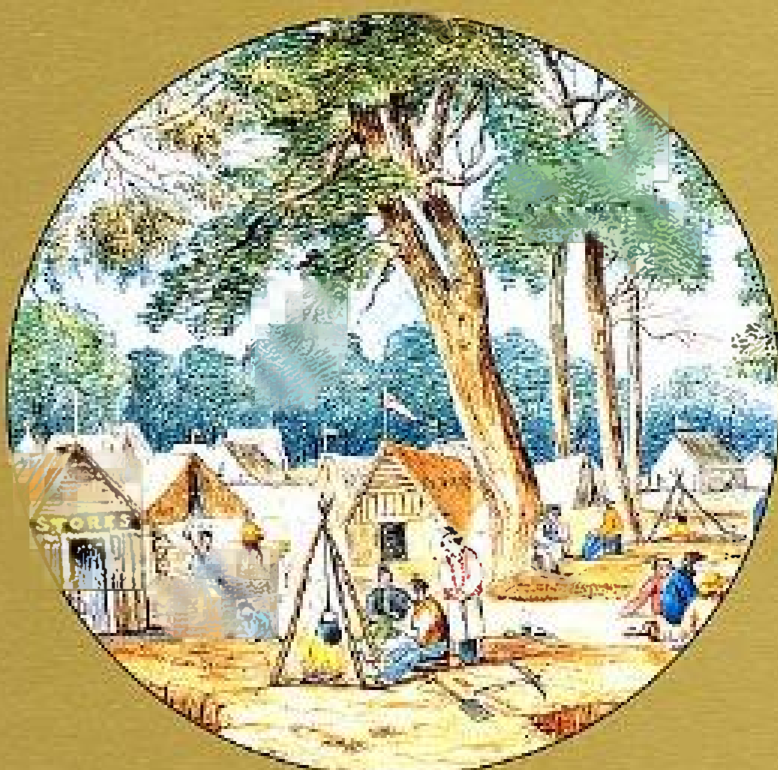
VICTORIA 150 Years of GOLD

Victorian Historical Journal



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EVOLUTION OF THE VICTORIAN GOLD PROVINCE: GEOLOGICAL AND HISTORICAL

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IN BENDIGO and Ballarat, Victoria has two of the world's largest gold fields, and the total production of the Victorian gold province ranks behind only South Africa, and the larger areas of Western Australia, eastern Canada, and western USA (Figure 1, Table 1). To date the Victorian gold province has produced 2 per cent of the world's gold, worth around $40,000 million at today's gold price. Gold played a crucial economic and social role in the development of Victoria, and therefore Australia. It created much of the wealth on which Victoria's economy was founded, and this is evidenced by the stately Victorian architecture that we prize today, both in Melbourne and in regional cities and towns such as Ballarat. The Victorian goldrushes even affected Britain, where:

> By 1856 the gold holdings of the Bank of England were seven times what they had been before the Australian goldrush. Interest rates were lowered, and with abundant capital available, the British economy prospered, opening the way for continuing expansion of industry and great progress in international trade.[1]

In the early 1850s, nearly half of the world's gold production came from Victoria, where the output exceeded total world production of a few years earlier.

Gold has been Victoria's most important metallic commodity, its value being one hundred times greater than the next most valuable metal, copper. Despite earlier reports of local finds, e.g. Warrandyte (1841), Bendigo (1844), Ballarat (1845), Castlemaine (1848), the official discovery in Victoria of gold of economic importance was at Clunes in mid-1851.[2] A minor discovery at Warrandyte was recognized simultaneously. Reports of previous discoveries had been suppressed, although even the Clunes discovery had been reported in the *Argus* as early as 31 January 1849. The period of

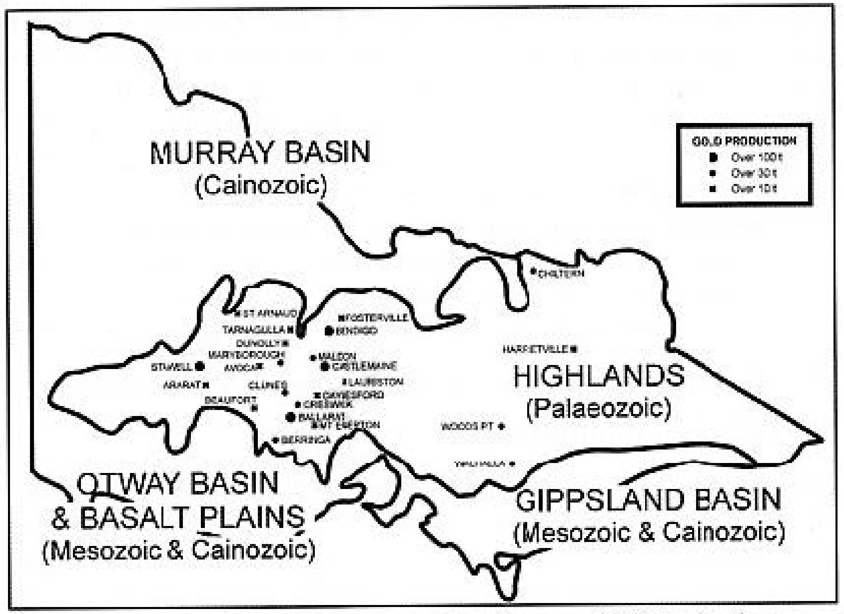

Figure 1. Gold production from Victoria's largest goldfields, showing post-Palaeozoic basins.

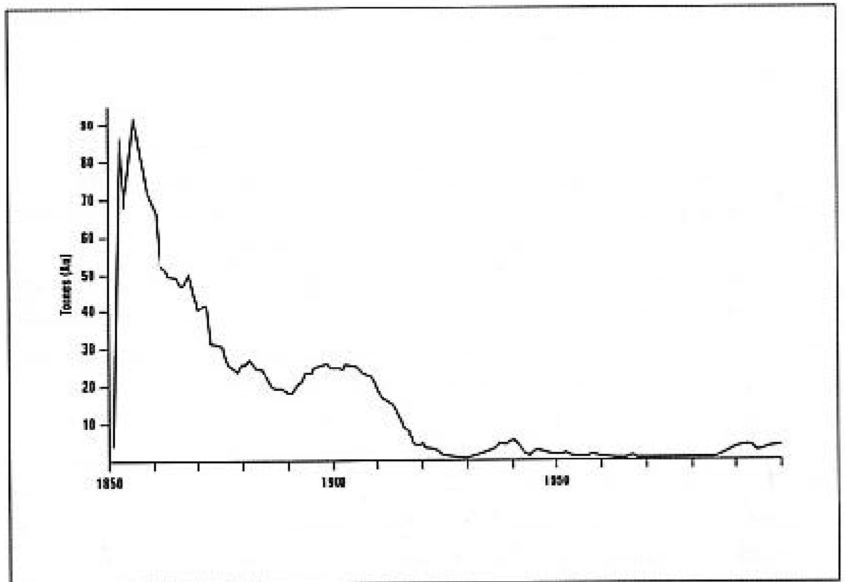

Figure 2. Annual gold production of Victoria since discovery of gold in 1851.

major gold production in Victoria spanned more than sixty years, with peak production reached in the mid-1850s, followed by slow decline as gold production from quartz veins replaced alluvial gold mining. Production revived slightly around 1900, but rapidly declined after 1909 and all but finished by 1920 (Figure 2). There is now only a very small gold industry, Stawell goldmine being the only significant producer. Stawell has been operating again since the 1980s and its annual production recently has been around 100,000 ounces, with substantial new resources discovered. In 1951, Bendigo became the first town in Australia to record a century of continuous gold mining, and the only town since is Kalgoorlie (1993).

Geological framework of the Victorian gold province

The two main gold-forming events

The formation of the Victorian gold province took place during two distinct and relatively brief events in the State's geological history. The first event was when all the 'hard rock' or primary gold deposits (e.g. those in quartz veins) formed in the Palaeozoic Era, this process terminating towards the end of the Devonian Period around 350 my (million years) ago, that is during the age of fishes (Figure 3). During and immediately preceding the Devonian Period, Victoria changed from an area of deep seas, distant from land, which had existed for hundreds of millions of years since the beginning of the Palaeozoic Era, to become part of the continent of Gondwana, with mountains, major rivers and explosive volcanoes. Gondwana was the great southern continent of which Australia, New Zealand and Antarctica were once part. Earth movements fractured the rocks during this transition, and hot water circulated in these fractures and formed auriferous quartz veins. No important primary gold deposits formed at the close of the Palaeozoic Era, when Victoria was briefly covered by ice sheets and glaciers. Likewise, no gold deposits formed later during the Mesozoic Era, when dinosaurs roamed Victoria's mostly geologically peaceful plains and swamps (to end with their bones preserved in places like the cliffs of Port Campbell). Bass Strait and the Victorian highlands formed towards the close of this era when Gondwana underwent its final fragmentation into Australia, Antarctica and New Zealand. It was only later, during the Cainozoic Era, that the second event that formed gold deposits occurred. Mammals, including giant marsupials, had now replaced the dinosaurs. These roamed forests of Southern Beech (*Nothofagus*) that extended in

Table 1. Victorian gold production by goldfield.

Major Goldfields	All-time (Moz)	Percentage alluvial
Bendigo	22.5	23%
Ballarat	13.2	84%
Castlemaine	5.6	84%
Stawell	3.6	21%
Creswick	2.6	100%
Walhalla	2.2	0%
Maldon	2.1	14%
Woods Point	1.7	23%
Clunes	1.5	21%
Chiltern	1.5	98%
Maryborough	1.0	91%
Berringa	1.0	40%
Egerton	0.9	41%
Harrietville	0.8	50%
Avoca	0.7	100%
Ararat	0.6	95%
Daylesford	0.6	15%
Tarnagulla	0.4	
St Arnaud	0.4	low
Beaufort	0.3	most
Dunolly-Moliagul	0.3	most
Taradale-Lauriston	0.3	
Minimum from above Fields	63.5	
Total: Victorian Province	80.3	

Table 1. Production of twenty largest Victorian goldfields.

Victoria from the newly developed Bass Strait, northwards through the highlands to Broken Hill. The pre-existing hard-rock gold deposits, formed during the Palaeozoic gold-forming event, were exposed by erosion and decomposed as their host Palaeozoic rocks weathered to clay. Streams developed on the highlands, and gold was transported down gullies as small particles and rarer nuggets to accumulate in the quartz-rich gravel of creek and riverbeds as alluvial gold deposits. Some of these deposits were subsequently buried beneath the alluvium of later rivers and lakes, under lava flows (the *deep leads*), and even under the sands of shallow seas.

Thus the Devonian Period was the culmination of the formation of the gold province, whereas the Cainozoic Era involved large-scale modification and rearrangement of the gold and generated the alluvial gold deposits. Both events were essential in shaping the Victorian gold province as it appeared to the prospectors in 1851. The Devonian Period is responsible for the quartz vein gold (hard-rock, or reef gold); the Cainozoic Era for alluvial gold (placer gold, and palaeoplacer or deep lead gold).[3]

Events leading up to formation of the gold deposits

The earliest recorded rocks in Victoria are basalts, and a vast sequence of sedimentary rocks including sandstone, shale, mudstone and slate. Being some of the oldest rocks in the State, the basalts and sedimentary rocks have been subject to all the subsequent geological events and so are mostly buried or not well preserved. The basalt flowed from relatively passive, mostly submarine fissures on the sea floor more than 500 my ago, much as is occurring on submarine ridges on the ocean floor today. The characteristic products, pillow lavas, can be seen in the Stawell gold mine today.[4] There are no remaining traces of the eruption points, but slices of the lava have been faulted into overlying rocks where they now form narrow north-south belts which stretch 50 km or more in length, such as through Stawell. The overlying sedimentary rocks were formed close to land, over a long interval from approximately 550 to 400 my, during which time the oceans continued to cover Victoria. Sand and clay were carried from neighbouring continental areas to be deposited beneath the ocean, on top of the basalt. These sedimentary rocks are found throughout the upland regions of Victoria, from near the Grampians through the Central Highlands to the high plains and east Gippsland, and they are the rocks that host auriferous quartz veins in most of the major goldfields.

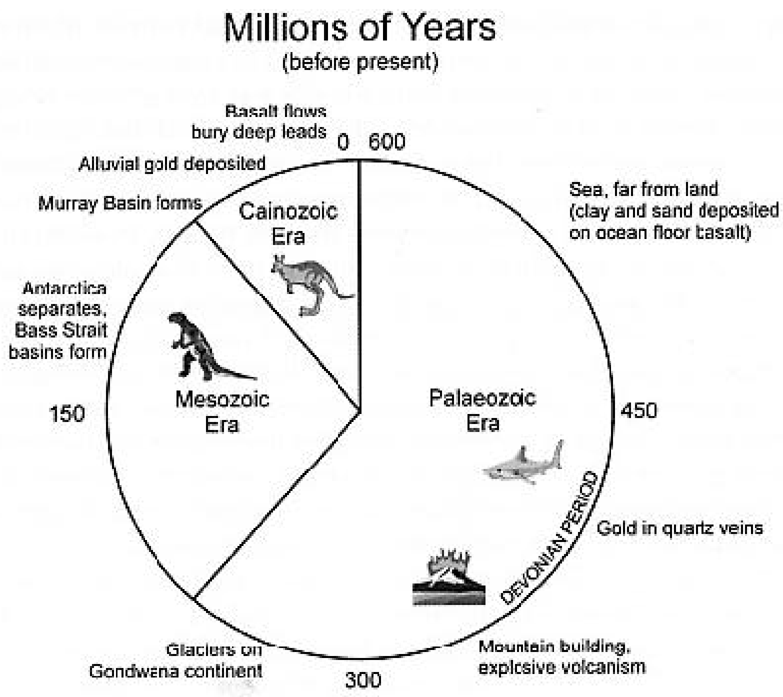

Figure 3. Time clock for the last 600 million years (My), showing key events related to the geology of Victorian gold.

Formation of the primary gold deposits

The Devonian Period from 420 my to 360 my ago (and also the immediately preceding Silurian Period in the east and west of the State), was possibly the most active and eventful time during the whole geological history of Victoria. It marked the end of a long interval during which oceans covered the State, and it witnessed mountain building and catastrophic volcanism on a scale not seen in the region before or since. As the south-east part of Australia was compressed during the Devonian Period by global-scale movements, the ocean basins closed and the existing rock sequences were folded to form mountain ranges where the oceans had been. The evidence today of this earlier compression is the faults and folds seen in many road cuttings, and the strong cleavage that produced commercial slates. During this compression and mountain building, high temperatures developed in the deeper crust causing rocks to melt. Much of this molten rock rose to the surface and erupted as explosive volcanoes. These volcanoes are apparent today in areas such as around Violet Town, Tatong–Tolmie, Eildon–Marysville, and Snowy Bluff. Molten rock that did not come to the surface as volcanoes cooled beneath the surface to form large granite masses that dominate much of the modern Victorian landscape, such as the Cobaw Range, Strathbogie Ranges, Powelltown–Baw Baw Ranges and Buffalo Plateau. Although these volcanic rocks and granites are themselves sparse in gold, all have played an important part in dictating the upland areas, the distribution of outcropping and non-outcropping rocks, the courses of ancient and modern rivers, and ultimately the Cainozoic processes that influenced gold redistribution. These granites, or their 'plutonic waters', were also considered by some nineteenth century geologists, such as Gregory[5], and many twentieth century geologists to be the direct source of gold in all the goldfields, but the weight of opinion had moved against this by the late twentieth century.

The same high temperatures that formed these volcanoes and granites also generated hot waters many kilometres deep in the earth's crust. At 350°C, these waters had the capability to dissolve and transport significant gold and other minerals, including silica, to form quartz. As these waters rose along the faults and folds that had formed during the mountain building, they cooled and precipitated their gold along with the silica on the walls of fractures to form quartz veins (i.e. quartz was precipitated from water, not intruded as a molten mass). These gold-bearing quartz veins are most widespread in the uplands from near the Grampians to the Kiewa valley, but the limits both north and south are poorly known due to Cainozoic events (see below). Only locally do these vein systems occur in the size and abundance, and with sufficient gold grade, to make economic deposits. These veins formed in any of the rock types of Devonian age or older, but it is thought by many geologists, including the authors, that black, carbon-rich slates were the most effective hosts in causing gold to precipitate, and these slates occur at many of the larger gold deposits. At Stawell, where basalt was present, its iron was an effective precipitant of gold. Iron in dyke rock was important in precipitating gold at Woods Point and Walhalla. Some early geologists and prospectors recognized the relationship between gold and black slates, although this concept was hotly debated among the geologists.[6] The prospectors referred to these and similar rocks as *indicators*, which they used to explore for areas of possible gold enrichment.

By the close of the Devonian Period 360 my ago, the high crustal temperatures had waned. Also by this time, the volcanism, granites, folding, faulting (except block faulting causing uplift of large areas), quartz vein formation and the formation gold had essentially ceased. There are extensive rocks in Victoria younger than Devonian in age, but none contain significant gold-bearing quartz veins.

Modification of gold deposits during the Cainozoic Era

Because they were formed by the youngest set of geological processes, rocks of the Cainozoic Era have been unaffected by major folding or heating, and are more extensively preserved in their original form than rocks of Devonian age or older. In the time interval of 300 my from the Devonian to the Cainozoic there was insignificant volcanism and no deep ocean coverage throughout central Victoria. Instead, much of this time would have involved the gold-bearing areas being above sea level and prone to weathering, erosion and, locally, to glaciation (e.g. Permian glacial rocks are well exposed around Bacchus Marsh). Victoria was already a plain by the Triassic, and remnants of this plain, since uplifted and eroded, are reflected in the similar elevations of ridge tops throughout the high plains.

The early Cainozoic was a time when deep weathering affected all rocks that were near the surface, and this weathering, and erosion associated with block-fault uplift of the highlands, liberated gold from Palaeozoic rocks for transport into local creeks, and then deposition as gold-bearing gravels in valleys. This process formed much of the alluvial gold that has been mined in the Victorian goldfields. Much younger uplift and an interval of erosion with shallow weathering occurred in the late Cainozoic Era, and liberated gold grains from both Palaeozoic rocks and early Cainozoic gravels, concentrating them nearby in young streams. This gold was buried at shallow depth in poorly consolidated rocks, so that it became some of the first gold to be extracted by prospectors. Weathering during the Cainozoic also set up the chemical conditions near the surface suitable for primary gold to re-dissolve in shallow underground water (e.g. in thick soil and deeply-weathered rock). Gold was dissolved from the upper parts of primary gold deposits, moved in the ground waters many metres, and was then redeposited. This small-scale chemical transport of gold in groundwater may have formed many of the gold nuggets so characteristic of some Victorian goldfields.[7] This process appears to have been partly understood by nineteenth century geologists. Some, such as Bradford, argued that the gold had been deposited from solutions that descended from above, whereas others such as Gregory argued that the solutions came from both above and below.[8]

At several stages during the Cainozoic, thick sedimentary rocks have covered gold-bearing alluvial gravels. These sedimentary rocks include sediments from lakes (some formed by the damming of streams by lava flows), younger river alluvium, and shallow marine sediments (but not deep ocean sediments). As the level of the sea relative to the continental mass of southeastern Australia changed during the Cainozoic Era, there was a time when the sea flooded eastwards well into the Murray Basin (e.g. north of Bendigo), to form an inland sea (Figure 1). The sea also flooded part of the Otway Basin (e.g. to near Berringa, south of Ballarat). Conversely, at another time of low sea level the Murray River only met the ocean well south of Goolwa in South Australia, in an area that is now the Southern Ocean. Clay and sand was continually being brought down-slope from the uplands towards these seas. Sediments from the invading sea and different sediments being washed off the hills combined to form a blanket that covered the lower-lying northern and southern parts of the Victorian gold province. The sediments, of whatever type, are still poorly consolidated and permeable, so mining beneath them can involve unstable ground and large water flows. More importantly, it is difficult to explore beneath them. The paucity of knowledge about gold deposits in areas covered by marine and other sediments almost certainly derives from the difficulty in prospecting, rather than an inherent lack of deposits; so there lies one of the untapped opportunities in the Victorian gold province.

One of the most recent events in Victorian geological history has been the outpouring of basalt lavas from numerous volcanoes from Melbourne to west of the South Australian border. The oldest volcanoes commenced seven my ago, but near Melbourne they are only one to three my old and their conical shape and flows can still be easily recognized on the landscape, e.g. Mt Fraser, Mt Kororoit and Smeaton Hill. Some of the volcanoes farther west are even younger, as little as thousands of years old, and are better preserved. During the eruptions, lava, guided by gravity, followed natural watercourses, mostly southward, and a few lava flows reached the sea e.g. at Cape Bridgewater near Portland. Others flowed north towards the Murray River, e.g. along the former Loddon River valley. Individual flows can still be identified where they cooled and solidified en route. In following the watercourses, the lava covered over any alluvial gold contained in gravel of the streambed. There are special requirements for mining under basalt to extract this deep lead gold. Although fresh basalt is hard and fairly impervious, the numerous cracks in every flow have provided access for surface waters that have flowed down through the basalt and then laterally through the old stream alluvium beneath the lava. Mining involves removing vast amounts of water and continuous shoring up of the dangerously unconsolidated alluvium beneath the lava flows. The most important deep leads beneath basalt were at Ballarat, Creswick, Chiltern–Rutherglen and Maryborough.

In the little geological time since these basaltic volcanoes, streams that flow over the basalt flows have deposited virtually no alluvial gold.

Historical factors

A number of geological factors, including the fertile nature of soil in the goldfields, influenced the rate and pattern of settlement and of agricultural and industrial development in Victoria, as well as the nature of employment and investment at different times. The first factor was the rich nature of the shallow, easily mined alluvial gold deposits, which resulted from the interplay of high rainfall, deep weathering and mostly gentle hillslopes. Only a limited amount of equipment was required to mine this gold, little more than a pick, shovel, gold pan and handmade cradle or sluice box. Gold in modern stream gravel was easily tested by panning, which proved a very successful method for locating the major goldfields. This was immediately followed by the mining of fossil stream gravels buried a few metres beneath valley alluvium (sand and clay), which could be tested and mined by small pits and shafts dug easily into the soft sediment (Figure 4). The gravel could be hauled to surface by a hand-operated (or horse-powered) windlass or whip, and the clay removed in a simple puddling machine prior to separation of the gold. In 1859, long after the peak of alluvial gold production, the puddling machines in eastern Bendigo still produced more than 2 million cubic metres of solid sludge per year, 85 per cent of which flowed downstream.[9] Even at this production rate, over a 10-year period the escaped material would cover an area of 40 square kilometres to a

Figure 4. Gold-bearing gravel of Cainozoic age, Vaughan (lens cap for scale).

depth of 5 centimetres. In practice it formed a layer 3 centimetres to 3 metres thick, locally up to 60 centimetres thick at 50 kilometres from its source, which is still hard enough to prevent ploughing. A royal commission was convened in 1859 to deal with this disruption of farmland by sludge.

The relative ease with which such deposits could be prospected and mined for potentially great economic reward meant that individuals and small groups of prospectors rapidly spread throughout Victoria. By the end of 1851, Bendigo, Ballarat and Castlemaine had been discovered in a remarkable prospecting campaign that identified these three major goldfields in less than one year. As early as 1851 there were reports of gold discoveries in the Victorian Alps (e.g. Omeo). The first government survey teams to explore even remoter areas found streams that had already been worked for gold (e.g. Alfred Howitt's survey of the Dargo area in 1860).

Individual fortunes were made in the first few years. For example at Ballarat, with claims only 8 x 8 (to 24 x 24) feet in size, yields were recorded of 50 pounds of gold in two days, 31 pounds in one day, 8 pounds from two gold-pans and 13,800 ounces from one claim.[10] Gold nuggets were a feature of the Victorian goldfields, with eleven of greater than 500 ounces found at Ballarat, one being the 2218 ounce Welcome nugget, the second-largest ever recorded worldwide. This pattern was repeated throughout the goldfields west of Melbourne, the largest nugget recorded being the 2268 ounce Welcome Stranger at Moliagul, which would be worth more than a million Australian dollars if sold in 2001.[11] Fifty nuggets greater than 500 ounces and 1327 nuggets greater than 20 ounces were recorded in Victoria prior to the advent of metal detectors. There are numerous reports of nuggets lying on the ground like potatoes, diggers turning over gravel with shovels at Bealiba to pick out the nuggets, and of one tonne of nuggets picked from the surface at Donkey Gully, Castlemaine. Such claims are given credence by the well-documented fact that more than one tonne of gold came from the Wedderburn–Inglewood–Dunolly–Tarnagulla area from just the reliably recorded nuggets greater than 1.5 kg in mass. The last significant goldrush was at Poseidon (Tarnagulla) in 1906, with the discovery of 953, 675, 502, 387, and 373 ounce nuggets plus recovery of 3000 ounces from a 25 metre claim. However a street was torn up in a minor goldrush at Wedderburn in the 1950s, when three nuggets