the east and north. In the Troms basin, these sub-Cretaceous rocks are deeply buried, so younger reservoir zones have been drilled. Jurassic and younger rocks will be the main targets in the virgin Harstad basin.

The gas has been generated from Lower Jurassic coals and shales. These, and Upper Jurassic shales with oil source potential, will probably also be the source for most hydrocarbons to be discovered in the future. Some deep Paleozoic structures will be dependent on older source rocks.

The hydrocarbon potential of the relatively well-known Troms and Hammerfest basins is considered low and moderate, respectively. More promising today are Paleozoic structures on the Loppa high and structures in the Harstad basin.

SURLYK, FINN, J. M. HURST, S. PIASECKI, F. ROLLE, L. STEMMERIK, E. THOMSEN, and P. WRANG, Grønlands Geologiske Undersøgelse, Copenhagen, Denmark

Permian of Norwegian-Greenland Sea Margins—Future Exploration Target

Oil and gas exploration in the northern North Sea and the southern Norwegian shelf has mainly been concentrated on Jurassic and younger reservoirs with Late Jurassic black shale source rocks. New onshore investigations in Jameson Land, central East Greenland, suggest that the Permian of the Norwegian-Greenland Sea margins contains relatively thick sequences of potential oil source rocks interbedded with carbonate reefs.

The East Greenland, Upper Permian marine basin is exposed over a length of 400 km (250 mi) from Jameson Land in the south to Wollaston Forland in the north, parallel with the continental margin. The maximum width of the onshore part of the basin is 200 km (125 mi), and the maximum thickness of preserved sediments is about 300 m (1,000 ft). The Upper Permian lies unconformably on faulted, tilted, and peneplaned Lower Permian red beds or older rocks. The Upper Permian sediments are indicative of a transgressive sequence. Initial sedimentation in the marginal parts of the basin are characterized by evaporites and hypersaline carbonates, whereas normal marine carbonate and black shale prevail in the more offshore parts of the basin. Continued transgression led to the development of normal marine conditions throughout the basin and carbonate reefs were formed over structural highs. Black shale rich in organic matter was deposited under anaerobic to dysaerobic conditions between and around the reefs. Toward the end of the Permian, reef growth ceased and many reefs were draped by black shale that finally gave way to coarser grained, carbonaceous sandy shale, deposited under well-oxygenated normal marine conditions. A very short but marked regression took place at the Permian-Triassic boundary, so that along basin margins and over structural highs, the top of the Permian was eroded. Subsequently, the Early Triassic sea transgressed the area and deposition of marine sandstone and shale continued. The Triassic shale is reminiscent of the Upper Permian shale, but the organic content of the former is low and mainly of terrestrial origin (spores and pollen). Accordingly, the Triassic shale has no source rock potential. Following the Early Triassic marine interlude, a major regression took place. The remaining part of the Triassic was characterized by intermontane graben deposition of alluvial fan, fluvial, eolian, and lacustrine red beds.

The Upper Permian black shale is relatively thick, widely distributed, has a high organic carbon content, and a favorable kerogen type. According to vitrinite reflectance and pyrolysis data, it is premature to slightly mature in the surface exposures along the basin margin. If buried under 2-3 km (6,500-9,800 ft) of younger sediments, as is expected in the onshore and offshore basins, the shale will most probably be developed as a mature source rock for oil. It is interbedded with and overlies carbonate reef and platform sequences that have undergone several periods of karstification in some areas. This karstification may have enhanced the reservoir potential considerably. The Upper Permian shale has a combined source rock and seal potential, and uppermost Permian and Lower Triassic coarse sandstone interbedded with the shale may also have reservoirs properties. The Lower Triassic also contains several tight shale and evaporite units that may function as seals. In the northern North Atlantic area, the Early to Middle Triassic was a period of rifting activity; thus, combined structural-stratigraphic traps are an obvious exploration target. Consequently, the possibilities for a Permian play in the northern part of the Norwegian shelf and along parts of the Norwegian-Greenland Sea margins are worth evaluating.

WATKINS, JOEL S., Gulf Research & Development Co., Houston, TX, and A. M. PYTTE, Gulf Oil Exploration and Production Co., Houston, TX

Exploration History and Future Prospects of United States Atlantic Margin

The Atlantic Margin of the United States comprises four large basins that are, from north to south, Georges Bank basin, Baltimore Canyon Trough, Carolina Trough, and Blake Plateau basin (which includes the Georgia Embayment and Bahama Platform). Most exploratory drilling has focused on structures in the postrift basin depocenters, with eight Georges Bank wildcats having been drilled into structures formed by block faulting and salt movement. Target zones were Upper and Middle Jurassic sandstones and carbonates. All were dry holes with some minor gas shows. Twenty-nine exploratory wells have been drilled into four types of structures in Baltimore Canyon Trough: an intrusive dome, deep-seated diapirs, fault blocks, and most recently a Lower Cretaceous-Upper Jurassic shelf-edge "reef." Some hydrocarbons were associated with a deep-seated diapir structure, but the other wells were dry. Wells in the Southeast Georgia Embayment penetrated Lower Cretaceous-Upper Jurassic continental clastics and shallow Paleozoic basement rocks. All wells were dry. No exploratory wells have been drilled in the Carolina Trough or Blake Plateau.

Recent leasing in Georges Bank has been delayed because of litigation. In the Baltimore Canyon Trough, most recent leasing appears targeted at a prominent Lower Cretaceous-Upper Jurassic paleo-shelf edge, where it is hoped that synrift deposits rich in organic matter source porous shelf-edge carbonates and overlying clastics. Shell Oil, the largest leaseholder, is drilling a series of wells to test this structure. Between the Baltimore Canyon and Carolina Troughs, several leases have been taken over a large anticline possibly cored by salt. Another block of leases has been taken in the Carolina Trough immediately south of Cape Fear over a large grabenlike structure. Other, smaller groups of blocks appear to have lesser structures as targets. The Blake Plateau as yet has no active leases.

WOOD, DENNIS S., Robertson Research International Limited, Llanduduo, Gwynedd, North Wales

Petroleum Potential of Western Desert of Egypt

The Western Desert of Egypt, despite many discouragements, has major potential as a petroleum province. Approximately 150 exploratory wells have discovered nine commercial oil and gas fields, with flows of oil or gas recorded from an additional 21 wells.

All discoveries have been in marine inner shelf sandstones and carbonates that range from Aptian to Turonian in age. Potential reservoir rocks are known in Paleozoic to Tertiary sedimentary rocks. Mature source rocks have been recognized in the Devonian and in Jurassic to Upper Cretaceous strata. Seals, mainly shale, but including carbonates and some evaporites, are present in most formations in most areas. Structural traps are abundant.

Despite these favorable factors, in-place reserves of only 800 million bbl of oil and condensate, and up to 1,185 bcf of natural gas have been found. Almost all exploration has been limited to the drilling of relatively small onshore structures and no giant fields have been found. All significant discoveries to date have been in anticlinal traps, commonly modified by faulting.

New investigations utilizing a broad regional tectonic framework provide a means both of recognizing the more prospective provinces of the Western Desert and for understanding the structural evolution in terms of the timing of growth folding and growth faulting. These new investigations have been based on an approximately 10 by 10 km (6 by 6 mi) seismic grid and have identified many structural prospects and leads in the onshore area. Most structures are in the Abu Gharadig, Kattaniya (Gindi basin), and northern province of the Western Desert. The Abu Gharadig basin is of particular interest, being recognized as a major rhombochasmic basin containing numerous localized "highs" provided by northeast-southwest-oriented, doubly plunging (periclinal) anticlines. There are, therefore, sufficient structures to warrant extensive additional exploration.

Particular attention should be given to testing the lower part of the Cretaceous and Jurassic. The Paleozoic section also warrants further attention as demonstrated by a review of drilling results and by indications from gravity data. The new investigations indicate a considerable potential within the Western Desert for discovery of small to moderate-size accumulations of oil and gas. In addition, possible reefal, carbonate bank, and partially dolomitized trends (largely in the immediate offshore areas) are recognized. More exploration should test these features, which although high-risk leads, may contain giant fields.

ZHAI GUANG MING, Petroleum Corporation of the People's Republic of China, Beijing, China

Geology and Petroleum Potential of Northwestern China

The northwestern part of China is one of the country's most prospective onshore oil and gas regions, where many large sedimentary basins are located (i.e., the Zhungeer, Talimu, Tulufan, Chaidamu, and West Gansu). In all these basins, both Mesozoic-Cenozoic sediments of continental origin and Paleozoic sediments of marine origin were deposited, totaling more than 10,000 m (33,000 ft) in thickness. As the rocks are mostly unmetamorphosed, they are highly prospective targets for oil and gas exploration. Tectonically, the northwest basins are widely different from others in China, most of which are formed by tension and normal faults that tend to produce fault structure zones or rollover anticlines. In the northwest, the basins are mostly formed by compression in which thrust faults and reverse faults that develop into many structure zones and local structures occur. The rows of structural zones at the piedmont of Tianshan, Kunlunshan, Alkinshan, and Nanshan mountains are good objectives for oil exploration.

Although most of the reservoir rocks in northwest China are of Mesozoic age, with only a small amount of Cenozoic strata, Paleozoic rocks are also considered as exploration objectives. It is anticipated that varied types of oil pools, typical structural oil pools, or large-scale stratigraphic accumulations may be found in these Paleozoic rocks.

Many oil and gas fields have already been discovered in these basins and are in production. They may constitute an important oil production base in China.

1984 ANNUAL CONVENTION WITH DIVISIONS: SEPM/EMD/DPA May 20-23, 1984 San Antonio, Texas

Late Abstracts

CUSHMAN, ROBERT A., JR., H. PAUL BUCHHEIM, and LANNY H. FISK, Loma Linda Univ., Riverside, CA

Palynology and Oil Shale Genesis in Fossil Butte Member of Eocene Green River Formation, Wyoming

The palynoflora of the Fossil Butte Member of the Green River Formation was studied to relate the flora and climate to the genesis of oil shale in ancient Fossil Lake. Samples were collected from measured sections representing open and marginal lacustrine environments. These samples were analyzed using standard palynologic and visual kerogen techniques.

Evidence from the palynoflora suggests that during deposition of the Fossil Butte Member, the climate was in transition between humid, subtropical to a cooler, drier, warm temperate one with moderate fluctuations during various episodes of deposition. Additional evidence indicates that moist lowlands and flood plains existed around Fossil Lake, with upland forests on the surrounding ridges and mountains. Streams originating in the highlands supplied water to Fossil Lake and the surrounding vegetation. The age of the palynoflora along with K-Ar age determinations indicate that deposition of oil shale in Fossil basin was contemporaneous with deposition of the evaporite facies of the Wilkins Peak Member in the Green River basin. This suggests that factors affecting oil shale deposition in the two basins were locally, as well as regionally, controlled. The dominance of amorphous kerogen in the kerogen samples suggests an algal origin for the majority of the oil shales.

The palynoflora, the kerogen type, and the stratigraphic relationships indicate that the deposition of oil shale in Fossil basin was due to local climatic and environmental conditions.

WALI, ASHRAF, Cairo Univ., Giza, Egypt

Implications of Some Flow Sedimentary Structures Within Miocene Evaporitic Sequence, Red Sea, Egypt

Some typical flow sedimentary structures were clearly detected within the middle Miocene alternating gypsiferous and anhydritic clays of the evaporitic sequence in Ras Gemsa and Um El-Huweitat localities.

Sedimentologic analyses of the different structural forms revealed that they were originally formed from unlithified sediments and due to submarine flowage. These structures were formed as a result of stress—load, compression, and rotation.

Such a genetic approach is helpful in deducing the environmental conditions within which these sediments accumulated. Degrees of flowage and affected stresses on similar lithologic associations could be considered strong evidence for correlation within the extended Miocene evaporitic sequence along the Red Sea coast.

Fossil Fuels of Europe Conference and Exhibition July 15-18, 1984 Geneva, Switzerland

Late Abstract

CORNELIUS, CARL-DETLEF, Veba Oel Entwicklungs-Gesellschaft MBH, D 4650, Gzlsenkirchen, Federal Republic of Germany

Heavy and Tar Sand Oil Deposits of Europe

Several hundred heavy and extra-heavy oil and natural bitumen occurrences from 26 European countries (including European Turkey and the western borderlands of the USSR) were compiled. The definitions used for heavy crude oils and natural bitumens, as proposed by or prepared with the UNITAR/UNDP information centre, were applied.

Information on stratigraphy, lithology, and depth as well as on gravity, viscosity, and gas and water content, is given.

Deposits are characteristically distributed along the flanks of the basins or within the separating uplifts. Nevertheless, they are found from the surface down to depths of 3,000 m (9,800 ft). Up to now, big accumulations have been exploited in Albania and Sicily, but they have been discovered also in the British North Sea, France, Spain, and West Germany. In carbonates, they were mostly encountered in fractures of synsedimentary or tectonic origin. The accumulations are the result of either intrusion of immature heavy oil from a source rock or of the immigration of mature oil, which was biodegraded afterward. In many cases, there have been at least two separate migration/accumulation events. In some cases paleoseepages did supply a source rock with asphaltic material or became an effective seal of a later hydrocarbon accumulation.