optimum stage of current petroleum expulsion but still buried deeply enough for entrapment of giant oil accumulations.

Regions for analogous exploration application of this hypothesis, in addition to the western Gulf of Alaska, include continental or island margins adjacent to other deep oceanic trenches such as the Japan, Mindanao, Java, Solomon Sea, Peru-Chile, and Central American trenches, and the southern end of the Puerto Rico Trench northeast of Trinidad.

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SEDIMENTATION AND TECTONICS OF PACIFIC CONTINENTAL MARGIN OF BRITISH COLUMBIA

A triple junction of three lithospheric plates at the British Columbia continental margin has had considerable influence on structure and sedimentation in marginal basins. South of the triple point, compressional forces from subduction of oceanic plate beneath the continent have resulted in deformation mainly by folding and block faulting, but north of the triple point stresses are relieved by strike-slip movement along transform faults with only broad folding taking place in Tertiary sediments.

Tofino basin, south of the triple junction, has undergone major uplift, linear en echelon folding, and elongate diapirism on the outer shelf. More than 12,000 ft of Tertiary mudstone and siltstone has been drilled adjacent to such structures by Shell Canada Ltd. The fine clastics in these distal facies are not conducive to petroleum accumulation. However, potentially productive reservoir beds may exist in the proximal turbidite sequences nearer shore. Subsequent uplift and erosion of the latter also may have resulted in clean second-cycle wedges west of the uplift boundary. In the Tofino basin, as in other areas of the west coast, hydrocarbon prospects appear to have the highest potential in stratigraphic traps.

North of Brooks Peninsula, structural style is dominated by shelf-edge faulting which, west of Queen Charlotte Islands, is transform movement between the Pacific and North America plates. The Queen Charlotte basin has undergone net subsidence of several thousand feet with late Tertiary nonmarine sediments over Tertiary and Mesozoic volcanic basement and Paleozoic intrusives in the north, and late Tertiary marine sediments over Tertiary volcanic rocks in the south. Sediments reach 15,000 ft in thickness. Permeabilities are reduced by silts and clays, but facies changes between interfingering marine and nonmarine depositional sites should make good stratigraphic traps.

Winona basin at the base of the slope is folded only gently and broadly in the north but more highly deformed into prominent sedimentary ridges in the south. Three to six km of sediment fills the deepest point under the base of the slope. The oldest sediments in the flank of the basin are Pliocene. The present deepwater basin undoubtedly has received a high proportion of second-cycle clastic deposits from the uplifted older Tertiary belt.

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HYDROCARBON POTENTIAL OF COASTAL BASINS OF PERU

Along the coast of Peru, the shelf between the Andes Mountains and the 100-fm isobath is narrow, about 100 km wide in a few places. Between lat. 6 and 14°S nearly all of it is a wide offshore shelf. This shelf has been the site of marine deposition throughout the Tertiary. Basement highs and irregularities define six subbasins. In the north, the mainly offshore Progreso basin extends into Peru from the Gulf of Guayaquil. It is filled with upper Tertiary shales, sands, and conglomerates with a maximum thickness of 6,000 m. The small abandoned Zorritos field was in this basin and some undeveloped oil and gas have been discovered recently. The basin has an estimated potential of 350 million bbl.

The Talara basin, which has produced over 800 million bbl, is both onshore and offshore. Sedimentary rocks consist of Upper Cretaceous and lower Tertiary silicate clastic rocks with a maximum thickness of 8,000 m, but nearly all production comes from Eocene deltaic, fluvial, and turbidite sandstones. Intense block faulting, gravity sliding, and submarine slumping complicate development operations. The onshore part does not have large undiscovered potential, but the offshore is estimated to have a potential of one billion bbl. The Sechura basin is between the Andes and a discontinuous chain of low coastal mountains which separates it from the Talara basin. It is mostly onshore but extends southward onto the offshore. Up to 3,000 m of marine, brackish, and nonmarine sedimentary rocks, including diatomite and phosphatic and tuffaceous elements, fill the basin. Most of the strata are upper Tertiary, but lower Tertiary and Cretaceous beds also are present. In the 1950s, 28 wildcat wells were drilled with the discovery of moderate reserves of gas. A total potential for the basin is estimated to be 100 million bbl.

The Salaverry basin is the largest of the coastal basins. It is 500 km long and up to 100 km wide, is entirely offshore, and extends to within 100 km of Lima. It contains up to 3,000 m of Tertiary marine shales, silts, and calcareous sedimentary rocks with sandstones at the base. Two wells have been drilled in this basin and the estimated potential for the basin is 500 million bbl. The Pisco basin begins about 100 km south of Lima in the offshore, but southward splits into onshore and offshore parts. Up to 2,000 m of lower and upper Tertiary sedimentary rocks are present. The lower Tertiary is composed of conglomerates, sandstones, and calcareous shales. The upper Tertiary consists of sediments similar to those of the upper Tertiary in the Sechura basin. One well has been drilled in the basin. The estimated potential for the basin is 100 million bbl. The Moquegua basin is a narrow onshore basin between the Andes and the coastal chain of mountains. Marine sediments are found only in the northern part and are of insufficient volume to have significant potential. The total potential of the coastal basins is estimated to be about two billion bbl.

VEERABURUS, M.

FLUORITE RESOURCES IN THAILAND

Thailand, now one of the world's leading producers of fluorite, produced 395,070 metric tons in 1972, somewhat less than the record level of 427,498 tons the previous year. More than 155 deposits have been reported throughout the country; the main producing areas are in the northern and central regions.

Fissure veins and fault-fissure fillings of varied geometry are associated with hydrothermal minerali-

zation genetically related to granitic igneous rocks. Regional geologic structure and the lithology of country rocks are the most important factors controlling localization and deposition of fluorite.

In some replacement fluorite deposits, both the fluorite and the country rocks have very similar visual characteristics. Microscopic study of thin sections can be of assistance in solving the problems of identification, quality control, and beneficiation of crude fluorite.

Experiments using geophysical methods for locating fluorite deposits have been introduced into exploration work. Gravimeter and magnetometer studies have been applied to the deposits, but they have been found useful only in broadly outlining local structures. Unfortunately, fluorite cannot be detected directly by these methods.

Until now, only easily worked surface fluorite has been mined at the several known deposits. Intensive exploration, underground mining, and sophisticated beneficiation facilities are needed to maintain high-production levels.

Estimated potential reserves of metallurgical-grade fluorite in Thailand are thought to exceed 11,500,000 metric tons.

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ANTARCTICA: UNPROSPECTED AND UNEXPLOITED CONTINENT

Antarctica is a storehouse of mineral wealth. All other continents are. There is no reason to believe that Antarctica is unique in this respect. The continent was discovered about 150 years ago. Because of the unfavorable environment and high costs, exploration proceeded slowly and intermittently for a century. Since 1957 multi-nation efforts have revealed a fairly complete knowledge of the geomorphology, structure, and general geology of the continent. A program of detailed geologic surveying and prospecting is needed. In the not too distant future the natural resources of Antarctica will be in demand.

Antarctica is a difficult continent to explore. Over 90% of it is located within the Antarctic Circle. Approximately 95% of the continent is buried beneath ice sheets some of which exceed 3,000 m in thickness. The climate is severe and the field and shipping seasons are short. All supplies and equipment must be shipped in; the continent provides nothing.

East Antarctica is an ancient shield composed of a Precambrian basement under locally thick deposits of Devonian-Jurassic terrestrial sedimentary rocks. West Antarctica is an archipelago composed of segments of deformed Precambrian and Paleozoic continental crust. The late Mesozoic Circum-Pacific orogeny resulted in the emplacement of granitic plutons in coastal West Antarctica. Volcanism has occurred along the Pacific margin since the middle Tertiary.

Deposits of minerals containing such metals as chromium, cobalt, copper, gold, iron, lead, manganese, molybdenum, nickel, silver, tin, uranium, vanadium, and zinc have been noted. Nonmetallic deposits include beryl, micas, and coal. Offshore deposits of petroleum and natural gas are possibilities.

Under a treaty signed by 16 nations, operations in Antarctica are restricted to exploration and research. There are political aspects to be considered, but surely they can be resolved and the program of exploration and prospecting can proceed at an accelerated rate.

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COAL IN ALASKA

Estimates indicate that Alaska contains 130 billion tons of coal of different rank and age distributed over approximately 33 million acres. Commercial coal production began in Alaska in 1916, but peaked after World War II, and today less than a million tons are produced annually. Only the Nenana coalfield is currently active.

The northern coal province includes several coalfields of Cretaceous age with a reserve potential of 120 billion tons of high-volatile B and C bituminous and subbituminous coals. In central Alaska, 7 billion tons of subbituminous coal and lignite are estimated in the Nenana coalfield and in associated Tertiary coal basins. The Broad Pass, Susitna, Matanuska, and Kenai coalfields of south-central Alaska may contain 3 billion tons of high-volatile B bituminous and lesser rank coal.

Subbituminous coal and lignite of Late Cretaceous and Tertiary age are present at Hereenden Bay, Chignik, and Unga Island on the Alaska Peninsula, along the Yukon River, and on the Seward Peninsula, but their extents are poorly known. Low-volatile, high-rank bituminous coal is present in the Bering River coalfield, southeast Alaska, but is highly deformed and no reliable resource estimates exist. Coal deposits of Paleozoic age are local in northwest Alaska and on the upper Yukon River. Some of the coals of the Bering River coalfield and of the northwest part of the northern coal province may have coking potential; all Alaska coals are low in sulfur.

Development of the Alaskan coals has been restricted because of land-status problems, hostile environment, inaccessibility, and high costs of exploration and production. Probably only strip mining can be competitive with other energy sources.

Future planning should include investigation of potential coking coals, large-scale strip and underground mining, in situ gasification and development of chemical industries utilizing low-rank coal.

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PETROLEUM POTENTIAL ON CONTINENTAL RISE OFF CENTRAL CALIFORNIA

The JOIDES program has demonstrated the technical feasibility of drilling in the deep ocean. However, except for petroleum shows in the Sigsbee Knolls in the Gulf of Mexico, there is no firm evidence of petroleum reservoirs in the deep ocean beyond the limits of the continental slope to require economic use of such technology.

Emery suggested the possibility of vast petroleum resources in deep water adjacent to the continents in areas of hemipelagic sedimentation. One such area adjacent to the United States is the continental rise off California between Point Conception and Cape Mendocino, which covers 200,000 sq km and consists of three major submarine fans, the Arguello, Monterey, and Delgada, at depths of about 3,000 m to 4,500 m.

The fans are composed of continental debris carried down submarine canyons and deposited on the fan through a system of branching and meandering sub-