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 Mineria 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

Tertiary to recent basins of four main types underlie 75% of Southeast Asia's 10 million sq km. Structural style is related to: (1) basement composition; (2) petrotectonic assemblages involved; (3) relative balance between extensional, compressional, and transcurrent forces; (4) availability of preexisting fabric; (5) susceptibility to impact of changes in plate motions; and (6) sedimentary diapirism developed in overpressured clastic wedges.

Shelfal basins have continental crust on all flanks. Examples are north, central, and south Burma, central and south Sumatra, Gulf of Thailand, Sunda, west and east Java, Billiton, and Barito. Plate-margin activity is not obviously reflected in shelfal basins but may exert fundamental influence. Shelfal basins develop basement-controlled tectonic patterns except where sedimentary diapirism overprints flowage structures at shallow levels in deep-basin areas.

Continental-margin basins have continental crust on one flank and oceanic on the other. Examples include the Gulf of Martaban, Sunda outer-arc basins, Mekong, Brunei, and East Kalimantan basins. These basins mirror principal movement changes in adjacent plates, enabling fairly satisfactory tying of internal unconformities to changes in spreading direction and rate. The 10-m.y. and 26-m.y. events are particularly widespread. Outer-arc basins (continental-margin basins associated with island arcs) filled mainly by volcanosedimentary input from andesitic inner volcanic arcs and also by subduction accretion from buoyant inner trench wall wedges with fan-shaped internal structure. Structural style results from interplay of compressional and transcurrent movements.

Archipelagic island-arc basins are intraoceanic arc-basin complexes. Philippine examples include the Cagayan Valley, the Central Luzon trough, Agusan-Davao, and Cotabato. They form between intricate subparallel arc-trench systems with strong vertical mobility and relatively stable map-view configuration. Structural style is exceedingly complex.

Small ocean basins form by interarc spreading or by trapping of older oceanic crust behind newly risen intraoceanic island arcs. Examples include the Andaman Sea, South China Sea, Southeast Sulu Sea, Celebes Sea, and Banda Sea.

Transitional types of basins are known and some basins change category during evolution.

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MINERAL RESOURCES OF PACIFIC OCEAN SHELF AND DEEP OCEAN BASINS OFF BRITISH COLUMBIA

No abstract available.

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CHARACTERISTICS OF GEOTHERMAL RESOURCES FROM GEOLOGIC AND GEOCHEMICAL VIEWPOINTS IN JAPAN

The distribution of thermal areas in Japan is geologically divided into the following units: (1) Neogene Tertiary sedimentary basins, (2) Neogene Tertiary plutonic rock areas, (3) Neogene Tertiary green-tuff areas, (4) Pliocene-Quaternary sedimentary basins, and (5) Quaternary volcanic areas.

Among these, the Pliocene-Quaternary sedimentary basins are areas of normal terrestrial heat flow. The Tertiary plutonic rock areas have locally abnormal heat flow, but heat flow from the Tertiary sedimentary basins and green-tuff areas is in general higher than that of normal heat-flow areas.

There are about 100 geothermal areas with water temperatures higher than 80°C in the mentioned areas and most of these are distributed in the Quaternary volcanic areas. Some hot springs issuing from the active volcanic areas are characterized by a low pH because of contained hydrochloric acid. These can be called typical volcanic hot springs.

To promote geothermal development, the Geological Survey of Japan is carrying on geothermal investigations in 30 promising areas. These investigations commenced last year and will be continued for a period of three years. Exploratory wells will be drilled in the areas selected by detailed surveys. These wells will be financed by governmental special funds commencing this year. The present investigations are being made to find new geothermal areas consisting of hot-water and/or dry-steam systems. However, if a study on the extraction of heat from hot dry rocks is commenced in the near future, the Quaternary dacite areas as well as the active volcanic areas will be selected as promising.

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RELATION BETWEEN TECTONICS AND METALLOGENESIS IN PERIPHERAL SEA-ISLAND-ARC COMPLEX OF JAPAN AND VICINITY

Several attempts have been made to discover the genetic relation between the tectonic development and metal concentration in this area. A brief synthesis of the relations in the following four geologic periods and their respective major ore deposits in Japan and vicinity indicates: (1) Quaternary-recent, sulfur deposits; (2) Miocene, "Kuroko" deposits; (3) end of Mesozoic, Mo-W and base-metal deposits; and (4) end of Paleozoic, standard massive sulfide deposits. The distribution of these mineral deposits is related to the tectonic development of the area.

Although more revisions and refinements are needed, the following conclusions may be of practical use.

1. The theory of plate consumption at the subduction zone is compatible with the distribution of mineral deposits in general.

2. Large scale distribution patterns of certain mineral deposits are influenced closely by the tectonic development of large geologic units, such as island arcs.

3. Localization of richly mineralized areas is controlled by the deep structural features of the subducting plate and magmatic activities most probably initiated at or above the upper friction surface of these plates.

4. The hypothesis of the oceanward migration of arcs leaving peripheral seas behind near Japan is compatible with the ore distribution. A prevailing tension environment in the rear, and the resulting tension breaks or basins, could produce favorable locations for metal concentration.

5. Amount of erosion after the final emplacement of the ore deposits is another controlling factor of ore distribution at the presently feasible depth.