ronments. Trace preservation is poor, but is typified by low diversity and high abundance. Uppermost Pennsylvanian turbidite deposits on Bovine Mountain contain *Helminthoida* and *Chondrites;* basal Wolfcampian rocks of the Grassy Mountains bear *Helminthoida, Protopaleodictyon,* and *Lophoctenium.*

Upper Wolfcampian fetid, soft-sediment-folded, arenaceous siltstones locally yield indigenous fauna that suggests an off-shelf origin. In the Hogup and Grassy Mountains, *Helminthoida* is preserved, but in general the trace-fossil record is scanty in this interval.

In Leonardian time, the Oquirrh basin filled to shelf depth, and a mixture of vertical and horizontal bioturbation again prevailed.

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Regional Tectonics and Petroleum Geology of Tunisia—Introduction and Overview

Tunisia can be divided into five tectonic provinces: (1) La Galite–Numidian zone, (2) zone of diapirs–Zaghouan fault, (3) Kasserine Island, (4) Gabes basin–Cretaceous platform–Offshore, and (5) Djefarra-Paleozoic complex. Thin-skin tectonics dominate the La Galite–Numidian zone. Perhaps as much as 20 km of shortening indicates that the best petroleum prospects may lie beneath the thrusts. Oil and gas seeps in Algeria suggest that lower Numidian clastics induce favorable hydrocarbon generating environments. In the Kasserine Island area, as much as 5 km of late Miocene shortening complicates earlier extensional structures. Basement involvement in early extension and its possible influence on later compressive events could generate significant hydrocarbon accumulations. The section beneath the decollement also may have significant petroleum potential.

The zone of diapirs–Zaghouan fault, intermediate between the allochthonous Numidian–La Galite complex and the Kasserine Island may have potential beneath a possible decollement. Of particular interest are favorable autochthonous Jurassic facies. These prospects must have been generated during Early Cretaceous time with the subsequent trap improved during the Miocene orogeny. The Gabes basin–Cretaceous platform–Offshore province has well-developed extensional structures. Hydrocarbon source and maturation appear to be sufficient, as seen in the Isis and Ashtart fields. Reservoir quality is the major problem. The Paleozoic tectonic province has favorable extensional structures in the Djefarra complex, but source problems and tilting may have a negative effect. Paleozoic truncation plays south of the Djefarra are possible. However, large structures and thick reservoirs have not been found. The petroleum potential of Tunisia must be rated high, but only sophisticated and imaginative exploration programs will realize this potential.

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Tunisia—Plate Tectonics and Hydrocarbon Accumulation of Contiguous Areas

The position of Tunisia on the African plate is of importance to explorationists. Present work suggests that the African plate margin roughly coincides with the present northern African-Sicilian coastline. The eastern margin of this Algerian-Tunisian-Sicilian salient of the African plate is marked by the east coast of Sicily and the Malta Scarp. This sharply defined feature continues into the Gulf of Sirte where it joins with the post-Jurassic extensional Sirte basin. This represents a zone where eastern North Africa (Egypt and Cyrenaica) moved northeastward and western North Africa (Morocco, Algeria, Tunisia, and western Tripolitania) have a more northwesterly vector of movement. There may be a shear component in addition to the extensional faulting on the west side of the Sirte basin, which continues into the Malta Scarp.

Active rifting in Tunisia extends from Late Triassic through early Miocene with no appreciable compression. Miocene to Holocene compression is associated with collision along the northern continental margin. The Pantelleria trough and horst zone in central Tunisia developed in response to these stresses, as did the final tectonic framework of the zone of diapirs–Zaghouan fault and the Kasserine Island. These features buffered the Gabes basin and Cretaceous platform on the south from this compression.

This model defines as prospective all of northern Tunisia (except the northern Numidian zone), Sicily and the offshore Malta Bank, Gabes basin, and the Cretaceous shelf area.

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Oil Generation and Migration in Lusitanian Basin, Portugal

The Lusitanian basin covers coastal Portugal and the adjacent offshore and received sediments from Triassic to Tertiary time. Presence of source beds, reservoirs, diapirs, and surface indications has attracted exploration since the late 1940s. Three principal potential source-rock zones have been identified from surface and subsurface work: Permian coals and Lower and Upper Jurassic kerogenous beds. The Permian coals occur only in localized basins and are of limited significance only as a potential gas source. The Lower and Upper Jurassic potential oil source rocks are confined to two subbasins in the center of the Lusitanian basin. Net source-rock thickness decreases from the subbasin centers toward the rims. Source maturity, established by various and independent techniques, appears to be rather low, suggesting a low resulting generation, expulsion, and migration efficiency. Surface indications and crude oil derived from tests support the hypothesis of a not very mature system. Although the subsurface data confirm the early interpretation that the Lusitanian basin contains the necessary basic ingredients for a successful exploration play (i.e., structures, reservoirs, source rocks), the absence of sufficient source maturation

seems to be a downgrading factor, at least for parts of the basin explored.

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Origin of Regional Pre–Middle Devonian Dolomitization in Williston Basin

Lower Paleozoic limestones in the Williston basin are only preserved from complete dolomitization where they are overlain by an argillaceous member of the Ordovician Stony Mountain Formation. This umbrellalike relation was originally interpreted as indicating that dolomitization resulted from the actions of descending brines. Basin-wide dolomitization of overlying strata (including the Middle Devonian Winnipegosis Formation) and an absence of Upper Devonian and higher regional dolomitization suggest that dolomitization was also a Middle Devonian event, which occurred during deposition of the overlying Prairie Evaporite.

Winnipegosis–Prairie Evaporite relations in Saskatchewan, however, indicate that a different genetic link existed between evaporite deposition and the regional dolomitization of subjacent carbonate rocks. It is believed that the Prairie evaporites were precipitated largely from groundwaters that entered the basin by means of carbonate buildups in the Winnipegosis Formation. Groundwater seepage first deposited travertine, "vadose" pisolites, and carbonate muds on mound tops and flanks, then caused massive precipitation and growth of interstitial, sediment-replacing and sediment-displacing gypsum in the mound-flanking beds. Concentration and processing of brines during their downward migration allowed final precipitation of chevron halite in salt flats on the basin floor. Groundwater movements also caused regional dolomitization of pre–Prairie Evaporite carbonate rocks which lay along flow paths. Groundwaters beneath the relatively impermeable Stony Mountain shale were stagnant and, consequently, did not cause dolomitization of their carbonate hosts.

Dolomitization of lower Winnipegosis blanket ("platform") limestones occurred concurrently with early compaction. This timing is consistent with the suggested dolomitization model.

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Late Cenozoic Calcareous Microfossil Biostratigraphy, Paleo-oceanography, and Biogeography—Poles to Tropics

Deep-sea drilling has provided a set of marine sedimentary sequences for global Cenozoic paleo-oceanographic studies. The CENOP (Cenozoic Paleo-oceanography) program is conducting paleo-oceanographic studies of the late Cenozoic from tropics to poles within the framework of plate tectonism and polar-glacial evolution. This requires detailed correlations between high- and low-latitude regions using different approaches.

Quantitative planktonic foraminiferal investigations have been conducted on late Cenozoic sequences in the South Pacific ranging from temperate to warm subtropical latitudes (41 to 26°S). Previous nonquantitative biostratigraphic studies have enabled the establishment of biostratigraphic schemes and correlation between the sequences which differ markedly in faunal characteristics as a result of the latitudinal range. Species frequency, diversity, faunal groupings (principal component and factor analyses), and coiling directions of *Neogloboquadrina pachyderma* have been determined for each sequence. Oxygen- and carbon-isotopic stratigraphy also has aided in intersite correlation.

During the Cenozoic, major changes have occurred in planktonic microfossil biogeography as reflected in the biostratigraphic sequences. These changes have been created largely in response to evolution of the Southern Ocean circulation system as obstructing landmasses moved apart. Included in these changes are the development of the Antarctic and Subantarctic water masses and the Antarctic Convergence and the evolution of cold, high-latitude climates. Nearly all evolution of calcareous planktonic microfossils has occurred outside of the Antarctic-Subantarctic, in subtropical-tropical areas, followed by limited migration into high latitudes. Virtually no endemism occurs among calcareous microfossils at high latitudes, but it is marked in late Cenozoic siliceous forms.

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Potential Resources of Natural Gas in United States—Case History of Potential Gas Committee

Since the early 1960s the Potential Gas Committee (PGC) has been preparing periodic estimates of potential resources of natural gas in the United States. The committee operates independently from any other group, either industry or government, and its published estimates represent the consensus of the working members who are organized into committees, one for each major producing area of the United States. Over the years, many different people have participated. The total U.S. natural gas resource consists of cumulative past production plus present proved reserves plus undiscovered potential resources. The work of the PGC involves the estimation of the potential resources only. With time the various components of the total recoverable resource should reflect a gradual shift from the potential category through proved reserves into production. Indeed, as the cumulative production in the United States has increased and the proved reserves have gradually decreased in recent years, the potential estimated independently by the PGC has changed gradually and the estimate of the total recoverable resource has remained remarkably consistent. Within individual areas the estimate of the undiscovered potential has shifted rather markedly, but the overall picture for the entire country has varied within close limits. Variations in the estimate of potential for the individual areas can be attributed to the progress of exploration and the exploration philosophy of the members of the committee.

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