Recent mineralisation

Cainozoic surficial deposits

Oil shale

Oil shale, a dark brown to black, fine-grained layered rock of low density, is rich in solid organic matter that yields oil when heated to about 500°C. The oil shales are commonly interlayered with other rocks, such as sandstone and ordinary shale which formed when sand or mud were swept into the 'oil shale' basin. The oldest known oil shale in Australia is of Cambrian age and occurs at depth in the *GEORGINA BASIN*.

Permian oil shales associated with coal seams occur in the *SYDNEY BASIN*, where they were worked from the mid 1860s to 1952, and in the *BOWEN BASIN*. Seams are thin and of limited extent but often high yielding. Permian oil shale has also been worked along the Mersey River in Tasmania (**Latrobe**).

More extensive Cretaceous oil shale deposits are thought to extend at depth throughout much of the *EROMANGA BASIN*. Seams at **Julia Creek** are, for example, about 10 m thick.

Cainozoic oil shale deposits occur in rifts in eastern Queensland (at **Rundle**, **Stuart**, **Duaringa**, **Lowmead**, **Condor**, **Nagoorin** and **Yaamba**). The deposits consist of several oil shale beds, some individually tens of metres thick, separated by barren shale beds. These deposits have minimal overburden and are amenable to opencut mining. However, technical, economic and environmental problems at present remain a barrier to large scale exploitation.

Phosphate rock

Australia's sedimentary phosphate ranges in age from Cambrian to Tertiary. The middle Cambrian deposits of the *GEORGINA BASIN* are the largest. Of these the **Phosphate Hill**, **Sherrin Creek**, **Lily Creek**, **D-Tree**, **Lady Annie** and **Lady Jane** deposits, all formed in shallow water, are the most significant. The principal phosphate horizon, the Beetle Creek Formation, is a series of phosphatic siltstones (phosphorite) and cherts overlying limestone and basal sandstone conglomerate.

Phosphate is associated with early Cambrian limestones in the *KANMANTOO FOLD BELT*, apparently formed during a Tertiary weathering cycle.

Manganese

A world-ranking manganese province extends over an area of 150 km^2 on **Groote Eylandt** (N.T.). The deposit occurs as a single, relatively flat Cretaceous sedimentary unit averaging 3–4 m in thickness. The orebody comprises pebbles, cobbles and boulders of manganese oxides, in a sandy clay matrix, which were precipitated from seawater in a shallow, sheltered basin.

A seam of precious opal in weathered sandstone at Mintabie (S.A.)
Opal consists of minute spheres of crystallised silica which variably diffract light into a kaleidoscope of colours. These spheres crystallised from silica-rich groundwater, the silica being trapped as a gel in joint and bedding planes above impermeable strata as the climate became more arid and the water table fell. The silica was derived from the weathering of sandstones and sandy mudstones during wetter Tertiary times. These sediments were deposited on the edge of a Cretaceous sea which closely matched the margin of the Great Artesian Basin, along which opal mining takes place today.

The largely unconsolidated surface cover of rock fragments, soil, blown sand and alluvium (now commonly referred to as the 'regolith'), which rests upon solid rock, contains two major types of mineral deposits—those concentrated through deposition (*detrital* deposits) and those formed through chemical alteration of the near-surface rocks (*secondary* deposits).

Detrital deposits

When rocks are weathered and eroded some chemically stable minerals are little affected and accumulate *in situ* if the topography is flat or are carried down drainage channels by streams. The winnowing effect of streamflow separates the light from the heavy minerals, such as gold or tin, which accumulate as deposits in favourable places. Wave and wind action have a similar sorting effect on beach sands; deposits of rutile, ilmenite, zircon and monazite are formed in this way. Some gemstones, particularly diamonds and sapphires, are also found in detrital deposits.

Mineral sands

The east coast of Australia, from Byfield near Rockhampton to the mouth of the Hawkesbury River north of Sydney, is fringed by beaches, plains and dunes containing heavy mineral deposits. In Western Australia they extend intermittently from Eneabba, 270 km north of Perth, to the far south-western corner of the state.

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

The sands of the beach-dune systems represent accumulated material eroded from the land and carried seawards by rivers. The coastal plains were built up during a time of falling sea level, allowing steady advancement of the beach line with continued sediment influx. Some deposits mined in Western Australia are now 30 km inland from the present coastline whereas along the east coast most are close to present-day beaches.

Average heavy mineral grades are 20% in Western Australia, where ilmenite is predominant, but less than 5% in eastern Australia. The remainder of the sand is mostly quartz or silica.

Diamonds

In the past small quantities of alluvial diamonds have been mined intermittently in several parts of Australia. More recently, the Smoke Creek deposit, downstream from the lamproite pipe source rock at **Argyle** in the Kimberley region of Western Australia, has been an important source.

Sapphires

Australia's sapphire deposits occur in stream alluvium in the *NEW ENGLAND FOLD BELT* (**Glen Innes** and **Inverell**) in northern New South Wales and the *ANAKIE INLIER* (**Anakie**) in central Queensland. The sapphires are thought to have originated at great depth near the crust/mantle boundary and then been carried to the surface by volcanic activity before being released during subsequent weathering and erosion.

Secondary deposits

Chemical alteration of rocks by circulating groundwater during weathering has formed many valuable mineral deposits. Some elements may be carried away, while others are concentrated in particular zones in relation to the surface and to the water table. Clays and talc are common products of weathering. In some circumstances many elements are removed and the chemical composition of the near-surface rocks may be changed profoundly. Bauxite and laterite are formed under such circumstances.

Bauxite

Australia's most important regolith mineral is bauxite. Large world-ranking deposits occur in the Darling Range east of Perth and at **Cape Bougainville** and **Mitchell Plateau** in Western Australia; at **Gove** in the Northern Territory; and in the **Weipa** area of far north Queensland.

Bauxite is localised in pockets within the extensive laterite cover which has developed on Archaean rocks of the *YILGARN BLOCK* in the Darling Range area (at **Jarrahdale**, **Del-Park**, **Huntly**, **Willowdale** and **Mount Saddleback**). The *KIMBERLEY BASIN* bauxite deposits—**Cape Bougainville** and **Mitchell Plateau**—formed on basic volcanics and interbedded sediments. Although they are higher grade than the Darling Range deposits their economic viability is diminished by the remoteness of the Kimberley region.

The **Gove** bauxite deposit formed over Mesozoic sandstones which overlie the Precambrian crystalline basement of the *ARNHEM INLIER*. The very large **Weipa** deposits in the *CARPENTARIA BASIN* were formed on Tertiary sandstone and siltstone during several lateritic weathering cycles.

Lateritic nickel

The **Greenvale** nickel orebody in north-eastern Queensland consists of a series of residual weathering mantles formed on serpentinite. Even though average grades approach those of sulphide nickel deposits the lateritic nickel is in silicate or oxide form and is thus more costly to process because of higher energy requirements.

Manganese

Extensive secondary manganese deposits occur in the eastern parts of the *HAMERSLEY BASIN* (**Ripon Hills**, **Ant Hill**, **Mount Rove**, **Mount Nicholas** and **Balfour Downs**). The manganese was concentrated in two stages of enrichment, the first during the Proterozoic and the second in the Tertiary.

Opals

The main fields are in central Queensland (**Opalton–Yowah**), northern New South Wales (**White Cliffs** and **Lightning Ridge**) and northern South Australia (**Andamooka**, **Coober Pedy** and **Mintabie**), where the opal was formed by deposition of silica from groundwater in the enclosing sediments.