regarding the cost, risk and time that will be involved in developing production from those resources. Even from a national sense of supply security, the vast reserves of oil in the tar sands and in-situ recovery deposits of heavy oil in western Canada will provide a competitive ceiling that will limit future development of frontier basins to those where production costs are not significantly higher than those of the tar sands.

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Future Petroleum-Productive Regions of USSR and Mongolia

The potential for major discoveries of oil and gas is high in the USSR, but remote in Mongolia. Development of the USSR's potential is plagued by six factors: (1) remoteness of prospective basins from commercial markets, (2) lack of adequate infrastructure within prospective basins, (3) inadequate drilling technology for economic development below depths of 3,200-3,800 m (10,500-12,500 ft), (4) poor-quality indigenous equipment, (5) absence of offshore capabilities, not only in the warm Caspian and Black Seas, but also in the ice-plagued Arctic and Pacific Oceans, and (6) a chronic manpower shortage. Imports of foreign technology are alleviating the problems gradually, but they are far from solved.

European USSR.—The most important objectives of the future are: (1) Jurassic through Devonian in the Greater Barents basin and Svalbard platform, offshore Barents Sea, (2) deep Carboniferous-Ordovician of Timian-Pechora basin, (3) subthrust plays of western Urals, (4) pre-Kungurian salt section of the Pricaspian basin, (5) Devonian of the Dnepr-Donets graben, (6) Jurassic through Paleogene of the Black Sea shelf, (7) pre-Tertiary formations of the North Caucasus trough, and (8) deep Tertiary objectives near Baku in the central and southern Caspian Sea.

Asiatic USSR.—The most important targets are: (1) deep Mesozoic and Paleozoic (Carboniferous, Devonian, Silurian) carbonates of the Nyurol'ka, Frolovo, and other depressions in and below the West Siberian basin, including the Kara Sea, (2) late Paleozoic-Mesozoic of the Aral' Sea, the Ustyurt depression, the Chu-Sarysu basin, and the Turgay and Syrdar'ya syneclises, most of them unexplored, (3) the pre-Upper Jurassic of the central Asian basins, (4) the deep Tertiary of the Cheleken district, (5) the subthrust and pre-Tithonian salt section of the South Tadzhik basin, (6) the Proterozoic-Silurian marine sequences of the Tunguska, Lena, and Sukhana basins, and of the Nepa-Botuoba arch, (7) the Carboniferous-Lower Jurassic of the Vilyuy, Lena-Anabar, Khatanga, and Yenisey basins, with the associated subthrust plays of the Taymyr and Verkhoyansk ranges, and (8) the numerous late Paleozoic-Mesozoic offshore basins of the Arctic shelf plus the Tertiary basins of the Pacific, especially the Severny basin.

Mongolia.—Principal objectives are Jurassic and Cretaceous fluviatile and lacustrine sandstones in southeastern Mongolia, especially in the East Gobi basin and in the Hailar basin, which is shared with China. Similar basins in China have giant fields, such as Karamay in the Junggar basin and Daqing in the Songliao basin.

Resources.—Through 1983, the USSR had produced about 75 billion bbl of oil and condensate and 217 tcf of gas. Estimated proved plus probable liquids was 35-36 billion bbl and, of gas, about 800 tcf. Resource potential, above and beyond proved plus probable, is estimated at about 90 billion bbl and 1,000 tcf (these numbers will increase as offshore ice-pack technology is improved). In contrast, Mongolia's produced and proved oil is less than 2 million bbl, but the resource potential could be large.

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Oil and Gas Potential of Amazon Paleozoic Basins

The Paleozoic basins, covering an area of about 800,000 km^2 (309,000 mi^2) in the Amazon region, are elongate symmetrical intracratonic synclines filled with as much as 4,000 m (13,000 ft) of sediments, separated by basement uplifts or major arches and located in continental interior areas (as are the United States Illinois, Michigan, and Williston basins). These Amazon basins resulted from an initial crustal thinning followed by rifting with associated ultrabasic intrusions and, finally, cooling and subsidence. Gravity anomalies, coinciding with the axes of the synclines, support this genetic hypothesis.

These synclines were filled during the Silurian-Devonian with one cycle of continental alluvial sediments grading upward to deltaic marine clastics and minor periglacial deposits. A regional unconformity separates the Devonian from the Permo-Carboniferous cycle when, following fluviodeltaic sedimentation, highly restricted marine conditions developed a sequence of evaporite deposits.

Tectonics affected differentially these basins during the Triassic-Jurassic and Early Cretaceous, associated with widespread basic volcanism. A northeast-southwest thrust-fault system, branching southwest, characterizes a compressional orogenic province in the Upper Amazon basin. This compressional province, located in the Jurua River area, constitutes a major structural trend. Adjacent to those faults and extending for over 500 km (310 mi), large natural gas accumulations occur in several domal features. Sandstones of the Permian Monte Alegre Formation, sealed by evaporite strata, are the main reservoir rock. Geologic estimates of natural gas resources are presently rated at 120 billion m^3 (4.237 tcf) and exploration follows the productive trend toward the west-southwest.

The Middle Amazon basin, separated from the Upper Amazon by the Purus arch, was affected by lineament-block tectonics, also with associated volcanism and some local mild shearing. Minor domal features of Devonian periglacial Oriximina Formation sandstones comprise small subcommercial oil accumulations. In contrast with the Upper and Middle Amazon basins, the Lower Amazon basin has been the site of rifting since the Permo-Triassic. The rifting was associated with a nearby hot spot that uplifted the eastern part of the basin, forming the Gurupa arch. As a consequence of this uplift, a set of collapse grabens developed in the Lower Amazon basin. Potential reservoir rocks in Middle and Lower Amazon basins are Permian Monte Alegre and Devonian Oriximina sandstones. Major source rocks in all three basins are Devonian Barreirinha black shales. Organic geochemistry data indicate that both Upper and Lower Amazon basins are predominantly gas-prone, whereas the Middle Amazon basin shows potential for oil generation.

Forecasts for the major exploratory trends in the Upper Amazon indicate a good possibility of extending the already discovered natural gas province. In the Lower Amazon basin, further exploration will consist in drilling well-defined structural features identified for the first time by seismic methods, with a possibility of discovering another gas province. Prospects in the Middle Amazon basin are for both oil and gas, but the main problem is identification of adequate structures, as well as stratigraphic traps.

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Geology of Barents Sea

The Barents Sea is situated on the continental shelf between Norway, the Spitsbergen Islands, and Novaya Zemlya. The main structural framework of the area was formed during the Caledonian and Hercynian orogenies, whereas the western parts were reactivated by the Kimmerian and Alpine orogenies. Because of the complex opening of the Greenland-Norwegian Sea, important Tertiary reactivation of Mesozoic normal faults occurred along southwest-northeast-trending systems of wrench faults.

Owing to substantial erosion in the late Tertiary, the subsidence history and thermal development are more difficult to unravel in this area than in other places along the Norwegian Shelf. The erosion products were deposited in a huge sedimentary wedge extending onto the oceanic crust.

The hydrocarbon discoveries in the Troms area in the southern part of the Barents Sea are encouraging for further exploration. However, the petroleum potential for large areas is not well known at this stage.

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Wrench Faults as Factor Controlling Petroleum Occurrences in West Siberia

The morphology of west Siberia suggests the presence of huge wrench faults, which also can be seen on Landsat imagery. Many of these faults have been confirmed by geophysical surveys and subsurface data. However, Soviet geologists have not always recognized the importance of