

GEOLOGY

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INTRODUCTION

Rocks outcrop on hillsides, along creek and river banks, in road cuttings and in quarries. The geological history of an area is discovered by examining the composition of these rocks, the manner in which they were deposited and the fossils which they may contain. In the Dubbo Region this history spans a period of 450 million years and covers four separate geological episodes ([stratigraphy timeline](#) and [geological map](#)):

1. The ancient rocks of the *Lachlan Fold Belt*, mainly of volcanic and marine origin, occupying the area south of an arc stretching from north of Narromine, through Toongi, Geurie and on to north-east of Dunedoo.
2. Freshwater fluvial deposits of the *Sydney* and *Great Artesian Basins* to the north of the ancient rocks.
3. Basalt flows centred around Dubbo and Mendooran.
4. Recent alluvium of the Western Plains and in areas adjacent to present rivers and streams.

GEOLOGICAL HISTORY

Prior to 450 million years ago, the present day Dubbo area lay beneath the great depths of the ancient Pacific Ocean which extended to the then eastern shore of Australia in the vicinity of Broken Hill. A westward movement of the Pacific Oceanic Plate against the Australian Continental Plate resulted in the buckling of a several hundred kilometre wide strip of sea floor into a series of north-south folds. This strip is now known as the *Lachlan Fold Belt*. Toward the eastern side of the belt a line of volcanic activity formed along the crest of a fold (the *Molong Rise*) running north-south through Wellington. To the west of the *Molong Rise*

there was a deep sea (the *Cowra Trough*) and to the east, the *Monaro Slope*, which dropped away to the depths of the ancient Pacific Ocean (Fig. 1). In Silurian time another volcanic ridge (the *Capertee Rise*) developed to the east. The *Capertee Rise* was separated from the *Molong Rise* by the deep waters of the *Hill End Trough* (Fig. 2). Mountain-forming earth movements (orogenies) occurred during the Ordovician, Devonian and Carboniferous Periods. Areas of deep water sediments were folded, and where raised above sea level, a new cycle of erosion and deposition took place. The intense folding during the Middle Devonian and Carboniferous orogenies resulted in the emplacement of molten magma from deep within the earth's crust, into the interior of the mountain folds. The solidified magma is seen today in the outcrops of *Yeoval*, *Wuuluman* and *Gulgong Granites*, from which the overlying sediments have been eroded away.

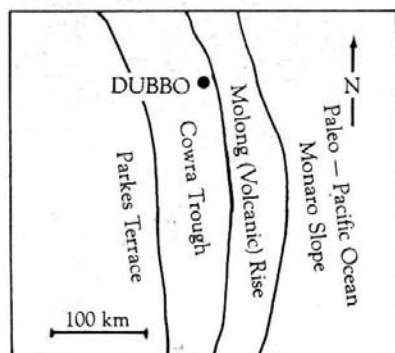


Figure 1 The Dubbo region in late Ordovician time.

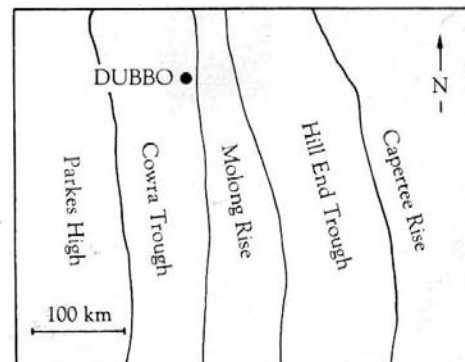


Figure 2 The Dubbo region in middle Silurian time.

During the Late Carboniferous and Early Permian Periods the sediments above the *Wuuluman* and *Gulgong Granites* still formed lofty ice-covered mountains as this part of the earth passed through one of its greatest ice ages.

During the Permian Period a shallow depression of flood plains and swamps formed to the east and north-east of the *Lachlan Fold Belt*. This was a part of the *Sydney-Bowen Basin* in which huge coal deposits were formed from the vegetation that grew in the swamps. The *Gulgong*, *Goolma*, *Spicers Creek*, *Ballimore* and *Dunedoo* areas lay close to the margin of the *Sydney Basin* and here a thin layer of Permian sediments was deposited over the tilted beds of older rocks.

At the close of the Permian Period, the *Great Artesian Basin* was formed by a new and separate subsidence. The south-eastern margin of this basin lay south of Dubbo, through *Geurie* to *Ballimore* and *Dunedoo* where it overlapped the *Sydney Basin*. During the Early and Middle Triassic, sediments which were eroded from the mountains to the south were deposited into the basin. After this, there was a break in sedimentation of 30 million years until the Jurassic Period, when vast quantities of sediment again flowed into the *Great Artesian Basin*. At the same time volcanic rocks were extruded in the area between *Gunnedah* and *Binnaway*.

By the Early Tertiary Period the Australian Continent had eroded to an almost flat surface. A renewal of earth movement then resulted in extensive volcanic activity and up-lifting of the Eastern Highlands. Widespread basalt flows occurred in the Dubbo Region during the Miocene Epoch (12 million years ago).

25 kilometres south of Dubbo, in the vicinity of *Toongi*, are a series of Jurassic aged trachyte plugs. These trachytes are some of a number of alkaline igneous

bodies which form part of a relatively extensive alkaline igneous complex in the Dubbo region which in turn form part of the major Eastern Australian alkaline volcanic event.

The Toongi trachyte has been the subject of intense exploration activity since 1999 by Alkane Exploration Ltd. This intrusive rock exhibits uniformly elevated grades for Zirconium, Hafnium, Niobium, Tantalum, Yttrium and Rare Earth Elements.

At the present time the highlands are again being eroded away to form the alluvial flats along the rivers and the vast areas of alluvium of the Western Plains.

STRATIGRAPHY

The major rock units of the Dubbo region are described in their order of deposition, commencing with the oldest. The relationship of the various geological formations to each other is set out in [Fig. 3](#) - stratigraphy timeline

The oldest rocks in the area were formed during the initial stages of development of the *Lachlan Fold Belt* in the Ordovician Period about 450 million years ago. Volcanic activity along the *Molong Rise* produced great volumes of lavas. The extruded andesite lava and andesite breccia (similar to a conglomerate but having angular fragments) built up islands from which large quantities of eroded material poured down the submarine slopes and into the deeper water. Rocks of this episode are exposed in a strip 20 km long, running north from Wellington and lying between Maryvale and Bodangora. The rocks are mostly andesite and andesite breccia with some conglomerate and fine-grained shale. Occasional limestone lenses are evidence of algal and coral reefs around the islands. To the north-east of Wellington, in the area between Lincoln, Comobella, Saxa and Gillinghall, there are outcrops of altered rocks of lava, tuff (consolidated volcanic ash), marble and slate which may be Ordovician. The volcanic rocks in these areas decompose to form rich farming land of heavy red soil. To the south-west of the region, Ordovician metamorphosed (altered by heat and/or pressure) slate, andesite and conglomerate were deposited in the *Cowra Trough*. These rocks form a belt from Peak Hill to Narromine but are mostly obscured by soil cover. From a lack of close investigation none of the above formations of Ordovician rocks has a formal name. Due to later folding, the Silurian *Chesleigh Formation* outcrops in three parallel south-south-east to north-northwest belts which cross the Wellington/Gulgong road from west of Mt Bodangora to east of Goolma. The quartz-rich greywackes and slates were deposited in deep water in the *Hill End Trough*. These rocks form grey soils of low fertility.

Undifferentiated Silurian slates outcrop around the margin of the Ordovician volcanics in the Bodangora and Combo areas. In the *Cowra Trough* to the west of Wellington, undifferentiated Silurian chert, tuff, shale and some andesite form a belt running from east of Arthurville southward between Walmer and Fingerpost. Further volcanic activity on the *Molong Rise* in the Late Silurian produced the *Cuga Burga Volcanics*. Andesite, shale and limestones of this formation outcrop on the hills to the east and north-east of Wellington.

The Late Silurian-Early Devonian *Tucklan Beds* of andesite, tuff and shale were deposited in the shallower waters of the *Capertee Rise* (Fig. 4). They outcrop south of a line from Craboon to about 10 km west of Dunedoo and taper southward to Wyaldra Creek, being bounded on the east by the *Gulgong Granite* and on the west by the rocks of the *Chesleigh Formation*.

Two late Silurian-Early Devonian rock units were deposited in the *Hill End Trough* – the *Gollan Beds* and the *Lana Formation*. The *Gollan Beds* of shale, tuffaceous sandstone and limestone form a 5 km wide and 25 km long strip from the north side of Mt Bodangora to north of Gollan. Outcrops of greywacke, shale and tuff of the *Lana Formation* alternate with the belts of the *Chesleigh Formation* between Mt Bodangora and Goolma. To the south of Dubbo, in the vicinity of Toongi, unfossiliferous Silurian-Devonian siltstones, shale and greywacke were deposited in the northern section of the *Cowra Trough*. The sequence, known as the *Toongi Group*, has a maximum thickness of 5500 metres. The greywackes are quartz-rich in the lower part but near the top they contain fragments of rhyolite and andesite. Evidence of volcanism is found throughout the section.

On the Molong Rise, the Lower Devonian *Garra Formation*, a 900-1200 metre thick sequence of limestone and shale was deposited in still, shallow water. The limestone stretches from Geurie southwards for 100 km. The maximum width is about 8 km and outcrops may be seen on both sides of the Catombal Range south and east of Wellington and north to Geurie. The limestone is of organic origin and in places coral reefs are preserved in their place of growth.

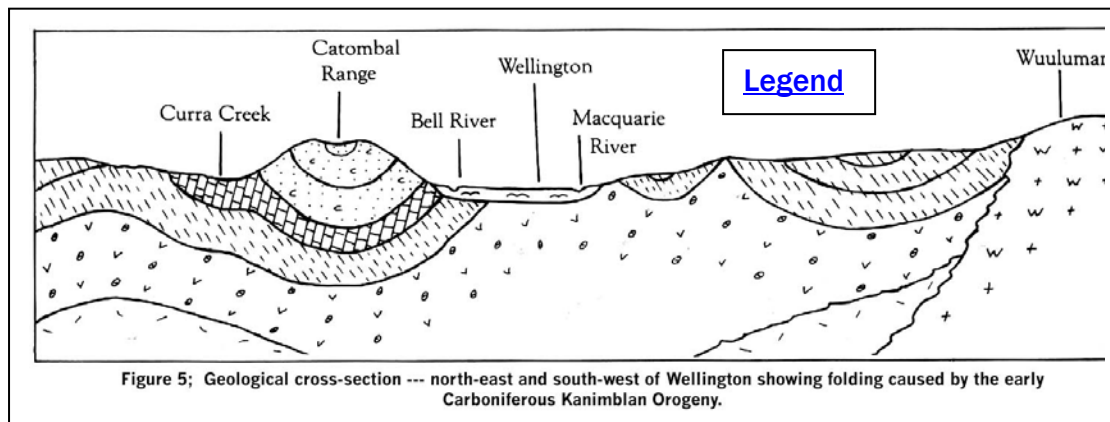
At the same time, volcanic activity in the *Cowra Trough* was responsible for the *Dulladerry Rhyolite* of red, black and white banded rhyolite (fine-grained quartz-rich lava) which covers a large area to the east, north and northwest of the Herveys Range but is mostly obscured by a grey soil cover.

About 10 km from Dubbo, on the Newell Highway to Peak Hill, the belt of *Hyandra Creek Rhyolite* crosses the road and runs in a south-easterly direction.

During the Tabberabberan Orogeny in the Middle Devonian, much of the *Lachlan Fold Belt* was extensively raised and folded. Molten magma was intruded into the north-south fold mountains which were composed of rocks deposited in the former *Cowra Trough*. The magma cooled to form the *Yeoval Granite*, which, in places, is very coarsely crystalline. The granite forms the Sappa Bulga Range and occupies a large area around Yeoval and northwards to east of Narromine. The pink granite porphyry of Mt Foster and Mt Harris, near Warren, is possibly an extension of the *Yeoval Granite*.

During the Late Devonian Period great quantities of silt, sand and conglomerate flowed into two north-south depressions; one to the east and south-east of Peak Hill and the other just to the west and south-west of Wellington. These sediments formed the *Hervey Group* in the Peak Hill area and the *Catombal Group* in the Wellington area. The basal beds of the *Catombal Group* are a marine sequence but pass upwards into red beds with massive conglomerates which contain clasts ranging in size from 1 cm to 30 cm in diameter. The quartzite pebbles in the conglomerate were carried a great distance from the south or south-west by a large stream. The *Catombal Group* outcrops from west of Maryvale then southwards to form the rugged hills of the Mt Arthur Reserve and the Catombal Range. The maximum thickness occurs along Curra Creek in Glen Finlass west of Wellington where 1580 metres are preserved, of which

1000 metres are *Curra Creek Conglomerate*. Outcrops of the *Hervey Group* form the spectacular cliffs of the Hervey Range to the east and south-east of Peak Hill. In this area 1500 metres of quartzose sediments were deposited under shallow water conditions. Current bedding and ripple marks are common in the sandstone and mudcracks, wormtracks and burrows occur in the red siltstones and shales.



areas which lay close to the margin of the *Sydney Basin*. These sediments of conglomerate, sandstone, claystone, porcellanite and some coal which form the *Dunedoo Formation* outcrop mainly on the floors and sides of pre-Late Permian valleys which were cut into the basement rocks. The thickness is between 30m and 50m but is considerably more in the Ballimore area. South of Dunedoo and in the area between Gollan and Goolma the *Dunedoo Formation* is exposed on hilltops, but in the Ballimore, Elong and Saxa areas it is overlain by Triassic rocks. *Glossopteris* leaves and silicified tree trunks are plentiful at some localities.

Sedimentation continued into the Triassic Period with the *Wollar Sandstone* forming thick beds east of Gulgong and Dunedoo and thinning westwards to 15 m or less near Ballimore.

The Early to Middle Triassic *Wallingarah Formation* succeeds the *Wollar Sandstone* but extends further westward to south-west of Dubbo. The strata are of fluvial origin and form rather poor outcrops except for some massive



Fossilised leaves from a woodland that grew near Dubbo during the Triassic Period, 210 million years ago.

(Photo: Terry Korn)

beds of sandstone and conglomerate. Exposures in creeks and cuttings reveal conglomerate, sandstone, siltstone and shale, with numerous ironstone concretions and occasional coal seams. This formation, which forms the basal beds of the *Great Artesian Basin*, outcrops from south of Binnaway, through Neilrex and Mendooran to south of the Talbragar River where it underlies large areas in the Sandy Creek, Elong, Ballimore and Dubbo districts. Its south-western margin runs from Comobella through Geurie to near Toongi. At Dubbo, rocks of this formation outcrop along the west bank of the Macquarie River and in road cuttings near the Western Plains Zoo. Two historic sandstone quarries can be

found in the vicinity of Roden Cutler Park (below West Dubbo Bowling Club). The stone quarried here was used to build some of Dubbo's few sandstone buildings. No sediments were deposited in the *Great Artesian Basin* for 30 million years from the Middle Triassic until the Jurassic Period when volcanic activity in the Mullaley-Tambar Springs area produced the basalts of the *Garrawilla Volcanics* east of Binnaway. The basalt has been radiometrically dated at 200 to 170 million years old. A renewal of sedimentation into the *Basin* produced the Jurassic *Ukebung* and *Digilah Formations* which are composed of stream and floodplain deposits. Exposures are poor and they are often hard to distinguish from the underlying *Wallingarah Formation*. The clayrocks of the *Ukebung Formation* are the principal source of kaolinite in Australia for the manufacture of refractory bricks. Both the *Ukebung* and *Digilah Formations* have been traced from near Binnaway south-west to Ballimore. The upper portion of the *Ukebung Formation* and the complete section of the *Digilah Formation* are exposed on the escarpment where the Talbragar River has cut into Ballimore Hill.

Overlying the eroded surface of the *Digilah Formation* is the Middle Jurassic *Pilliga Sandstone*, composed of massive and cross-bedded white to orange sandstone, quartz-pebble conglomerate and occasional siltstone and shale. In the Binnaway, Ballimore, Dapper, Wongarbon, Mugga Hill and Minore areas, the maximum thickness is probably about 100m but to the north-west the thickness increases greatly to form the main water-bearing horizon in the eastern part of the *Great Artesian Basin*. In its area of outcrop the *Pilliga Sandstone* produces very poor sandy soils with the result that large areas have never been cleared of their original vegetation, e.g. Wongarbon Nature Reserve, Beni and Goonoo Forests and the Pilliga Scrub.

From the Middle Jurassic to the Early Tertiary erosion reduced most of the Australian continent to a flat surface. Following the break-up of the southern Gondwanaland continent about 75 million years ago, the Australian continental plate drifted northwards from Antarctica. Stresses associated with this movement caused some fracturing, faulting and folding which culminated in the uplifting of the high lands of eastern and south-eastern Australia. Up-welling of magma beneath the crust developed into volcanic activity especially in areas where fracture lines intersected. During the Middle Miocene the Warrumbungle Volcano was active from 17 million years to 14 million years ago and the Canobolas Volcano was active from 12.7 million years to 10.9 million years ago. In the Dubbo region there were many fissure eruptions from which flood basalt poured over the countryside. A flow 8 km north of Dubbo has been dated at 12 million years. The largest Tertiary basalt areas are north and south-east of Dubbo and west of the Castlereagh River between Binnaway and Mendooran. In the Gulgong district, gold-bearing gravels in the ancient river-beds were sometimes buried by basalt flows which filled the valleys. Much of this gold was recovered from the deep-leads during the goldrush days. Smaller basalt flows are scattered through the central and eastern portions of the region forming either a smoothly contoured landscape or a capping on isolated hills. The basalt breaks down to produce fertile black, chocolate or red soils.

Over the past few million years, the elevated land to the east has been eroded away. During long periods when rainfall was much higher than now, vast

quantities of sediment were washed down the Western Slopes and spread over the Western Plains by a network of streams which were the ancestors of the present day rivers. In places, especially in the lower reaches of the Macquarie River, the recent alluvium may be hundreds of metres deep and this is added to by each new flood. In the valleys of the Western Slopes alluvium has been deposited in the past to form flat areas along the rivers and streams, but in many places these soils are again being eroded away.

FOSSILS OF THE DUBBO REGION

Fossils are the preserved remains of once living animals and plants which became buried in sediments that have since been changed to rock through great pressure. Fossils provide evidence of the types of life which existed on earth during geological times. They may be found in sedimentary rocks such as sandstone, limestone and shale, only rarely in metamorphosed rocks and never in igneous rocks (basalt and granite).

Fossils in the older rocks of the *Lachlan Fold Belt* are all of marine origin. Along the *Molong Rise* during Ordovician time, lime-secreting algae and corals formed fringing reefs in the shallow water around the volcanic islands. Beds of limestone created from these reefs outcrop in the Wellington area and east of Gollan. Fossils are rare due to the limestone mostly having been recrystallised.

Graptolites (Fig. 6A), an extinct group of organisms, formed delicate, floating colonies on the surface of the sea. When they died they sank to the bottom and their remains sometimes became preserved in the fine-grained deepwater sediments. Diligent searching may reveal graptolite fossils in the vertical black slate in the roadside quarry 2 km from Wellington on the Gulgong road and in slate on the mine waste-heaps at Tomingley village.

Fossils have not been recorded from the Silurian *Chesleigh Formation* and *Toongi Group*.

Limestone and shale of the Early Devonian *Cuga Burga Volcanics* outcrop along the Wuuluman road, north-east of Wellington. Very occasional corals and brachiopods may be found.



Fig. 6 A
Diplograptus sp.
Graptolite Ordov.



Fig. 6 D
Phacops sp.
Trilobite Sil-Dev.

The Ear
Garra
outcrop
Caves
western
portion
Range
south
fossil r



Fig. 6 E
Rhynchonellid Dev. Brachiopods



Fig. 6 G
Cyrtospifer sp. Dev.



Fig. 6 F
Atrypa sp. Sil-Dev.



lugose

Combo and Ponto Falls areas many species of corals may be seen in weathered outcrops and in loose boulders scattered through the paddocks. Brachiopods (Fig. 6E-G), trilobites (Fig. 6D), crinoids and fish remains have been discovered in the shale and sandstone associated with the limestone. Complete small rhynchonellid brachiopods (Fig. 6E) have sometimes been found

on the surface of the soil on the hillside below the old Geurie quarry (private property).

Cyrtospirifer brachiopods (Fig. 6G) occur in sandstone and shale at the base of the Late Devonian *Catombal Group* at Wellington. Isolated plates of the fish *Bothriolepis* (Fig. 6I) and impressions of stems of a lycopod tree, *Leptophloeum australe* (Fig. 6H) occur in the freshwater sandstone and shale in both the *Catombal Range* and the *Hervey Range*.



Fig. 6 I
Bothriolepis sp.
Armour plated fish Dev.



Fig. 6 H
Lycopod stem Dev.

Except for a few occurrences of volcanic rocks, all the Permian, Triassic and Jurassic rocks in the region were laid down under freshwater conditions. Remains of plants which grew in the swamps and along stream banks are sometimes preserved as fossils. The best places to look for fossil plants are in freshly exposed beds of grey shale or other fine-grained rocks. *Glossopteris* leaves (Fig. 6J), *Vertebraria* — the root of the *Glossopteris* tree (Fig. 6K) and fragments of petrified wood are common in the *Dunedoo Formation*. The standing stumps of a petrified fossil forest at Lahey's Creek were destroyed during land clearing operations several years ago.



Fig. 6 J
Glossopteris sp.
Perm.

A rich and completely different flora is found in the Triassic *Wallingarah Formation*. Leaves of ferns, cycads, conifers, ginkgos and seed-



Fig. 6K
Vertebraria Perm.



Fig. 6 L
D. zuberi



Fig. 6 M
D. odontopteroides



Fig. 6 N
D. elongatum

Leaves of the *Dicroidium* Seed-Fern Triassic.

ferns have been recorded. The most common leaves belong to the seed-fern genus *Dicroidium* (Fig. 6L-N) which is very variable in form but which always has a forked frond. Triassic plants have been found in the grey shale in the Newell Highway road cuttings near the Western Plains Zoo, on the banks of Spicers Creek near Saxa and in the Benelong Road area to the south of Dubbo.

There are few records of Jurassic fossils, mainly because the rocks of this age form poor outcrops. Conifers and cycads (Fig. 6P,Q) have been reported from the Binnaway area and conifers from Gilgandra. Numerous plant remains have been



Fig. 6 P
Cycad leaf Jurassic



Fig. 6 Q
Conifer shoot Jurassic

found in shallow bore cores.

Many Tertiary fossils were collected from the Gulgong gold diggings in the deep leads beneath basalt flows. They included fossil leaves and fruits and bones of extinct marsupials. It is possible that similar finds could be made in clays beneath basalt flows in other areas.

The Pleistocene bone breccia deposit in the Wellington Caves is famous for the remarkable number of bones of extinct marsupials (Fig. 7) that are preserved there. Similar bones were also discovered in cave fillings in the Geurie limestone quarry.

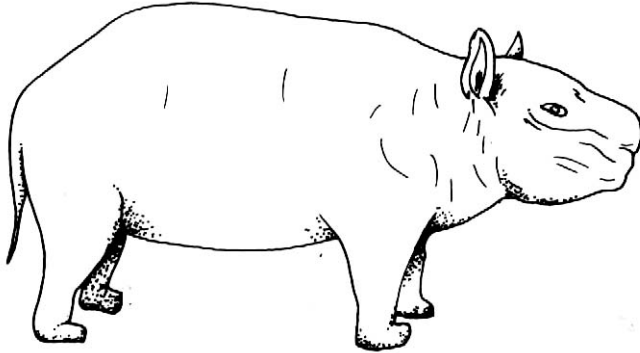


Figure 7. Reconstruction of a Diprotodon.

PLACES OF GEOLOGICAL INTEREST

The Gulgong Goldfield. Gold was first discovered in the Gulgong area in 1867. Within three years the population was as great as that of Dubbo today. The total known production of gold was 15.5 million grams, most of it found in the first seven years. Gold was won from both alluvial deep leads and reef workings, the major proportion coming from the alluvial deposits. The alluvial workings were the richest in the state but were often abandoned because of trouble with flooding and moving drifts.

The Gulgong Historical Museum exhibits many relics from the goldrush days. Lines of mullock heaps from the alluvial workings can be seen from the Ulan and Wellington roads in the vicinity of Gulgong.

Tomingley. Gold was discovered at Tomingley (30 minutes drive south of Dubbo) in 1881. The gold occurred in quartz reefs in Ordovician slate. In the first seven years over 45,000 pounds worth of gold was recovered. Remains of some of the mine shafts can be seen in Tomingley village opposite the hall and hotel. Five kilometres south of Tomingley was a township called McPhail. This prospect had 300 men working on it 1883. Today there is nothing left at McPhail but a recently constructing tailings dam (east of the highway truckstop). Tailings Treatment Pty Ltd re-treated many of the Tomingley, McPhail and Peak Hill battery tailings between 1997 and 1998.

Peak Hill. Alluvial gold was discovered in on the slopes of Peak Hill in 1889. Hard rock mining commenced in 1890 and continued trough until 1917 when the mine was closed and machinery sold off. It was mined mainly from reefs on the hill east of the town and from alluvial workings on the north-western and eastern slopes. Many shafts of the old reef workings are still open and may be inspected with care. Lack of a water supply was a great problem for the population of 2,000 people in 1890. In each of the first few years about 40,000 pounds worth of gold was produced.

Gold Mining at Peak Hill resumed between 1996 and 2005. Alkane Exploration operated a heap leach operation from five open cut pits which won 125,000 ounces of gold. The mined landscape has been transformed into a tourist attraction – The Open Cut Experience.

Tallawang Iron Ore Quarry. Between 1902 and 1927 over half a million tonnes of magnetite and haematite iron ore was quarried at Tallawang, north of Gulgong for the Hoskins Steelworks at Lithgow.

Nott's Quarry. 'Oakfield', Cobbora. Permian porcellanite was quarried here for use as ornamental stone. The white to cream slabs of rock are covered with exquisite impressions of *Glossopteris* leaf fossils in which the veining has been replaced by orange, red or brown limonite. Occasional leaves are found with a cluster of seeds attached to the leaf base (Fig. 6J). The owner, Mr M.C. Nott charges a fee to visit the quarry and must be contacted beforehand.

Wellington Caves. 8 km south of Wellington, the caves have been excavated by the action of water in the limestone of the Devonian *Garra Formation*. Rainwater combining with small amounts of carbon dioxide from the atmosphere becomes

slightly acidic and over long periods of time, dissolves the limestone to form large systems of caves and passageways. The huge stalagmite in the Cathedral Cave is reputed to be the largest in the world. Contorted layers of black shale are exposed in the roof of this cave. The smaller Garden Cave has examples of many types of stalactites, stalagmites and encrustations. The Bone Cave, which is not open to visitors, is world-famous for its deposit of bones of many extinct marsupials, including the hippopotamus-sized *Diprotodon* (Fig. 7) and the tiger-like *Thylacine*. The explorer, Thomas Mitchell collected bones from this cave and sent them to England for examination. It is thought that these fossils provided some of the evidence for Charles Darwin to formulate his theory of Evolution. Wellington Council has developed an historic phosphate mine centred on one of the caves as a tourist attraction. Tourists can don a hard hat and take a guided tour through the underground workings. Plenty of mammalian bones are exposed in the walls.

FURTHER READING

- Annual Reports of the Mines Department.* These records cover all mining activities for over a century. All reports dealing with gold mining at Tomingley, Peak Hill, Wellington and Gulgong have been collated and may be read at the Geological Survey Library in Sydney.
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