

fracture zones, a second is in the Central Pacific basin, and a third is in the vicinity of the Musician Seamounts. Correlation of hiatuses in sedimentation during the Neogene, with these areas of high nodule coverage, suggests that a low rate of sediment accumulation is of primary importance. Although the nodule distribution in the other three quadrants of the Pacific is less well documented, that of the central part of the South Pacific may be comparable in extent and consistently high coverage to those areas in the northeast Pacific. Bottom photographic stations, which show a high nodule coverage elsewhere in the South Pacific, are located in areas of active bottom currents.

The distribution of four, generally non-overlapping, groups of nodules has been examined in conjunction with the regional variation in nodule coverage. These four groups, distinguished by their composition, are those containing the following: (1) greater than 1.8% Ni + Cu, (2) between 1 and 1.8% Ni + Cu, (3) greater than 1% Co, and (4) greater than 35% Mn. No simple relation between the distribution of these groups and the degree of coverage is apparent. It is noteworthy, however, that nodules in the last two groups occur only in areas in which the nodule coverage is less than 10%. Nodules in the first two groups are found in all coverage categories, but those containing greater than 1.8% Ni + Cu have their highest frequency of occurrence in the area of high coverage between the Clarion and Clipperton fracture zones.

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Devonian Reef Prospects, Canning and Bonaparte Gulf Basins, Western Australia

Middle and Upper Devonian reefs outcrop spectacularly for some 220 mi (350 km) along the northern margin of the Canning basin, in a series of rugged limestone ranges. They extend into the subsurface of the basin, and may originally have continued for some 750 mi (1,200 km) in a belt girdling the Precambrian Kimberley block, to join with similar reefs known in the onshore Bonaparte Gulf basin. There is also evidence that they once extended into the Carnarvon basin, 930 mi (1,500 km) to the south.

The Canning basin reefs show similarities to the Devonian reefs of Canada, and for the past 25 years, they have been regarded as prime targets for oil exploration. However, the first potentially commercial discovery was not made in the basin until 1981, when oil was recovered from an Upper Devonian (Famennian) reef complex in the Blina 1 well. This well yielded flows of up to 905 bbl per day from the reefal carbonates.

Recent encouragement of oil exploration in Devonian reefs has also been obtained in the Bonaparte Gulf basin, in this case as a result of mineral-exploration activities. More than 20 drill holes, exploring for lead-zinc, encountered significant showings of oil and bitumen in Upper Devonian reefal carbonates and overlying Carboniferous carbonates, in a belt some 95 mi (150 km) long. They are probably the most extensive near-surface oil showings known in Australia. There appears to be a genetic relationship between secondary porosity development, base-metal deposition, and oil emplacement (in that order) in these carbonates.

There are strong grounds for optimism that further reef-associated oil discoveries will be made in the northern Canning basin, and the outlook is also promising for similar discoveries in the Bonaparte Gulf basin and the offshore area adjoining the Kimberley block.

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Geology and Geothermal Exploration, Southernmost Peru

The geothermal potential of a 1,350 mi² (3,500 km²) area in the Andes of southernmost Peru was studied using Landsat imagery, aerial photos, and published maps and reports. In the study area, andesitic stratovolcanoes of Pliocene to Holocene age are situated on a 16,400 ft (5,000 m) high plateau underlain dominantly by Oligocene and Miocene silicic volcanic rocks and clastic sediments. The Tertiary section consists of >5,500 ft (>1,700 m) of permeable ignimbrites, lava flows, breccias, and tuffs capped by as much as 2,950 ft (900 m) of impermeable lacustrine sediments. Using satellite imagery and aerial photos, glaciated Pliocene and Pleistocene volcanoes were readily distinguished from those of Holocene age which probably are underlain by magmatic heat sources. Swarms of northwest-trending normal faults cut Quaternary volcanics and glacial deposits, and are coextensive with the belt of Holocene volcanism. Several elliptical structures 5 to 10 mi (8 to 32 km) across, defined by arcuate faults and chains of volcanic vents, may be traces of buried caldera sources for some of the older silicic volcanics. Surface hydrothermal features observed in the field (April 1980) include hot springs and geysers, fumaroles, altered areas, and extensive travertine and sinter deposits, many of them visible on Landsat imagery, but not shown on any published maps. The hydrothermal features occur near the main areas of Holocene volcanism and are localized along linear and arcuate fault zones and especially at intersections of faults. Sampling of thermal waters for geochemical thermometry and test drilling are planned for 1982, to assess the potential for geothermal power generation.

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Rock-Multielement-Geochemistry at Copper-Gold Anomaly in Kaputusan (Bacan Island), Moluccas, Indonesia

Geological reconnaissance and mineral prospecting on Bacan Island (Moluccas, Indonesia) by the Directorate of Mineral Resources of the Republic of Indonesia, from 1977 to 1979, resulted in the discovery of a copper-gold anomaly situated 7.5 mi (12 km) north of Kaputusan village. Technical cooperation with the Bundesanstalt für Geowissenschaften und Rohstoffe of the Federal Republic of Germany, from 1980 to 1981, detailed the prospect with geochemical analyses and geologic mapping.

The interpretation of a geochemical pattern, based on analyses of 32 elements in 149 rock samples from test pits in the anomalous area, indicated porphyry copper mineralization. In the center of the anomaly, enrichment of Au, Mo, Bi, Zr, Rb, and K₂O was detected, with surrounding halos of Pb, Zn, Sr, MnO, Fe₂O₃ and trace elements. Ratios of Rb/Sr and K₂O/Na₂O provided further evidence.

SiO₂ and SO₃ are relatively rich in the southern part of the anomaly, confirming a previously mapped quartz sericite alteration, and secondary mica, in fractures and replacing mafic minerals, characterizes the northern, K₂O part. A rather high copper concentration (up to 1%) in weathered rocks of the northern part may record a relatively small pyrite concentration which served to prevent leaching by the acidic environment.