logical Survey of Indonesia (GSI) throughout the entire Indonesian territory. At the end of 1973 55% of the area has been explored in a preliminary way; the work covered mainly the vast volcanic region.

Data on geothermal indications or visible surface phenomena, such as hot springs, hot water, hot mud pools, solfataras, and fumaroles, are indicated on topographic maps, and data on temperature, pH, estimated discharge, and chemical analyses are included.

From these data, the potential energy has been calculated. The local geologic features should be studied in more detail to enable us to interpret the existence of geothermal potential and to guide future exploration. This will be carried out during the Second Five-Year Development Program in the framework of the national demand for electric power outside the "conventional electrically supplied" areas.

Results of prefeasibility studies on geothermal resources in Indonesia were evaluated and two localities in volcanic areas, the Dieng Highlands and Kawah Kamojang, were recommended for further exploration. Exploration drilling has been started in Dieng, but unfortunately it was stopped because of technical difficulties before any results were obtained. Exploration drilling in Kawah Kamojang is scheduled for February 1974.

HAYAKAWA, M., Tokai University, Japan, and K. BABA, Geological Survey of Japan

GEOTHERMAL RESOURCES AND ENERGY IN JAPAN ESTIMATED FROM GEOPHYSICAL DATA

At present, we are using heat in the form of volcanic steam from dormant volcanoes in Japan for electric power generation.

However, in due time it will be possible to make use of the heat, itself, from present volcanoes. For this, necessary techniques must be developed. Heat from the Cenozoic granitic rocks also may be utilized.

At the beginning of the Miocene, Japan seems to have entered into a new geologic evolution. Depression, violent volcanism, and some igneous intrusion took place rather abruptly on the land, and the Miocene sea began to transgress and finally covered almost all of Japan. The deep depression of Fossa Magna formed and separated northeast Japan from southwest Japan. In the Pleistocene, the sea largely regressed, but volcanism continued until the present, and has constructed many volcanic cones and lava plateaus.

The writers are calculating the heat generated by each stage of the igneous activity. Ages and heat of subterranean heat sources can be learned from analysis of heat-flow-profile data utilizing the method of differences of running-mean-values, which acts as a kind of filter for different wavelengths. The long wavelength corresponds to a large-scale source of heat, probably started during very ancient time, whereas the middle wavelength corresponds to a middle-scale source, probably started later than the first one, and very short wavelength expresses the heat flow caused by a smaller, very young heat source.

The method has been applied in a preliminary manner to the present study, and some significant correlation with past igneous activity can be demonstrated. Finally, the geothermal energy, which will be available now for use in Japan, is being calculated.

HEALY, J., Dept. of Scientific and Industrial Research, Rotorua, New Zealand

p126

GEOTHERMAL STEAM PROSPECTS AROUND PACIFIC

Geothermal energy is normally dissipated at the surface. Hot water and steam extracted from drilled wells so far have constituted the main economic sources of geothermal energy. Geothermal areas have been developed or explored in several countries around the Pacific margin.

The geothermal areas are commonly in regions of Quaternary volcanism, though hydrogen and oxygen isotopic studies of the waters fail to reveal the presence of magmatic water. The waters are of meteoric origin. Geothermal systems are of two main types—hot-water systems and vapor systems. Hot-water systems are numerically dominant and are typically located in discharge areas at low levels. Evidence suggests that their locations are affected by, or related to, regional groundwater flow in which there may be a strong horizontal component. Temperature controls include rainfall, rock permeabilities and local heat flux. Vapor systems are usually in elevated recharge areas where groundwater movement normally would be downward and outward; temperatures and pressures are controlled by the thermodynamic properties.

The fluids in hot-water systems are mineralized to varied extents. The energy available from hot-water systems is limited by the amount of steam that can be extracted, and disposal of the remaining effluent can constitute a pollution problem. A vapor system yields relatively more energy and no pollution problem.

In the Pacific region a close relation exists among the distribution of thermal springs, known geothermal fields, and Quaternary volcanism. No specific relation exists between hydrothermal areas and active volcanoes. Rather, all tend to be located above subduction zones or on spreading ridges. This suggests the presence of a large common heat source.

The known geothermal potential in the region is limited, but the ultimate potential is unknown. Future expansion may be in two main directions. The first involves testing the ultimate production capacity of selected known fields, seeking additional zones where no superficial indications exist, and investigating regional hydrology in selected geothermal areas. Geologic, geophysical, and geochemical explorations are required in combination with exploratory drilling. The second promising direction is toward the use of low-boiling-point fluids in equipment and methods for increasing permeability of the rocks.

HEALY, J., and R. JAMES, Dept. of Scientific and Industrial Research, Rotorua, New Zealand

REVIEW OF GEOTHERMAL ENERGY IN NEW ZEALAND

Generation of electric power in New Zealand from geothermal steam at the present time amounts to 148 MW at the Electricity Department's station at Wairakei, and $\leq$10 MW at the Tasman Pulp and Paper Company's mill at Kawerau. Exploration commenced in 1950, and in association with geologic, geophysical, and geochemical surveys, wells were drilled at Waiotapu,