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Geology and Nonfuel Mineral Deposits of Asia and the Pacific

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Introduction

This report on nonfuel mineral deposits and resources of the Asia and the Pacific region is one of a series of geologic regional reports produced by the U.S. Geological Survey to provide up to date summary information of known and undiscovered mineral resources around the globe (Cunningham and others, 2005; Nokleberg and others, 2005; Zientek and others, 2005). These geologic regional reports are designed to be informative with respect to the location and endowment of mineral resources for each region. Boundaries of these regions are those of the USGS Minerals Yearbooks, which monitor production and economic factors affecting the mineral industries of the regions. Additional and historic information related to mineral production statistics also can be found in the Yearbooks. The area described within each of the regional reports is shown on Figure 1 and the Yearbooks are available on line at *http://minerals.usgs.gov/minerals/pubs/myb.html*.

Information included in each regional report includes the age and type of rocks that contain the deposits, summary of known mineral deposit types, location of known representative nonfuel mineral deposits, regional exploration history, recent significant mineral discoveries for metal and industrial minerals, and a discussion of the potential for undiscovered mineral resources in the region. This report on the nonfuel mineral resources of the Asia and Pacific region provides both geologic- and commodity-based mineral-resource information on a regional-multinational basis.

This report also summarizes information on known deposits that are the basis, in part, for on-going international quantitative mineral assessments led by the USGS of global undiscovered nonfuel mineral resources at scales of 1:1,000,000 (Briskey and others, 2001, 2002). In this global assessment, tracts, or areas permissive for particular types of undiscovered mineral deposits, are delineated and, where data are adequate, include estimates of the quantity and quality of the undiscovered resources. The on-going quantitative global assessment results are designed to assist the global community to maintain the availability of essential mineral resources from areas of the earth most able to sustain the economic, social, and environmental effects of mining.

Briskey and others (2001, 2002) have described some of the uses of the global mineral assessment of undiscovered nonfuel mineral resources and have concluded that the world will continually face decisions involving the supply and utilization of raw materials, substitution of one resource for another, competing land uses, and the environmental consequences of resource development. Informed planning and decision making concerning sustainability and resource development require a long-term perspective together with an integrated approach to land-use, resource, and environmental management planning. This, in turn, requires that unbiased information be available on the global distribution of known and especially undiscovered mineral resources, the economic factors influencing their development, and the environmental and social consequences of their exploitation.

The Asia and the Pacific region is large and diverse. The region contains rocks of all geologic ages, which in turn contain a large variety of major mineral deposit types, containing copper, gold, nickel, potash, titanium, gemstones, and many other commodities (Dixon, 1979; Derry, 1980; Mitarbeiterstab der Bergbauabteilung, 1987; Vaněček, 1994; Johnson, 1996; Kamitani and Naito, 1998, Ariunbileg and others, 2003) (table 1). Topography and bathymetry of the region are represented in Figure 2, which shows that differences in elevation range from the highest points on earth in the Himalayan Mountains to the depths of the Pacific Ocean. Also shown on Figure 2 are locations of the tectonic plate boundaries that are associated with current seismic activity (earthquakes) and volcanoes. Many mineral deposits were formed by geologic processes through long periods of geologic time operating along and within these tectonic plate boundaries. Distribution of rocks by age is shown on the geologic map in Figure 3 and this time distribution has had a significant effect, because of the geologic history, on the location of different mineral deposit types.

Large deposits of important mineral commodities are present in several parts of the Asia and Pacific region (fig. 4, table 2). The region contains and has significant potential for iron in sedimentary deposits in Australia and India. Smaller deposits of iron in contact metamorphic deposits around igneous bodies also are mined in Laos, Cambodia and other countries. Resources and potential for nickel are present in volcanic nickel-copper deposits in Australia, and in smaller nickel-laterite (intensely weathered) deposits in Indonesia, New Caledonia, India, the Philippines, and Australia. Large deposits of lead, zinc, and silver in sedimentary zinc-lead deposits are present in Australia, India, Burma, and China. A number of very large copper and copper-gold deposits are present in the Asia and the Pacific region. Examples include the Olympic Dam copper-uranium-gold deposit in Australia, and many porphyry copper-gold deposits in Indonesia, Papua New Guinea, Australia, China, and the Philippines (fig. 4, table 2). Bauxite aluminum deposits in India, Australia, Cambodia, Laos, and Indonesia contain significant world resources. Gold deposits are numerous in Asia and the Pacific region, but the largest of these are the gold-quartz vein deposits in Australia, China, and India and a number of hot-spring gold-silver deposits in the Philippines, Indonesia, and other countries (fig. 4, table 2). Small- to medium-size tin and tungsten lode and placer deposits are abundant in China, Burma, Thailand, Malaysia, and Indonesia.

Many kinds of industrial mineral deposits are present in the Asia and Pacific region. Building stone, aggregate (sand and gravel) deposits, limestone deposits, a number of semi-precious gem deposits, as well as other industrial mineral deposits, are present throughout much of the region. The Asia and Pacific region is a premier source of gemstones and contains many important deposits, such as emerald, lapis lazuli, ruby, and tourmaline deposits in Afghanistan, opal deposits in Australia, jade deposits in Burma, and additional gemstone deposits in Cambodia, Laos, India, Pakistan, Sri Lanka and Thailand. Australia is a major producer of diamonds from the *Argyle* deposit (table 2), and India also has many recent primary diamond deposit discoveries. In addition, a number of small diamond placer deposits also are present in the region, suggesting further potential for large diamond discoveries. *Bayan Obo* in China is associated with igneous intrusions and is the largest rare-earth element deposit in the world.

Marine and lake deposits have been a large source of industrial minerals in the Asia and Pacific region. A significant part of the world's titanium and zirconium supply originates in the

Asia and Pacific region where these commodities occur as large, heavy-mineral beach sand deposits that are rich in titanium, zirconium, and rare-earth elements. These deposits are present along the coastlines of New Zealand, Australia, Bangladesh, India, China, Sri Lanka, and Vietnam. Phosphate deposits are present in Australia, India, and Cambodia, and extensive large deposits of potash and halite deposits have been discovered in northeastern Thailand and in Laos and show increasing potential. *Mangampeta* in India is the largest barite deposit in world. Deposits of clays, lithium, mica, magnesite, building stone, and graphite in Asia and the Pacific region are significant contributors to global and regional markets (fig. 4, table 2).

Regional geologic framework

The geology of the Asia and Pacific region is complex and is represented by rocks of all Eons of earth history (fig. 3). The geologic framework is the result of a long and repeated history of sedimentation, volcanism, igneous intrusion, metamorphism, and mountain building. These processes formed ancient and recent mountain chains, folded rocks, and broad sedimentary basins throughout the region. The multiple geologic settings, together with the location of the region north and south of the equator, contribute to a wide variation in geography and climate that ranges from high, remote mountains, to dense jungles, to expansive, dry deserts, multiple islands and expasive shorelines. Nonfuel mineral deposits are associated with specific geologic rock types and tectonic settings, and therefore the extensive geologic history of the Asia and Pacific region has been conducive to the formation of many kinds of large and abundant mineral deposits. The known mineral deposits are best characterized by their location within major geologic provinces and structures and by their relation to the geologic and tectonic history of the region. This context allows speculation on the location, number and size of a large number of undiscovered deposits.

Major geologic provinces and structures

The Asia and the Pacific region is largely comprised of the Tethys tectonic province that trends east from Europe through central Asia and the Himalayan Mountains but also intersects with the north-south tectonic province of the Pacific Rim (figs. 2 and 3). Geologic provinces and structures in the region result from a number of tectonic plates that have collided and fused together in the region over the past 15 million years (Hamilton, 1979; Zheng and others, 1984; Nokleberg and others, 1994; Hall, 2002). Australia and southern India are contained in the Indo-Australian plate, which lies south of, and is colliding with (fig. 3), the Eurasia plate including China, Mongolia, and the Mekong Delta area (see also Ji and Coney, 1985; Yin and Nie, 1996). The eastern, oceanic part of Asia and the Pacific region is composed of the Pacific plate and the smaller Philippine plate, which are converging to the west against the Eurasian and Indo-Australian plates.

The Himalayan Mountains and Tibet Plateau formed by uplift that was caused by the collision of the Indo-Australian and Eurasian continental plates (figs. 2 and 3). Oceanic crust of the Indo-Australian plate is being subducted under the Indo-China plate along the Jawa trench beneath the island arc of Indonesia underplated by the continent of Australia. In the east, the west-moving Pacific plate is colliding with the Indo-China plate along the Japan, Mariana, New Guinea, Philippine, Solomon, and MaGuire trenches (fig. 3). Plate boundaries near the trenches are marked by earthquakes, volcanoes, active mountain building, mineralizing hot springs, and other mineralizing systems that have produced a number of recent nonfuel mineral deposits. Intense tropical rain fall has produced extensive zones of intense weathering, called laterite, which have modified the surface and produced or obscured many mineral deposits.

Overview of geologic and tectonic history

The oldest rocks in the Asia and the Pacific region are >2.5 billion-year-old Archean metamorphic rocks of the Yilgarn and Wiluna cratons in Australia, the Indian craton, and parts of the north and south China cratons (fig. 3). These Archean rocks mainly are metamorphic gneiss and granite, and make up the continental cores of the Indio-Australian and Eurasian tectonic plates, and are partially covered by <2.5 billion– to 570 million–year-old Proterozoic sedimentary, igneous, and metamorphic rocks. The Proterozoic rocks are wide-spread in Australia and India, and also are abundant in the southern Himalayan Mountains and Mongolia, and in northern and southern China (fig. 3). Proterozoic rocks also are commonly metamorphosed and include a wide variety of ancient volcanic, sedimentary, and igneous rocks. The Archean and Proterozoic rocks contain many large deposits of iron, gold, nickel, and copper and also have some local potential for potash and uranium.

Paleozoic-age (570 to 245 million year-old) and Mesozoic-age (245 to 66 million year-old) rocks are common throughout the Asia and the Pacific region and are present as sedimentary and volcanic rocks that formed in basins along the margins of the Archean and Proterozoic cratons (fig. 3). In the major mountain chains, these rocks were folded, faulted, metamorphosed, and intruded by igneous rocks, particularly along the south part of the Eurasian tectonic plate, along the eastern margin of Australia, in New Zealand, the Mekong Delta area, and Mongolia (fig. 3). Paleozoic igneous and sedimentary rocks in the region contain many major mineral deposits. These rocks contain a number of contact metamorphic rare-earth element deposits, where igneous bodies have intruded reactive limestone rocks. In addition, a number of other mineral deposits are present, including porphyry copper deposits in Australia, and many large industrial and some metal mineral deposits in the sedimentary rocks.

Mesozoic rocks cover and are interfolded with Paleozoic rocks and consist of sedimentary and volcanic rocks and chains of intrusive igneous bodies. A wide variety of major deposits in the Asia and Pacific region are associated with Mesozoic igneous and sedimentary rocks. The major deposits include Mesozoic porphyry copper-molybdenum and copper-gold deposits in igneous rocks in Mongolia, China, and the Mekong Delta area, and tin-tungsten deposits in Thailand, Burma, and Malaysia. Sedimentary rocks also contain large evaporite deposits of potash, salt, and gypsum in Thailand, Laos, and Cambodia, which also locally are associated with sedimentary copper deposits.

Cenozoic rocks are younger than 66 million years old and formed in sedimentary and volcanic basins in the stable continental areas, particularly in India, China, and Australia. They also formed in volcanic and igneous island arcs where the tectonic plates collide (figs. 2 and 3), such as in Malaysia, the Philippines, Indonesia, Papua New Guinea, and Japan. Cenozoic rocks in the region along these island arcs contain a number of major mineral deposits including the large porphyry copper-gold and gold deposits of the Philippines, Papua New Guinea, and Indonesia. The extensive uplift that results from tectonic plate collision has caused significant erosion adjacent to the major mountain chains, such as the Himalayan Mountains and Tibet Plateau, and has resulted in deposition of thick sequences of Cenozoic gravels and sediments that have shed from these high areas by erosion (fig. 3). The region varies greatly from the arid, north and south parts of the region to intense tropical climates in the central parts. Climate in the late Cenozoic has greatly affected the recent landscape. Dry, stable, inland areas in northern China and Australia have low erosion rates, whereas many tectonically active areas contain tropical climates with high erosion and weathering rates. The climatic conditions have lead to the formation of bauxite and laterite deposits of aluminum and nickel (fig. 5), as well as a number of river, stream, and ocean shoreline placer deposits of gold, tin, tungsten, titanium, diamonds, gemstones, and rare-earth elements (fig. 10B).

Major mineral regions and significant known mineral deposits

Mineral deposits of metal and industrial minerals in the Asia and Pacific region formed at different times in the earth's history and therefore mineral deposits of different types are distributed in the five main age subdivision of rocks, the Archean, Proterozoic, Paleozoic, Mesozoic, and Cenozoic. Earth processes and climates have changed throughout earth history. Consequently, old Archean and Proterozoic rocks that compose the original Eurasian and Indo-Australian tectonic plates contain some specific types of mineral deposits, such as large, rich, iron, and nickel-copper deposits that are not present in the younger rocks. Gold deposits are present in all age of rocks, but the types of gold deposits vary among different age rocks throughout the region. The large porphyry copper deposits formed mainly during the Mesozoic and Cenozoic, although Paleozoic-age porphyry copper deposits are present in Australia and Mongolia. Many of the weathering-enhanced deposits, such as aluminum-bauxite deposits and nickel-laterite deposits, as well as most placer deposits of gold, diamonds, and platinum group elements (PGEs) are of Cenozoic age.

A number of representative main deposits in the Asia and Pacific region are presented in table 2. The deposits also are plotted on Figure 4. A more complete listing of significant mineral deposits in the region can be found in the following references: Reports of the Economic and Social Commission for Asia and the Pacific (ESCAP), Metal Mining Agency of Japan (MMAJ) (1998); Triller and Lauenstein (1987), and the Mineral Data bases of the U.S. Geological Survey (MRDS and MILS). More specific compilations of mineral deposits are for NE Asia, Ariunbileg and others (2003); for New Zealand, Williams (1974), for Australia, Hughes (1990), and Solomon and Groves (2002), for China, Liu (1990), for sedimentary copper deposits, Kirkham and others (1994), Kirkham and Rater, 2003, Cox and others (2003); for porphyry copper deposits, Sillitoe and Gappe (1984), and Singer and others (2002).

Metals

Large deposits of important metals are present throughout the Asia and Pacific region (fig. 4A - C, tables 2). The region contains and has significant potential for aluminum, chromium, copper, gold and silver, iron, nickel, zinc and lead, and a number of other metals. Smaller known deposits of these and other metals are abundant and potential for future discovery of large deposits is good.

Aluminum deposits

Aluminum-rich bauxite deposits are present in India, which hosts the largest deposits of this type in the world. In addition, aluminum-rich bauxite deposits are present in Vietnam, and at *Weipa* in northern Queensland, Australia, and in Afghanistan, Cambodia, China, Indonesia, and Laos (fig. 4B, table 2). Aluminum deposits derived from igneous rocks are present in the *Beltsesin gol* and *Duchin gol* areas in Mongolia.

Laterite-type bauxite aluminum deposits (Patterson, 1987) are a main world source of aluminum ore and form in intensely weathered, residual material in subsoil formed on rocks containing aluminum. Weathering enhances the aluminum content and makes the concentrations economic (fig. 5). The Indian deposits lie along the western and northeastern parts of the country (Das Gupta, 1984) with >250 million tons of ore that contains approximately 10 weight percent aluminum. The aluminum producing centers in Australia in the *Weipa, Gove*, and *Mount*

Saddleback areas contain about 4,000 million tons of bauxite aluminum ore (Loughman and Sadleir, 1984). Reserves of high-grade (38 weight percent aluminum) laterite bauxite in *West Kalimatan*, Indonesia are about 810 million tons ore (Rodenburg, 1984). Most of these deposits are Cenozoic in age; however, major aluminum-bauxite deposits that formed during the Late Paleozoic are an important source of alumina in northern China (table 2) from low-iron-aluminum bauxite deposits (Ikonikov, 1984).

Antimony deposits

Antimony is contained in veins and disseminations associated with igneous and sedimentary rocks. China contains the largest deposits of antimony and is the largest producer of the metal in the world (Weber, 2003). Additional smaller antimony deposts also are present in Burma, Thailand, and Australia.

Chromium (chromite) deposits

Mesozoic- and Cenozoic-age podiform chromite deposits formed in basaltic volcanic rocks on the ocean floor that were later pushed up on land as part of the plate tectonic cycle. India is the third largest producer of chromite in the world, particularly from the *Sukinda Valley* area in Proterozoic rocks (table 2, fig. 4B). Other important deposits in the region include the *Loghar* deposit, Afghanistan, *Bunap* and *Sonaro* deposits, Pakistan and the *Acoje* and *Coto/Masinloc* deposits in the Philippines (table 2, fig. 4B). Some chromite deposits also contain platinum-group elements, such as the *Sakhakot-Quila Ophio* deposit, Pakistan.

Cobalt deposits

Most cobalt is produce as a bi-product of polymetallic ores. Australia is the largest producer of cobalt in the world, mainly from the Archean volcanic nickel-copper deposits in Western Australia. Cobalt also is a bi-product of nickel laterite ores and therefore Burma, India, Indonesia, New Caledonia, and Philippines produce by product cobalt. Sedimentary copper deposits also produce bi-product cobalt, such as the Proterozoic deposits in southern China, and sedimentary deposits in Australia.

Copper deposits

The main deposits containing copper in the Asia and Pacific region are formed in sedimentary rocks and porphyry igneous bodies. Another source of copper is iron-oxide-copper-gold deposits. In addition, copper deposits are present in contact metamorphic zones and veins around igneous bodies and associated with volcanic rocks in massive sulfide accumulations (fig. 6). Porphyry copper deposits are one of the most significant resources of copper in the region and are represented by world class-size porphyry copper-gold deposits. Indonesia is the third largest producer of copper in the world from these deposits (Weber, 2003). Porphyry copper deposits have disseminated copper sulfide ore minerals and are mined by large, surface open pit methods with adjacent mill complexes. Concentrates from the mills are processed by smelter. Most copper is currently produced from deposits in Australia, China, Indonesia, Mongolia, and Papua New Guinea.

Many copper deposits in the eastern part of the region are Cenozoic in age. Porphyry copper-gold deposits formed during this time as a result of collision between major tectonic plates (Cox, 1987b; Singer and others, 2002). The largest porphyry-gold deposit is the *Grasberg* deposit, Indonesia (fig.6*A*), which contains over 2,000 million tons of ore and 23 million tons of copper and substantial amounts of gold. Additional significant deposits are present at *Marcopper*, Philippines, and *Batu Hijau,* Indonesia (fig. 4A, table 2), which are associated with igneous arcs through the islands of these countries. Similar Cenozoic-age porphyry copper-gold deposits also are present at the *Saindak* and *Reko Diq* deposits, Pakistan and in Yunnan and Tibet areas of China.

Porphyry copper deposits also are present in Archean, Proterozoic, Paleozoic, and Mesozoic igneous bodies in the region. The *Coppin Gap* porphyry copper-molybdenum deposit (Singer and others, 2002) (table 2) in Western Australia is of Archean age. The *Malanjkhand* porphyry copper-gold deposit in India and some porphyry copper deposits in China (table 2) (Fan, 1984; Singer and others, 2002) are contained in Proterozoic igneous rocks. Additional Paleozoic igneous-related deposits are porphyry copper-gold deposits in Mongolia and northeast China (fig. 4A, table 2). Major Mesozoic porphyry copper-molybdenum and porphyry molybdenum deposits are present at *Erdenetiin Ovoo* and *Aryn nuur*, Mongolia (fig. 4A, table 2) and Mesozoic-age porphyry copper-gold deposits are being exploited in southern China, Burma, Thailand, and Laos. Associated with these types of deposit are major contact metamorphic replacement deposits of copper-gold and strontium in the *Tonglushan-Daye* area, China (Peters, 2002) (fig. 4A, table 2). Contact metamorphic deposits of copper also are present at *Khokhbulgiin khondii*, Mongolia and *Kamaishi* (fig. 4B), Japan (table 2). Contact metamorphic deposits of iron and copper are present in China.

Significant iron-oxide-copper-gold deposits (Cox, 1987a) are represented by the giant *Olympic Dam* deposit in South Australia (fig. 6*B*), which contains about 2,320 million tons of ore and over 30 million tons of copper with substantial resources of uranium and gold. These type of deposits mainly are associated with Proterozoic rocks and form as tabular or pipe-like bodies that contain more than 20 percent iron oxide minerals, whereas the ore minerals are copper sulfide minerals (Haynes, 2002). The *Olympic Dam* deposit is hidden under several hundred meters of sedimentary rocks and was discovered by using geophysical techniques and drilling. In addition, the *Aynak* sediment-hosted copper (175 million tons, grading 2.5 weight percent copper, Abdullah and others, 1977) in Afghanistan has similarities to these deposits as do Proterozoic rock-hosted copper-iron deposits in northwest Vietnam and south China.

Sedimentary and volcanic rocks also host some significant copper deposits in the Asia and Pacific region (figs 6*C* and *D*). Proterozoic volcanic massive sulfide copper deposits are present in the south China craton and at *Borts Uul*, Mongolia (table 2). The Singhbhum copper-uranium belt and Khetri copper area in India also contain large deposits in Proterozoic rocks. Volcanic massive sulfide copper deposits also are present in some Archean rocks of the south China craton. Many of the largest sedimentary deposits are Proterozoic age in China and Australia. Paleozoic sedimentary copper deposits and evaporite deposits are present in sedimentary basins of Pakistan, China, Mongolia, and Australia that also contain significant industrial minerals. Mesozoic sedimentary rocks contain sedimentary copper deposits in Laos, Thailand, Cambodia and southwest China. Mesozoic volcanic rocks contain copper-zinc-silver and copper-zinc massive sulfide deposits in Japan (table2, fig.6*D*). Cenozoic age massive sulfide deposits of copper formed in volcanic rocks on the ocean floor and were later pushed up on land as part of the plate tectonic cycle.

Gold and silver

The Asia and Pacific region contains a large number of major gold deposits, many of which also contain significant silver. The deposits are of different ages and types. The two main gold producing countries are Australia and China. Large gold-quartz vein deposits are present in Archean rocks, such as those of the Golden Mile area, which contains 40 million ounces gold, in the *Kalgoorlie* area of Australia, the *Kolar-Hutti* gold belt, India, and the *Jiadong* and *Paishanlou* gold deposit districts, China (see also Berger, 1987) (table 2, figs. 4A and 7*A*). These deposits are mined from underground and by surface open pit methods. Most gold deposits are processed by gravity methods or by milling and chemical treatment near the mine sites.

Paleozoic, Mesozoic, and Cenozoic rocks contain a large number of additional gold and silver deposits in the region that are present as veins and disseminations in and around copper-gold porphyry deposits in Papua New Guinea, Indonesia, the Philippines and Malaysia, and in metamorphic contact zones around igneous bodies in China and Mongolia. Cenozoic deposits also are present on the Coramandel Peninsular in New Zealand. In addition, hot-spring gold-silver veins are present in most countries, and sedimentary rock-hosted gold deposits are an emerging type of deposit in central and southern China, similar to the large Carlin-type gold deposits in Nevada, USA (Peters, 2002) (table 2, fig. 4A). Many quartz vein deposits contain native gold particles that are easily processed by gravity methods, and when weathered shed gold particles and nuggets into adjacent streams and valleys forming gold placer deposits. Placer gold deposits are present in China, Papua New Guinea, southern New Zealand, and Australia, and along the coastlines of Burma, Malaysia, Thailand, and Indonesia. Submarine deposits of high-grade gold have recently been discovered in the territorial waters of Papua New Guinea (Martens, 2003).

Iron deposits

Iron deposits mainly are present in metamorphic and sedimentary Archean and Proterozoic rocks in the region. Major Archean-age sedimentary banded iron formation (BIF) deposits include the *Sijiaying,* and *Yuanjiachun* deposits, (fig. 4B, table 2); (Cannon, 1986), China and constitute a major iron resource (up to 2,200 million tonnes iron). The best examples are the world's largest sedimentary rock-hosted banded iron formation (BIF) iron deposits that are present in the Proterozoic rocks of the *Hamersley Basin* in northwestern Australia and in the Karnataka, Anhra, Pradesh, and Orissa areas of India (figs. 4B and 8) (Cannon, 1987). Additional major deposits in Proterozoic rocks include iron (magnetite) deposits at *Xiafangshen*, China. The deposits typically are of large lateral extent, but may have been modified and enhanced by folding, faulting, or deep weathering. The size of the deposits is between 20 and 980 million tons of ore, which average about 63 weight percent iron. The ores are composed of the iron-oxide minerals, hematite and magnetite, but also contain iron carbonate and quartz. The iron minerals are magnetic and the ore bodies are easily explored using magnetic geophysical methods. Mining usually is by open pit methods.

Additional medium-sized deposits of iron in the region are contained in metamorphic contact zones around igneous bodies and associated with iron-oxide deposits (fig. 4B, table 2). Many of the contact metamorphic deposits contain bi-product metals, such as copper, molybdenum, strontium, tantalum, vanadium, tungsten, zinc, and cadmium. For instance, the *Bayan-Obo* deposit, China produces a significant amount of iron, and iron-rare-earth element-niobium (Bayan-Obo type) deposits also are present on the Korean Peninsula (table 2). Contact metamorphic deposits of iron and copper are present in China, and iron-zinc deposits are present in Korea. Iron oxide (copper-gold) deposits are large sources of iron in Asia and the Pacific and are present in the Proterozoic iron-rich rocks in southern and northern Australia and in Afghanistan at the *Hajigak* iron deposit, which is the largest iron deposit in Central Asia and contains 2,070 million tons ore at 62.83 to 68.68 weight percent iron. Small but numerous iron deposits also are worked in the Mekong delta countries, particularly in Burma from iron and iron-manganese laterite deposits.

Lead deposits

Lead deposits are discussed with zinc deposits below, because these metals commonly occur together. Silver and cadmium may also be present in many lead-zinc deposits. The largest deposits of lead are contained in sedimentary rocks, and locally in volcanic rocks, in contact metamorphic zones around igneous bodies, and as veins (table 2). The larger deposits are present in sedimentary rocks in Australia, China, and India (fig. 4A).

Molybdenum deposits

Molybdenum is mainly produced as a bi-product from porphyry copper deposits. Locally some molybdenum porphyry deposits also are present, such as in Indonesia, China, and New Zealand. China is the third largest producer of molybdenum (Weber, 2003), and further bi-product resources of the metal lie in deposits in Fiji, Pakistan, Australia, Indonesia, Mongolia, Papua New Guinea, and Afghanistan.

Nickel deposits

The Asia and Pacific region contains a number of large nickel deposits (fig. 4B). The metal occurs as sulfide minerals in basaltic volcanic and igneous rocks, and also as oxides in nickel-laterite deposits. The most significant group of nickel-copper deposits are present in Archean rocks in the Yilgarn craton of Western Australia (table 2, figs. 2 and 3) in the komatiitic nickel-copper deposits in Western Australia. Komatiitic nickel-copper deposits (Page, 1987), such as the *Kambalda* nickel-copper deposits (fig. 9), are lenticular or irregular, elongate orebodies that are associated with komatiites, a dark magnesium-rich lava that was extruded in the Archean (Solomon and Groves, 2000). The size of the large deposits is between 2 and 300 million tons of ore that contains less than 1 weight percent nickel. Numerous smaller deposits with high percent nickel content also are present in the Yilgarn craton. Ore minerals are nickel- and copper-bearing iron sulfide minerals. The ores are mined by both underground and open pit methods and are concentrated by mill flotation and the concentrates sent to smelter. The large Proterozoic *Jinchuan* nickel, copper, cobalt, platinum and palladium deposit occurs in central China also is associated with igneous rocks (table 2).

Lateritic nickel deposits result from deep weathering and enrichment of nickel-bearing source rocks (fig. 5), and these deposits are present and locally abundant in Burma, New Caledonia, Indonesia, Philippines, India, and north Queensland, Australia (table 2).

Rare-earth elements, uranium, and thorium deposits

A significant Paleozoic igneous-related deposit is the *Bayan Obo* iron-rare-earth element deposit in China (figs. 11 and 4B - C), which is the largest producer of rare-earth elements in the world (Singer, 1987; Lin and others, 1994). The deposit has several bodies that are present along an 18–km-long, 5–km-wide contact metamorphic zone of the igneous rock. The Bayan-Obo deposit ore mineralogy is very complex and contains about sixty niobium, rare-earth element, titanium, zirconium, and iron minerals.

Multi-element deposits of rare-earth elements, iron-niobium of the Bayan Obo-type (Singer, 1987; Drew and others, 1990) also are present along a zone northern margin of the north China craton on the Korean Peninsula. Proterozoic igneous rocks of the Paleozoic *Bayan Obo* deposit are enriched in phosphorous and rare-earth elements and similar deposits include deposits at *Eppawalla*, Sri Lanka, and *Mount Weld*, Australia (see also, Singer, 1987). Additional igneous-related niobium-zirconium-rare-earth element deposits (*Beltesin gol, Duchin gol*) and significant tantalum-niobium-rare-earth element deposits (*Ulaantolgoi*) are present in Mongolia (table 2). Major deposits in Proterozoic igneous rocks include the *Samgoe-Soryong* uranium deposit, Korean Peninsula. Mesozoic igneous rocks contain the *Mushgai Khudag* rare-earth element and *Lugin gol* rare-earth element (± tantalum, niobium, and iron) deposits. Cenozoic igneous bodies contain the *Khanneshin* deposit in Afghanistan that is enriched in phosphorous, uranium, thorium, and rare-earth elements. In addition, rare-earth element pegmatite and lithium-tin-tantalum deposits in Australia are major igneous-related mineral deposits in Proterozoic rocks.

Cenozoic age lake sediments at *Khanneshin* are enriched in phosphorous, uranium, thorium, and rare-earth elements. Other significant Cenozoic age deposits include the fluorine-phosphorous-rare-earth element deposit at *Amba Dongar*, India. Large coastline placer deposits of titanium–rare-earth elements-zirconium are present along the shorelines of India, Bangladesh, Sri Lanka, Vietnam, Australia, and New Zealand, and at *Ke Sung*, and *Mi Tho*, Vietnam (fig. 4B, table 2). Sedimentary uranium deposits are present at *Samgoe-Soryong*, Korea, and *Nars*, Mongolia.

Silver deposits

Silver is a bi-product of lead ores, but also is contained in sulfide-bearing ores associated with igneous rocks and with many types of gold deposits. Australia is the third largest producer of silver in the world (fig. 4A) (Weber, 2003).

Tin and tungsten deposits

The Asia and Pacific region contains large and productive tungsten and tin deposits that formed in and around Mesozoic igneous rocks in southeast China (Li and others, 1994) and in Mesozoic and Cenozoic igneous rocks along a number of tin-tungsten belts through Burma, Thailand, and Malaysia (table 2, fig. 4C). China is the major producer of tungsten in the world and China and Indonesia are the first and second largest producers of tin in the world (Weber, 2003). Australia also contains tin deposits in Queensland and Tasmania. Other Mesozoic igneous rocks in the Asia and Pacific region contain the *Tsagaan dabaa* tungsten-molybdenum-beryllium deposits in Mongolia. In addition, the fluorite veins of *Bor Undur*, Mongolia, and the lithium-tantalum-niobium-tin deposits of the *Pasghushta* pegmatite field, Afghanistan provide sources of these metals. Cenozoic offshore placer deposits contain tin, tungsten and gold and placer deposits containing these metals also are present in major drainages and along the coastlines of Burma, Malaysia, Thailand, and Indonesia.

Titanium deposits

Large coastline placer deposits of titanium-rare-earth elements with zirconium are present in mineral sands along the shore lines of India, Bangladesh, Sri Lanka, with Vietnam, Australia, and New Zealand (fig. 4B, table 2). Australia is the largest producer of titanium. Many titanium-iron (vanadium) deposits in China are related to igneous rocks (table 2), and are a major source of iron and titanium. Shoreline placer titanium deposits consist of ilmenite (titanium oxide) and other heavy minerals that have been concentrated by beach processes and enriched by weathering. The heavy minerals are transported by longshore current drift and are sorted and concentrated by currents and wind. This results in economic titanium placer deposits that are mined both onshore, from raised marine terraces, present beaches and, offshore, in submerged ancient shorelines as deep as 200 m below sea level.

Zinc and lead deposits

Most large zinc and lead deposits in the region are present in Proterozoic sedimentary or metamorphosed sedimentary rocks (table 2, figs. 4A and C). Deposits also are present in some younger sedimentary rocks in China, in volcanic rocks, in veins, and around contact-metamorphic zones of igneous bodies. The deposits commonly are accompanied by silver, and locally copper and other metals. Sedimentary zinc-lead deposits are large deposits present in Proterozoic sedimentary rocks of the *Mt. Isa* and *Broken Hill* areas in Australia (Briskey, 1987; Hughes, 1990), in the Rajasthan basin, and in the *Rampura Agucha* deposit in the Aravalli belt in India. Similar Proterozoic deposits also are present in China (Tu and others, 1989). The size of the Australian deposits is between 30 and 280 million tons of ore with approximately 10 weight percent zinc, 5 weight percent lead and additional copper and silver. The Indian deposits in the Rajasthan basin usually contain between 11 and 60 million tons ore that grades about 6 weight percent zinc, and 1.5 weight percent lead (Large and others, 2002).

Paleozoic volcanic rocks host significant zinc-lead-copper massive sulfide deposits at *Hitachi*, Japan, the *Bawdwin* deposit, Burma and similar deposits in northern China and Australia (fig. 4A, table 2). Major Cenozoic volcanic-hosted zinc-lead-copper massive sulfide deposits also are present in Japan (figs. 4A and C, table 2). Mongolia contains a significant copper-silver-lead vein deposit (*Dulaan khar uul*); Paleozoic sedimentary rocks also host (oxidized) zinc-lead deposits in Laos, Thailand, and Burma (table 2). Mesozoic sedimentary rocks contain sediment-hosted lead-zinc deposits in Pakistan, and bedded celestite (strontium) deposits in China, (table 2). Sedimentary lead-zinc deposits formed in Mesozoic rocks in Pakistan. The *Jinding* deposit (fig. 4A) in Mesozoic and Cenozoic sedimentary rocks in western Yunnan contains more than 200 million tons combined lead and zinc. Contact metamorphic deposits of lead-zinc are present in Mongolia and Japan, and iron-zinc deposits are present in Korea.

Other metal deposits

Major Jurassic age silver-antimony and fluorite vein deposits are present in Mongolia associated with Mesozoic igneous rocks. Igneous-related Cenozoic deposits in the Asia and Pacific region include mercury-antimony-tungsten veins and manganese deposits in the Philippines, Indonesia, Papua New Guinea, Japan, and southeastern China. Small placer deposits of platinum group elements are prevalent in Burma and Papua New Guinea.

Industrial minerals

Industrial minerals are mineral commodities that are not metallic and therefore commonly are produced and sold according to purity and economic considerations in addition to commodity pricings. Many industrial mineral deposits are present in the Asia and Pacific region. Building stone, aggregate sand and gravel deposits, barite, limestone, a number of semi-precious gem deposits, as well as other industrial mineral deposits, are present throughout much of the region. The region is a premier source of gemstones. The *Bayan Obo* in China is the largest rare-earth element deposit in the world. A significant part of the world's titanium and zirconium supply originates in placer deposits in the Asia and Pacific region where these commodities area associated with rare-earth elements. Phosphate deposits are abundant, and extensive large deposits of potash and halite have been discovered in Thailand. Deposits of clays, lithium, magnesite, and graphite are significant contributors to global and regional markets (figs. 4A - C, table 2).

Barite

Barite is an important commodity in oil and gas exploration and also is used as a filler. Most of the largest producing barite deposits in the world are in China, although India also contains large deposits (fig. 4C). The largest barite deposits are sedimentary, but barite also occurs in veins. Bedded barite deposits consist of barite interbedded with sedimentary rocks. The deposits commonly are spatially associated with sedimentary zinc-lead deposits. The sedimentary *Mangampeta* deposit, India is the largest single barite deposit in world. Additional large Paleozoic sedimentary barite deposits are present in China, such as the *Gongxi* bedded barite deposit (table 2). A major barite vein deposit is present at *Hagigak*, Afghanistan, (table 2) in Proterozoic rocks.

Beryllium

Beryllium deposits are associated with igneous bodies at *Darrahe-Nur,* Afghanistan, and *Keketuohai*, China (fig. 4C). These types of deposits also produce bi-product niobium, tin, and tantalum.

Boron

The sedimentary *Wengquangou* borate deposit, northern China, is hosted by Proterozoic rocks. The evaporite salts and brines of China's *Qaidam-Qarhan Basin* are an extensive, but remote, resource of boron, lithium (fig.4C).

Clays, bentonite and kaolin

Residual kaolin deposits are highly weathered deposits composed of high-alumina kaolin with mica as by-products. Deposits related to Cenozoic weathering include residual kaolin deposits, at *Skarndon River*, Australia, and *Maoming*, China. Bentonite deposits are present in sedimentary rocks in Australia. Late Paleozoic sedimentary rocks contain the large *Kerjian* bentonite deposit, China, and Paleozoic sedimentary rocks also contain the *Pingshan* sodium-bentonite deposit, China. Significant Cenozoic age deposits include the largest bentonite deposit in China (*Ningming*) (fig. 4C, table 2). Some clay deposits are associated with coal deposits.

Diamonds

Diamond deposits are present in kimberlite pipes in Australia, India, and China. Australia is a major producer of diamonds from the *Argyle* deposit (fig. 4C, table 2). A number of new kimberlite pipes have been discovered in India and numerous small diamond placer deposits present in Australia, India, and China suggest further potential for large diamond discoveries.

Gemstones

The region is a premier source of gemstones and contains many important deposits (fig. 4C). The most notable of the deposits present in Archean rocks is the *Sary Sang* lapis lazuli mines, Afghanistan. The ruby deposits of *Jegdalek,* Afghanistan (table 2) are hosted by Proterozoic rocks, but Paleozoic-age rocks host the *Darkhenj* emerald district. Cenozoic deposits or placers of world-famous precious and semi-precious stones (emerald, ruby, sapphire, and lapis lazuli) are present in northwest Pakistan and northeast Afghanistan. The jade, ruby and sapphire placers of Burma are highly productive, as are the Thailand (sapphire), Laos (sapphire), Cambodia (sapphire, zircon) and garnet placers at Orissa, India. Opal and sapphire deposits are present in south Australia. Deposits related to Cenozoic weathering include the gem fields of Sri Lanka (table 2).

Fluorite (fluorspar) deposits

Fluorite is used for production of aluminum and steel, and also is used in insulating foams and refrigerants. Large deposits of fluorite are common in Mongolia as sedimentary and vein deposits and the fluorine-phosphorous-rare-earth element deposit at *Amba Dongar*, India associated with igneous rocks, is a significant deposit. Fluorite also is a bi-product of a number of vein, pegmatite, and sedimentary deposits throughout the region (fig. 4C).

Graphite deposits

Disseminated flake graphite deposits and vein graphite in metamorphic rocks develop from carbonaceous material in sedimentary rocks that have been subjected to metamorphism (Sutphin, 1991a, b). China is the most important producer of graphite in the world, followed by India (Weber, 2003). In China and India, Proterozoic sedimentary rocks host graphite, deposits. Paleozoic mineral deposits in the region also include the graphite deposits of *Khepchishi Hill*, Bhutan (fig. 4C).

Evaporite minerals and fertilizers (phosphate, potash, salt)

Sediment-hosted evaporite deposits are a main source of minerals that have evaporated during accumulation of sediments. The Asia and Pacific regions contains a number of these deposits in the Paleozoic sedimentary basins of Pakistan, China, Mongolia, and Australia. Paleozoic rocks also contain the major salt deposits *Warcha, Kalabagh*, and *Khewr,* Pakistan and the salt and gypsum deposits at *Davst uul*, Mongolia (table 2). Mesozoic rocks contain extensive potash and salt deposits in northeastern Thailand at *Udon Thani* (Khorat Plateau) and western Laos (Vientianed and Savannakhet Plains) and parts of Cambodia and include rocks that also contain gypsum and copper deposits (table 2). The salt deposits at *Weixi,* China also are contained in similar extensive evaporite sedimentary rocks (fig. 4C, table 2). Significant Cenozoic age deposits include the salt deposits in Afghanistan and western Pakistan. Other Cenozoic evaporite deposits include *Sangiyn Dalay Nuur*, Mongolia, and at *Lake Macleod*, Australia.

Phosphate is used for fertilizers and detergents. The large phosphate deposits in the region are contained in phosphorite marine organic-rich sediments that formed as pellets, nodules, shells and bone. The most important producing country in the world is China (Weber, 2003). Large deposits of phosphate, iron-vanadium, and manganese are associated with the large Proterozoic *Gongxi* bedded barite deposit, China and significant deposits are also present in India (table 2). Cenozoic and the sedimentary phosphate deposits also include deposits in western Pakistan and the phosphate (guano) deposits of *Christmas Island*.

Magnesite, talc and asbestos

Magnesite is the most important raw material for fire-proof products. China is the largest producer of magnesite and talc (Weber, 2003). Magnesite deposits form in sedimentary rocks or occur as altered products of magnesium-rich igneous rocks. The alteration process commonly also forms talc and asbestos. Magnesite is mined from old lakes at *Kunwarara*, Australia. Similar significant sedimentary magnesite deposits are present in the Haicheng region, China and Proterozoic igneous magnesite-talc deposits are present in the *Cobb Valley*, New Zealand, and in Afghanistan and Nepal (table 2, fig. 4C). In China and India, Proterozoic sedimentary rocks host magnesite-talc, deposits, for example the *Achin*, deposit Afghanistan (table 2). Paleozoic mineral deposits include serpentinite-hosted magnesite-talc deposits in New Zealand. Hydrothermal talc and asbestos deposits also are present in China.

Manganese

Manganese deposits in the region mainly are associated with sedimentary and volcanic rocks and are composed of large concentrations of manganese oxide and carbonate minerals. China is the largest single producer of manganese in the world, followed by India, which contains Proterozoic deposits in the Madhya Pradesh, Maharastra, and Bihar-Orissa areas. Manganese is derived from volcanic rocks in Mongolia and vein manganese, associated with zinc and lead, is present in veins in Japan (table 2, fig. 4B).

Perlite and pyrophyllite

In China, Cretaceous volcanic rocks host the large *Xinyang* perlite deposit and South Korea contains hydrothermal-derived pyrophyllite deposits at *Wando* (fig. 4C, table 2).

Silica sand

Silica sand deposits at *Cape Flattery*, Australia, *Puqian*, China, and Parengarenga (fig. 4C), New Zealand are related to Cenozoic weathering; commonly of well-sorted beach sand.

Other industrial mineral deposits

The Asia and Pacific region contains a number of other industrial mineral deposits, such as deposits containing tantalum, vanadium, wollastonite, zirconium, and zeolites (table 2, fig. 4C). Many of these commodities are present in deposits as bi-products, but some, such as the Paleozoic *Tsagaantsav* zeolite deposit, Mongolia occur separately. Deposits of building stone are abundant in many countries, such as the extensive dolomite deposits of Bhutan, limestone deposits of New Zealand, and numerous deposits in India and China.

Regional exploration history and significant recent discoveries

Substantial exploration has been conducted in the Asia and Pacific region by governments and by domestic and international mining and exploration companies for metalliferous deposits of gold, platinum, copper, lead-zinc, and molybdenum, as well as for many industrial minerals. The current and potential mineral endowment of the Asia and Pacific region is significant for these and other commodities, because known deposits are leading to new discoveries, and additional exploration in remote or concealed areas will develop known and new mineral deposit types. Because the region contains significant concentrations of deposits of metals and industrial minerals, exploration for, and discovery and development of new deposits, has been and should remain successful.

The main exploration activity is in Australia; the islands of Indonesia, Papua New Guinea, the Philippines; the Mekong Delta countries; and China, India, and Mongolia. Mining and exploration in Japan and South Korea has slowed considerably because known major deposits (table 2) are becoming mined out and major reserves or resources are closed because of unfavorable economic or environmental conditions. Afghanistan contains known resources, exploited for local use, but has been under explored for many decades because of war and internal strife.

Exploration for metal deposits

Large deposits of important metals are present in several parts of Asia and the Pacific (figs. 4A - C, table 2). Large exploration efforts for porphyry copper-gold deposits, hot-spring gold-silver deposits, as well as some industrial minerals, has taken place from the 1960s to the present for these deposits in adjacent or similar settings.

Exploration for and discovery of large porphyry copper-gold deposits has been very successful in the Asia and Pacific region. Recent discoveries include the large Cenozoic porphyry copper-gold deposits at *Grasberg, Ok Tedi*, Papua New Guinea, at *Batu Hijau*, Indonesia, and numerous deposits in the north and southern Philippines. A new and emerging porphyry copper-goldfield in southwest Australia, which includes the *Cadia Hill and Ridgeway* deposits (table 2, fig. 4A), recently has been developed and has led to increased production and exploration activity. In west central and southern China, exploration has led to the discovery of a number of deposits and the identification of new belts of potential porphyry copper deposits. Additional exploitation of Mesozoic-age porphyry copper-gold deposits in Thailand, Laos, Vietnam, and Burma has led to new exploration and discoveries in these countries. Exploration for Cenozoic porphyry copper-gold deposits in western Pakistan is a good example of the scale and development time frame involved in porphyry copper exploration in the region. The *Saindak* deposit, Pakistan, which contains 440 million tons at 0.41 weight percent copper, 0.5 grams per ton gold was discovered in the 1960s, defined by drilling in the 1970s, and developed into production 1980s. This activity lead to nearby discoveries of the new *Reko-Diq* porphyry copper deposit, Pakistan that contains 730 million tons at 0.64 weight percent copper, 0.39 grams per ton gold, and the *Dash-e-Kain* deposit that contains 350 million tons at 0.3 weight percent copper.

Gold deposits flank many of the larger porphyry copper-gold deposits and have been discovered and exploited as part of the exploitation and exploration for the porphyry deposits. Large gold exploration efforts have been taking place in the Asia and Pacific region since the 1980s and have led to discoveries in Queensland Australia, Australia, Indonesia, and Papua New Guinea, as well as additional deposits in China and the Mekong Delta area. Archean-age goldfields in Western Australia, India, and China also have received increased activity and extensions of existing orebodies and new gold-quartz vein deposits have been discovered.

Discovery of the *Olympic Dam* copper-uranium-gold deposit in southern Australia has led to additional discoveries of iron-oxide copper-gold deposits in Proterozoic-age rocks in northern Australia and additional discoveries in the area around the Olympic Dam deposit, southern Australia. The importance of this deposit type has led to additional exploration activity in the Asia and Pacific region, most notably the feasibility study on *Hajigak* iron deposit, Afghanistan in 1972 by Franco-German group. Feasibility study on *Aynak* sediment-hosted copper deposit by USSR in 1978 led to the drilling of 120,000 m drill holes between 1974 and 1977.

Additional exploration in the Asia and Pacific region has been responsible for the discovery of volcanic massive sulfide deposits in Tasmania, Australia. Recent and current exploration in Pakistan has resulted in the identification of sedimentary lead-zinc deposits in Mesozoic rocks and in Paleozoic rocks in Burma and China, podiform chromite in western Pakistan, and placer gold deposits in India. There has been no significant exploration in Afghanistan for the last 20 years, where prior exploration there was almost exclusively by USSR.

Exploration for industrial mineral deposits

Exploration and development of many industrial mineral deposits has taken place during the 1960s through the 1990s in the Asia and Pacific region and continues. Industrialization in the region has led to development and expansion of existing mining sites of building stone, aggregate, and limestone. Diamond exploration in Australia led to the discovery of the *Argyle* deposit and additional prospecting has led to additional diamond discoveries in Australia, India, and China (table 2). Feasibility studies and drilling have taken place along the coastlines of New Zealand, Australia, Bangladesh, India, China, Sri Lanka, and Vietnam on a number of large coastline placer deposits that contain titanium, rare-earth elements, zirconium, iron, and other elements. Development of phosphate deposits in Australia, India, and Cambodia, and deposits of potash, gypsum and salt in Thailand and Laos has been on going since the 1990s.

Potential for occurrence of undiscovered mineral resources

The geologic setting in the Asia and Pacific region (table 2, fig. 3) is consistent with the discovery of a number of new, important mineral belts, which may contain potential for the occurrence of undiscovered deposits. In addition, the presence of known mineral deposits suggests that well-known belts also may be areas of new discoveries. In the1990s to the present, substantial exploration has been conducted by local governments and by major Asian and western mining companies for mineral deposits of gold, silver, platinum group elements, copper, and zinc, as well as rare-earth elements, germanium, diamonds, phosphate, potash deposits and other industrial mineral deposits. The main areas of mineral potential naturally overlap the areas of intense exploration and include Australia, Indonesia, Papua New Guinea, the Philippines, the Mekong Delta Countries, China, India, and Mongolia. Potential for future new discoveries of large deposits in Japan and South Korea is hampered by competition for land for urban and agricultural use. Afghanistan and parts of Pakistan contains known resources, exploited for local use, but has been under explored for many decades due to internal issues.

Potential for metal deposits

The Asia and Pacific region contains considerable potential for further discovery of new reserves of aluminum-bauxite deposits in India, Australia, and China, with new additional discovery and development of similar deposits likely in Cambodia, Laos, Vietnam, and Indonesia. Expansion of aluminum production also is likely from known aluminum-bauxite deposits in India, Australia, Cambodia, Laos, and Indonesia. Additional potential for additional discoveries or extensions of known igneous-related aluminum and niobium-rare-earth element deposits near known deposits in Mongolia also is likely.

Potential exists for discovery of new Mesozoic- and Cenozoic-age porphyry copper-gold deposits in a number of areas in the Asia and Pacific region. In the western part of the region, there is high potential for discovery in a belt extending from western Pakistan to eastern Afghanistan, and probably into Iran, which contains the known *Saindak* and *Reko Diq* porphyry deposits, Pakistan. Numerous copper-gold prospects along this belt, particularly in Afghanistan, indicate that further potential exists. In the central part of the Asia and Pacific region, significant discoveries, and mining expansion of currently known Cenozoic porphyry copper-gold deposits and associated gold deposits are likely in Indonesia, Philippines, and Papua New Guinea. Considerable potential for discovery of and expansion of existing porphyry copper-gold deposits also exists in China in highly prospective mineral belts in the east, west, south, and northwest parts of the country, and also in Tibet, Thailand, and Laos. Exploitation and expansion of known porphyry copper-gold deposits in Australia in the *Cadia Hill* area also is likely. Discovery or expansion in Mongolia of known Paleozoic porphyry copper deposits in the region around *Oyu Tolgoi* and *Tsagaan Suvarga*, and Mesozoic-age porphyry copper deposits *Aryn nuur* and other known deposits, also is likely.

Discovery of medium to large iron-oxide copper-gold-uranium deposits, similar to the *Olympic Dam* copper-uranium-gold deposit, Australia, is probable in Australia and in other parts of Asia and the Pacific (figs. 4A - C, table 2), especially in Proterozoic to Mesozoic sedimentary rocks in western and southern China, as well as Afghanistan and Pakistan. Development and discovery of medium-sized Paleozoic volcanic copper deposits in south China and Laos also is likely, as well as of sediment-hosted copper deposits in China, Laos, Thailand, Cambodia, Pakistan, and Afghanistan.

Gold deposits are numerous in the Asia and Pacific region, and future discovery of new, large deposits, notwithstanding gold in porphyry copper-gold deposits, is likely to be Archean gold-quartz deposits in Australia, China, and India and Cenozoic-age gold-silver vein and disseminated deposits in the Philippines, Indonesia and Papua New Guinea and Mekong Delta area (fig. 4A, table 2). Discovery of sedimentary rock-hosted gold deposits in central and southern China should continue to increase and production from these deposits will continue to expand with increases in processing technology. In addition, potential exists for discovery of additional Mesozoic granitoid-related gold vein deposits near *Bayan uul 1* and *Boroo*, Mongolia, and *Jiadong*, China.

The region contains and has significant potential for additional discoveries and production of sedimentary iron deposits in Australia, India, and China, and the region should be a continued and reliable source of iron. Discovery of smaller contact metamorphic deposits containing iron along with iron, lead, zinc, and copper volcanic deposits, particularly in China, Laos, and Cambodia, is likely. Potential also exists for discovery and exploitation of sedimentary iron-vanadium in China and manganese deposits in China, India, and Mongolia.

The probability of discovery of large, new deposits of lead, zinc, and silver in Proterozoic and Paleozoic sedimentary zinc-lead deposits in Australia, India, Thailand, and Burma is good. Areas of new exploration are guided by the potential for undiscovered volcanic massive sulfide deposits in Laos, Thailand, and western China in late Paleozoic and early Mesozoic rocks and in the potential for Proterozoic volcanic copper-zinc massive sulfide deposits in Mongolia. West China contains favorable rocks for undiscovered volcanic massive sulfide deposits and for sedimentary lead-zinc massive sulfide deposits. The *Jinding* sedimentary lead-zinc deposit in west Yunnan deposit has potential for expansion. In addition, potential exists for the discovery of additional Paleozoic silver-lead vein deposits near *Dulaan khar uul*, Mongolia.

There is potential in the Archean and Proterozoic cratonic rocks in China, Vietnam, and Mongolia to provide potential targets for igneous nickel-copper-platinum group element deposits. An unexploited type of sediment-hosted platinum group element deposit found in southern China and the northern Mekong Delta area shows potential for future exploitation if economic extraction methods improve. Potential for exploration for and new discovery of volcanic Archean nickel-copper deposits is likely in Western Australia and India, and there is additional potential for exploitation of known and newly discovered nickel-laterite deposits in Indonesia, New Caledonia, India, the Philippines, and Australia.

Expansion of production of tungsten and tin from deposits in southern China is likely, and discovery and exploitation of small- to medium-size tin and tungsten deposits in lode and placer in the Burma, Thailand, Malaysia, and Indonesia also is likely to continue.

Undiscovered Mesozoic sediment-hosted uranium deposits may be present near *Nars*, Mongolia. New sedimentary uranium deposits also are likely to be discovered in Australia.

Potential for industrial mineral deposits

Potential for the discovery and expanded production of a variety of industrial mineral deposits is very favorable in the Asia and Pacific region. Significant production of industrial minerals is on going from large and small deposits in Afghanistan, Australia, Nepal, New Zealand, Vietnam, Bhutan, and China, and potential exists in these countries for additional production of building stone, aggregate, and limestone, talc, and dolomite. Semi precious gem deposits continue to be mined, expanded and discovered throughout much of the region. The presence of a number of small diamond placer deposits and favorable geology suggest further potential for large hard-rock diamond discoveries, in Australia, China, and India. Cenozoic marine and fluvial deposits will continue to be a large source of industrial minerals in the Asia and Pacific region. Significant large heavy-mineral sand deposits rich in titanium, zirconium, and rare-earth elements along the coastlines of New Zealand, Australia, Bangladesh, India, China, Sri Lanka, and Vietnam may have extensive resources of these commodities and new discoveries and expansion of reserves is likely.

Potential exists for the discovery of large phosphate deposits in Australia, India, and Cambodia. Similarly, there are potentially extensive large deposits of potash, gypsum, and salt in Thailand, Laos, and Cambodia in the Khorat Plateau and Vientianed and Savannakhet Plains. Similar potential also is present for these deposits in the Murray Basin, Australia. Substantial growth in discovery and production is likely around the Paleozoic salt and gypsum deposits in Mongolia. Resources of Mesozoic volcanic-hosted zeolite deposits are likely to expand at *Tsagaantsav*, Mongolia. The large *Mangampeta* barite deposit, India is the largest such deposit in the world and the *Bayan Obo* iron-rare-earth element- niobium deposit, China is the largest rare-earth element deposit in world, and these two deposits should retain extensive reserves and production into the future. Mesozoic fluorspar vein deposits at *Berkh 1* and *Bor-Undur*; Mongolia, and the igneous rare-earth elements deposit at *Mushgai Khudag,* Mongolia also are likely to expand production. Deposits of clays, such as ion adsorption clays at *Qaidam Basin*, China, and deposits of lithium, magnesite, and graphite deposits, India, should remain significant global and regional sources of these materials.

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Tables

Table 1. Major nonfuel known commodities of mineral deposits in each country in the Asia and Pacific region.

COUNTRY	MINERAL RESOURCES
Afghanistan	Aluminum, barite, beryllium, copper, chromium, gold, iron, lead, mercury, zinc, phosphorous, talc, sulfur, salt, and gemstones.
Australia	Aluminum, copper, gold, iron, lead, magnesite, nickel, silver, tin, titanium, tungsten, uranium, zinc, rare earth elements, salt, talc, phosphorous, gemstones, diamonds.
Bangladesh	Titanium.
Bhutan	Calcium carbide, dolomite, graphite, gypsum
Brunei	minor
Burma	Antimony, copper, nickel, lead, tin, tungsten, zinc, limestone, marble, precious stones.
Burundi	Cobalt, copper, nickel, uranium, rare earth metals, platinum, vanadium.
Cambodia	Iron, gemstones, manganese, phosphorous.
China	Aluminum, antimony, arsenic, barite, copper, gold, iron, lead, magnesite, manganese, mercury, molybdenum, silver, strontium, tin, tungsten, vanadium, magnetite, zinc, uranium, cement, graphite, gypsum, garnet, lime, lithium, perlite, rare earth elements, phosphorous, potash, salt, strontium, sulfur, talc, fluorite.
East Timor	Gold, manganese, marble.
Fiji	Gold, copper.
India	Aluminum, iron, titanium, chrome, copper, gold, lead, zinc, diamonds, limestone-dolomite-marble, barite, manganese, mica, cement, garnet, graphite, rare earth metals, salt, talc, wollastonite.
Indonesia	Aluminum, copper, gold, silver, tin, nickel.
Japan	Copper, gold, silver, lead, zinc, mercury, iron, diatomite, perlite, sulfur.
Korea, North	Copper, gold, lead, tungsten, zinc, graphite, manganese, iron, sulfur, salt, fluorite, magnesite.
Korea, South	Tungsten, graphite, molybdenum, lead.
Laos	Aluminum, gold, iron, molybdenum, tin, gemstones, gypsum, potash, rock salt.
Malaysia	Tin, copper, iron, bauxite, rare earth elements.
Mongolia	Copper, gold, iron, molybdenum, silver, tantalum, tungsten, phosphate, tin, nickel, lead, zinc, fluorite, manganese, phosphate, salt, gypsum, zeolite.
Marshall Islands	Deep seabed minerals.
Nauru	Phosphate
Nepal	Quartz, limestone, copper, cobalt, iron, magnesite
New Caledonia	Copper, cobalt, chromium, iron, gold, manganese, silver, lead, nickel,
New Zealand	Iron, sand, gold, limestone, magnesite.

COUNTRY	MINERAL RESOURCES
Pakistan	Copper, iron, lead, zinc, chromium, barite, salt, phosphorous, limestone, gemstones.
Papua New Guinea	Gold, copper, silver.
Philippines	Copper, cobalt, silver, gold, nickel, salt.
Pitcairn Islands	Manganese, iron, copper, gold, silver, zinc
Solomon Islands	Gold, bauxite, phosphate, lead, zinc, nickel
Sri Lanka	Gemstones, titanium, phosphate, graphite
Thailand	Tin, tungsten, tantalum, lead, gypsum, fluorite, cement, dolomite, feldspar, salt, kaolin, ball clay, limestone, potash, diatomite
Vietnam	Aluminum, copper, chromium, manganese, phosphorous, kaolin, silica sand, limestone, rare earth elements

Table 2. Main nonfuel known mineral deposits in the Asia and Pacific region.

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Obatu-Shela	Afghanistan	32.0000	66.2833	Aluminum	Bauxite	Orris and Bliss, 2002
Hagigak	Afghanistan	34.6778	68.0625	Barite	Vein	Orris and Bliss, 2002
Darrahe-Nur	Afghanistan	34.6611	70.5417	Beryllium-niobium-tin	Igneous	Orris and Bliss, 2002
Loghar	Afghanistan	34.1670	68.0330	Chromium	Igneous	Orris and Bliss, 2002
Aynak	Afghanistan	34.2660	69.3010	Copper	Sedimentary copper	ESCAP, 1996
Kundalyan	Afghanistan	32.3128	66.5328	Copper-molybdenum-gold	Porphyry copper	Orris and Bliss, 2002
Darkhenj	Afghanistan	35.4139	69.7583	Emerald	Gemstone	Orris and Bliss, 2002
Samty	Afghanistan	37.5840	69.8590	Gold	Placer	Orris and Bliss, 2002
Hajigak	Afghanistan	34.6667	68.0667	Iron	Iron-oxide-copper-gold	Orris and Bliss, 2002
Kulam deposit	Afghanistan	35.2019	70.3344	Kunzite	Igneous	Orris and Bliss, 2002
Sary Sang	Afghanistan	36.1667	70.8167	Lapis Lazuli	Gemstone	Orris and Bliss, 2002
Pasghushta	Afghanistan	35.3928	71.0144	Lithium-tantalum	Igneous	Orris and Bliss, 2002
Achin	Afghanistan	34.0500	70.7167	Magnesite-talc	Igneous	Orris and Bliss, 2002
Khanneshin	Afghanistan	30.0333	63.5833	Phosphorous-rare earths	Igneous	Orris and Bliss, 2002
Jegdalek	Afghanistan	34.4333	69.8167	Ruby	Gemstone	Orris and Bliss, 2002
Nilaw-Kolum	Afghanistan	35.2083	70.3539	Tourmaline	Gemstone	Orris and Bliss, 2002
Gove	Australia	-12.3000	136.7500	Aluminum	Bauxite	Loughnan and Sadleir, 1984
Mitchel Plateau	Australia	-15.2167	125.9333	Aluminum	Bauxite	Loughnan and Sadleir, 1984
Mount Saddleback	Australia	-32.9333	116.1000	Aluminum	Bauxite	Loughnan and Sadleir, 1984
Weipa	Australia	-12.6667	141.9167	Aluminum	Bauxite	Loughnan and Sadleir, 1984
Gurrunda	Australia	-34.6840	149.4830	Barite	Sedimentary	GSA, OZMIN
Arumpo	Australia	-33.7500	142.8333	Clay (bentonite)	Sedimentary	Lishmund and others, 1999
Gurumundi	Australia	-26.4333	149.8833	Clay (bentonite)	Uncertain	Cooper and others, 1996

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Cape York	Australia	-12.6833	141.8667	Clay (kaolin)	Weathering	Driessen, 1990
Skarndon River	Australia	-11.7333	142.0500	Clay (kaolin)	Weathering	Cooper and others, 1996
Mount Lyell	Australia	-42.1167	145.5500	Copper	Volcanic massive sulfide	Hughes, 1990
Cadia Hill/Ridgeway	Australia	-33.4667	149.0000	Copper-gold	Porphyry copper	Singer and others, 2002
Endeavour	Australia	-32.9167	148.0333	Copper-gold	Porphyry copper	Singer and others, 2002
Coppin Gap	Australia	-20.8833	120.1000	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Olympic Dam	Australia	-30.4500	136.8833	Copper-uranium-lead	Iron-oxide-copper-gold	Hughes, 1990
Mount Isa	Australia	-20.7000	139.3000	Copper-zinc-lead-silver	Sedimentary copper	Hughes, 1990
Argyle	Australia	-16.7144	128.3839	Diamond	Igneous	Hughes, 1990
Merlin	Australia	-16.8508	136.3451	Diamond	Igneous	GSA, OZMIN
Kalgoorlie	Australia	-30.7500	121.5333	Gold	Vein	Hughes, 1990
Palmer River	Australia	-15.8816	143.4654	Gold	Placer	GSA, OZMIN
Lake Macleod	Australia	-24.1667	113.6333	Halite-gypsum	Evaporite	Industrial Minerals, 1996
Iron Range	Australia	-12.7157	143.2967	Iron	Sedimentary copper	GSA, OZMIN
Koolanooka	Australia	-29.2170	116.2330	Iron	Sedimentary copper	GSA, OZMIN
Middleback Range	Australia	-33.0500	137.1500	Iron	Sedimentary copper	GSA, OZMIN
Mt Whaleback	Australia	-23.3623	119.6846	Iron	Sedimentary copper	GSA, OZMIN
Mt. Newman	Australia	-23.3830	119.6660	Iron	Sedimentary	GSA, OZMIN
Hilton	Australia	-20.5500	139.2833	Lead-zinc-silver	Sedimentary zinc-lead	Hughes, 1990
McArthur River	Australia	-16.5000	136.0833	Lead-zinc-silver	Sedimentary zinc-lead	Hughes, 1990
Greenbushes	Australia	-33.8594	116.0653	Lithium	Igneous	Driessen, 1990
Kunwarara	Australia	-22.9167	150.2167	Magnesite	Sedimentary	Driessen, 1990
Agnew/Leinster	Australia	-27.4667	120.7000	Nickel-copper	Volcanic	Hughes, 1990
Kambalda	Australia	-31.2000	121.6700	Nickel-copper	Volcanic	Hughes, 1990

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Mt Keith	Australia	-27.7167	120.5333	Nickel-copper	Volcanic	Hughes, 1990
Greenvale	Australia	-18.9167	144.9833	Nickel-copper-cobalt	Nickel laterite	Hughes, 1990
Coober Pedy	Australia	-28.8333	134.7500	Opal	Gemstone	Keeling and others, 1990
Christmas Island	Australia	-10.4219	105.7158	Phosphorous	Guano	Barret, 1989
Georgina Basin	Australia	-21.8833	139.9667	Phosphorous	Evaporite	Industrial Minerals, 1998
Lady Annie	Australia	-19.7600	139.1120	Phosphorous	Sedimentary	GSA, OZMIN
Mount Weld	Australia	-28.8667	122.5333	Phosphorous-rare earths	Igneous	Pell, 1996
Cape Flattery	Australia	-14.9333	145.2500	Silica sand	Placer	Cooper and others, 1996
Three Springs	Australia	-29.5047	115.8609	Talc, asbestos	Uncertain	Sims, 1997
Bayfield	Australia	-22.8000	150.7667	Titanium-zirconium-REE	Placer	Jackson and Christiansen, 1993
Cataby	Australia	-30.7167	115.5167	Titanium-zirconium-REE	Placer	Jackson and Christiansen, 1993
Chetwynd	Australia	-37.2167	141.4167	Titanium-zirconium-REE	Placer	Komesaroff, 2001
Coojarloo	Australia	-30.6667	115.3333	Titanium-zirconium-REE	Placer	ESCAP and ABMRGG, 1988
Eneabba	Australia	-29.9000	115.2667	Titanium-zirconium-REE	Placer	Hughes, 1990
Frazer Island	Australia	-24.6667	153.2500	Titanium-zirconium-REE	Placer	Hughes, 1990
Ginko	Australia	-33.3833	142.1500	Titanium-zirconium-REE	Placer	Komesaroff, 2001
Mindarie	Australia	-34.8167	140.2167	Titanium-zirconium-REE	Placer	Komesaroff, 2001
North Stradbroke Island	Australia	-27.5833	153.4500	Titanium-zirconium-REE	Placer	Towner, 1992
Stradbroke Island	Australia	-27.5000	153.9000	Titanium-zirconium-REE	Placer	Hughes, 1990
WIM 150	Australia	-36.7167	142.2167	Titanium-zirconium-REE	Placer	Hughes, 1990
Jabiluka	Australia	-12.5020	132.8957	Uranium-gold	Sedimentary	GSA, OZMIN
Rosebery	Australia	-41.8167	145.5000	Zinc-copper-lead-sulfur	Volcanic massive sulfide	Hughes, 1990
Century	Australia	-18.7410	138.6250	Zinc-lead	Sedimentary zinc-lead	GSA, OZMIN
Broken Hill	Australia	-32.0000	141.4500	Zinc-lead-silver	Sedimentary zinc-lead	Hughes, 1990

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Cannington	Australia	-21.8692	140.9194	Zinc-lead-silver	Sedimentary zinc-lead	GSA, OZMIN
Elura	Australia	-31.3333	145.8333	Zinc-lead-silver	Volcanic massive sulfide	Hughes, 1990
Moiskal Island	Bangladesh	21.3333	91.9167	Titanium-zirconium-REE	Placer	McFaul and others, 2002
Khepchishi Hill	Bhutan	27.3833	89.3333	Graphite	Sedimentary	ESCAP, 1991
Khothakpa	Bhutan	27.0167	91.4000	Gypsum	Evaporite	ESCAP, 1991
Monywa	Burma	22.2500	95.0833	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Hwehka	Burma	25.4842	96.2786	Jade	Gemstone	ESCAP, 1995
Kansi	Burma	25.7836	96.3717	Jade	Gemstone	ESCAP, 1995
Tawmaw	Burma	25.7036	96.2578	Jade	Gemstone	ESCAP, 1995
Bawdwin	Burma	23.1167	97.3500	Lead-zinc-nickel-cobalt	Volcanic massive sulfide	Kamitani and Naito, 1998
Mwaytung	Burma	23.5000	94.0000	Nickel-copper-cobalt	Nickel laterite	Schellman, 1989
Heinde	Burma	14.1167	98.4500	Tin	Igneous	Kamitani and Naito, 1998
Haute Chhlong	Cambodia	12.3830	107.2000	Aluminum	Bauxite	ESCAP, 1993
Pailin-Samlot	Cambodia	12.8330	102.6000	Corundum	Gemstone	ESCAP, 1993
Phnom Deck	Cambodia	13.2330	105.0500	Iron	Contact metamorphic	ESCAP, 1993
Pailin	Cambodia	12.8333	102.6000	Sapphire	Gemstone	ESCAP, 1993a
Bokeo	Cambodia	12.6667	107.1667	Zircon	Gemstone	ESCAP, 1993a
Baiquan/Qianmuping	China	37.8667	113.5333	Aluminum	Bauxite	Kamitani and Naito, 1998
Duchun, Xiaoyi	China	37.3222	111.5028	Aluminum	Bauxite	Ariunbileg and others, 2003
Guopanliang	China	38.7528	111.1708	Aluminum	Bauxite	Ariunbileg and others, 2003
Ke'er	China	37.3361	111.4889	Aluminum	Bauxite	Ariunbileg and others, 2003
Re'er	China	37.3361	111.4889	Aluminum	Bauxite	Ariunbileg and others, 2003
Shuiquliu	China	44.5500	127.0667	Aluminum	Bauxite	Wen Lu, 1998
Taihushi	China	37.8667	113.5667	Aluminum	Bauxite	Wen Lu, 1998

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Xihedi, Xiaoyi	China	37.3361	111.4861	Aluminum	Bauxite	Ariunbileg and others, 2003
Dongfenggou	China	32.9833	104.6667	Barite	Sedimentary	Wen Lu, 1998
Gongxi	China	27.1167	109.1667	Barite	Sedimentary	Wen Lu, 1998
Lifang	China	27.3833	117.1333	Barite	Sedimentary	Wen Lu, 1998
Pancun	China	23.9667	109.6833	Barite	Vein	Wen Lu, 1998
Keketuohai	China	47.2067	89.8150	Beryllium-tantalum	Igneous	Ariunbileg and others, 2003
Wengquangou	China	40.7000	124.0500	Boron	Sedimentary	Ariunbileg and others, 2003
Qaidam Qarhan	China	37.5000	95.0000	Boron-lithium-potassium	Evaporite	Wen Lu, 1998
Hebuksaler	China	46.7833	85.7167	Clay (bentonite)	Uncertain	Industrial Minerals, 1990b
Kerjian	China	42.7833	88.6333	Clay (bentonite)	Sedimentary	Wen Lu, 1998
Ningming	China	22.1333	107.0667	Clay (bentonite)	Sedimentary	Wen Lu, 1998
Pingshan	China	28.9333	118.9833	Clay (bentonite)	Sedimentary	Wen Lu, 1998
Xingsheng	China	38.5167	111.0667	Clay (bentonite)	Uncertain	Industrial Minerals, 1990a
Yangxian	China	33.2167	107.5333	Clay (bentonite)	Sedimentary	Wen Lu, 1998
Donggongxia	China	25.1000	117.0167	Clay (kaolin)	Weathering	Wen Lu, 1998
Maoming	China	21.9167	110.8667	Clay (kaolin)	Weathering	Yao Shaode, 1995
Xuzhou	China	34.2667	117.1833	Coal and clay	Sedimentary	Industrial Minerals, 1990b
Bainaimiao	China	42.3000	112.7833	Copper	Porphyry copper	Ariunbileg and others, 2003
DaTongChang	China	30.6667	105.0667	Copper	Sedimentary copper	Cox and others, 2003.
Disue-1	China	41.3333	81.2500	Copper	Sedimentary copper	Cox and others, 2003.
Dongchuan area	China	23.5000	103.0000	Copper	Sedimentary copper	Ariunbileg and others, 2003
FengShan	China	24.1500	102.1667	Copper	Sedimentary copper	Cox and others, 2003.
JiuquiWan	China	26.2500	113.0833	Copper	Sedimentary copper	Cox and others, 2003.
LaoQingShan	China	23.0500	103.9167	Copper	Sedimentary copper	Kirkham and others, 1994

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
LaoXue	China	26.2833	102.3333	Copper	Sedimentary copper	Cox and others, 2003.
OmeiHsien	China	29.2833	106.2000	Copper	Sedimentary copper	Cox and others, 2003.
ShiShan	China	24.1167	102.1667	Copper	Sedimentary copper	Cox and others, 2003.
TangDan	China	26.2500	102.6667	Copper	Sedimentary copper	Cox and others, 2003.
Tongquanshan	China	30.9333	117.7833	Copper	Contact metamorphic	Metals Economics Group, 1995.
YinMin	China	26.3167	102.3333	Copper	Sedimentary copper	Cox and others, 2003.
Lalachang	China	26.1000	101.9000	Copper-gold-silver	Sedimentary copper	Cox and others, 2003.
Yongping	China	28.2167	117.8000	Copper-gold-silver	Sedimentary copper	Cox and others, 2003.
Tianbaoshan	China	42.9167	129.9839	Copper-lead-zinc	Contact metamorphic	Ariunbileg and others, 2003
Aselei/Ashele	China	48.2833	86.4667	Copper-lead-zinc-silver	Sedimentary	Kamitani and Naito, 1998
Yinshan	China	28.8500	117.4833	Copper-lead-zinc-silver	Hydrothermal	Kamitani and Naito, 1998
Duoxiasonduo	China	31.1500	97.8833	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Malasongduo	China	31.1667	98.1500	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Tongkuangyu	China	35.5000	111.7000	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Wunugetushan	China	49.3928	117.4333	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Yulong	China	31.6333	97.9167	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Chengmenshan	China	28.6667	115.8333	Copper-molybdenum-gold	Porphyry copper	Singer and others, 2002
Dexing,	China	29.0167	117.5833	Copper-molybdenum-gold	Porphyry copper	Singer and others, 2002
Doubaoshan	China	50.1833	125.6833	Copper-molybdenum-gold	Porphyry copper	Singer and others, 2002
Wushan	China	29.7500	155.6833	Copper-molybdenum-gold	Contact metamorphic	Metals Economics Group, 1995.
Kalatongke	China	46.8083	89.8347	Copper-nickel	Igneous	Ariunbileg and others, 2003
Duobaoshan	China	50.1833	125.6833	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Zijinshan	China	25.1000	116.5000	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Toudaohe	China	39.5000	122.1667	Diamond	Placer	Ariunbileg and others, 2003

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Baguamiao	China	33.9292	106.9472	Gold	Sedimentary	Peters, 2002
Dongping	China	40.9361	115.6375	Gold	Igneous	Ariunbileg and others, 2003
Erdaogou	China	42.0833	120.3472	Gold	Vein	Ariunbileg and others, 2003
Hanshan	China	39.0833	96.4750	Gold	Vein	Ariunbileg and others, 2003
Huanan	China	46.3333	130.9167	Gold	Placer	Ariunbileg and others, 2003
Huma	China	50.0833	126.6667	Gold	Placer	Ariunbileg and others, 2003
Jiaodong	China	33.8833	106.6500	Gold	Vein	Kamitani and Naito, 1998
Jiayin	China	47.1667	130.5000	Gold	Placer	Ariunbileg and others, 2003
Jinchanggouliang	China	42.1667	120.3000	Gold	Igneous	Metals Economics Group, 1995
Laozhuoshan	China	46.2667	131.5347	Gold	Igneous	Ariunbileg and others, 2003
Liba	China	34.4167	105.0433	Gold	Sedimentary	Peters, 2002
Mohe	China	52.6167	121.6667	Gold	Placer	Ariunbileg and others, 2003
Paishanlou	China	40.8056	121.9306	Gold	Vein	Ariunbileg and others, 2003
Getang	China	25.1944	105.1583	Gold-antimony	Sedimentary	Peters, 2002
Lannigou	China	25.3500	105.6900	Gold-arsenic-mercury	Sedimentary	Peters, 2002
Huangshilaoshan	China	30.8972	117.8136	Gold-copper-lead	Contact metamorphic	Peters, 2002
Xinqiao	China	30.9183	117.9767	Gold-copper-lead	Contact metamorphic	Peters, 2002
Banqi	China	24.7344	105.6042	Gold-mercury	Sedimentary	Peters, 2002
Jilongshan	China	33.5403	109.0000	Gold-mercury	Sedimentary	Peters, 2002
Zimudang	China	25.0506	105.4600	Gold-mercury	Sedimentary	Peters, 2002
Dongbeizhai	China	32.7250	103.5569	Gold-silver	Sedimentary	Peters, 2002
Jiapigou	China	42.9000	127.3833	Gold-silver	Hydrothermal	Ariunbileg and others, 2003
Manaoke	China	33.0503	104.0667	Gold-tungsten	Sedimentary	Peters, 2002
Laerma	China	34.0011	102.5928	Gold-uranium	Sedimentary	Peters, 2002

DEPOSIT NAME	COUNTRY	LATITUDE dec deg	LONGITUDE dec deg	COMMODITIES	DEPOSIT TYPE	CITATION
Liumao	China	45.0856	130.7847	Graphite	Metamorphic	Ariunbileg and others, 2003
Yunshan	China	45.9167	132.4833	Graphite	Sedimentary	Wen Lu, 1998
Jintan	China	31.7500	119.5667	Halite	Evaporite	Industrial Minerals, 1990b
Weixi	China	30.2000	106.6500	Halite	Evaporite	Wen Lu, 1998
Anshan,/Hongai	China	40.9833	123.3667	Iron	Sedimentary	Kamitani and Naito, 1998
Baizhiyan	China	39.0861	113.7681	Iron	Sedimentary copper	Ariunbileg and others, 2003
Baoguosi, Liaoning	China	42.1042	120.8444	Iron	Sedimentary copper	Ariunbileg and others, 2003
Caiyuan	China	40.0500	118.5500	Iron	Sedimentary	Kamitani and Naito, 1998
Fengjiayu	China	40.6417	116.9681	Iron	Sedimentary copper	Ariunbileg and others, 2003
Jinling	China	36.8550	118.1181	Iron	Contact metamorphic	Ariunbileg and others, 2003
Laoniugou	China	42.8792	127.4611	Iron	Sedimentary copper	Ariunbileg and others, 2003
Mengjiagou	China	40.1667	118.5297	Iron	Sedimentary copper	Ariunbileg and others, 2003
Nanfen	China	41.2278	124.0000	Iron	Sedimentary copper	Liu, 1990
Pingxingguan	China	39.3167	114.1194	Iron	Sedimentary copper	Lin and Zhang, 1993.
Qidashan	China	41.1389	123.3417	Iron	Sedimentary copper	Ariunbileg and others, 2003
Sanheming	China	41.4333	110.9500	Iron	Sedimentary copper	Ariunbileg and others, 2003
Shachang	China	40.4278	117.0000	Iron	Sedimentary copper	Ariunbileg and others, 2003
Shanyangping	China	39.1514	113.3361	Iron	Sedimentary copper	Ariunbileg and others, 2003
Shirengou	China	40.2361	117.8806	Iron	Sedimentary copper	Ariunbileg and others, 2003
Sijiaying	China	39.6750	118.7569	Iron	Sedimentary copper	Liu, 1990
Tadong	China	43.8444	128.6444	Iron	Volcanic	Ariunbileg and others, 2003
Xishimen	China	36.8161	114.2331	Iron	Contact metamorphic	Li, 1993.
Yuanjiachun	China	38.2528	111.4633	Iron	Sedimentary copper	Ariunbileg and others, 2003
Zhalanzhangzh	China	40.3278	119.3694	Iron	Sedimentary copper	Ariunbileg and others, 2003

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Bayan Obo	China	41.1667	117.8833	Iron-tantalum-vanadium	Igneous	Ariunbileg and others, 2003
Chuihongshan	China	48.4569	128.6889	Iron-tungsten	Contact metamorphic	Ariunbileg and others, 2003
Xieertala	China	49.2000	120.6333	Iron-zinc-cadium	Volcanic	Ariunbileg and others, 2003
Chaihe	China	42.2667	124.1667	Lead-zinc	Sedimentary zinc-lead	Ariunbileg and others, 2003
Huanren	China	41.3000	125.3681	Lead-zinc	Contact metamorphic	Ariunbileg and others, 2003
Jiashengpan	China	41.2306	109.3000	Lead-zinc	Sedimentary zinc-lead	Ariunbileg and others, 2003
Qingchengzi	China	40.7667	123.6333	Lead-zinc	Volcanic massive sulfide	Metals Economics Group, 1995.
Xiaoxilin	China	47.3500	128.9667	Lead-zinc	Volcanic massive sulfide	Ariunbileg and others, 2003
Xiaoyingzi	China	42.7833	118.9667	Lead-zinc	Contact metamorphic	Ariunbileg and others, 2003
Lengshukeng	China	27.9500	117.2500	Lead-zinc-silver	Hydrothermal	Metals Economics Group, 1995.
Jinding	China	26.3833	99.4500	Lead-zinc-silver-strontium	Sedimentary zinc-lead	Metals Economics Group, 1995.
Xitieshan	China	36.3167	95.5167	Lead-zinc-tin	Sedimentary zinc-lead	Metals Economics Group, 1995.
Fenzishan (Haicheng)	China	37.1667	119.9167	Magnesite	Sedimentary	Wen Lu, 1998
Huaziyu (Haicheng)	China	40.8500	122.7333	Magnesite	Sedimentary	Wen Lu, 1998
Jinjiapuzi (Haicheng)	China	40.6000	122.7167	Magnesite	Sedimentary	Wen Lu, 1998
Wangjiapuzi (Haicheng)	China	40.5000	123.1500	Magnesite	Sedimentary	Wen Lu, 1998
Xiafangshen	China	40.6667	122.8333	Magnesite	Sedimentary	Ariunbileg and others, 2003
Dawan	China	39.3111	115.1278	Molybdenum	Porphyry copper	Ariunbileg and others, 2003
Jinchuan	China	38.4667	102.1000	Nickel-copper	Igneous	Metals Economics Group, 1995.
Xinyang	China	32.0500	114.0833	Perlite	Perlite	Wen Lu, 1998
Huangmailing	China	31.4833	114.1667	Phosphorous	Sedimentary	Wen Lu, 1998
Kaiyang	China	27.0500	106.9167	Phosphorous	Uncertain	Wen Lu, 1998
Kunming (Junning)	China	25.0667	102.6833	Phosphorous	Evaporite	Wen Lu, 1998
Wengfu	China	26.7000	107.5500	Phosphorous	Evaporite	Fountain, 1999

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Yichang	China	30.8000	111.3333	Phosphorous	Evaporite	Jasinski, 2000
Anpeng	China	32.5667	113.1500	Potash	Evaporite	Garrett, 1992
Dashanling	China	30.4167	103.8167	Potash	Evaporite	Wen Lu, 1998
Wucheng	China	32.4167	113.5000	Potash	Evaporite	Garrett, 1992
Bayan Obo	China	41.8667	109.9667	Rare earth elements-iron	Igneous	Drew and others, 1990
Puqian	China	20.0333	110.5833	Silica sand	Placer	Wen Lu, 1998
Sandaogou	China	45.1750	130.5125	Sillimanite	Metamorphic	Jiang, Jisheng, 1994.
Jiawula	China	48.8000	116.3333	Silver-gold-lead	Contact metamorphic	Ariunbileg and others, 2003
Fanjiapuzi	China	40.7500	122.9500	Talc, asbestos	Hydrothermal	Ariunbileg and others, 2003
Jizhua	China	25.8000	110.0000	Talc, asbestos	Sedimentary	Wen Lu, 1998
Liboshikuang	China	37.2833	120.8000	Talc, asbestos	Sedimentary	Wen Lu, 1998
Mangya	China	37.8333	91.7667	Talc, asbestos	Igneous	Wen Lu, 1998
Dachang	China	24.8333	107.8333	Tin	Contact metamorphic	Ariunbileg and others, 2003
Fuhezhong	China	24.5333	111.5167	Tin	Placer	Liu, 1990
Limu	China	24.8500	110.8000	Tin	Igneous	Liu, 1990
Shizhuyuan	China	25.7667	113.2000	Tin	Igneous	Liu, 1990
Yuxhia	China	29.8333	106.0333	Tin	Sedimentary	Wen Lu, 1998
Baima	China	27.0500	102.1667	Titanium-vanadium-iron	Igneous	Kamitani and Naito, 1998
Daijishan	China	24.6333	114.4000	Tungsten	Contact metamorphic	Kamitani and Naito, 1998
Damingshan	China	23.6000	108.3667	Tungsten	Contact metamorphic	Ariunbileg and others, 2003
Lianhuashan	China	23.6500	116.8667	Tungsten	Igneous	Liu, 1990
Xihuashan	China	25.3667	114.3167	Tungsten	Vein	Liu, 1990
Xingluokeng	China	26.1500	116.7833	Tungsten	Igneous	Liu, 1990
Yaogangxian	China	25.6500	113.3000	Tungsten	Contact metamorphic	Liu, 1990

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Tengchong	China	25.0333	98.4667	Wollastinite	Contact metamorphic	Wen Lu, 1998
Tiegsongshan	China	43.3000	124.3167	Wollastinite	Contact metamorphic	Wen Lu, 1998
Fangniugou	China	43.6083	125.0875	Zinc	Volcanic massive sulfide	Ariunbileg and others, 2003
Tanyaokou	China	40.9667	106.8333	Zinc-copper	Sedimentary zinc-lead	Metals Economics Group, 1995.
Dongshengmiao	China	41.1667	107.0667	Zinc-lead-copper	Sedimentary zinc-lead	Ariunbileg and others, 2003
Namosi	Fiji	-18.0417	178.1750	Copper-gold-molybdenum	Porphyry copper	Singer and others, 2002
Emperor	Fiji	-17.5500	177.5117	Gold	Vein	Kwak, 1990
Amarkantak area	India	22.7333	81.7667	Aluminum	Bauxite	Geological Survey India, 1974
Gangapur-Hamla/K.ar	India	23.0500	69.4000	Aluminum	Bauxite	Geological Survey India, 1974
Kolhapur area	India	16.4667	74.0833	Aluminum	Bauxite	Geological Survey India, 1974
Natarhat Palamau ar	India	23.2500	84.3667	Aluminum	Bauxite	Geological Survey India, 1974
Udgiri-Dhangarwadi	India	16.9000	73.9667	Aluminum	Bauxite	Geological Survey India, 1974
Mangampeta	India	14.4167	22.8167	Barite	Sedimentary	Orris, 1985
Sukinda Valley	India	21.0333	85.7500	Chromium	Igneous	DeYoung and others, 1984
Khetri	India	28.0597	75.7944	Copper	Volcanic massive sulfide	Roonwal and Wilson, 1998
Surda	India	22.5500	86.4333	Copper	Vein	Raghu and others, 1981
Malanjkhand	India	22.0167	80.7167	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Bahradih pipes	India	20.2000	82.2000	Diamond	Igneous	McFaul and others, 2002
Amba Dongar	India	22.0000	74.0833	Fluorite-phosphorous	Igneous	Pell, 1996
Kolar	India	13.1667	78.1667	Gold	Vein	Roonwal and Wilson, 1998
Bababudan	India	13.5000	75.8667	Iron	Sedimentary copper	McFaul and others, 2002
Bailadila	India	18.7000	81.4667	Iron	Sedimentary copper	McFaul and others, 2002
Bolani	India	22.1333	85.3167	Iron	Sedimentary copper	Kamitani and Naito, 1998
Chiknayakanhalli	India	13.5500	76.9000	Iron	Sedimentary copper	McFaul and others, 2002

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Chitaldrug area	India	14.4167	76.3000	Iron	Sedimentary copper	Kamitani and Naito, 1998
Kiriburu	India	22.0833	85.2833	Iron	Sedimentary copper	Kamitani and Naito, 1998
Sandur area	India	14.8000	76.7500	Iron	Sedimentary	McFaul and others, 2002
Sargipalli	India	22.0333	83.5833	Lead	Sedimentary	Roonwall and Wilson, 1998
Dongri-Buuzurg area	India	21.5833	79.7500	Manganese	Sedimentary	Geological Survey India, 1974
Sukinda	India	20.5000	84.8333	Nickel-copper-cobalt	Nickel laterite	McFaul and others, 2002
Tuesnsang	India	26.2667	94.7500	Nickel-copper-cobalt	Nickel laterite	McFaul and others, 2002
Kudiraimozhi	India	8.6667	78.0833	Rare earth elements-tin	Placer	Harben and Kuzvart, 1996
Chatrapur	India	19.3000	84.9500	Titanium-zirconium-REE	Placer	Jackson and Christiansen, 1993
Chavara	India	9.0000	76.5000	Titanium-zirconium-REE	Placer	Jackson and Christiansen, 1993
Manavala Kurichi	India	8.1667	77.2500	Titanium-zirconium-REE	Placer	Geological Survey India, 1974
Nindakara	India	8.6667	76.5833	Titanium-zirconium-REE	Placer	Geological Survey India, 1974
Vishakhapatnam	India	17.8333	83.5333	Titanium-zirconium-REE	Placer	Geological Survey India, 1974
Belkappahar	India	25.7667	73.4333	Wollastinite	Contact metamorphic	Pearson, 2000
Dariba-Rajpura	India	24.9667	74.1333	Zinc-lead	Sedimentary zinc-lead	Roonwal and Wilson, 1998
Rampura-Agucha	India	25.8333	74.7333	Zinc-lead	Sedimentary zinc-lead	Roonwal and Wilson, 1998
Zawarmala	India	24.3500	73.7333	Zinc-lead	Sedimentary zinc-lead	Raghu and others, 1981
W. Kalimantan	Indonesia	-1.0000	112.0000	Aluminum	Bauxite	Rodenburg, 1984
Tombulilato	Indonesia	0.3667	123.4000	Copper-gold	Porphyry copper	Singer and others, 2002
Tangse	Indonesia	5.0333	95.9500	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Batu Hijau	Indonesia	-8.9653	116.8725	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Grasberg	Indonesia	-3.8167	137.2333	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Kelian	Indonesia	-6.1667	106.8333	Gold	Vein	Van Leeuwen and others, 1990
Gagu	Indonesia	-0.4667	130.8833	Nickel-copper-cobalt	Nickel laterite	Van Leeuwen, 1994

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Pomalaa	Indonesia	-4.0667	121.7500	Nickel-copper-cobalt	Nickel laterite	Carlile and Mitchell, 1994
Soroako	Indonesia	-2.1333	121.1667	Nickel-copper-cobalt	Nickel laterite	Carlile and Mitchell, 1994
Waigeo	Indonesia	-0.0500	129.8667	Nickel-copper-cobalt	Nickel laterite	Van Leeuwen, 1994
Hitachi	Japan	36.6272	140.6039	Copper	Volcanic massive sulfide	Mariko and Koto, 1994.
Makimine	Japan	32.6239	131.4556	Copper	Volcanic massive sulfide	Geologic Survey Japan, 1980
Okuki	Japan	33.5094	132.6531	Copper	Volcanic massive sulfide	Geologic Survey Japan, 1980
Besshi	Japan	33.8747	133.3189	Copper-gold-silver	Volcanic massive sulfide	Watanabe and others, 1998.
Osarizawa	Japan	40.1808	140.7472	Copper-lead-zinc	Vein	Geologic Survey Japan, 1980
Ashio	Japan	36.6442	139.4208	Copper-zinc-lead-silver	Vein	Omori and others, 1986.
Yamagano	Japan	31.9150	130.6236	Gold	Vein	Mining and Materials Processing Institute of Japan, 1989.
Hishikari	Japan	32.0050	130.6822	Gold-silver	Vein	Sekine and others, 1998.
Konomai	Japan	44.1333	143.3500	Gold-silver	Vein	Mining and Materials Processing Institute of Japan, 1990.
Kushikino	Japan	31.7533	130.3011	Gold-silver	Vein	Geologic Survey Japan, 1980
Sado	Japan	38.0439	138.2661	Gold-silver	Vein	Mining and Materials Processing Institute of Japan, 1994.
Taio	Japan	33.1236	130.8800	Gold-silver	Vein	Geologic Survey Japan, 1980
Takatama	Japan	37.5075	140.2925	Gold-silver	Vein	Seki, 1993.
Kamaishi	Japan	39.3056	141.7111	Iron-copper	Contact metamorphic	Haruna and others, 1990.
Toyoha	Japan	42.9781	141.0417	Lead-zinc-silver	Vein	Geologic Survey Japan, 1980
Yakumo	Japan	42.1683	140.1461	Manganese-zinc-lead	Vein	Geologic Survey Japan, 1980
Ryushoden	Japan	44.3128	143.3236	Mercury	Vein	Geologic Survey Japan, 1980
Yamatosuigin	Japan	34.4733	135.9775	Mercury	Vein	Kamitani and Naito, 1998
Seikoshi	Japan	34.9006	138.8242	Silver-gold	Vein	Mining and Materials Processing Institute of Japan, 1994.
Ikuno	Japan	35.1689	134.8256	Silver-gold-copper	Vein	Geologic Survey Japan, 1980

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Chichibu	Japan	36.0172	138.8150	Silver-gold-lead	Uncertain	Geologic Survey Japan, 1980
Hanaoka-Matsumine	Japan	40.3067	140.5586	Zinc-copper-lead-silver	Volcanic massive sulfide	Nakajima, 1989.
Hanawa	Japan	40.1800	140.8725	Zinc-copper-lead-silver	Volcanic massive sulfide	Nakajima, 1989.
Shakanai	Japan	40.3167	140.5561	Zinc-copper-lead-silver	Volcanic massive sulfide	Nakajima, 1989.
Hosokura	Japan	38.8058	140.9006	Zinc-lead-copper	Vein	Geologic Survey Japan, 1980
Kosaka	Japan	40.3461	140.7656	Zinc-lead-copper	Volcanic massive sulfide	Nakajima, 1989.
Hanaoka-Fukasawa	Japan	40.2861	140.6694	Zinc-lead-copper-silver	Volcanic massive sulfide	Geologic Survey Japan, 1980
Kamioka Tochibora	Japan	36.3517	137.3167	Zinc-lead-silver	Contact metamorphic	Geologic Survey Japan, 1980
Nakatatsu	Japan	35.8714	136.5761	Zinc-lead-silver	Contact metamorphic	Murao and others, 1991.
Geumdeogsan	Korean Peninsula	39.7000	125.9500	Iron	Contact metamorphic	Kamitani and Naito, 1998
Jaeryeong	Korean Peninsula	38.4000	125.6667	Iron	Contact metamorphic	Kamitani and Naito, 1998
Musan	Korean Peninsula	42.1667	129.1667	Iron	Contact metamorphic	Kamitani and Naito, 1998
Dongnam	Korean Peninsula	37.2778	128.7917	Iron-molybdenum	Contact metamorphic	Seo and others, 1983.
Hongcheon-Jaun	Korean Peninsula	37.8583	128.0167	Iron-strontium	Igneous	Park and Hwang, 1995.
Wando	Korean Peninsula	34.3500	126.6833	Pyrophyllite	Hydrothermal	O'Driscoll, 1993
Samgoe-Soryong	Korean Peninsula	36.2167	127.4333	Uranium	Sedimentary	Koo and others, 1977.
Ban Namtang	Laos	15.1500	106.0000	Aluminum	Bauxite	ESCAP, 1990b
Savannakhet	Laos	16.5000	105.1833	Gypsum-halite-potassium	Evaporite	ESCAP, 1990b
Pha Lek	Laos	19.0170	103.0000	Iron	Contact metamorphic	ESCAP, 1990b
Phu Nhouan	Laos	19.4000	103.0000	Iron	Contact metamorphic	ESCAP, 1990b
Vientiane Plain	Laos	18.0000	102.0000	Potash	Evaporite	ESCAP, 1990b
Ban Houei Sai	Laos	20.3500	100.3833	Sapphire	Gemstone	ESCAP, 1990b
Nam Pathene Valley	Laos	17.9333	104.6167	Tin	Weathering	ESCAP, 1990b
Mamut	Malaysia	6.0333	116.4667	Copper-silver-gold	Porphyry copper	Singer and others, 2002

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Bukit/Sungai	Malaysia	3.8833	103.0667	Tin	Placer	Kamitani and Naito, 1998
Kinta Valley	Malaysia	4.3000	101.0000	Tin	Placer	Kamitani and Naito, 1998
Pahang/Selangor	Malaysia	3.8333	101.6667	Tin	Placer	Kamitani and Naito, 1998
Beltesin gol	Mongolia	50.4500	99.3500	Aluminum	Igneous	ESCAP, 1999b
Duchin gol	Mongolia	50.3667	99.6167	Aluminum	Igneous	Ariunbileg and others, 2003
Borts Uul	Mongolia	49.3167	93.9500	Copper	Volcanic massive sulfide	Ariunbileg and others, 2003
Oyu Tolgoi	Mongolia	43.0028	106.8583	Copper	Porphyry copper	Ariunbileg and others, 2003
Oyut tolgoi 2	Mongolia	49.2667	95.9667	Copper	Igneous	Ariunbileg and others, 2003
Khokhbulgiin khondii	Mongolia	46.4833	99.6000	Copper-gold	Contact metamorphic	Watanabe and others, 1999.
Avdartolgoi	Mongolia	49.6708	114.8444	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Erdenet	Mongolia	49.0172	104.1192	Copper-molybdenum	Porphyry copper	ESCAP, 1999b
Erdenetiin Ovoo	Mongolia	49.0000	104.1333	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Tsagaan Suvarga	Mongolia	43.8722	108.3333	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Berkh 1	Mongolia	47.7750	111.1708	Flourite	Vein	Ariunbileg and others, 2003
Bor Undur	Mongolia	46.2333	109.4333	Flourite	Vein	ESCAP, 1999b
Bor-Undur	Mongolia	46.2639	109.4361	Flourite	Vein	Jargalsaihan and others, 1996
Khajuu Ulaan	Mongolia	46.2667	109.8667	Flourite	Uncertain	ESCAP, 1999b
Urgen 2	Mongolia	44.7014	110.7347	Flourite	Sedimentary	Kleiner and others, 1977
Boroo	Mongolia	48.7500	106.1500	Gold	Igneous	Ariunbileg and others, 2003
Bumbat	Mongolia	48.2833	104.5167	Gold	Vein	ESCAP, 1999b
Tolgoit	Mongolia	49.4667	107.3667	Gold	Placer	ESCAP, 1999b
Tsagaantsakhir Uul	Mongolia	46.0861	100.0500	Gold	Igneous	Ariunbileg and others, 2003
Bayan Uul	Mongolia	48.8528	115.6278	Gold-silver-lead	Igneous	Ariunbileg and others, 2003
Baruun Tserd	Mongolia	50.4167	91.7167	Gypsum	Evaporite	Ganbaatar, 1999,

DEPOSIT NAME	COUNTRY	LATITUDE dec deg	LONGITUDE dec deg	COMMODITIES	DEPOSIT TYPE	CITATION
Davst uul	Mongolia	50.3333	93.3333	Halite	Evaporite	Ariunbileg and others, 2003
Sangiyn Dalay	Mongolia	48.6333	92.9333	Halite	Evaporite	ESCAP, 1999b
Bayan Gol	Mongolia	49.6000	107.0167	Iron	Contact metamorphic	ESCAP, 1999b
Tumurtei	Mongolia	49.6833	107.2500	Iron	Contact metamorphic	ESCAP, 1999b
Bagatsagaan gol	Mongolia	50.6833	100.0833	Manganese	Volcanic	Ariunbileg and others, 2003
Saihangol	Mongolia	50.8667	100.1333	Manganese	Volcanic	Ariunbileg and others, 2003
Aryn nuur	Mongolia	47.2167	113.9500	Molybdenum	Porphyry copper	Ariunbileg and others, 2003
Khalzanburegtei	Mongolia	48.3667	91.9333	Niobium-zirconium	Contact metamorphic	Ariunbileg and others, 2003
Burenhan	Mongolia	49.8000	99.9500	Phosphorous	Evaporite	Byamba, 1996
Hubsgul Basin	Mongolia	50.6833	100.1667	Phosphorous	Uncertain	ESCAP, 1999b
Hubsugul	Mongolia	50.6833	100.1667	Phosphorous	Evaporite	Ilin, 1973
Tsagaan Nuur	Mongolia	51.2333	99.3833	Phosphorous	Evaporite	Ilin, 1973
Uhagol	Mongolia	51.7000	100.0333	Phosphorous	Evaporite	Ilin, 1973
Lugin Gol	Mongolia	42.9500	108.5667	Rare earth elements	Igneous	ESCAP, 1999b
Mushgai hudag	Mongolia	44.4000	104.0500	Rare earth elements	Igneous	Munkhtsengel and Iizumi, 1999.
Mushgai Khudag	Mongolia	44.3333	104.0000	Rare earth elements	Igneous	ESCAP, 1999b
Mongon Ondor	Mongolia	47.8333	110.1833	Silver	Vein	Ariunbileg and others, 2003
Asgat	Mongolia	49.8722	89.6417	Silver-antimony	Vein	Ariunbileg and others, 2003
Tolbo nuur	Mongolia	48.5861	90.2583	Silver-antimony	Vein	Ariunbileg and others, 2003
Dulaan khar uul	Mongolia	49.3167	90.4333	Silver-gold-lead	Vein	Ariunbileg and others, 2003
Altanboom	Mongolia	50.3333	98.5000	Tantalum	Contact metamorphic	Jargalsaihan and others, 1996.
Ondortsagan	Mongolia	47.8667	110.1667	Tungsten-molybdenum	Igneous	Ariunbileg and others, 2003
Tsagaan dabaa	Mongolia	48.1833	106.0667	Tungsten-molybdenum	Igneous	Ariunbileg and others, 2003
Nars	Mongolia	44.9167	113.5500	Uranium	Sedimentary	Ochirbat, 1999.

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Hitagiin gol	Mongolia	49.8167	99.8333	Vanadium	Sedimentary	Ariunbileg and others, 2003
Tsagaan Tsav	Mongolia	45.6500	91.2333	Zeolite	Zeolite	ESCAP, 1999b
Tsagaantsav	Mongolia	44.6333	109.7500	Zeolite	Volcanic	Ariunbileg and others, 2003
Ulaan	Mongolia	49.0500	114.0833	Zinc-lead-silver	Uncertain	ESCAP, 1999b
Mungon-Ondur	Mongolia	47.8500	110.1833	Zinc-lead-tin-silver	Igneous	Ariunbileg and others, 2003
Ulaantolgoi	Mongolia	49.4667	93.0333	Zirconium-tantalum-REE	Igneous	Ariunbileg and others, 2003
Kharidhunga	Nepal	27.6333	85.9417	Magnesite-talc	Uncertain	ESCAP, 1993b
Kouaoua	New Caledonia	-21.4000	165.7500	Nickel-copper-cobalt	Nickel laterite	Dixon, 1979
Moneo	New Caledonia	-21.1500	165.4833	Nickel-copper-cobalt	Nickel laterite	Dixon, 1979
Poro district	New Caledonia	-21.3167	165.7000	Nickel-copper-cobalt	Nickel laterite	Dixon, 1979
Thio district	New Caledonia	-21.6167	166.1667	Nickel-copper-cobalt	Nickel laterite	Dixon, 1979
Reefton	New Zealand	-42.0833	171.8500	Gold	Vein	Williams, 1974
Waihi	New Zealand	-37.3889	175.8461	Gold	Vein	Williams, 1974
Otago	New Zealand	-45.3833	170.4333	Gold-tungsten	Placer	Williams, 1974
Waikato	New Zealand	-37.3527	174.7315	Iron-tantalum	Placer	ESCAP, 1988a
Cobb Valley	New Zealand	-41.0965	172.6830	Magnesite	Igneous	ESCAP, 1988b
Parengarenga	New Zealand	-31.5283	172.9587	Silica sand	Placer	ESCAP, 1988b
Barrytown	New Zealand	-42.2080	171.3167	Titanium-zirconium-REE	Placer	McPherson, 1978
Westport	New Zealand	-41.7833	171.5500	Titanium-zirconium-REE	Placer	McPherson, 1978
Khuzdar	Pakistan	26.7667	66.5167	Barite-lead-zinc	Sedimentary	Grundstofftechnik, 1992
Bunap area	Pakistan	28.8000	64.9500	Chromium	Igneous	Grundstofftechnik, 1992
Sonaro	Pakistan	26.3583	66.4861	Chromium	Igneous	Grundstofftechnik, 1992
Sakhakot-Qila Ophio	Pakistan	34.4667	71.9000	Chromium-platinum	Igneous	Grundstofftechnik, 1992
Reko Diq	Pakistan	29.1333	62.0333	Copper-gold	Porphyry copper	Singer and others, 2002;

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Dash-e-Kain	Pakistan	29.5544	64.5042	Copper-gold-molybdenum	Porphyry copper	Singer and others, 2002;
Saindak	Pakistan	29.2708	61.6056	Copper-gold-molybdenum	Porphyry copper	Singer and others, 2002;
Swat Emerald Mine	Pakistan	34.7500	72.3333	Emerald	Gemstone	Kazmi and others, 1986
Jatta Salt Mines	Pakistan	33.3333	71.3333	Halite	Evaporite	Lee, 1980
Khewra Salt Mines	Pakistan	32.6500	73.0167	Halite	Evaporite	Lee, 1980
Kalabagh	Pakistan	32.9667	71.5667	Halite-potassium	Evaporite	Lee, 1980
Warcha Salt Mine	Pakistan	32.6000	72.7500	Halite-potassium	Evaporite	Lee, 1980
Pachin Koh	Pakistan	29.1944	62.9139	Iron	Iron-oxide-copper-gold	Grundstofftechnik, 1992
Gunga	Pakistan	27.7417	66.5333	Lead-zinc-barite	Sedimentary zinc-lead	Grundstofftechnik, 1992
Loe Shilman	Pakistan	34.2208	71.1411	Phosphorous	Evaporite	Pell, 1996
Hunza Valley area	Pakistan	36.2750	75.5917	Ruby-spinel-sapphire	Gemstone	Grundstofftechnik, 1992
Duddar	Pakistan	26.0972	66.8272	Zinc-lead-silver	Sedimentary zinc-lead	McFaul and others, 2002
Bougainville	Papua New Guinea	-6.3167	155.5000	Copper-molybdenum	Porphyry copper	Singer and others, 2002
Ok Tedi	Papua New Guinea	-5.2000	141.1333	Copper-molybdenum-gold	Porphyry copper	Singer and others, 2002
Frieda River	Papua New Guinea	-4.7000	141.7833	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Yandera	Papua New Guinea	-5.7500	145.1667	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Porgera/Waruwari	Papua New Guinea	-5.4667	143.0833	Gold-silver	Vein	Kamitani and Naito, 1998
Acoje	Philippines	15.9667	119.9333	Chromium	Igneous	Bureau of Mines and Geosciences, 1986
Coto/Masinloc	Philippines	15.7667	119.9333	Chromium	Igneous	Bureau of Mines and Geosciences, 1986
San Fabian	Philippines	16.3833	120.9833	Copper-gold	Porphyry copper	Singer and others, 2002
Tampakan	Philippines	6.4700	125.0667	Copper-gold	Porphyry copper	Singer and others, 2002
Atlas	Philippines	10.3667	123.8333	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Basay	Philippines	9.5667	122.6333	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Hinobaan	Philippines	9.7500	122.5667	Copper-silver-gold	Porphyry copper	Singer and others, 2002

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Kingking	Philippines	7.1667	125.9917	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Mankayan	Philippines	16.8583	120.7833	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Marcopper	Philippines	13.4500	122.0833	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Santo Ni	Philippines	16.4903	120.6556	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Santo Tomas II	Philippines	16.2556	120.6250	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Sipalay	Philippines	9.8167	122.4500	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Taysan	Philippines	13.8000	121.1333	Copper-silver-gold	Porphyry copper	Singer and others, 2002
Bagacay	Philippines	11.8000	125.2667	Copper-sulfur	Volcanic massive sulfide	Hutchison and Taylor, 1978
Lepanto	Philippines	16.8500	120.7528	Gold-copper	Vein	Mitchell and Leach, 1991
Baguio	Philippines	16.4236	120.6417	Gold-silver	Vein	Mitchell and Leach, 1991
Nonoc I	Philippines	10.2000	125.6333	Nickel-copper-cobalt	Nickel laterite	Bureau of Mines and Geosciences, 1986
Rio Tuba	Philippines	8.7000	117.3333	Nickel-copper-cobalt	Nickel laterite	Bureau of Mines and Geosciences, 1986
Elahera	Sri Lanka	7.7833	80.7833	Gem	Gemstone	ESCAP, 1989
Okkampitiya	Sri Lanka	6.7833	81.2667	Gem	Gemstone	ESCAP, 1989
Ratnapura	Sri Lanka	6.5000	80.4167	Gem	Gemstone	ESCAP, 1989
Eppawella	Sri Lanka	8.1667	80.6667	Phosphorous	Igneous	Jayawardena, 1998
Pulmoddai	Sri Lanka	8.9500	80.9500	Titanium-zirconium-REE	Placer	ESCAP, 1989
Khon Kaen	Thailand	16.3333	102.8667	Halite-potassium	Evaporite	ESCAP, 2001
Non Sung	Thailand	15.5000	101.7500	Halite-potassium	Evaporite	ESCAP, 2001
Udon Thani- North	Thailand	17.5000	103.0833	Halite-potassium	Evaporite	ESCAP, 2001
Udon Thani- South	Thailand	17.3333	102.6667	Halite-potassium	Evaporite	ESCAP, 2001
Udon Thani	Thailand	17.4167	102.7500	Potash	Evaporite	ESCAP, 2001
Kamchanaburi	Thailand	14.3333	99.5000	Sapphire	Gemstone	ESCAP, 2001
Nakhon Si Thammarat	Thailand	9.0500	99.8000	Tin	Placer	Kamitani and Naito, 1998

DEPOSIT NAME	COUNTRY	LATITUDE	LONGITUDE	COMMODITIES	DEPOSIT TYPE	CITATION
		dec deg	dec deg			
Phuket Area, Offsh	Thailand	7.9167	98.2500	Tin	Placer	Kamitani and Naito, 1998
Ranong Area	Thailand	9.8500	98.6333	Tin	Placer	Kamitani and Naito, 1998
Takua Pa/Phang Nga	Thailand	8.8333	98.2833	Tin	Placer	Kamitani and Naito, 1998
Mae Sod/Padaeng	Thailand	16.6833	98.7167	Zinc	Sedimentary zinc-lead	Hutchison and Taylor, 1978
Sin Quyen	Vietnam	22.6670	104.5500	Copper-gold	Iron-oxide copper-gold	Singer and others, 2002
Thach Khe	Vietnam	18.3000	105.9333	Iron	Contact metamorphic	Kamitani and Naito, 1998
Lao Cai Basin	Vietnam	22.5000	103.9500	Phosphorous	Uncertain	ESCAP, 1990a
Vientiane Plain	Vietnam	18.0000	102.6667	Potassium-gypsum-halite	Evaporite	ESCAP, 1990a
Nam Xe	Vietnam	22.4833	103.5000	Rare earth elements	Uncertain	ESCAP, 1990a
Cat Khanh	Vietnam	13.5000	105.2000	Titanium-zirconium-REE	Placer	ESCAP, 1990a
Ke Sung	Vietnam	16.5000	107.5833	Titanium-zirconium-REE	Placer	ESCAP, 1990a
Mi Tho	Vietnam	13.7500	109.2500	Titanium-zirconium-REE	Placer	ESCAP, 1990a
Vinh Mi (Vinh My)	Vietnam	16.3333	107.7500	Titanium-zirconium-REE	Placer	ESCAP, 1990a

Figures

Figure 1. World map showing location of regional reports and the countries of the Asia and Pacific region. Countries and commodities are tabulated on Table 1.

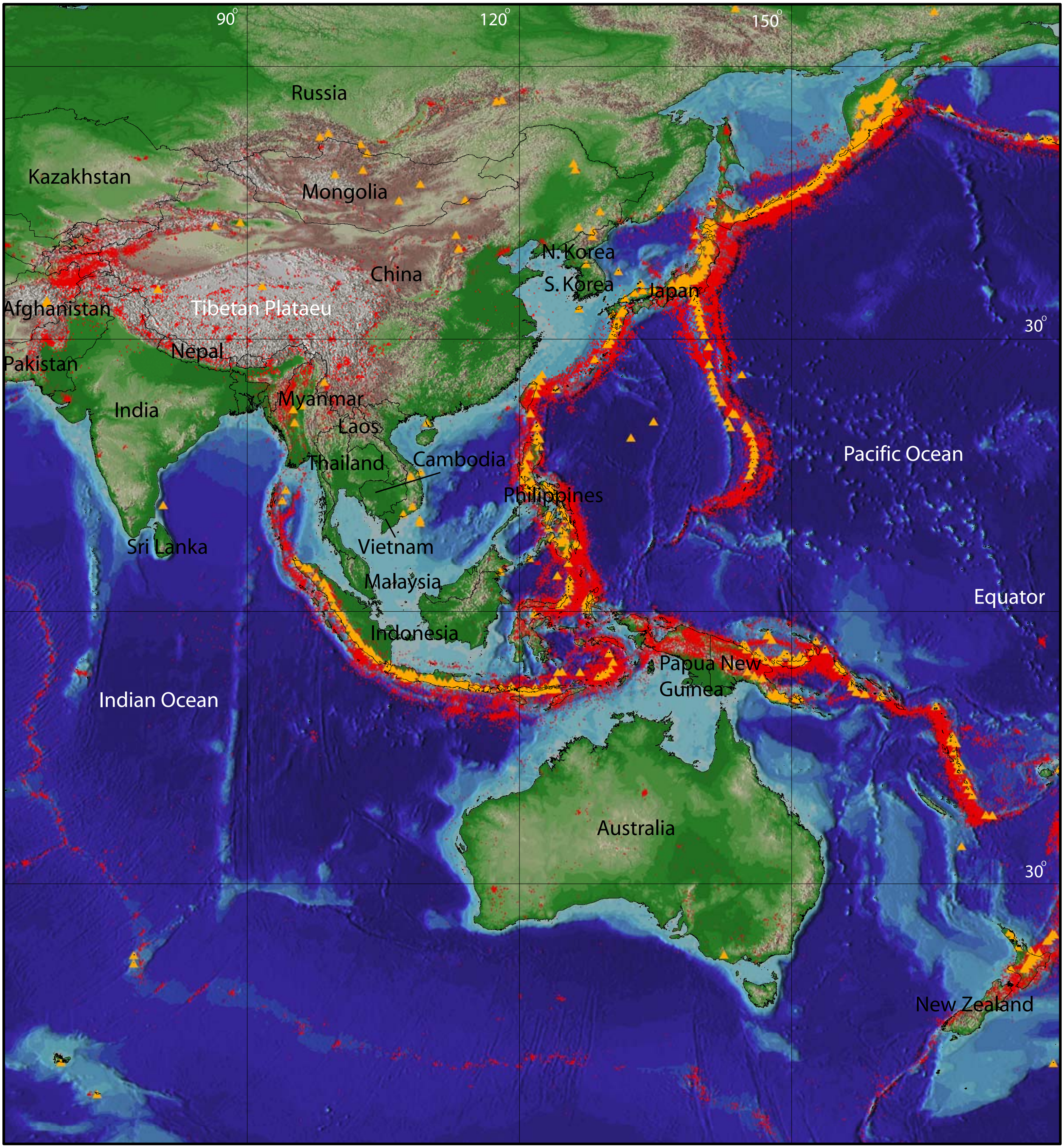


Figure 2. Location of countries and geographic features in the Asia and Pacific region. Green areas are low elevations, browns are intermediate elevations, and light colored areas, such as the Tibetan Plateau, are high elevations. Desert areas are common north and south of the equator at about 30 degrees latitude, except near coastlines, where rain fall is greater due to the effect of the ocean. Red dots are recorded earthquake epicenters that lie at the margins of the tectonic plates shown in Figure 3. Volcanoes are shown as orange triangles (images from Hearn, et al., 2003)

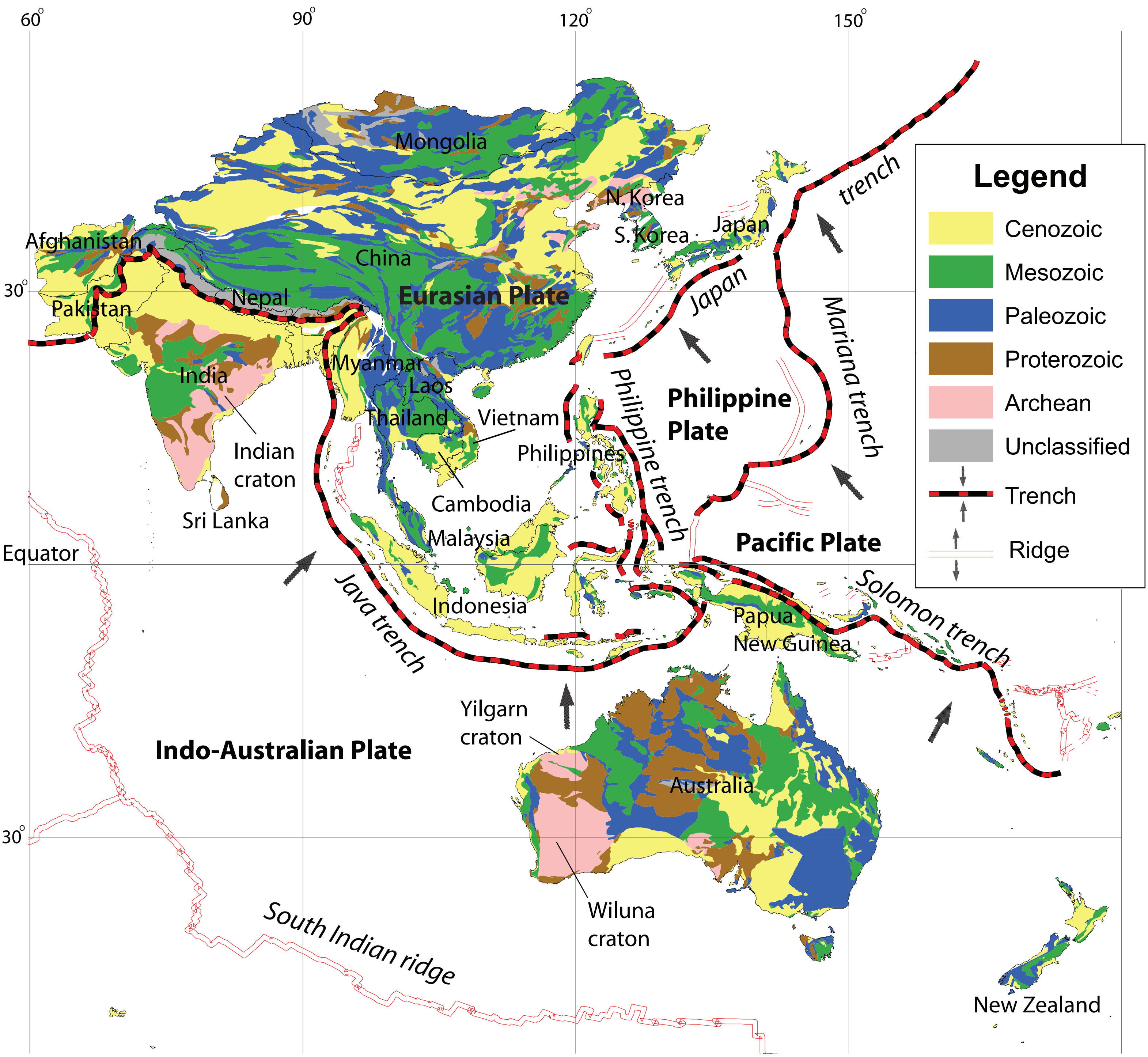


Figure 3. Distribution of rocks divided into the five main ages of earth history in the Asia and Pacific region (Geological Survey of Canada, 1995). The ages and ranges of units depicted on the map include:

	From (Million Years)	To (Million Years)
Cenozoic	66.4	Recent
Mesozoic	245	66.4
Paleozoic	570	245
Proterozoic	2,500	570
Archean	3,800(?)	2,500

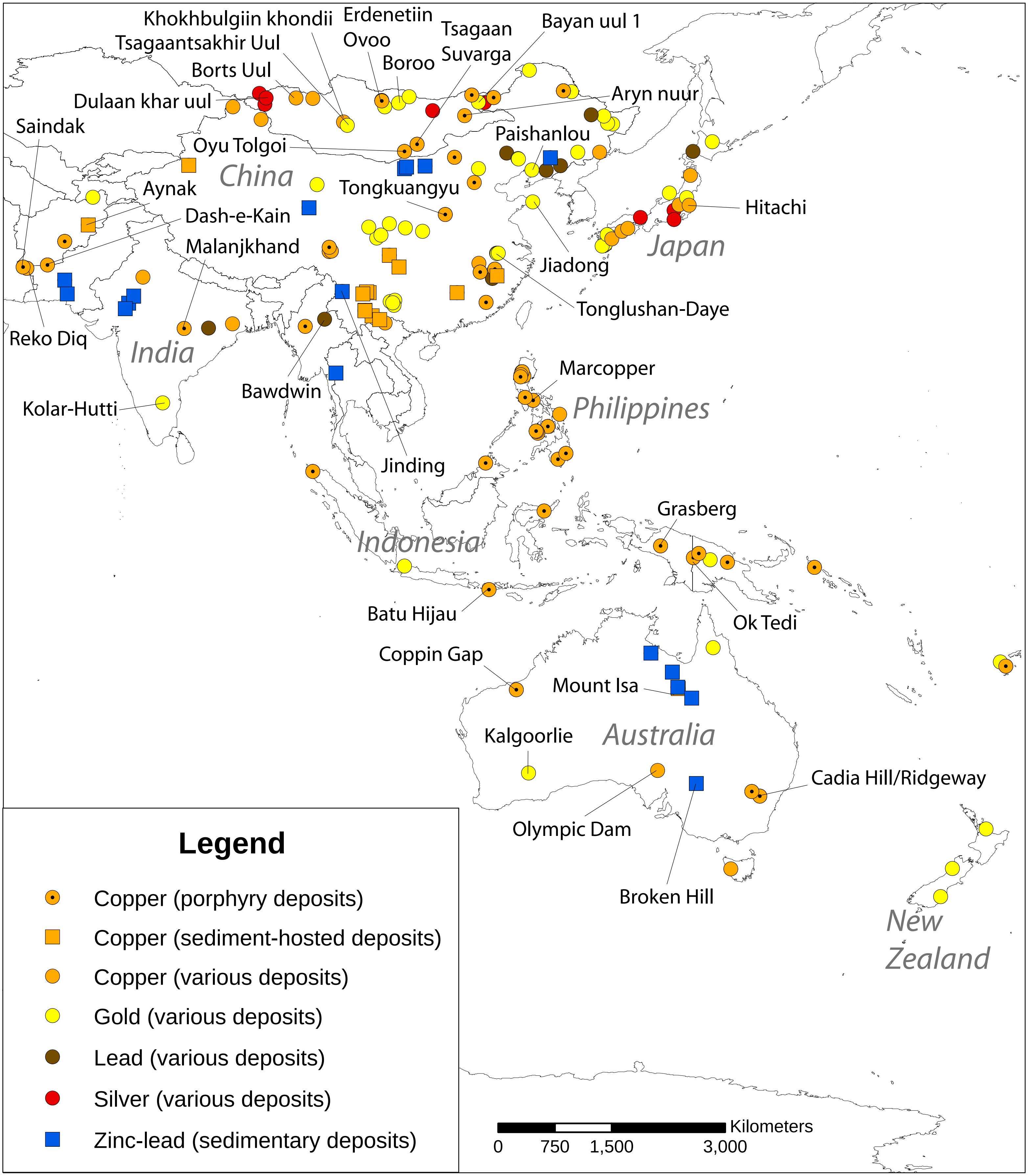


Figure 4A - Main nonfuel mineral deposits in the Asia and Pacific Region. The deposits are tabulated on table 2.

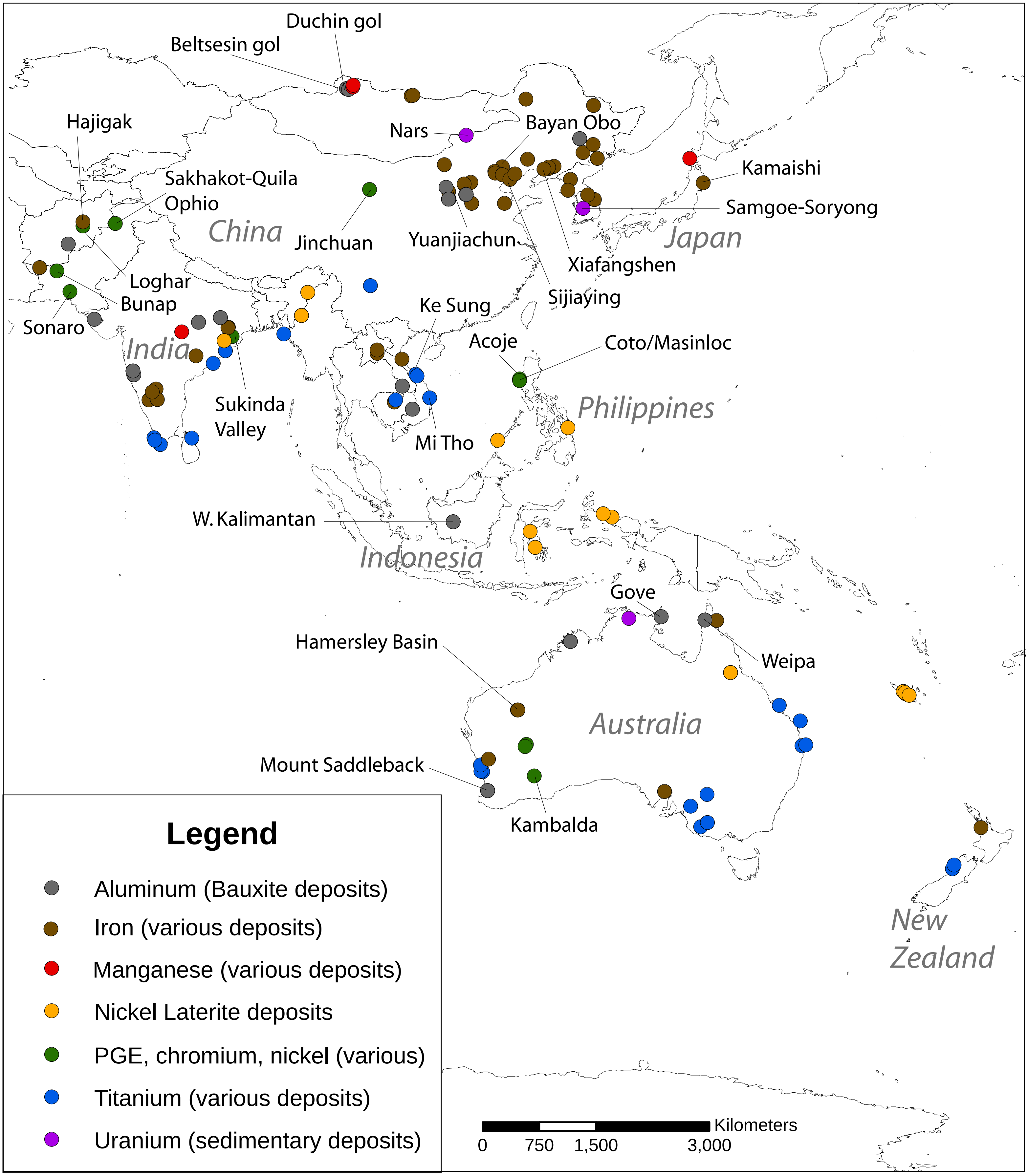


Figure 4B - Main nonfuel mineral deposits in the Asia and Pacific Region. The deposits are tabulated on table 2.

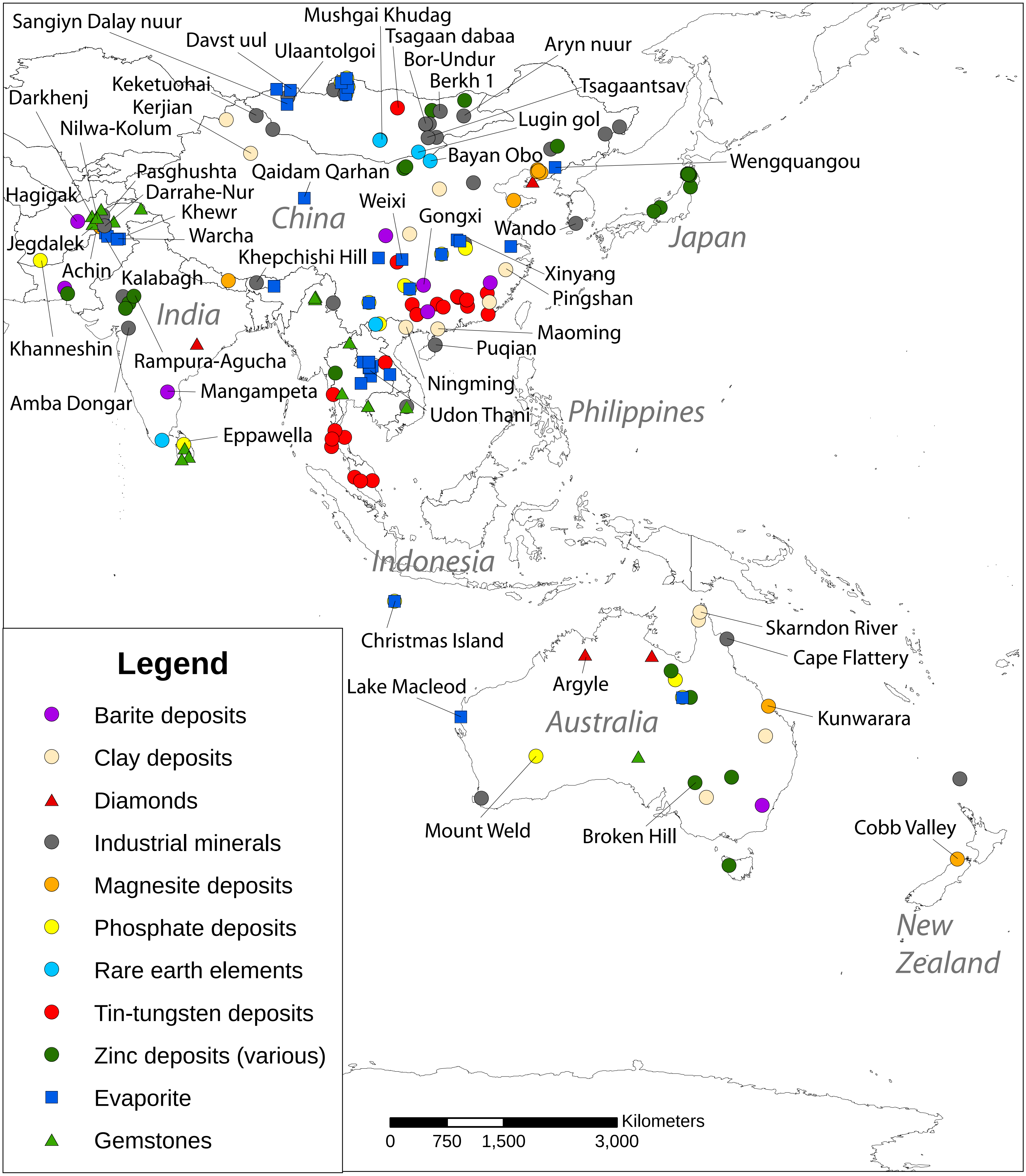


Figure 4C - Main nonfuel mineral deposits in the Asia and Pacific Region. The deposits are tabulated on table 2.

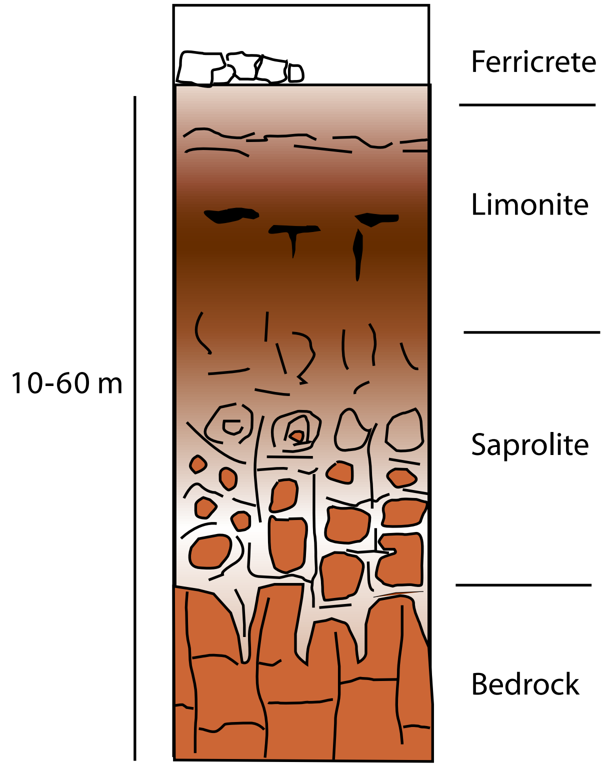
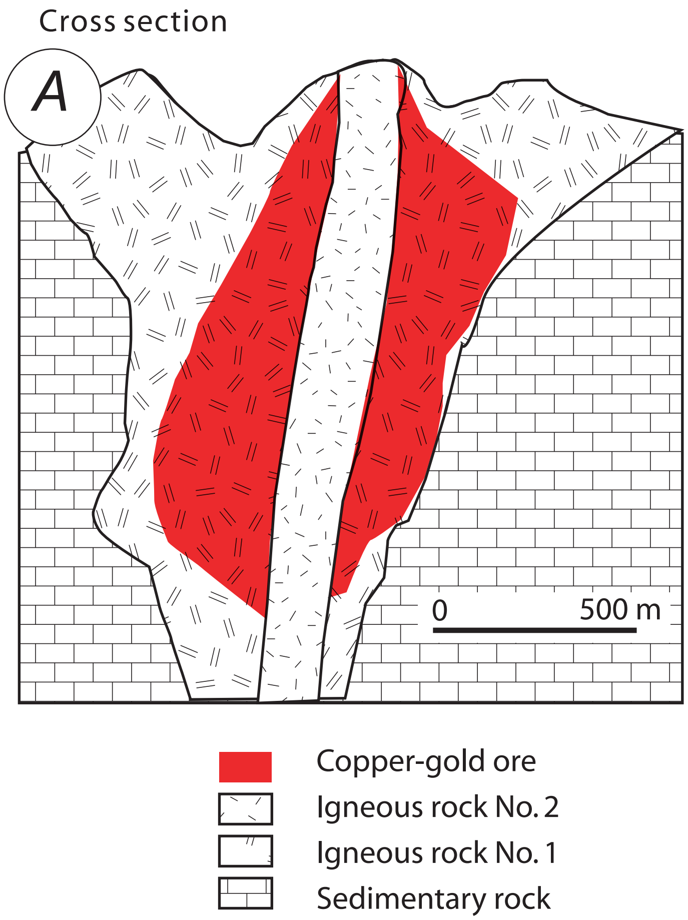
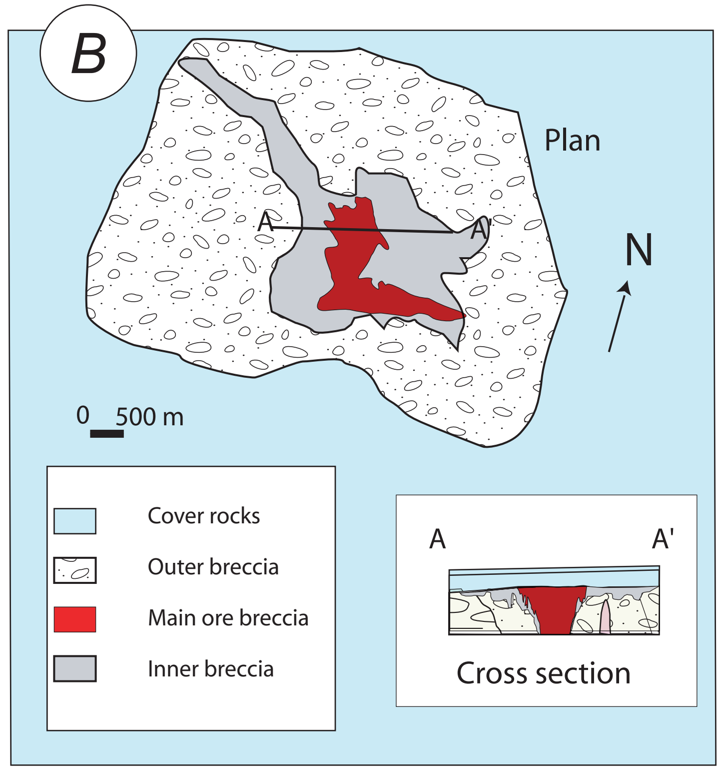
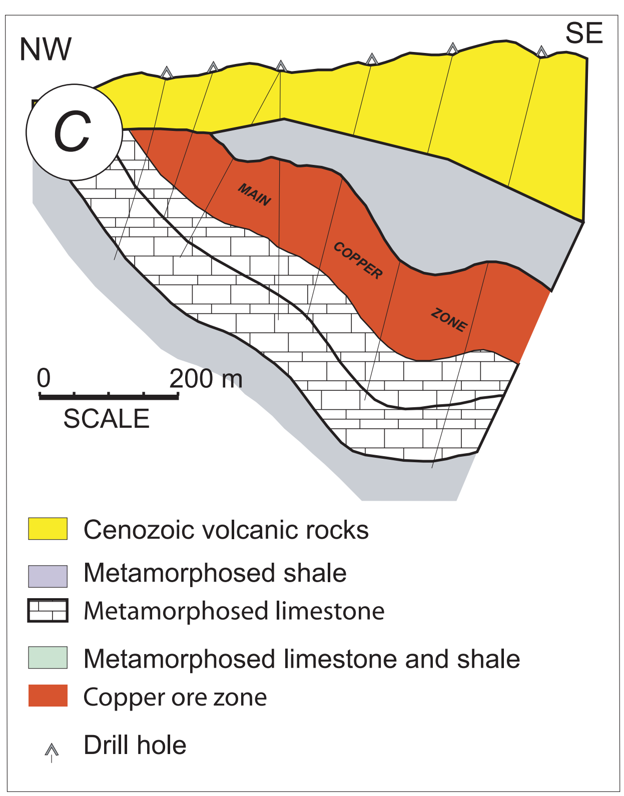


Figure 5. Schematic laterite profile, showing the effect of deep weathering in the tropical climates of the Asia and Pacific region. Intense weathering leaches minerals from one part of the weathering profile and enhances them in another part of the profile producing either aluminum-bauxite or nickel-laterite deposits, depending on the original composition of the rock. These deposits are near surface, they cover large areas and they are easy to excavate because they are soft and are therefore commonly easily mined and economic. Modified from Elias (2002).


Cross section
A
0
500 m
Copper-gold ore
Igneous rock No. 2
Igneous rock No. 1
Sedimentary rock


B
Plan
A
A'
N
0
500 m
Cover rocks
Outer breccia
Main ore breccia
Inner breccia
A
A'
Cross section


NW
SE
C
MAIN
COPPER
ZONE
0
200 m
SCALE
Cenozoic volcanic rocks
Metamorphosed shale
Metamorphosed limestone
Metamorphosed limestone and shale
Copper ore zone
Drill hole

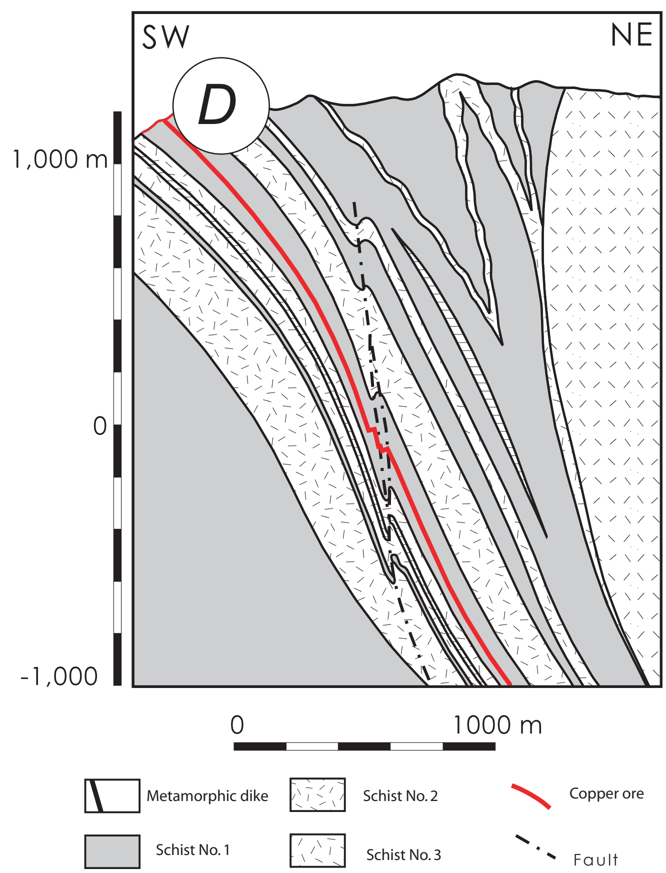

SW
NE
D
1,000 m
0
-1,000
0
1000 m
Metamorphic dike
Schist No. 1
Schist No. 2
Schist No. 3
Copper ore
Fault

Figure 6. Schematic geologic diagrams of copper deposit types in the Asia and Pacific region. (*A*) Cross section through the *Grasberg* porphyry copper-gold deposit, Indonesia, largest porphyry copper–gold deposit. Porphyry copper-gold deposits are common in the Cenozoic and Mesozoic intrusive rocks of Papua New Guinea, Philippines, and Indonesia and are also present in belts in Burma, Thailand, Laos and China, as well as Mongolia. The deposits are a significant source of copper, and gold in the world and are usually mined by open pit methods. The large size and significant amounts of metals associated with these deposits means that the mining operations are large and can have lasting environmental impacts. Peripheral vein deposits of base and precious metals are common adjacent to many porphyry copper deposits. (*B*) Geologic section through the Aynak sediment-hosted copper deposit in Afghanistan (modified from ESCAP, 1995). Original sedimentary sequence has been metamorphosed. Ore reserves are 175 million tonnes averaging 2.5 percent copper (modified from ESCAP, 1995). Similar deposits are present in the Mekong Delta area, and in Australia and China. (C) Geologic plan and cross section of the Olympic Dam copper-gold-iron deposit, Southern Australia, showing that the deposit is hidden under 0.5 km of cover sedimentary rocks. The plan shows the outline of a large breccia mass that is hidden at the surface by sedimentary rocks. The deposit was found using geophysics and deep drilling. Mining is by underground methods. Similar deposits are present near the main Olympic dam deposit and also are present in the Asia and Pacific region. The deposits are typically of giant to medium size (simplified from Hughes, 1990). (*D*) Cross section through a massive sulfide copper deposit in the *Sambagawa-Chichib-Shimanto* belt, Japan. Adapted from the Sumitomo Mining Co. (1981). The deposits formed with the volcanic rocks and are rich and very economic. Similar deposits are present in China, Burma and other countries in the Asia Pacific region.

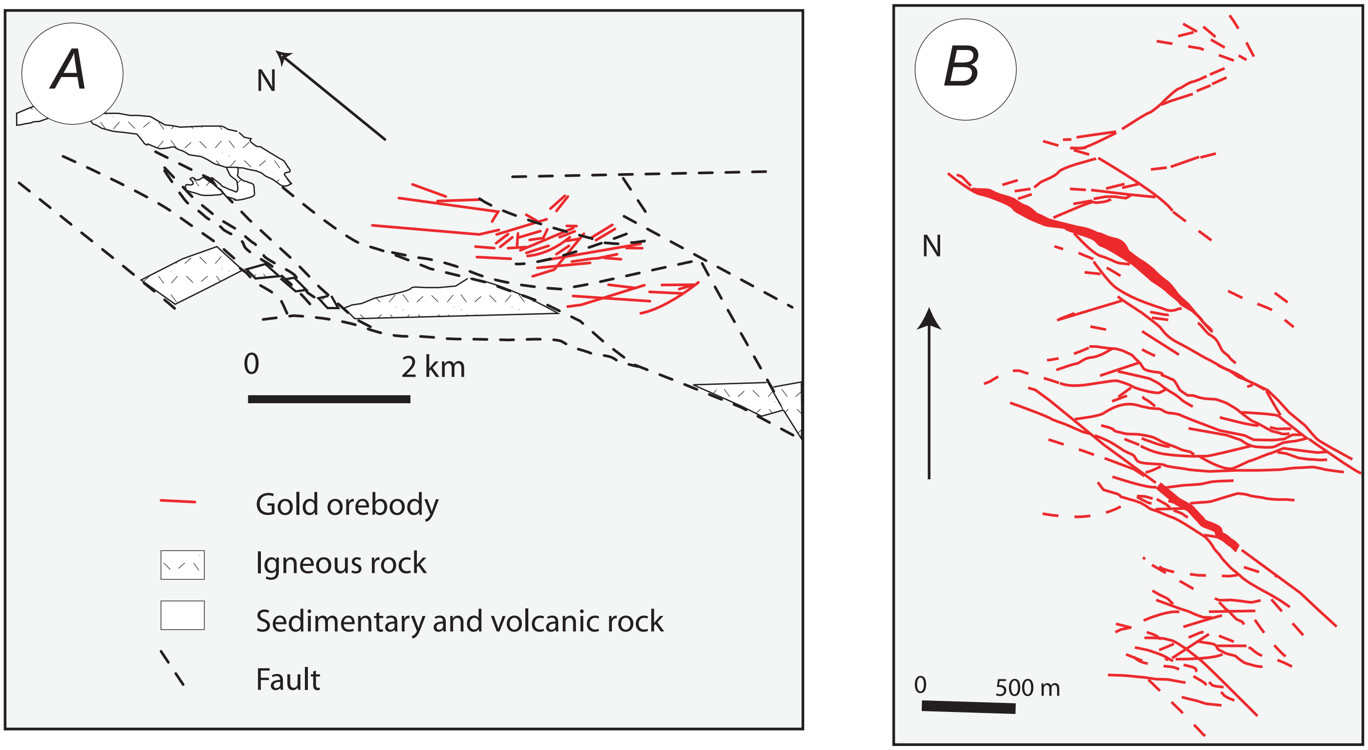


Figure 7. Schematic geologic diagrams of gold and silver deposit types in the Asia and Pacific region. (A) Geologic map of the Kalgoorlie area, Western Australia, showing gold orebodies along the Golden Mile shear zone. The shear zone is one of many complex fault zones in the Wiluna craton that contains large to medium-size, high-grade gold orebodies. Similar orebodies are present in India and China. Placer deposits commonly form adjacent to these orebodies where the climate is wet and streams. Modified from Hughes (1991). (B) Vein geometry of the large Antamok gold deposit, Baguio district, Philippines. These vein deposits typically are spatially associated with porphyry copper–gold deposits. The veins from these types of deposit are mined either individually in underground mines or together in surface open pit mines.

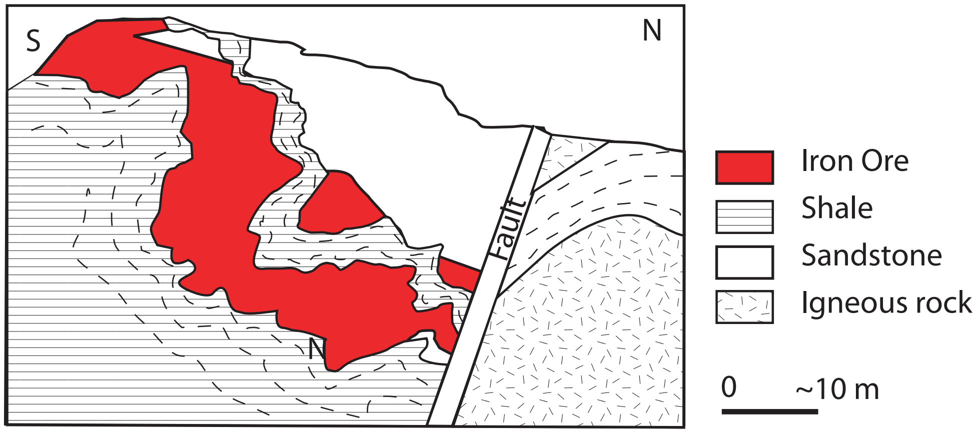


Figure 8. North-south cross section, looking west through the Mount Whaleback sedimentary iron deposit (from Mt. Newman Mining Co. Pty. Ltd.).   These deposits form in the Proterozoic and also Archean rocks of Western Australia, India, and China, and form large relatively uniform orebodies that are mined by open pit methods. Folding and metamorphism has enriched some of the orebodies to high percentages of iron and made them more economic.

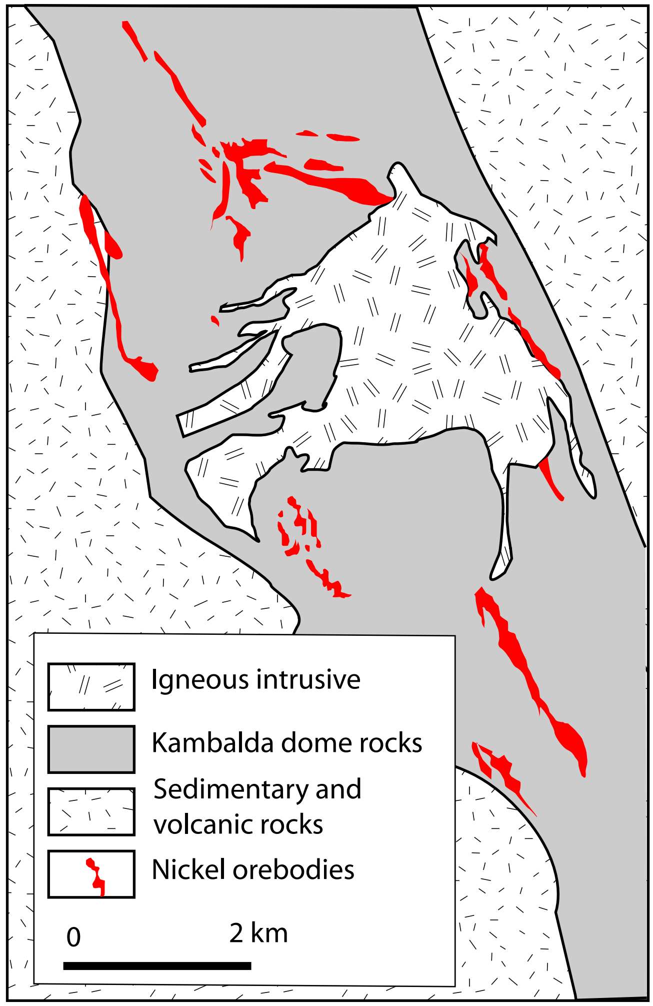
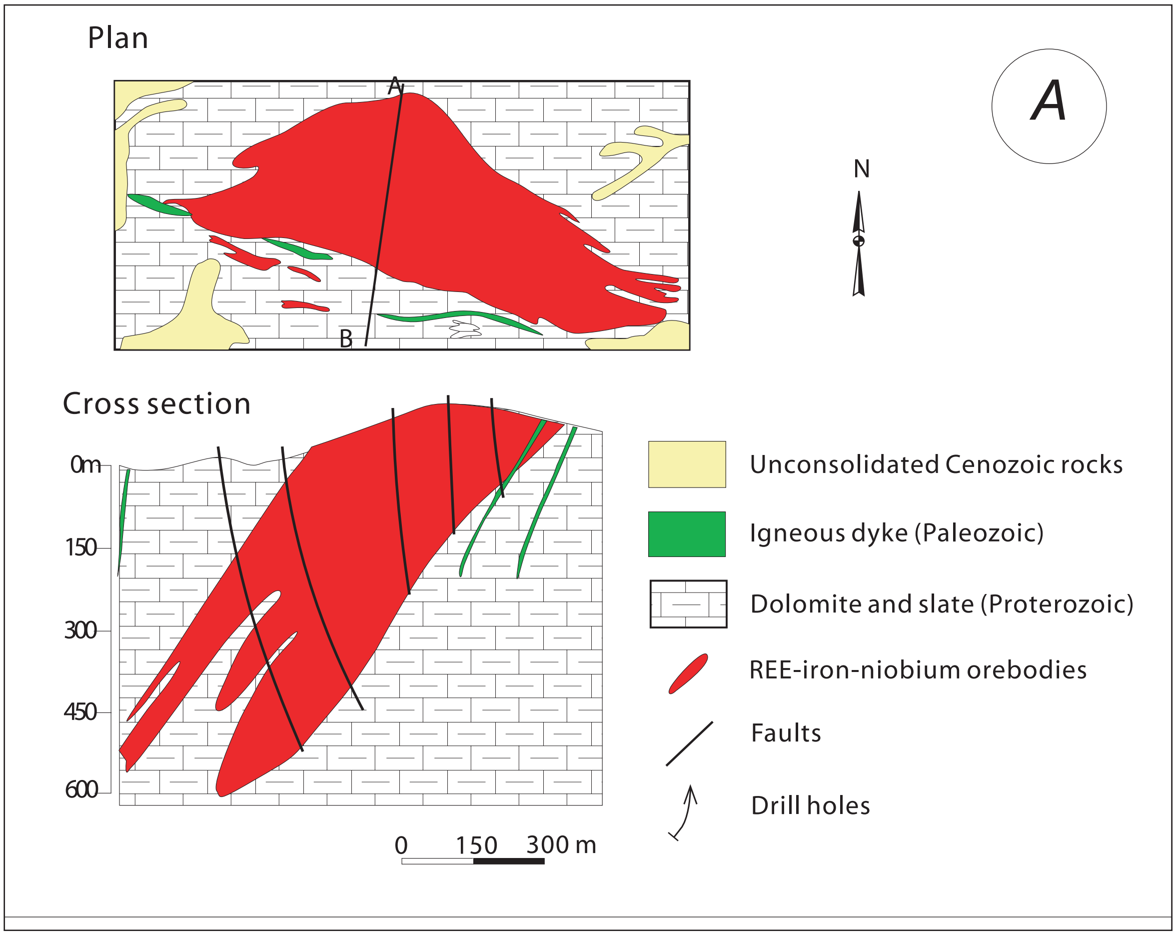


Figure 9. Geology of the Kambalda Dome, Western Australia, showing nickel oreshoots. The large, rich orebodies are mined by underground methods and processed by mills with flotation and smelter. A number of other nickel-copper orebodies are present throughout Western Australia in the volcanic rocks of the Wiluna craton (see fig. 3) (modified from Hughes, 1990).


Plan
A
A
B
N
Cross section
0m
150
300
450
600
0
150
300 m
Unconsolidated Cenozoic rocks
Igneous dyke (Paleozoic)
Dolomite and slate (Proterozoic)
REE-iron-niobium orebodies
Faults
Drill holes

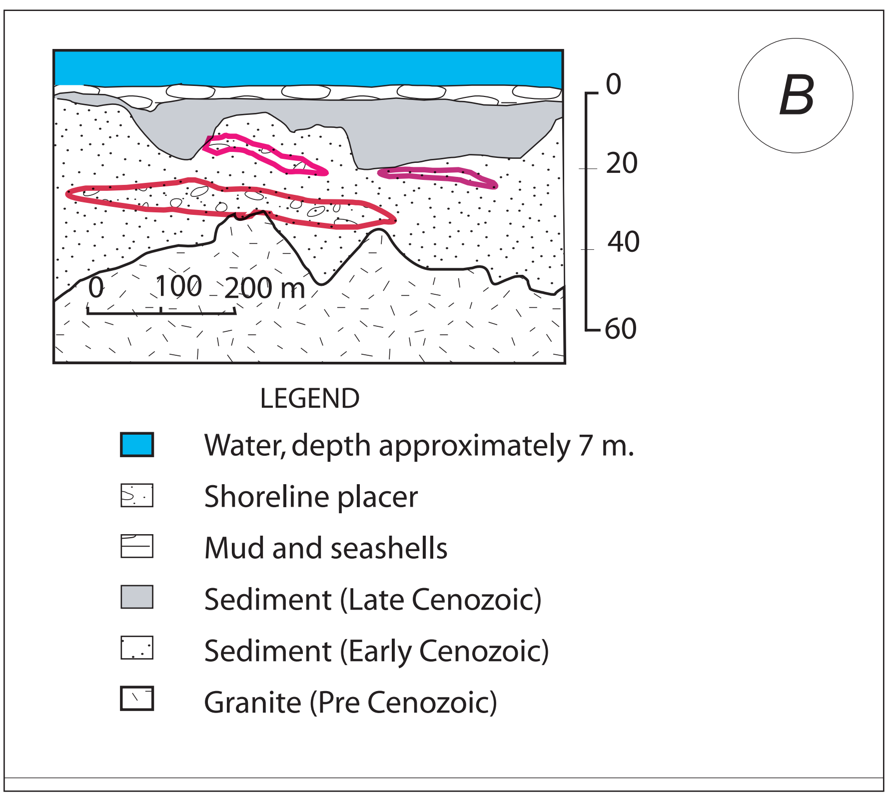

B
0
20
40
60
0
100
200 m
LEGEND
Water, depth approximately 7 m.
Shoreline placer
Mud and seashells
Sediment (Late Cenozoic)
Sediment (Early Cenozoic)
Granite (Pre Cenozoic)

Figure 10. Geologic diagrams of Rare-earth element and, uranium and thorium deposits in the Asia and Pacific region. (*A*) Plan and section of the giant *Bayan Obo* rare-earth elements-iron-niobium deposit, northern China. Geologic map and cross section of main orebodies, adapted from Li (1993). Much of the ore is contact metamorphic rocks next to igneous rocks. Similar deposits are present in Mongolia and India. (*B*) Cross section through a typical shoreline placer deposit. Deposits of tin-tungsten (gold) are prevalent in southern Thailand and Malaysia and titanium-zirconium-rare-earth elements shoreline deposits are present along the coastlines of New Zealand, Australia, Vietnam, and India. The titanium-zirconium-rare-earth element deposits are vast and contain significant resources.

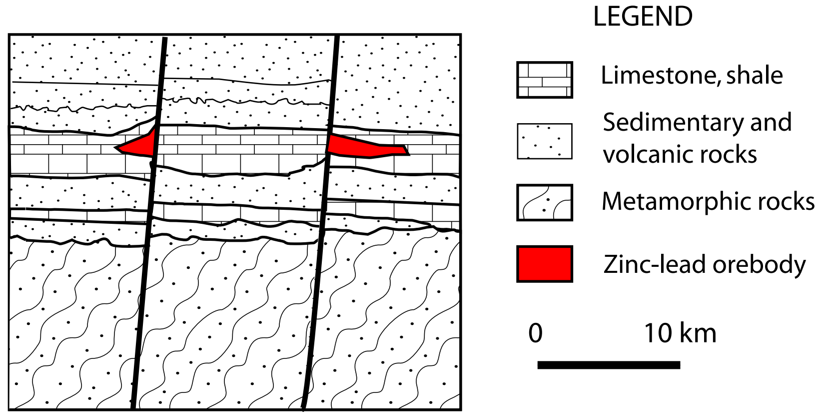


Figure 11. Idealized cross section through sedimentary rock-hosted zinc-lead deposit, similar to those in Australia and India. The deposits are of large size with uniform distribution of metals and commonly are mined using underground methods and flotation milling. The deposits are a significant source of zinc and lead and are found in the Proterozoic rocks of Australia and India and Paleozoic rocks of the Mekong Delta area.