Milparinka is situated within one of the most significant, interesting and historical areas of northwestern New South Wales. When Captain Charles Sturt journeyed here in 1844 on his final expedition to discover the great inland sea and was ultimately stranded at Depot Glen during 1845, it marked the commencement of a slow colonisation process which culminated in the discovery of gold nearby in 1880. The Mount Browne gold field sparked a gold rush to the region which expanded to include new fields at Warratta and Tibooburra in 1881 and brought many hundreds of miners to the region with the trappings of civilisation including coach services and town amenities. The gold rush was over by 1883, but its legacy remains in the clusters of workings, derelict buildings and machinery, and impact upon the evolving history of the far west.

This geological drive comprises two sections, both of which are suitable for conventional vehicles (Figure 1). The northern drive travels from Milparinka to Depot Glen, Poole's grave and Mount Poole, then retraces back past Depot Glen to finish westward of Mount Poole homestead. This drive outlines the geology of the area, examines the rocks of the Cambrian inliers (an *inlier* is an area of older rocks surrounded by younger rocks), and describes the younger rocks visible at Milparinka and Mount Poole. There are opportunities to fossick for attractive samples of chalcedonic, coloured silcrete.

The southern drive departs Milparinka for the Mount Browne gold field, which is accessed via the track to Mount Browne woolshed. This drive examines some of the younger rocks and the remnants of the gold workings. There are opportunities to fossick for petrified wood, various forms of ironstone including coprolites (fossilised animal dung), and as you are visiting a nuggety gold field, you may just strike it lucky!

The Milparinka-Depot Glen-Mount Poole drive is about 31 km one way, whereas the Milparinka-Mount Browne route is about 17 km one way. Sites are described by distances and by grid references (for those with GPS). Note that grid references are in Map Grid Australia 1994 Zone 54 units.

Be prepared with adequate water, sturdy footwear and first aid equipment. For your safety, it is desirable that you alert the staff at the Milparinka visitor's centre of your intended departure, and advise them of your return.

The geology of the region comprises ancient sedimentary rocks which were laid down in a deep marine ocean during the Cambrian period, about 496 million years ago (Table 1). These rocks were folded and faulted, and about 430 million years ago during the Silurian period were intruded by gold-bearing quartz veins. Over the following millions of years the ancient rocks were eroded away, eventually exposing the white quartz veins with their enclosed gold. The masses of quartz formed thick, extensive gravel beds, with the heavy gold concentrated in the base of the gravels.

The region was inundated by a shallow marine sea during the Cretaceous period about 130 million years ago. The gold-bearing, white quartz-rich gravels and sands were buried beneath the sands and muds of the ice-filled polar sea of this region, becoming rocks of what we now refer to as the *Great Artesian Basin*.

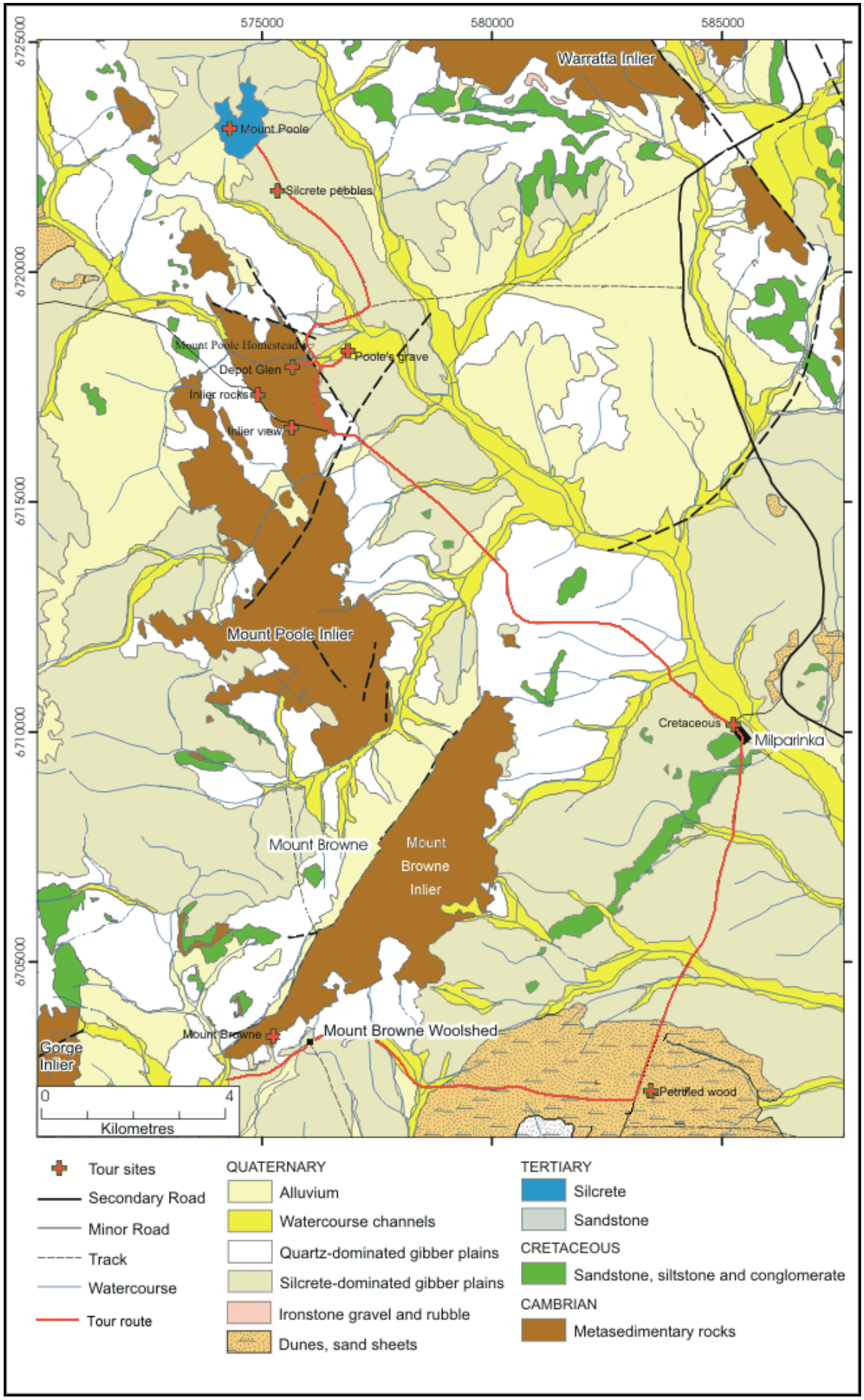

Figure 1. Simplified geological map of the Milparinka area, showing tour sites. Geology modified from original NSW Geological Survey data.

PERIOD	YEARS AGO	LIFE FORMS ORIGINATING	GEOLOGICAL EVENTS
QUATERNARY	0 2,000,000	Human Beings	Deposition on land by wind and water
TERTIARY	65,000,000	Grazing and carnivorous mammals	Tropical conditions produced widespread sandy deposits from abundant rivers. Groundwater movement produced silcrete
CRETACEOUS	145,000,000	Last dinosaurs First flowering plants	Polar conditions. Widespread inundation beneath a shallow marine sea. Uplift of seafloor and deposition on land by end of Cretaceous
JURASSIC	200,000,000	First birds	No rocks preserved from this period in local area
TRIASSIC	251,000,000	First dinosaurs and mammals	No rocks preserved from this period in local area
PERMIAN	299,000,000	Mammal-like reptiles, last Trilobites	No rocks preserved from this period in local area
CARBONIFEROUS	359,000,000	First reptiles; fern forests	No rocks preserved from this period in local area
DEVONIAN	416,000,000	First amphibians and insects	Period of major fracturing and faulting
SILURIAN	443,000,000	Vascular land plants	Major period of folding and gold-bearing quartz vein emplacement followed by intrusion of granodiorite and associated aplite, pegmatite and diorite at 421 million years
ORDOVICIAN	488,000,000	First corals, fish with vertebrae	
CAMBRIAN	542,000,000	Shellfish, Trilobites	Deposition of sands and muds in very deep ocean about 496 million years ago. Volcanic mud and gravel introduced periodically
PRECAMBRIAN	700,000,000 1,500,000,000 3,500,000,000 4,500,000,000	Algae Complex cells Primitive cells Formation of the Earth	No record

Table 1. Geological history of the Milparinka-Tibooburra area.

Uplift of the continent at the end of the Cretaceous period completed the last period of marine deposition in the region. A lengthy period of erosion during the hot, wet Tertiary period deeply weathered the Cretaceous rocks, resulting in bleached, chalky sandstones and siltstones beneath the subsequently deposited Tertiary sandstones. The movement of groundwater through the rocks during the Tertiary period dissolved silica (quartz) from the rocks, redepositing it in the porous sandstones to form *silcrete*. The tough, durable silcrete has slowly eroded over the succeeding millions of years, forming extensive gibber plains. Remnants of the silcrete form resistant caps on some mesa-like hills (*jump-ups* or *cordillos*), preserving the softer, bleached Cretaceous sandstones beneath.

The arid, post ice age environment of inland Australia has developed typical desert-like landforms and geology. Flat topped, steep sided mesas and cordillos contrast with the flat and rolling gibber plains and areas of wind blown sand. Meandering watercourses, with complex, shifting gravelly channels cut across the region, in some cases winding their way towards the major drainage basins, whereas others dissipate in the flat, dry plains or in internally-draining lakes.

Milparinka-Depot Glen-Mount Poole Route

Stop 1 (Cretaceous, Figure 1) - the prominent outcrop of rock on the eastern side of the intersection between the Depot Glen road and the Milparinka-Mount Browne road (Grid reference 585182 6710186). These rocks are cross-bedded sandstones and pebbly sandstones (photos 1 and 2) that were deposited close to a shore line during the Cretaceous period, about 140 million years ago. The cross-beds are very prominent in these rocks. They represent the leading edge of sand masses which were migrating downstream under strong current flow.

Photo 1. Cross-bedded Cretaceous sandstone near Milparinka.

Consequently, the cross-beds tell us which direction the prevailing currents were flowing, information which is of great value to geoscientists researching these rocks. As you can see in Photo 1, the currents were flowing from left to right (i.e. flowing to the west). Some beds show no cross beds (e.g. bed at top of Photo 1). This may be because the current velocity was very high. It could also indicate that the sandy bed was burrowed and worked by feeding organisms (e.g. worms, shellfish) which destroyed the original internal structures of the bed.

Photo 2. Pebbly sandstone, with pebbles of white and grey quartz.

Some of the sandstones are pebbly (Photo 2). The pebbles comprise white and grey quartz, and some fragments of the more resistant *metasedimentary* rocks (sedimentary rocks altered by heat and pressure) present in the Cambrian inliers (see Map 1) to the north and west. Pebbly sandstones and *conglomerates* (rocks made up mostly of pebbles) are more abundant beneath these outcrops, but don't outcrop here. Their presence is inferred from the abundant quartz pebbles covering the ground surface towards the inliers, where these pebbly rocks once outcropped. Erosion over millions of years has eroded the pebbles and sand from these rocks, littering the ground with an abundance of white quartz pebbles around the margins of the inliers. This relationship is depicted in Figure 2. These conglomerate-rich rocks also contain gold - this will be described later.

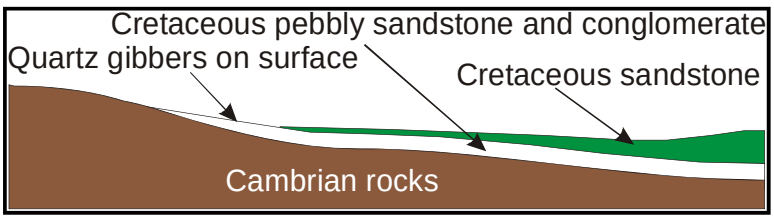

Figure 2. Simplified cross section of the Milparinka area, showing the relationship between the quartz pebble-rich Cretaceous rocks, the Cambrian inliers, and the distribution of white quartz gibbers on the land surface close to the inliers.

Drive from here to **Depot Glen** (grid reference 575003 6717798), a distance of about 14 km. As you travel you will note the rolling gibber-covered plain (see geological map - Figure 1) which overlies non-outcropping Cretaceous rocks, with pebbles varying from grey-brown silcrete to white quartz. At Depot Glen, follow the track from the parking area west.

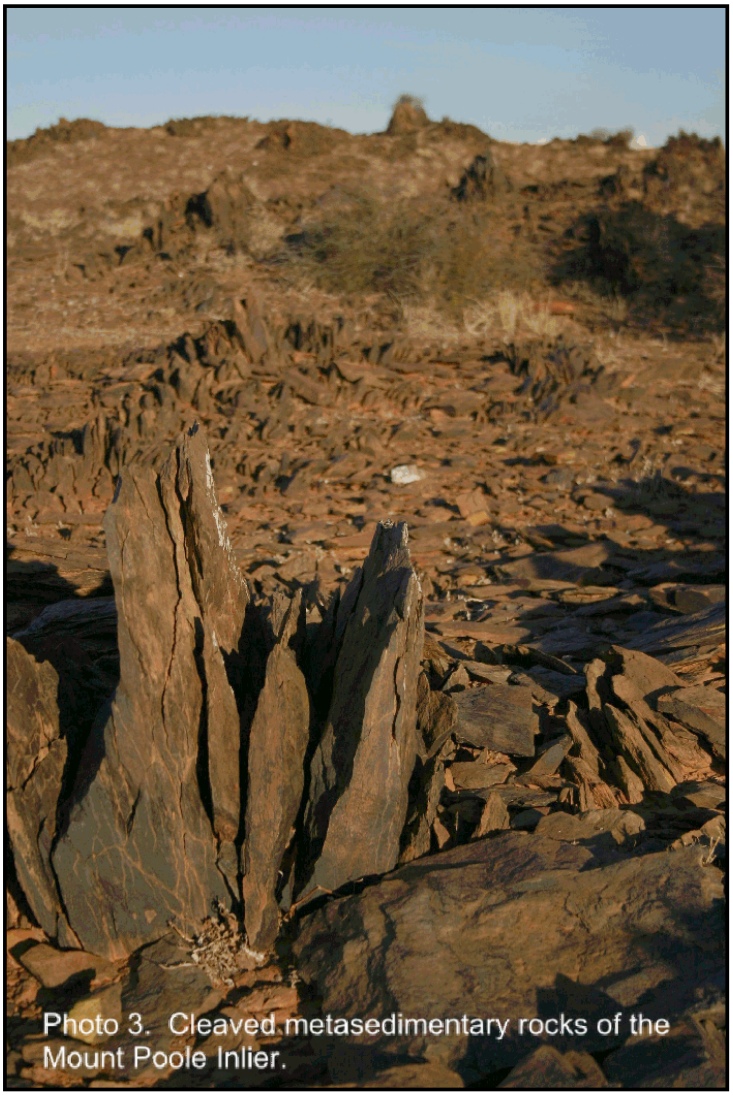

Photo 3. Cleaved metasedimentary rocks of the Mount Poole Inlier.

The rocks present along the track and bordering Depot Glen Creek are Cambrian metasedimentary rocks (Photo 3). These were deposited in a deep ocean about 496 million years ago as silts and muds. Since then the rocks have been deeply buried, then subjected to severe compression which folded, faulted and recrystallised the rocks. One direct effect of the folding is the formation of a slaty cleavage - a vertical, closely spaced fracture in the rocks. In places the rocks are classic, grey slates. In Sturt's description of the site, he erroneously described the rocks as *basalts*.

The Cambrian rocks are generally buried beneath the younger Cretaceous rocks and extensive gibber plains and sand dunes. In some places, relatively young faulting events have pushed the Cambrian rocks upward. Where older rocks are exposed at the surface with younger rocks surrounding them, the older rocks are known as an *inlier*. In the Milparinka-Tibooburra area there are a number of inliers - Cambrian rocks surrounded by large areas of Cretaceous rocks and younger unconsolidated sand, gravel and gibber plains. Near Milparinka there are four inliers (see Figure 1): the *Mount Browne, Mount Poole, Warratta* and *Gorge Inliers*. Depot Glen is situated within rocks of the Mount Poole Inlier.

Continue along the track to the Depot Glen water hole (Photo 4). This is the area where Charles Sturt and his exploration party journeyed to in 1845 on their way to search for the supposed inland sea and the mountain chain which was theorised to divide the continent. Sturt's party, complete with drays, cattle, sheep and boat had traveled from Adelaide to Menindee (then Laidley's Chain of Ponds) then via the southern Barrier Ranges, moving between waterholes and exploring the region about their path as they proceeded. Sturt chose to use Depot Glen as a base as the water supply present at the time was deemed sufficient for two years stay. The Sturt party is believed to be the first Europeans to have entered this part of Australia.

Photo 4. The main waterhole at Depot Glen.

Sturt's summer arrival was accompanied by drought conditions, forcing his party to remain at this oasis until conditions changed for the better. It was to be a six month wait. In an attempt to maintain morale, Sturt commissioned the construction of a cairn on what he later named Mount Poole (about 5 km north from here) from mid April when temperatures had diminished. Little did Sturt realise that they were camped adjacent to an area of nuggety alluvial gold, a treasure which was finally discovered 35 years later!

Rainy weather returned in July. By this time, the party had significantly depleted their supplies, and it was decided to send 7 men (nearly half the contingent) back to Menindee, from where they would travel by

steamer down the Darling River to Adelaide to organise relief supplies. Although many of Sturt's party were suffering from mild scurvy, Poole was severely debilitated and it was decided that he would be one of the seven men to return to Menindee. Poole died on the first day of the return journey, and was buried beneath a prominent beefwood tree near the Depot Glen camp (Photo 5).

After the remaining six men returned to Menindee, Sturt and the remaining party mounted several major exploration ventures to the northwest corner of the state, establishing Fort Grey as a base camp for exploration into what is now Queensland and South Australia. Sturt failed to find the inland sea, and by then suffering severe scurvy himself retraced their steps to Depot Glen, hauling the boat with them. A frantic return to Menindee was undertaken in December 1845, abandoning the boat on the Depot Glen waterhole.

It was fifteen years before the next European explorer visited Depot Glen. J. Crawford and party traveled from Adelaide in 1860 to explore for mineral deposits in the Barrier Ranges. Sturt's dray tracks were followed to Depot Glen, and the inscription in the tree overlooking Poole's grave was touched up. Crawford explored the local area but was also unaware of the alluvial gold under foot in the local area. He returned to Adelaide without any mineral finds.

Settlers began entering the area about Depot Glen in the early 1870s. By 1876 several settlements had been established, and flocks of sheep were grazing the area. Farmhand John Thompson spotted nuggety gold amongst the white quartz gibbers near Depot Glen in 1880, sparking a gold rush which resulted in the discovery of alluvial gold at Mount Browne in 1881, and subsequently at Warratta and Tibooburra later in the same year. The gold rush lasted three years, imported many hundreds of hopeful miners to the area, and resulted in countless deaths.

It is interesting to note that Sturt's boat was wrecked by floods some years after his visit. Fragments of the boat were trapped amongst other flood debris in the trees bordering the creek 20 years later. At least some of those fragments were still present up to the mid 1970s, after which the huge floods of the time removed this tangible reminder of Sturt's folly forever.

Travel from here to **Poole's grave**, following the sign posted road (about 700 m from the Mount Poole road). This is not a geological site, but is worth visiting to experience a significant historical site. Poole was the only person to die on Sturt's final expedition. The cairn erected here (Photo 5) was placed many years ago by a previous inhabitant of Mount Poole homestead.

Return to the Mount Poole road and turn right toward Mount Poole. Follow the sign posted road for about 5.5 km. Stop on the gibber plain (grid reference 575357 6721752) with Mount Poole about 1 km to the north.

Silcrete fossicking. This is a site where beautiful pebbles and cobbles of brown, white, yellow and grey silcrete can be found. The silcrete is *chalcedonic*, i.e. glassy, very hard and breaks with razor sharp edges. Many pebbles have broad, widely spaced concentric layering similar to agate. Some show chipped edges indicative of indigenous tool making.

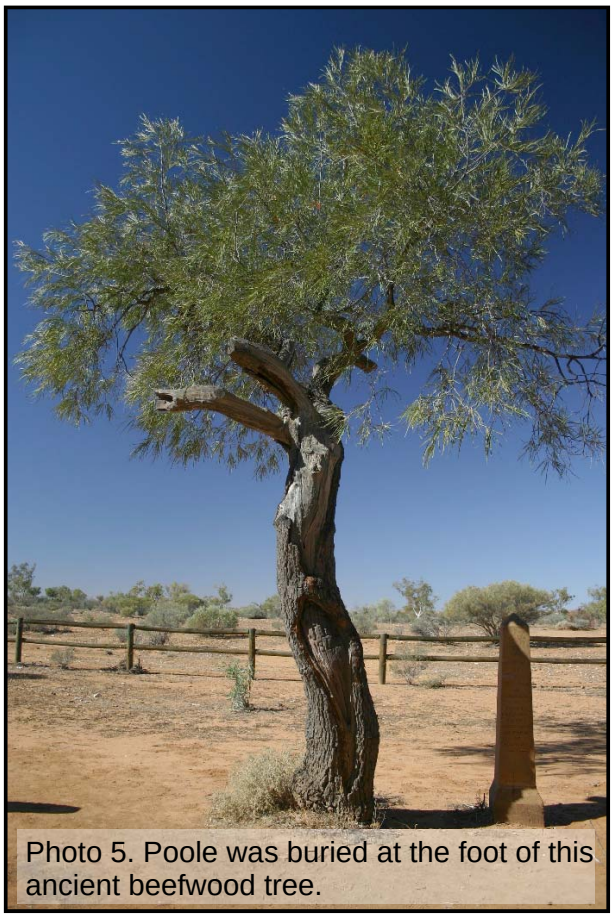

Photo 5. Poole was buried at the foot of this ancient beefwood tree.

Continue to the parking area at the foot of **Mount Poole.** Pass through the gate and follow the walking track up Mount Poole. After the initial steep climb across bouldery debris derived from the crest of the hill, the slope levels off briefly (see cross section of Mount Poole, Figure 2). Whilst ascending this section you may observe weathered Cretaceous sandstone and mudstone amongst the silcrete boulders. These Cretaceous rocks form the body of the hill, with a hard, resistant capping of silcrete (Figure 2). The silcrete is a hard, siliceous rock formed by the deposition of quartz (silica) in the open pore spaces of the original sand during the Tertiary period. The silcrete resulted from movement of groundwater through the sand, with silica being introduced in solution

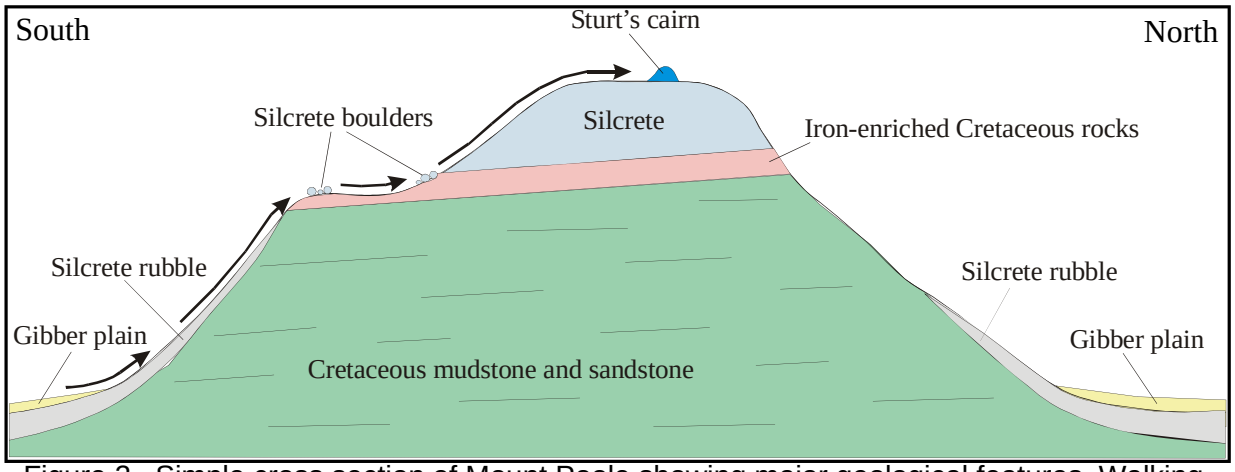

Figure 2. Simple cross section of Mount Poole showing major geological features. Walking track shown by arrows.

from deep weathering of older Cretaceous rocks beneath. This process took place about 33 million years ago at a time when Australia was subjected to a hot, wet environment. The underlying Cretaceous rocks were deposited more than 100 million years ago. The Tertiary environment was ideal for producing plentiful groundwater, then drawing it through the rocks by rapid evaporation, resulting in the precipitation of the dissolved iron, silica or lime. In places the original structure of the sandstone or sand can be seen, with small, very glossy, white quartz pebbles being a common feature. The boundary between the Tertiary silcrete and Cretaceous sedimentary rocks is generally marked by a thick zone of deep weathering, where the Cretaceous rocks have been chemically altered by groundwater movement during the Tertiary, resulting in white, chalky rocks with local areas of iron oxide-rich rock.

The break in slope beneath the crest of Mount Poole marks the contact of the silcrete and Cretaceous rocks. Locally abundant iron oxide-rich rock (*ironstone*) is present on the ground surface. Large silcrete boulders are abundant here, remnants of the silcrete bed which once covered this part of the hill. The silcrete pebbles on the gibber plain below have been derived from the slow erosion away of the silcrete which once must have covered this region. Some of the silcrete boulders here are very siliceous, and break with a razor sharp edge. Many blocks of silcrete have been hand worked to produce stone tools, the chipped rock littering the ground.

This point of the climb is useful for observing the main landforms to the south (Photo 6). In the far distance the ridges of the Cambrian Mount Browne Inlier (Figure 1) are apparent, with areas of white quartz gibber plains along their flanks. Somewhat closer are the lower hills of the Mount Poole Inlier (just to the right of the Mount Poole buildings near Depot Glen Creek), also with a rim of quartz gibbers. Between there and Mount Poole are low, rolling hills of silcrete pebble gibbers. The significance of the white quartz gibbers was described at stop 1 near Milparinka.

Photo 6. View south from Mount Poole.

Continuing further up the hill solid masses of silcrete are abundant. Boulders of

this were used to construct Sturt's cairn (Photo 7). The view is spectacular, showing the dominant gibber plains cut by sparse, dry watercourses. The northeastern flanks of Mount Poole are cut by gullies in which weathered Cretaceous rocks are exposed. A scramble down the gullies will show some of these rocks, and the veins of colourless gypsum which is abundant in the arid zone.


Photo 7. Sturt's cairn with large silcrete boulders in foreground.

The view to the northwest (Photo 8) shows Mount Sturt homestead in the distance at the northern end of a small Cambrian inlier (Figure 1). The dark coloured rocks of the inlier are characteristically flanked by a rim of white quartz gibbers, attesting to the presence of the quartz pebble-rich lowermost Cretaceous conglomerates and pebbly sandstones.

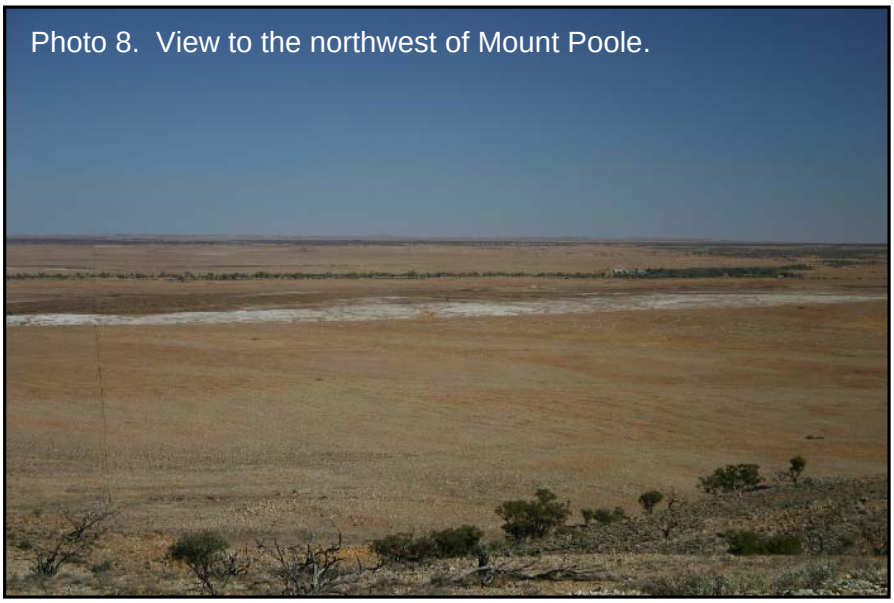
Photo 8. View to the northwest of Mount Poole.

Return to the foot of the hill and return to the Milparinka road. Turn right and travel for 800 m. Stop before the beginning of the downward slope.

This site (**Inlier view**: grid reference 575622 6716529) gives some great views of the local inliers and their adjacent quartz gibber plains (Photo 9).

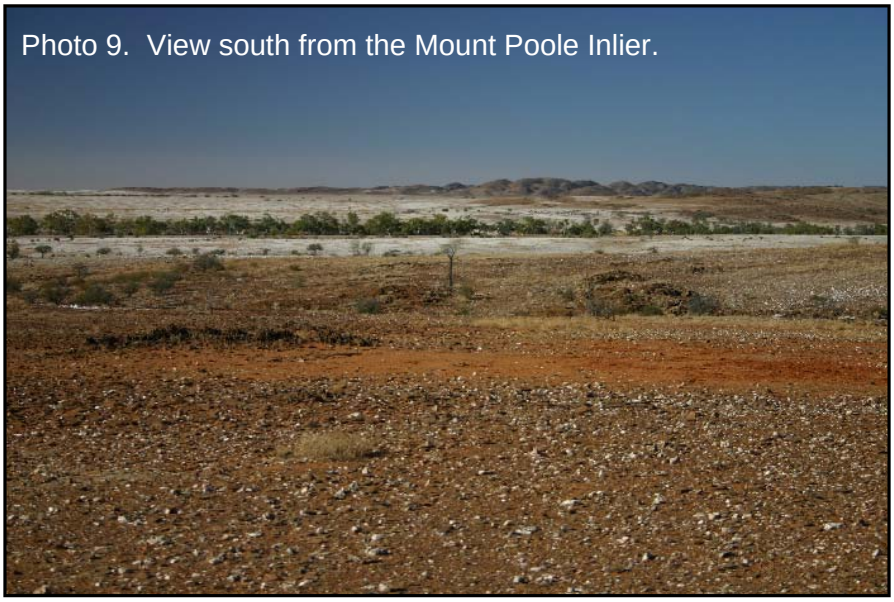
Photo 9. View south from the Mount Poole Inlier.

The tall, photogenic ridges of the Mount Browne Inlier are present on the horizon, with broad expanses of quartz gibbers extending towards the southern edge of the Mount Poole Inlier in the foreground. The view to the west also shows the extensive quartz gibber plains trailing away from the margin of the Mount Poole Inlier.

These quartz gibber plains hosted the first gold nuggets discovered in 1880. Sturt and his party evidently tramped across these on their daily trek to Mount Poole, unaware of the gold beneath their boots. The gold was sourced from the original gold-bearing quartz veins which were abundant in the Cambrian rocks before they were eroded downward to their present level. Most of the erosion occurred prior to the Cretaceous period, the resulting thick accumulations of quartz pebbles and gold being incorporated into sedimentary rocks which have been exposed to weathering and

erosion, releasing the pebbles and gold. Fossickers armed with metal detectors stroll through these quartz gibber plains, commonly rewarded with finds of beautiful nuggets.

Resume travel to the base of the hill (about 1.1 km) and park near the prominent outcrops on the east of the road (**Inlier rocks:** grid reference 574914 6717326).


Photo 10. Metasedimentary rocks of the Mount Poole Inlier.

This stop shows some examples of the Cambrian rocks of the Mount Poole Inlier. The rocks here are cleaved metasedimentary rocks similar to those at Depot Glen . Near the base of the hill the rocks are very slaty, with closely spaced cleavage planes and a thick quartz vein paralleling the edge of the outcrops and the cleavage within the rocks. This may indicate the presence of a large fault at, or near the base of the ridge. The fault would parallel the cleavage and quartz vein. Many similarly oriented faults have been mapped by geoscientists through the area (Figure 1). Some of these faults are ancient, but have periodically reactivated, resulting in the elevation of the inlier rocks. The eastern margins of the Mount Poole and Warratta Inliers, and the northern margin of the Mount Browne Inlier are bounded by faults which have raised those margins upward relative to the Cretaceous rocks on their opposite flanks. Research has shown that multiple periods of movement have resulted in erosional terraces in the inlier rocks, some of which may be only thousands of years old!

The rocks along the hillside show lesser cleavage (Photo 10). Some contain small pebbles of rock similar to the enclosing rock. Note the white quartz gibber plain adjacent to the ridge. The underlying rock would be pebbly Cretaceous conglomerate and sandstone.

This completes this leg of the geological drive. Return to Milparinka.

Milparinka-Mount Browne Route

Take the road to Mount Browne, crossing the silcrete gibber plain with sparse outcrops of Cretaceous sandstones. The distance to the first stop is about 8.2 km. The gibber plain disappears beneath sand sheets as the road slowly ascends, the rich soil and its trapped moisture supporting a community of Mulgas and woody herbs. Stop near the Mount Browne woolshed turnoff, walking to the low hill on the eastern side of the road.

Petrified wood, grid reference 583441 6702190. The low hill is capped by silcrete. Some of the silcrete is identical to that examined on Mount Poole, although much of the silcrete here is also rich in calcium carbonate (lime). The lime-rich silcrete has etched surfaces similar to some limestones, and shows a yellow-grey colour.

Photo 11. Petrified wood from Mount Browne.

The presence of abundant ironstone pebbles about the edge of the hill suggest that the contact of the silcrete with the underlying Cretaceous rocks is nearby. The ironstone pebbles are accompanied by fragments and blocks of petrified wood (Photo 11). Petrified wood is relatively common in some places throughout the region. Fossilised tree bases have been found in their original growth positions in Cretaceous rocks at a number of sites near Milparinka and Tibooburra, so presumably this petrified wood is Cretaceous in age. You may find more along the edge of this hill, and

in similar positions on hillsides and near gullies along the Mount Browne woolshed track.

Coprolites (fossilised animal dung) have been found amongst the ironstone pebbles at this (Photo 12), and other similar localities. The original animal droppings were enclosed within sand and silt during the Cretaceous period, and were infilled with iron oxide during the Tertiary. Recent erosion of the enclosing rocks has released the coprolites. Several intact examples were observed here, and many fractured segments are present amongst the ironstone pebbles.

Photo 12. Ironstone coprolite from Mount Browne.

Continue along the Mount Browne track. The drive crosses silcrete gibber plains and enters an extensive area of quartz gibbers which continue to the Cambrian rocks of the Mount Browne Inlier visible to the west. Near the woolshed numerous shallow diggings are apparent (Photo 13), and several very deep shafts occur on the plain to the east. The diggings continue along the eastern and southern flanks of the inlier (Figure


Photo 13. Shallow gold diggings near Mount Browne.

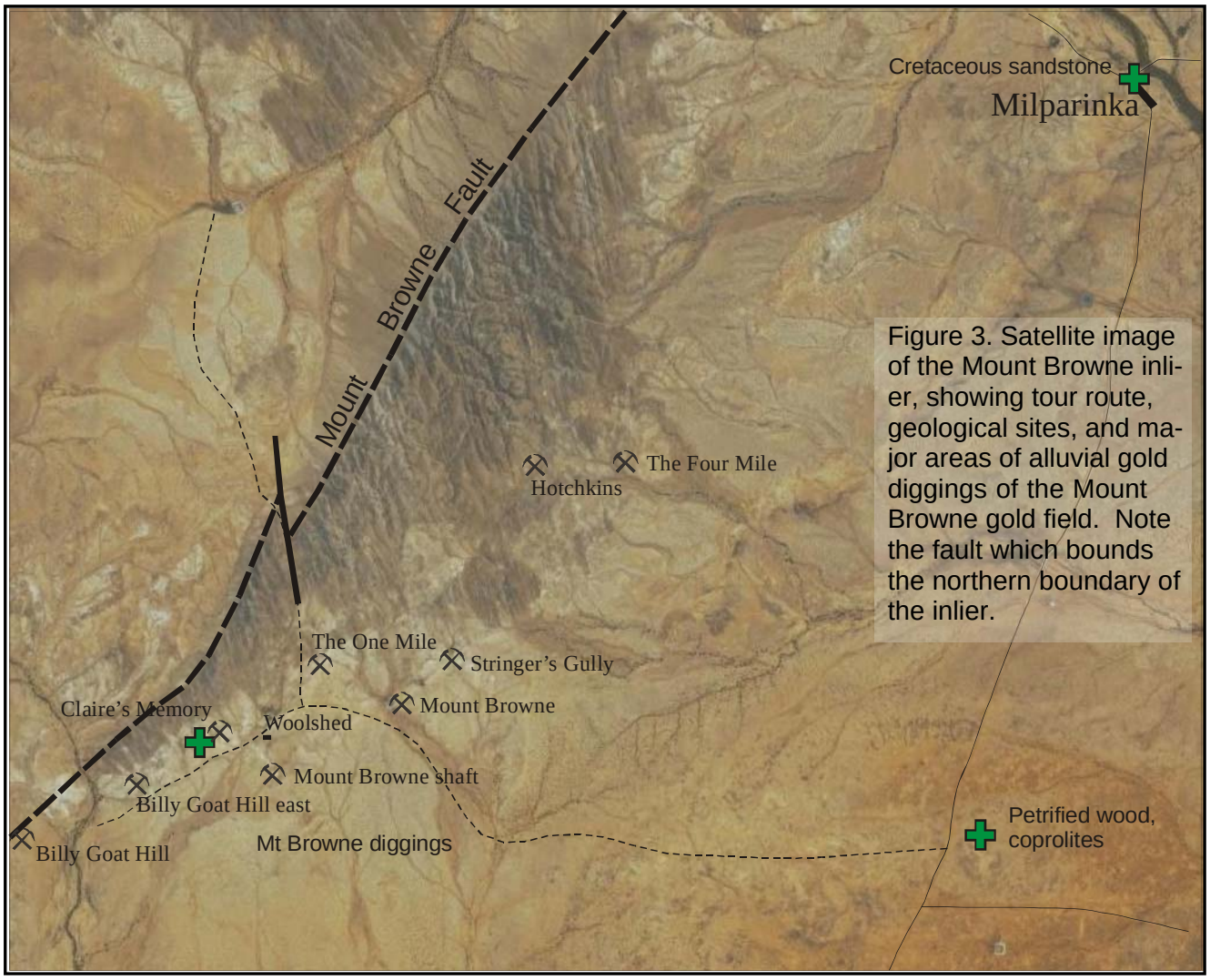

Figure 3. Satellite image of the Mount Browne inlier, showing tour route, geological sites, and major areas of alluvial gold diggings of the Mount Browne gold field. Note the fault which bounds the northern boundary of the inlier.

3), representing the remnants of the Mount Browne gold field discovered in early in 1881. The nuggety gold occurs from the surface to depths of about 1 metre or more in quartz pebble gravels. Some gold was discovered at the base of the Cretaceous conglomerates underlying the quartz pebble gibbers, although this source was never considered of economic grade by the miners of the time.

The Mount Browne gold field attracted more than 400 miners to the area in its first year of operation, with many more to follow soon after. Most miners traveled to the field with no idea of the harsh, waterless character of the area, with no nearby settlements to provide them with supplies. Many died of thirst, but many more perished from typhoid and cholera resulting from lack of hygiene and contaminated water. The nearby graveyard contains numerous unmarked graves of miners who were buried hastily and without identification.

Although the gold rush which was sparked by Mount Browne petered out after 3 years, its legacy to the district remains in the establishment of the towns of Milparinka and Tibooburra (originally *The Granites*) and the infrastructure accompanying settlement. The region has undergone an ongoing gold rush since the 1970s when sophisticated and affordable metal detectors became available, resulting in the discovery of large numbers of small to large gold nuggets. Few fossickers leave the region without a find. Considering the extent of the area with potential gold-bearing gravels, and the continuing enhancement of metal detector technology, it is unlikely that this modern gold rush will ever end.

This concludes the geological drive. We hope that you have enjoyed the tour and taken home some of the magnificent images and experiences of this wonderful part of Australia. We would be delighted to have any constructive feedback on this tour, and invite you to partake of some of our other geological tours available locally and in other parts of New South Wales.