origin. Bed sets are of the "AE" and "ABE" types. The channel-fill sandstones appear to have been deposited in constructional channels, narrowly bordered by more thinly bedded levee deposits. Multiple-channel sandstones cross anticlinal structure at Northeast Thompsonville field, but in other areas the occurrence of oil and gas is not related to structural closure. The sandstones are highly quartzose, and maximum permeabilities are in the range of 100 to 200 md.

Oligocene Vicksburg sandstones at McAllen Ranch field form a thick series of channel turbidites of the "AE" and "ABE" types with interbedded, more complete, turbidite sequences. These stacked-channel sandstones probably represent inner-fan deposits. Associated anticlinal structures are probably the result of differential compaction over thick concentrations of channel turbidites. The sandstones are clayey, and maximum permeabilities are in the range of 10 to 50 md.

The relatively abundant turbidites in these deep sections indicate that sand transport in a dip direction was a common mechanism that operated through much of the Tertiary. Although many of these sandstones have low permeabilities, they have the potential to form important, stratigraphic accumulations of natural gas through most of the deep, basinal section.

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Deep-Sea Drilling and Major Themes of Ocean Evolution

The major trends and events of the evolution of ocean life, circulation, and chemistry since the Early Cretaceous have been established through deep-sea drilling. A. G. Fischer and M. A. Arthur emphasized the long-term correlations between variations in global characteristics of ancient oceans (diversity, temperature, sediment continuity, oxygenation, eustatic sea level, carbon-isotope values). H. Thierstein and W. Berger summarized the evidence for the occurrence of abrupt changes in such ocean characteristics.

It is argued that relatively few basic mechanisms—activated by crustal motion, ocean circulation and basin-basin exchange, and atmospheric feedback within the global heat budget—can account for the observed paleo-oceanographic phenomena. The "geologic setting" of the various periods of earth history and the partitioning of the record within the established time scale hinge on these paleo-oceanographic factors.

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Exploration Results and Potential of Norwegian Continental Shelf

The delimitation of the Norwegian continental shelf is not finalized, but the size of the area with a sediment thickness of significance from hydrocarbon potential is of the order of 1.5×10^6 sq km. From an exploration point of view the shelf can be subdivided into 2 areas: (1) the North Sea south of 62°N where exploration drilling has been going on since 1966; by November 1, 1978, 205 exploration wells had been spudded; (2) the area north of 62°N where no exploration drilling has been permitted up to now.

Recoverable reserves of 1.4×10^9 tons of oil or oil equivalents have been discovered. The fields are located along the Central and Viking grabens, north-south Mesozoic basins along the central North Sea. Three zones have proven to be the main reservoir rocks. (1) In Jurassic sandstone, Statfjord is the most prominent field. (2) In Maestrichtian-Danian chalk, Ekofisk is the most prominent field. (3) In Paleocene-Eocene sandstone, Frigg is the most prominent field.

The Norwegian Petroleum Directorate (NPD) has risk evaluated undrilled structures south of 62°N and concluded that another 2×10^9 tons of oil or oil equivalent recoverable reserves are to be found. Evaluation of the area north of 62°N is based mainly on NPD seismic surveys. The three main areas are: (1) Møre Lofoten between 62 and 69°N, (2) Barents Sea north of 70°N, and (3) Jan Mayen Ridge.

The first two areas are the most extensively explored and are considered to be the most prospective. Several different types of basin development are defined. Favorable conditions for formation and accumulation of substantial amounts of hydrocarbons prevail over extensive parts. The two areas are generally considered highly prospective, but there are variations within them. The Jan Mayen Ridge is considered to be a continental block with sediments of considerable thickness. The possibility of commercial hydrocarbon deposits is highly questionable but should not be ruled out.

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Isotopic Compositions of Biogenic Carbonate Cements

In addition to inorganic precipitation, carbonate cements can be formed from organically derived bicarbonate. The most dominant source of this "biogenic" bicarbonate is sulfate reduction. As bacterially produced bicarbonate increases in the pore water, precipitation of calcium carbonate can occur. Deeper in the sediment column, where sulfate has been microbially depleted, production of methane and carbon dioxide occurs from bacterial fermentation of organic matter. Methane produced below the sulfate zone can diffuse upward and is almost completely reoxidized before reaching the surface. Oxidized carbon is again introduced into the pore water as bicarbonate, thus enhancing carbonate precipitation. The resultant cement forms as a micrite crust and probably has been mistaken as a surface-precipitated marine cement.

Ideally, the sources of cement can be delineated by carbon isotope signatures that can be approximated (versus PDB) as follows, in parts per thousand: inorganic, 0; sulfate reduction, −25; fermentation, +10; and methane oxidation, −80. The origins of selected microcrystalline cements from the reef plate at Enewetak Atoll, Marshall Islands, have been determined by examining their isotope ratios. Since these ratios can be measured to better than 0.1 parts per thousand, analysis of cements from core samples is often diagnostic of the origin of the cement, although some "mixing" is common.