cement is developed beneath some exposure surfaces.

Twelve lithofacies, based on texture, fauna, color, porosity, and stratigraphic position are recognized. In the lagoons, poorly connected thin beds of porosity are present, whereas the reef flank porosity is relatively thick and contiguous.

Three major depositional cycles, each about 40 ft (12 m) thick, are interpreted. The first terminated with subaerial exposure and local erosional truncation. A few inches of green shale formed in the lagoon. The second cycle began with a major transgression characterized by dense dark brown laminar strom bindstone containing brachiopods, corals, and crinoids. A shallowing-upward gradation to porous massive and branching strom framestone followed. A second exposure surface, capped by discontinuous green shale, marks the termination of this cycle. The third cycle is predominantly biostromal, thickening gradually to the southwest into thin-bedded lagoonal sediments. Local well-washed rudstones suggest beach environments.

Stylolites are common in the lagoonal areas, and less numerous toward the reef front. Fractures are poorly developed and have only sparse porosity. Examples of porous stylolites and fractures from the nearby Goose River reef complex are shown.

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Episodic Sedimentation—How Normal is Average? How Rare is Rare? Does it Matter?

Do sedimentary rocks record mainly average, continuous, day-to-day processes or relatively rare, large-magnitude ones separated by long nondepositional intervals? Subtle legacies from Lyellian uniformitarianism may still impose a subconscious abhorrence of unique events, discontinuities, and large deviations from "average" magnitudes. Where repeated sharp changes of sedimentation are inescapable, periodic cycles are commonly invoked to preserve uniform, orderly variations from some supposed norm. The sedimentary record rarely reflects such uniformity, however, as sedimentologists have gradually realized.

Magnitude versus frequency of processes has long been debated in geomorphology, but has received less attention in sedimentology. *Recurrence interval, recovery time,* and *preservation potential* are critical factors for evaluating significance for the sedimentary record. Large-magnitude processes, which represent positive deviations from the norm and are rare on the human time scale, must be significant over geologic time. But how significant? Could not everyday processes have obliterated much of the evidence? Flood deposits have relatively low preservation potential because they lie above base level. Marine gravel layers dispersed by abnormal waves have greater preservation potential because most ordinary processes are not competent to modify them. Sandy or shelly deposits formed by large waves and displaying either hummocky cross-stratification or graded bedding have a moderate preservation potential, especially if too thick for burrowing animals to homogenize them. Turbidites, which provide exceptional records of episodicity, have excellent preservation potential because they lie well below base level. Many bedding planes are important records of episodicity, too; some are surfaces of erosion, others of nondeposition. These represent negative deviations from average process magnitudes.

The sedimentological importance of rare events is difficult to