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prior to others. The temperatures of wells at depths of 1 km show a pattern with the reservoir boundary on density measurements.

enhanced permeability has proved a problem. Measurements of resistivity vs depth show a good correlation in one area. Attempts are underway to deep fissured zones at about 2-km-thick basement. Sites for wells at the hottest parts of the field which are closest to the upwelling source of the

vents have satisfactorily indicated a weak basement rocks (1 to 2 km) areas of enhanced density interpreted as long-term discharge paths. Reduced polarization effects in several suggest that abundant mineral deposits exist at these sites.

2. Chevron Oil Field Research Co.

LANDSAT Imagery in Circum-Pacific

coverage provided by LANDSAT is a reconnaissance studies of the vast Circum-Pacific area. Much of the area has been explored for extended periods, but the repeat coverage of LANDSAT enables images to be obtained during quiet periods. Some applications of the Circum-Pacific region are: (1) correlations between plate boundaries and tectonic features, (2) improvement of bathymetric monitoring volcanic activity, (3) monitoring volcanic activity, (4) areas associated with the margins of the Pacific are of three main configurations: (a) which California is an example as illustrated by the Andes; and (b) marginal seas in Indonesia. The major tectonic boundary configuration of the Circum-Pacific region is shown in LANDSAT images, which also show hydrocarbon accumulations. The marginal seas of the area have attractive potential and are being actively explored. Surveys may be hampered by shallow waters that either are not charted or are uncharted. The geometric accuracy of the images and the ability to penetrate shallow waters are important for recognizing and mapping hazards, such as reefs and shoals in the Celebes Sea.

The area is surrounded by a belt of islands studded with "hot spots" such as the Hawaiian Islands. These hot spots are readily recognized in LANDSAT images. The plumes of smoke from volcanoes have been detected on images. Landsat has acquired images in the visible and infrared bands of the electromagnetic spectrum. Landsat 3, which was launched in March 1978, has the additional capability to acquire images in the infrared spectral band. Active volcanic

processes may be monitored on calibrated thermal infrared images as illustrated with aircraft examples of Mauna Loa and Kilauea.

ALDIVAR-SALI, ARTHUR, Bur. Energy Development, Manila, Philippines

Geothermal Energy Exploration in Philippines

Until recently the Philippines was the missing link in the southeast Asian chain of oil-producing countries. In March 1976, the Philippine Petroleum Board (now the Department of Energy) announced that significant amounts of oil flowed from the Nido 1 well of Philippines-Cities Service, Inc., and Husky Oil (Philippines) Inc., in their production-sharing contract area in offshore northwest Palawan. In 1977, two more discovery wells were drilled by Amoco Philippines Petroleum Co. and Philippines-Cities Service, Inc.

The flow rates measured during the testing of these wells range from 1,400 to 7,250 bbl/day and well logs measured reservoir porosities up to 37% with extensive secondary porosity in the form of fractures and vugs. Vertical closures of the reef traps are from 600 to more than 1,000 ft (180 to 300 m) in reefal buildups in excess of 2,000 ft (600 m).

Prior to these finds many explorationists had "written off" the Philippines as a potential oil producer, because of the 300 wells drilled in almost 80 years of exploration were either dry or noncommercial. With the discovery of the oil-bearing reefs, it is apparent that the exploration approach, not the geologic potential, was wanting. Oil exploration in the Philippines thus has been given a definite direction. Consequently, other Philippine sedimentary basins now are being reevaluated. Ongoing geologic and geophysical work shows that the source, reservoir, and porous reservoir-rock conditions present in the reef complex also may be repeated in other basins.

ALDIVAR-SALI, ARTHUR, and E. V. OLYMPIA, Energy Development, Manila, Philippines

Geothermal Energy Exploration and Development in Philippines

In 1976 the Philippines will join the other countries of the Circum-Pacific belt in the use of geothermal energy for power generation. The Tiwi geothermal field, operated by Philippine Geothermal, Inc. (PGI), is expected to generate its first 110 Mw of power by mid-year and Makiling-Banahaw in Laguna is operating its first 55-Mw power plant before the end of the year. In July 1977, a 3-Mw noncondensing plant was installed in Tongonan, Leyte, and another plant is being installed in Ormoc City. Large-scale development of 55-Mw capacity will be started in various areas in various stages of development are being developed in Dauin in Negros Oriental and Manat-Masape in Negros Occidental and Albay.

The Philippine archipelago lies on a high-heat-flow area of past and recent volcanism, a geologic setting that has given the country its present geothermal resources. Reservoir rocks are generally

lava flows of andesitic to dacitic composition associated with pyroclastic rocks. Possible heat sources are Quaternary dormant volcanoes. Secondary porosity in the form of fractures caused by volcano-tectonic systems seems to be the dominant control of the hydrologic system. Geochemical analyses and well data show a hot-water dominated system in every area being explored and developed. Flow tests gave well capacities as high as 18 Mw, and an average of 6 Mw per well.

A nationwide inventory of geothermal resources is being conducted to define more priority areas for further exploration and development. From this bold program, a total of 1,595 Mw of power is expected to be generated by geothermal energy in the year 1987.

SALVESON, J. O., Chevron Resources Co., San Francisco, Calif.

Future Potential for Development of Geothermal Energy in Contiguous United States

Geothermal energy, long known for the tourist attractions it provided at Yellowstone National Park, now is being used for generating commercial amounts of electricity, for space heating, and as an aid to agriculture. Potential for development exists in many parts of the country in the form of geologic reservoirs of steam, hot water, warm water, and hot dry rock.

Areas with the most obvious potential are related to hot springs, active faulting, active seismicity, and recent volcanism. Heat-flow and subsurface-temperature data are particularly useful in localizing areas of geothermal activity. Plate-tectonic setting and physiography, together with those data, provide the basis for dividing the United States into a series of geothermal provinces. To date, the western provinces have shown the greatest potential. The Geysers steam field has a generating capacity of 522 Mw with an estimated eventual capacity around 2,000 Mw. Five hot water fields are indicated in the Imperial Valley with a total estimated potential of 5,000 Mw. At least three hot water fields are indicated in widely separated parts of the Great Basin and one has been found in the Rio Grande rift.

Research projects sponsored by the U.S. Department of Energy (DOE) are in progress to determine the feasibility of producing electricity from moderate temperature waters at Raft River, Idaho, and from hot dry rock at Fenton Hill, New Mexico. In the Gulf of Mexico province, the U.S. Department of Energy (DOE) has sponsored the testing of a well in Louisiana and will drill a 16,500-ft (4,950 m) test in Brazoria County, Texas, this year to evaluate geopressed reservoir potential.

Warm water has been used for space heating in Klamath Falls, Oregon, and Boise, Idaho, for some time, and many other direct-utilization projects are planned or in progress for use in space heating and agriculture. The search for warm water has been extended to the southeast Atlantic coastal plain where DOE plans a series of shallow holes to provide temperature data for determining the location for one or more deep tests.

Geothermal potential exists in broad areas of the western United States, where it appears capable of competing economically with other energy forms. Else-

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