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U.S. GEOLOGICAL SURVEY

TO ACCOMPANY MAP CP-42

EXPLANATORY NOTES FOR THE MINERAL-RESOURCES MAP OF THE CIRCUM-PACIFIC REGION SOUTHWEST QUADRANT

1:10,000,000

CIRCUM-PACIFIC COUNCIL FOR ENERGY AND MINERAL RESOURCES

1996

CIRCUM-PACIFIC COUNCIL FOR ENERGY AND MINERAL RESOURCES
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CIRCUM-PACIFIC MAP PROJECT
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EXPLANATORY NOTES FOR THE MINERAL-RESOURCES MAP OF THE CIRCUM-PACIFIC REGION SOUTHWEST QUADRANT

Scale: 1:10,000,000

By

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Explanatory Notes to Supplement the

MINERAL-RESOURCES MAP OF THE CIRCUM-PACIFIC REGION SOUTHWEST QUADRANT

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INTRODUCTION

CIRCUM-PACIFIC MAP PROJECT

By
George Gryc

The Circum-Pacific Map Project is a cooperative international effort designed to show the relationship of known energy and mineral resources to the major geologic features of the Pacific Basin and surrounding continental areas. Available geologic, mineral-resource, and energy-resource data are being integrated with new project-developed data sets such as magnetic lineations, seafloor mineral deposits, and seafloor sediment. Earth scientists representing some 180 organizations from more than 40 Pacific-region countries are involved in this work.

Six overlapping equal-area regional maps at a scale of 1:10,000,000 form the cartographic base for the project: the four Circum-Pacific quadrants (Northwest, Southwest, Southeast, and Northeast), and the Antarctic and Arctic regions. There is also a Pacific Basin Sheet at a scale of 1:17,000,000. Published map series include the Base (published from 1977 to 1989), the Geographic (published from 1977 to 1990), the Plate-Tectonic (published from 1981 to 1992), and the Geodynamic (published from 1984 to 1990); all of them include seven map sheets. Thematic map series in the process of completing publication include Geologic (publication initiated in 1983), Tectonic (publication initiated in 1991), Energy-Resources (publication initiated in 1986), and Mineral-Resources (publication initiated in 1984). Altogether, 60 map sheets are planned. The maps are prepared cooperatively by the Circum-Pacific Council for Energy and Mineral Resources and the U.S. Geological Survey. Maps published prior to mid-1990 are distributed by the American Association of Petroleum Geologists (AAPG) Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101, U.S.A.; maps published from mid-1990 onward are available from the Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225, U.S.A.

The Circum-Pacific Map Project is organized under six panels of geoscientists representing national earth-science organizations, universities, and natural-resource companies. The regional panels correspond to the basic map areas. Current panel chairs are Tomoyuki Moritani (Northwest Quadrant), R.W. Johnson (Southwest Quadrant), Ian W.D. Dalziel (Antarctic Region), José Corvalán D. (Southeast Quadrant), Kenneth J. Drummond (Northeast Quadrant), and George W. Moore (Arctic Region).

Project coordination and final cartography are being carried out through the cooperation of the Office of International Geology of the U.S. Geological Survey under the direction of Map Project General Chair George Gryc of Menlo Park, California, with the assistance of Warren O. Addicott, consultant. Project headquarters are located at 345 Middlefield Road, MS 952, Menlo Park, California 94025, U.S.A. The project has been overseen from its inception by John A. Reinemund, Director of the Project since 1982.

The framework for the Circum-Pacific Map Project was developed in 1973 by a specially convened group of 12 North American geoscientists meeting in California. The project was officially launched at the First Circum-Pacific Conference on Energy and Mineral Resources, held in Honolulu, Hawaii, in August 1974. Sponsors of the conference were the American Association of Petroleum Geologists (AAPG), Pacific Science Association (PSA), and the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP). The Circum-Pacific Map Project operates as an activity of the Circum-Pacific Council for Energy and Mineral Resources, a nonprofit organization that promotes cooperation among Circum-Pacific countries in the study of energy and mineral resources of the Pacific basin. Founded by Michel T. Halbouty in 1972, the Council also sponsors quadrennial conferences, topical symposia, scientific training seminars, and the Earth Science Series of publications.

Published thematic maps of the Southwest Quadrant include the Plate-Tectonic Map (Doutch, 1986), the Geodynamic Map (Doutch, 1985), the Geologic Map (Palfreyman, 1988), and the Tectonic Map (Scheibner, 1991). The Energy-Resources Map is now in cartographic preparation at Circum-Pacific Map Project headquarters in Menlo Park, California.

MINERAL-RESOURCES MAP SERIES

The Mineral-Resources Map series is designed to be as factual as possible, with a minimum of interpretation. The small scale, 100 km/cm or 10,000 km^2/cm^2 (about 160 miles per inch or 25,000 square miles per square inch), requires an enormous simplification of both the background information and the mineral-deposit data; hence, the maps can only give a general impression of the distribution, character, and geologic environment of these resources. Nevertheless, this map series provides a unified overview of the mineral resources of a region encompassing more than half the globe. It should identify areas broadly favorable for the occurrence of specific minerals and thus assist both in resource assessment and, with additional data from more detailed sources, in exploration planning. The maps also serve to show the relation of deposits to major earth features, such as divergent and convergent plate margins, hotspots, and accreted terranes, and thus should stimulate analysis of the role of geologic processes in the genesis of ores.

The maps show both land and seafloor deposits of most metallic and nonmetallic minerals, except for construction materials. Uranium and thorium are included, although their principal use is for energy production. Deposits on land are shown regardless of their status of exploration, and some deposits may have been totally exhausted. The maps do not, therefore, necessarily represent the present resource picture. In general, only deposits of economic size and grade are shown, but some small or low-grade occurrences have been included, where space permits, in order to indicate a resource potential. Deposits on land are shown by colored symbols outlined in black that are explained in detail on the maps.

Because most seafloor deposits have not been evaluated for their economic potential, the criterion for their inclusion on the maps is simply knowledge of their existence. Reported occurrences of nearshore heavy minerals (placer deposits) are indicated by chemical symbols (letters) in blue.

Offshore mineral resources depicted are: (1) manganese-iron oxide nodules that contain varying amounts of nickel, copper, and cobalt, and trace amounts of other metals; (2) sulfide deposits; and (3) phosphatic deposits. No attempt has been made to show the distribution of metalliferous sediments which are known to be widespread but are so low in grade that they are not considered to be resources at the present time (Field and others, 1981).

Mineral-resource information for the land and nearshore areas is assembled by members of the individual quadrant panels; compilers, contributors, and data sources are cited on the maps themselves. Information on the offshore resources has been assembled for the entire ocean area of the project principally by geologists of the U.S. Geological Survey.

The geologic features on the Mineral-Resources Maps are taken from the corresponding Geologic Maps, but are in general simplified and in part modified to emphasize features that may be significant in explaining the distribution of the mineral deposits. Although the project aims at a uniform presentation throughout the Circum-Pacific region, differences among the compilers in interpretation of its geologic evolution may result in some variation in the representation of the background information of land areas from map to map. Similarly, the method of representing land-based mineral deposits varies somewhat to reflect the views of the compilers.

The only exception is Antarctica, where no economically minable deposits are known; the criteria for inclusion on that map have been relaxed to show mineral occurrences without regard to their size (shown on the map as small) or grade.

Bathymetry and the nature of surficial sediment constitute the background for the oceanic areas. The 4 types of surficial sediment shown are simplified from the 13 categories shown in the Geologic Map series. Active plate boundaries are taken from the Plate-Tectonic Maps, but spreading axes are depicted as lines of uniform width rather than by varying widths reflecting spreading rates.

Mineral-Resources Map of the Southwest Quadrant

The Mineral-Resources Map of the Southwest Quadrant of the Circum-Pacific region is the second published in a series of six overlapping 1:10,000,000-scale mineral-resources maps. The Northeast Quadrant Mineral-Resources Map (Drummond) was published in 1985.

Compilation of this map involved contributions from many individuals and organizations. Philip W. Guild, as advisor to the Mineral-Resources Map series since the inception of the Circum-Pacific Map Project, took the lead in the selection of the map elements, units, and symbols, especially for onshore resources. David Z. Piper and Theresa R. Swint-Iki did most of the compilation and analysis of seafloor mineral data. Australian mineral-deposit data were compiled from a number of (mainly published) geologic and metalliferous maps of various scales produced by the Australian Geological Survey Organisation (AGSO), and by State and Territory government geoscience organizations.

These data were plotted on a 1:10,000,000-scale base to produce a draft compilation which was forwarded to the appropriate organization for correcting and updating. Their assistance in this work is much appreciated. This procedure was also followed for the compilation of the mineral data for Papua New Guinea and the smaller Southwest Pacific island nations. The cooperation of the geological survey departments of these countries is also acknowledged. Dr. R.L. Brathwaite, New Zealand Geological Survey, Department of Science and Industrial Research, Geology and Geophysics, compiled the mineral data for that country. His assistance and that of his colleagues is also much appreciated. Data for Irian Jaya (western New Guinea) was checked by Mr. D.S. Trail (AGSO) and his colleagues in the Irian Jaya geologic mapping project. Data on Pacific island phosphate deposits and on Antarctic minerals were obtained from literature research. For mineral data for the overlap area with the Northwest Quadrant, the Geological Survey of Japan must be thanked. Finally, Mr. A.S. Mikolajczak of the Cartographic Services Unit (AGSO) is to be thanked for compiling the draft of the minerals data map.

RESOURCE SYMBOLS

Because mineral resources vary widely in their characteristics, the symbols that represent the deposits have been designed to impart as much information as possible at the map scale. Although the map explanations give the details, a brief discussion of the system may be helpful to the reader.

LAND RESOURCES

The legend for the land mineral resources has been modified and simplified from the Preliminary Metallogenic Map of North America (North American Metallogenic Map Committee, 1981) and described by Guild (1981), with later revisions to deposit symbology for the Southwest Quadrant Map (Guild, 1988). The map symbols show the metal or mineral content of the deposits by colored geometric shapes. The colors, insofar as possible, show metals or minerals of similar type: copper and associated metals are orange, precious metals are yellow, lead-zinc and associated minerals are blue, and so forth. The 5 shapes and 10 colors indicated on the legend of the map provide for 50 combinations, but not all of them have been used here.

Three sizes of symbols denote the relative importance of the deposits. Limits between the size categories for each commodity are, for the most part, in terms of metric tons of the substance(s) contained before exploration. These limits are obviously arbitrary; they have been selected on the basis of the worldwide abundance of the commodity concerned in deposits that are exploitable under current economic and technological conditions.

Some deposits shown as small on this map correspond only to occurrences; they have been included because they may help to identify areas broadly favorable for exploration planning of specific minerals.

Some differences from the Northeast Quadrant Mineral-Resources Map should be noted. Age of mineralization categories have changed, and three new deposit-type classification symbols have been included, in order to distinguish them more easily.

One or more ticks on the symbol indicate the general nature of the deposit–stratiform, stratabound, vein or shear-zone filling, and so forth. A description of the eleven deposit types shown on the Southwest Quadrant are as follows:

Stratiform. Deposits more or less rigorously confined to one or more layers in stratified (sedimentary or volcanic) rocks. Some are of great lateral extent in relation to thickness. May be layered (banded). Usually syngenetic with enclosing rocks. Examples: evaporites, phosphorites, iron formations. Most massive sulfide deposits belong here.

Stratabound. Deposits, generally of limited horizontal extent, that occur at more or less the same horizon in stratified rocks. May be partly concordant, partly discordant with enclosing rocks. Usually considered to be epigenetic. Examples: carbonate-hosted (Mississippi Valley) base-metal deposits, sandstone ("red bed") copper deposits, uranium deposits of Colorado Plateau, Wyoming Basin, and so forth.

Vein or shear-zone filling. Crosscutting, epigenetic deposits in any type of host rock. The major dimensions are transverse to stratification in sedimentary or volcanic hosts. Most stockworks fit here; some in igneous hosts are better equated with the irregular disseminated deposits.

Manto. Deposits that combine stratabound and crosscutting features. Characteristically, one or several ore horizons (of replacement origin?) are underlain and/or joined by vein or stockwork ore shoots. Examples: Leadville and Gilman, Colorado, lead-zinc-silver; Santa Eulalia, Chihuahua, lead-zinc-silver; La Encantada and others, Coahuila, fluorite.

Skarn. Contact-metamorphic (tactite) deposits. Stratified, usually carbonate rocks intruded by intermediate to acid igneous rock.

Porphyry deposits. Irregular disseminated deposits, in or associated with intrusive igneous rocks. Parts of some have been described as stockworks. Hydrothermal alteration, including greisenization, common.

Magmatic (irregular massive) deposits. Includes pegmatites. Examples: podiform chromite, some magnetite and magnetite-ilmenite deposits.

Magmatic cumulate deposits. Concordant in layered, generally mafic or ultramafic igneous rocks. Examples: stratiform chromite, ilmenite, platinum-group metals of Bushveld type; certain nickel-sulfide (komatiite-hosted) deposits.

Pipe. Includes breccia pipe. Essentially a two-dimensional deposit with long-axis vertical (crosscutting). Examples: diamondiferous kimberlite, diapir-related (salt dome) sulfur.

Surficial chemical concentration. Includes laterite, bauxite, uraniferous calcrete, and some manganese oxide deposits. The criterion is that supergene processes were responsible for producing ore-grade material.

Surficial mechanical concentration (placer) deposits. Includes "fossil" black sands.

The ticks indicating nature of deposit have been omitted on many of the small symbols either because of ignorance of their type or because it was felt unnecessary to identify all of them where they occur in clusters of deposits of the same kind.

Mineralization ages for most deposits are indicated by double ticks placed according to a clockwise order from older to younger. Where a tick to indicate the deposit type already occurs in the required position, a single tick for age is added and the two must be read together.

Space limitations on the map do not permit identifying by name all the deposits shown, but many of the larger ones are named, especially in relatively open areas. Deposits underlined in the text are listed by number keyed to page-size index maps and accompanying tables (see figs. 2-13 and tables 1-15).

SEAFLOOR RESOURCES

The potential value of manganese nodules depends on their abundance and composition. Abundance data have been derived principally from seafloor photographs, typical examples of which are reproduced in the explanation of the map. Nodule coverage of the sea floor ranges from 0 to nearly 100 percent. On the map, squares 2 mm on a side, empty to totally filled in black, indicate graphically where bottom photographs have been taken and the abundance of nodules at these points. Additional information on the occurrence of nodules was gained from core sampling; small black x's and o's indicate where nodules have been recovered or not recovered, respectively, in cores. Details of the methods used in studying these data sources and in deriving abundance contours are described later.

The composition of analyzed nodules is indicated within certain limits by different colored +'s for ranges of nickel plus copper content and by brown +'s with chemical symbol for those with high manganese. Areas of nodules averaging 1.8 percent or more nickel plus copper (considered as potentially exploitable; McKelvey and others, 1979) are outlined in red. Composition of analyzed manganese crusts is indicated by colored asterisks for four ranges of cobalt content (Manheim and Lane-Bostwick, 1989).

The polymetallic sulfide deposits thus far discovered on the spreading ridges are shown by black semicircles.

Submarine hot springs known to be precipitating metallic minerals (though not in economic quantities) are shown by open semicircles.

Seafloor phosphorite occurrences are depicted by brown horizontal lozenges without an outline. Although this symbol is approximately as large as that used for the medium-sized land deposit, it has no size or grade significance. The many guano-type phosphate deposits on oceanic islands so small that the symbol obscures them entirely are distinguished by having a black outline and the tick indicating a surficial chemical concentration.

LAND RESOURCES

The geologic background shown on the Mineral-Resources Map has been simplified from the Geologic Map of the Southwest Quadrant (Palfreyman, 1988). The main difference from the latter map is that, unlike the Geologic Map, on the Mineral-Resources Map color is used to denote the structural state (unfolded, deformed, or strongly metamorphosed) and depositional environment of the stratified rocks; igneous rocks are differentiated by color and patterned screen. However, letter symbols keyed to the correlation diagram indicate ages in most areas, and time divisions are used for older and younger Precambrian rocks and, by implication, for surficial deposits (late Cenozoic). In the succeeding sections the principal features of the map units and their mineral resources will be sketched and an attempt made to fit the latter into their geologic frameworks. The units will be discussed by country.

A general account of the geology of the quadrant is given by Doutch (Palfreyman, 1988) and of the Australian continent by Palfreyman (1984). The tectonics of the quadrant have been described by Scheibner (1991). Comprehensive descriptions of the major mineral deposits of Australia and Papua New Guinea are given in Hughes (1990). A more popular account of the geology, mineral resources, and mineral industries of Australia is given in Australian Surveying and Land Information Group (1988).

AUSTRALIA

By
C. M. Mock

In Australia, a few comparatively short time intervals in the Archean, the Early and Middle Proterozoic, and the Tertiary-Quaternary were the most important ore-forming periods. The most productive environments have been the ultramafic-mafic volcanic sequences with minor sedimentary rocks (gold–Kalgoorlie/Boulder (Deposit #66–fig. 2, table 1)–and nickel–Kambalda/St. Ives/Tramways (Deposit #77–fig. 2, table 1)–in the Yilgarn Block); closed-basin sedimentation (lead-zinc at Mt. Isa (Deposit #118–fig. 3, table 2) and Zinc Corporation/New Broken Hill (Deposit #87–fig. 4, table 3)); and secondary concentration (iron ore in the Hamersley Basin, and lateritic bauxite); followed by the felsic volcanic environments (copper, lead, and zinc in the composite Tasman Fold Belt System, made up of the Lachlan, New England, and Thomson Fold Belts, and some smaller sections in Queensland) (see Paleozoic fold belts, p. 11). Figure 1 shows the principal morphostructural features of Australia.

Archean

Early crustal tectonism was dominated by widespread, mantle-derived igneous activity and metamorphism, which produced the distinctive volcanogenic belts (greenstones) and granite-gneiss complexes that typify Archean shield terranes. Sedimentation was mainly of iron-rich and detrital material, producing banded iron formation (BIF), chert, and impure sandstone.

Archean mineralization is a function of a high level of igneous activity from a sulfur-rich mantle source. The main metals represented are those concentrated in mafic or ultramafic rocks and those concentrated in pegmatites.

Yilgarn and Pilbara Blocks

The Archean is represented in Australia mainly by the Yilgarn and Pilbara Blocks of Western Australia, the oldest cratonic nuclei from which the continent grew. The chief economic minerals are nickel and gold, which are associated with the greenstones.

Also important are tin, tantalum, tungsten, beryllium, molybdenum, lithium, niobium, and rare earth elements (REE) associated with pegmatites or greisenized granitoids (Greenbushes (Deposit #100–fig. 2, table 1), Mt. Mulgine (Deposit #133–fig. 2, table 1)). Molybdenum also occurs in porphyry copper-molybdenum deposits in the Pilbara Block.

Copper-zinc deposits occur at Whim Creek (Deposit #220–fig. 2, table 1) and Mons Cupri (Deposit #218–fig. 2, table 1) in the Pilbara Block, and at Golden Grove/Scuddles (Deposit #134–fig. 2, table 1) and Teutonic Bore (Deposit #34–fig. 2, table 1) in the Yilgarn Block. These deposits represent a primitive volcanogenic base-metal sulfide association and probably formed as a result of seafloor ore-fluid exhalation in areas peripheral to volcanic eruptions. Paleozoic base-metal sulfide deposits carry increasing proportions of lead and silver at the expense of copper and gold.

BIF ore deposits occur at Koolyanobbing (Deposit #119–fig. 2, table 1), Weld Range (Deposit #151–fig. 2, table 1), and elsewhere in the Yilgarn Block, and at Shay Gap/Sunrise Hill-Nimingarra (Deposit #239–fig. 2, table 1) and other localities in the Pilbara Block.

Greenstone sequences and pegmatites host the major deposits of nonmetallic and industrial minerals–barite (North Pole (Deposit #224–fig. 2, table 1)), magnesite (Bandalup (Deposit #90–fig. 2, table 1)), chrysotile asbestos (Nunyerry (Deposit #214–fig. 2, table 1), Lionel (Deposit #230–fig. 2, table 1)), and talc occur in greenstones; feldspar, fluorite, emerald, and beryl are mined from pegmatites.

A phosphate-REE deposit is hosted by carbonatite at Mt. Weld (Deposit #43–fig. 2, table 1).

Gold province

Gold deposits are widespread in Archean cratons, and are characteristically associated with the greenstone belts, more specifically with mafic rocks and their associated sedimentary wall rocks.

The Pilbara Block is relatively poor in gold, the largest deposit being Bamboo Creek (Deposit #228–fig. 2, table 1).

By contrast, the Yilgarn Block is richly endowed and has dominated Australian gold production. Historically the richest deposits have been those within a major mineralized zone extending from Norseman to Wiluna (the Norseman-Wiluna Belt in Western Australia), which includes the legendary "Golden Mile" at Kalgoorlie/Boulder (Deposit #66–fig. 2, table 1). Major centers of past production outside the Norseman-Wiluna Belt include the mining districts of Southern Cross, Laverton (Lancefield (Deposit #39–fig. 2, table 1)), Mt. Magnet (Hill 50/St. George (Deposit #142–fig. 2, table 1)), Meekatharra, and Cue (Big Bell (Deposit #145–fig. 2, table 1)).

Sustained higher gold prices during the early 1980s, combined with new exploration concepts, improved extraction technology, and innovative financing methods, led to a resurgence in the gold industry. Operations were expanded at existing centers, such as Kalgoorlie/Boulder (Deposit #66–fig. 2, table 1), Mt. Charlotte (Deposit #65–fig. 2, table 1), and Princess Royal/Mararoa-Crown (Norseman) (Deposit #86–fig. 2, table 1), and exploration led to the discovery and development of lower grade ore in known fields, and new styles of deposits, the larger ones being Paddington (Deposit #61–fig. 2, table 1), Kambalda/St. Ives/Tramways (Deposit #77–fig. 2, table 1) Victory/Defiance/Orion/Revenge (Deposit #79–fig. 2, table 1), Big Bell (Deposit #145–fig. 2, table 1), Moonlight/Wiluna (Deposit #17–fig. 2, table 1), Mt. Gibson (Deposit #132–fig. 2, table 1), and Boddington (Deposit #107–fig. 2, table 1). The latter two deposits are lateritic concentrations of gold.

The major gold deposits of the Yilgarn Block are structurally controlled epigenetic bodies associated with regional fault zones. Deposits commonly occur as silicified shears, quartz vein stockworks, quartz veins, or stratiform quartz-sulfide replacements in splays off the regional faults. Silver, arsenic, and antimony are common associates of the gold ores.

Most major deposits, except Big Bell (Deposit #145–fig. 2, table 1), occur in carbonate rocks in greenschist facies metamorphic terrain. Mafic igneous rocks are the most common host, particularly in the greenstone belt in the Norseman-Kalgoorlie region, but sedimentary rocks, principally BIF, are a common host in the Southern Cross, Mt. Magnet (Hill 50/St. George (Deposit #142–fig. 2, table 1)), Laverton (Lancefield (Deposit #39–fig. 2, table 1)), and Leonora (Mt. Morgans/Westralia (Deposit #41–fig. 2, table 1)) districts.

Nickel sulfide province

Nickel sulfide mineralization is largely confined to ultramafic lava sequences (komatiites) of the greenstone belts centered on Norseman-Wiluna and Forrestania. Cobalt, platinum, and palladium accompany the nickel. The principal deposits are concentrated in the Kambalda/St. Ives/Tramways (Deposit #77–fig. 2, table 1) group; other important deposits are the Mt. Windarra (Deposit #38–fig. 2, table 1), Forrestania (Deposit #88–fig. 2, table 1), and Perseverance/Agnew (Deposit #30–fig. 2, table 1) and Mt. Keith (Deposit #25–fig. 2, table 1) groups.

Two main classes of deposit have been distinguished:

(1) Massive sulfide bodies hosted by thin flows, represented by Kambalda/St. Ives/Tramways (Deposit #77–fig. 2, table 1), Perseverance/Agnew (Deposit #30–fig. 2, table 1), Widgiemooltha (Deposit #82–fig. 2, table 1), Mt. Windarra (Deposit #38–fig. 2, table 1), and Forrestania (Deposit #88–fig. 2, table 1). Orebodies are generally made up of small, high-grade localized shoots.

(2) Disseminated sulfides in large layered bodies; for example, Mt. Keith (Deposit #25–fig. 2, table 1) and Six Mile (Deposit #28–fig. 2, table 1). Deposits are generally large, low to medium grade.

Archean-Proterozoic transition

The Archean-Proterozoic transition is marked by a fundamental change in tectonic style. The first small continental cratons emerged, and tectonism gradually contracted to narrow linear zones separating thicker, stable crustal areas. The continents grew by lateral cratonization of the intracratonic or marginal "mobile zones".

The Australian Proterozoic is characterized by large, stratiform, sediment-hosted base-metal sulfide deposits, and high-level structurally controlled hydrothermal deposits that are commonly polymetallic.

Early Proterozoic

The important mineral deposits of the Early Proterozoic are associated either with quartz-rich platform-cover sedimentary rocks of the first epicratonic basins, or with orogenic zones formed over thin primitive continental or oceanic crust. The metals present (mainly iron, uranium, gold, copper, and manganese) reflect the Archean crustal provenance. Volcanic exhalative base-metal deposits of the orogenic zones carry an increasing abundance of lead.

The North Australian Craton was formed from the stabilization of Early Proterozoic mobile zones now represented by the Halls Creek Province, The Granites-Tanami Block, and the Pine Creek, Arnhem, Murphy, and Tennant Creek Inliers.

In Western Australia, platform-cover sedimentary rocks were laid down in the Early Proterozoic Hamersley Basin, Nabberu Basin, and Ashburton Trough, and the Middle-Late Proterozoic Bangemall Basin. Mobile zones formed around the unstable margins of the Archean Yilgarn and Pilbara Cratons, and subsequently stabilized to form the Western Australian Craton. The mobile zones are preserved in the Early Proterozoic Gascoyne Province, the Early-Late Proterozoic Paterson Province, and the Middle-Late Proterozoic Northampton and Leeuwin Blocks and Albany-Fraser Province.

Platform cover

Hamersley Basin

The sedimentary group that is host to the Early Proterozoic Hamersley iron ore deposits in Western Australia comprises a sequence of five main BIFs separated by shale, limestone, and volcanic rocks that crop out over 100,000 km^2. The bulk of the ore resource occurs as hematite-enrichment bodies in the lower three BIFs. The ore zones are localized in structurally controlled sites and were apparently formed by a complex process of repeated supergene enrichment and structurally controlled metasomatic replacement at depth during burial metamorphism.

A small proportion of ore occurs as pisolitic limonitic ore, as at Deepdale (Deposit #208–fig. 2, table 1), which accumulated by the fixation of iron in meandering river beds that drained the Hamersley iron province during the Tertiary.

Typical dimensions of the larger deposits such as Mt. Whaleback (Deposit #185–fig. 2, table 1), Mt. Tom Price (Deposit #176–fig. 2, table 1), and Paraburdoo (Deposit #168–fig. 2, table 1) are strike length 5-7 km, width up to 1.5 km, and thickness 50-70 m. Such deposits contain about 150 million tonnes of ore grading 60-65 percent iron per km of strike length, or, in total, over 1,000 million tonnes of high-grade iron ore each.

Total resources of the Hamersley Basin are about 24,000 million tonnes. Large though the figure is, it probably represents less than 0.1 percent of the total original iron deposits in the basin, the remainder having been lost through erosion or still existing as unenriched BIF.

Supergene enrichment deposits of manganese occur at Mt. Rove (Deposit #233–fig. 2, table 1) and Ripon Hills (Deposit #237–fig. 2, table 1) (see Secondary manganese, p. 14).

Large deposits of crocidolite, an iron-rich variety of asbestos, are associated with altered BIF at Wittenoom (Deposit #199–fig. 2, table 1).

The Nabberu Basin and Ashburton Trough host significant stratabound gold-sulfide mineralization at Peak Hill (Deposit #157–fig. 2, table 1) and Horseshoe (Deposit #156–fig. 2, table 1). Minor vein base-metal deposits have been mined at Kooline (Deposit #162–fig. 2, table 1) and elsewhere.

Orogenic zones

Important mineral associations of the Early Proterozoic orogenic domains are: uranium, gold, copper, and iron associated with sedimentary black-shale host rocks; volcanic exhalative silver-lead-zinc; hydrothermal vein tin, tungsten, niobium, tantalum, and molybdenum; and gold, silver-lead, bismuth, and cobalt associated with late orogenic granite.

Granitoids and high-grade metasedimentary rocks of the Gascoyne Province have minor associated vein base-metal (Uaroo (Deposit #163–fig. 2, table 1)), uranium mineralization, skarn tungsten, and pegmatitic minerals.

Early Proterozoic metasedimentary rocks in the basement complex of the Paterson Province host unconformity-related uranium mineralization at Kintyre (Deposit #234–fig. 2, table 1) similar to uranium deposits of the Alligator Rivers Uranium Field (see Pine Creek Inlier, below). The overlying Late Proterozoic sedimentary rocks host stratabound gold and copper (see Late Proterozoic, p. 10).

The Halls Creek Province is a world-ranking diamond province, the main deposits being the high-grade Argyle (Deposit #8–fig. 2, table 1) and the lower grade Ellendale (Deposit #11–fig. 2, table 1) pipes. Emplacement of diamondiferous lamproites was controlled by major basement faults that were active from the Early Proterozoic to at least the end of the Paleozoic. Much of the resource at Argyle (Deposit #8–fig. 2, table 1), the first-mined material, was contained in alluvial deposits (see Alluvial diamonds, p. 14).

Subeconomic deposits of magmatic copper-nickel sulfides (Sally Malay (Deposit #9–fig. 2, table 1)), volcanogenic base metals (Koongie Park (Deposit #15–fig. 2, table 1)), volcanogenic REE (Mt. Brockman (Deposit #14–fig. 2, table 1)), and magmatic chromium-platinum also occur in the Halls Creek Province. Alluvial and vein gold in the province is largely only of historical interest.

The only economic mineral of The Granites-Tanami Inlier is gold (The Granites (Deposit #36–fig. 5, table 4), Tanami (Deposit #37–fig. 5, table 4)).

The Murphy Inlier contains minor hydrothermal vein deposits of uranium-gold (Pandanus Creek (Deposit #14–fig. 5, table 4)), tin-tungsten, and copper.

The Pine Creek and Tennant Creek Inliers are extensively mineralized, the former carrying deposits of uranium, copper, silver-lead-zinc, iron, gold, tin-tungsten-tantalum-molybdenum, and the latter gold-copper-bismuth, lead, zinc, and silver. Hatches Creek (Deposit #24–fig. 5, table 4) in the Davenport Geosyncline to the south of the Tennant Creek Inlier is an important tungsten field.

Pine Creek Inlier

The Pine Creek Inlier is notable as one of the world's largest and richest uranium provinces, containing the Alligator Rivers, South Alligator Valley, and Rum Jungle Uranium Fields. Uranium(-gold) deposits of the Alligator Rivers Uranium Field (Ranger (Deposit #3–fig. 5, table 4), Jabiluka (Deposit #1–fig. 5, table 4), Koongarra (Deposit #4–fig. 5, table 4), and Nabarlek (Deposit #2–fig. 5, table 4)) are stratabound in carbonaceous metasedimentary rocks close to the Early Proterozoic land surface. Mineralization is localized in breccia zones and in disseminations in pyritic shales, and is associated with intense chloritic alteration. Theories of ore genesis differ in detail, but the concensus view favors a multistage, low-temperature hydrothermal epigenetic model. Uranium-gold and gold-platinoid deposits at Coronation Hill (Deposit #7–fig. 5, table 4) in the South Alligator Valley Mineral Field occur in felsic volcanic and related sedimentary rocks at a higher stratigraphic level than the host rocks of the Alligator Rivers Uranium Field. The uranium-gold deposit has features of epigenetic sandstone-type uranium deposits.

The complex pattern of mineralization in the Rum Jungle Uranium Field is the product of overlapping of a series of mineral zones, which may reflect varying conditions during synsedimentary metal concentration. Uranium alone occurs in the north, successively replaced southward by uranium-cobalt-copper-lead-silver, copper, and lead-zinc-silver (Browns (Deposit #56–fig. 5, table 4), Woodcutters (Deposit #55–fig. 5, table 4)).

The Cullen Mineral Field and smaller fields in the Pine Creek Inlier contain economic vein and stratiform gold mineralization; for example, Enterprise (Deposit #41–fig. 5, table 4) and Cosmo Howley (Deposit #46–fig. 5, table 4). Tin-tungsten and base metals were historically important.

Tennant Creek Mineral Field

The Tennant Creek gold-copper-bismuth field encompasses six major mined deposits (Warrego (Deposit #15–fig. 5, table 4), Peko (Deposit #20–fig. 5, table 4), Nobles Nob (Deposit #17–fig. 5, table 4), Juno (Deposit #21–fig. 5, table 4), Orlando (Deposit #16–fig. 5, table 4), and Gecko (Deposit #18–fig. 5, table 4)) and about 120 smaller lodes, distributed over an area of 3,500 km^2. The mineralization is associated with lodes composed of quartz, hematite, and minor magnetite that have been emplaced in shears in a sedimentary and volcanic sequence.

A two-stage hydrothermal model of ore formation has been proposed: ironstone was formed by replacement of iron-rich sedimentary rocks during deformation; mineralization was introduced as a late-stage overprint on deformed magnetite lodes.

Middle Proterozoic

The Middle Proterozoic was notable for the formation of large sedimentary lead-zinc-silver sulfide deposits, which greatly overshadow the Archean volcanogenic base-metal deposits. The presence of sedimentary base-metal sulfides is directly related to the proliferation of life during the period, as formation of these deposits depends on the action of algae and bacteria in "fixing" sulfur in bottom sediment, typically deep-water black shale.

Organic activity was also instrumental in the development of thick carbonate (limestone and dolomite) sequences, formed partly from the accumulation of organic remains, in the shallow-water depositional zones. Carbonate rocks were loci for a variety of stratabound and vein mineralization, particularly of copper and uranium.

Other factors responsible for the richness and diversity of mineralization may include abundant felsic magmatism which could have provided both heat and metals, and extensive evaporitic carbonate sequences which would have favored formation of saline, oxidized basinal fluids with high metal-carrying capacity.

Iron and gold were still significant but waning in relative importance. Lead became proportionately more abundant in base-metal associations.

The evolution of the Australian continent became increasingly complex, with the opening up of rift zones between cratonic nuclei.

As the North Australian Craton was stabilized, platform-cover sediment accumulated in the Kimberley, Victoria River, Birrindudu, McArthur, and South Nicholson Basins. At the same time, the locus of orogenesis shifted eastward to the developing geosynclines now exposed in the Mt. Isa, Georgetown, Yambo, and Coen Inliers, and southward to the Gawler Craton and the concealed, inferred Curnamona Craton, subsequently stabilized to the north as the North East Orogens, and to the south as the Gawler Craton, Broken Hill Block, Mt. Painter and Peake-Denison Inliers, and the Wonominta Block.

The Broken Hill Block and equivalents were incorporated in a broad structural corridor consisting of a series of mainly east-trending intracratonic mobile zones, which were subjected to repeated episodes of intense deformation over a protracted period and not finally stabilized until the Late Proterozoic.

Platform cover

Mineral associations are predominantly stratabound: copper in mafic volcanic rocks and shoreline to continental-facies sedimentary rocks; lead-zinc-silver in black shale and carbonate associations; iron in nearshore marine-facies sedimentary rocks; and lead-zinc, copper, and uranium associated with regional unconformities.

Kimberley Basin

Iron-rich sedimentary rocks of the Kimberley Basin reach ore grade in Yampi Sound (Koolon Island (Deposit #2–fig. 2, table 1)). The orebodies are primary sedimentary deposits of detrital hematite and hematitic sandstone derived by reworking of ferruginous sediment.

Minor subeconomic stratabound copper deposits are widespread in basaltic volcanic rocks; fluorite-rich lead-zinc occurrences and subeconomic diamondiferous lamproite pipes have also been recorded.

Victoria River and Birrindudu Basins

Minor base metals and manganese occur in carbonate-rich units in the Victoria River Basin; subeconomic iron ore is known from hematite-rich sequences. Gold and copper occurrences are recorded from the Birrindudu Basin.

Bangemall Basin

Stratabound low-grade base-metal deposits in the Bangemall Basin (Jillawarra/Abra (Deposit #161–fig. 2, table 1)) are localized by fault structures. Minor subeconomic vein gold and base occurrences are also present.

McArthur Basin

The McArthur Basin and its southerly extension, the South Nicholson Basin, formed over a rapidly subsiding fault-bounded rift zone, allowing the accumulation of great thicknesses of sediment in a subgeosynclinal environment. Mineralization in the rift basins is essentially the unmetamorphosed equivalent of that in the extensively deformed Mt. Isa Inlier and multiply metamorphosed Broken Hill and equivalent blocks.

Stratiform lead-zinc mineralization is widespread in the McArthur Basin but reaches significant grades and dimensions only in the HYC (Here's Your Chance) (Deposit #12–fig. 5, table 4)) deposit and several smaller subjacent deposits.

The stratiform lead-zinc mineralization is close to but spatially distinct from stratabound brecciated carbonate-hosted copper mineralization.

Several small deposits of carbonate-hosted stratabound (Mississippi Valley-type) lead-zinc mineralization are also found in the McArthur Basin.

Other mineralization in the McArthur Basin includes a distinctive copper deposit in a volcanic breccia pipe (Redbank (Deposit #13–fig. 5, table 4)), silver-lead veins, uranium mineralization associated with dolerite-filled fault zones (Westmoreland

(Deposit #132–fig. 3, table 2)), and sedimentary iron deposits (Roper River (Deposit #11–fig. 5, table 4)).

Orogenic zones

In the Broken Hill and Mt. Isa provinces, stratiform lead-zinc-silver is the dominant mineral association. Other major minerals are copper, iron, uranium, tin, and tungsten; gold, cobalt, and manganese are locally important. In contrast, mineralization of the Gawler Craton is dominated by iron, copper, and gold, and in the Georgetown Inlier by copper and gold. Tin and tungsten are common in both the latter provinces.

The bulk of the lead, zinc, silver, and much of the copper of the Middle Proterozoic orogenic zones occurs in elongate stratiform sulfide deposits in black shale. Uranium, cobalt, gold, silver, and molybdenum, along with remobilized vein lead-zinc and copper, were introduced hydrothermally during metamorphism. In general, only the zones of secondary enrichment of the vein deposits have been of sufficient grade to be of economic interest. Tin and tungsten were deposited in pegmatites derived from late orogenic granite. Iron occurs as sedimentary deposits, minor except for the enriched ores of the Gawler Craton.

Mt. Isa Inlier

At Mt. Isa (Deposits #117 and 118–fig. 3, table 2), separate lead-zinc-silver and copper orebodies occur in pyritic and dolomitic black shale and siltstone at the top of a predominantly sandstone-volcanic succession.

Smaller lead-zinc-silver deposits occur at Hilton (Deposit #119–fig. 3, table 2), Dugald River (Deposit #120–fig. 3, table 2), and Lady Loretta (Deposit #125–fig. 3, table 2), and copper occurs at Mt. Oxide (Deposit #129–fig. 3, table 2).

Other styles of mineralization in the inlier include stratiform gold (Starra (Deposit #113–fig. 3, table 2)), and sediment-hosted, shear/fault-controlled skarn or pegmatitic deposits of gold, uranium, and cobalt, as well as manganese, cadmium, bismuth, tungsten, beryl, and mica.

Curnamona Province

The Broken Hill Block, the Mt. Painter and Peake-Denison Inliers, and the Wonominta Block are exposed remnants of a concealed inferred Middle Proterozoic craton (Curnamona Province).

The Wonominta Block carries minor copper mineralization; the Mt. Painter and Peake-Denison Inliers are more abundantly mineralized in copper, uranium (Mt. Painter (Deposit #2–fig. 6, table 5)), and gold.

The Broken Hill Block is extensively and diversely mineralized, carrying lead, zinc, silver, copper, tungsten, cobalt, tin, and lesser uranium, gold, iron, nickel, platinum, beryllium, bismuth, and barium. The extent and diversity of metallic mineralization increases southeastward with an increasing degree of metamorphism.

Mineralization displays a strong stratigraphic control. Mainly stratiform iron-copper-cobalt mineralization dominates in the lower levels of the sequence, stratiform and stratabound lead-silver-zinc-tungsten is the predominant association in the middle part, and chiefly transgressive tin mineralization is increasingly abundant in the upper levels.

The Broken Hill silver-lead-zinc deposit (Deposits-#86 and 87–fig.4, table 3) comprises six elongate, complexly deformed lodes: four zinc lodes, which lie at the southwestern end of the field, and two lead lodes, which are stratigraphically higher than the zinc lodes and are more evenly distributed along the length of the field. The lead lodes are distinguishable from each other by different metal contents and gangue-mineral assemblages.

Gawler Craton and Stuart Shelf

Early Proterozoic metasediment of the Early-Middle Proterozoic Gawler Craton contains iron ore deposits similar to but more deformed and metamorphosed than those of the Hamersley Basin in the Middleback Range (Deposit #41–fig. 6, table 5), South Australia. The deposits all lie at the same stratigraphic level in jaspilites and occupy synclinal keels of a strongly folded sequence.

The Olympic Dam (Deposit #55–fig. 6, table 5) copper-uranium-gold-silver deposit lies in Middle Proterozoic rocks concealed at depth beneath Late Proterozoic and Cambrian sequences of the Stuart Shelf. Mineralization is hosted by a breccia pipe in the upper level of a basement volcano-plutonic complex and is disseminated through a large volume of rock exceeding 20 km^2 in areal extent and up to 350 m thick. The deposit lies in a tectonic corridor, and features are consistent with ore formation by a complex interplay of hydrothermal, volcanogenic, sedimentary, and tectonic processes. Copper deposits occur in a similar environment at Mt. Gunson (Deposit #53–fig. 6, table 5).

Georgetown-Coen Province

The Georgetown-Coen Province comprises the Georgetown, Coen, and Yambo Inliers. The pattern of mineralization in the province is the product of several mineralizing episodes in the Proterozoic and Paleozoic. Proterozoic deposits include granite-hosted vein gold at Croydon (Deposit #131–fig. 3, table 2) and minor stratabound iron and base metals.

The Proterozoic mineral province is overprinted by more widespread Paleozoic igneous-associated mineral provinces that formed in the Cambrian-Ordovician, Silurian-Devonian, and Carboniferous-Permian (see Tasman Fold Belt, Queensland, p. 12)

Central Australian Mobile Belts

As a result of their long and complex deformational history, the Arunta and Musgrave Blocks are made up of complexly folded and faulted and intensely metamorphosed rocks. Gneissic granite is most extensive in the northern part of the Arunta Block, and a major layered mafic intrusive complex extends across the block in an east-trending zone related to deep-seated fracture systems.

The blocks are poorly mineralized by comparison with the orogenic belts of northern or northeastern Australia. Mineralization in the Arunta Block comprises numerous small granite-associated tin-tungsten-tantalum deposits (Molyhill (Deposit #29–fig. 5, table 4), vein and stratiform copper-lead-zinc deposits (Jervois (Deposit #26–fig. 5, table 4)), and gold deposits in highly deformed zones considered to have been formed during Paleozoic deformation (Artunga (Deposit #31–fig. 5, table 4)).

The main deposits of possible economic interest in the Musgrave Block are associated with the mafic intrusive rocks (for example, vanadium-bearing titaniferous magnetite and lateritic nickel).

Late Proterozoic

The Late Proterozoic was a time of worldwide consolidation of Precambrian cratons. In Australia the Precambrian cratons were consolidated with the final stabilization of the Central Australian Mobile Belts. A 10-km-thick craton cover sequence is preserved in the Adelaide Geosyncline, which formed over a platform downwarp between the Gawler and Curnamona Cratons.

Platform cover

Adelaide Geosyncline

The Adelaide Geosyncline is moderately mineralized, much of the mineralization having been introduced or reconcentrated during metamorphism. Copper is the major metal, occurring as stratiform sediment-hosted deposits (Burra (Deposit #16–fig. 6, table 5)) and in diapiric (pipe-like) intrusions at fault intersections. The belt is also a rich barite province (Oraparinna (Deposit #9–fig. 6, table 5)); deposits are vein type, or stratiform associated with limestone. Gold, lead, zinc, and silver are widely distributed but of minor importance. Altered limestone is a source of magnesite at Copley (Deposit #5–fig. 6, table 5), Balcanoona (Deposit #4–fig. 6, table 5), Robertstown (Deposit #22–fig. 6, table 5), and Mt. Fitton (Deposit #1–fig. 6, table 5).

Paterson Province

Late Proterozoic metasediment of the Paterson Province hosts stratabound ?epigenetic hydrothermal gold (Telfer (Deposit #235–fig. 2, table 1)) and copper (Nifty (Deposit #236–fig. 2, table 1)).

Late Proterozoic-Phanerozoic basins

At various times from the Late Proterozoic and through the Phanerozoic, large parts of the Australian continent were covered by vast intracratonic and epicratonic basins which extended offshore onto the continental shelf.

A Late Proterozoic-Cambrian sequence of sedimentary and minor volcanic rocks crops out over much of northwest Tasmania. At Savage River (Deposit-#21–fig. 7,table 6) , magnetite-pyrite deposits occur in a mafic volcanic-sediment association. Magnesite deposits are also found in this association.

Lead-zinc

In Western Australia, carbonate sequences in the Bonaparte and Canning Basins have emerged as a major Mississippi Valley-type lead-zinc province. Blendevale (Deposit #12–fig. 2, table 1) and the more recently discovered Cadjebut (Deposit #13–fig. 2, table 1) base-metal deposits are localized on faults on the Lennard Shelf, an area of shallowing sediments on the north margin of the Canning Basin. Sorby Hills (Deposit #7–fig. 2, table 1), in the Bonaparte Basin, occurs in a similar environment.

Phosphate rock

Australian sedimentary phosphate occurrences range in age from Cambrian to Tertiary but by far the largest are deposits hosted by Middle Cambrian rocks of the Georgina Basin. Some eighteen phosphorite deposits are known, the largest being Phosphate Hill (Deposit #112–fig. 3, table 2), Lady Annie (Deposit #126–fig. 3, table 2), Lady Jane (Deposit #128–fig. 3, table 2), D Tree (Deposit #127–fig. 3, table 2), and Wonarah (Deposit #22–fig. 5, table 4).

Ordovician marine sequences of the Amadeus Basin contain subeconomic phosphate deposits.

Secondary phosphate occurs in Early Cambrian limestone in the Kanmantoo Fold Belt; phosphatic sedimentary rocks occur in the Paleozoic rocks in east central Victoria.

Uranium

Devonian-Carboniferous sandstone hosts sub-economic roll-front-type uranium mineralization at Bigrlyi (Deposit #35–fig. 5, table 4) in the Ngalia Basin, and at Angela (Deposit #33–fig. 5, table 4) in the Amadeus Basin.

Proterozoic-Paleozoic transition

Stabilization of the Precambrian cratons in the Late Proterozoic heralded a fundamental change in tectonic style. Although the principal elements of the Precambrian geosynclinal cycle remained, their underlying tectonic controls are interpreted in terms of movement of discrete crustal plates about the earth's surface. Collision boundaries between plates (the island-arc environment) and rift zones within plates were the sites of development of the Phanerozoic mobile belts. The complex nature of interaction at the plate margins, coupled with a mature crustal source, fostered great diversity in patterns of mineralization.

Phanerozoic metallic mineralization is predominantly igneous-associated. Volcanic exhalative base metals and high-level granite-associated hydrothermal ores comprise the bulk of metallic mineralization of Australian Paleozoic rocks.

Paleozoic fold belts

Consolidation of the Australian Proterozoic cratons was followed by development of the composite Tasman Fold Belt System, which cratonized progressively northward and eastward during the Paleozoic. The oldest belts are the Kanmantoo Fold Belt, South Australia, and the Dundas Trough, Tasmania, which stabilized during sedimentation in the younger easterly-developing Lachlan Fold Belt and Hodgkinson Basin, which in turn stabilized while sedimentation commenced farther east in the youngest block, the New England Fold Belt.

Tasman Fold Belt, South Australia

The Tasman Fold Belt is represented in South Australia by the Kanmantoo Fold Belt, a deep basin that transected the southern part of the Adelaide Geosyncline.

Copper mineralization predominates, occurring as stratiform sulfides in slightly metamorphosed pyritic shale (Kanmantoo (Deposit #25–fig. 6, table 5)), and in younger remobilized vein deposits. Smaller iron, gold, silver, lead, zinc, uranium, arsenic, mercury, and barium vein deposits also occur.

Lachlan Fold Belt, Tasmania

In Tasmania, the main Paleozoic fold belt, the Dundas Trough, developed over an extension of the Precambrian basement, between the Tyenna and Rocky Cape Blocks. Deep trough sequences were deposited in northeastern Tasmania at a slightly later stage.

The Dundas Trough formed as a deep marine basin flanked to the east by a volcanic island chain. Ultramafic bodies that intrude the trough sequence have been mined for nickel (the only Australian source prior to Kambalda, Western Australia), gold, osmiridium, and asbestos. Large deposits of volcanogenic massive sulfides (zinc-lead-copper-silver-gold) occur at Rosebery (Deposit #13–fig. 7, table 6), Que River (Deposit #11–fig. 7, table 6), Hercules (Deposit #17–fig. 7, table 6), and Hellyer (Deposit #10–fig. 7, table 6); volcanic-associated iron-copper-gold occur at Mt. Lyell (Deposit #14–fig. 7, table 6).

Major tin and tungsten and minor bismuth and molybdenum mineralization are associated with late orogenic granite which was emplaced extensively throughout Tasmania in the Devonian-Carboniferous. The granites in western Tasmania and in northeastern Tasmania have different styles of associated mineralization. Vein tin-tungsten deposits (Aberfoyle-Storeys Creek (Deposit #9–fig. 7, table 6)) are numerous in northeastern Tasmania, but are smaller than the major carbonate replacement tin orebodies such as Renison (Deposit #16–fig. 7, table 6), Cleveland (Deposit #20–fig. 7, table 6), Mt. Bischoff (Deposit #22–fig. 7, table 6), and the tungsten skarn orebodies of King Island (Deposit #23–fig. 7, table 6) and Kara (Deposit #1–fig. 7, table 6), which dominate the granite-associated mineralization of western Tasmania.

Polymetallic silver-lead-zinc vein deposits around centers of Devonian tin mineralization (North Mt. Farrell (Deposit #12–fig. 7, table 6)) have been historically important. Vein gold deposits (Beaconsfield (Deposit #3–fig. 7, table 6)) have also been mined, mainly in northern Tasmania.

Lachlan Fold Belt, Victoria

The Victorian part of the Lachlan Fold Belt contained Australia's largest Paleozoic accumulation of gold, the bulk concentrated in the east half of the Ballarat Trough (Stawell (Deposit #21–fig. 7, table 7)). The lode gold occurs mainly as structurally controlled quartz veins or reefs in Cambrian to Early Devonian volcanic and sedimentary rocks and dykes intruding them, with the bulk of mineralization concentrated in black pyritic shales of Ordovician age. Reefs are located in strike faults or in faulted fold crests–the famous "saddle reefs" of Bendigo (Deposit #1–fig. 7, table 7) and elsewhere. Approximately 60 percent of the historical production from the Victorian goldfields was taken from rich

Tertiary alluvial deposits concentrated by weathering and erosion of the lode gold ores.

Volcanic exhalative base-metal sulfide deposits (Currawong (Deposit #7–fig. 7, table 7), Wilga (Deposit #6–fig. 7, table 7)) are associated with felsic volcanic rocks and shallow marine sedimentary rocks in fault-bounded rifts.

Lachlan Fold Belt, New South Wales

The Lachlan Fold Belt in New South Wales consists of six main pairs of north-trending synclinorial-anticlinorial belts that have been variably affected by up to five orogenic events. Similar patterns of mineralization are repeated in the tectonic belts across the fold belt, but the density of mineralization is highly variable. For example, most of the stratiform base-metal sulfide deposits occur in two synclinorial zones, the Cobar and Captain's Flat-Goulburn Troughs. The granite batholiths that form the Snowy Mountains are poorly mineralized, whereas major breccia vein deposits of tin (Ardlethan (Deposit #64–fig. 4, table 3), tungsten, gold, and other minerals are associated with granite farther west.

Serpentinite belts host deposits of chromium (Coolac (Deposit #59–fig. 4, table 3)), platinum (Fifield (Deposit #70–fig. 4, table 3)), iron-copper-nickel sulfides, manganese, mercury, and magnesite (Thuddungra (Deposit #61–fig. 4, table 3) and Fifield (Deposit #71–fig. 4, table 3)).

Volcanogenic copper-iron sulfides (Girilambone (Deposit #77–fig. 4, table 3)) occur in deformed Ordovician flysch sequences.

Mafic to intermediate Ordovician-Silurian volcanic rocks host gold mineralization of several types: epithermal deposits (Gidginbung (Deposit #63–fig. 4, table 3)), structurally controlled vein gold, and porphyry copper-gold (Goonumbla (Deposit #69–fig. 4, table 3)). Many of the volcanic-associated deposits are close to a regional tectonic lineament that is also the locus of other styles of gold mineralization: associated with granitoids (Adelong (Deposit #60–fig. 4, table 3) and West Wyalong (Deposit #65–fig. 4, table 3)), and associated with high-level intrusive rocks.

Stratabound volcanic exhalative auriferous base-metal sulfide deposits lie within Silurian rift or basin felsic volcanic sequences (Woodlawn (Deposit #55–fig. 4, table 3), Captains Flat (Deposit #56–fig. 4, table 3), Mineral Hill (Deposit #73–fig. 4, table 3), Galwadgere (Deposit #41–fig. 4, table 3)). Barite deposits are associated with felsic volcanic rocks at Kempfield (Deposit #50–fig. 4, table 3).

Stratabound vein, disseminated, pipe, and skarn mineralization is widespread, associated with Silurian-Devonian, and to a lesser extent Carboniferous, late orogenic granites. Roughly in order of historical importance, the metals are gold, tin, tungsten, molybdenum, copper, lead, zinc, silver, arsenic, and bismuth. At Ardlethan (Deposit #64–fig. 4, table 3), porphyry tin-style cassiterite-sulfide mineralization is disseminated through a zone of altered and brecciated biotite granite. Skarn or hydrothermal gold deposits have been developed at Sheahan-Grants (Deposit #49–fig. 4, table 3).

Epithermal gold deposits occur in Devonian felsic volcanic rocks at several localities.

Stockwork and massive sulfide deposits hosted by Devonian fine-grained sedimentary rocks in the Cobar Trough (CSA (Deposit #80–fig. 4, table 3), Great Cobar (Deposit #82–fig. 4, table 3), Elura (Deposit #81–fig. 4, table 3), New Occidental/Chesney/New Cobar (Deposit #79–fig. 4, table 3)) have been major producers of copper and gold, and significant producers of silver, lead, and zinc.

Structurally controlled vein-gold deposits occur in deformed flysch sequences (slate belt-type deposits) at Cowarra (Deposit #57–fig. 4, table 3) and Hill End (Deposit #42–fig. 4, table 3).

Tasman Fold Belt, Queensland

Similar patterns of mineralization are displayed in the Tasman Fold Belt in Queensland, which comprises the Thomson Fold Belt, Hodgkinson Basin, and Broken River Embayment. The Thomson Fold Belt is exposed in the Anakie Inlier, Lolworth-Ravenswood Block, and transitional tectonic basins Drummond Basin, Burdekin Basins, and smaller basins.

Volcanogenic massive sulfides occur at Thalanga (Deposit #56–fig. 3, table 2) and Liontown (Deposit #57–fig. 3, table 2) in the Lolworth-Ravenswood Block, and at Dianne (Deposit #11–fig. 3, table 2) in the Hodgkinson Basin. The Hodgkinson Basin hosts historically productive synmetamorphic quartz vein-type gold deposits and associated alluvial placers (Palmer River (Deposit #10–fig. 3, table 2)).

The major mineralization comprises abundant small but rich granite-associated ore deposits of diverse types. The deposits are associated with widespread late orogenic high-level igneous activity that affected the entire Hodgkinson Basin and Broken River Embayment, and also adjacent areas of the Lolworth-Ravenswood Block and Drummond and Burdekin Basins, and the Proterozoic Georgetown and Yambo Inliers.

High-grade veins, pipes, and skarns are abundant in contact zones of composite granite, and rich alluvial deposits derived from the hard-rock lodes are widespread: tin, tungsten, molybdenum, and bismuth occur at Herberton (Deposit #29–fig. 3, table 2), Kangaroo Hills/Ewan (Deposit #46–fig. 3, table 2), Wolfram Camp (Deposit #26–fig. 3, table 2), Mt. Carbine (Deposit #17–fig. 3, table 2), and Bamford Hill (Deposit #27–fig. 3, table 2), and gold at Charters Towers (Deposit #53–fig. 3, table 2). Gold is disseminated in subvolcanic breccia pipes at Kidston (Deposit #41–fig. 3, table 2) and Mt. Leyshon

(Deposit #54–fig. 3, table 2), and in skarn at Red Dome (Deposit #22–fig. 3, table 2). Epithermal gold deposits occur at Pajingo (Deposit #59–fig. 3, table 2), Wirralie (Deposit #63–fig. 3, table 2), and Mt. Coolon (Deposit #64–fig. 3, table 2) in the Drummond Basin.

Other mineralization includes stockworks of porphry copper(-molybdenum), vein deposits of uranium (Maureen (Deposit #34–fig. 3, table 2)), vein and skarn deposits of base metals, and volcanogenic base metals (Balcooma (Deposit #42–fig. 3, table 2)).

New England Fold Belt, New South Wales

The important deposits of the New South Wales portion of the New England Fold Belt comprise pervasive vein and replacement mineralization associated with extensive igneous activity.

Complexly zoned veins, pipes, and skarns surrounding high-level granitic rocks carry a diversity of metal associations. The general progression of metals in vein sequences is molybdenum, bismuth, tungsten, tin, antimony, gold, arsenic, copper, lead, zinc, and silver. Some associations are antimony-gold-silver-arsenic (Hillgrove (Deposit #32–fig. 4, table 3)), tin-tungsten-arsenic-silver, tungsten-molybdenum-bis-muth, and tin-molybdenum-antimony-arsenic. Vein and stockwork gold-silver mineralization occurs at Drake (Deposit #16–fig. 4, table 3).

Asbestos (Woodsreef (Deposit #5–fig. 4, table 3)), chromite, and magnesite are associated with serpentinite belts.

New England Fold Belt, Queensland

Volcanogenic sulfides are represented by Mt. Morgan (Deposit #76–fig. 3, table 2) and Mt. Chalmers (Deposit #74–fig. 3, table 2) gold-copper deposits.

Subvolcanic stockwork and disseminated porphyry copper(-molybdenum)(-gold) mineralization is also abundant, although mostly in small subeconomic deposits. The Cracow (Deposit #85–fig. 3, table 2) and Mt. Rawdon (Deposit #89–fig. 3, table 2) gold deposits are of this type, while at Gympie (Deposit #94–fig. 3, table 2) gold originated as a sediment-hosted deposit, possibly also related to volcanic activity.

Cenozoic platform cover and regolith deposits

Manganese

A world-ranking manganese province extends over an area of 150 km^2 in Groote Eylandt (Deposit #9–fig. 5, table 4), Northern Territory. The deposit occurs as a single, relatively flat sedimentary unit, averaging 3 to 4 m thick, within a Cretaceous sequence of shallow-marine sandstone and claystone.

Regolithic deposits

The regolith or weathering profile hosts many mineral deposits of economic significance. Deposits in laterite profiles include bauxite (Weipa (Deposit #3–fig. 3, table 2)), nickel-cobalt (Greenvale (Deposit #44–fig. 3, table 2)), gold (Boddington (Deposit #107–fig. 2, table 1)), and iron ore (Yandicoogina (Deposit #192–fig. 2, table 1)). Supergene enrichment has upgraded deposits of iron ore (Hamersley Basin), gold, phosphate-REE (Mt. Weld (Deposit #43–fig. 2, table 1)), silver-lead-zinc (Zinc Corporation/New Broken Hill (Deposit #87–fig. 4, table 3) gossans), and copper (secondary copper deposits in Mt. Isa Inlier). Another form of supergene enrichment is shown by the paleochannel calcrete uranium deposits of Western Australia (Yeelirrie (Deposit #20–fig. 2, table 1)) and South Australia (Honeymoon (Deposit #13–fig. 6, table 5)). Placer or alluvial deposits contain large resources of heavy mineral sands (Adamson (Deposit #127–fig. 2, table 1) and Fraser Island (Deposit #92–fig. 3, table 2)), diamonds (Argyle (Deposit #8–fig. 2, table 1) and Copeton (Deposit #8–fig. 4, table 3)), gold (Bendigo (Deposit #1–fig. 7, table 7) and Ballarat (Deposit #16–fig. 7, table 7) deep leads), tin, platinoids (Fifield (Deposit #70–fig. 4, table 3)), silica sand, and a variety of gemstones (Anakie (Deposit #66–fig. 3, table 2)). Other regolithic minerals include evaporites–for example, gypsum (Lake MacDonnell (Deposit #51–fig. 6, table 5) and Shark Bay (Deposit #152–fig. 2, table 1))–and precipitates–for example, opal (Yowah-Black Gate (Deposit #102–fig. 3, table 2), Andamooka (Deposit #54–fig. 6, table 5), and Lightning Ridge (Deposit #1–fig. 4, table 3)).

Mineral sands

For approximately 1,000 km from Fraser Island off the southeast Queensland coast to the mouth of the Hawkesbury River in New South Wales, the east coast of Australia is fringed by heavy-mineral-bearing sand beaches, plains, and dunes. In Western Australia, heavy-mineral-bearing beach and dune sands extend intermittently from about 270 km north of Perth to the far southwestern tip of the state.

The heavy-mineral components of economic interest are the titanium-bearing oxide minerals ilmenite and rutile, the refractory mineral zircon, and monazite.

Australian deposits occur both on present-day beaches and in the ancient strandlines farther inland. In Western Australia, a series of mineralized fossil shorelines have been mined along the Swan Coastal Plain. The inner shorelines lie up to 60 km inland. By contrast, the bulk of eastern Australia's deposits are on present-day beaches.

Tertiary sands of the Murray Basin in Victoria have recently been shown to host extensive, although mostly low-grade, mineral-sand deposits at depth, the largest deposit being WIM 150 (Deposit #22–fig. 7, table 7).

Bauxite

Australia's most important regolithic mineral is bauxite. Large world-class deposits occur in the Darling Range and at Cape Bougainville and Mitchell Plateau in Western Australia, at Gove in the Northern Territory, and at Weipa and Aurukun in Queensland.

Major bauxite deposits cap Archean rocks of the Yilgarn Block in the Darling Range-Mt. Saddleback region (Jarrahdale (Deposit #110–fig. 2, table 1), Del Park/ Huntly (Deposit #108–fig. 2, table 1), and Willowdale (Deposit #104–fig. 2, table 1)). The basement rocks are mainly granite and gneissic granite, with zones of metamorphic, volcanic, and sedimentary rocks, densely cut by dolerite dikes. The bauxite ore is localized in pockets within the extensive laterite cover.

The Kimberley Basin bauxite deposits, Cape Bougainville (Deposit #6–fig. 2, table 1) and Mitchell Plateau (Deposit #5–fig. 2, table 1), cap basic volcanic and interbedded sedimentary rocks. Although they are higher grade than the Darling Range deposits, their economic viability is relatively diminished by the absence of established infrastructure and the remoteness of the Kimberley region.

The Gove (Deposit #5–fig. 5, table 4) bauxite deposit formed over Mesozoic sandstone which overlies Precambrian crystalline basement. The ore shows evidence of having been eroded from high areas and redeposited in low areas.

The Weipa (Deposit #3–fig. 3, table 2), Aurukun (Deposit #1–fig. 3, table 2), and other bauxite deposits of the Carpentaria Basin were formed during several lateritic weathering events over a bedrock of Tertiary sandstone and siltstone.

Surficial uranium

Uranium in the form of carnotite is widespread in calcreted trunk valleys of Tertiary drainage systems that are present over large areas of southwestern and southern Australia. Significant mineralization is restricted to areas in the northern part of the Yilgarn Block (Yeelirrie (Deposit #20–fig. 2, table 1) and Lake Way (Deposit #18–fig. 2, table 1)) and the Frome region of South Australia (Beverley (Deposit #3–fig. 6, table 5) and Honeymoon (Deposit #13–fig. 6, table 5)). The distribution of high-grade uranium concentrations is controlled by the proximity to a uranium-enriched provenance, and to interaction of climatic, hydrologic, and geomorphic factors. Three types of deposits are distinguished: valley, playa, and terrace deposits.

Lateritic nickel

The Greenvale (Deposit #44–fig. 3, table 2) orebody in Queensland comprises a series of terraced residual weathering mantles over serpentinite.

Secondary manganese

Secondary manganese deposits are extensive in the eastern parts of the Hamersley and Bangemall Basins, Western Australia (Ripon Hills (Deposit #237–fig. 2, table 1) and Mt. Rove (Deposit #233–fig. 2, table 1)). Manganese was apparently concentrated in two stages of supergene enrichment, the first during the Proterozoic, the second in the Tertiary.

Alluvial diamonds

Minor occurrences are widespread. Economic deposits are associated with diamondiferous pipes in the Halls Creek Province of Western Australia; for example, alluvial diamonds in gravel in Cenozoic drainage channels downstream from the Argyle (Deposit #8–fig.-2, table 1) primary lamproite source.

Opal

The main fields are in central Queensland (Opalton-Mayneside (Deposit #110–fig. 3, table 2) to Yowah-Black Gate (Deposit #102–fig. 3, table 2)), northern New South Wales (White Cliffs (Deposit #84–fig. 4, table 3) and Lightning Ridge (Deposit #1–fig. 4, table 3)), and northern South Australia (Andamooka (Deposit #54–fig. 6, table 5), Coober Pedy (Deposit #58– fig. 6, table 5), and Mintabie (Deposit #60–fig. 6, table 5)).

Sapphire

Australian sapphire deposits are concentrated in the New England Fold Belt (Glen Innes (Deposit #26–fig. 4, table 3) and Inverell (Deposit #27–fig. 4, table 3), New South Wales, and Anakie (Deposit #66–fig. 3, table 2), Queensland) in the alluvium of creeks in areas where Tertiary basalt and pyroclastic rocks cap Paleozoic granite-metasediment-felsic volcanic terrain.

NEW ZEALAND

By
R. L. Brathwaite

The New Zealand microcontinent, embracing the North and South Islands and many outlying islands together with the surrounding continental shelf, shows considerable variety in its geology and associated mineral deposits. This variety has resulted from a geologic history of sustained tectonic activity at the mobile margin of the Pacific Ocean that started in the early to middle Paleozoic (Tuhua Orogeny) and has continued in the Mesozoic (Rangitata Orogeny) and Cenozoic (Kaikoura Orogeny). These orogenic cycles are represented by three main structural elements: the Paleozoic Tuhua Orogen, the late Paleozoic and Mesozoic "geosynclinal" terranes of the Rangitata Orogen, and Cenozoic sedimentary and volcanic rocks of the Kaikoura Orogen.

The metallic mineral deposits are localized into several metallogenic districts and provinces that include: Hauraki epithermal gold-silver; West Coast North Island titanomagnetite ironsands; West Coast South Island ilmenite beach sands; Westland gold placers; Reefton gold-quartz lodes; and Otago gold-scheelite-quartz lodes and gold placers. Comprehensive accounts of mineral deposits in New Zealand are given in Williams (1974) and Kear (1989), and recent reviews are by Pirajno (1980), Brathwaite and Pirajno (1985), and Brathwaite (1989). Gold deposits dominate in number and economic value (Brathwaite and others, 1986).

Tuhua Orogen

The Tuhua Orogen of western South Island is a fragment of Gondwana and its geology and metallogeny show a broad similarity to the Tasman Orogenic Zone of eastern Australia. It consists of several tectono-stratigraphic terranes composed dominantly of marine sedimentary rocks of Cambrian to Devonian age (Cooper, 1989) that have been deformed and metamorphosed, and intruded by granitoid and gabbroic rocks.

A quartzose greywacke terrane of Ordovician age is host to shear-zone gold-quartz lodes in west Nelson-Westland at Golden Blocks (Deposit #54–fig. 8, table 8), Lyell (Deposit #51–fig. 8, table 8), and Reefton (Deposit #47–fig. 8, table 8), and in Fiordland at Preservation Inlet (Deposit #36–fig. 8, table 8). The Reefton field was by far the largest producer and the lodes are localized along shear zones parallel to fold axes in weakly metamorphosed greywacke.

In northwest Nelson a Cambrian island-arc volcanic-sedimentary assemblage contains an ultramafic-mafic complex with associated chrysotile asbestos and talc-magnesite deposits (Cobb (Deposit #24–fig. 8, table 8)).

The main deformation phase of the Tuhua Orogeny in the Middle to Late Devonian was associated with intrusion of extensive S-type granites, but mineralization is confined to minor scheelite veins. A Late Devonian mafic-ultramafic intrusion in northwest Nelson contains magmatic cumulate nickel-copper sulfides with minor platinum group metals.

In the Jurassic to Early Cretaceous the Tuhua Orogen was intruded, mainly along its eastern side, by I-type granitoids (Tulloch, 1983).

Small stocks of granodiorite in west Nelson are associated with porphyry-style molybdenum mineralization at Karamea Bend (Deposit #52–fig. 8, table 8), and with a copper skarn at Copperstain Creek (Deposit #23–fig. 8, table 8). An altered alkali granite dike hosts vein and disseminated gold-arsenopyrite-pyrite-quartz mineralization in the Nelson area.

Rangitata Orogen

The Rangitata Orogen is in tectonic contact with the Tuhua Orogen to the west and is made up of an assemblage of tectonostratigraphic terranes that vary and overlap in age from Carboniferous to Early Cretaceous (Coombs and others, 1976; Bishop and others, 1985). These terranes are predominantly composed of quartzofeldspathic and volcaniclastic greywacke. They also contain several ophiolite belts and an extensive zone of regionally metamorphosed schist.

A belt of ophiolite of Permian age extends discontinuously from Nelson to Otago and consists of fault-bounded lenses of serpentinized peridotite, gabbro, spilitic lava, volcaniclastic breccia, and tectonic melange. At Dun Mountain (Deposit #26–fig. 8, table 8) in Nelson, podiform chromite is contained in serpentinized dunite at the top of a basal peridotite zone. In northwest Otago, chrysotile asbestos deposits occur at Pyke River (Deposit #42–fig. 8, table 8) in serpentinized zones marginal to massive peridotite bodies.

The extensive quartzofeldspathic greywacke terrane of the axial ranges of both the South and North Islands is mainly Triassic, Jurassic, and Early Cretaceous in age, and is dominantly composed of greywacke and argillite, with minor basaltic lava and tuff, chert, and limestone.

Mineralization is sparse; at Maharahara (Deposit #13–fig. 8, table 8) a stratiform pyrite-chalcopyrite lens is hosted by red chert in a volcaniclastic argillite-sandstone unit.

Several Permian to Jurassic terranes are composed of volcaniclastic greywacke with minor basaltic volcanic rocks and chert. Small stratiform manganese deposits, associated with chert and basaltic volcanic rocks, are widely distributed in Northland and south Auckland as at Otau (Deposit #18–fig. 8, table 8). At Kawau Island (Deposit #4–fig. 8, table 8), north of Auckland, a stratiform pyrite-chalcopyrite lens is hosted in chert and argillite with spilitic lava at the base of the local sequence.

In Otago, Westland, and Marlborough the greywacke terranes are regionally metamorphosed to pumpellyite-actinolite and greenschist facies schist grading to amphibolite facies gneiss in Westland. At Wakamarina (Deposit #25–fig. 8, table 8) in Marlborough, quartzofeldspathic schist contains veins of quartz with gold and scheelite in a shear zone. Similar gold-scheelite lodes occur throughout the Otago region, most notably at Macraes (Deposit #31–fig. 8, table 8), Bendigo (Deposit #28–fig. 8, table 8), and Glenorchy (Deposit #41–fig. 8, table 8). All of these deposits were probably formed from metamorphic dewatering fluids during the postmetamorphic uplift of the schist in the Cretaceous (Paterson, 1986).

In the Mid Cretaceous to early Tertiary, the New Zealand microcontinent was separated from Antarctica and southeast Australia by the opening of the Southern Ocean and Tasman Sea. This extensional phase is represented on the South Island by intraplate igneous activity and rift basins, which contain sandstone-type uranium mineralization in arkosic sandstone and granite breccia beds at Buller Gorge (Deposit #50–fig. 8, table 8), west Nelson, and placer gold in quartz conglomerate at Gabriels Gully (Deposit #33–fig. 8, table 8) in Otago.

Kaikoura Orogen

The still-continuing Kaikoura Orogeny commenced in the middle Tertiary with the establishment through the New Zealand region of the boundary between the Pacific and Indian-Australian Plates. The present-day plate boundary extends southward from the Tonga-Kermadec Trench as a subduction zone with an associated continental-margin volcanic arc (Taupo Volcanic Zone) through a transform fault zone (including the Alpine Fault) to link with the Macquarie Ridge south of New Zealand.

An early Miocene obduction event in Northland is represented by the tectonic emplacement of allochthonous sheets of Cretaceous to early Tertiary marine sedimentary rocks and ophiolite. At Pakotai (Deposit #20–fig. 8, table 8), Cretaceous mudstone, interbedded with tuff and basalt, is host to small Cyprus-type massive sulfide bodies.

The giant gold-placer fields of Westland and Otago were formed by erosion and reworking during several depositional cycles that culminated with Quaternary fluvioglacial and alluvial gravel. Most of the Cenozoic placer gold was originally derived from erosion of gold-bearing rocks of the Tuhua and Rangitata Orogens. Miocene and Pliocene gravel, commonly associated with coal measures or lignite, are gold-bearing, as at St. Bathans (Deposit #29–fig. 8, table 8) and Naseby (Deposit #30–fig. 8, table 8) in Otago. The extensive Quaternary gold placers are represented by deposits such as Collingwood (Deposit #22–fig. 8, table 8) in northwest Nelson; Grey Valley, (Deposit #46–fig. 8, table 8), Taramakau-Greenstone/Kumara (Deposit #45–fig. 8, table 8), Rimu-Kaniere (Deposit #44–fig. 8, table 8), and Ross (Deposit #43–fig. 8, table 8) in Westland; Shotover (Deposit #40–fig. 8, table 8), Nevis (Deposit #38–fig. 8, table 8), and Clutha (Deposit #39–fig. 8, table 8) in Otago; and Waikaka (Deposit #34–fig. 8, table 8) in Southland. At Round Hill-Orepuki (Deposit #35–fig. 8, table 8) in western Southland, gold with minor platinum-group metals occurs in late Quaternary placers derived from erosion of a mafic-ultramafic complex.

The west coasts of both main islands contain extensive late Quaternary black-sand shoreline deposits. On North Island, the erosion of Quaternary andesite and rhyolite volcanic rocks has led to the formation of titanomagnetite deposits at numerous locations along 480 km of coastline; those at Muriwai (Deposit #19–fig. 8, table 8), Waikato North Head (Deposit #17–fig. 8, table 8), Raglan North Head (Deposit #16–fig. 8, table 8), Taharoa (Deposit #15–fig. 8, table 8), and Waipipi (Deposit #14–fig. 8, table 8) are the largest. On South Island, metamorphic rocks of the Rangitata Orogen along the Southern Alps are the main source of ilmenite-garnet(-gold) concentrations at intervals along 320 km of coastline, as at Karamea North (Deposit #53–fig. 8, table 8), Carters Beach/Nine Mile Beach/Westport (Deposit #49–fig. 8, table 8), and Barrytown Beach (Deposit #48–fig. 8, table 8).

Subduction-related continental-margin volcanism commenced in the early Miocene in Northland and progressed southeast with time through the Coromandel Volcanic Zone in the Miocene and Pliocene to the active Taupo Volcanic Zone. The Coromandel Volcanic Zone hosts the Hauraki Goldfield, a major epithermal gold-silver province containing some 50 deposits within a 200-km by 40-km belt (Christie and Brathwaite, 1986). Jurassic greywacke of the Rangitata Orogen forms the basement of a subaerial volcanic sequence, consisting predominantly of andesite-dacite volcanism in the Miocene and mainly rhyolite volcanism in the late Miocene to early Pliocene. Diorite porphyry, which occurs locally as an intrusive phase of the Miocene andesite, is associated with porphyry copper mineralization, as at Miners Head (Deposit #3–fig. 8, table 8) on Great Barrier Island. The epithermal deposits consist of extensional quartz veins and hydrothermal breccia carrying electrum, acanthite, and generally minor base-metal sulfides. Wall-rock alteration is characterized by adularia-sericite alteration bordering the veins, grading out to propylitic and argillic alteration. The majority of the deposits, although hosted by andesite, are associated with hydrothermal activity related to the rhyolitic volcanism. The largest historic producers were Coromandel (Deposit #5–fig. 8, table 8), Kuaotunu (Deposit #6–fig. 8, table 8), Thames (Deposit #7–fig. 8, table 8), Waihi (Deposit #8–fig. 8, table 8) (the giant of the field), and Muirs Reefs

(Deposit #11–fig. 8, table 8). The Tui (Deposit #9–fig. 8, table 8) deposit has been mined for lead, zinc, and copper.

Mercury mineralization is found in eastern Northland, as at Puhipuhi (Deposit #2–fig. 8, table 8) and Ngawha (Deposit #21–fig. 8, table 8), where cinnabar occurs in Pliocene or Holocene siliceous-sinter deposits associated with fossil or still active hot springs.

A low-grade bauxite deposit at Otoroa (Deposit #1–fig. 8, table 8) in Northland is the product of subtropical weathering of Pliocene to early Quaternary basalt.

The Quaternary Taupo Volcanic Zone contains rhyolite, dacite, and andesite volcanoes, and active geothermal systems that provide examples of currently forming epithermal gold-silver and base-metal sulfide deposits, and also stratiform sulfur in lake beds occupying a hydrothermal explosion crater at Lake Rotokaua (Deposit #12–fig. 8, table 8). Fumarolic sulfur deposits occur in the crater of the active andesite volcano on White Island (Deposit #10–fig. 8, table 8).

FIJI

By
W. D. Palfreyman

Fiji occupies a tectonic position at the northeastern corner of the Australia-India Plate between the Vanuatu subduction zone at the west and the Tonga-Kermadec subduction zone at the east. Geologically, only rocks of Tertiary or Quaternary age are exposed. These can be divided in three: a preorogenic period (late Eocene to middle Miocene), an orogenic period (late Miocene), and a postorogenic period (late Miocene to Holocene) (Colley and Greenbaum, 1980; Greenbaum, 1980).

Preorogenic period

Rocks of this period are found in the west, south, and central parts of the island of Viti Levu and in the islands of the Yasawa Group to the northwest. Here the late Eocene basement consists of interbedded volcaniclastic rocks, basaltic to intermediate lavas, and limestone metamorphosed to zeolite or greenschist facies. These rocks are overlain by early to middle Miocene shallow volcaniclastic and epiclastic sedimentary rocks, limestone, and volcanic rocks.

The main examples of mineralization in these preorogenic rocks are manganese deposits in western Viti Levu at Nabu/Vunamoli (Deposit #10–fig. 9, table 9) and Nasaucoko (Deposit #11–fig. 9, table 9). These were formed by exhalative processes controlled by faulting and were later modified by supergene enrichment. Copper, zinc, and lead mineralization occurs at several localities in eastern Viti Levu, notably at Wainivesi (Deposit #7–fig. 9, table 9). Here massive stratabound sulfide lodes, probably of exhalative origin, occur in a sequence of felsic to mafic volcanic and derived volcaniclastic rocks.

Orogenic period

During the late Miocene the preexisting basement was folded, metamorphosed, and intruded by intermediate to mafic intrusive rocks. Minor vein, skarn, limestone replacement, and disseminated deposits had their origins in this activity.

Postorogenic period

Following the orogenic period, volcanic activity and volcaniclastic and some epiclastic sedimentation became widespread. On Viti Levu, mafic to intermediate lavas and associated volcaniclastic rocks were deposited while similar sequences formed the basement of the islands of the Lau Group and of Vanua Levu. On the latter island these rocks are overlain in turn by felsic flows and derived sedimentary rocks. During the Pliocene and into the Holocene, ocean-island mafic lavas have dominated igneous activity throughout the Fijian chain.

Rocks of the postorogenic period contain the main economic deposits so far found in Fiji and are thus the most prospective group for unidentified resources. Disseminated porphyry-type mineralization occurs in high-level volcanic-intrusive complexes in southern and northwestern Viti Levu. The main deposit is at Waisoi (Deposit #8–fig. 9, table 9) where copper with some molybdenum, gold, and silver is found in intermediate lavas and derived sediment where they are intruded by porphyry bodies in a dissected late Miocene volcano.

Of by far the greatest economic importance has been the epithermal gold deposits, notably those at Vatukoula (Deposit #13–fig. 9, table 9) on Viti Levu, and Mt. Kasi (Deposit #2–fig. 9, table 9) on Vanua Levu. At Vatukoula gold and silver, mostly as tellurides, occur with quartz and calcite as shear fillings in mafic lavas adjoining the faulted margin of a late Miocene-Pliocene caldera, the mineralization being related to late-stage activity in the caldera. And at Mt. Kasi, gold and silver (with lesser copper, zinc, and lead) mineralization in quartz-barite veins is associated with shears in intermediate volcanic and volcaniclastic rocks of a late Miocene caldera. Massive Kuroko-type sulfide deposits are found in late Miocene-Pliocene volcanic and volcaniclastic rocks in northeastern Vanua Levu. The main deposit is at Undu (Deposit #3–fig. 9, table 9) where a pipe of mineralized breccia contains pyritic ore containing copper, zinc, and lead sulfides.

Bauxite deposits are found in flat-lying areas throughout the island chain. The most important are in western Vanua Levu, notably at Wainunu (Deposit #1–fig. 9, table 9). Mineralized beach sands occur at the mouth of the Singatoka River (Deposit #9–fig. 9, table 9) in southern Viti Levu and in northwestern Viti Levu along the Mba River (Deposit #12–fig. 9, table 9). Derived from the breakdown of mafic lavas they contain magnetite and ilmenite. The remaining economic-mineral commodity in Fiji is phosphate which is found on isolated islands in the Lau Group. The main deposits are at Tuvutha (Deposit #4–fig. 9, table 9), Vanua Vatu (Deposit #5–fig. 9, table 9), and Ongea Ndriki (Deposit #6–fig. 9, table 9).

SOLOMON ISLANDS

By
W. D. Palfreyman

The Solomon Islands group continues a major southeast-trending late Mesozoic-Cenozoic island-arc system that extends from New Ireland (in Papua New Guinea) in the north to the Vanuatu chain and beyond in the south.

The group consists of a double en echelon chain of islands bounded on the northeast and southwest by a major thrust fault and a subduction zone respectively (Doutch, 1986). The geologic evolution of the region can be divided into three phases: a Cretaceous-early Tertiary mafic and ultramafic metavolcanic and intrusive basement with intercalated deep-marine carbonate rocks; a middle-late Tertiary intermediate volcanic and intrusive complex with intercalated volcaniclastic rocks and reefal limestone; and late Tertiary-Quaternary mafic and potassium-rich volcanic and intrusive complexes with shallow-marine carbonate rocks and minor continental and shallow-marine clastic rocks (Doutch and others, 1988).

Mineralization associated with the Cretaceous-early Tertiary mafic and ultramafic rocks of the basement include minor stratiform and vein copper deposits in altered mafic lavas; volcanogenic stratiform manganese deposits; occurrences of disseminated gold and nickel and copper sulfides in gabbro; and nickel, chrome, and asbestos deposits associated with ultramafic intrusive rocks (Arthurs, 1979). The only deposit of importance found in the basement rocks is a copper, gold, and silver-bearing stratiform pyrite body in basaltic pillow lava at Hanesavo (Deposit #4–fig. 10, table 10) in the Florida Islands.

The middle-late Tertiary intermediate volcanic and intrusive complex hosts several metalliferous deposit types: porphyry-type copper-gold sulfide stockworks in diorite complexes at Mbetilonga (Deposit #10–fig. 10, table 10), Koloula (Deposit #9–fig. 10, table 10), and Lower Poha (Deposit #11–fig. 10, table 10) on Guadalcanal Island; small vein and low-grade copper disseminations in andesites; and gold-bearing sulfide veins at Gold Ridge (Deposit #6–fig. 10, table 10) on Guadalcanal Island.

Minor sulfur deposits are associated with the late Tertiary-Quaternary mafic volcanism.

The potentially most important mineral deposits on the Solomon Islands are residual, formed by mechanical or chemical concentration processes operating in the Quaternary. These include bauxite at Vaghena (Deposit #1–fig. 10, table 10) and West Rennell (Deposit #7–fig. 10, table 10), nickeliferous laterite developed on ultramafics at Jejevo (Deposit #2–fig. 10, table 10), Tataka (Deposit #3–fig. 10, table 10), and San Jorge (Deposit #12–fig. 10, table 10). Placer beach-sand deposits containing chromite are found at San Jorge (Deposit #13–fig. 10, table 10), and gold occurs in a river at Chovohio (Deposit #5–fig. 10, table 10) downstream from the Gold Ridge (Deposit #6–fig. 10, table 10) deposit. A medium-sized phosphate deposit occurs on Bellona (Deposit #8–fig. 10, table 10), a raised coral atoll to the southeast of the main island group.

VANUATU

By
W. D. Palfreyman

Vanuatu forms part of the Tertiary-Quaternary island-arc system extending in the north from New Ireland through the Solomon Islands to Fiji, Tonga, and the Kermadec Islands in the east and south. The Vanuatu segment can be divided into three parts: a Western Belt (late Oligocene-middle Miocene in age), an Eastern Belt (early Miocene-late Pliocene); and a Central Chain (late Pliocene-Holocene) (Carney and Macfarlane, 1980; Macfarlane, 1982).

Western Belt

This comprises the islands of Espiritu Santo, Malakula, and the Torres group. It consists of basal sequences of intermediate to mafic lavas and derived sedimentary rocks with minor reefal limestones. These rocks have been faulted and intruded by mafic to intermediate intrusive rocks and overlain by volcaniclastic greywacke. Following a period of uplift and erosion, carbonate and epiclastic sedimentary sequences were deposited. Minor sulfide mineralization is known in this belt. Epithermal gold has also been found in small quantities in southern Espiritu Santo Island and southern Malakula Island.

Eastern Belt

Rocks of this belt crop out on the islands of Maéwo and Pentecost. Here a basal sequence of deep-water clastic and volcaniclastic rocks is overlain by mafic volcanic-arc rocks followed by further pelagic sedimentary rocks. The whole has been uplifted, faulted, and, on Pentecost Island, during the Pliocene an ophiolite complex was emplaced. Minor nickel mineralization is associated with this latter complex. Some minor copper sulfide mineralization is found associated with mafic intrusions on Pentecost Island.

Central Chain

The Central Chain islands are composed primarily of subaerial mafic to intermediate volcanic and volcaniclastic rocks fringed in places by reefal limestone. Minor sulfide mineralization occurs in mafic lava on several islands, but the main mineral commodity (and the only one in the country to have been mined) is manganese. At Forari (Deposit #1–fig. 10, table 11) on Efaté Island, manganese oxide occurs at the base of a soil profile underlying reefal limestone. Similar deposits are also found at Raouisse (Deposit #2–fig. 10, table 11) and Immeus (Deposit #3–fig. 10, table 11) on Erromango Island. These deposits are the result of the leaching of volcanic rocks and the subsequent redeposition of the manganese in a littoral environment. The only other economic commodity found in Vanuatu is heavy-mineral sand. Beach sand containing titaniferous magnetite occurs on several islands but substantial deposits are found only on northern Espiritu Santo (Deposit #6–fig. 10, table 11), southern Espiritu Santo (Deposit #5–fig. 10, table 11), and southwest Efaté (Deposit #4–fig. 10, table 11) Islands.

NEW CALEDONIA

By
R. N. Brothers

Greenschist of inferred pre-Permian age is mainly fine-grained metatuff enclosing metabasalt pillows and calc-schist. Adjacent less-altered Permian to Lower Triassic strata comprise two main assemblages. The lower part, several hundred meters thick, contains variegated nonfragmented volcanic rocks (andesite, dacite, keratophyre) and tuff, plus calcareous siltstone with abundant plant and shell fossils. The upper part is largely siltite and arenite rich in white mica and plant debris. Middle Triassic to Upper Jurassic fossiliferous calc-alkaline volcaniclastic rocks form a predominantly littoral facies along the western part of the island and a deeper water, more volcanic assemblage in the central part. Late Jurassic gabbro-dolerite-basalt complexes are tholeiitic.

A major Late Jurassic pre-Senonian orogeny folded the older formations, which are covered discordantly by several kilometers of Upper Cretaceous (Senonian) conglomerate, sandstone, and coaly siltstone with some intercalated basalt and rhyolite lava. Extensive sheets of calc-alkaline to tholeiitic basalt, of Senonian to Eocene age, extend along the west coast. Paleocene-Eocene sedimentary rocks, with a total thickness of about five km, are predominantly siliceous-calcareous facies. Oligocene sedimentary rocks are entirely absent, and a few small areas of Miocene rocks are interdigitations of continental peridotitic debris with marine lagoonal or coral-reef associations. A vast ultramafic nappe, resting on early Eocene and older rocks, forms a series of massifs throughout the length of the island.

Two early metamorphic events, pre-Permian and post-Jurassic to pre-Senonian in age, were dominantly low-pressure low-temperature in character and produced prehnite-pumpellyite to greenschist associations. Late Eocene high-pressure metamorphism developed a regional belt (175 x 25 km) of lawsonite-glaucophane schist grading eastward into eclogite in an *in situ* igneous and sedimentary protolith.

Peridotite of the ultramafic nappe carries primary chromite (for example, at Tiebaghi (Deposit #33–fig. 11, table 12), Plaine des Lacs (Deposit #18–fig. 11, table 12), Yate (Deposit #15–fig. 11, table 12), and Mt. Humboldt (Deposit #12–fig. 11, table 12)), which persists also in laterite and derived Quaternary sediment (Nepoui (Deposit #27–fig. 11, table 12)). Lateritic decomposition of the ultramafic rock produced surface layers rich in iron (45-60 percent; Goro (Deposit #16–fig. 11, table 12)) and slightly deeper, but still near-surface, concentrations of nickel (up to 2-5 percent) and cobalt (up to 0.4 percent; Ouazangou (Deposit #31–fig. 11, table 12), Kopeto (Deposit #26–fig. 11, table 12), Thio (Deposit #10–fig. 11, table 12), Kouaoua (Deposit #7–fig. 11, table 12), and Poro (Deposit #6–fig. 11, table 12)). Minor manganese and antimony deposits are associated with Senonian basalt and pre-Senonian schist (Taom (Deposit #30–fig. 11, table 12), Temala (Deposit #29–fig. 11, table 12), Kone (Deposit #28–fig. 11, table 12), Raymond (Deposit #25–fig. 11, table 12), Bourail (Deposit #21–fig. 11, table 12), La Tontouta (Deposit #20–fig. 11, table 12), and Nakety (Deposit #9–fig. 11, table 12)). Exhalative stratiform Cu-Pb-Zn(-Ag-Au) mineralization accompanied acid volcanism within a northern area of Cretaceous sediment (Pilou (Deposit #1–fig. 11, table 12), Meretrice (Deposit #3–fig. 11, table 12), La Balade (Deposit #2–fig. 11, table 12), and Poya (Deposit #24–fig. 11, table 12)); this metallogenic volcano-sedimentary sequence subsequently was metamorphosed during the late Eocene regional high-pressure event.

Fuller accounts of the geology and mineral resources of New Caledonia are given in Brothers and Lillie (1988) and Paris (1981).

PAPUA NEW GUINEA

By
W. D. Palfreyman

The geology of Papua New Guinea can be divided into three major tectonic divisions (Davies, 1978). They are the Papuan Basin in the southwest, the central Orogenic Belt, and the Bismarck-Solomons region in the northeast.

The Papuan Basin contains undeformed to moderately deformed Mesozoic and Cenozoic sedimentary rocks. These rocks, with increasing deformation and the appearance of metamorphism, merge with the central Orogenic Belt rocks to the northeast. This latter belt contains thick sedimentary sequences of Mesozoic and Cenozoic age with intercalated volcanic rocks, igneous intrusive rocks, and faulted blocks of metamorphic rocks. The Bismarck-Solomons region farther to the northeast is an allochthonous Cenozoic island-arc terrane characterized by volcanic, volcaniclastic, and carbonate rocks.

Within the Papuan Basin, sedimentary sequences range from thin, undeformed epicratonic sedimentary rocks in the southwest to thick, deformed shelf and trough sedimentary rocks adjacent to the central Orogenic Belt. Neogene to Quaternary volcanic rocks and dioritic stocks occur throughout the basin, and in the far northwest porphyry copper-gold-silver mineralization is associated with the latter at Nong River (Deposit #2–fig. 12, table 13) (Pliocene), Ok Tedi (Deposit #1–fig. 12, table 13) (Pleistocene), and Tifalmin (Deposit #3–fig. 12, table 13) (Pliocene). Gold and silver occurs with sulfides in veins and stockworks in a Miocene dioritic complex at Porgera (Deposit #5–fig. 12, table 13), and similar mineralization occurs at Mt. Victor (Deposit #28–fig. 12, table 13) associated with a Miocene andesite porphyry. Lenses of massive copper-gold-silver-bearing sulfides within Eocene argillite and shale have been mined at Laloki (Deposit #47–fig. 12, table 13). Small deposits of manganese as lenses, nodules, and disseminations within Eocene chert occur at Rigo (Deposit #46–fig. 12, table 13) in the southeastern part of the basin.

The central Orogenic Belt contains metasedimentary and metavolcanic rocks that have been cut by major fault systems and have been overlain by unmetamorphosed Neogene sedimentary rocks, particularly in the northwest and southeast. Fault-bounded ophiolite complexes are found throughout the belt, as are intrusive igneous complexes. Two large porphyry-type deposits have been found within rocks of the Orogenic Belt. At the Frieda (Deposit #4–fig. 12, table 13) deposit, copper-gold mineralization is associated with a Miocene porphyritic microdiorite, whereas at Yandera (Deposit #7–fig. 12, table 13) copper-molybdenum mineralization occurs within a Miocene quartz monzonite body. Several small- or medium-sized vein-gold deposits all within or adjacent to high-level intrusive or associated volcanic rocks of Neogene age have been located in the southeastern half of the belt. In the Wau area, quartz or quartz-manganese vein deposits are found associated with dacite at Edie Creek (Deposit #32–fig. 12, table 13) and granodiorite at Hidden Valley (Deposit #32–fig. 12, table 13). Similar gold-bearing quartz fissure veins are found at Umuna (Deposit #42–fig. 12, table 13) (associated with diorite). At Wapolu (Deposit #38–fig. 12, table 13), gold mineralization occurs along the faulted contact between the basement metamorphic and cover rocks. Massive lenses of nickel-iron sulfides with magnetite occur within an ophiolite complex at Doriri (Deposit #45–fig. 12, table 13) in the southeastern part of the belt.

Within the Bismarck-Solomons region, Paleogene basement volcanic and volcaniclastic rocks or argillite with some carbonate rocks are overlain by Neogene carbonate and volcanic rocks. Mineralization is characterized by porphyry and epithermal deposits. Porphyry copper-gold and copper-molybdenum deposits, which are associated with a range of felsic and intermediate intrusive rocks, include Panguna (Deposit #22–fig. 12, table 13) (Neogene-diorite), Legusulum (Deposit #20–fig. 12, table 13) (Paleogene-Neogene-quartz diorite), Pelapuna (Deposit #24–fig. 12, table 13) (Paleogene-granodiorite and monzonite), Plesyumi (Deposit #26–fig. 12, table 13) (Paleogene-quartz diorite), Kulu River (Deposit #27–fig. 12, table 13) (Paleogene-tonalite), Mt. Kren (Deposit #16–fig. 12, table 13) (Neogene-diorite), and Arie (Deposit #14–fig. 12, table 13) (Neogene-diorite).

Epithermal vein gold deposits are found associated with Neogene-Holocene intrusive and extrusive rocks. Notable is the deposit on Lihir Island (Deposit #19-fig. 12, table 13) (Holocene-monzonite), the largest single gold deposit in the western world outside the Republic of South Africa. Other epithermal gold deposits in this region include Pigibut (Deposit #18–fig. 12, table 13) (Paleogene-Neogene?), Kabang (Deposit #21–fig. 12, table 13) (Holocene-trachyte), Wild Dog (Deposit #23–fig. 12, table 13) (Neogene-andesite-dacite complex), and Kulumadau (Deposit #40–fig. 12, table 13) (Neogene-feldspar porphyry).

Several medium- to large-sized lateritic nickel deposits, as yet unworked, have been identified overlying ultramafic rocks of the central Orogenic Belt; they include Ramu (Deposit #8–fig. 12, table 13), Lake Trist (Deposit #33–fig. 12, table 13), Bovio Hill (Deposit #34–fig. 12, table 13), Kokoda (Deposit #36–fig. 12, table 13), and Wowo Gap (Deposit #37–fig. 12, table 13). The Ramu (Deposit #9–fig. 12, table 13) deposit also contains a major resource of chromite.

Small, scattered bauxite deposits occur on several offshore islands, but only the deposit at Lepatuan (Deposit #13–fig. 12, table 13) is of any significance. Placer gold deposits have been worked extensively in the past; they include Sudest Island (Deposit #43–fig. 12, table 13), Lakekamu (Deposit #29–fig. 12, table 13), and Bulolo (Deposit #30–fig. 12, table 13). Mt. Kare (Deposit #6–fig. 12, table 13) alluvial-colluvial gold deposit is at present being mined. Beach placer deposits include the large chromite resource at Hessen Bay (Deposit #35–fig. 12, table 13) and scattered magnetite deposits in the Deception Bay (Deposit #48–fig. 12, table 13) and Table Bay (Deposit #44–fig. 12, table 13) regions. Industrial mineral deposits include sulfur at the

Iamelele (Deposit #39–fig. 12, table 13) geothermal area and at Pago (Deposit #25–fig. 12, table 13) volcano. Small phosphate deposits have been found on scattered offshore islands, most notably at Nauna (Deposit #17–fig. 12, table 13).

Detailed accounts of Papua New Guinea mineral deposits are given in Hughes (1990).

IRIAN JAYA (Indonesia)

By
W. D. Palfreyman

The major structural divisions of Irian Jaya can be carried westward from those recognised in Papua New Guinea. These three major divisions of Irian Jaya, named the Continental Province, Transitional Zone, and Oceanic Province by Pieters and others (1983), thus broadly correspond with the Papuan Basin, the central Orogenic Belt, and the Bismarck-Solomons region respectively (Davies, 1978) of Papua New Guinea.

The Continental Province consists of a Paleozoic to Mesozoic basement of sedimentary and minor felsic intrusive rocks, in places metamorphosed, which is overlain by Tertiary and Quaternary carbonate rocks and intruded by Pliocene porphyry and diorite. At the Ertsberg/Grasberg (Deposit #5–fig. 12, table 14) deposit, Pliocene quartz monzonite has intruded carbonate rocks to form extensive copper and gold-bearing skarns.

The Transitional Zone contains rocks equivalent in age to the Paleozoic-Mesozoic sequences of the Continental Province. These rocks, however, have been folded, strongly metamorphosed, and cut by major faults resulting from continent/island-arc collision in the Tertiary. They do not contain any significant mineral deposits.

The Oceanic Province consists of Paleogene and Neogene island-arc volcanic, volcaniclastic, and intrusive rocks with ultramafic plutonic and interbedded carbonate rocks in places. Overlying these are Neogene-Quaternary marine and continental sedimentary rocks. Lead-zinc mineralization as veins and stockworks in fractured and altered andesitic pyroclastic rocks is found at Amberbaken (Deposit #1–fig. 12, table 14), and similar copper mineralization occurs south of the Cyclops Mountains (Deposit #2–fig. 12, table 14) in the northeast of the country. Here also small-scale lateritic nickel and chromium deposits are found associated with ultramafic rocks.

SOUTHWEST PACIFIC OCEAN

By
W. D. Palfreyman

Babelthuap Island, Palau group

An epithermal gold deposit occurs on the southeast coast of Babelthuap Island (Deposit #8–fig. 13, table 15) (Miller and others, 1987). Here mineralized veins, shears, and brecciated zones cut altered and weathered mafic and intermediate volcanic rocks of Paleogene age.

Phosphate islands

Insular phosphate deposits have been formed by the leaching of phosphorus from bird guano, accumulated during the Holocene, and the subsequent precipitation of phosphate minerals in the bedrock (Hutchinson, 1950).

This mechanism resulted in thin and scattered deposits on numerous southwest Pacific islands that were rapidly mined out during the latter part of the last century. Exceptions were the thick high-volume deposits on a few raised coral islands such as Christmas Island (Indian Ocean) (Deposit #1–fig. 13, table 15), Nauru (Deposit 18–fig. 13, table 15), and Ocean Island (Deposit #19–fig. 13, table 15). These deposits were generally not recognized until the beginning of this century and in some instances are still being mined.

ANTARCTICA

By
W. D. Palfreyman

The Antarctic continent can be divided into two geologically contrasting parts: east Antarctica, consisting of Archean and Proterozoic cratonic rocks, and west Antarctica, consisting mostly of Phanerozoic fold-belt and cover rocks (Rowley and others, 1983). A portion of east Antarctica is included on the accompanying map.

In the Bunger Hills (Deposit #41–fig. 13, table 15) (Wilkes Land), iron occurs as magnetite (up to 25 percent) in Proterozoic schist and gneiss. Molybdenite is also reported from a pegmatite in the same area.

Farther east, on the Clark Peninsula (Deposits #39 and 40–fig. 13, table 15), near Casey Station, magnetite occurs in Proterozoic BIF. Manganese also occurs as pods in Proterozoic gneiss. Molybdenite is found nearby as an accessory mineral in Precambrian granite along the shore of Ainsworth Bay (Deposit #37–fig. 13, table 15). This mineral also occurs in small quantities together with pyrite and arsenopyrite in quartz veins cutting gneiss at Cape Denison (Deposit #38–fig. 13, table 15). Cassiterite has been found in heavy mineral concentrates taken from Paleozoic sandstone near Horn Bluff (Deposit #36–fig. 13, table 15).

SEAFLOOR RESOURCES

Seafloor deposits shown on the map include ferromanganese nodules, hydrothermal sulfide deposits, phosphorites, and heavy-mineral sand deposits. The information available on sulfide deposits, phosphorites, and heavy-mineral sands is so limited as to preclude estimating abundance; we have merely denoted their locations. Greatest attention has been devoted to the abundance and metal content of nodules.

Nodule abundance (seafloor coverage) at discrete locations has been ascertained from seafloor photographs and sediment cores. The nickel, copper, cobalt, and manganese contents of nodules in many of the core samples and in dredge samples have also been shown, rather than their iron content or other minor element composition. The aim of this section is to explain the procedures used to display these data.

Ferromanganese crust, recovered by dredging, is also shown on the map. No attempt is made to show all dredge sites. They are divided into four groups, based on their elemental contents (Lane and others, 1986; Manheim and Lane-Bostwick, 1989).

SEAFLOOR SEDIMENT

By
Floyd W. McCoy

Seafloor sediment is classified in four categories by its dominant component: (1) calcareous debris (calcareous ooze/clay or marl), (2) biosiliceous material (biosiliceous ooze/mud/clay), (3) terrigenous clastics (gravel/sand/silt), and (4) clays (including pelagic clay). These 4 sediment types are generalized from the 13-category classification scheme used to depict surficial deposits on the various Circum-Pacific Geologic quadrant maps, a scheme defining 30-60 percent boundaries for sediment nomenclature following that devised by Murray and Renard (1891). On the Southwest Quadrant Mineral-Resources Map, a stippled pattern is superimposed where coarse-grained particles (gravel, sand or coarse-silt sizes) form greater than 15 percent of the sediment (for example, silty or sandy clay, volcanic gravel/sand/silt; calcareous gravel/sand/silt, or biosiliceous silt).

Sedimentary components were identified and abundances estimated via smear-slide analyses of core-top deposits in piston and gravity cores archived at the Lamont-Doherty Earth Observatory. Quantitative control came from analyses of $CaCO_3$ on selected samples. Additional smear-slide and $CaCO_3$ data came from published and unpublished sources. These data formed a primary data base for plotting sediment distributions. A secondary data base was constructed from general sediment descriptions in the literature that lacked quantitative component and $CaCO_3$ information; this information was used to estimate the geographic extent of distribution patterns. Information from Deep Sea Drilling Project (DSDP) samples were not incorporated because rotary drilling techniques do not recover undisturbed seafloor sediment. Data available at the time of map compilation from Ocean Drilling Program (ODP) sampling by hydraulic piston corers were incorporated. For clastic debris, the Wentworth grade scale was used. Constraints, problems, and assumptions in establishing these data bases and using them for mapping are discussed in the various Explanatory Notes booklets that accompany each Geologic quadrant map.

For simplification on the Southwest Quadrant Mineral-Resources Map, stations where surficial sediment was sampled or identification of sediment criteria derived from primary/secondary data bases are not shown; refer to the Southwest Geologic Map for this information (Palfreyman, 1988).

Mapping boundaries of sediment types were controlled by bathymetry, regional water depth of the calcite compensation depth, proximity to land (including knowledge of local geology), documented seafloor sedimentation processes, and the deposits left by this activity, as well as oceanographic/biologic phenomena.

This map depicts unconsolidated sediment recovered primarily by coring and presumably exposed on the ocean floor at the sediment/water interface. This sediment is not necessarily of Holocene age, nor is it necessarily the result of Holocene sedimentary processes.

FERROMANGANESE NODULES

By
David Z. Piper and Theresa R. Swint-Iki

Nodules, consisting mainly of manganese and iron oxides, were first recovered from the Pacific Ocean by HMS *Challenger* during its voyage from 1872 to 1876 (Murray and Renard, 1891). They were most frequently recovered from abyssal depths where the bottom sediment is composed of red clay. Analyses of samples collected during that cruise, as well as of many samples collected subsequently, showed contents of nickel, copper, and cobalt in the range of a few tenths of one percent to about three percent. Interest in mining these deposits developed following a series of papers by Mero (1959, 1965), who called attention to the feasibility of their commercial recovery. McKelvey and others (1983) suggested that molybdenum, vanadium, and several of the rare-earth elements might also be recoverable as byproducts of possible future extractions of nickel, copper, and cobalt. These elements, as well as titanium, zinc, barium, lead, strontium, and yttrium, are present in the nodules in the range of ≤0.01 to nearly 0.1 percent (McKelvey and others, 1983).

Mero (1965) outlined the features of the geographic distribution of nodules in the Pacific Ocean and the regional variations in their composition. More recent studies include those by Cronan and Tooms (1969), Piper and Williamson (1977), and Calvert (1978), and still others are reported in the compendia of Glasby (1976), Bischoff and Piper (1979), and Sorem and Fewkes (1979). Other efforts to delineate the distribution of nodules on maps include those of Ewing and others (1971), Frazer and others (1972), Cronan (1977, 1980), Rawson and Ryan (1978), and McKelvey and others (1979, 1983).

These maps suggest that nodule occurrence and composition in the Pacific Ocean exhibit a rather uniform distribution over areas as great as several thousand square kilometers. Both parameters, however, show uneven variations on the scale of a few tens of square meters. For example, nodule coverage at individual stations, in the area at lat 10°N and long 150° W, ranges from 0 to greater than 50 percent. Furthermore, coverage at one of these stations, for which there were 550 photographs, ranges from 0 to 75 percent; photographs were taken at this station as the ship drifted a distance of only about 1.5 km. Such variability (patchiness) makes it extremely difficult to estimate seafloor coverage on any scale, and particularly at the scale of this map. All maps showing the distribution of abundance and metal content at such scales have, therefore, a significant degree of uncertainty. Individual data points of nodule abundance and metal content are shown on the map by sets of symbols in order to permit evaluation of the procedures used in the contouring, which are explained below.

Ideally, nodule abundance should be expressed in mass per unit area; for example, kilograms per square meter. Such data, however, are sparse and the abundance is therefore shown in terms of percentage of the sea floor covered. No attempt is made to convert seafloor coverage to mass per unit area for three reasons: (1) Photographs may underestimate the seafloor coverage by as much as 25 percent, because nodules often are partially covered by a layer of "fluffy" sediment 5 to 15 mm thick (Felix, 1980). The degree to which they are covered is likely to vary between areas with different seafloor environments and with different nodule morphologies; it varies considerably even between box cores from a single relatively small area. (2) No simple relation exists between nodule cross-sectional area and nodule volume; nodule shapes vary from roughly spherical to strongly discoidal (Sorem and Fewkes, 1979). (3) Photographs are taken with the camera nearly on the bottom to as much as several meters above the bottom, thus making it impossible to ascertain accurately from the photographs the nodule size.

Nodules are identified on the bottom photographs as dark and roughly equidimensional objects, with the entire population having a distribution strongly peaked in the size range of 1 to 12 cm in diameter. Angular objects and sub-rounded objects, often several tens of centimeters across, are identified as rock debris. In most cases, the difference between nodules and rocks is clear. Three people examined all photographs; still some errors in identification may have occurred.

Seafloor coverage of nodules was determined by comparing each photograph with templates showing a light background covered to varying degrees by black objects. The upper limit of 100 percent represents an arrangement of closest packing. The average coverage for all photographs at any one station was plotted as a single point. The number of photographs at a single station ranges from 1 to 850, although for most stations it is between 5 and 15.

Data from sediment cores (including box, gravity, and piston cores) supplement the photographic data. Core stations are plotted merely as recovering or not recovering nodules. Although the core sizes vary from a half-meter on a side (box cores) to 2.5-cm diameter (gravity cores), integrating these measurements with the photographic data was achieved in the following way.

Areas of varying seafloor coverage of nodules were delineated initially by using only the data obtained from the seafloor photography. In areas for which abundant cores were available, seafloor coverage was further refined using the core data. A contour of one percent was drawn to exclude areas in which photo stations recorded zero coverage. Several sediment cores recovered nodules in these areas, but the coverage outside this contour is certainly less than 1 percent and probably less than 0.1 percent. The position of the one-percent contour was further defined by using the core data in two ways: (1) a nodule-bearing core was allowed in the <1-percent area only when its 5 nearest neighboring cores did not recover nodules, and (2) the contour was drawn to exclude all areas having at least 20 cores, of which 10 percent or fewer recovered nodules. In most areas as large as 12,000 km^2, cores recovering nodules average less than 1 percent of the total number of cores.

The second step was to draw the 50-percent contours to include both photographic stations of greater than 50 percent coverage and areas where recovery of nodules was greater than 75 percent.

The 10-percent contours were then drawn. This contour enclosed photographic stations that showed the complete range of coverage. Emphasis was placed, however, on photographic stations that showed greater than 25 percent coverage. Some photographic stations that recorded greater than 25 percent coverage lie outside the 10-percent contour line if their nearest neighbor recorded zero percent coverage or if 4 of 5 nearest cores failed to recover a nodule.

The 25-percent contours were drawn lastly to enclose areas of high coverage, as supported by either core or photographic data.

The percentage of cores recovering nodules between the 1-percent and 10-percent contours is surprisingly high: within the northeast and southeast quadrants of the Pacific Ocean, nodule recovery varied from 8 to 70 percent and averaged 40 percent in areas containing more than 10 cores. In the areas where contours define nodule coverage at 10-25 percent, nodule recovery by cores averaged 55 percent and ranged from 25 to 62 percent. For the area of 25-50 percent coverage, nodule recovery by cores averaged 64 percent and ranged from 30 to 92 percent. In the area where coverage exceeded 50 percent, nodule recovery by cores averaged 83 percent. Many fewer cores have been collected from the Southwest Quadrant. High nodule recovery rates, however, are strongly suggested by the data. One possible explanation for such high recoveries by cores is that we have not distinguished between box cores, which sample a relatively large surface area of the sea floor, and gravity and piston cores. Alternatively, seafloor coverage based on bottom photographs may be biased on the low side owing to sediment cover.

Dredge hauls were not used as a supplement to the photographic and core data because the area sampled by dredging generally is not accurately known.

Nodules were divided according to their chemical composition into four partly overlapping categories: (1) greater than 1.8 percent nickel plus copper, (2) 1.0 to 1.79 percent nickel plus copper, (3) greater than 35 percent manganese, and (4) less than 1.0 percent nickel plus copper (McKelvey and others, 1983). These categories are shown on the map for stations for which data were available in the Scripps Sediment Data Bank. Only one contour, that of 1.8 percent nickel plus copper, in the Central Pacific Basin, is shown and it is based largely on the data collected and published by McKelvey and others (1979). The problem of contouring the chemical data is similar to that encountered in contouring the coverage data. Small-scale variability precluded exclusion of all conflicting data from the area enclosed by the contour.

One area of greater than 50 percent seafloor coverage is delineated by the contour in the Central Pacific Basin. This large area corresponds to the area in which the nodules frequently contain more than 1.8 percent nickel plus copper. A second area, but of lower abundance, occurs at 50 to 60°S latitude, along the northern flank of the Pacific-Antarctic Ridge. By contrast, nodules within this area contain less than 1.8 percent nickel plus copper. An additional area of consistently high coverage occurs in the Southeast Pacific Basin, but is shown on the Southeast Quadrant Mineral-Resources Map (Corvalán, in proof).

Nodules and crusts with high cobalt content (these include dredge material) occur in areas of elevated relief, such as the seamounts and ridges. In many areas where cobalt-rich nodules are present, encrustations of the same composition can exceed 2 cm in thickness (Manheim and Halbach, 1982). Nodules with high manganese content (>35 percent Mn) tend to be restricted to hemipelagic sediment; for example, the east margin of the Pacific. The few analyses of nodules from this environment of the Southeast Quadrant preclude any comment on the chemical trends.

The distribution of nodules is strongly related to sediment lithology, shown on the map as a background to the nodule distribution, and to sediment accumulation rates, not shown on this map but included on a 1:17,000,000-scale map of the Pacific Basin (Piper and others, 1985). The distribution of nodules shows a strong preference for siliceous sediment and pelagic clay. They tend not to occur on calcareous sediment, although the area north of the Southeast Indian Rise at lat 35 to 40°S exhibits an exception to this generalization. In this and other areas, however, nodules are apparently further restricted to areas showing sediment accumulation rates of less than approximately 5 mm per thousand years (Piper and Swint, 1984; Piper and others, 1987). The Guatemala Basin in the east-central Pacific represents a somewhat unusual region in that nodules have wide distribution in this area of high sediment accumulation. This area has been examined extensively in projects funded by the National Science Foundation (Dymond and others, 1984).

Many factors influence the rather complex patterns of sea-bottom sediment lithology and nodule coverage. These include the supply of material to the seafloor and the secondary processes in the deep ocean that alter or redistribute that supply. The supply is controlled largely by (1) proximity to a source of alumino-silicate material and (2) primary productivity in the photic zone of the ocean. The source of silicates (clay minerals as well as coarse debris) may be local (marine volcanic activity) or terrigenous (continents contribute material via both rivers and the atmosphere). Primary productivity, on the other hand, controls the "rain" of biogenic detritus to the seafloor. This fraction of organics consists mostly of siliceous and calcareous tests of planktonic organisms, but contains lesser amounts of phosphatic material and organic matter from the soft parts of organisms.

Secondary processes include the dissolution of organic matter at depth in the ocean and the redistribution of sediment by deep-ocean currents. The occurrence of calcareous sediment and the depth of the seafloor show a strong relation, owing to the dissolution of $CaCO_3$ in the deep ocean. This relation can be seen on and around the Campbell Plateau in the South Pacific (McCoy, 1988, 1989). Calcareous mud predominates on the Plateau and down its flanks to a depth of approximately 4000 m, at which depth it gives way to pelagic clay or siliceous sediment. The exclusion of calcareous debris from the deeper sediment is controlled by the balance between the rate of supply of $CaCO_3$ to the seafloor and its rate of dissolution. The latter increases with water depth, owing to the increase in the solubility of $CaCO_3$ with decreasing water temperature and increasing pressure.

Many measurements of deep-ocean bottom currents have been made, but their usually weak intensity and the complex seafloor bathymetry have combined to thwart attempts to evaluate quantitatively their importance as a control on sediment accumulation rates and thus indirectly on nodule distribution, except for several rather careful studies of a few small areas (Lonsdale, 1981).

The origin of nodules is still uncertain after more than 100 years of research. Their distribution in the Pacific Ocean as shown on this map and the other quadrant maps of the Pacific, however, exhibits rather strong relations to the lithology of surface sediment and to seafloor bathymetry, relations which may help to elucidate the question of nodule genesis.

Bottom photographs used in this study are from the Bundesanstalt fur Geowissenshaften und Rohstoffe, Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, Geological Survey of Japan, Hawaii Institute of Geophysics, Institut Français de Recherches pour l'Exploitation de la Mer, Lamont-Doherty Earth Observatory, Kennecott Exploration, Inc., National Oceanic and Atmospheric Administration, Scripps Institution of Oceanography, Smithsonian Institution, U.S. Navy Electronics Laboratory, and from published literature (Zenkevich, 1970; Andrews and Meylan, 1972; Bäcker and others, 1976; Greenslate and others, 1978; and Meylan and others, 1978). The chemical data on the nodules are from the Scripps Institution of Oceanography Sediment Data Bank.

FERROMANGANESE CRUSTS

By
Frank T. Manheim and Candice M. Lane-Bostwick

The cobalt values indicated in the map represent data normalized to a hygroscopic moisture and substrate-(detrital matter) free basis. The algorithm to obtain these values is given by Co* = Co x 51.23/(Fe+Mn), as determined in Manheim and Lane-Bostwick (1989). Samples designated as being of possible hydrothermal origin are identified by Mn/Fe >5 and Co <0.2 percent. Some classes of samples are excluded; data of Barnes (1967) in the Scripps Institution Nodule Data Bank, samples lacking Mn and/or Fe data (which do not permit normalization), and samples having Mn <5 percent. Multiple samples at one location have been averaged.

The geographical distribution of samples has been largely published in Lane and others (1986). Discussion of the significance of cobalt distributions and of the development of the U.S. Geological Survey Ferromanganese Crust Database is given in Manheim (1986) and Manheim and Lane-Bostwick (1989). The majority of the ferromanganese crust analyses are from two sources; the U.S. Geological Survey World Ocean Ferromanganese Crust Database and the Scripps Institution Nodule Data Bank. Evaluation of these data are discussed in Manheim and Lane-Bostwick (1989). These and other sources are described in Manheim and Lane-Bostwick (1989).

POLYMETALLIC SULFIDES

By
Theresa R. Swint-Iki

The initial discovery of warm-water springs rising from mounds of hydrothermal sediment at the Galapagos spreading center (Corliss, 1971; Weiss and others, 1977) and sulfide deposits forming at active high-temperature discharge sites at 21°N on the East Pacific Rise (Spiess and others, 1980) confirmed that hydrothermal circulation at seafloor-spreading axes leads to the precipitation of metal sulfides from hydrothermal fluids strongly enriched in sulfide and metals (Von Damm and others, 1985a, 1985b). Several types of deposits (metal oxides and sulfides) form directly or indirectly from this hydrothermal activity at divergent plate boundaries.

The thermal balance in oceanic crust along spreading axes is considered to be dominated by hydrothermal circulation and advective cooling because conductive heat-flow measurements taken along ridge crests consistently show lower than expected values (Lister, 1972; Sleep and Wolery, 1978). Models of hydrothermal processes in oceanic crust developed by Lister (1977, 1982), Sleep and Wolery (1978), Edmond and others (1979), Fehn and Cathles (1979), Bischoff (1980), and Fehn and others (1983) are largely based on investigations of seafloor-spreading axes in the northeast quadrant of the Pacific.

Since the initial observations of hydrothermal activity along the Galapagos spreading center and segments along the East Pacific Rise, polymetallic sulfides have been found in backarc basins where seafloor spreading occurs above subduction zones along convergent plate boundaries. The occurrence of metal-enriched sediment (Fe, Mn, Cu, Zn, As, Ag, and Au) is also indicative of hydrothermal activity in regions of backarc basins (Cronan, 1989). Metalliferous sediment occurs in the central Lau Basin, North Fiji Basin, and in the Manus Basin, east of Papua New Guinea (Von Stackelberg and Von Rad, 1990; Hannington and others, 1991). In the region of the Southwest Quadrant, the Lau, North Fiji, and Manus Basins and Mariana Trough have been examined to study hydrothermal processes in backarc basins.

In 1984, during the R/V *Sonne* cruise SO-35 to the southern Lau Basin, sulfide mineralization was reported at seamounts near Valu Fa Ridge, a ridge of recently formed crust (Von Stackelberg and Von Rad, 1990). In the Lau Basin at approximately 15°30'S, 174°30'W, fragments from hydrothermal vent chimneys composed of iron, zinc, and copper sulfides were recovered during the 1985 Papatua Expedition of Scripps Institution of Oceanography (Hawkins, 1986). During the 1989 Nautilau cruise to the southern Lau Basin, an active "black smoker" in a hydrothermal field was observed. It was the first active vent discovered in a backarc basin. Samples of polymetallic sulfides were collected from the site using the submersible *Nautile* (Nautilau Group, 1990; Herzig and others, 1990). The samples were found to contain grains of native gold, averaging 2.9 ppm Au from 44 samples (SMB, 1990).

In the southern region of the North Fiji Basin, hydrothermal sulfides in volcanic rocks were recovered at approximately 16°15'S, 177°25'E during the 1984 R/V *Sonne* cruise SO-35 (Von Stackelberg and others, 1985). An active hydrothermal site on North Fiji Basin Ridge was discovered in 1989 during the Nautilau cruise during dives of the submersible *Nautile* (Auzende and others, 1992).

West of Papua New Guinea, in a spreading zone in the western Woodlark Basin, an active hydrothermal field was recently discovered within the caldera of Franklin Seamount at approximately 152°E, 10°S during a 1990 cruise of R/V *Akademik Mstislav Keldys* to explore for hydrothermal mineralization in the region (Lisitsyn and others, 1991).

Further north, inside the rift zone of Manus Basin, north of Papua New Guinea, at approximately 3°09.7'S and 150°16.8'E and a depth of 2,500 m, hydrothermal chimneys were observed (Both and others, 1986); and during a later investigation in 1990 by the R/V *Akademik Mstislav Keldysh*, five hydrothermal fields, three active, two extinct, were discovered (Lisitsyn and others, 1993). Dredging in the region has recovered manganese-rich crusts of hydrothermal origin, indicating this region may contain possible reserves of polymetallic sulfide deposits (Bolton and others, 1988).

North of Manus Basin, at approximately 14°N, 145°E, fumarolic activity was reported at Esmeralda Bank, along the flanks of the submarine volcano in the Mariana Trough (Stüben and others, 1992). Further north, hydrothermal vents have been reported at 18°13'N, 144°42.6'E, within the axial region of the Mariana Trough (Botz and Stoffers, 1992).

Much further work is required to evaluate the extent and composition of known seafloor polymetallic sulfide deposits along spreading centers at divergent plate boundaries and in backarc basins, to evaluate possible future economic potential of polymetallic sulfide deposits, and to explore for new deposits.

PHOSPHORITES AND PHOSPHATIZED ROCKS

By

David Z. Piper and Theresa R. Swint-Iki

Submarine phosphate deposits consist of rock encrustations, nodules, and pellets. Occurrences in the Southwest Quadrant are reported on the continental shelf of western Tasmania, Australia (Noakes and Jones, 1975), on the upper continental slope off northern New South Wales, Australia, at depths between 210 and 385 m (Von der Borch, 1970), and on Pacific seamounts at variable depths (Burnett and Lee, 1980).

An area of high phosphorite coverage is located east of New Zealand along the crest of Chatham Rise at depths of 250 to 500 m. Reserves of phosphorite in a 378-km^2 area along Chatham Rise are estimated at 25 million tons. The phosphorite in this area averages 22 percent P_2O_5 (Kudrass, 1984). Estimated total reserves of phosphorite are 100 million tons for the region along the crest of Chatham Rise between 179°E and 180°E (Cullen, 1989). The region may be of interest when New Zealand's source of phosphorite from Nauru and Christmas Island is depleted.

HEAVY-MINERAL DEPOSITS

By

Theresa R. Swint-Iki

Submerged beaches and river channels are favorable sites in the marine environment for the occurrence of concentrations of heavy minerals (placers) such as gold, platinum, chromite, rutile (TiO_2), and ilmenite ($FeTiO_3$). Beginning with the formation of the great ice sheets during the Quaternary, sea level has repeatedly fallen and risen more than 200 m. As a result of sea-level fluctuations, fossil beaches are found both above and below present sea level. Offshore placers are known to occur off New Zealand's North Island, the east coast of Australia, Fiji, and Vanuatu, and are shown on the map by chemical symbols (letters) in blue. Placer deposits on modern beaches are also shown because they are clues to the presence offshore of additional deposits.

In New Zealand, marine titaniferous-magnetite deposits have been mined onshore at Taharoa (Stokes and others, 1989) and Waikato North Head on North Island, providing over two million tons per year of titaniferous magnetite used for steel-making (Minehan, 1989). Offshore Auckland and New Plymouth, North Island, sands with greater than 15 percent titano-magnetite were identified during exploration in 1968 (Sprague, 1970). Other heavy-mineral deposits offshore New Zealand include gold (10 km off Hokitia), mercury (occurring in cinnabar in Whangaroa Harbour, Northland), and tin (occurring in alluvial cassiterite (SnO_2) in the Foveaux Strait (Utting, 1989). However, the deposits must be examined in more detail to determine feasibility of offshore mining. To date, no offshore mining has occurred in New Zealand except for silica sand of Parengarenga Harbour and sand of Waiapa.

In Australia, in southeast Queensland, onshore beach-dune sand containing high concentrations of rutile and zircon is mined in Quaternary coastal sediment. Continental shelf sediment along eastern Australia was surveyed for heavy minerals in 1980 (Von Stackelberg, 1982). The shelf sediment sampled between Newcastle and Fraser Island contains lower concentrations of heavy minerals (average 0.1-1.6 percent) than onshore deposits

(Riech and others, 1982; Jones and others, 1982). Reconnaissance investigations were made in 1967 offshore southern New South Wales for alluvial gold deposits, but results were not released (Noakes, 1970).

On the shelf of east Tasmania, Australia, reconnaissance studies conducted in 1966 indicated prospects of offshore tin off the central east coast of Tasmania, in Ringarooma Bay, and east of King Island (Noakes, 1970).

In Fiji, titaniferous sands occur offshore from the Singatoka dune deposits on the south coast of the island of Viti Levu, and iron sands rich in titanomagnetite are found in the Mba River delta of north Viti Levu, but neither occurrence is considered economic at present (ESCAP, 1987).

In the region of the Solomon Islands, the shelf sediment along the north shore of Guadalcanal Island was sampled for gold to investigate terrigenous sediment transport by the Matepono River from the Gold Ridge deposit of central Guadalcanal. Traces of gold were found in the sediment sampled offshore from the Matepono River, and an old channel of the Matepono River, located by sub-bottom reflection profiles of Tetere Bay, may also contain gold that was concentrated by wave action (Turner and others, 1977).

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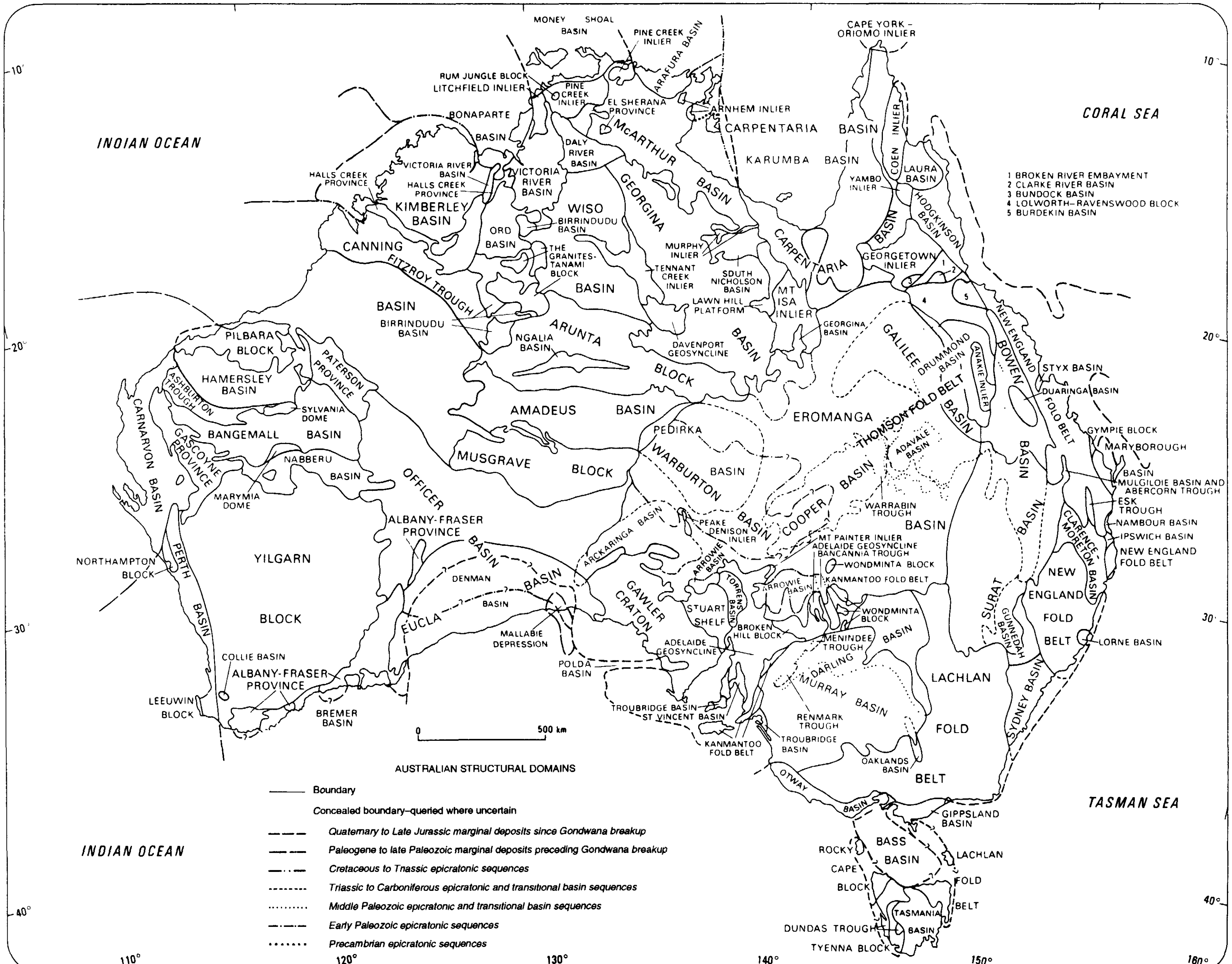


Figure 1. Principal morphostructural features of Australia

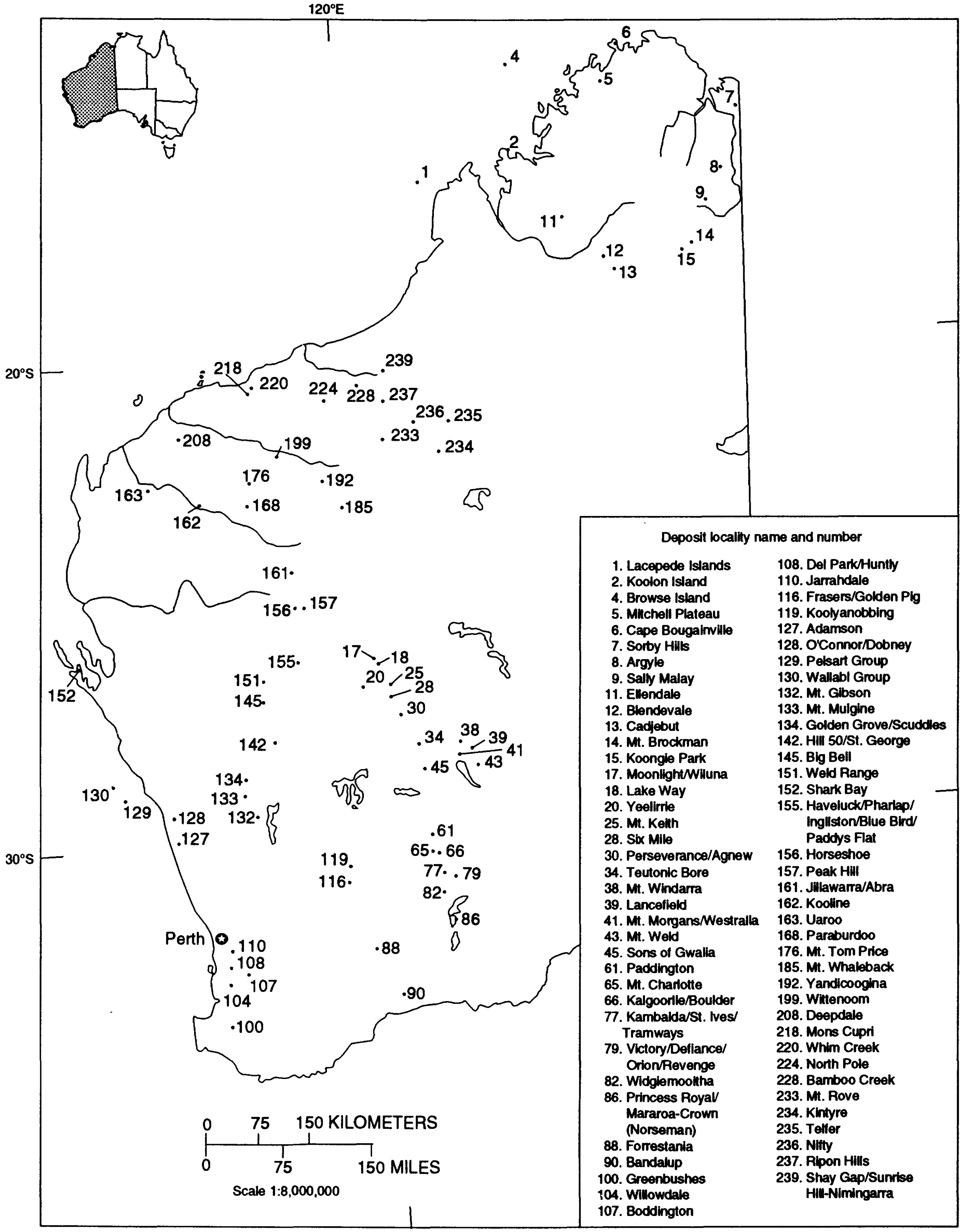


Figure 2. Mineral deposits of Western Australia, Australia [Numbers refer to table 1]

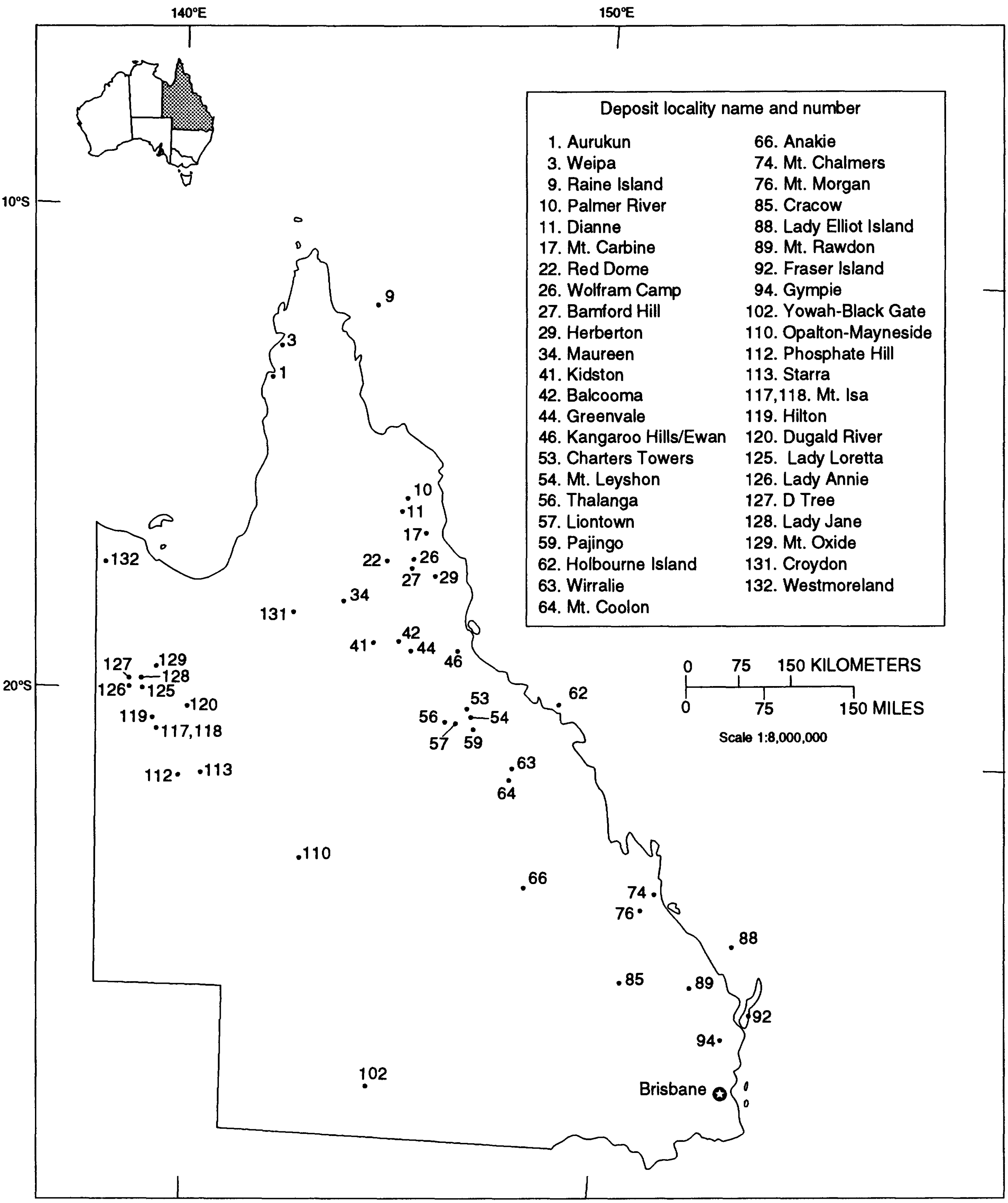


Figure 3. Mineral deposits of Queensland, Australia [Numbers refer to table 2]

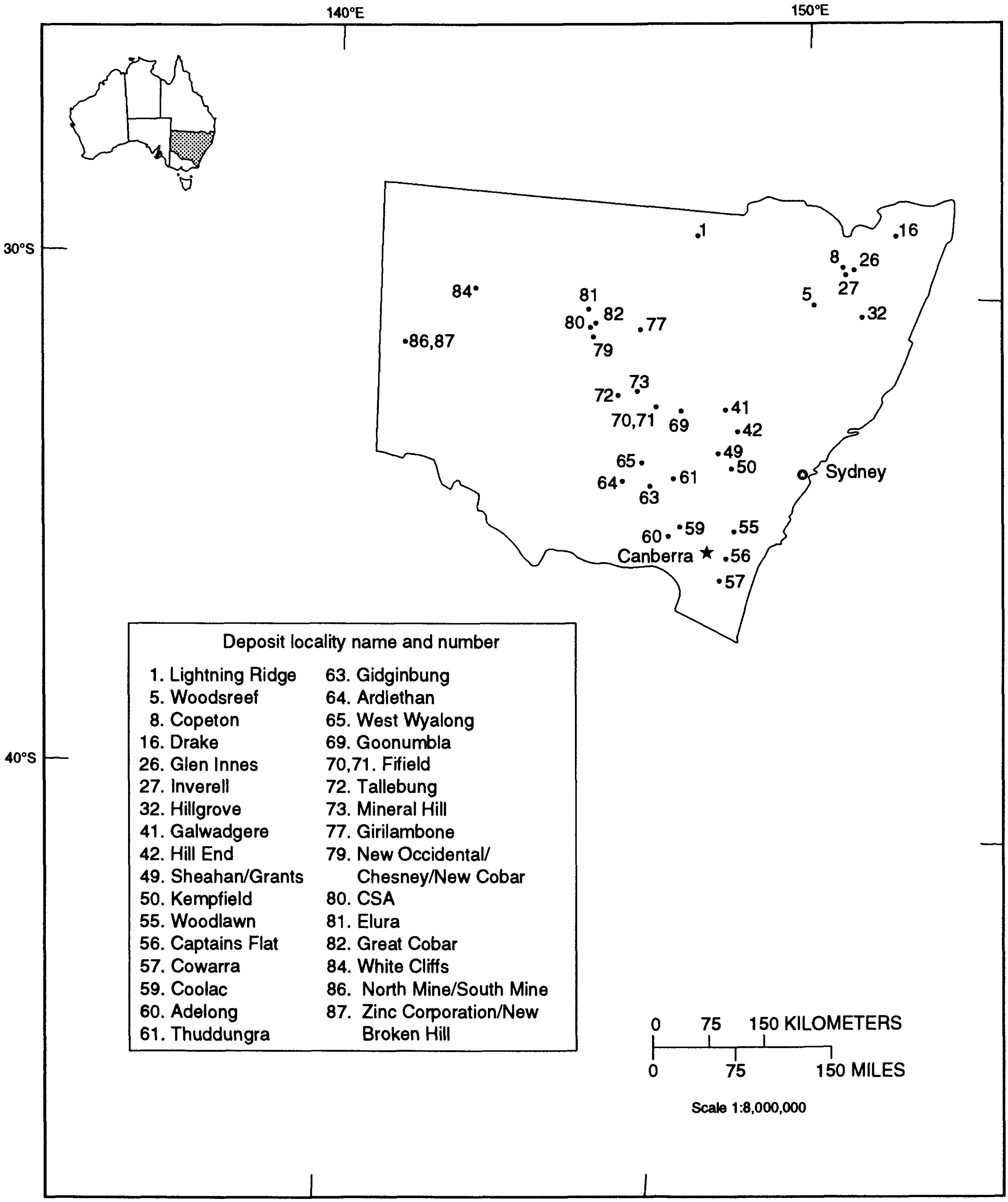


Figure 4. Mineral deposits of New South Wales, Australia [Numbers refer to table 3]

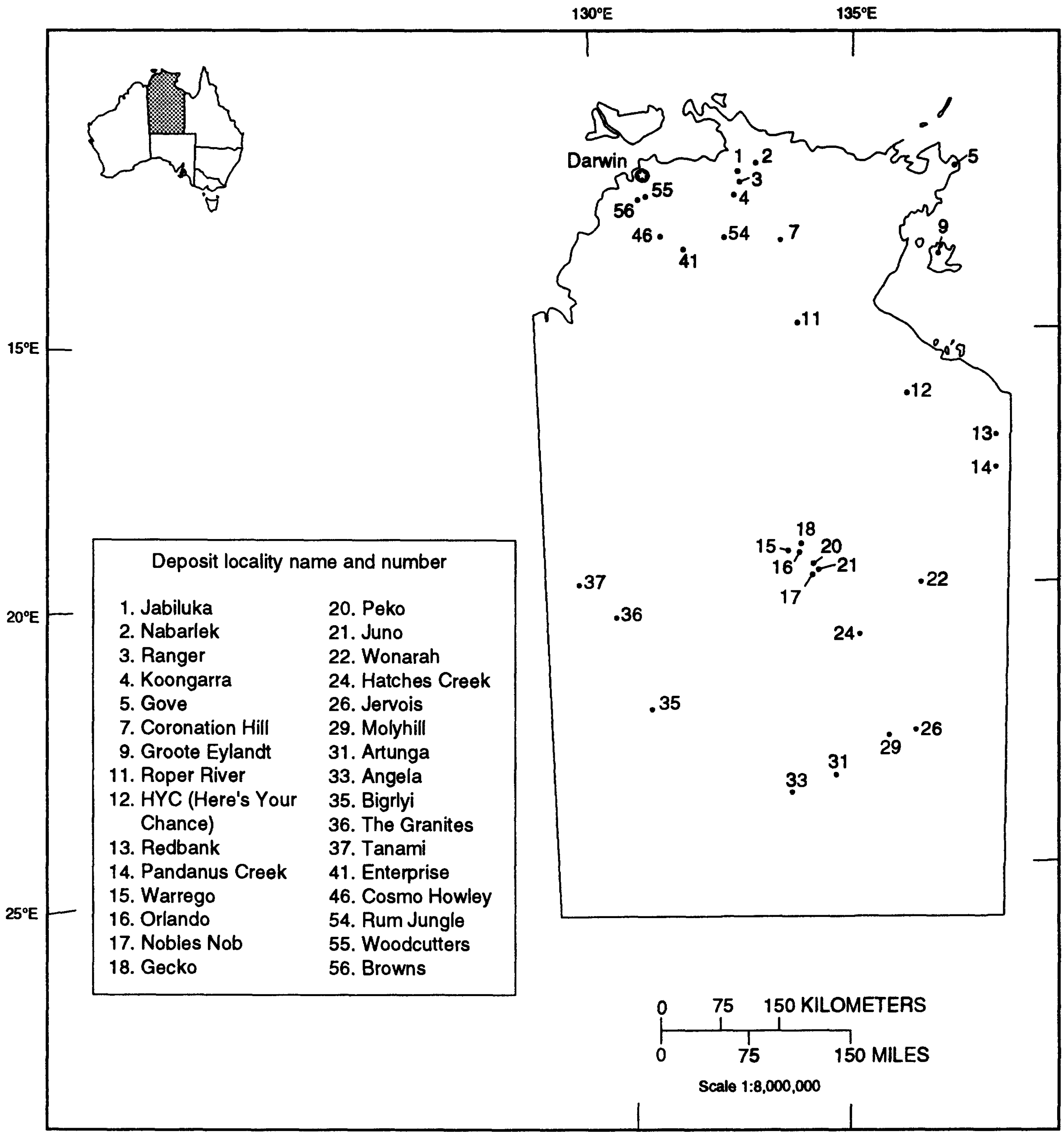


Figure 5. Mineral deposits of Northern Territory, Australia [Numbers refer to table 4]

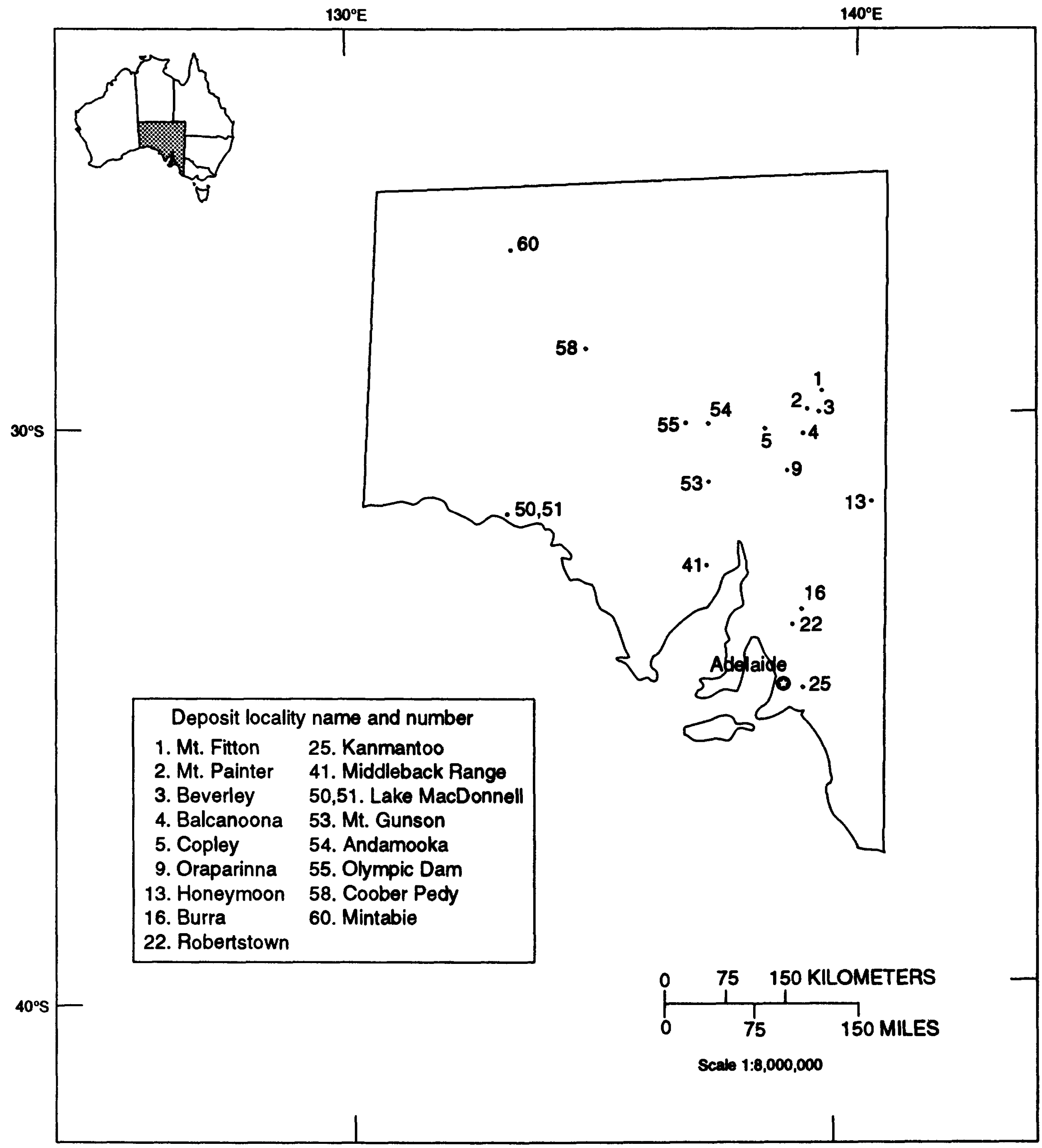


Figure 6. Mineral deposits of South Australia; Australia [Numbers refer to table 5]

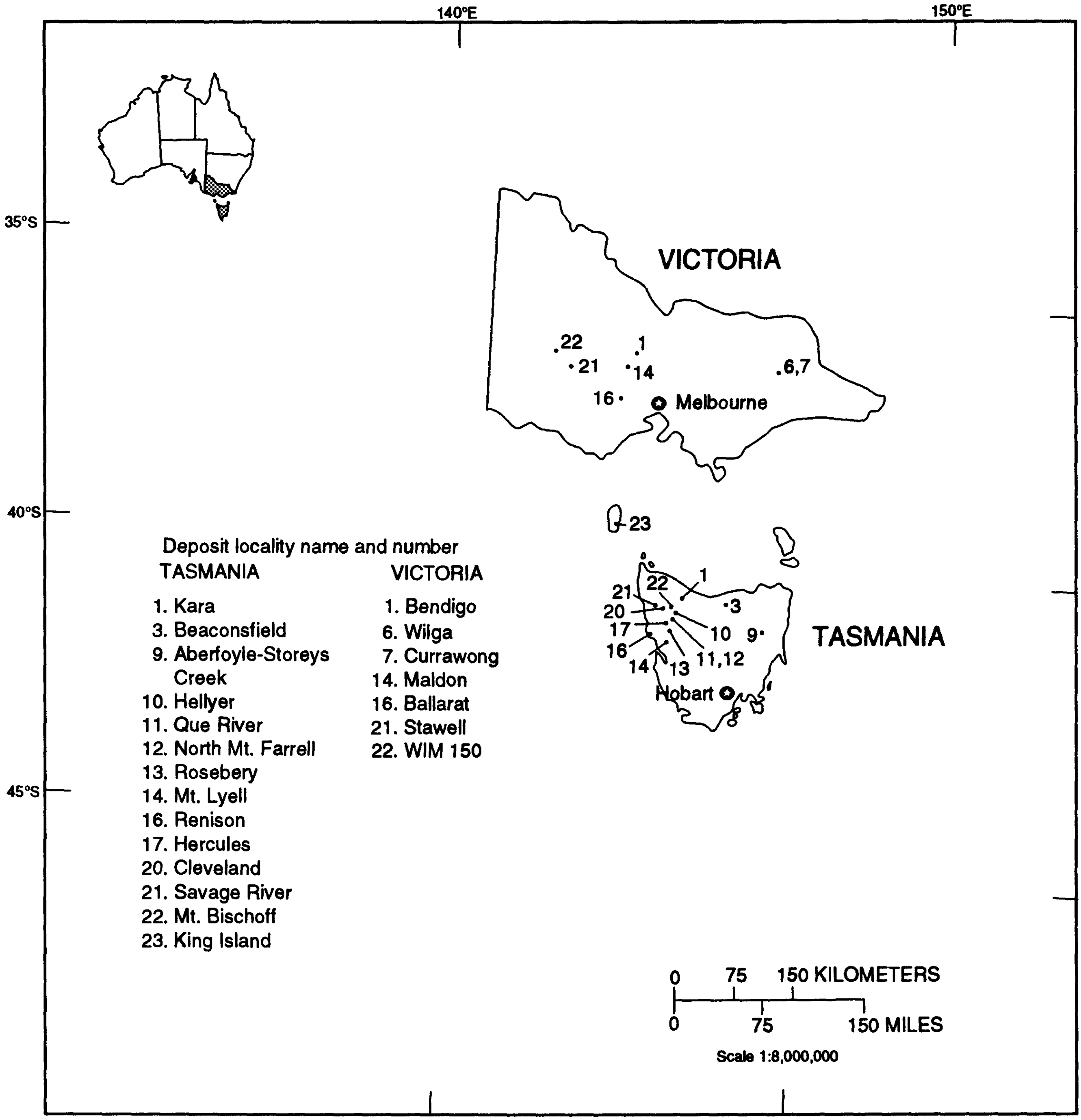


Figure 7. Mineral deposits of Tasmania and Victoria, Australia [Numbers refer to tables 6 and 7]

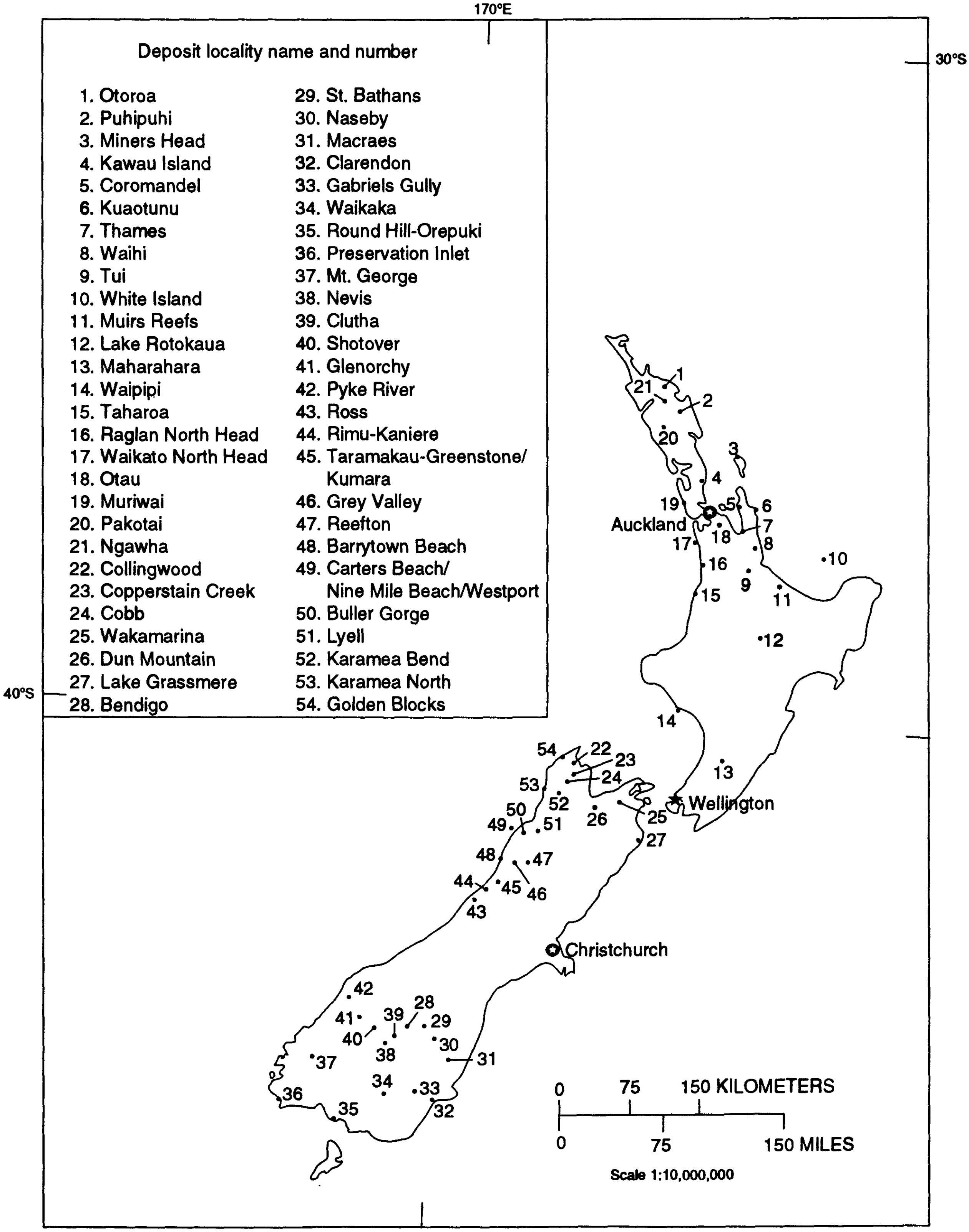


Figure 8. Mineral deposits of New Zealand [Numbers refer to table 8]

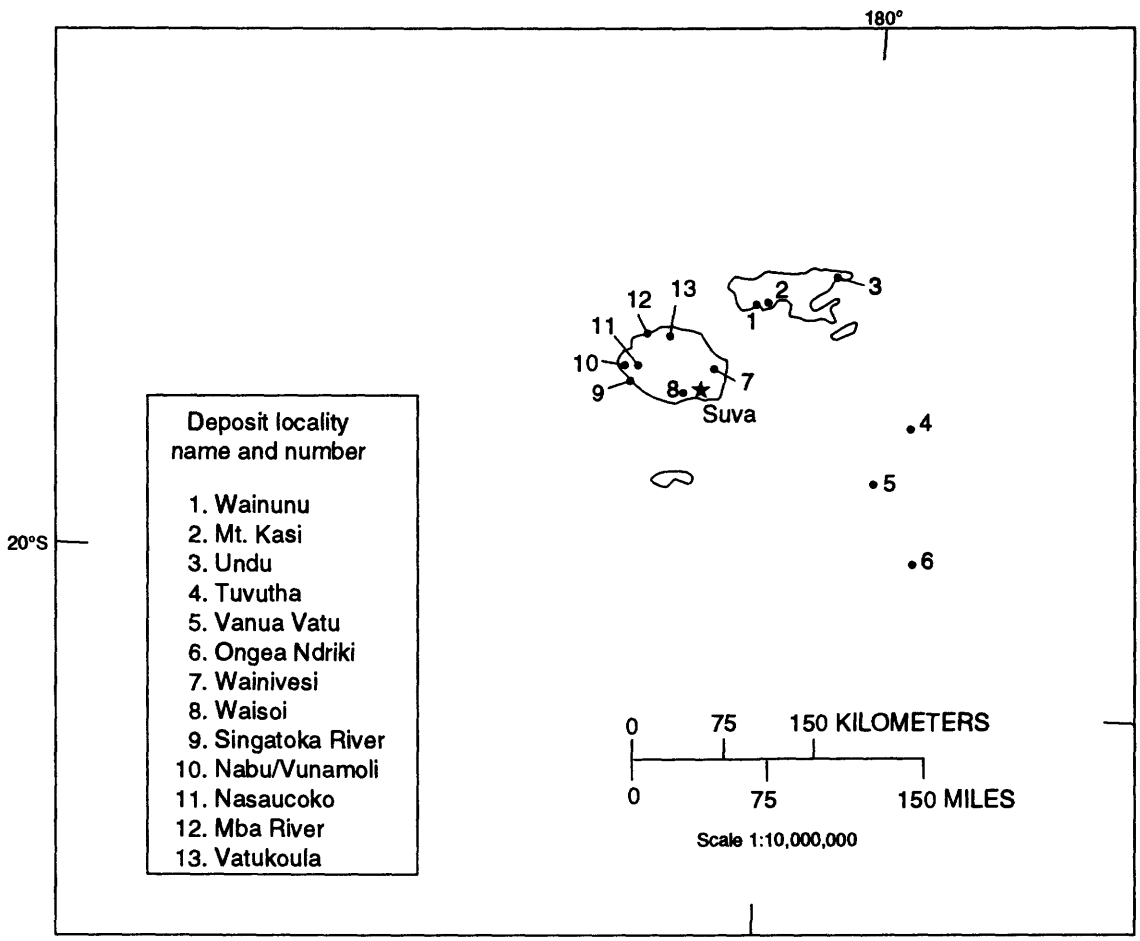


Figure 9. Mineral deposits of Fiji [Numbers refer to table 9]

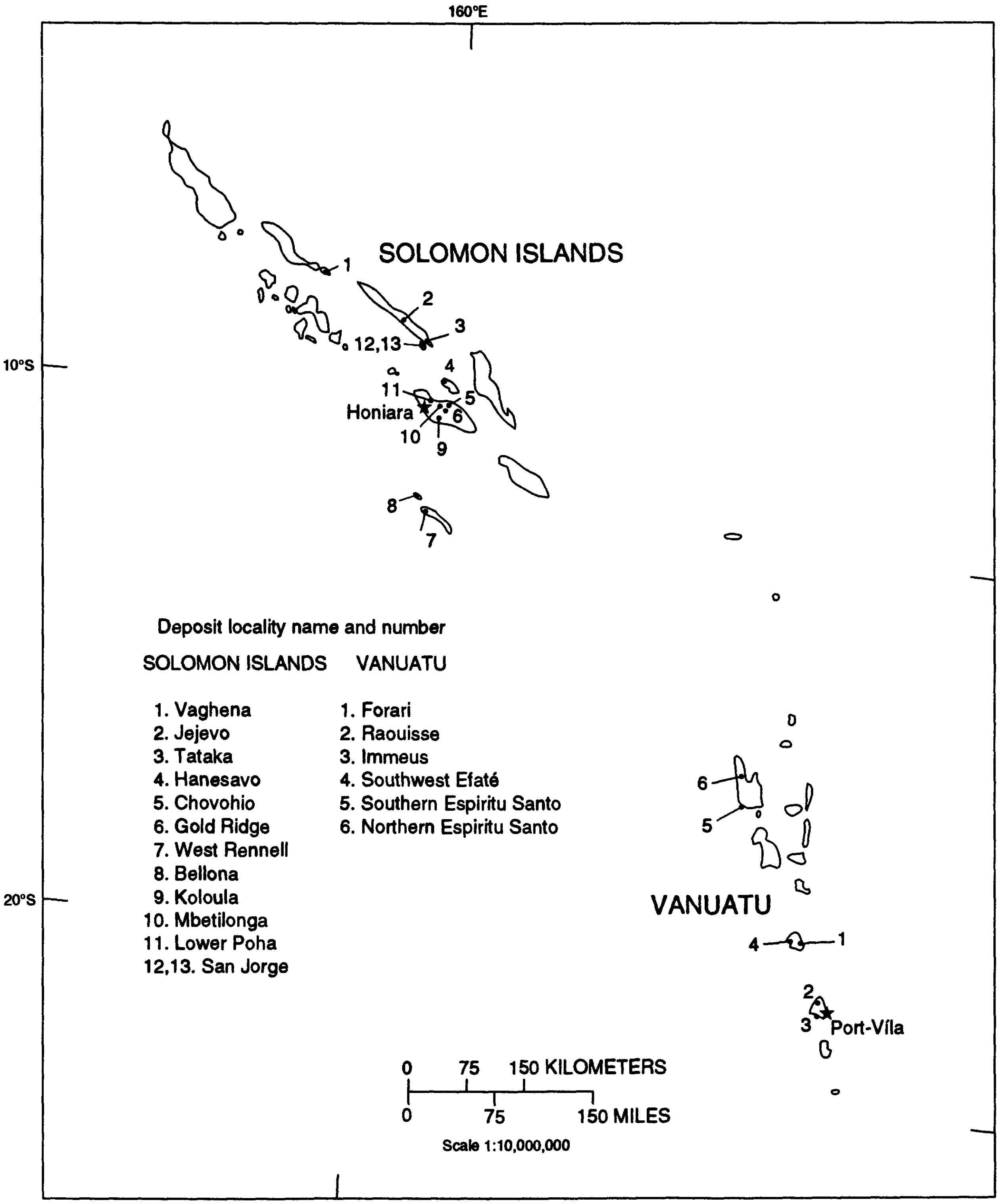


Figure 10. Mineral deposits of the Solomon Islands and Vanuatu [Numbers refer to tables 10 and 11]

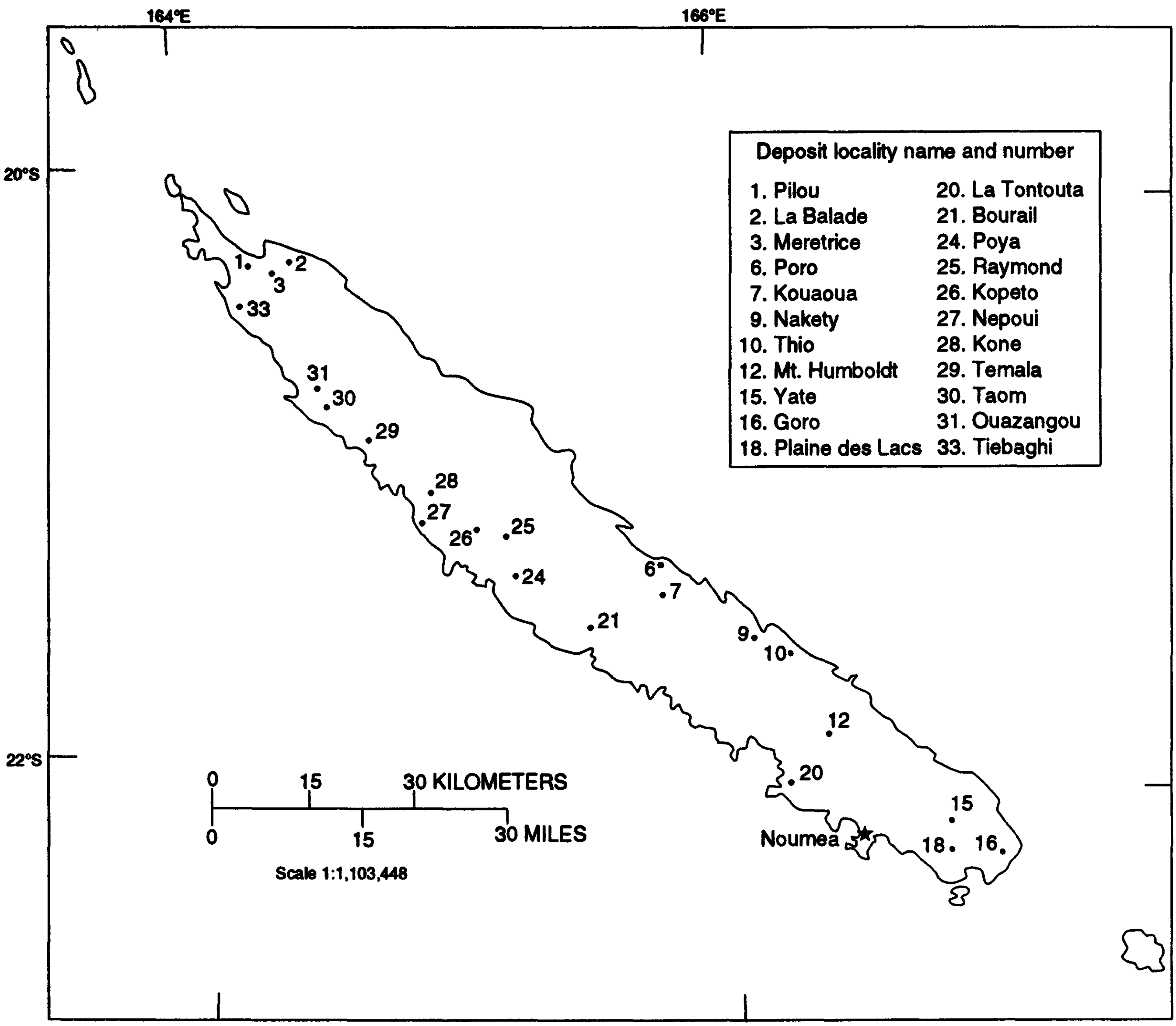


Figure 11. Mineral deposits of New Caledonia [Numbers refer to table 12]

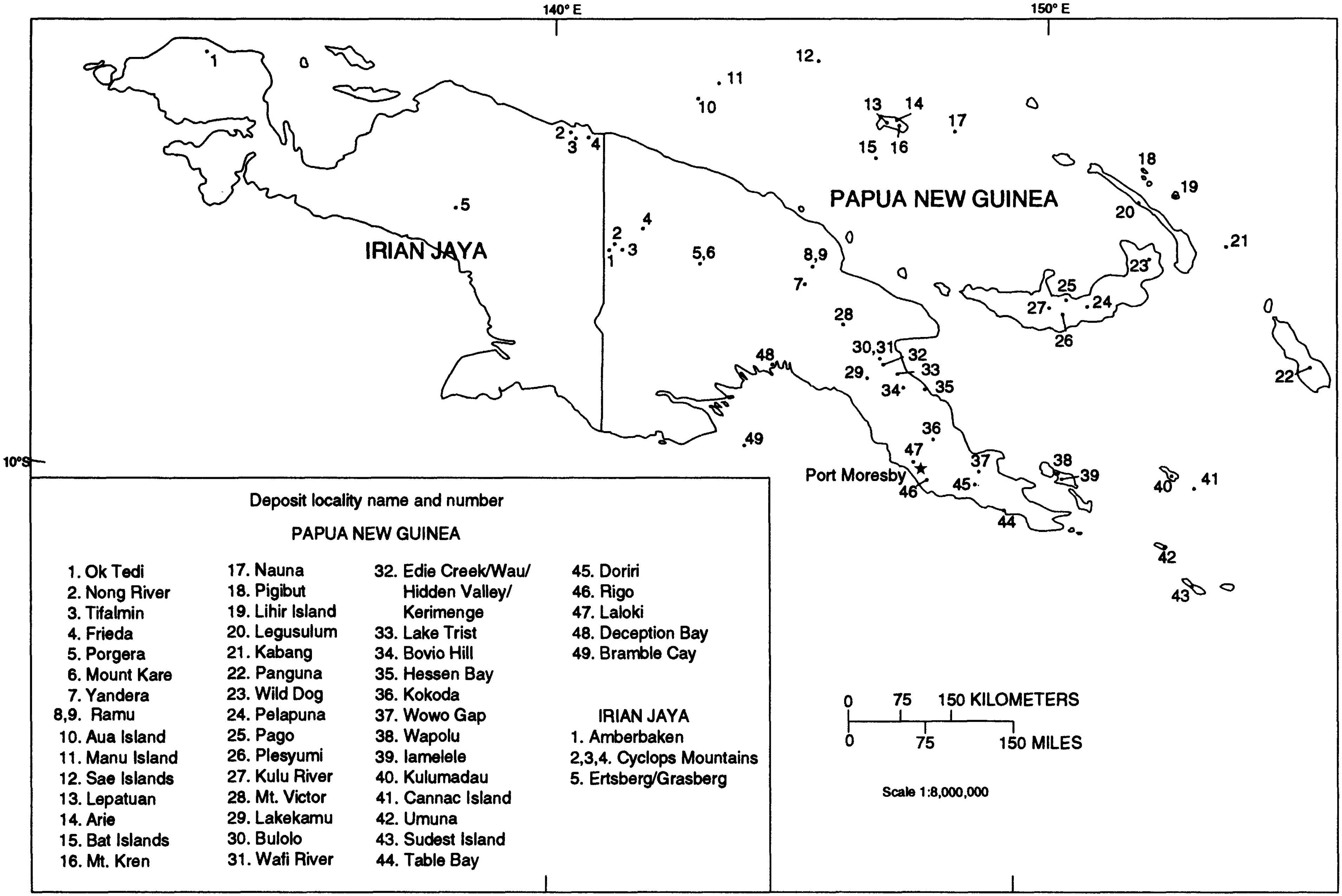
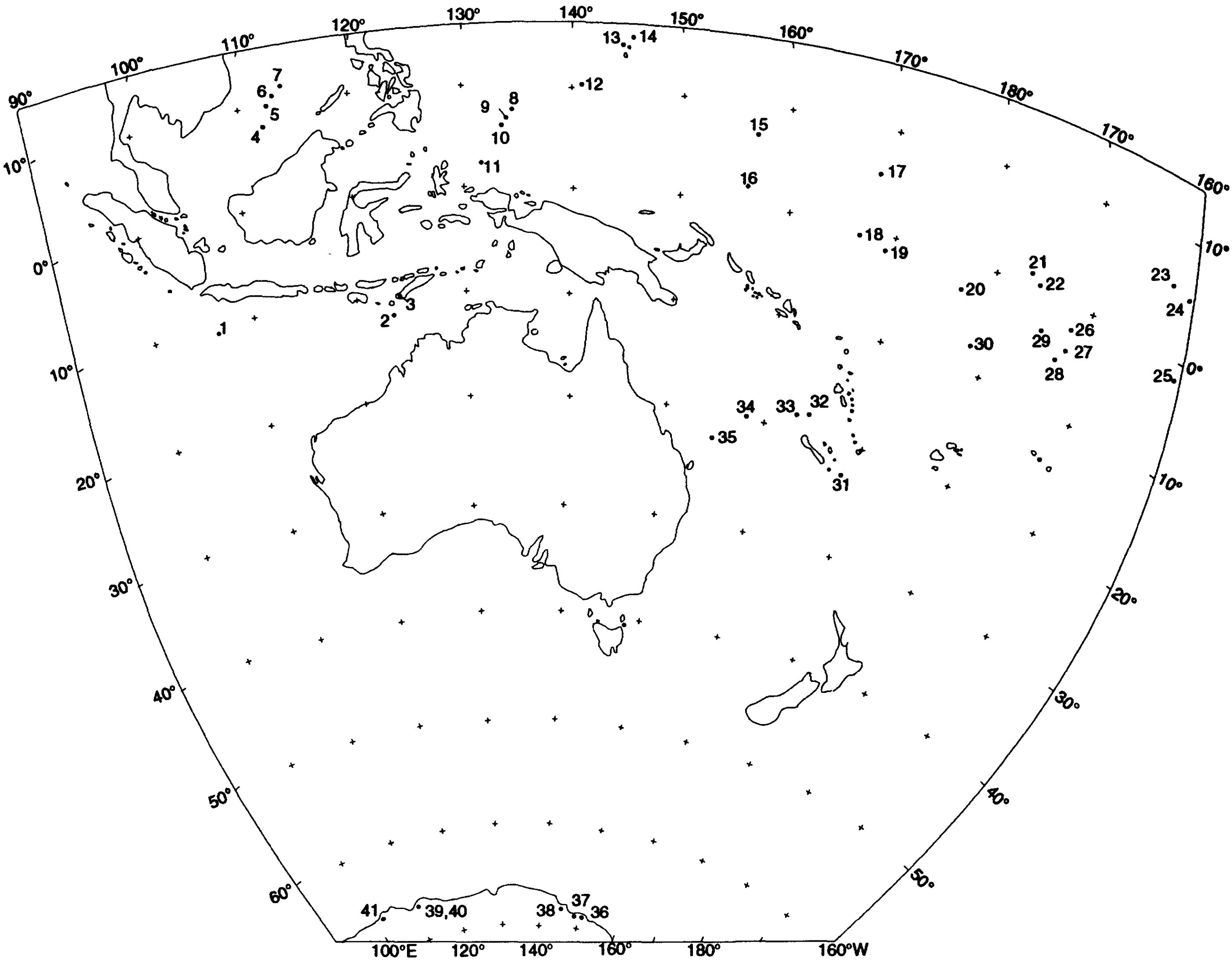


Figure 12. Mineral deposits of Papua New Guinea and Irian Jaya [Numbers refer to tables 13 and 14]



Deposit locality name and number

1. Christmas Island
2. Ashmore Islands
3. Kupang, Timor
4. Spratly Island
5. Itu Aba Island
6. Thi-tu Island
7. North Danger Island
8. Babelthuap Island
9. Peleliu Island
10. Angaur Island
11. Tobi Island
12. Fais Island
13. Rota Island
14. Saipan Island
15. Ngatik Island
16. Kapingamarangi Island
17. Ebon Island
18. Nauru
19. Ocean Island
20. Tamana Island
21. Howland Island
22. Baker Island
23. Palmyra Island
24. Washington Island
25. Jarvis Island
26. Enderbury Island
27. Phoenix Island
28. Sydney Island
29. McKean Island
30. Vaitupu Island
31. Walpole Island
32. Surprise Island
33. Fabre Island/Le Leizour Island
34. Long Island
35. Wreck Reefs
36. Horn Bluff, Antarctica
37. Ainsworth Bay, Antarctica
38. Cape Denison, Antarctica
39, 40. Clark Peninsula, Antarctica
41. Bunger Hills, Antarctica

Figure 13. Mineral deposits of Antarctica and Indian and Pacific Ocean islands [Numbers refer to table 15]

Table 1. Mineral deposits of Western Australia, Australia

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Lacepede Islands	Surficial concentration	Quaternary	P	Small
2	Koolon Island	Stratabound	Early Proterozoic	Fe	Medium
3	Oobagooma	Surficial concentration	Tertiary	U	Medium
4	Browse Island	Surficial concentration	Quaternary	P	Small
5	Mitchell Plateau	Surficial concentration	Tertiary	Al	Large
6	Cape Bougainville	Surficial concentration	Tertiary	Al	Large
7	Sorby Hills	Stratabound	Devonian-Cretaceous	PbZn	Medium
8	Argyle	Pipe	Mid Proterozoic	Precious gems	Large
9	Sally Malay	Magmatic	Early Proterozoic	Ni(CoCuPt)	Medium
10	Narlarla	Stratabound	Devonian-Cretaceous	PbZn(AgCuAu)	Small
11	Ellendale	Pipe	Tertiary	Precious gems	Large
12	Blendevale	Stratabound	Devonian-Cretaceous	ZnPb	Large
13	Cadjebut	Stratabound	Devonian-Cretaceous	ZnPb	Medium
14	Mt. Brockman	Stratiform	Early Proterozoic	Nb(Ta)U	Medium
15	Koongie Park	Stratiform	Early Proterozoic	CuZn(PbAgAu)	Medium
16	Mt. Angelo	Vein	Early Proterozoic	Cu(AgAu)	Small
17	Moonlight/Wiluna	Vein	Archean	Au(Ag)	Medium
18	Lake Way	Surficial concentration	Tertiary	U	Medium
19	Centipede	Surficial concentration	Tertiary	U	Medium
20	Yeelirrie	Surficial concentration	Tertiary	U	Large
21	Gidgee	Vein	Archean	Au(Ag)	Small
22	Barrambie	Magmatic cumulate	Archean	V	Large
23	Black Range/Oroya	Vein	Archean	Au(Ag)	Small
24	Lake Mason	Surficial concentration	Tertiary	U	Medium
25	Mt. Keith	Magmatic	Archean	Ni(CoCuPt)	Large
26	Lake Maitland	Surficial concentration	Tertiary	U	Medium
27	Mt. Joel	Surficial concentration	Tertiary	U	Medium
28	Six Mile	Magmatic	Archean	Ni(CoCuPt)	Medium
29	Bellevue	Vein	Archean	Au(Ag)	Small
30	Perseverance/Agnew	Magmatic	Archean	Ni(CoCuPt)	Large
31	Emu/Waroonga	Vein	Archean	Au(Ag)	Small
32	Weebo Bore	Magmatic	Archean	Ni(CoCuPt)	Medium
33	Great Eastern	Vein	Archean	Au(Ag)	Small
34	Teutonic Bore	Stratiform	Archean	PbZn(AgCuAu)	Medium
35	Thatcher Soak	Surficial concentration	Tertiary	U	Medium
36	Wingelinna	Surficial concentration	Tertiary	Ni(CoCuPt)	Large
37	Cork Tree Well	Vein	Archean	Au(Ag)	Small
38	Mt. Windarra	Magmatic	Archean	Ni(CoCuPt)	Medium
39	Lancefield	Vein	Archean	Au(Ag)	Medium
40	South Windarra	Magmatic	Archean	Ni(CoCuPt)	Medium
41	Mt. Morgans/ Westralia	Vein	Archean	Au(Ag)	Small
42	Ida H	Vein	Archean	Au(Ag)	Small
43	Mt. Weld	Pipe	Early Proterozoic	Nb(Ta)U	Large
44	Pykes Hill	Surficial concentration	Tertiary	Ni(CoCuPt)	Medium
45	Sons of Gwalia	Vein	Archean	Au(Ag)	Medium
46	Lake Raeside	Surficial concentration	Tertiary	U	Medium
47	Timoni	Vein	Archean	Au(Ag)	Small

Table 1. *Mineral deposits of Western Australia, Australia*–Continued

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
48	Harbour Lights/Tower Hill	Vein	Archean	Au(Ag)	Small
49	Cosmopolitan	Vein	Archean	Au(Ag)	Small
50	Porphyry	Vein	Archean	Au(Ag)	Small
51	Edjudina	Vein	Archean	Au(Ag)	Small
52	Mulga Rocks	Surficial concentration	Tertiary	U	Medium
53	Princess May/Lady Shenton-Crusoe	Vein	Archean	Au(Ag)	Small
54	Gladsome/Sand Queen	Vein	Archean	Au(Ag)	Small
55	Ora Banda (Siberia)	Surficial concentration	Tertiary	Ni(CoCuPt)	Medium
56	Sand King	Vein	Archean	Au(Ag)	Small
57	Scotia	Magmatic	Archean	Ni(CoCuPt)	Small
58	Carr Boyd Rocks	Magmatic	Archean	Ni(CoCuPt)	Small
59	Ora Banda/ Gimlet-Slippery/ Gimlet-Victorious	Vein	Archean	Au(Ag)	Small
60	Broad Arrow/ Mt. Pleasant	Vein	Archean	Au(Ag)	Small
61	Paddington	Vein	Archean	Au(Ag)	Medium
62	Grants Patch	Vein	Archean	Au(Ag)	Small
63	Mt. Percy/Hannans North	Vein	Archean	Au(Ag)	Small
64	White Feather	Vein	Archean	Au(Ag)	Small
65	Mt. Charlotte	Vein	Archean	Au(Ag)	Medium
66	Kalgoorlie/Boulder	Vein	Archean	Au(Ag)	Large
67	Yindarlgooda	Stratiform	Archean	FeS_2	Large
68	Coolgardie/Bonnie Vale	Vein	Archean	Au(Ag)	Small
69	Location 50	Vein	Archean	Au(Ag)	Small
70	Londonderry	Magmatic	Archean	Li	Small
71	Tindals	Vein	Archean	Au(Ag)	Small
72	Golden Ridge	Vein	Archean	Au(Ag)	Small
73	Bayleys/Barbara-Surprise	Vein	Archean	Au(Ag)	Small
74	Burbanks	Vein	Archean	Au(Ag)	Small
75	Nepean	Magmatic	Archean	Ni(CoCuPt)	Small
76	Jubilee	Vein	Archean	Au(Ag)	Small
77	Kambalda/St. Ives/ Tramways	Magmatic	Archean	Ni(CoCuPt)	Large
78	Spargoville	Magmatic	Archean	Ni(CoCuPt)	Small
79	Victory/Defiance/ Orion/Revenge	Vein	Archean	Au(Ag)	Medium
80	Mt. Edwards	Magmatic	Archean	Ni(CoCuPt)	Medium
81	Lake Lefroy	Surficial concentration	Quaternary	Sodium salt	Large
82	Widgiemooltha	Magmatic	Archean	Ni(CoCuPt)	Small
83	Wannaway	Magmatic	Archean	Ni(CoCuPt)	Medium
84	Redross	Magmatic	Archean	Ni(CoCuPt)	Small
85	Lake Cowan	Stratiform	Quaternary	Gypsum	Small

Table 1. Mineral deposits of Western Australia, Australia–Continued

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
86	Princess Royal/ Mararoa-Crown (Norseman)	Vein	Archean	Au(Ag)	Medium
87	Iron King	Stratiform	Archean	FeS_2	Medium
88	Forrestania	Magmatic	Archean	Ni(CoCuPt)	Medium
89	Ravensthorpe	Magmatic	Archean	Li	Medium
90	Bandalup	Surficial concentration	Tertiary	Magnesite	Medium
91	Bandalup Hill	Surficial concentration	Tertiary	Ni(CoCuPt)	Large
92	Bremer Bay	Placer	Quaternary	TiZr REO	Small
93	Cheyne Bay	Placer	Quaternary	TiZr REO	Small
94	Griffins Find	Vein	Archean	Au(Ag)	Small
95	Scott River	Placer	Quaternary	TiZr REO	Medium
96	Witchcliffe	Placer	Quaternary	TiZr REO	Medium
97	Yallingup	Placer	Quaternary	TiZr REO	Small
98	Busselton	Placer	Quaternary	TiZr REO	Large
99	Tutunup	Placer	Quaternary	TiZr REO	Medium
100	Greenbushes	Magmatic	Archean	Sn	Medium
101	Yoganup Central/ Yoganup Extended	Placer	Quaternary	TiZr REO	Large
102	Capel South/ Capel North	Placer	Quaternary	TiZr REO	Large
103	Boyanup	Placer	Quaternary	TiZr REO	Large
104	Willowdale	Surficial concentration	Tertiary	Al	Large
105	Hamel	Placer	Quaternary	TiZr REO	Medium
106	Mt. Saddleback	Surficial concentration	Tertiary	Al	Large
107	Boddington	Surficial concentration	Tertiary	Au(Ag)	Medium
108	Del Park/Huntly	Surficial concentration	Tertiary	Al	Large
109	Mundijong	Placer	Quaternary	TiZr REO	Medium
110	Jarrahdale	Surficial concentration	Tertiary	Al	Large
111	Coates	Magmatic cumulate	Archean	V	Large
112	Great Victoria	Vein	Archean	Au(Ag)	Small
113	Palmers Find	Vein	Archean	Au(Ag)	Small
114	Nevoria	Vein	Archean	Au(Ag)	Small
115	Marvel Loch	Vein	Archean	Au(Ag)	Small
116	Frasers/Golden Pig	Vein	Archean	Au(Ag)	Small
117	Lake Seabrook	Stratiform	Quaternary	Gypsum	Small
118	Copperhead	Vein	Archean	Au(Ag)	Small
119	Koolyanobbing	Surficial concentration	Tertiary	Fe	Medium
120	Mt. Jackson	Surficial concentration	Tertiary	Fe	Medium
121	Edna May	Vein	Archean	Au(Ag)	Small
122	Lake Brown	Stratiform	Quaternary	Gypsum	Small
123	Cowcowing Lakes	Stratiform	Quaternary	Gypsum	Small
124	Gingin	Placer	Quaternary	TiZr REO	Medium
125	Cooljarloo	Placer	Quaternary	TiZr REO	Medium
126	Jurien Bay	Placer	Quaternary	TiZr REO	Medium
127	Adamson	Placer	Quaternary	TiZr REO	Large
128	O'Connor/Dobney	Placer	Quaternary	TiZr REO	Medium
129	Pelsart Group	Surficial concentration	Quaternary	P	Small

Table 1. Mineral deposits of Western Australia, Australia–Continued

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
130	Wallabi Group	Surficial concentration	Quaternary	P	Small
131	Yarra Yarra Lakes	Stratiform	Quaternary	Gypsum	Medium
132	Mt. Gibson	Surficial concentration	Tertiary	Au(Ag)	Small
133	Mt. Mulgine	Vein	Archean	Mo	Medium
134	Golden Grove/ Scuddles	Stratiform	Archean	CuZn(PbAgAu)	Medium
135	Golden Grove	Stratiform	Archean	Au(Ag)	Medium
136	Narra Tarra	Vein	Cambrian-Devonian	Pb(Ag)	Small
137	Baddera	Vein	Cambrian-Devonian	Pb(Ag)	Small
138	Surprise	Vein	Cambrian-Devonian	Pb(Ag)	Small
139	Boodanoo	Placer	Quaternary	TiZr REO	Medium
140	Youanmi	Stratabound	Archean	Au(Ag)	Small
141	Anketell	Surficial concentration	Tertiary	U	Medium
142	Hill 50/St. George	Stratabound	Archean	Au(Ag)	Medium
143	Morning Star/Galtee Moore	Vein	Archean	Au(Ag)	Medium
144	Mainline/Light of Asia/Cue	Vein	Archean	Au(Ag)	Small
145	Big Bell	Stratabound	Archean	Au(Ag)	Medium
146	Great Fingall/Golden Crown	Vein	Archean	Au(Ag)	Medium
147	Reedy/Triton/Kurara	Vein	Archean	Au(Ag)	Small
148	Nowthanna	Surficial concentration	Tertiary	U	Medium
149	Yarrabubba	Magmatic cumulate	Archean	V	Large
150	Gabanintha	Magmatic cumulate	Archean	V	Large
151	Weld Range	Surficial concentration	Tertiary	Fe	Medium
152	Shark Bay	Stratiform	Quaternary	Gypsum	Medium
153	Shark Bay	Surficial concentration	Quaternary	Sodium salt	Large
154	Nannine	Vein	Archean	Au(Ag)	Small
155	Haveluck/Pharlap/ Ingliston/Blue Bird/Paddys Flat	Vein	Archean	Au(Ag)	Medium
156	Horseshoe	Surficial concentration	Tertiary	Mn	Medium
157	Peak Hill	Vein	Early Proterozoic	Au(Ag)	Small
158	Horseshoe Lights	Stratabound	Early Proterozoic	Au(Ag)	Small
159	Lake MacLeod	Surficial concentration	Quaternary	Sodium salt	Large
160	Lake MacLeod	Stratiform	Quaternary	Gypsum	Medium
161	Jillawarra/Abra	Stratabound	Middle Proterozoic	PbZn(AgCuAu)	Large
162	Kooline	Vein	Early Proterozoic	Pb(Ag)	Small
163	Uaroo	Vein	Early Proterozoic	Pb(Ag)	Small
164	Manyingee	Surficial concentration	Tertiary	U	Medium
165	Turee Creek	Vein	Middle Proterozoic	U	Medium
166	Death Valley	Surficial concentration	Tertiary	Fe	Large
167	Channar	Surficial concentration	Early Proterozoic	Fe	Large
168	Paraburdoo	Surficial concentration	Early Proterozoic	Fe	Large
169	Rocklea	Surficial concentration	Tertiary	Fe	Large
170	Metawandy	Surficial concentration	Tertiary	Fe	Large
171	Pinara Well	Stratiform	Tertiary	Fe	Large

Table 1. Mineral deposits of Western Australia, Australia–Continued

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
172	Boolgeeda Creek	Stratabound	Tertiary	Fe	Large
173	Brockman	Surficial concentration	Tertiary	Fe	Large
174	Beasley River	Stratiform	Tertiary	Fe	Large
175	Mt. Turner	Surficial concentration	Tertiary	Fe	Large
176	Mt. Tom Price	Surficial concentration	Early Proterozoic	Fe	Large
177	Area C	Surficial concentration	Tertiary	Fe	Large
178	Mt. Robinson	Surficial concentration	Tertiary	Fe	Large
179	Wonmunna	Surficial concentration	Tertiary	Fe	Large
180	Parallel Ridge	Surficial concentration	Tertiary	Fe	Large
181	West Angelas	Surficial concentration	Tertiary	Fe	Large
182	Angelo River	Surficial concentration	Tertiary	Fe	Large
183	Giles Mini	Surficial concentration	Early Proterozoic	Fe	Large
184	Ophthalmia	Surficial concentration	Early Proterozoic	Fe	Large
185	Mt. Whaleback	Surficial concentration	Early Proterozoic	Fe	Large
186	Eastern Ridge	Surficial concentration	Early Proterozoic	Fe	Large
187	Shovelanna North	Surficial concentration	Early Proterozoic	Fe	Large
188	Jimblebar	Surficial concentration	Early Proterozoic	Fe	Large
189	Coobina	Magmatic	Archean	Cr	Small
190	Kalgan	Surficial concentration	Tertiary	Fe	Large
191	Rhodes Ridge	Surficial concentration	Tertiary	Fe	Large
192	Yandicoogina	Stratiform	Tertiary	Fe	Large
193	Marillana Creek	Stratiform	Tertiary	Fe	Large
194	Marillana	Surficial concentration	Tertiary	Fe	Large
195	Koodaiderie	Surficial concentration	Tertiary	Fe	Large
196	Mt. Lockyer	Surficial concentration	Tertiary	Fe	Large
197	Yampire North	Surficial concentration	Tertiary	Fe	Large
198	Yampire	Stratiform	Early Proterozoic	Asbestos	Small
199	Wittenoom	Stratiform	Early Proterozoic	Asbestos	Medium
200	Marandoo	Surficial concentration	Tertiary	Fe	Large
201	Mt. Stevenson	Surficial concentration	Tertiary	Fe	Large
202	South Fortescue	Stratiform	Tertiary	Fe	Large
203	Nammuldi	Surficial concentration	Tertiary	Fe	Large
204	Silver Grass	Surficial concentration	Tertiary	Fe	Large
205	Mt. Pyrton	Surficial concentration	Tertiary	Fe	Large
206	Bungaroo	Stratiform	Tertiary	Fe	Large
207	Red Hill	Stratiform	Tertiary	Fe	Large
208	Deepdale	Stratiform	Tertiary	Fe	Large
209	Deepdale "A"	Stratiform	Tertiary	Fe	Large
210	Warramboo	Stratiform	Tertiary	Fe	Large
211	Fortescue	Stratabound	Early Proterozoic	Fe	Large
212	Dampier	Surficial concentration	Quaternary	Sodium salt	Large
213	Mt. Scholl	Magmatic	Archean	Ni(CoCuPt)	Small
214	Nunyerry	Vein	Archean	Asbestos	Small
215	Roy Hill	Surficial concentration	Tertiary	Fe	Large
216	Balfour Downs	Surficial concentration	Tertiary	Mn	Medium
217	Croydon	Placer	Tertiary	Au(Ag)	Small
218	Mons Cupri	Stratiform	Archean	CuZn(PbAgAu)	Medium
219	Sherlock Bay	Magmatic	Archean	Ni(CoCuPt)	Medium
220	Whim Creek	Stratiform	Archean	CuZn(PbAgAu)	Medium

Table 1. Mineral deposits of Western Australia, Australia–Continued

[Numbers refer to figure 2]

Number	Name	Type	Age of Mineralization	Commodity	Size
221	Port Hedland	Surficial concentration	Quaternary	Sodium salt	Large
222	Wodgina	Magmatic	Archean	Nb(Ta)U	Small
223	Shaw River	Placer	Quaternary	Nb(Ta)U	Small
224	North Pole	Vein	Archean	Ba	Medium
225	Cooke Bluff	Vein	Archean	Ba	Medium
226	Comet	Vein	Archean	Au(Ag)	Small
227	Moolyella	Placer	Quaternary	Sn	Small
228	Bamboo Creek	Vein	Archean	Au(Ag)	Small
229	Coppin Gap	Porphyry	Archean	CuMo(AuAg)	Medium
230	Lionel	Vein	Archean	Asbestos	Small
231	Nullagine Blue Spec	Vein	Archean	Au(Ag)	Small
232	Cookes Creek	Vein	Archean	W	Small
233	Mt. Rove	Stratabound	Mid Proterozoic	Mn	Large
234	Kintyre	Vein	Middle Proterozoic	U	Large
235	Telfer	Stratabound	Late Proterozoic	Au(Ag)	Medium
236	Nifty	Stratabound	Late Proterozoic	CuPb(ZnAgAu)	Medium
237	Ripon Hills	Stratabound	Mid Proterozoic	Mn	Large
238	Braeside	Vein	Early Proterozoic	Pb(Ag)	Small
239	Shay Gap/Sunrise Hill-Nimingarra	Surficial concentration	Tertiary	Fe	Medium

Table 2. Mineral deposits of Queensland, Australia

[Numbers refer to figure 3]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Aurukun	Surficial concentration	Tertiary	Al	Large
2	Pera Head	Surficial concentration	Tertiary	Al	Large
3	Weipa	Surficial concentration	Tertiary	Al	Large
4	Andoom	Surficial concentration	Tertiary	Al	Large
5	Port Musgrave	Surficial concentration	Tertiary	Al	Large
6	Scardon River	Surficial concentration	Tertiary	Al	Large
7	Horn Island	Vein	Devonian-Cretaceous	Au(Ag)	Small
8	Escape River	Surficial concentration	Tertiary	Al	Medium
9	Raine Island	Surficial concentration	Quaternary	P	Small
10	Palmer River	Placer	Quaternary	Au(Ag)	Medium
11	Dianne	Stratiform	Cambrian-Devonian	CuZn(PbAgAu)	Small
12	Kings Plains	Placer	Quaternary	Sn	Medium
13	Annan River	Placer	Quaternary	Sn	Small
14	Collingwood	Vein	Devonian-Cretaceous	Sn	Medium
15	Cannibal Creek	Vein	Devonian-Cretaceous	Sn	Small
16	Watershed	Skarn	Devonian-Cretaceous	W	Small
17	Mt. Carbine	Vein	Devonian-Cretaceous	W	Medium
18	Station Creek	Placer	Quaternary	Sn	Medium
19	OK	Stratiform	Cambrian-Devonian	Cu(AuAg)	Small
20	Chillagoe	Vein	Devonian-Cretaceous	F	Medium
21	Mungana/Chillagoe	Skarn	Devonian-Cretaceous	CuPb(ZnAgAu)	Medium
22	Red Dome	Skarn	Devonian-Cretaceous	Au(Ag)	Medium
23	Tate River	Placer	Quaternary	Sn	Small
24	Kangaroo Creek	Placer	Quaternary	Sn	Medium
25	Hodgkinson	Vein	Cambrian-Devonian	Au(Ag)	Small
26	Wolfram Camp	Vein	Devonian-Cretaceous	W	Medium
27	Bamford Hill	Vein	Devonian-Cretaceous	W	Small
28	Tommy Burns	Vein	Devonian-Cretaceous	SnW	Small
29	Herberton	Vein	Devonian-Cretaceous	Sn	Medium
30	Baalgammon	Vein	Devonian-Cretaceous	Sn	Medium
31	Irvinebank	Vein	Devonian-Cretaceous	Sn	Medium
32	Pinnacles	Skarn	Devonian-Cretaceous	F	Medium
33	O'Briens Creek	Placer	Quaternary	Semi-precious gems	Small
34	Maureen	Vein	Devonian-Cretaceous	U	Medium
35	Mt. Garnet	Placer	Quaternary	Sn	Medium
36	Gillian	Skarn	Devonian-Cretaceous	Sn	Medium
37	Georgetown	Vein	Cambrian-Devonian	Au(Ag)	Small
38	Forsayth	Vein	Cambrian-Devonian	Au(Ag)	Small
39	Lava Plains	Placer	Quaternary	Precious gems	Small
40	Agate Creek	Placer	Tertiary	Semi-precious gems	Large
41	Kidston	Pipe	Devonian-Cretaceous	Au(Ag)	Medium
42	Balcooma	Stratiform	Cambrian-Devonian	CuZn(PbAgAu)	Medium
43	Conjuboy	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Medium
44	Greenvale	Surficial concentration	Tertiary	Ni(CoCuPt)	Large
45	Gilberton	Vein	Cambrian-Devonian	Au(Ag)	Small
46	Kangaroo Hills/Ewan	Placer	Quaternary	Sn	Medium
47	Sardine	Vein	Devonian-Cretaceous	Sn	Small
48	Ruxton	Placer	Tertiary	Sn	Small
49	Dinner Creek	Placer	Tertiary	Sn	Small
50	Sandy Flat	Placer	Tertiary	Sn	Small
51	Cheviot Hills	Placer	Quaternary	Semi-precious gems	Small
52	Ben Lomond	Vein	Devonian-Cretaceous	U	Medium
53	Charters Towers	Vein	Cambrian-Devonian	Au(Ag)	Medium

Table 2. Mineral deposits of Queensland, Australia–Continued

[Numbers refer to figure 3]

Number	Name	Type	Age of Mineralization	Commodity	Size
54	Mt. Leyshon	Pipe	Devonian-Cretaceous	Au(Ag)	Small
55	Cape River	Placer	Quaternary	Au(Ag)	Small
56	Thalanga	Stratabound	Cambrian-Devonian	PbZn(AgCuAu)	Medium
57	Liontown	Stratabound	Cambrian-Devonian	PbZn(AgCuAu)	Small
58	Highway	Vein	Devonian-Cretaceous	Au(Ag)	Small
59	Pajingo	Vein	Devonian-Cretaceous	Au(Ag)	Small
60	Ravenswood	Vein	Devonian-Cretaceous	Au(Ag)	Medium
61	Bowen	Surficial concentration	Quaternary	Na salt	Small
62	Holbourne Island	Surficial concentration	Quaternary	P	Small
63	Wirralie	Vein	Devonian-Cretaceous	Au(Ag)	Small
64	Mt. Coolon	Vein	Devonian-Cretaceous	Au(Ag)	Small
65	Peak Downs	Stratiform	Cambrian-Devonian	Cu(AuAg)	Small
66	Anakie	Placer	Tertiary	Precious gems	Large
67	Marlborough	Vein	Tertiary	Semi-precious gems	Large
68	Marlborough	Surficial concentration	Tertiary	Ni(CoCuPt)	Medium
69	Kunwarara	Stratiform	Tertiary	Mg	Large
70	Byfield	Placer	Quaternary	TiZr	Small
71	Canoona	Surficial concentration	Tertiary	Ni(CoCuPt)	Medium
72	Princhester	Magmatic	Devonian-Cretaceous	Cr	Medium
73	Yaamba	Stratiform	Tertiary	Mg	Large
74	Mt. Chalmers	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
75	Moonmera	Porphyry	Devonian-Cretaceous	CuMo	Medium
76	Mt. Morgan	Pipe	Devonian-Cretaceous	Cu(AuAg)	Large
77	Elgalla	Magmatic	Devonian-Cretaceous	Cr	Small
78	Port Alma	Surficial concentration	Quaternary	Na salt	Medium
79	Curtis Island	Placer	Quaternary	TiZr	Small
80	Mt. Miller	Surficial concentration	Tertiary	Mn	Small
81	Middle Island	Placer	Quaternary	TiZr	Small
82	Agnes Water	Placer	Quaternary	TiZr	Small
83	Many Peaks	Skarn	Devonian-Cretaceous	Cu(AuAg)	Small
84	Mt. Cannindah	Porphyry	Devonian-Cretaceous	Cu(AuAg)	Small
85	Cracow	Vein	Devonian-Cretaceous	Au(Ag)	Medium
86	Eidsvold	Vein	Devonian-Cretaceous	Au(Ag)	Small
87	Mt. Perry	Vein	Devonian-Cretaceous	Cu(AuAg)	Small
88	Lady Elliot Island	Surficial concentration	Quaternary	P	Small
89	Mt. Rawdon	Vein	Devonian-Cretaceous	Au(Ag)	Medium
90	Coalstoun	Porphyry	Devonian-Cretaceous	CuMo(AuAg)	Medium
91	Ban Ban	Skarn	Devonian-Cretaceous	Zn	Small
92	Fraser Island	Placer	Quaternary	TiZr	Large
93	Kilkivan	Vein	Devonian-Cretaceous	Hg	Small
94	Gympie	Vein	Devonian-Cretaceous	Au(Ag)	Medium
95	Agricola	Vein	Devonian-Cretaceous	Au(Ag)	Small
96	Anduramba	Porphyry	Devonian-Cretaceous	Mo	Medium
97	Moreton Island	Placer	Quaternary	TiZr	Small
98	North Stradbroke Island	Placer	Quaternary	TiZr	Large
99	Gold Coast	Placer	Quaternary	TiZr	Medium
100	Stanthorpe	Placer	Quaternary	Sn	Medium
101	Sundown	Vein	Devonian-Cretaceous	Sn	Small
102	Yowah-Black Gate	Surficial concentration	Tertiary	Precious gems	Small
103	Coparella-Duck Creek	Surficial concentration	Tertiary	Precious gems	Small
104	Kyabra	Surficial concentration	Tertiary	Precious gems	Small
105	Hayricks-Bull Creek	Surficial concentration	Tertiary	Precious gems	Small
106	Bulgroo	Surficial concentration	Tertiary	Precious gems	Small

Table 2. Mineral deposits of Queensland, Australia–Continued

[Numbers refer to figure 3]

Number	Name	Type	Age of Mineralization	Commodity	Size
107	Harlequin	Surficial concentration	Tertiary	Precious gems	Small
108	Opalville	Surficial concentration	Tertiary	Precious gems	Small
109	Thomas Mountains	Surficial concentration	Tertiary	Precious gems	Small
110	Opalton-Mayneside	Surficial concentration	Tertiary	Precious gems	Small
111	Pegmont	Stratiform	Early Proterozoic	PbZn	Small
112	Phosphate Hill	Stratabound	Cambrian-Devonian	P	Medium
113	Starra	Stratiform	Early Proterozoic	Au(Ag)	Medium
114	Julia Creek	Stratabound	Devonian-Cretaceous	V	Large
115	Andersons Lode	Stratiform	Early Proterozoic	U	Small
116	Mary Kathleen	Skarn	Early Proterozoic	U	Large
117	Mt. Isa	Vein	Mid Proterozoic	Cu(AuAg)	Large
118	Mt. Isa	Stratiform	Mid Proterozoic	PbZn	Large
119	Hilton	Stratiform	Mid Proterozoic	PbZn	Large
120	Dugald River	Stratiform	Early Proterozoic	ZnPb	Large
121	Skal	Stratiform	Early Proterozoic	U	Small
122	Valhalla	Stratiform	Early Proterozoic	U	Small
123	Skerrin Creek	Stratabound	Cambrian-Devonian	P	Large
124	Lily Creek	Stratabound	Cambrian-Devonian	P	Large
125	Lady Loretta	Stratiform	Mid Proterozoic	ZnPb	Large
126	Lady Annie	Stratabound	Cambrian-Devonian	P	Large
127	D Tree	Stratabound	Cambrian-Devonian	P	Large
128	Lady Jane	Stratabound	Cambrian-Devonian	P	Large
129	Mt. Oxide	Vein	Mid Proterozoic	Cu(AuAg)	Small
130	Gunpowder	Vein	Early Proterozoic	Cu(AuAg)	Medium
131	Croydon	Vein	Mid Proterozoic	Au(Ag)	Medium
132	Westmoreland	Stratiform	Mid Proterozoic	U	Medium

Table 3. Mineral deposits of New South Wales, Australia

[Numbers refer to figure 4]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Lightning Ridge	Surficial concentration	Tertiary	Precious gems	Large
2	Grawin	Surficial concentration	Tertiary	Precious gems	Large
3	Attunga	Vein	Devonian-Cretaceous	Magnesite	Medium
4	Watsons Creek	Placer	Quaternary	Sn	Small
5	Woodsreef	Magmatic	Devonian-Cretaceous	Asbestos	Large
6	Barraba	Magmatic	Devonian-Cretaceous	Cr	Small
7	Conrad	Vein	Devonian-Cretaceous	PbZn(AgCuAu)	Small
8	Copeton	Placer	Quaternary	Precious gems	Small
9	Brickwood/Becketts	Placer	Tertiary	Sn	Small
10	Oakwood	Surficial concentration	Tertiary	Al	Medium
11	Emmaville	Surficial concentration	Tertiary	Al	Medium
12	Vegetable Creek	Placer	Quaternary	Sn	Medium
13	Torrington	Vein	Devonian-Cretaceous	Sn	Small
14	Stannum	Placer	Quaternary	Sn	Small
15	Ottery	Vein	Devonian-Cretaceous	Sn	Small
16	Drake	Vein	Devonian-Cretaceous	Au(Ag)	Small
17	Undercliffe	Skarn	Devonian-Cretaceous	Graphite	Small
18	Tweed Heads/ Brunswick Heads	Placer	Quaternary	TiZr REO	Medium
19	Byron Bay/Ballina	Placer	Quaternary	TiZr REO	Small
20	Evans Head/Brooms Head	Placer	Quaternary	TiZr REO	Small
21	Baryulgil	Magmatic	Devonian-Cretaceous	Asbestos	Small
22	Oakey Creek	Magmatic	Devonian-Cretaceous	Cr	Small
23	Cangai	Stratiform	Cambrian-Devonian	Cu(AuAg)	Small
24	Grampians Range	Vein	Devonian-Cretaceous	Sn	Small
25	Y Waterholes/ Murdering Creek/ Graveyard Creek	Placer	Quaternary	Sn	Small
26	Glen Innes	Placer	Quaternary	Precious gems	Large
27	Inverell	Placer	Quaternary	Precious gems	Large
28	Copes Creek/Middle Creek/Ponds Creek	Placer	Quaternary	Sn	Medium
29	Magword	Vein	Devonian-Cretaceous	Sb(AuW)	Small
30	Wild Cattle Creek	Vein	Devonian-Cretaceous	Sb(AuW)	Medium
31	Red Rock/Mylestom	Placer	Quaternary	TiZr REO	Small
32	Hillgrove	Vein	Devonian-Cretaceous	Sb(AuW)	Medium
33	Halls Peak	Stratiform	Devonian-Cretaceous	PbZn(AgCuAu)	Small
34	Hat Head/Port Macquarie	Placer	Quaternary	TiZr REO	Small
35	Port Macquarie	Surficial concentration	Tertiary	Co	Small
36	North Haven/ Harrington	Placer	Quaternary	TiZr REO	Small
37	Forster/Hawks Nest	Placer	Quaternary	TiZr REO	Small
38	Williamstown	Placer	Quaternary	TiZr REO	Small
39	Newcastle/The Entrance	Placer	Quaternary	TiZr REO	Small
40	Bodangora	Vein	Cambrian-Devonian	Au(Ag)	Small
41	Galwadgere	Stratiform	Cambrian-Devonian	Cu(AuAg)	Medium
42	Hill End	Vein	Devonian-Cretaceous	Au(Ag)	Medium
43	Mt. Bulga	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Small
44	Lucknow	Vein	Cambrian-Devonian	Au(Ag)	Small
45	Sunny Corner	Vein	Cambrian-Devonian	Ag(PbZnCuAu)	Small

Table 3. Mineral deposits of New South Wales, Australia–Continued

[Numbers refer to figure 4]

Number	Name	Type	Age of Mineralization	Commodity	Size
46	Iron Duke	Stratabound	Cambrian-Devonian	Fe	Small
47	Carcoar	Magmatic	Cambrian-Devonian	Fe	Small
48	Wisemans Creek	Stratiform	Cambrian-Devonian	CuPb(ZnAgAu)	Small
49	Sheahan/Grants	Stratiform	Cambrian-Devonian	Au(Ag)	Small
50	Kempfield	Vein	Cambrian-Devonian	Barite	Small
51	Burraga	Stratiform	Cambrian-Devonian	Cu(AuAg)	Small
52	Yerranderie	Vein	Cambrian-Devonian	Ag(PbZnCuAu)	Small
53	Crookwell	Surficial concentration	Cambrian-Devonian	Fe	Small
54	Kangiara	Vein	Cambrian-Devonian	PbZn(AgCuAu)	Small
55	Woodlawn	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Medium
56	Captains Flat	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Medium
57	Cowarra	Vein	Cambrian-Devonian	Au(Ag)	Small
58	Carboona	Vein	Cambrian-Devonian	F	Small
59	Coolac	Magmatic	Cambrian-Devonian	Cr	Small
60	Adelong	Vein	Cambrian-Devonian	Au(Ag)	Small
61	Thuddungra	Surficial concentration	Tertiary	Magnesite	Medium
62	Grenfell	Stratabound	Cambrian-Devonian	Mn	Small
63	Gidginbung	Vein	Cambrian-Devonian	Au(Ag)	Small
64	Ardlethan	Porphyry	Cambrian-Devonian	Sn	Medium
65	West Wyalong	Vein	Cambrian-Devonian	Au(Ag)	Small
66	Gibsonvale	Placer	Tertiary	Sn	Medium
67	Parkes (Southleads)	Placer	Tertiary	Au(Ag)	Small
68	Parkes/Tichborne	Placer	Tertiary	Au(Ag)	Small
69	Goonumbla	Porphyry	Cambrian-Devonian	Cu(AuAg)	Medium
70	Fifield	Placer	Quaternary	Pt group	Small
71	Fifield	Surficial concentration	Tertiary	Magnesite	Medium
72	Tallebung	Placer	Quaternary	Sn	Small
73	Mineral Hill	Stratiform	Cambrian-Devonian	Ag(PbZnCuAu)	Small
74	Mt. Hope	Stratabound	Cambrian-Devonian	Cu(AuAg)	Small
75	Gilgunnia	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Small
76	Nymagee	Stratabound	Cambrian-Devonian	Cu(AuAg)	Small
77	Girilambone	Stratiform	Cambrian-Devonian	Cu(AuAg)	Small
78	Mt. Boppy	Stratiform	Cambrian-Devonian	Au(Ag)	Small
79	New Occidental/ Chesney/New Cobar	Stratabound	Cambrian-Devonian	Au(Ag)	Small
80	CSA	Stratabound	Cambrian-Devonian	CuPb(ZnAgAu)	Medium
81	Elura	Stratabound	Cambrian-Devonian	ZnPb	Large
82	Great Cobar	Stratabound	Cambrian-Devonian	Cu(AuAg)	Medium
83	Paka	Surficial concentration	Quaternary	Gypsum	Small
84	White Cliffs	Surficial concentration	Tertiary	Precious gems	Small
85	Euriowie	Magmatic	Early Proterozoic	Be	Medium
86	North Mine/South Mine	Stratiform	Early Proterozoic	PbZn	Large
87	Zinc Corporation/ New Broken Hill	Stratiform	Early Proterozoic	PbZn	Large
88	Pinnacles	Stratiform	Early Proterozoic	PbZn	Small
89	Triple Chance	Magmatic	Early Proterozoic	Be	Medium
90	Gypsum Palace	Surficial concentration	Quaternary	Gypsum	Medium
91	Gol Gol	Surficial concentration	Quaternary	Gypsum	Large

Table 4. Mineral deposits of Northern Territory, Australia

[Numbers refer to figure 5]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Jabiluka	Stratabound	Early Proterozoic	U	Large
2	Nabarlek	Stratabound	Early Proterozoic	U	Medium
3	Ranger	Stratabound	Early Proterozoic	U	Large
4	Koongarra	Stratabound	Early Proterozoic	U	Large
5	Gove	Surficial concentration	Tertiary	Al	Large
6	El Sherana	Stratabound	Early Proterozoic	U	Small
7	Coronation Hill	Pipe	Early Proterozoic	Au(Ag)	Medium
8	Bulman	Stratabound	Mid Proterozoic	ZnPb	Small
9	Groote Eylandt	Stratabound	Devonian-Cretaceous	Mn	Large
10	Maranboy	Vein	Early Proterozoic	Sn	Small
11	Roper River	Stratiform	Late Proterozoic	Fe	Large
12	HYC (Here's Your Chance)	Stratiform	Mid Proterozoic	ZnPb	Large
13	Redbank	Pipe	Mid Proterozoic	Cu(AuAg)	Medium
14	Pandanus Creek	Vein	Early Proterozoic	U	Small
15	Warrego	Vein	Early Proterozoic	Cu(AuAg)	Medium
16	Orlando	Vein	Early Proterozoic	Au(Ag)	Small
17	Nobles Nob	Vein	Early Proterozoic	Au(Ag)	Medium
18	Gecko	Vein	Early Proterozoic	Cu(AuAg)	Medium
19	Argo	Vein	Early Proterozoic	Au(Ag)	Small
20	Peko	Vein	Early Proterozoic	Cu(AuAg)	Medium
21	Juno	Vein	Early Proterozoic	Au(Ag)	Medium
22	Wonarah	Stratabound	Cambrian-Devonian	P	Large
23	Wauchope	Vein	Early Proterozoic	W	Small
24	Hatches Creek	Vein	Early Proterozoic	W	Small
25	Home of Bullion	Vein	Early Proterozoic	CuZn(PbAgAu)	Small
26	Jervois	Stratiform	Early Proterozoic	CuZn(PbAgAu)	Medium
27	Green Parrot	Stratiform	Early Proterozoic	PbZn	Small
28	Jinka	Vein	Early Proterozoic	F	Medium
29	Molyhill	Skarn	Early Proterozoic	W	Medium
30	Harts Range	Magmatic	Early Proterozoic	Semi-precious gems	Small
31	Artunga	Vein	Late Proterozoic	Au(Ag)	Small
32	Mud Tank	Magmatic	Late Proterozoic	Semi-precious gems	Small
33	Angela	Stratabound	Cambrian-Devonian	U	Small
34	Walbiri	Stratabound	Devonian-Cretaceous	U	Small
35	Bigrlyi	Stratabound	Devonian-Cretaceous	U	Small
36	The Granites	Stratiform	Early Proterozoic	Au(Ag)	Medium
37	Tanami	Vein	Early Proterozoic	Au(Ag)	Small
38	Inverway	Vein	Cambrian-Devonian	Ba	Small
39	Legune	Stratabound	Cambrian-Devonian	PbZn	Small
40	Dorisvale	Vein	Cambrian-Devonian	Ba	Small
41	Enterprise	Vein	Early Proterozoic	Au(Ag)	Medium
42	Union Reefs	Vein	Early Proterozoic	Au(Ag)	Small
43	Frances Creek	Stratiform	Early Proterozoic	Fe	Medium
44	Mt. Bonnie	Stratiform	Early Proterozoic	ZnPb	Small
45	Margaret River	Placer	Quaternary	Au(Ag)	Small
46	Cosmo Howley	Stratiform	Early Proterozoic	Au(Ag)	Small
47	Fountain Head	Vein	Early Proterozoic	Au(Ag)	Small
48	Mt. Wells	Vein	Early Proterozoic	Sn	Medium
49	Mary River	Vein	Early Proterozoic	Zn	Medium
50	Mt. Ringwood	Vein	Early Proterozoic	Au(Ag)	Small
51	Mt. Bundey	Skarn	Early Proterozoic	Fe	Small
52	Daly River	Vein	Early Proterozoic	Cu(AuAg)	Small
53	Geolsec	Surficial concentration	Mid Proterozoic	P	Medium
54	Rum Jungle	Stratiform	Early Proterozoic	U	Medium
55	Woodcutters	Stratiform	Early Proterozoic	ZnPb	Medium
56	Browns	Stratiform	Early Proterozoic	PbZn	Large
57	Bynoe	Magmatic	Early Proterozoic	Sn	Small

Table 5. Mineral deposits of South Australia, Australia

[Numbers refer to figure 6]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Mt. Fitton	Stratabound	Cambrian-Devonian	Magnesite	Medium
2	Mt. Painter	Vein	Early Proterozoic	U	Medium
3	Beverley	Stratiform	Tertiary	U	Large
4	Balcanoona	Stratabound	Cambrian-Devonian	Magnesite	Large
5	Copley	Stratiform	Late Proterozoic	Magnesite	Large
6	Myrtle Springs	Stratiform	Late Proterozoic	Magnesite	Large
7	Witchelina	Stratiform	Late Proterozoic	Magnesite	Large
8	Puttapa	Stratiform	Late Proterozoic	Zn	Medium
9	Oraparinna	Vein	Cambrian-Devonian	Ba	Medium
10	Linkes Lode	Vein	Cambrian-Devonian	Ba	Medium
11	Billeroo	Stratiform	Tertiary	U	Medium
12	Yarramba	Stratiform	Tertiary	U	Medium
13	Honeymoon	Stratiform	Tertiary	U	Medium
14	Mt. Mulga	Stratiform	Early Proterozoic	Ba	Medium
15	Olary	Magmatic	Mid Proterozoic	Be	Medium
16	Burra	Stratiform	Late Proterozoic	Cu(AuAg)	Medium
17	Morgan	Placer	Quaternary	Gypsum	Small
18	Rotten Lake	Placer	Quaternary	Gypsum	Small
19	Yamba/Noora	Placer	Quaternary	Gypsum	Medium
20	Ramco	Stratiform	Quaternary	Gypsum	Medium
21	Blanchetown	Stratiform	Quaternary	Gypsum	Medium
22	Robertstown	Surficial concentration	Tertiary	Magnesite	Small
23	Tantanoola	Stratabound	Tertiary	Mg	Large
24	Cooke Plains	Placer	Quaternary	Gypsum	Small
25	Kanmantoo	Stratiform	Cambrian-Devonian	Cu(AuAg)	Medium
26	Langhorne Creek	Surficial concentration	Quaternary	Sodium salt	Small
27	Dry Creek	Surficial concentration	Quaternary	Sodium salt	Large
28	Salt Lake/New Lake	Stratiform	Quaternary	Gypsum	Medium
29	Everard	Placer	Quaternary	Gypsum	Small
30	Lake Bumbunga	Placer	Quaternary	Gypsum	Small
31	Price	Surficial concentration	Quaternary	Sodium salt	Medium
32	Ardrossan	Stratabound	Cambrian-Devonian	Mg	Large
33	Lake Fowler	Placer	Quaternary	Gypsum	Small
34	Stenhouse Bay	Stratiform	Quaternary	Gypsum	Medium
35	Wallaroo-Moonta	Vein	Mid Proterozoic	Cu(AuAg)	Medium
36	Lochiel	Surficial concentration	Quaternary	Sodium salt	Small
37	Point Patterson	Surficial concentration	Quaternary	Sodium salt	Small
38	Mundallio	Stratiform	Late Proterozoic	Magnesite	Medium
39	Whyalla	Surficial concentration	Quaternary	Sodium salt	Medium
40	Lake Gilles	Placer	Quaternary	Gypsum	Small
41	Middleback Range	Stratiform	Early Proterozoic	Fe	Large
42	Middleback Lakes	Placer	Quaternary	Gypsum	Medium
43	Cowell	Vein	Mid Proterozoic	Semi-precious gems	Large
44	Uley/Mikkira	Stratabound	Early Proterozoic	Graphite	Medium
45	Koppio	Stratabound	Early Proterozoic	Graphite	Medium
46	Lake Malata	Stratiform	Quaternary	Gypsum	Medium
47	Kappakoola	Placer	Quaternary	Gypsum	Medium
48	Streaky Bay	Stratiform	Quaternary	Gypsum	Medium
49	Bielamah	Stratiform	Quaternary	Gypsum	Medium
50	Lake MacDonnell	Surficial concentration	Quaternary	Sodium salt	Medium
51	Lake MacDonnell	Stratiform	Quaternary	Gypsum	Large
52	Coorabie/Sturdee	Stratiform	Quaternary	Gypsum	Medium
53	Mt. Gunson	Stratiform	Late Proterozoic	Cu(AuAg)	Medium
54	Andamooka	Surficial concentration	Tertiary	Precious gems	Medium

Table 5. Mineral deposits of South Australia, Australia–Continued

[Numbers refer to figure 6]

Number	Name	Type	Age of Mineralization	Commodity	Size
55	Olympic Dam	Stratiform	Early Proterozoic	Cu(AuAg)	Large
56	Stuart Creek	Surficial concentration	Tertiary	Precious gems	Medium
57	Curdimurka	Surficial concentration	Tertiary	Sr	Small
58	Coober Pedy	Surficial concentration	Tertiary	Precious gems	Medium
59	Oodnadatta	Surficial concentration	Tertiary	Sr	Small
60	Mintabie	Surficial concentration	Tertiary	Precious gems	Medium

Table 6. Mineral deposits of Tasmania, Australia

[Numbers refer to figure 7]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Kara	Skarn	Devonian-Cretaceous	W	Large
2	Moina	Skarn	Devonian-Cretaceous	SnW	Large
3	Beaconsfield	Vein	Devonian-Cretaceous	Au(Ag)	Medium
4	Lefroy	Vein	Devonian-Cretaceous	Au(Ag)	Small
5	Lisle	Vein	Devonian-Cretaceous	Au(Ag)	Small
6	Anchor	Porphyry	Devonian-Cretaceous	Sn	Medium
7	Great Pyramid	Vein	Devonian-Cretaceous	Sn	Medium
8	Mathinna	Vein	Devonian-Cretaceous	Pb(Ag)	Small
9	Aberfoyle/Storeys Creek	Vein	Devonian-Cretaceous	SnW	Medium
10	Hellyer	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Large
11	Que River	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Medium
12	North Mt. Farrell	Vein	Devonian-Cretaceous	Pb(Ag)	Medium
13	Rosebery	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Large
14	Mt. Lyell	Stratabound	Cambrian-Devonian	Cu(AuAg)	Large
15	Zeehan	Vein	Devonian-Cretaceous	Pb(Ag)	Medium
16	Renison	Manto	Devonian-Cretaceous	Sn	Large
17	Hercules	Stratiform	Cambrian-Devonian	PbZn(AgCuAu)	Medium
18	Oakleigh Creek	Vein	Devonian-Cretaceous	W	Medium
19	Saint Dizier	Skarn	Devonian-Cretaceous	Sn	Medium
20	Cleveland	Manto	Devonian-Cretaceous	Sn	Medium
21	Savage River	Stratiform	Late Proterozoic	Fe	Medium
22	Mt. Bischoff	Manto	Devonian-Cretaceous	Sn	Large
23	King Island	Skarn	Devonian-Cretaceous	W	Large

Table 7. Mineral deposits of Victoria, Australia

[Numbers refer to figure 7]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Bendigo	Vein	Cambrian-Devonian	Au(Ag)	Large
2	Costerfield	Vein	Cambrian-Devonian	Sb	Small
3	Beechworth/Eldorado	Placer	Tertiary	Au(Ag)	Small
4	Bethanga	Vein	Cambrian-Devonian	Au(Ag)	Small
5	Harrietville/Bright	Placer	Tertiary	Au(Ag)	Small
6	Wilga	Stratiform	Cambrian-Devonian	CuZn(PbAgAu)	Medium
7	Currawong	Stratiform	Cambrian-Devonian	CuZn(PbAgAu)	Medium
8	Cassilis	Vein	Cambrian-Devonian	Au(Ag)	Small
9	Wandiligong	Vein	Cambrian-Devonian	Au(Ag)	Small
10	Gaffneys Creek	Placer	Tertiary	Au(Ag)	Small
11	Walhalla/Woodspoint	Vein	Cambrian-Devonian	Au(Ag)	Medium
12	Blackwood	Vein	Cambrian-Devonian	Au(Ag)	Small
13	Castlemaine/Chewton	Placer	Tertiary	Au(Ag)	Medium
14	Maldon	Vein	Cambrian-Devonian	Au(Ag)	Medium
15	Creswick	Placer	Tertiary	Au(Ag)	Medium
16	Ballarat	Placer	Tertiary	Au(Ag)	Medium
17	Clunes	Vein	Cambrian-Devonian	Au(Ag)	Medium
18	Maryborough	Placer	Tertiary	Au(Ag)	Small
19	Tarnagulla	Vein	Cambrian-Devonian	Au(Ag)	Small
20	St. Arnaud	Vein	Cambrian-Devonian	Au(Ag)	Small
21	Stawell	Vein	Cambrian-Devonian	Au(Ag)	Medium
22	WIM 150	Placer	Tertiary	TiZr REO	Large

Table 8. Mineral deposits of New Zealand

[Numbers refer to figure 8]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Otoroa	Surficial chemical concentration	Tertiary	Al	Medium
2	Puhipuhi	Manto	Tertiary	Hg	Small
3	Miners Head	Porphyry	Tertiary	Cu(AuAg)	Small
4	Kawau Island	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
5	Coromandel	Vein	Tertiary	AuAg	Small
6	Kuaotunu	Vein	Tertiary	AuAg	Small
7	Thames	Vein	Tertiary	AuAg	Medium
8	Waihi	Vein	Tertiary	AuAg	Large
9	Tui	Vein	Tertiary	ZnPb	Small
10	White Island	Stratiform	Quaternary	S	Small
11	Muirs Reef	Vein	Tertiary	AuAg	Small
12	Lake Rotokaua	Stratiform	Quaternary	S	Medium
13	Maharahara	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
14	Waipipi	Placer	Quaternary	FeTi(V)	Medium
15	Taharoa	Placer	Quaternary	FeTi(V)	Large
16	Raglan North Head	Placer	Quaternary	FeTi(V)	Medium
17	Waikato North Head	Placer	Quaternary	FeTi(V)	Large
18	Otau	Stratiform	Devonian-Cretaceous	Mn	Small
19	Muriwai	Placer	Quaternary	FeTi(V)	Medium
20	Pakotai	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
21	Ngawha	Manto	Quaternary	Hg	Small
22	Collingwood	Placer	Quaternary	AuAg	Small
23	Copperstain Creek	Skarn	Devonian-Cretaceous	Cu(AuAg)	Small
24	Cobb	Vein	Cambrian-Devonian	Magnesite	Medium
25	Wakamarina	Vein	Devonian-Cretaceous	AuAg	Small
26	Dun Mountain	Irregular magmatic	Devonian-Cretaceous	Cr	Small
27	Lake Grassmere	Surficial concentration	Quaternary	Sodium salt	Medium
28	Bendigo	Vein	Devonian-Cretaceous	Au(Ag)	Small
29	St. Bathans	Placer	Tertiary	Au(Ag)	Small
30	Naseby	Placer	Tertiary	Au(Ag)	Small
31	Macraes	Vein	Devonian-Cretaceous	Au(Ag)	Medium
32	Clarendon	Stratiform	Tertiary	P	Medium
33	Gabriels Gully	Placer	Tertiary	Au(Ag)	Small
34	Waikaka	Placer	Quaternary	Au(Ag)	Small
35	Round Hill-Orepuki	Placer	Quaternary	Au(Ag)	Small
36	Preservation Inlet	Vein	Cambrian-Devonian	Au(Ag)	Small
37	Mt. George	Magmatic cumulate	Devonian-Cretaceous	FeTi(V)	Small
38	Nevis	Placer	Quaternary	Au(Ag)	Small
39	Clutha	Placer	Quaternary	Au(Ag)	Small
40	Shotover	Placer	Quaternary	Au(Ag)	Small
41	Glenorchy	Vein	Devonian-Cretaceous	W	Medium
42	Pyke River	Vein	Devonian-Cretaceous	Asbestos	Medium
43	Ross	Placer	Quaternary	Au(Ag)	Small
44	Rimu-Kaniere	Placer	Quaternary	Au(Ag)	Medium
45	Taramakau-Greenstone/Kumara	Placer	Quaternary	Au(Ag)	Medium
46	Grey Valley	Placer	Quaternary	Au(Ag)	Medium
47	Reefton	Vein	Cambrian-Devonian	Au(Ag)	Medium
48	Barrytown Beach	Placer	Quaternary	TiZn REO	Medium
49	Carters Beach/Nine Mile Beach/Westport	Placer	Quaternary	TiZn REO	Medium

Table 8. Mineral deposits of New Zealand–Continued

[Numbers refer to figure 8]

Number	Name	Type	Age of Mineralization	Commodity	Size
50	Buller Gorge	Stratabound	Devonian-Cretaceous	U	Small
51	Lyell	Vein	Cambrian-Devonian	Au(Ag)	Small
52	Karamea Bend	Porphyry	Devonian-Cretaceous	Mo	Small
53	Karamea North	Placer	Quaternary	TiZn REO	Medium
54	Golden Blocks	Vein	Cambrian-Devonian	AuAg	Small

Table 9. Mineral deposits of Fiji

[Numbers refer to figure 9]

Number	Name	Type	Age of mineralization	Commodity	Size
1	Wainunu	Surficial concentration	Quaternary	Al	Medium
2	Mt. Kasi	Vein	Tertiary	Au(Ag)	Small
3	Undu	Vein	Tertiary	CuZn(PbAgAu)	Small
4	Tuvutha	Surficial concentration	Quaternary	P	Small
5	Vanua Vatu	Surficial concentration	Quaternary	P	Small
6	Ongea Ndriki	Surficial concentration	Quaternary	P	Small
7	Wainivesi	Stratabound	Tertiary	CuZn(PbAgAu)	Small
8	Waisoi	Porphyry	Tertiary	CuMo(AuAg)	Large
9	Singatoka	Placer	Quaternary	FeTi(V)	Medium
10	Nabu/Vunamoli	Surficial concentration	Quaternary	Mn	Medium
11	Nasaucoko	Surficial concentration	Quaternary	Mn	Small
12	Mba River	Placer	Quaternary	FeTi(V)	Medium
13	Vatukoula	Vein	Tertiary	Au(Ag)	Medium

Table 10. Mineral deposits of the Solomon Islands

[Numbers refer to figure 10]

Number	Name	Type	Age of mineralization	Commodity	Size
1	Vaghena	Surficial concentration	Quaternary	Al	Small
2	Jejevo	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
3	Tataka	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
4	Hanesavo	Stratiform	Tertiary	Cu(AuAg)	Small
5	Chovohio	Placer	Quaternary	Au(Ag)	Medium
6	Gold Ridge	Vein	Tertiary	Au(Ag)	Small
7	West Rennell	Surficial concentration	Quaternary	Al	Small
8	Bellona	Surficial concentration	Quaternary	P	Medium
9	Koloula	Porphyry	Tertiary	Cu(AuAg)	Small
10	Mbetilonga	Porphyry	Tertiary	Cu(AuAg)	Small
11	Lower Poha	Porphyry	Tertiary	Cu(AuAg)	Small
12	San Jorge	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
13	San Jorge	Placer	Quaternary	Cr	Small

Table 11. Mineral deposits of Vanuatu

[Numbers refer to figure 10]

Number	Name	Type	Age of mineralization	Commodity	Size
1	Forari	Surficial concentration	Quaternary	Mn	Medium
2	Raouisse	Surficial concentration	Quaternary	Mn	Medium
3	Immeus	Surficial concentration	Quaternary	Mn	Medium
4	Southwest Efaté	Placer	Quaternary	FeTi(V)	Small
5	Southern Espiritu Santo	Placer	Quaternary	FeTi(V)	Small
6	Northern Espiritu Santo	Placer	Quaternary	FeTi(V)	Small

Table 12. Mineral deposits of New Caledonia

[Numbers refer to figure 11]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Pilou	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
2	La Balade	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
3	Meretrice	Stratiform	Devonian-Cretaceous	PbZn,ZnPb	Small
4	Fern Hill	Vein	Tertiary	Au(Ag)	Small
5	Cap Bocage	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
6	Poro	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
7	Kouaoua	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
8	Canala	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
9	Nakety	Vein	Tertiary	Sb	Small
10	Thio	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
11	Dent de St.Vincent	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
12	Mt. Humboldt	Irregular magmatic	Tertiary	Cr	Medium
13	Kouakoue	Surficial concentration	Quaternary	Ni(CoCuPt)	Small
14	(Unnamed)	Irregular magmatic	Tertiary	Cr	Medium
15	Yate	Irregular magmatic	Tertiary	Cr	Medium
16	Goro	Surficial concentration	Quaternary	Fe	Small
17	Ile Ouen	Vein	Tertiary	Semi-precious gems	Small
18	Plaine des Lacs	Irregular magmatic	Tertiary	Cr	Medium
19	Mont Dore	Irregular magmatic	Tertiary	Cr	Small
20	La Tontouta	Stratiform	Tertiary	Mn	Small
21	Bourail	Stratiform	Tertiary	Mn	Small
22	(Unnamed)	Irregular magmatic	Tertiary	Cr	Small
23	Me Maoya	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
24	Poya	Stratiform	Devonian-Cretaceous	Cu(AuAg)	Small
25	Raymond	Stratiform	Tertiary	Mn	Small
26	Kopeto	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
27	Nepoui	Placer	Quaternary	Cr	Small
28	Kone	Stratiform	Tertiary	Mn	Small
29	Temala	Stratiform	Tertiary	Mn	Small
30	Taom	Stratiform	Tertiary	Mn	Small
31	Ouazangou	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
32	Kaala	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
33	Tiebaghi	Irregular magmatic	Tertiary	Cr	Large
34	Poum	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium

Table 13. Mineral deposits of Papua New Guinea

[Numbers refer to figure 12]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Ok Tedi	Porphyry	Quaternary	Cu(AuAg)	Large
2	Nong River	Porphyry	Tertiary	Cu(AuAg)	Medium
3	Tifalmin	Porphyry	Tertiary	Cu(AuAg)	Medium
4	Frieda	Porphyry	Tertiary	Cu(AuAg)	Large
5	Porgera	Vein	Tertiary	AuAg	Large
6	Mt. Kare	Suficial concentration	Quaternary	Au(Ag)	Small
7	Yandera	Porphyry	Tertiary	CuMo	Large
8	Ramu	Surficial concentration	Quaternary	Ni(CoCuPt)	Large
9	Ramu	Surficial concentration	Quaternary	Cr	Large
10	Aua Island	Surficial concentration	Quaternary	P	Small
11	Manu Island	Surficial concentration	Quaternary	P	Small
12	Sae Islands	Surficial concentration	Quaternary	P	Small
13	Lepatuan	Surficial concentration	Quaternary	Al	Small
14	Arie	Porphyry	Tertiary	Cu(AuAg)	Small
15	Bat Islands	Surficial concentration	Quaternary	P	Small
16	Mt. Kren	Porphyry	Tertiary	Cu(AuAg)	Small
17	Nauna	Surficial concentration	Quaternary	P	Small
18	Pigibut	Vein	Quaternary	Au(Ag)	Medium
19	Lihir	Vein	Quaternary	Au(Ag)	Large
20	Legusulum	Porphyry	Tertiary	Cu(AuAg)	Medium
21	Kabang	Vein	Quaternary	Au(Ag)	Small
22	Panguna	Porphyry	Tertiary	Cu(AuAg)	Large
23	Wild Dog	Vein	Tertiary	AuAg	Small
24	Pelapuna	Porphyry	Tertiary	CuMo	Small
25	Pago	Stratiform	Quaternary	S	Small
26	Plesyumi	Porphyry	Tertiary	Cu(AuAg)	Small
27	Kulu River	Porphyry	Tertiary	CuMo	Small
28	Mt. Victor	Vein	Tertiary	Au(Ag)	Small
29	Lakekamu	Placer	Quaternary	Au(Ag)	Medium
30	Bulolo	Placer	Quaternary	Au(Ag)	Medium
31	Wafi River	Vein	Tertiary	AuAg	Medium
32	Edie Creek/Wau/ Hidden Valley/ Kerimenge	Vein	Tertiary	AuAg	Medium
33	Lake Trist	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
34	Bovio Hill	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
35	Hessen Bay	Placer	Quaternary	Cr	Large
36	Kokoda	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
37	Wowo Gap	Surficial concentration	Quaternary	Ni(CoCuPt)	Medium
38	Wapolu	Vein	Quaternary	Au(Ag)	Small
39	Iamelele	Stratiform	Quaternary	S	Small
40	Kulumadau	Vein	Tertiary	Au(Ag)	Small
41	Cannac Island	Surficial concentration	Quaternary	P	Small
42	Umuna	Vein	Tertiary	AuAg	Medium
43	Sudest Island	Placer	Quaternary	Au(Ag)	Small
44	Table Bay	Placer	Quaternary	FeTi(V)	Small
45	Doriri	Vein	Devonian-Cretaceous	Ni(CoCuPt)	Small
46	Rigo	Stratabound	Tertiary	Mn	Small
47	Laloki	Stratiform	Tertiary	Cu(AuAg)	Small
48	Deception Bay	Placer	Quaternary	FeTi(V)	Small
49	Bramble Cay	Surficial concentration	Quaternary	P	Small

Table 14. Mineral deposits of Irian Jaya

[Numbers refer to figure 12]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Amberbaken	Vein	Tertiary	PbZn	Small
2	Cyclops Mountains	Vein	Tertiary	CuZn(PbAgAu)	Small
3	Cyclops Mountains	Surficial concentration	Quaternary	Ni(CoCuPt)	Small
4	Cyclops Mountains	Surficial concentration	Quaternary	Cr	Small
5	Ertsberg/Grasberg	Skarn	Tertiary	Cu(AuAg)	Large

Table 15. Mineral deposits of Antarctica and Indian and Pacific Ocean islands

[Numbers refer to figure 13]

Number	Name	Type	Age of Mineralization	Commodity	Size
1	Christmas Island	Surficial concentration	Quaternary	P	Large
2	Ashmore Islands	Surficial concentration	Quaternary	P	Small
3	Kupang, Timor	Surficial concentration	Devonian-Cretaceous	Mn	Small
4	Spratly Island	Surficial concentration	Quaternary	P	Small
5	Itu Aba Island	Surficial concentration	Quaternary	P	Small
6	Thi-tu Island	Surficial concentration	Quaternary	P	Small
7	North Danger Island	Surficial concentration	Quaternary	P	Small
8	Babelthuap Island	Vein	Tertiary	Au(Ag)	Small
9	Peleliu Island	Surficial concentration	Quaternary	P	Small
10	Angaur Island	Surficial concentration	Quaternary	P	Medium
11	Tobi Island	Surficial concentration	Quaternary	P	Small
12	Fais Island	Surficial concentration	Quaternary	P	Medium
13	Rota Island	Surficial concentration	Quaternary	P	Small
14	Saipan Island	Surficial concentration	Quaternary	P	Small
15	Ngatik Island	Surficial concentration	Quaternary	P	Small
16	Kapingamarangi Island	Surficial concentration	Quaternary	P	Small
17	Ebon Island	Surficial concentration	Quaternary	P	Small
18	Nauru	Surficial concentration	Quaternary	P	Large
19	Ocean Island	Surficial concentration	Quaternary	P	Large
20	Tamana Island	Surficial concentration	Quaternary	P	Small
21	Howland Island	Surficial concentration	Quaternary	P	Small
22	Baker Island	Surficial concentration	Quaternary	P	Small
23	Palmyra Island	Surficial concentration	Quaternary	P	Small
24	Washington Island	Surficial concentration	Quaternary	P	Small
25	Jarvis Island	Surficial concentration	Quaternary	P	Small
26	Enderbury Island	Surficial concentration	Quaternary	P	Small
27	Phoenix Island	Surficial concentration	Quaternary	P	Small
28	Sydney Island	Surficial concentration	Quaternary	P	Small
29	McKean Island	Surficial concentration	Quaternary	P	Small
30	Vaitupu Island	Surficial concentration	Quaternary	P	Small
31	Walpole Island	Surficial concentration	Quaternary	P	Small
32	Surprise Island	Surficial concentration	Quaternary	P	Small
33	Fabre Island/Le Leizour Island	Surficial concentration	Quaternary	P	Medium
34	Long Island	Surficial concentration	Quaternary	P	Small
35	Wreck Reefs	Surficial concentration	Quaternary	P	Small
36	Horn Bluff, Antarctica	Surficial concentration	Quaternary	Sn	Small
37	Ainsworth Bay, Antarctica	Stratiform(?)	Proterozoic	Mo	Small
38	Cape Denison, Antarctica	Stratiform	Proterozoic	Mo	Small
39	Clark Peninsula (Casey Station), Antarctica	Stratiform	Mid Proterozoic	Fe	Small
40	Clark Peninsula, Antarctica	Stratiform	Mid Proterozoic	Mn	Small
41	Bunger Hills, Antarctica	Stratiform	Mid Proterozoic	Fe	Small