U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

MINERAL-RESOURCES MAP SERIES

Maps of the Mineral-Resources Series show both land-based and seafloor deposits and occurrences of metallic and non-metallic mineral. Land-based deposits are shown without regard to their status of exploitation; therefore, some have been largely or entirely mined out, but they are included as indicative of where elements have been concentrated by geological processes to form ores in the past and thus may suggest favorable areas for exploration.

Only nearshore marine deposits have been exploited to date; most are concentrations of heavy minerals derived by erosion and transportation of onshore materials to the coastal zone. Known deep-sea mineral resources shown on the map consist of (1) widespread ferromanganese oxide nodules and crusts that contain appreciable amounts of nickel, copper, and cobalt, and minor amounts of other metals; (2) deposits of zinc, copper, and other metallic sulfides that form by hydrothermal activity along active spreading ridges (and possibly elsewhere); and (3) accumulations of phosphorite-bearing crusts, nodules, and finer grained material on the seafloor.

SOURCES OF DATA

LAND RESOURCES

The mineral-deposit data for Australia, New Guinea, Antarctica, and the islands in the eastern part of the quadrant were compiled by W. David Palfreyman and A.S. Mikolajczak of the Australian Geological Survey Organisation Map Compilation Section. Masaharu Kanitani compiled data for Southeast Asia and Robert L. Brathwaite for New Zealand. Principal sources were recent metallogenic and mineral-deposit maps and unpublished data provided by Australian State and Territory geological surveys and the geological surveys of Papua New Guinea and New Zealand. Other sources used in the preparation of the compilation, for which the compilers are grateful, Other useful references were Australian Surveying and Land Information Group (AUSLIG) (1988), United Nations Economic and Social Commission for Asia and Pacific (ESCAP) (1985), Rowley and others (1983), Hughes (1990), Kear (1989), Cronan (1986), and those contained in Davies (1985), and Jossanie and Thompson (1983).

SEAFLOOR RESOURCES

Data were provided by Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany, Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, Geological Survey of Japan, Hawaii Institute of Geophysics, Lamont-Doherty Earth Observatory, National Oceanic and Atmospheric Administration, Scripps Institution of Oceanography, Universitetet i Bergen, Norway, U.S. Geological Survey, Woods Hole, U.S. Geological Survey, and W.C. Burnett, Florida State University, updated the phosphorite data. R.A. Koski, U.S. Geological Survey, provided information on polymetallic sulfides. Other sources were Hein and others (1990), Mashima and Lane-Bostwick (1989), Burnett and Lee (1980), Ewing and others (1971), McKelvey and Wang (1969), Hutchinson (1950), and Rawson and Ryan (1978).

BACKGROUND INFORMATION

Land geology generalized from Palfreyman (1988). Seafloor sediment data generalized from McCoy (1988, 1989). Active plate boundaries and intraplate structures from Moore (1986).

REFERENCES CITED

Australian Surveying and Land Information Group (AUSLIG), 1988, Minerals other than fuels, *in* Geology and minerals–atlas of Australian resources, 3rd series: Canberra, Australia, Department of Administrative Services, scale 1:5,000,000.

Burnett, W.C., and Lee, A.J.N., 1980, The phosphate supply system in the Pacific Ocean: Oceanus, v. 23, no. 3, p. 67-73.

Cronan, D.S., ed., 1986, Inorganic, land and mineral deposits in the southwestern Pacific Ocean: London, Academic Press, 344 p.

Davies, H.L., 1985, Mineral potential of the southwest Pacific islands, *in* Environment and resources in the Pacific: United Nations Environment Programme Regional Seas Reports and Studies, no. 69, p. 129-142.

Ewing, M., Hern, D., Sullivan, L., Aiken, T., and Thorndike, E., 1971, Photographing manganese nodules on the ocean floor: Oceanology International, v. 6, no. 12, p. 26-32.

Hein, J.R., and others, 1990, Geological, geochemical, geophysical, and oceanographic data and interpretations of seamounts and Co-rich ferromanganese crusts from the Marshall Islands, Exclusive Economic Zone and Development Institute-U.S. Geological Survey R/V *Farnella* Cruise F10-89-PN: U.S. Geological Survey Open-File Report 90-696, 75 p.

Hughes, F.E., ed., 1990, Geology of the mineral deposits of Australia and Papua New Guinea: Melbourne, Australia, Australasian Institute of Mining and Metallurgy, Monograph 14, 2 v., 1824 p.

Hutchinson, G.E., 1950, The comparative geochemistry of guano minerals-3. The biogeochemistry of vertebrate excretion: American Museum of Natural History Bulletin, v. 96, 554 p.

Jossanie, C.E., and Thompson, R.-M., eds., 1983, Bibliography of geology and geophysics of the southwestern Pacific: United Nations Economic and Social Commission for Asia and the Pacific Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, Technical Bulletin 5, 258 p.

Kear, David, ed., 1989, Mineral deposits of New Zealand; a collection of papers summarizing the results of mineral exploration in New Zealand, 1974-87: Parkville, Victoria, Australasian Institute of Mining and Metallurgy, Monograph 15, 223 p.

Mashima, F.T., and Lane-Bostwick, C.M., 1989, Chemical composition of ferromanganese crusts in the world ocean; a review and comprehensive database: U.S. Geological Survey Open-File Report 89-020, 450 p.

McCoy, F.W., 1988, Seafloor sediment, *in* Craddock, Campbell, chairmen, Geologic map of the circum-Pacific region, southwest quadrant: Houston, Circum-Pacific Council for Energy and Mineral Resources, scale 1:10,000,000, 37 p.

McCoy, F.W., 1989, Seafloor sediment, *in* Craddock, Campbell, chairmen, Geologic map of the circum-Pacific region, Antarctic sheet: Houston, Circum-Pacific Council for Energy and Mineral Resources, scale 1:10,000,000, 32 p.

McKelvey, V.E., and Wang, F.F.H., 1969, World subsea mineral resources: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-632, scale 1:30,383,200, 4 sheets.

Moore, G.W., 1986, Plate perimeters and motion vectors, *in* Donich, H.F., chairman, Plate-tectonic map of the circum-Pacific region, southwest quadrant: Houston, Circum-Pacific Council for Energy and Mineral Resources, scale 1:10,000,000, 14 p.

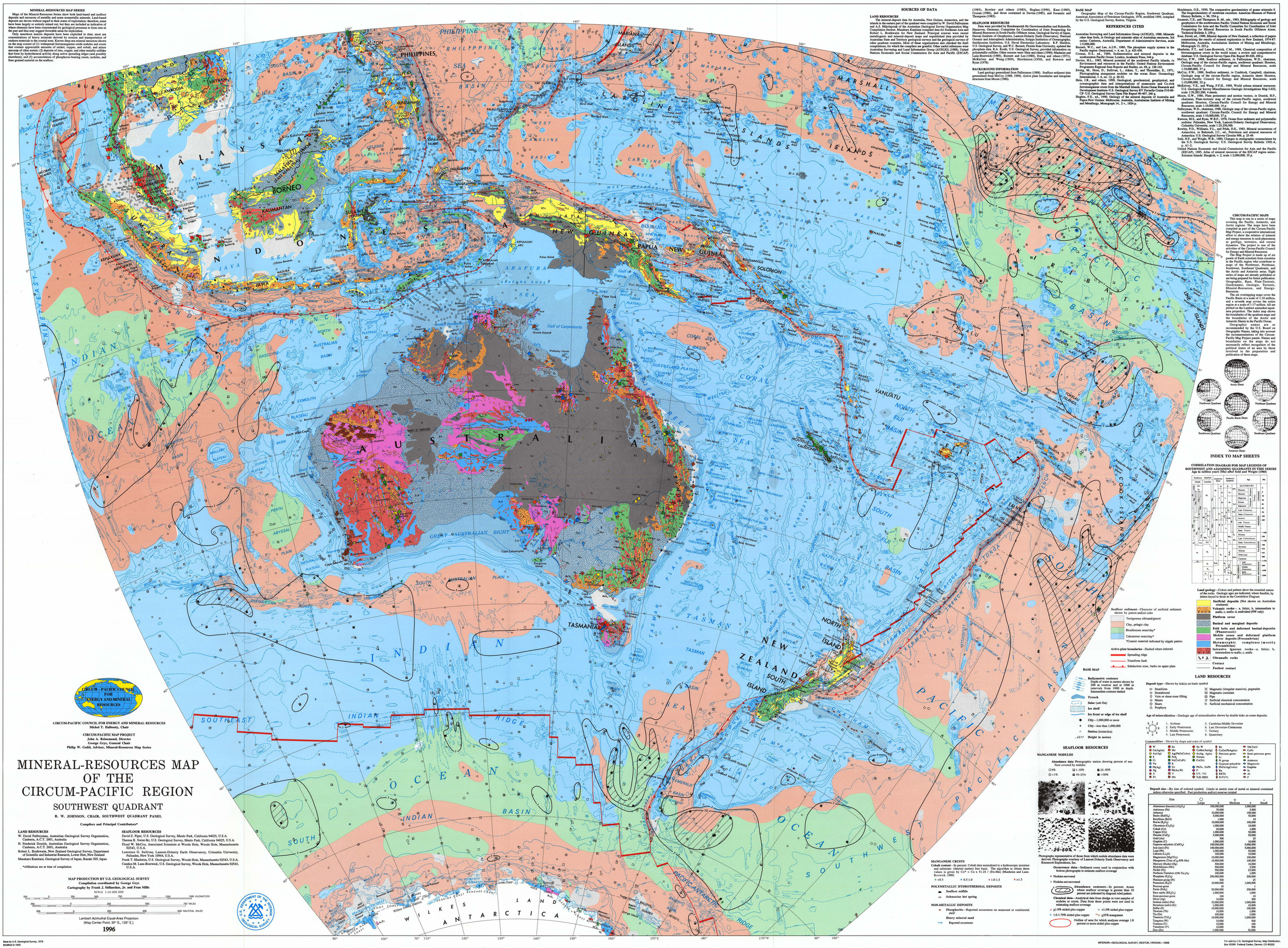
Palfreyman, W.D., chairman, 1988, Geologic map of the circum-Pacific region, southwest quadrant: Circum-Pacific Council for Energy and Mineral Resources, scale 1:10,000,000, 37 p.

Rawson, M.S. and Ryan, W.B.F., 1978, Ocean floor sediment and polymetallic nodules: Palisades, New York, Lamont-Doherty Geological Observatory, Columbia University, scale 1:25,250,500.

Rowley, P.D., Williams, P.L., and Pride, D.E., 1983, Mineral occurrences of Antarctica, *in* Behrendt, J.C., ed., Petroleum and mineral resources of Antarctica: U.S. Geological Survey Circular 909, p. 25-49.

Sohl, N.F., and Wright, W.B., 1980, Changes in stratigraphic nomenclature by the U.S. Geological Survey: U.S. Geological Survey Bulletin 1502-A, p. A1-2.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 1985, Atlas of mineral resources of the ESCAP region series-Solomon Islands: Bangkok, v. 2, scale 1:2,000,000, 35 p.



CIRCUM-PACIFIC COUNCIL FOR ENERGY AND MINERAL RESOURCES
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MINERAL-RESOURCES MAP OF THE CIRCUM-PACIFIC REGION

SOUTHWEST QUADRANT

R. W. JOHNSON, CHAIR, SOUTHWEST QUADRANT PANEL

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SCALE 1:10 000 000

Lambert Azimuthal Equal-Area Projection
(Map Center Point: 35° S., 135° E.)

1996

CIRCUM-PACIFIC MAPS

This map is one in a series of maps covering the Pacific, Antarctic, and Arctic regions. The maps have been compiled as part of the Circum-Pacific Map Project, a cooperative international effort to show the relation of mineral and petroleum resources to such features as geology, tectonics, and coastal dynamics. The project is one of the activities of the Circum-Pacific Council for Energy and Mineral Resources.

The Map Project is made up of six panels of Earth scientists from countries in the Pacific region who contribute to maps of the Northwest, Northeast, Southwest, Southeast Quadrants, and the Arctic and Antarctic areas. Eight sheets in each quadrant are planned and are being prepared for future publication: Geographic, Base, Plate-Tectonic, Geodynamic, Geologic, Tectonic, Mineral-Resources, and Energy-Resources.

The six overlapping maps cover the Pacific Basin at a scale of 1:10 million, and a seventh map covers the entire region at a scale of 1:17 million. All are plotted on the Lambert azimuthal equal-area projection. The maps show also the boundaries of the quadrant maps and the boundaries of the Arctic and Antarctic Sheets in the Pacific Ocean.

Geographic names are as recommended by the U.S. Board on Geographic Names, taking into account the recommendations of the Circum-Pacific Map Project panels. Names and boundaries on the map do not necessarily reflect recognition of the political status of an area by those involved in the preparation and publication of these maps.

INDEX TO MAP SHEETS

CORRELATION DIAGRAM FOR MAP LEGENDS OF SOUTHWEST AND ADJOINING QUADRANTS IN THIS SERIES
Age in million years (Ma) after Sohl and Wright (1980)

Land geology—Colors and pattern show the essential nature of the rocks. Geologic ages are indicated, where feasible, by letters keyed to those in the Correlation Diagram

- Surficial deposits (Not shown on Australian continent)
- Volcanic rocks— a, felsic; b, intermediate to mafic; c, mafic; d, undivided (NW only)
- Platform cover
- Basinal and marginal deposits
- Fold belts and deformed basinal deposits (Phanerozoic)
- Mobile zones and deformed platform cover deposits (Precambrian)
- Metamorphic complexes (mostly Precambrian)
- Intrusive igneous rocks— a, felsic; b, intermediate to mafic; c, mafic
- Ultramafic rocks
- Contact
- Faulted contact

Seafloor sediment—Character of surficial sediment shown by pattern and(or) color

- Terrigenous silt/sand/gravel
- Clay, pelagic clay
- Biosiliceous ooze/clay*
- Calcareous ooze/clay*

*Coarser material indicated by stipple pattern

Active plate boundaries—Dashed where inferred

- Spreading ridge
- Transform fault
- Subduction zone, barbs on upper plate

BASE MAP

Bathymetric contours
Depth of water in meters shown by 200 m contour and at 1000 m intervals from 1000 m depth. Intermediate contours dashed

- Trench
- Sahul (salt flat)
- Ice shelf
- Ice front or edge of ice shelf
- City—1,000,000 or more
- City—less than 1,000,000
- Station (Antarctica)
- 4317 Height in meters

LAND RESOURCES

Deposit type—Shown by tick(s) on basic symbol

- Stratiform
- Stratabound
- Vein or shear-zone filling
- Mantle
- Skarn
- Porphyry
- Magmatic (irregular massive), pegmatite
- Magmatic cumulate
- Pipe
- Surficial chemical concentration
- Surficial mechanical concentration

Age of mineralization—Geologic age of mineralization shown by double ticks on some deposits.

1. Archean
2. Early Proterozoic
3. Middle Proterozoic
4. Late Proterozoic
5. Cambrian-Middle Devonian
6. Late Devonian-Cretaceous
7. Tertiary
8. Quaternary

Commodities—Shown by shape and color of symbol

W	Sn	Sb W	Be	Nb(Ta)U
Cu(Ag,Au)	Mo	Cu(Mo)(Au)(Ag)	Co(Zn)(Pb)(Ag,Au)	Cr(Pt)
Au(Ag)	Ag(Pb)(Cu)(Au)	Au(Ag, Ag,Au	Precious gems	Semi-precious gems
Sn	FeS_2	Nitrate	Li	B
Cr	Ni(Co)(Pt)	Cu(Ni)	Pt group	Asbestos
Ni	Au		Gypsum-anhydrite	Magnesite
Pb(Ag)	Zn	Pb(Zn, ZnPb	Mn(Zn)(Ag)(Cu)(Au)	Graphite
Hg	Sb(Au,W)	F	Ba	Sr
U	V	U, VU	REE's	Au
Fe	Mn	TiZr REO	Fe(Ti,V)	P

Deposit size—By size of colored symbol. Limits in metric tons of metal or mineral contained unless otherwise specified. Past production and(or) reserves totaled

Size	Large	Medium	Small
	>	>	>
Aluminum (bauxite) (Al_2O_3)	100,000,000	1,000,000
Antimony (Sb)	50,000	5,000
Asbestos	10,000,000	100,000
Barite ($BaSO_4$)	5,000,000	50,000
Beryllium (BeO)	1,000	10
Boron (B_2O_3)	10,000,000	100,000
Chromium (Cr_2O_3)	1,000,000	10,000
Coal (C)	1,000,000	10,000
Copper (Cu)	1,000,000	50,000
Fluorite (CaF_2)	5,000,000	50,000
Gold (Au)	500	35
Graphite (C)	1,000,000	10,000
Gypsum-anhydrite ($CaSO_4$)	100,000,000	5,000,000
Iron (ore) (Fe)	100,000,000	5,000,000
Lead (Pb)	1,000,000	50,000
Lithium (Li_2O)	100,000	10,000
Magnesite ($MgCO_3$)	10,000,000	100,000
Manganese (Ton of $_2$,40% Mn)	10,000,000	100,000
Mercury (flasks) (Hg)	500,000	10,000
Molybdenum (Mo)	500,000	5,000
Nickel (Ni)	500,000	25,000
Niobium-Tantalum (Nb_2O_5-Ta_2O_5)	100,000	1,000
Phosphate (P_2O_5)	200,000,000	200,000
Platinum group (Pt)	100	1
Potassium (K_2O)	10,000,000	1,000,000
Precious gems	10	1
Pyrite (FeS_2)	20,000,000	200,000
Rare-earths (RE_2O_3)	1,000,000	1,000
Semi-precious gems	100	10
Silver (Ag)	10,000	500
Sodium (salts) (Na)	10,000,000	1,000,000
Sulfur (salts) (S)	1,000,000	10,000
Tin (Sn)	10,000,000	100,000
Thorium (Th)	10,000	1,000
Tin (Sn)	100,000	5,000
Titanium (TiO_2)	10,000,000	1,000,000
Tungsten (W)	10,000	500
Uranium (U)	10,000	100
Vanadium (V)	10,000	500
Zinc (Zn)	1,000,000	50,000

SEAFLOOR RESOURCES

MANGANESE NODULES

Abundance data Photographic station showing percent of seafloor covered by nodules

- 0%
- <1%
- 1–10%
- 10–25%
- 25–50%
- >50%

Photographs representative of those from which nodule abundance data were derived. Photographs courtesy of Lamont-Doherty Earth Observatory and Kennecott Explorations, Inc.

Occurrence data—Sediment cores used in conjunction with bottom photographs to estimate seafloor coverage

- Nodules not recovered
- Nodules not recovered

Abundance contours—In percent. Areas where seafloor coverage is greater than 10 percent are indicated by diagonal ruled pattern

Chemical data—Analytical data from dredge or core samples of nodules or crusts. Data from these points were not used in estimating seafloor coverage

- ≥1.5% nickel plus copper
- <1.0% nickel plus copper
- 1.0-1.79% nickel plus copper
- ≥35% manganese
- Outline of area for which analyses average 1.8 percent or more nickel plus copper

MANGANESE CRUSTS

Cobalt content—In percent. Cobalt data normalized to a hydroxycopic moisture and substrate- (detrital matter) free basis. The algorithm to obtain these values is given by Co* = Co x 51.23 / (Fe+Mn) (Manheim and Lane-Bostwick, 1989)

- <0.5
- 0.5-1.0
- 1.0-1.5
- >1.5

POLYMETALLIC HYDROTHERMAL DEPOSITS

- Seafloor sulfide
- Submarine hot spring

NON-METALLIC DEPOSITS

- Phosphorite—Reported occurrence on seamount or continental shelf
- Heavy mineral sand
- Auly Reported occurrence

Base by U.S. Geological Survey, 1979
Modified in 1993

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