phyllosilicate pore fill, (4) late calcite and siliceous overgrowths and formation of prehnite and epidote.

The Poul Creek Formation is the richest source rock present in the Gulf of Alaska. It has acted as the source of most of the oil seeps in the area. The lower Tertiary section has been a minor source section for oil and gas in the area. The Yakataga Formation is mainly glacial in nature and is a very poor source rock. Organic maturity parameters indicate all formations except the Yakataga have experienced sufficient time-temperature conditions to be fully mature and in a generative hydrocarbon stage. Normalized interval-velocity analysis of offshore geophysical data suggests likelihood of poor source and reservoir rocks over much of the Gulf of Alaska basin.

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Speculations on Petroleum Resource Potential of Antarctica

Significant deposits of hydrocarbons are probably present beneath the continental margin of Antarctica in the areas of the Ross, Amundsen, Bellingshausen, and Weddell Seas. The onshore areas of Antarctica have uncertain petroleum potential, because the sedimentary rocks that do extend above the ice sheet are largely metamorphosed and intruded by igneous rocks. Large basins containing sedimentary rock may underlie the thick (average 3 km) moving ice sheet (e.g., Wilkes and Polar basins and areas west of the Pensacola Mountains).

Widely spaced marine geophysical surveys (by *Eltanin* and other ships) have been carried out over parts of the continental shelf, but only the Norwegian (1976-77) and German (1977-78) expeditions have collected modern deep-penetration multichannel seismic data. No systematic aeromagnetic surveys of the continental margins exist, although data from the early 1960s to 1978 suggest a section of sedimentary rocks several kilometers thick above magnetic basement. The Deep Sea Drilling Project (DSDP) sampled rocks that were as old as Miocene beneath the Ross Sea continental shelf (maximum penetration of 443 m) and as old as Oligocene to early Miocene beneath the Bellingshausen Sea continental rise. The only traces of hydrocarbons recovered so far are methane, ethane, and ethylene from DSDP cores beneath the Ross Sea shelf.

Comparisons with other continents in the Southern Hemisphere suggest the likelihood of thick Cretaceous and Tertiary sedimentary sections beneath the continental margins of the Ross, Amundsen, Bellingshausen, and Weddell Seas. Some of the areas of other continents adjacent to these parts of the Antarctic continental margin in the Gondwanaland reconstruction contain significant amounts of oil and gas. By analogy, therefore, the Antarctic continental margin may also. Published estimates suggest that undiscovered petroleum resources may be in the range of tens of billions of barrels in place.

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Middle Paleozoic Sedimentation and Paleogeography of Southern Great Basin

Based on detailed analysis of conodont distribution, middle Paleozoic rocks in the southern Great Basin have been divided into refined time intervals. These include late Middle through Late Ordovician; early to middle Early Silurian; late Early Silurian; Late Silurian; and Early to early Middle Devonian. Rocks of these intervals consist of fine-grained limestone, fine to medium-grained dolostone, and lesser amounts of silty limestones and impure calcareous shales. Based on the distribution of lithofacies, deposition occurred on an eastern craton margin and within inner- and outer-shelf regions on the Cordilleran miogeocline. Offset of these regions can be used to estimate movement along major faults (e.g., the Death Valley–Furnace Creek fault zone).

The craton margin was a region of supratidal to very shallow subtidal environments during part of this time interval. Regression and erosion of the craton margin during Early and Late Silurian time provided a source of carbonate mud as well as silt to sand-sized quartz which were redeposited on the shelf areas in the west. An unconformity separates Upper Ordovician rocks from overlying Lower Devonian rocks. Intertidal to subtidal environments with nearly continuous deposition existed on the inner shelf, providing evidence of regional regression during early and middle Early Silurian and Late Silurian time. The outer shelf was an area of complex environments including platforms and local basins. Uplift and erosion in Late Silurian time affected part of the outer shelf. In the northern Inyo Mountains an unconformity separates upper Lower Silurian rocks from overlying Lower Devonian rocks.

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Reservoir Morphologies for Gulf Coast Turbidite Sandstones, Texas

Turbidite sandstones form gas reservoirs in the deeper Tertiary section of the Gulf Coast province of Texas. Turbidite reservoirs are of three types: (1) thin-bedded sandstones of middle-shelf origin, (2) constructional-channel-fill sandstones, and (3) stacked-channel turbidites. Production in all these reservoirs is associated with structures, but it appears that stratigraphic control exerts a fundamental influence on the accumulation of gas.

Oligocene Frio sandstones at Nine Mile Point field are turbidites which formed in water depths of about 300 ft (100 m). The thin-bedded sandstones are interbedded with bioturbated shales. Sandstones are largely channel turbidites of the "AE" and "ABE" types, but more complete sequences are also present. Bed associations resemble those of submarine fans, but Frio turbidites are concentrated on the downthrown sides of major normal faults, and adjacent anticlinal crests are nearly barren of porous sand. The sandstones are clayey, and maximum permeabilities are in the range of 10 to 50 md.

Eocene lower Wilcox sandstones at Northeast Thompsonville field are massive turbidites of channel 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.