ground heat exchange device must be selected. These include the horizontal coil, the vertical heat exchanger, the buried water tank, and the buried flat plate. Third, the heat-exchange device must be sized relative to the heat pump, the load, and the solar components, if any. The ways in which these decisions have been approached in a variety of countries and climates have been analyzed as a base for assessing the outlook for ground-coupling applications in terms of economic, energy supply, and technology development scenarios which could work for or against ground coupling. These include availability and cost of the various forms of energy, in particular gas versus coal; availability of capital and interest rates; utility load profiles; and technical developments in air-to-air heat pumps, gas furnaces, and gas-fired heat pumps. The paper concludes with a discussion of research and development needs for ground coupling.

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Overview of International Solar Central Receiver Projects

(No abstract)

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Supply of Australian Export Coal—How Much at How Much?

In 1980-81, Australia exported 47.4 million tonnes of coal, split equally between New South Wales and Queensland. Forecasts by the Joint Coal Board for Australian exports in 1990 are in the range 115 to 180 million tonnes, increasing by 2,000 to 180 to 290 million tonnes; 55 to 60% is to come from New South Wales. The World Coal Study forecasts are at the lower end of the range. Will the supply factors allow these forecasts to be achieved?

Australia's measured and indicated recoverable reserves are sufficient to sustain the year 2000 (total) production level for about 70 years. The desire of companies to produce coal is also sufficient to achieve these forecasts. Committed and proposed projects could result in an export productive capacity, by 1990, of 110 million tonnes in Queensland and 80 million in New South Wales. However, port capacity will probably constrain exports to a maximum of 65 million tonnes for each state.

A more severe constraint upon exports will be the cost of the coal FOB port. Although the Australian coal industry has the world's highest output per manshift, wage scales are also very high. More critically, royalties and other government charges, particularly excess rail freight charges, are so high that many prospective mines will probably not be economic.

This prediction is expounded using supply curves for the existing and near term New South Wales and Queensland producers.

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Results of Exploration in Browse Basin, Northwest Shelf, Western Australia

The Browse basin lies entirely offshore beneath the remote northwestern continental shelf of Australia. It occupies an area of approximately 39,000 mi^2 (100,000 km^2), most of which lies in water depths exceeding 650 ft (200 m). The basin originated during the Paleozoic as a broad, intracratonic downwarp, which was considerably modified by tectonism association with continental break up during the Jurassic. After passing through restricted rift-basin and rim-basin phases during Early-Middle Jurassic and Late Jurassic-Early Cretaceous times the basin was opened to oceanic circulation in the Late Cretaceous, when its western margin subsided. Prograding Tertiary shelf carbonates subsequently covered the old basin and formed the present continental shelf.

Exploration of the basin and environs began in 1964 when license areas totaling some 63,000 mi^2 (164,000 km^2) were awarded to the "Northwest Shelf Joint Venture," a consortium of companies presently comprising the Woodside Group, together with Hematite Petroleum, Shell Development Australia, California Asiatic and BP Petroleum Development Australia. During the 11-year period to 1975, some 13,700 mi (22,000 km) of seismic were shot and 11 exploration wells drilled, resulting in the discovery of gas at Scott reef. At the end of the initial permit period some 62% of the total area was relinquished. The remaining permit areas, totaling 24,162 mi^2 (62,579 km^2) were renewed for the first renewal period of 5 years. During this renewal period a further 4,100 mi (6,700 km) of seismic were acquired and 8 wells drilled, resulting in 2 additional gas discoveries (Brecknock and Brewster) and one encouraging oil show (Caswell). In 1980, following statutory relinquishment, remaining permit areas, totaling 10,842 mi^2 (28,083 km^2), were renewed for a further 5-year period.

Initial obstacles to explorlation were water depth and the considerable thickness of multiple-generating Tertiary carbonates covering much of the basin. These have been largely overcome by advances in drilling technology and seismic data processing. Lost circulation zones and geopressured claystone intervals continue to cause problems with drilling.

Geochemical and maturation studies indicate that mature source rocks are present in the central basin, parts of which have been generative since the Late Cretaceous. Structural analysis suggests that the timing of trap formation is favorable with respect to likely hydrocarbon migration throughout much of the central basin, but is less favorable in the north, where a very late phase of structural growth is evident.

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Role of U.S. Geological Survey in Assessment of Conventional Energy Resources in Countries Other than USA

The U.S. Geological Survey has had a program of energy-resource studies in cooperation with counterpart agencies of other countries for many years. The products of the earlier cooperative activities were mainly reports of geologic research conducted to aid exploration and development of energy resources in specific areas such as coalfields or potentially petroliferous basins. In contrast, many of the more recent studies have been wide-ranging evaluations of conventional energy source materials and conditions in the developing countries. These recent studies are largely based on existing information, and attempt to assess the quantity and quality of known energy resources, to evaluate the potential for development of both known and hypothetical resources, and to act as guides for future research and development activities. The studies are made in collaboration with the appropriate agency of the foreign government and are funded by the U.S. Agency for International Development, the U.S. Department of Energy, or, in some cases, by the participating country itself.

The reports that have been produced range from administrative project reports of varying format to U.S. Geological Survey Professional Papers. Comprehensive reports

have been published on recent energy studies in Peru, Egypt, and Portugal; and similar reports will be available in the near future for Argentina and South Korea. Other countries for which preliminary reports have been prepared recently include: Pakistan, Indonesia, Bangladesh, Turkey, Costa Rica, Morocco, Mexico, Trinidad, Venezuela, USSR, the members of ECOWAS (Economic Community of West African States), and nations in the Persian Gulf area.

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Undrilled Reserves in Cook Inlet Oil Fields, Alaska

The Middle Ground Shoal and Granite Point fields in the Upper Cook Inlet, Alaska, are major oil fields discovered seismically 20 years ago. Development drilling was based on a structural model of an anticlinal ridge bounded by large thrust faults intersecting at depth in a cross sectional "V" configuration. The oil-bearing zones of the Middle Ground Shoal field were originally believed to be confined to a relatively small anticlinal area near the bottom of the fault-bounded "V." Wells were deviated from offshore platforms, and in places where a well was deviated from one flank to the other, the borehole was intially normal to bedding until the axial plane of the fold was crossed and the other limb encountered. From that point, the borehole continued down the limb parallel to the bedding, and was interpreted as having intersected the fault plane.

Additional well data and a review of older well logs indicated that the faults might not exist. If this were the case, the flanks of the structure were not being drained. A similar interpretation was shown to be applicable to the Granite Point field by a well drilled to test this same hypothesis. The well was directionally drilled in the shape of an open hook, deviating 4,000 ft (1,220 m) to the west, then curving back to the east so that the west flank would be encountered normal to the bedding. The well intersected the west dipping flank, which was not faulted, and was completed for 400 bbl of oil per day. A second well is now being drilled.

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Solar Enhanced Oil Recovery Project Using Heliostats

(No abstract)

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Tectonic Evolution of Pacific Ocean

In accordance with the lithosphere plate theory, the western part of the Pacific Ocean was occupied by an oceanic basin prior to the disintegration of Pangea. Linear magnetic anomalies and DSDP data indicate that the oldest oceanic crust is Late Jurassic in age. Little is known about the boundaries of the proto-Pacific plate and its fragments in the western part of the Pacific Ocean, but it is obvious that the oceanic crust fragments of this age occur along the western rim of the basin from the Koryak Mountains in Asia to eastern Australia as well as in various foldbelts on the east in Alaska and the Klamath Mountains. The most intensive tectonic movements and spreading within the Pacific Ocean, accompanied by subduction along both sides of the oceanic plate, occurred near the end of the Jurassic (Kimmeridgian-Tithonian) and during Early Cretaceous time (Aptian-Albian). A result was the formation of the Kula plate with tectonic nappes which stand as such submarine dome rises as the Shatsky Rise, Manihiki Plateau, Hess Rise, and Campbell Plateau, characterized by double thicknesses of oceanic crust. By comparing differences in Albian-Aptian facies, between the east Pacific Ocean and the west, it is possible to assume that shallow-water depths characterized the east, while the west was the site of a deep-water abyssal plain. Albian subsidence, in the eastern part of the ocean, coincided with tectonic uplift in the west and with the initiation of subduction along the East Asian volcanic belt.

Island arcs and trenches, formed at the end of the Cretaceous, caused oceanward migration of the subduction zones. This detached the Bering Sea and Philippine plates from the margin of the oceanic plate. Tertiary spreading along the East Pacific Rise was compensated by subduction under South America and within the deep-water trenches. Spreading in marginal seas during Oligocene-Miocene time resulted in the formation of back-arc basins, compression within the framework of island arcs and thrusting of the arcs onto the oceanic crust. Convergence of arcs may be explained by rapid oceanward displacement within marginal seas, and local movement along transform faults significantly affected the evolution of the Pacific Ocean and the distribution of mineral deposits within the oceanic basins and on the continental shelf.

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Thailand Gas Project—A Cooperative Effort of World Bank, Government of Thailand, and Private Enterprise

After Union Oil's discovery of large offshore reserves of gas in the early 1970s, Thailand was presented with an opportunity to reduce its almost complete dependence on oil imports for its commercial energy supplies. This, however, required considerable changes in the structure of its energy supply and the creation of a new industry in which Thailand had no previous experience. Faced with this challenge, the government of Thailand investigated several possible alternative scenarios, and associated the World Bank, which had a long experience in the power sector, the major potential gas consumer. This cooperation, involving the public sector, the international oil industry, and the international financial community resulted in one of the first successful developments of natural gas by an international oil company for the purpose of meeting the domestic demand of a developing country. The paper presents the various issues that had to be faced during the preparation and implementation of this project and elaborates on its possible value for other countries.

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On a Mechanism for Seam Splitting and Implications for Exploration, Evaluation, and Exploitation of Coal Resources

Exploitation of coal resources to meet both economic and community (environmental) expectations is commensurate with the scale of exploration, the comprehensiveness of data evaluation, and the "wisdom" shown in mine design. As accepted criteria, all three requirements rely on appropriate knowledge of the geology of the orebody and its associated sediments.