propriate now to consider its use in mineral prospecting. Its applications can include indirect ore-detection methods such as: tracing intrabasement horizons; qualitative interpretation of zones, using or adapting ideas of seismic stratigraphy; mapping structural features such as faults or folds; interpolating between or extrapolating from existing drill holes.

Direct detection may also be possible by using "bright" or "dim spot" techniques, or because some orebodies have characteristic reflection and diffraction responses.

In contrast with petroleum exploration, where variations in velocity are taken as a guide to reflection response, the evidence indicates that density contrast is more likely to be the governing factor. Thus, for example, increasing substitution of pyrrhotitic ore into a country rock consisting of siltstone does not substantially alter an intrinsic rock velocity of 5.5 km/s. The density, on the other hand, may change from 2.7 to 4.5 t/m^3. This is in agreement with the known relationship between velocity, density and mean atomic weight. Therefore, in metamorphic, igneous or mineral-bearing rocks, where porosity is low and exists mostly as microcracks, it is the variations in density which occur in predominantly monomineralic layers which may contribute to a significant reflection response. The thicknesses of such bands, the relative sizes of the targets and the degree of resolution sought of structural features requires the use of high resolution techniques and the recording of frequencies in excess of 200 Hz.

Modeling of the responses of known orebodies confirms the notion that some may have characteristic seismic response. It is a useful approach which assists in the design of field surveys, particularly when one seeks to avoid spatial aliasing problems in areas of steep dip and structural complexity. Processing techniques suitable for a particular area may also be examined using modeling techniques.

The use of common-depth-point stacking is inappropriate in structurally complex areas. However, as some form of stacking is necessary to yield adequate levels of signal above noise, the application of so-called slant-stacking techniques should be considered. These also alleviate problems associated with offset-dependent waveforms and reflection coefficients. Examples from various areas in Australia illustrate these concepts.

NEWCOMBE, KENNETH, STEPHEN MEYERS, WM. SAM PINTZ, and KIRK R. SMITH, East-West Resource Systems Inst., Honolulu, Hawaii

Energy Requirements of South Pacific and the Role of Renewables

During early 1982, a survey of the energy situation in ten countries of the South Pacific was undertaken to determine future energy policy options.

The ten survey countries fall into two natural size groups with larger countries (Papua New Guinea, Fiji, Solomons, Vanuatu) using 20 to 30% of export revenue to purchase imported oil. Western Samoa, however, showed an exceptionally high jump from 38% in 1979 to 60% in 1980. The smaller nations showed even greater balance of payment vulnerability with the most dramatic examples being Niue (where oil imports cost more than twice total exports) and the Cook Islands (where oil consumed 107% of export revenues). For all island nations, copra and other coconut products represent a substantial export earner which is relatively insensitive to energy costs so the possibility of a flow through of oil price increases to export revenues is considered to be unlikely.

Only in the region's largest countries do indigenous energy resources presently play a significant role with PNG and Samoa generating a significant (but declining) fraction of electricity from hydropower and Fiji utilizing bagasse for thermal generation. Many of the larger countries have hydropower schemes under construction or advanced study but the smaller and flatter nations have little hydro potential. For these nations, biomass potential will also be constrained by the limited land area and by competition with food export crops.

The energy survey concluded that feasible oil substitution strategies for South Pacific Island nations might focus on the generation of electricity and the provision of domestic fuels from biomass although a wide range of other options will play a part. One resource which has substantial potential throughout the Pacific are senisle coconut trees well past their productive economic lifetimes which could be developed through gasification or directly to generate island electricity. Beyond special circumstances favoring ethanol in PNG and Fiji, little potential for liquid fuel production is anticipated for the transportation sector over the next 10 to 15 years for most Pacific countries. Identified, as well, are policy changes leading to more efficient use, more rational mixes of fuel supplies, and increases in security of existing petroleum imports.

NISHIWAKI, CHIKAO, Inst. International Minerals Development, Tokyo, Japan

Tectonic Stress and Metallogenesis—Southwest Pacific Island Arc Region

In 1980, the author expressed a hypothesis that the extensional tectonic stress environment is favorable for volcanogenic massive sulfide mineralization, while the compressional stress environment is conducive to porphyry-type copper concentration. The genetic control of tectonic stress on major porphyry copper mines and prospects, with more than 3×10^5 tons of metallic copper in the Southwest Pacific, has been investigated.

(1) The distribution of these deposits is generally confined to the island arcs formed by collision/accretion tectonics.

(2) Highly compressional tectonic stress environments of collision tectonics, if active at the time of porphyry intrusions and the ore emplacement, seem to be one of the most favorable controlling factors for copper concentration of this type.

(3) Highly compressive tectonic stresses produce higher confining pressures in the porphyry intrusive body than those produced under extensional deviatoric stress conditions. When intrusive stocks solidify by cooling, high confining pressures retard second boiling of the stage of lower temperature and higher crystal ratio. The fluid phase, separated by the second boiling, will be more saline and may have a higher partitioning ratio of chalcophile metals. When inner pressure overcomes the outer strength, brittle failure causes myriads of minute cracks, in the surrounding solid rock, which the metal-laden fluid will permeate. Copper sulfides will be disseminated as a stockwork deposit.

(4) Physico-chemical processes, governed by tectonic dynamics, seem to be very favorable for rich concentration of porphyry-type metal deposits.

Metal concentration of the extensional stress environment, such as they produced by exhalation of hot metallic solutions at ocean rifts, can be compared to that of the compressive type.

NISHIWAKI, CHIKAO, Inst. International Minerals Development, Tokyo, Japan, and TAMOTSU NOZAWA and YOSHIHIKO SHIMAZAKI, Geol. Survey Japan, Tsukuba, Japan

Status of Geologic and Resource Mapping, Northwest Quadrant, Circum-Pacific Map Project

A draft of the Geologic Map was completed in 1978 with the

cooperation of the national geological services of the Northwest Pacific Region. While awaiting publication, new geologic maps for various areas have been published and the draft has been revised accordingly. However, the basic geologic subdivisions of the map are becoming somewhat obsolete and the Panel is exploring ways to cope with the problem.

Drafts of the Tectonic Map have been provided by the countries of the Northwest Region. The Panel is in the process of preparing a unified standard for the region.

A sample of the Mineral Resources Map with a tectonic background was prepared for the southwestern part of the Northwest Region Acquisition of published data on China and the USSR has been completed and the information is ready for plotting.

The plotting of coal occurrences for the Energy Resources Map from data provided from countries of the Northwest Region and from published information is nearing completion. There are some inconsistencies in coal classification among data received from different countries, but it is not practical to aim for complete unity throughout the region. Data on oil and gas have been acquired and can be plotted in accordance with the publication schedule. Regarding geothermal energy, published heat flow data have been plotted on a different projection.

A gravity anomaly map on a different projection has been prepared for areas with published gravity data for inclusion on the Geodynamics Map.

NOKLEBERG, WARREN J., and HENRY C. BERG, U.S. Geol. Survey, Menlo Park, California, IAN M. LANGE, Univ. Montana, Missoula, Montana, DONALD GRYBECK, U.S. Geol. Survey, Reston, Virginia, and DAVID L. JONES, U.S. Geol. Survey, Menlo Park, California

Relation of Metallogenesis to Accreted Tectono-Stratigraphic Terranes in Alaska

Alaska consists of a collage of about 50 fault-bounded tectono-stratigraphic terranes of regional extent, as well as numerous smaller blocks. Each terrane possesses a characteristic stratigraphy and structure that differ markedly from those of neighboring terranes. Their grossly different stratigraphic and structural histories imply juxtaposition by large-scale transport from diverse sites of origin in various parts of the Pacific basin. The resultant mosaic of terranes records a long and complex history of accretion to the continental margin of North America. Parts of the terranes have been substantially modified by post-accretion faulting, intrusion and volcanism, and metamorphism, principally during the Cenozoic. These fundamental differences between terranes imply corresponding differences in metallogenesis, because metallogenesis is directly related to the geologic history of the rocks hosting mineral deposits. Consequently, a metallogenic model can be constructed that predicts: (1) differences in mineral deposits that formed during the origin of various dissimilar terranes; (2) differences in mineral deposits that formed during the transport and accretion of various dissimilar terranes; and (3) similarities in mineral deposits that formed within adjacent terranes after accretion. Three studies illustrate this model relating markedly different syngenetic mineral deposits, in three dissimilar terranes, to the particular origin of each terrane. The three terranes and their syngenetic mineral deposits are: (1) the Mississippian shale, chert, and tuff of the Kagvik terrane of the northwestern Brooks Range, in Arctic Alaska, which hosts extensive stratiform Zn-Pb-Ag-Ba sulfide deposits; (2) the late Paleozoic island-arc volcanic rocks of the Wrangellia terrane, in southern Alaska, which hosts volcanogenic Cu-Ag sulfide deposits; and (3) the Triassic silicic volcanic rocks of the Alexander terrane in southeastern Alaska, which hosts volcanogenic Zn-Pb-Ag-Ba sulfide deposits.

NORMARK, WILLIAM R., U.S. Geol. Survey, Menlo Park, California

Geologic Setting of Polymetallic Sulfide Deposits on East Pacific Rise at 21°N and Juan de Fuca Ridge near 45°N

Massive sulfide deposits of zinc, copper, lead, and silver have been recovered from the East Pacific Rise (EPR) in the mouth of the Gulf of California and from the Juan de Fuca Ridge (JFR) west of Oregon. Both of these oceanic spreading centers have a separation rate of about 2.4 in./year (6 cm/year), and the metal composition of their deposits is nearly identical. In both areas, the bulk of the sulfide deposits occur on, or immediately adjacent to, the morphologic axis of spreading in a sediment-free zone underlain by fresh glassy basalt. The axial zone of the EPR at 21°N is nearly 985 ft (300 m) deeper than that of the JFR. An extensive international program at the EPR has photographed and sampled both hydrothermal fluids and mineral deposits. The existence of active hydrothermal vents at the JFR is inferred from the form and the absence of weathering of samples recovered during a recent U.S. Geological Survey cruise.

The EPR exhibits a moderate degree of morphologic symmetry, and the sulfide deposits are generally situated along a low axial pillow-basalt ridge that is flanked by slightly older crustal zones containing numerous fissures and faults. On the JFR, the massive sulfides occur within a continuous(?) depression along the center of a flat axial-valley floor 0.6 mi (1 km) wide that is underlain by extensive fresh glassy lava sheet flows; overall morphologic symmetry is strikingly developed at the JFR. Although the form and texture of the sulfide deposits are better known from the EPR, it is clear that the deposits and associated faunal communities differ between the two sites. The overall commonality of these deposits and their regional settings suggest that polymetallic sulfide deposits may be fairly common along spreading-center ridges in the East Pacific. To date, sulfide deposits have been discovered at six different widely separated sites.

OKURA, GARY N., Hawaii Electric Co.

Hawaii Deep Water Cable Program—Phase I Study

(No abstract)

OTTE, CAREL, Union Oil Co. California, La Canada, California

Geothermal Development in Pacific Basin—Problems, Issues, and Answers

Geothermal energy for power generation is being actively pursued in many countries of the Pacific basin. The largest producers of geothermal energy are, in order, the United States, Philippines, New Zealand, Japan, and El Salvador. All developments have common technical problems involving scaling, corrosion, well stimulation, excessive drilling costs, and environmental impact.

The countries are handling development in different ways, ranging from total government enterprise to full private enterprise. Some are mixed arrangements with the high risk resource development being handled by private enterprise and power