LIAW, ALFRED L., ARCO Oil and Gas Co., Dallas, Texas, and WAYNE SUYENAGA, ARCO Exploration Co., Dallas, Texas

Microtremor Studies in Roosevelt and Beowawe Geothermal Areas

The microtremors generated by pressure variations and microcracking of the hydrothermal system have been considered to be direct indicators of geothermal reservoirs. Despite the number of studies on this subject, it is still controversial. It is clear that a prime hypothesis has yet to be tested: that geothermal reservoirs generate a detectable seismic signal. Two passive seismic studies have been conducted in the Basin and Range province of the western United States, using state-of-the-art seismic data acquisition and processing techniques. The purpose of these studies was to investigate the correlation between microtremor activities and existing geothermal reservoirs.

A 256-element modified eight-arm geophone array was deployed to monitor microtremors at six sites in the vicinity of Roosevelt Hot Springs, Utah. Some 2 Hz coherent microtremors were detected, intermittently, in four recording sites; however, the directions of propagation did not indicate that the existing reservoir system was the common source region.

The microtremor data in Beowawe geothermal area, Nevada, were acquired by a 60-element cross array near the geyser. Low frequency (2 to 3 Hz) microtremors clearly appear on every record. Those microtremor activities are associated with the geothermal system at depth, as indicated by seismic body wave components propagating with extremely high apparent velocities.

LUND, JOHN W., Geo-Heat Center, Oregon Inst. Technology, Klamath Falls, Oregon

Direct Use of Geothermal Energy in Circum-Pacific Region

Geothermal energy is being utilized for direct use projects in several countries in the Circum-Pacific region. New Zealand has numerous projects in space conditioning and industrial processing. Most notable are the space heating in Rotorua, pulp and paper processing at Kawerau, sulfur extraction, alfalfa dehydration, and a planned salt extraction plant. At Tiwi, in the Philippines, experimental work has been carried out on salt production, grain drying, fish canning, and refrigeration. Many diverse uses have been attempted in Japan, including greenhouses, animal husbandry (chickens) fish breeding, carp, eel and alligator raising, space heating, pavement snow melting, and bathing. Presently, two national projects are under investigation at Shizukuishi, Iwate, and Kazuno, Akita. A cascaded use for district heating, greenhouse, snow melting, animal husbandry, and fish breeding is planned with water supplied from the Kakkonda and Onuma power plants. Experimental work is being carried on in Taiwan, especially in lumber and cereal drying. The People's Republic of China has been involved in wool piece goods and carpet manufacturing, using geothermal energy, along with poultry raising. Several district heating projects are planned in Tianjin and Beijing. The USA has planned space heating and greenhouse projects in Alaska, and has district heating projects under construction in Klamath Falls, Oregon, Boise, Idaho, Susanville, California, and Reno, Nevada. Onion dehydration and milk pastuerization are the only industrial processing uses. In Hawaii, near Puna, cane sugar and papaya processing plants, a cattle feed mill and an industrial park are being studied. Central and South America have no direct use projects in operation or under construction, however, a desalination plant is being considered for El Tatio, Chile.

MACFARLANE, A., Vanuatu Geol. Survey, Port Vila, Vanuatu (New Hebrides)

Minerals and Energy Prospects in Small Island Nations of Southwest Pacific: Vanuatu, a Type Example

The land geology of the southwest Pacific is now comparatively well known and areas of mineral and energy potential have been identified. The offshore potential, upon which the smaller island nations will largely depend, has yet to be identified. Regional prospecting programs are at present being carried out under the auspices of CCOP/SOPAC, and have this year culminated in a major resource study funded by the governments of Australia, New Zealand, and the United States. This research is aimed principally at an assessment of the petroleum potential of the region and could have important economic implications for the southwest Pacific.

MALAHOFF, ALEXANDER, National Ocean Survey, National Oceanic and Atmospheric Adm., Rockville, Maryland

Polymetallic Sulfides of Ocean Floor—A New Mineral Resource of the Pacific?

A mineral body estimated to contain several million tons of polymetallic sulfides with up to 10% copper was recently discovered along the Galapagos Rift in a water depth of 8,500 ft (2,600 m). This body is the largest of several mapped along the marginal walls of the axial rift valley of the Galapagos Ridge at 85°50′W, 0°45′N. SASS multibeam data, provided by the U.S. Navy, was used to map the site, together with bottom photography, visual observations and bottom sampling with the submersible *Alvin*. These deposits are the first known massive polymetallic sulfide deposits of the "Cyprus type" found on the ocean floor. The largest polymetallic sulfide field mapped extends for a distance of 3,300 ft (1,000 m) along the base of the northern boundary fault of the rift in the form of a metalliferous ridge, 115 ft (35 m) high and 492 ft (150 m) wide. The ridge consists of massive sulfides deposited within coalesced inactive "smokers" or chimneys, tens of meters high and several meters in diameter, formed during a period of intensive hydrothermal activity, lasting about 100 years. Preliminary chemical analyses suggest the sulfides to be largely Fe, Cu sulfides with considerable metallic components of Ag, Cd, Mn, Pb, Sn, and Zn. Massive deposits of the type mapped along the Galapagos Rift could mark a new source of renewable, commercially valuable metalliferous deposits on the ocean floor. Potential sites in the Pacific for these deposits include the East Pacific Rise, the Gorda and Juan de Fuca Ridges, and the active marginal basins of the western Pacific.

MATHESON, A., J. CLANCY, and D. GRIEVE, British Columbia Ministry of Energy, Mines & Petroleum Resources, Victoria, British Columbia

Growth of Coal Industry in British Columbia

The occurrence of coal in British Columbia was first reported by early explorers in the foothills of the Northern Rocky Mountains in 1801. It was the discovery on Vancouver Island, however, which led to the first exploitation of coal in the province in the middle of the 19th century, continuing

through until 1967 to supply essentially a thermal market. Meanwhile coal had been discovered in the Crowsnest Pass in the Rocky Mountains in 1873, and was first produced at the turn of the century for coking purposes. Coal production has grown in this area to become the sole supplier for today's export markets.

A notable increase has occurred in the production of coal since 1970, from 937,000 to 12,900,000 tons (850,000 to 11,700,000 MT) in 1981. Since the end of the moratorium on the issuance of coal licenses on February 10, 1978, a concentration of effort on exploration and development has taken place mainly in the southeast and northeast of British Columbia. Government policy was revised to meet present-day requirements with the passing of the Coal Act in 1974 and the Coal Act Regulations in 1979.

Based on the signing of contracts at the beginning of this decade, the projected production will increase to a total of about 27,500,000 tons (25,000,000 MT) in 1985 and possibly to 38,600,000 tons (35,000,000 MT) by 1990.

The coal measures are Cretaceous and Tertiary in age, the former is essentially coking whereas the latter is mainly thermal. The new mines will be in the Cretaceous measures in northeast and southeast British Columbia; some 85% of the production will be used for metallurgical purposes and the remaining 15% of oxidized coals will be used for thermal purposes.

MAURIZOT, P., and J. M. EBERLE, Bur. Recherches Geologiques et Minieres, Noumea, New Caledonia

Preliminary Metallogenic Map of New Caledonia—Second Part: Mineral Deposits Nonassociated with Ultrabasic Rocks

In 1979, the Bureau de Recherches Geologiques et Minieres of the New Caledonia Territory launched a 5-year program to inventory mining activities and design strategies for prospecting and exploiting mineral resources. Its aim is to bring about diversification in an industry which is presently based mainly on the extraction of nickel, chromium, and cobalt associated with ultrabasic rocks. The island's most prospective areas have been investigated with the aid of a new 1/200,000 scale geologic map, published by the B.R.G.M. (J. P. Paris, 1981), and the results, combined with studies of about 300 showings, ancient mines, and new discoveries, are presented on a preliminary metallogenic map.

Ore bodies are concentrated in certain provinces or geologic units, or are aligned along major and minor tectonic features. The following are the most significant metallic mineral concentrations: the pre-Senonian mafic plutono-volcanic central units with Cu (Au) deposits, probably of the massive sulfide type; the Diahot Province, to the north with Cu, Pb, Zn (Au, Ag) deposits of volcano-sedimentary type, related to Senonian-Eocene mafic volcanic activity; the West Coast Basalts Province, with Cu (Au) deposits of massive sulfide type, and Mn deposits, related to Senonian-Eocene mafic volcanic activity; the East Coast Basalts Province, identical to the former western province; the mineral deposits related to major faults with Sb, Hb, W, and Cu deposits; the mineral occurrences related to Oligocene-Miocene granodioritic intrusions with Mo, W, Sb (Cu, Au) minor deposits.

MCCOY, FLOYD W., Lamont-Doherty Geol. Observatory of Columbia Univ., Palisades, New York

New Surficial Sediment Maps of Pacific Ocean: Circum-Pacific Map Project (1:10,000,000)

Surface-sediment maps, just completed, are the first depiction of sea-floor sediment distributions on a systematic and uniform scheme for the entire Pacific basin. Ten dominant sediment types are mapped, using a classification based on calcareous-biosiliceous biogenic components and conventional textural categories for nonbiogenic components (gravel/sand/silt/clay); three minor sediment types distinguish volcanic and organic-skeletal gravels/sands/silts. Primary data were from more than 4,000 Pacific Ocean cores in the Lamont-Doherty Geological Observatory collection. Qualitative smear-slid analyses were done on these cores, using petrographic microscopes combined with laboratory determinations of $CaCO_3$ for quantitative control; many additional data were taken from unpublished smear-slide descriptions, the World Data Bank, and published information on sea-floor deposits. The maps depict unconsolidated sediments exposed on the ocean floor, presumably at the sediment-water interface, recovered by coring and do not necessarily represent Holocene material. Additional maps showing details of sediment types and the enormous data base, with an explanation of sea-floor sampling techniques and core samples of all 13 sediment types are also available for viewing.

MEYERHOFF, A. A., Meyerhoff and Cox, Inc., Tulsa, Oklahoma, CHIN CHEN, Western Connecticut State College, Danbury, Connecticut, and J.-O. WILLUMS, Oildeco, Sandvika, Norway

Economic Geology and Mineral Resource Base of People's Republic of China

China's oil production, essentially stabilized at 2.1 million bbl per day, will climb again as offshore Eocene, Oligocene, and Miocene discoveries in the Neocathaysian graben system are developed and produced. Exploration onshore has discovered several new fields in such geographically diverse areas as the Tarim basin (Miocene-Jurassic), the Qaidam basin (Cretaceous–Lower Pliocene), the Junggar basin (Permian-Cretaceous), and the Sichuan basin (Proterozoic-Jurassic). Indigenous, but commercial Proterozoic gas is produced in the Sichuan basin.

Coal production, which reached a high of 700 million tons (635 million MT) in 1979, once again is increasing. Principal deposits are of Permian, Jurassic, and early Tertiary ages. China's coal-resource base is among the three greatest in the world, and China's principal source of energy continues to be coal (67% of China's energy mix).

Shale oil is exploited on a modest scale. Most of the shale oil currently being mined is of early Tertiary age.

China's wealth of non-hydrocarbon minerals is enormous. Huge Mesabi-type and sedimentary iron ores are widespread in the country. Other resources present in great abundance include bauxite, copper minerals, lead-zinc, antimony, chromium, cobalt, manganese, platinum metals, rare earths and rare metals, tin, tungsten, uranium, asbestos, barite, borates, fluorspar, jade, magnesite, pyrite, various kinds of salts, and talc. The country has the potential to produce large amounts of molybdenum, gold, nickel, diamonds, phosphates, and potash. Silver and titanium are in short supply. Although the country is by no means self-sufficient in all minerals, it is more richly endowed than all countries of the world outside of the USSR.

MITCHELL, A. H. G., UNDP, Metro Manila, Philippines, and WERAPON JANTARANIPA, Dept. Mineral Resources, Bangkok, Thailand

Geology of Northern Thailand

Northern Thailand resembles the Great Basin of the western