10:15 **T. SUND:** Tectonic Development and Hydrocarbon Potential Offshore Troms, Northern Norway

10:40 **F. SURLYK*, J. M. HURST, S. PIASECKI, F. ROLLE, L. STEMMERIK, E. THOMSEN, P. WRANG:** Permian of Norwegian-Greenland Sea Margins—Future Exploration Target

11:05 **F. RIIS, J. VOLLSET*:** Barents Sea Oil and Gas

Abstracts

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California and Saudi Arabia—Geologic Contrasts

Assessing hydrocarbon futures in unexplored basins involves geology by analogy. These assessments are needed to help quantify the amount of oil and gas postulated. It is important for the geology and geologic history of known producing basins to be defined in some systematic way, so that their favorable or unfavorable attributes may be recognized, and subsequently looked for in untested basins. The California and Arabian analogs are important.

Through 1978, approximately 265 fields were discovered in California, containing 22 billion bbl of oil, 53% being in the 10 largest fields, ranging in size from 0.6 to 2.4 billion bbl. These fields occur in several different sedimentary basins. Through 1978, about 50 fields were found in Saudi Arabia containing 206 billion bbl of oil, 78% in the 10 largest fields, ranging in size from 7 to 83 billion bbl. All these fields occur in one part of a single very large basin. The contrasts in field size distribution and in the total amount of oil present are explained by the dramatically different geology and geologic histories.

California's surface geology is characterized by rare Precambrian, isolated Paleozoic, and widespread Mesozoic accreted terranes and intrusions, and by highly uplifted and depressed Tertiary sedimentary prisms bounded by widespread high-angle thrusting and strike-slip and normal faulting. Numerous families of medium to small anticlines and fault traps, commonly involving moderately dipping to overturned beds, have resulted from Tertiary tectonism, which segmented California dramatically. The sediments associated with the oil and gas are largely local fine to coarse-grained clastics, shed from nearby highlands, but with one important regional chert-limestone-dolomite sequence.

Saudi Arabia is characterized by a broad Precambrian shield area, flanked on the east by very long, gently dipping cuestas of Paleozoic and Mesozoic sediments, with an upper thin veneer of nearly flat Tertiary strata. Most structures involving the Mesozoic and Cenozoic are large, but gentle and unfaulted, representing a passive reaction of the sediments to underlying mild basement distortion and/or movement of Cambrian salt, all occurring while the Arabian plate continued to subside and "tip" to the northeast. The sediments associated with the oil are largely widespread carbonates of uniform thickness, with one interbedded sandstone wedge, and some shale.

The contrasts between California and Saudi Arabia oil fields and geology result from contrasting plate-tectonic settings and history.

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Paleozoic Oil and Gas Potential of Arabian Basin

The central and northwestern region of the greater Arabian basin contains more than 5,000 m (16,400 ft) of oil- and gas-prospective clastic and carbonate Paleozoic sediments. The Hail-Rutbah arch divides the region into two Paleozoic basins, the western Tabuk basin on the west and the Widyan basin on the east. The Tabuk basin is filled with Cambrian to Devonian sediments, whereas the Widyan basin contains sediments ranging in age from Cambrian through Late Permian. A north-south-trending Precambrian platform separates these basins from the eastern sector of the greater Arabian basin.

The Cambrian-Ordovician Saq Sandstone, composed of fluvial and marginal-marine sandstones and minor shales, overlies Precambrian basement.

The Ordovician-Silurian Tabuk Formation consists of cyclically deposited marine and marginally marine clastic sediments. Three shale members, the Hanadir, Ra'an, and Quasaiba, are separated by siltstones and sandstones that pinch out basinward where shale becomes dominant. These shale members are covered by regressive sandstones of the Sharawra Member. Uplift and erosion followed deposition of the Sharawra.

Unconformably overlying the Tabuk Formation is the coarse and pebbly continental sandstone of the Tawil Member of the Devonian Jauf Formation. Alternating marine and nonmarine conditions followed deposition of the Tawil Member, producing interbedded carbonates and clastics. A major regional uplift accompanied by erosion followed deposition of the Jauf Formation. The uplift affected the entire central and northwestern basin region and it is believed the Hail-Rutbah arch came into being at this time, creating the two basins.

No post-Devonian Paleozoic deposition is recorded in the rocks of the western Tabuk basin; however, thick Carboniferous-Upper Permian sediments occur in the Widyan basin. The Carboniferous to middle Permian Berwath Formation was deposited in the center of the Widyan basin and was covered by the Unayzah Formation, which transgressed the area and overlapped older rocks and paleohighs. The middle to Upper Permian is represented by carbonates of the Khuff Formation, laid down by the transgressive sea.

Precambrian structural features significantly influenced structural trends and sedimentary deposition during the Paleozoic. Major stratigraphic breaks or unconformities are believed associated with the Caledonian and Hercynian orogenies.

The most significant factor relating to the oil and gas prospectiveness of the Tabuk and Widyan basins is the presence of thick alternating source and reservoir sections. The facies vary laterally, with sandstone grading to shale basinward. The facies changes combined with several unconformities and structural folding and faulting enhance the hydrocarbon potential of the two basins. Also, known shows and recoveries of oil and gas from the Paleozoic section in the eastern Arabian basin further support the possibility of the presence of commercial quantities of hydrocarbons in these basins.

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Hydrocarbon Potential of Intracratonic Rift Basins

Significant world oil reserves have been added in recent years from rift systems. Examples of petroliferous rift basins may be found on nearly every major continent. As our understanding of the mechanisms of sedimentation and structure in rift basins grows, more rift systems will be found. With a few notable exceptions, rifts that have been explored in the past are those that formed along continental margins. These contain marine sediments, and the conditions of source rock, sediment type, depositional environment, and structural style are well-known exploration concepts.

Intracratonic rift systems containing continental sediments have received little exploration effort because few have been recognized, and also because of the problems perceived to accompany continental sedimentation. A good modern analog is the East African rift system. The source rock is lacustrine shale with an organic content that ranges from 5 to 20%. The organic materials are preserved by anoxic conditions of deep lake waters. Heat flow, as in continental-margin rifts, is moderate to high. Combined with a commonly thick section and depth of burial, the sediments can be well within the oil generation window for lacustrine shales. The volume of oil generated may be very large for a basin of limited areal extent. The oil is generally waxy, has an API range from the 20s to 30s, and has a low sulfur content. The reservoir quality is highly dependent on the type of sediments deposited, because there is little energy available for sorting or winnowing. Possibilities include first-cycle arkoses derived from crystalline basement rock and second-cycle or multicycle sands derived from earlier pre-rift depositional episodes. Eolian sands are also possible reservoirs. There may also be sharp facies variations across the rift, and aspect ratios of these facies may approach 1:1. Seals for the reservoirs are either lacustrine shales or evaporites deposited under hypersaline, closed drainage conditions. Structures are genetically similar to those found in continental margin rift valleys. Accumulation zones are found in series of tilted blocks controlled by listric, down-to-the-basin faults; in reverse drag anticlinal features on the downthrown side of growth faults; in basement "high" blocks with a sedimen-