

plain, and the foothills as far as the Penghu-Peikang swell, North and west of the island, offshore seismic profiles show an acoustic basement above which are the predeformation and the postdeformation sedimentary layers separated by a widespread unconformity. The unconformity above the acoustic basement developed after the Mesozoic but before the Miocene, whereas the unconformity between the pre- and postdeformation layers developed after the Miocene. Therefore, we conclude that the predeformation layer was folded under the influence of the Miocene tectonic movement on the margin of the China mainland, which had ceased by the Pliocene-Pleistocene so that the young sediments are flat-lying above the unconformity.

Although the sediments of western Taiwan and offshore on the north and west were deposited in the same sedimentary basin, the tectonic movements on land were from a different source from those offshore. The orogeny on land was strong and late with its influence limited to the development of the structures in western Taiwan. The youngest structures may be sites for the accumulation of oil. The offshore part of the basin was not influenced by this late tectonic movement so that the sedimentary environment and the structure resulting from the Miocene tectonic movement on the margin of the continent should be considered as a possibility on the generation and accumulation of hydrocarbons.

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POTENTIAL FOR GEOTHERMAL ENERGY DEVELOPMENT IN ALASKA

The existence of significant geothermal resources in Alaska is suggested by approximately 100 thermal springs and more than 80 volcanoes, most of which have been active within the past million years. The potential for development of geothermal energy appears to be greatest along the Aleutian volcanic arc and in the large andesitic volcanic pile in the western Wrangell Mountains of east-central Alaska. Many of the volcanic centers in these two regions are similar to geothermal areas elsewhere in the world now being either actively prospected or developed. The Aleutian arc, for example, is near the contact between the North American and Pacific plates and contains more than 40 historically active volcanoes, at least 20 calderas, and 34 reported thermal springs, including some with subsurface temperatures estimated by chemical geothermometers as being above 200°C. The Wrangell volcanic pile contains many large stratovolcanoes, one of which, Mount Wrangell, still displays fumarolic activity near its summit. Others, such as nearby Mount Drum and Mount Sanford, are young volcanic centers whose size and silicic composition make them attractive as geothermal exploration targets.

Thermal springs in interior and southeastern Alaska are along fractured margins of granitic plutons and appear to represent deeply circulating meteoric water. Chemical geothermometers and the geologic setting suggest subsurface temperatures less than 180°C and reservoirs characterized by relatively low-recharge rates. Because of the demand for energy in remote regions, these relatively small geothermal areas may be among the first to be utilized in Alaska. Much of the potential use of geothermal energy in Alaska is for space and

process heating rather than for producing electricity, but requirements and costs of electricity are changing rapidly.

The Wrangell volcanic pile is adjacent to major transportation routes and an intra-Alaska use would be likely for energy produced from a geothermal source in this region. The economic value of the potentially large geothermal areas in the Aleutian Islands and Alaska Peninsula, however, probably lies more in supplying the needs of industries with high-energy requirements.

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STATUS OF COAL EXPLORATION AND MINE DEVELOPMENT IN AUSTRALIA

The last decade has seen a spectacular increase in the growth of the Australian coal industry as a result primarily of the development of new mines in the Bowen basin of central Queensland. Queensland coal production has risen from less than 3 million tons in 1964 to over 18 million tons in 1973. Projected output in 1978 will be in excess of 34 million tons. This growth has followed the discovery of deposits of premium-grade metallurgical coal ideally suited for Japanese coke oven blends. These coals also have found recent acceptance in European steel mills, and 25% of the output of the largest producer, Utah Development Co., is now committed to this market. Also contributing to the industry's rapid growth is the amenability of the deposits to extraction by open-cut methods, and the proximity of the coalfields to good harbors in relatively unpopulated areas. The recent downturn in exploration has been the result of government policy to rationalize the utilization of the nation's coal resources, and to allow time for a reassessment of gross reserves. Previous estimates now have been upgraded dramatically. Gross reserves of New South Wales coal are assessed at over 100,000 million tons; 16,000 million tons of this are classified as first category. Queensland's gross reserves of first-category reserves have been assessed at nearly 9,000 million tons. Government and private company exploration now is being directed to less well-known coal basins and is expected further to increase the country's known reserves. Exploration programs now planned include a number to prove coal deposits for possible hydrocarbon generation in the Queensland Galilee basin and others to locate noncoking coal in southwestern and northwestern Western Australia. Work also is proceeding in delineating a large deposit of low-grade steam coal newly discovered in South Australia.

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HYDROGEOLOGY: PACIFIC SUMMARY

Plate tectonics has become a unifying concept in the earth sciences, and within its framework rational explanations of heretofore diverse and apparently singular geologic phenomena have followed. In the Pacific, hydrogeologic provinces fit naturally within the plate-tectonics framework.

Hydrogeologic provinces in the Pacific basin are classified as: (1) continental coasts and islands at the margins of continental plates; (2) arc islands associated with the margins of ocean plates; and (3) ocean islands thought to have formed as the result of hot spots

underlying ocean plates.

The hydrogeology of continental coasts and islands is usually an extension of continental-type hydrogeology, except that coastal hydrology often is overwhelmingly influenced by the relation between fresh water and sea water in aquifers. Arc-island hydrogeology is dominated by andesitic volcanic rocks, often acting as aquicludes, and in many places by fossil reefs, which are normally suitable as freshwater aquifers if extensive enough. The hydrogeology of ocean islands is characterized by permeable basalts, relatively impermeable sediments, and, occasionally, fossil reefs. Atolls are emerged fossil reefs overlying preexisting arcs or ocean islands.

The hydrogeology of islands is particularly crucial to successful economic development as examples of the importance of hydrogeology to economic growth show.

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SOME SHALE TECTONIC CONSEQUENCES OF POSSIBLE PHENOMENON OF SUBDUCTION AND ITS MEANING TO HYDROCARBON EXPLORATIONIST

No abstract available.

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TECTONIC FRAMEWORK OF PACIFIC REGION

No abstract available.

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HYDROCARBON POTENTIAL OF OFFSHORE CALIFORNIA

Seaward from the tideline of the California coast to the base of the continental slope is an area of 100,000 sq km (38,600 sq mi) containing 16 sedimentary basins covering 60,000 sq km (23,200 sq mi) with a volume of 166,000 cu km (39,800 sq mi).

The shelf is less than 10% explored and the activity has been confined largely to the coastal fringe of the Santa Barbara Channel and near Los Angeles. Nevertheless 1.8 billion bbl of oil and 1,200 billion cu ft of gas have been produced from 4,400 exploration and development wells. Reserves are estimated at 4.5 billion bbl.

The region has three distinct tectonic provinces. Clastic sediments with occasional pyroclastic and extrusive igneous rocks are common to all and cherts are abundant in the Santa Maria basin of the northern province. There are no carbonate rocks.

The southern province of 46,600 sq km (18,000 sq mi) is a region of tectonic extension with northwesterly trending horst and graben development that clearly reflects the bathymetry. Nine sedimentary basins occupy the deep-water areas; islands and shallow banks are underlain by thin or older sediments and basement rocks. Maximum sedimentary thickness is probably about 4,000 m (13,100 ft) with a volume of about 56,700 cu km (13,600 cu mi).

The Santa Barbara Channel province trends east-west. Compressional forces have formed several lines of sharp folds along the northern edge of the basin.

Many large faults on the north and south borders show left-lateral movement. Rocks from Cretaceous to Pleistocene aggregate up to 20,000 m (65,600 ft) in thickness. Basement is estimated at 12,000 m (39,360 ft) at the eastern end rising toward the sea floor at the western end. The basin has an area of 5,200 sq km (2,000 sq mi) and a volume of 41,700 cu km (10,000 cu mi).

The northern province has 6 basins covering 31,000 sq km (12,000 sq mi) with a volume of 67,600 cu km (16,200 cu mi). Structural trends are northwest and compression forces are indicated by marginal thrust faulting and folding. Erosional remnants of Upper Cretaceous and lower Cenozoic rocks are common but prospective sediments are of Miocene and Pliocene age. Five of the basins are 3,000 m (10,000 ft) deep or less. The Eel River basin may be as deep as 4,500 m (14,750 ft).

Future potential reserves are estimated as 23.3 billion bbl of oil and 16,200 billion cu ft of gas.

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MINERAL RESOURCES OF ECUADOR—DEVELOPMENT AND PROSPECTS

Mineral deposits in Ecuador are many but only one metalliferous mine, the Portovelo gold mine, now is operating. It was worked in colonial times but on a systematic basis only since 1904. Gold was the principal product together with silver, copper, lead, and zinc. At present, copper is more important but the ore reserves are virtually exhausted. The Macuchi mine was worked for copper, gold, and silver in the 1940s and prospects containing various combinations of copper, silver, lead, and zinc were discovered at La Plata, Sigchos, Molleturo, and Pilshum.

In 1965 the United Nations in cooperation with the newly established Servicio Nacional de Geologia y Minería began a seven-year mineral resources survey. The principal discovery was the Chaucha porphyry copper-molybdenum deposit where 55 million tons of 0.7-percent copper were proved. Other porphyry copper-molybdenum deposits were discovered at Los Linderos, Rio Playas, and Fierro Urco. At Fierro Urco 50 million tons of ore with low-gold values was indicated. Vein-type mineralization at Angas (copper, lead, zinc, silver, and gold), San Bartolome (silver and lead), and Uritohuaser (zinc, lead, and silver) also were discovered. Anomalies in tin and tungsten minerals were found near Saraguro.

Most surveys have been in the southern Andes where exposed Tertiary and older rocks are intruded by granitic bodies. The flanks of the Andes have not been explored thoroughly because of difficult access and dense forest. Much of the north-central Andes has a cover of Quaternary volcanic rocks mantling the older rocks, but until there are methods to probe through this thick mantle for possible mineralization the potential is unknown. The prospects however must be good because the Ecuadorian Sierra is part of the great mineralized mountain belt extending through the western Americas.

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STRUCTURAL EVOLUTION OF TERTIARY BASINS OF SOUTHEAST ASIA