environment offer optimum conditions for photosynthesis and bacterial action, small scale biomass systems should provide adequate renewable food, feed, fuel, fertilizer, and various raw materials for appropriate industries, not only to meet local needs, but also for export in order to buy machinery and equipment for meaningful social and economic development. The technology for such systems already exists, and can easily be transferred to all these islands and rural areas to solve many existing problems of malnutrition, sanitation, pollution, energy, and unemployment, in an inexpensive and self-reliant manner. But more important still, the political and cultural attitudes of the local leaders, the extent of government support for training and extension programs, and the needs of the people to conserve energy and other resources, can contribute considerably to the success of such alternative development.

CHANG, STANLEY S. L., and H. S. LIU,* Chinese Petroleum Corp., Taipei, Taiwan, Republic of China

Geochemistry of Geothermal Field in Eastern Taiwan, R.O.C.

The eight main hot-spring areas of eastern Taiwan, distributed in a belt 185 mi (300 km) long and 25 mi (40 km) wide, can be classified, according to their geologic and chemical characteristics, into three groups: (1) the Eocene slate, phyllite, and quartzite group, (2) the Miocene sedimentary rocks of the Coastal Range group, and (3) the Miocene argillite, slate, and phyllite group. Most of the springs belong to (3).

The laboratory analyses of the hot water and rock samples from the eight springs, performed for this paper, accompanied by earlier chemistry and temperature reports on water from these springs, reveal that little deviations in their characteristics exist for each spring, although the water temperatures have fluctuated.

The SiO_2 concentration geothermometer of the mixing model (Fournier and Truesdell in 1977) and a modified mixing model, accomplished for this paper, are presumably the best available to estimate the geothermal reservoir temperature. Their application, however, cannot be valid in the greenschist region. This fact should not deteriorate the accentuated exploration of the geothermal energy in eastern Taiwan. Meanwhile, the establishment of an alternative geothermometer for the greenschist region is desired.

CHEN, CHAO-HSIA, Central Geol. Survey, MOEA, Taipei, Taiwan, Republic of China

A Simple Geological Model for Geothermal Systems in Central Range of Taiwan

There are about 97 hot-spring areas in Taiwan, 70 of which are located in the Central Range metamorphic terrane. Among these 70 spring areas, 13 have maximum spring temperatures $\geq 85°C$ $\leq 99°C$; the rest have $\geq 36°C$ $\leq 79°C$. The five explored thermal areas in this region indicate maximum subsurface temperatures from 173° to 226°C. The Central Range is approximately 185 mi (300 km) long and 25 to 45 mi (40 to 70 km) wide, comprising more than 100 mountain peaks that are 9,840 to 13,100 ft (3,000 to 3,995 m) above sea level. Topographic relief is high, ranging from 1,640 to 4,900 ft (500 to 1,500 m) (ΔH, elevation difference between a mountain peak and the spring) in 1.25 mi (2 km) (D, horizontal distance between the mountain peak and the spring) to 8,200 to 9,840 ft (2,500 to 3,000 m) in 6.2 to 8.7 mi (10 to 14 km). High topographic relief facilitates deep circulation of meteoric water and upwelling of thermal water from depth, so that thermal springs mostly occur in deep valleys and production wells are all artesian. Analysis of the topographic effect on hydrothermal systems reveals that ΔH's of 2,300 to 7,200 ft (700 to 2,200 m) and D's of 1.25 to 6.2 mi (2 to 10 km) favor occurrence of high temperature thermal areas (max. spr. temp. $\geq 35°C$ or T_{SiO_2} $\geq 140°C$), whereas ΔH's of 2,300 to 5,900 ft (700 to 1,800 m) and D's of 1.25 to 4.4 mi (2 to 7 km) can only form low temperature thermal areas (max. spr. temp. $< 60°C$ or T_{SiO_2} $< 110°C$). A simple model for the hydrothermal system in the Central Range is based on these data.

CHEN, JU-CHIN, and FEI-JAN LIN, Inst. Oceanography, National Taiwan Univ., Taipei, Taiwan, Republic of China

Heavy Mineral and Manganese Nodule Distribution in Areas Adjacent to Taiwan

The heavy minerals in the sandy shelf sediments around Taiwan consist mainly of magnetite, ilmenite, amphiboles, pyroxenes, olivine, epidote, garnet, zircon, tourmaline, and monazite. The highest concentration of heavy minerals occurs on the eastern Taiwan shelf where average heavy mineral content is about 8%. This abundance of heavy minerals is closely related to the weathering of pyroxene andesite from the Coastal Range. Amphiboles dominate in the heavy minerals from the shelf of northern Taiwan while zircon and monazite are relatively abundant along the southwestern coast.

The manganese nodules dredged by R/V *Chiu-Lien* from the Philippine Sea consist essentially of akaganeite (β-FeOOH), birnessite, and todorokite, while the nuclei of the nodules contain phillipsite, illite, and feldspar. The average compositions of 18 nodules analyzed are Fe 14.10%, Mn 12.94%, Ca 0.26%, Mg 0.80%, Na 1.53%, K 0.62%, Co 2,588 ppm, Cr 30 ppm, Cu 1,257 ppm, Li 14 ppm, Ni 2,733 ppm, Pb 1,033 ppm, Sr 80 ppm, and Zn 518 ppm. The (Ni + Cu) contents tend to increase with increasing Mn/Fe ratios which vary from 0.6 to 1.1 averaging around 0.9. According to the criteria given by Toth, the Philippine Sea nodules are not related to hydrothermal activity. These nodules may have originated by catalytic oxidation and absorption of Mn, Fe, and other transition elements upon suitable submarine surfaces.

CHIANG, KAM, and CASWELL SILVER, Sundance Oil Co., Denver, Colorado

Hoadley—A Potential Supergiant Gas Field in South-Central Alberta, Canada

The Hoadley gas field is a potential supergiant gas condensate accumulation, discovered in November 1977 by Sundance Oil. The discovery well, Sundance et al Hoadley 6-2, has an AOF of 26 mmcf of gas per day with 60 bbl of natural gas liquids per mcf of gas. The field covers approximately 1,500 mi^2 (3,885 km^2) in south-central Alberta. The producing zone is in the Lower Cretaceous Glauconitic formation consisting of 25 to 80 ft (7.6 to 14.4 m) of sandstone pay. The sand was deposited as a gigantic marine barrier bar with an approximate width of 15 mi (24 km) and a length of more than 130 mi (209 km), trending southwest-northeast across south-central Alberta. The central and southwestern part of the barrier bar (approximately 100 mi [161 km] long) is entirely saturated with gas and natural gas liquids. Of more than 100 Glauconitic gas wells completed within this section of the barrier bar since discovery, none has tested or produced salt water. The field is estimated to contain a potential recoverable reserve of 6 to 7 tcf of gas, and a potential recoverable reserve of 350 to 400 million bbl of natural gas liquids.