GEOLOGICAL TOUR OF THE TIBOOBURRA DOME AREA

The Tibooburra dome is a broad physiographic and geological feature which is developed approximately concentrically about the Tibooburra inlier. The Cambrian metamorphic rocks and Silurian granodioritic rocks which comprise the Tibooburra inlier are described in the Tibooburra inlier tour and occur as the ridges and hills about Tibooburra village. As the name implies, the Tibooburra dome is a raised area of rocks in a general dome formation. The dome has formed as a result of the slow upward rise of the relatively dense Cambrian rocks in the Tibooburra area. These rocks have arched upward due to pressure from the large volumes of relatively light Silurian granodiorite bodies within them. This is a process much like rising air bubbles in a thick liquid. The air attempts to move upward because of the large contrast in density. This is a common phenomenon in geology, with trapped bodies of low density rocks being forced towards the earth's surface by surrounding high density rocks. As the high density metamorphic rocks can't simply move apart to allow the deeply buried granodiorite body to migrate upward, the rocks arch and fracture.

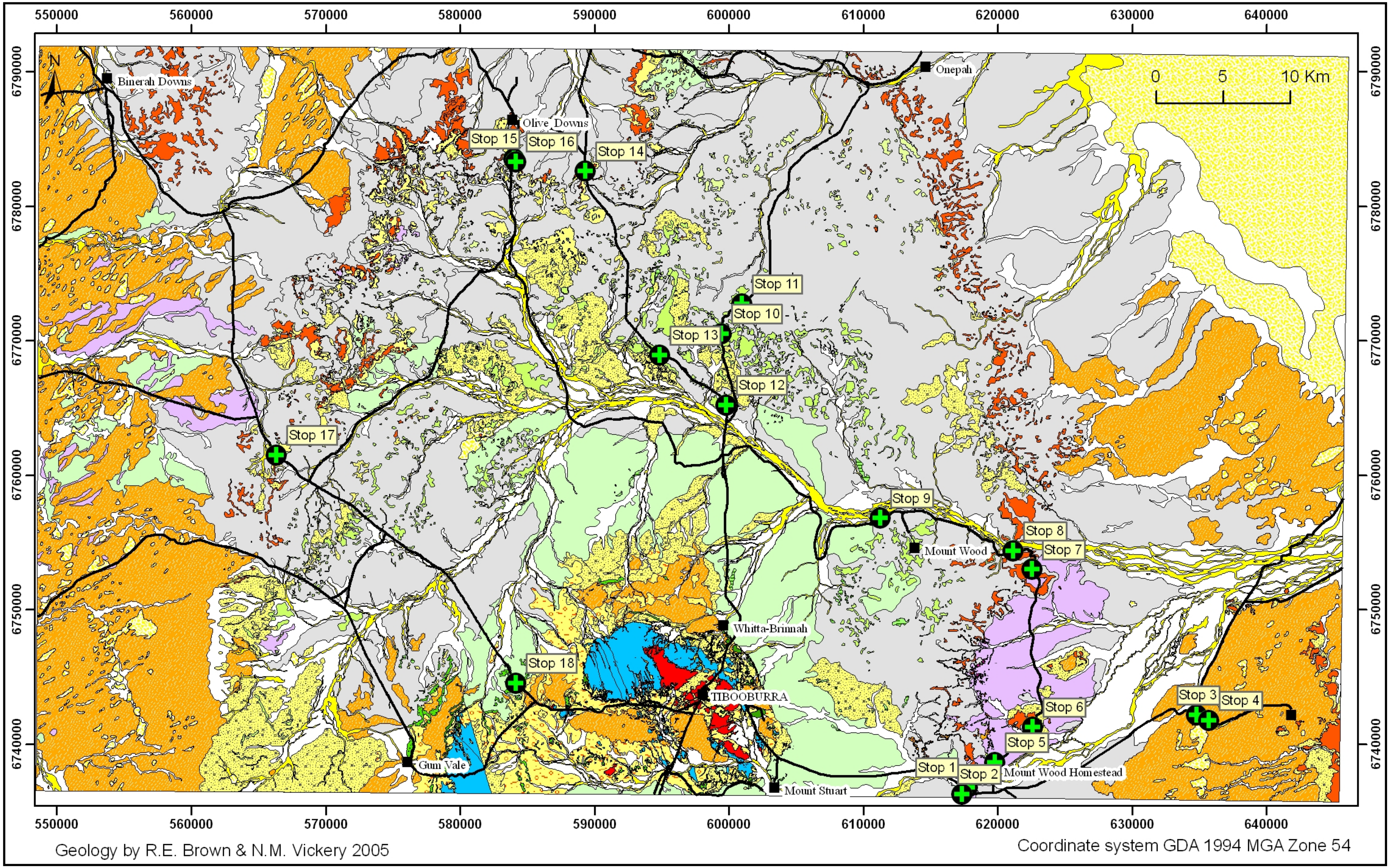
The Tibooburra dome is manifested in a number of obvious ways. We will examine some of these features on this tour. The most obvious is the raised topographic expression of the Cambrian metamorphic rocks about the outcropping granodiorites in the Tibooburra village area. We also see a general concentric dip of the younger Cretaceous and Tertiary rocks away from the inlier. This dip is present up to nearly 50 km from the inlier. And then there is the manner in which the silcrete-capped cordillos (*mesas, or jump-ups*) have eroded outward from the inlier, leaving in their wake the broad, relatively flat silcrete gibber plains. The presence of numerous, relatively young faults throughout the area (one of which is visited in the inlier tour) which show evidence of having been periodically reactivated is a further sign of instability and readjustment of the crust due to doming.

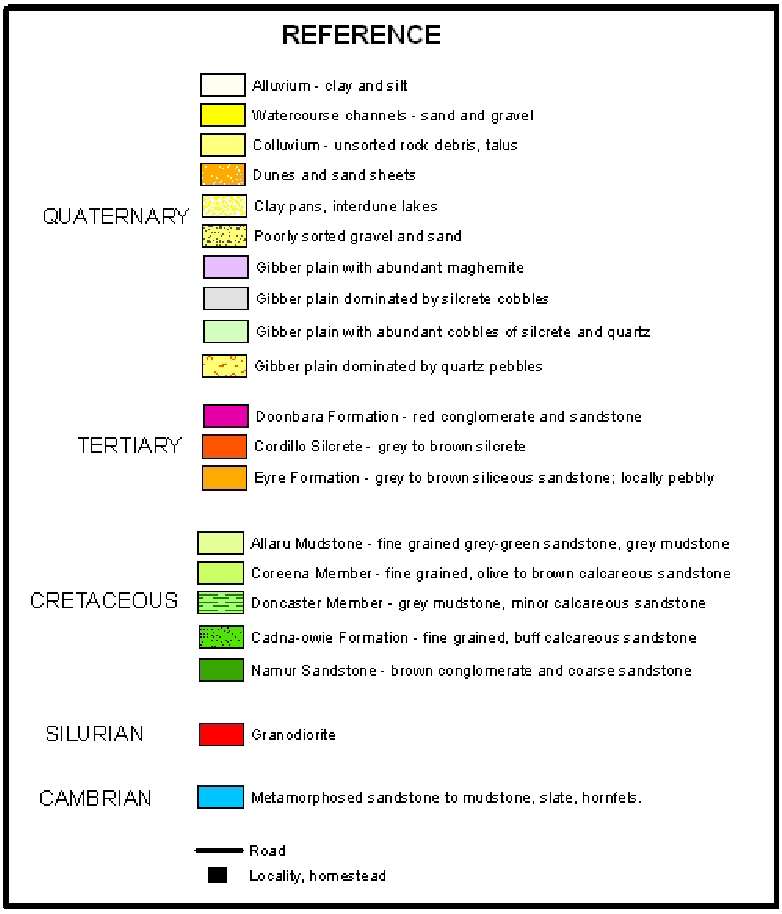
The aim of this tour is to acquaint you with the younger rocks, surface deposits and landforms of the Tibooburra dome. All will be placed into a geological and time-frame perspective.

This tour travels along some of the major unsealed roads to the east, north and west of Tibooburra. These are suitable for conventional two wheel drive vehicles. Many stops are within the Sturt National Park. The stops are not sign posted. To assist you with locating each stop detailed maps are included in this text, and conventional grid references are used for each site. The grid references are presented in both the older AMG (zone 54) coordinates and in the newer convention of MGA (zone 54). Please make certain that you are aware of the coordinates that your GPS is displaying. Also note that the grid shown on the accompanying maps is in MGA coordinates.

Enjoy the tour. We hope that you find it interesting and informative and welcome any feedback, questions or suggestions.

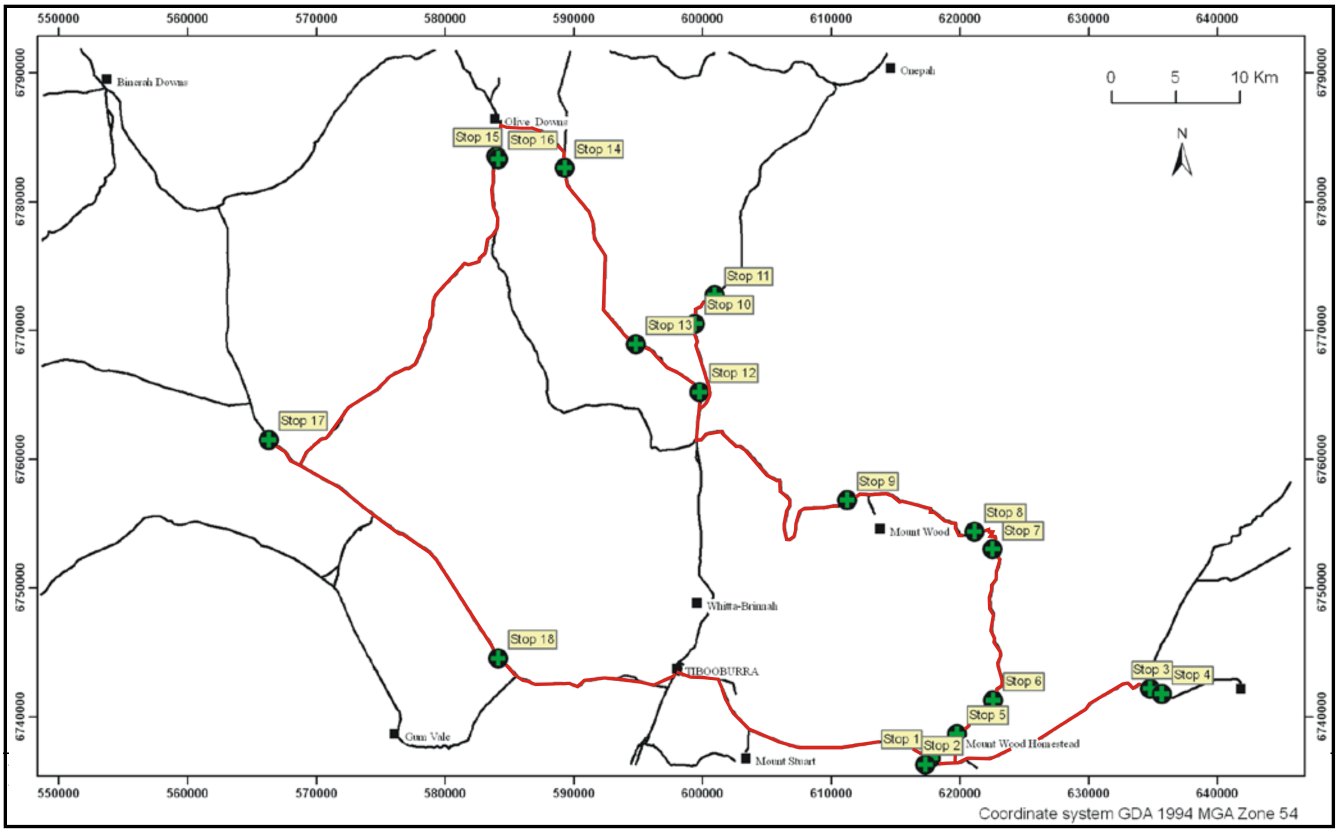
Map 1. Simplified geological map of the northern Tibooburra dome area, showing tour stops.





The geological tour initially travels to the east of Tibooburra on the Wanaaring Road (see Maps 1 and 2), then travels along the Onepah Road before returning to the Olive Downs Road and then looping back to Tibooburra. The tour can easily be undertaken in two stages, completing the eastern section as a circuit back to Tibooburra of about 130 km, and the northern section of about 170 km return. Short, easy walks of several hundred metres are necessary at some sites.

Map 2. Geological tour stops in the northern Tibooburra dome area. Tour route shown in red.



SIMPLIFIED GEOLOGICAL HISTORY OF THE TIBOOBURRA REGION

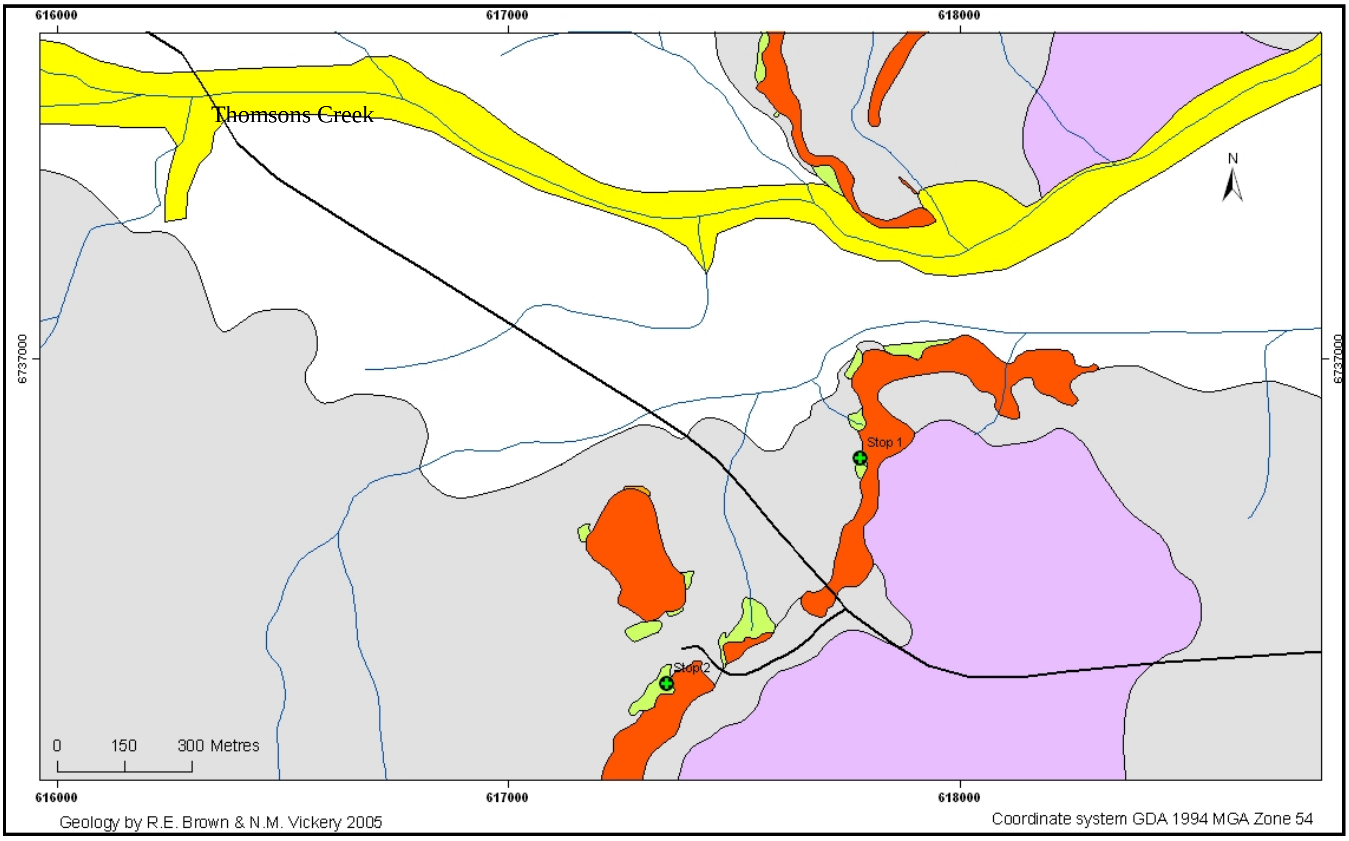
PERIOD	YEARS AGO	LIFE FORMS ORIGINATING	GEOLOGICAL EVENTS
QUATERNARY	0 2,000,000	Human Beings	Deposition on land by wind and water
TERTIARY	65,000,000	Grazing and carnivorous mammals	Tropical conditions produced widespread sandy deposits from abundant rivers. Groundwater movement produced silcrete
CRETACEOUS	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

Stop 1. Columnar and pebbly silcrete, cordillo. Grid reference MGA 617780 6736781, AMG 617658 6736603. See Map 3.

To travel to Stop 1, take the Wanaaring Road and travel for about 21 km. You will cross a long gibber plain and then descend slightly onto the Thomsons Creek floodplain. Cross Thomsons Creek then travel for about 1.5 km (see Map 3). Park on the roadside, walk northwards for about 200 metres to the low ridge.

At this locality we will examine some typical silcrete and observe a silcrete-capped cordillo. The hard, weathering-resistant rock which occurs here as a horizontal layer along the top of the hill is *silcrete*. This is one of the most widespread and common rocks in central Australia, forming a layer associated with rocks of the lake Eyre Basin. It is known as the *Cordillo Silcrete*.

Photo 1. Columnar silcrete with pebbly silcrete near the base of hill. Note the typical scree- or colluvium-covered slope below the silcrete.



Map 3. Simplified geological map of the area about Stops 1 and 2. For key to units, see reference on page 3.

Silcrete has formed from the crystallisation of silica in the pore spaces of what was originally a quartz-rich sand or sandstone. The silcrete resulted from movement of groundwater through the sand, with silica being introduced from the deep weathering of older rocks beneath. This process took place during the Tertiary period, about 33 million years ago, a time when Australia was subjected to a hot, wet environment. The underlying rocks are sandstones and siltstones of the Cretaceous period, which 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 Cordillo Silcrete at this locality shows some features typical of this rock type throughout the region. At the foot of the hill you will find a conglomerate (a pebbly rock) made up of pebbles of silcrete within a hard, massive silcrete. This is a very significant rock, as it shows us that there was a silcrete in existence prior to the deposition of the sand which was converted to Cordillo Silcrete. The earlier silcrete was eroded away by streams, resulting in rounded pebbles and sand, which was then incorporated into the widespread sandstone which now makes up the Cordillo Silcrete.

Also note the typical columnar structure of the Cordillo Silcrete (Photo 1) which is visible higher up the hill. This is one of the common forms of silcrete. The edges of each column show an interesting texture which resembles candle wax drippings. This is a product of the groundwater movement and silica precipitation which formed the silcrete.

At the base of the hill a small pit was constructed many years ago to extract soft sandstone for road repairs. This bleached, white

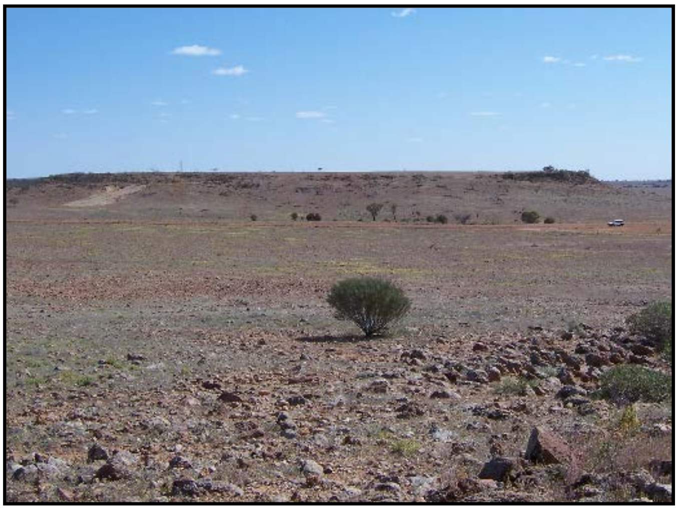


Photo 2. A silcrete-capped cordillo.

sandstone is of Cretaceous age, and typically shows bleaching immediately beneath silcrete layers. We will see an excellent section through the bleached Cretaceous rocks at the next stop.

Across the road is an example of a small *cordillo*. These mesa-like geomorphic features are very common throughout the arid zone. They are typically capped by an erosion-resistant rock such as silcrete, and commonly show a slightly raised upper surface near the cordillo edges.

To proceed to Stop 2, continue along the Wanaaring road for about 200 metres to the top of the hill and turn right onto the track (see Map 3). Follow this for about 400 metres to the fence, stopping outside the gate. Walk to the small quarry on the opposite side of the fence.

Stop 2. Deeply weathered Cretaceous rocks below the Tertiary unconformity. Grid reference MGA 617351 6736280, AMG 617229 6736102. See Map 3.

In the Tibooburra inlier tour there are several opportunities to examine the unconformity (the surface separating rocks of different ages) between the Cambrian and Cretaceous periods. The quarry examined in Stop 2 reveals the unconformity between Cretaceous and Tertiary rocks. This unconformity represents a break in sedimentary deposition which lasted for more than 70 million years.

The bleached, white sedimentary rocks exposed in this quarry are of Cretaceous age. Prolonged lateral and vertical movement of groundwater during the Tertiary period has dissolved the soluble components from the rock and altered some minerals to clays. The soluble components included large amounts of silica, iron and lime. These have been precipitated within fractures, open pore spaces and bedding planes as a range of minerals, largely represented here by *gypsum, limonite (iron oxide)*, and *silica*. The gypsum is present as glassy, clear to white veins occurring through the bleached Cretaceous rocks. The limonite has moved upwards and occurs within the very top of the Cretaceous rocks, immediately beneath the silcrete. Silica migrated upward into the overlying Tertiary sandstone, converting it to silcrete.

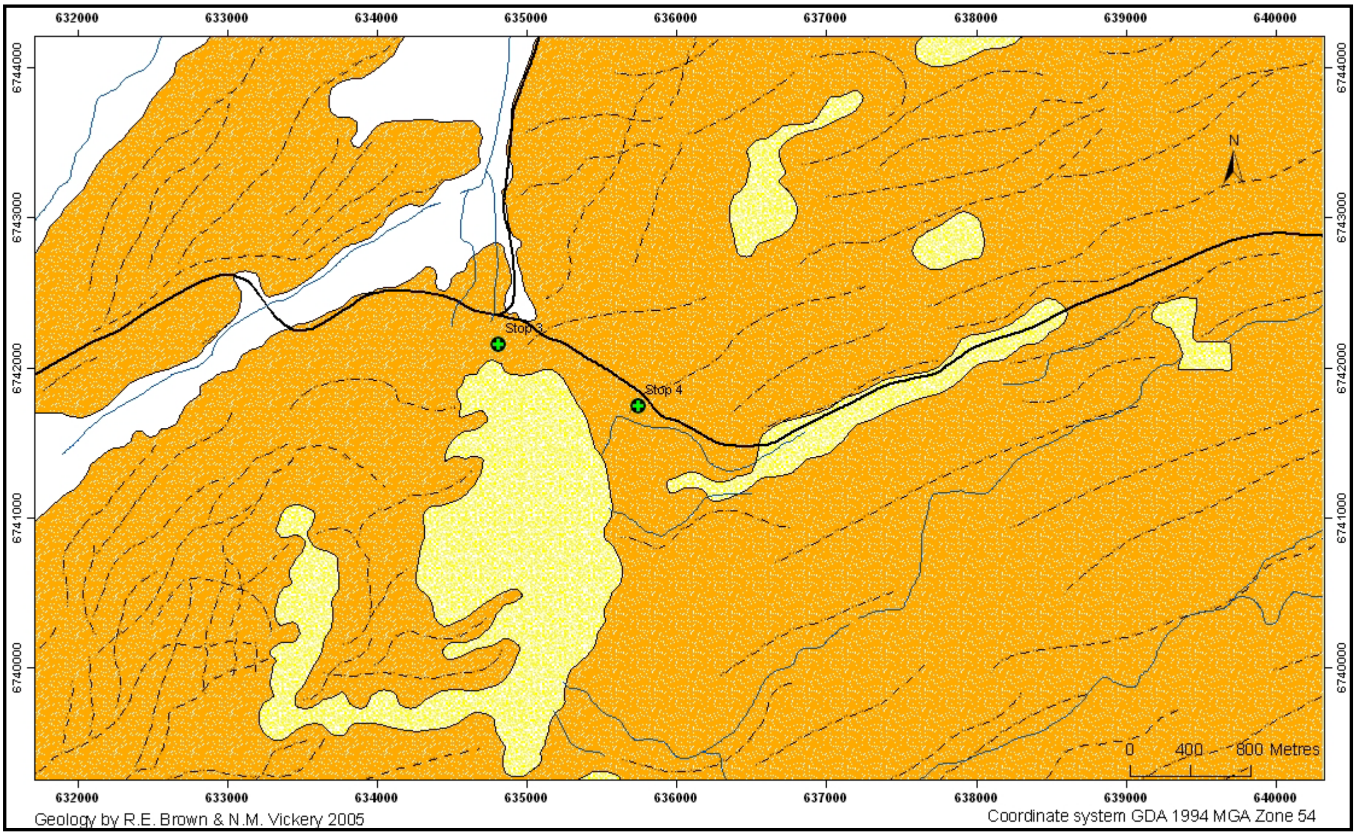
Photo 3. Deeply weathered Cretaceous sedimentary rocks beneath the Cordillo Silcrete at top of photo.

Compare the Cretaceous rocks you see here with those viewed on the Tibooburra inlier tour, and those to be examined in subsequent stops on this tour. The effects of groundwater leaching beneath the unconformity are strikingly obvious.

To travel to Stop 3, continue along the Wanaaring Road, past the Mount Wood turnoff. At the intersection of the Wanaaring Road and Pindera Downs track, take the left fork (to Pindera Downs) and follow this for about 16.2 km. Stop near the intersection of this track with the Teurika track.

Stop 3. Sand dunes and interdune lake. Grid reference MGA 634810 6742159, AMG 634688 6741981. See Map 4.

The drive from the previous stop passes across a long gibber plain with sparse, well rounded silcrete clasts. This is a residual gibber plain which represents the edge of a more typical gibber plain with abundant gibbers. Here the gibber plain has undergone thousands of years of water erosion with gradual removal of the pebbles during extreme floods. Minor areas of alluvial floodplain related to Thomsons Creek (the major tree-lined watercourse to the north) cross the track and finally dominate the landscape before the track enters the sand dune area further east. Note how the floodplain comprises grey clay, a feature common to all floodplains associated with inland, arid zone river systems. This colour is probably in part due to the low organic content of the alluvium. The track rises above the floodplain upon entering the fossil dune system. If you were to walk through the dunes along the western edge of the dune system you would encounter two dune crest orientations (see Map



Map 4. Simplified geological map of the area about Stops 3 and 4. For key to units, see reference on page 3.

4 and Photo 4). The oldest, stabilised dunes trend approximately east-northeasterly, whereas more recent dunes trend north-northeasterly. The older dunes represent prevailing winds generally from the south, and the recent dunes were derived from modern westerly wind directions. Most reshaping of the older dunes has occurred on the western edge of the dune fields, where the older dunes are most exposed to wind erosion and destabilisation.

Near the Stop 3 road intersection you can view a large, vegetation-filled clay pan to the south. A short walk will take you to the rim of this feature. This clay pan is an enclosed drainage basin between dunes. Water trapped after prolonged rainfall can convert the clay pan into a shallow lake. The entrapped moisture has resulted in a rich vegetation population. A concentric distribution of plant life and soil moisture is evident in Photo 4.

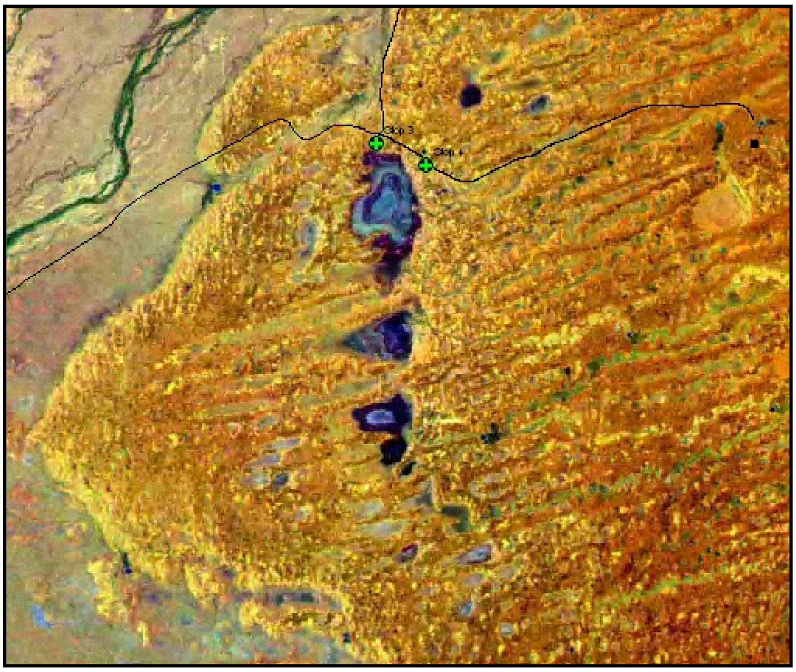


Photo 4. Satellite image of the sand dune system about Stops 3 and 4. Image colours are modified to enhance features. The dune field is coloured orange, and moist claypans in blue. Note the prominent, oldest dune crests trending east-northeast. On the western edge of the dune field the prominent dune structure is lost and a weaker, northerly trend is evident.

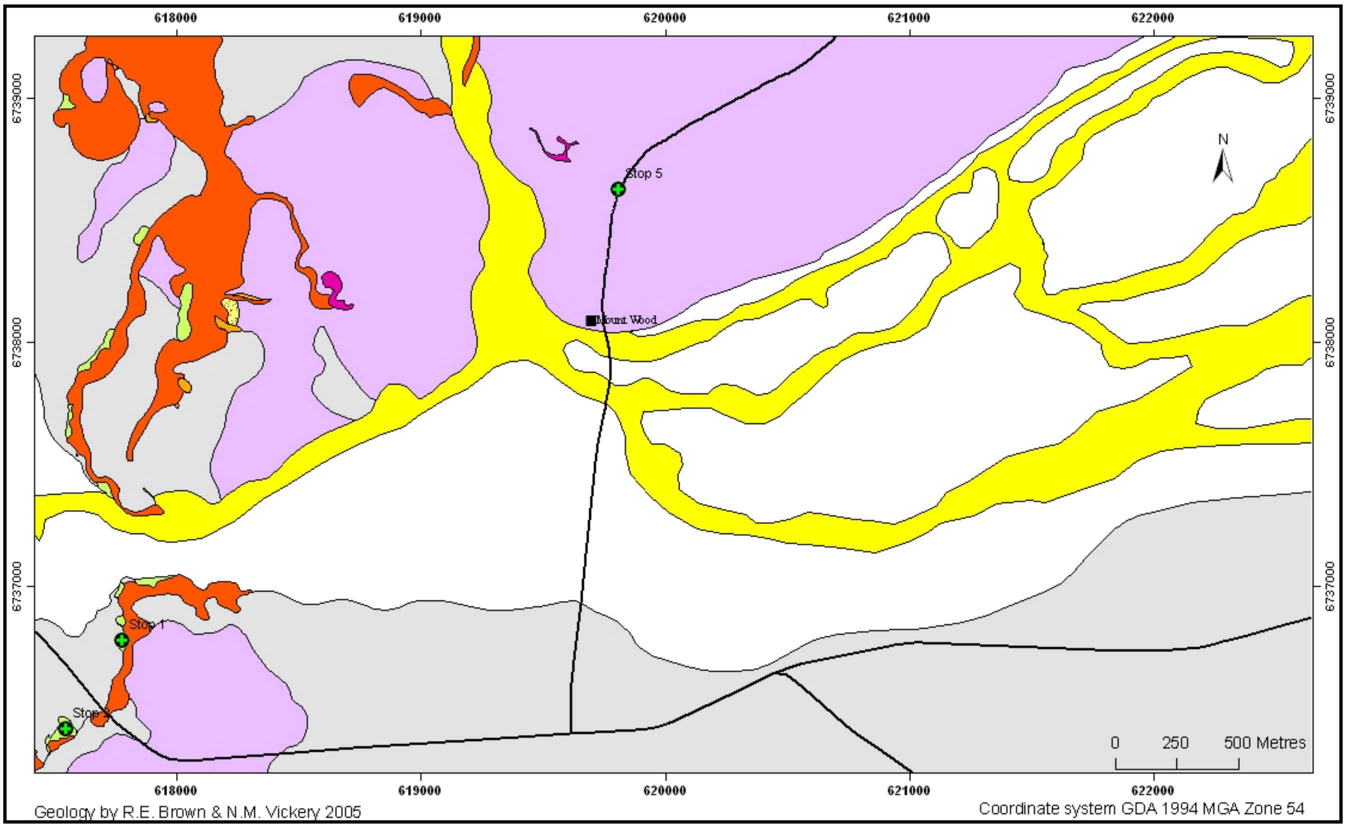
Continue along the Pindera Downs track for about 1 km, observing the colour, composition and shape of the dunes.

Stop 4. Sand dunes and interdune lake. Grid reference MGA 635743 6741749, AMG 635621 6741572. See Map 4.

The track from Stop 3 passes across the crests of the low stabilised dunes. Dune fields such as this are typical of arid inland Australia. Shifting dunes were a major feature of inland Australia from about 500,000 years ago, with the last period of significant dune formation occurring during the last ice age which ended about 17,000 years ago. After this time the dunes were stabilised by the return of vegetation which has helped preserve their ancient structure. The dune colour is probably related to small amounts of iron oxide amongst the sand and clay which comprise the dunes.

The relatively rich population of shrub and tree species is produced by the ability of the dunes to absorb moisture, and by the relatively high fertility of the dunes. After adequate rain in spring and summer these dunes support a rich carpet of flowering perennial plant species.

To travel to Stop 5, return toward Stop 2, taking the Mount Wood loop road turnoff. Proceed for about 2.2 km from the turnoff, passing Mount Wood homestead and stopping on the first low rise.



Map 5. Simplified geological map of the area about Stop 5. For key to units, see reference on page 3.

Stop 5. Maghemite-rich gibber plain. Grid reference MGA 619807 6738624, AMG 619685 6738447. See Map 5.

This stop introduces an unusual, but very significant geological unit. It is recognised by the presence of *maghemite*, a magnetic iron oxide mineral which is produced in the form we see here by heat from a bush fire!

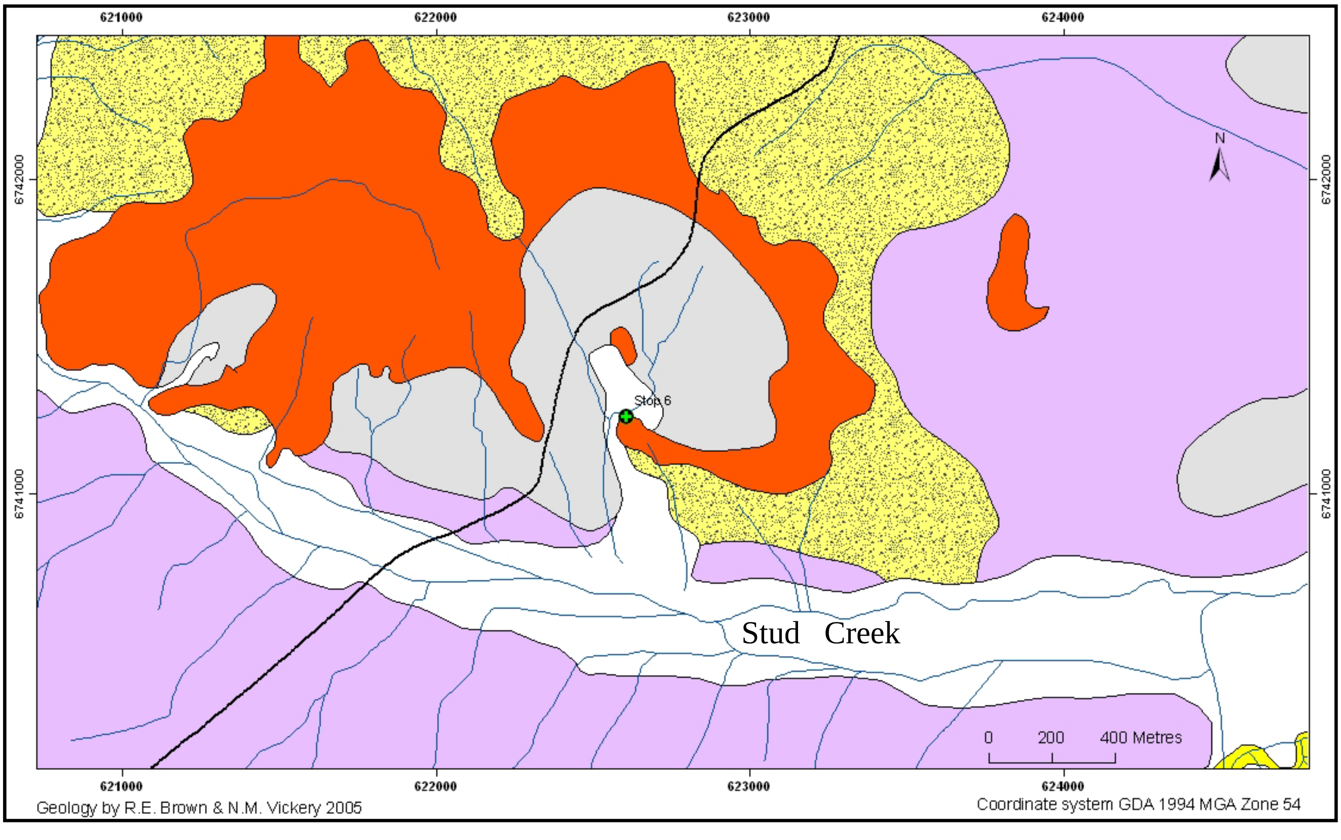
The maghemite is the small, dark brown to black, glossy grains present amongst the silcrete gibbers at this locality (see Photo 5). The maghemite has eroded out of sandstone and conglomerate which outcrops several hundred metres to the west of here. Those sedimentary rocks are about 16-28 million years old and occur extensively throughout inland South Australia. The maghemite was washed into the gravels which formed the conglomerate and sandstone from soils where it had formed as part of the soil profile. In South Australia these same rocks contain abundant non-magnetic iron oxides, whereas in the Tibooburra region the iron oxides are the magnetic species, maghemite.

From research work undertaken elsewhere in Australia we know that maghemite forms from other forms of iron oxide by intense heating associated with bush fires. Where the iron oxides occur at, or near the surface, beneath a carpet of dry organic litter, the heat from the combustion of that litter (and other burning plant material) can convert the iron oxides to maghemite. The logical conclusion from this suggests that during the Tertiary period (see page 4) the Tibooburra region was particularly verdant and prone to conditions favouring particularly hot-burning bushfires. A far cry from the Tibooburra we see today!

Photo 5. Black grains of maghemite scattered on the soil surface.

To travel to Stop 6, proceed northwards along the Mt Wood loop road for about 4 km, crossing Stud Creek and stopping about 750 m further along the road, just past the low silcrete outcrops on the western side of the road. Walk eastward toward the gully about 180 m away and cross the gully near its intersection with a second gully.

Stop 6. Silcrete pipes. Grid reference MGA 622609 6741248, AMG 622487 6741071. See Map 6.



Map 6. Simplified geological map of the area about Stop 6. For key to units, see reference on page 3.

At Stop 1 we examined a silcrete profile and learned of the process which formed the silcrete. In many places, particularly to the north of Stop 6, we find *silcrete pipes* eroded from the weathered Cretaceous rocks beneath the silcrete layer. Silcrete pipes probably represent pipe-like pathways within the Cretaceous sandstone through which groundwater passed upward with dissolved silica and iron. Over time, some of this silica and iron was precipitated into the pore spaces of the surrounding sandstone, resulting in the formation of a brown to white, pipe-shaped feature (see Photo 6). In some places these silcrete pipes are very abundant, ranging in diameter from several centimetres to more than half a

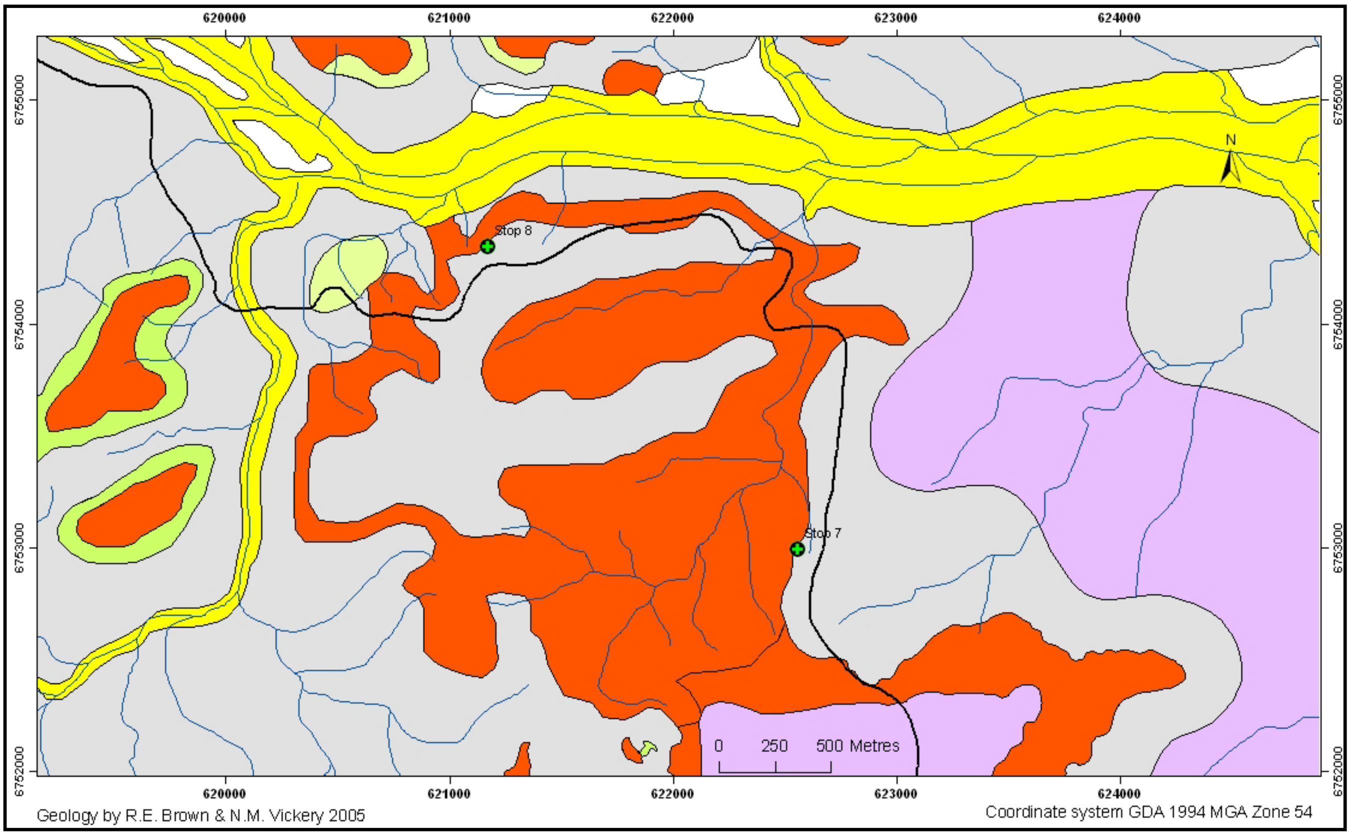
Photo 6. Silcrete pipes such as these are locally abundant beneath cordillo silcrete layers.

metre and in length from 20 centimetres to more than one metre. Many show concentric layering about the core, some are hollow and pipe-like, and others are completely solid from core to exterior.

This locality shows several silcrete pipes (Photo 6), some of which remain in their original vertical orientation. Note the typical colour contrasts within the silica and the irregular shape of the pipe exteriors. The Cordillo Silcrete layer is present on the low rise nearby (coloured orange on Map 6). The Cretaceous rocks beneath the silcrete do not crop out in this area.

To travel to Stop 7, continue along the Mt Wood loop road for about 12.7 km. Along the way you pass through low, rolling hills covered in silcrete gibbers with variable amounts of maghemite, and crossed by clay-rich alluvial flats bordering watercourses. Close to Stop 7 the track ascends a hill capped with silcrete. The stop site is in a gully about 60 metres west of the track.

Stop 7. Silcrete conglomerate. Grid reference MGA 622559 6752997, AMG 622437 6752819. See Map 7.



Map 7. Simplified geological map of the area about Stops 6 and 7. For key to units, see reference on page 3.

At Stop 1 we examined a thin silcrete conglomerate bed at the base of the Cordillo Silcrete. In many places the conglomerate is either absent, or is present as a thick bed with large pebbles and cobbles. Stop 7 shows an excellent example of coarse silcrete conglomerate, plus some of the sandstone which has not been entirely converted to silcrete.

Walk from the track to the gully. Close to the head of the gully you will encounter the conglomerate, comprising silcrete pebbles ranging in size from peas to boulders (Photo 7). Further down the gully a bank of sandstone with sparse pebbles of silcrete is exposed on the western bank. This sandstone has been partially converted to silcrete, and preserves many of the original sedimentary structures which would otherwise be lost with the strong silicification apparent in the Cordillo Silcrete. This sandstone is the Eyre Formation (see Reference, page 3), a very widespread unit throughout western New South Wales, South Australia, Queensland and the Northern Territory. Throughout most of that area this sandstone has been silicified to the Cordillo Silcrete, with only local areas showing its original characteristics.

Photo 7. Silcrete conglomerate, with well rounded silcrete pebbles.

To travel to Stop 8, continue along the Mt Wood loop road for about 3.2 km. Turn off the track into the small parking area on the northern side of the road.

Stop 8. Cordillos of the Tibooburra dome. Grid reference MGA 621173 6754343, AMG 621051 6754166. See Map 7.

The Tibooburra dome is a broad, dome-like physiographic feature which was described in the introduction to these notes. Stop 8 presents a view northwards along the eastern flank of the dome, showing the silcrete-capped cordillo escarpments which form a concentric ring about the dome (see Map 1 for the distribution of silcrete outcrops on the cordillos).

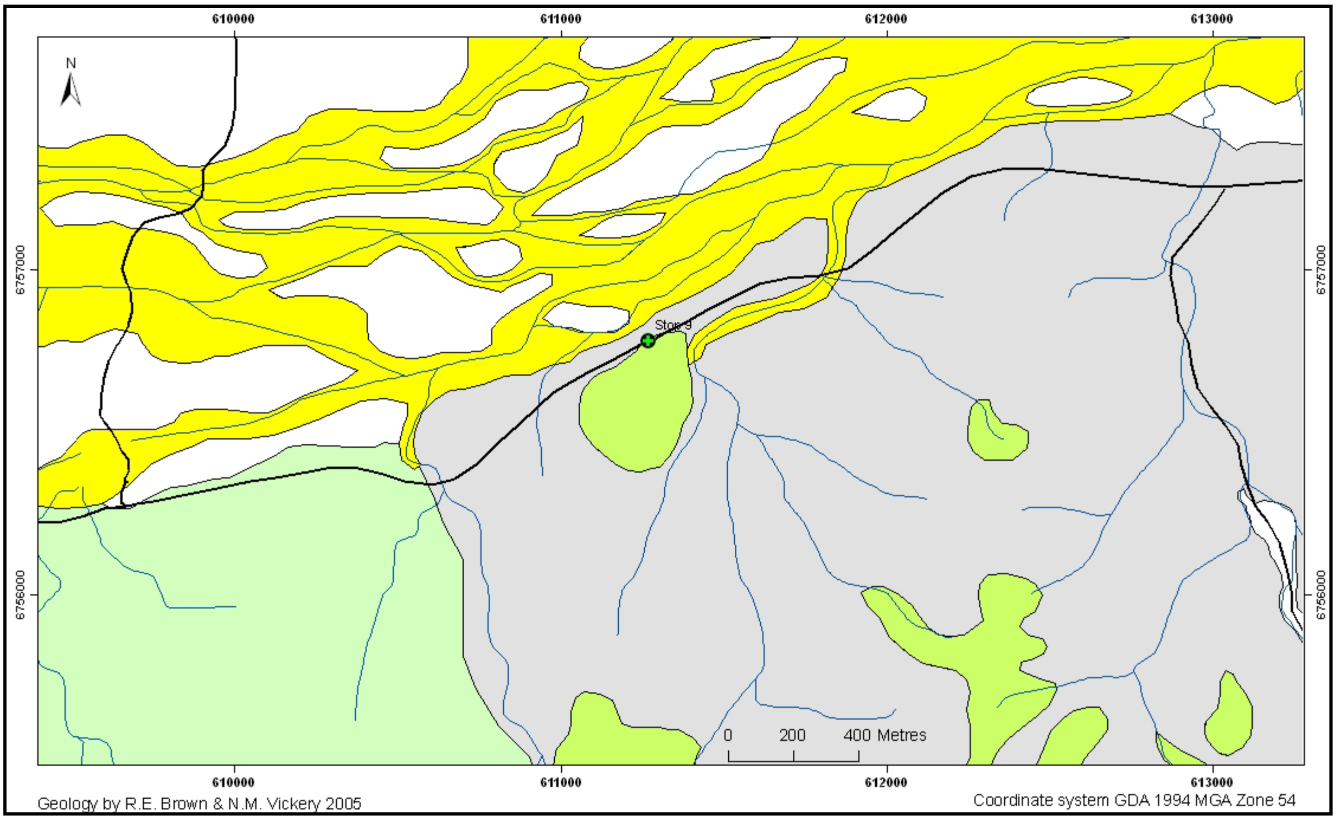
The view northward (Photo 8) shows a series of discontinuous escarpments which gradually curve around to the northwest. Note how the upper surfaces of the escarpments dip slightly towards the east. This is the manifestation of the Tibooburra dome by the Cordillo Silcrete. At Stops 15 and 16, on the opposite flank of the dome, you will note the opposite slope on the silcrete upper surfaces.

Photo 8. Silcrete-capped cordillos on the eastern flank of the Tibooburra dome.

As erosion has cut down into the silcrete, exposing the softer Cretaceous rocks beneath, cordillos and mesas have formed. The slope of the silcrete layer has resulted in erosion from the top of the dome outwards, creating extensive silcrete gibber plains in the wake of the retreating escarpments, and also down-slope of the cordillos.

To proceed to Stop 9, continue along the Mt Wood loop road for about 11.8 km. The road passes through more silcrete outcrops before dropping onto the gibber plane and paralleling Twelve Mile Creek. The track to Mount Wood on the southern side of the road can be taken for an additional view of the region’s landforms from the top of this prominent hill. Stop 9 is about 1.9 km past this turnoff and is marked by a large area of distinctive green-brown soil on the southern side of the track.

Stop 9. Weathered Cretaceous mudstone and gypsum veins. Grid reference MGA 611268 6756780, AMG 611146 6756603. See Map 8.



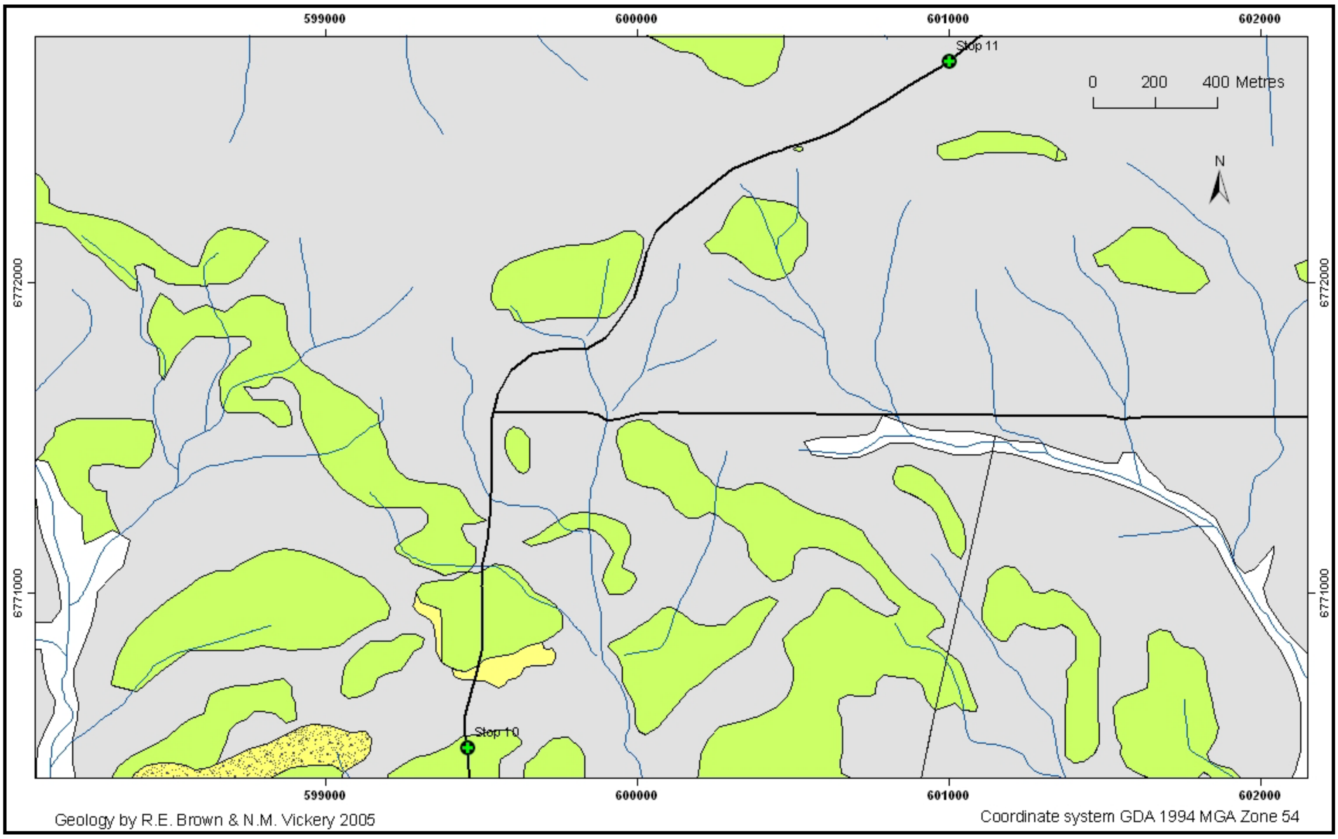
Map 8. Simplified geological map of the area about Stop 9. For key to units, see reference on page 3.

Many of the mudstones from the Cretaceous period were deposited in a shallow marine sea. The composition of the muds and the warm sea water were ideal conditions for the formation of the mineral *glauconite*, a soft, iron and potassium-rich mineral which is diagnostic of shallow marine environments. Glauconite is generally olive green to brownish-green in colour. It weathers to a dull green-brown colour on outcrop surfaces and in soils. We will examine glauconite-bearing sandstones at Stop 13.

Stop 9 demonstrates the weathering products of glauconitic mudstone. The brown, clayey soil is a thin veneer over these rocks, which are rarely present as outcrop. The soil is typically rich in *swelling clay*, a type of clay which responds to moisture by expanding. You will note that the soil is soft and easily compresses after being walked upon. This is also probably due to the presence of gypsum in the soil which disaggregates the clay and assists clayey masses and clods to break apart.

Colourless gypsum veins are also abundant at this site. Gypsum (calcium sulphate) is a common product of the arid weathering environment. Veins such as these have formed from the action of naturally occurring sulphuric acid upon calcium carbonate within the rocks. The acid has been produced from the weathering of pyrite in the marine mudstones, and the calcium carbonate is present as shelly fossil remains and calcite cement between grains. The presence of pyrite is an indicator of low oxygen levels in the sea water, probably due to limited water circulation such as can occur in sheltered lagoons and bays. Gypsum is the second softest mineral known and can be scratched by finger nail. Large deposits of this mineral are used for the production of plaster, soil conditioner and as a filler in paper, rubber and other products.

To travel to Stop 10, continue along the Mt Wood loop road until the intersection with the Silver City Highway. The journey to this point continues through rolling gibber plains and clay-rich alluvial flats. Turn northwards onto the highway for about 2.5 km, crossing Twelve Mile Creek. Take the eastern turnoff to Onepah and proceed for 7 km. Along the route you will pass through low outcrops of Cretaceous sandstone, some of which are associated with gypsum veins. Stop near the bend on top of the low hill, with outcrop on the western side of the road.



Map 9. Simplified geological map of the area about Stops 10 and 11. For key to units, see reference on page 3.

Stop 10. Weathered Cretaceous sandstone with spherical concretions. Grid reference MGA 599459 6770503, AMG 599337 6770326. See Map 9.

Some of the Cretaceous sandstone units in the Tibooburra area (such as the Coreena member; see page 3) are distinguishable throughout the region by distinctive spherical concretions (Photo 9). Concretions form by the nucleation of calcium or magnesium carbonate, silica or iron oxide about a grain in the rock. They proceed to grow concentrically outward whilst groundwater maintains a supply of the concretionary material. They range in size from microscopic to more than 1 metre diameter.

Photo 9. Spherical concretions weathered from Cretaceous calcareous sandstone.

The concretions exposed at this site are generally at least 20 cm diameter and show a series of cracks which commonly break the concretion into segments. They are carbonate and iron oxide concretions, commonly with bedding laminae preserved on the exterior surface (Photo 9). The concretions at this locality are particularly well formed, although the entire form of the concretion is concealed below ground. In some places the concretions have been eroded from the soil, forming bowling ball-like features. Blocks of sandstone excavated during cable trenching on the Silver City Highway show similar concretions within the host sandstone. Watch for these along the highway after Stop 13.

To proceed to Stop 10 continue along the Onepah road for approximately 3.1 km. Stop on the low rise with outcrop on the western edge of the road.

Stop 11. Cretaceous beach rocks. Grid reference MGA 601006 6772710, AMG 600884 6772532. See Map 9.

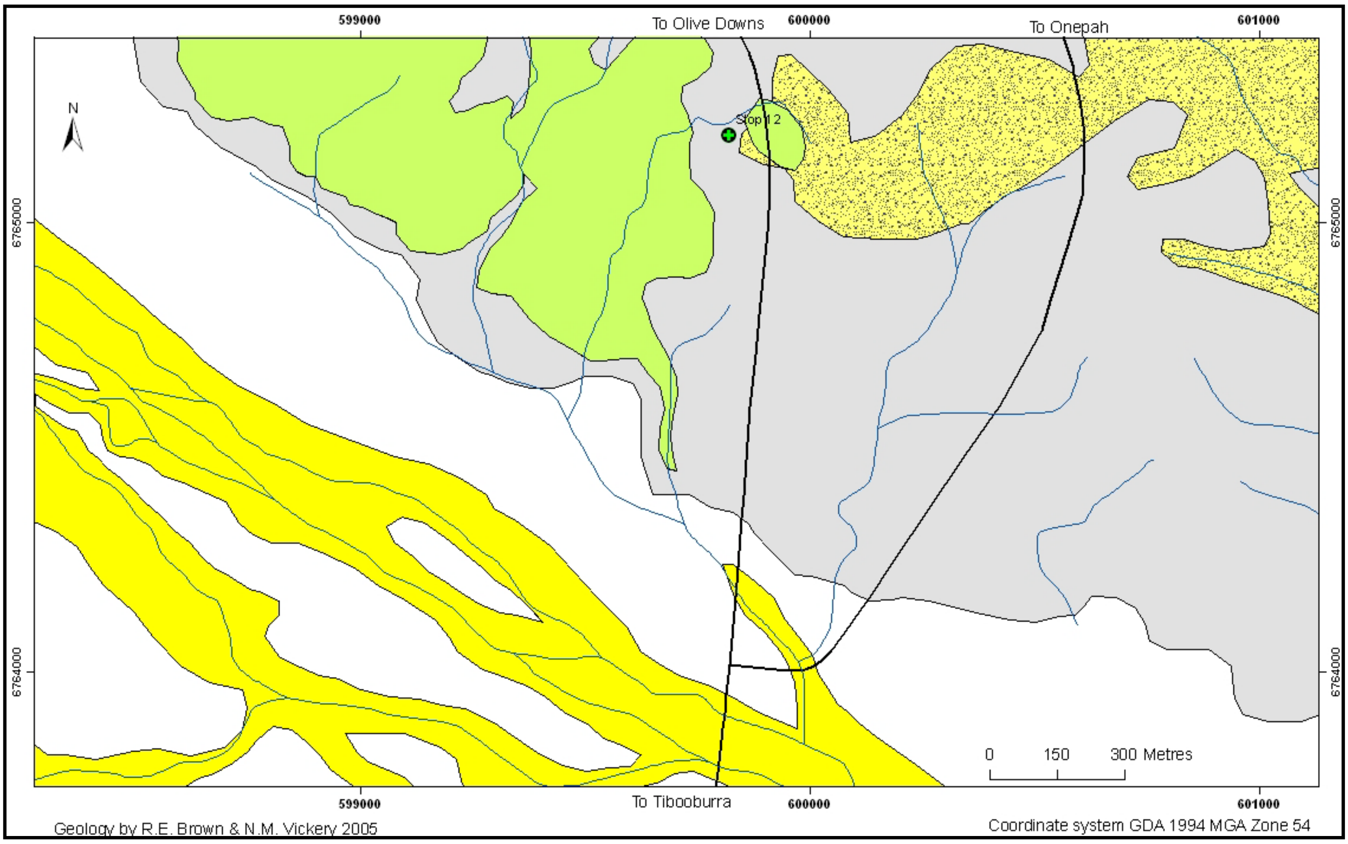
The shallow Cretaceous sea which had inundated inland Australia was prone to relatively rapid changes in depth and extent, probably to some degree as a result of the global cooling episodes prevalent throughout the Cretaceous. These changes in sea level resulted in the movement of the shoreline backward and forward for considerable distances across the shallow sea overlying the Tibooburra dome. Consequently it is not surprising that we encounter sands formed on a beach tens of kilometres into the sedimentary basin.

This site introduces Coreena member (see Reference, page 3) calcareous sandstones which were deposited on or very close to the shoreline. Some of the sandstones here contain millimetre-thick layers of heavy mineral sand grains, which include the minerals *magnetite* and *zircon*. An abundance of microscopic fish teeth were also found in these rocks. Magnetic data also show a continuous, narrow line of strongly magnetic rocks passing close to this site and extending further to the east and west. The high concentrations of magnetite sand in these rocks could be responsible for this magnetic feature. Such linear concentrations of heavy mineral sands are developed in some modern beaches, and were extensively mined along beaches in New South Wales and Western Australia. They are known as *strandlines*. The major Murray Basin heavy mineral sand mining operations are extracting similar minerals from Tertiary age, buried strandlines.

A careful search around this locality, and on the low hill to the west of here may reveal more rocks with significant amounts of magnetite and zircon sand.

To proceed to Stop 12, return to the Silver City Highway and turn north. Continue for about 1.2 km and stop on the western side of the sweeping bend.

Stop 12. Cretaceous beach rocks. Grid reference MGA 599821 6765196, AMG 599699 6765019. See Map 10.



Map 10. Simplified geological map of the area about Stop 12. For key to units, see reference on page 3.

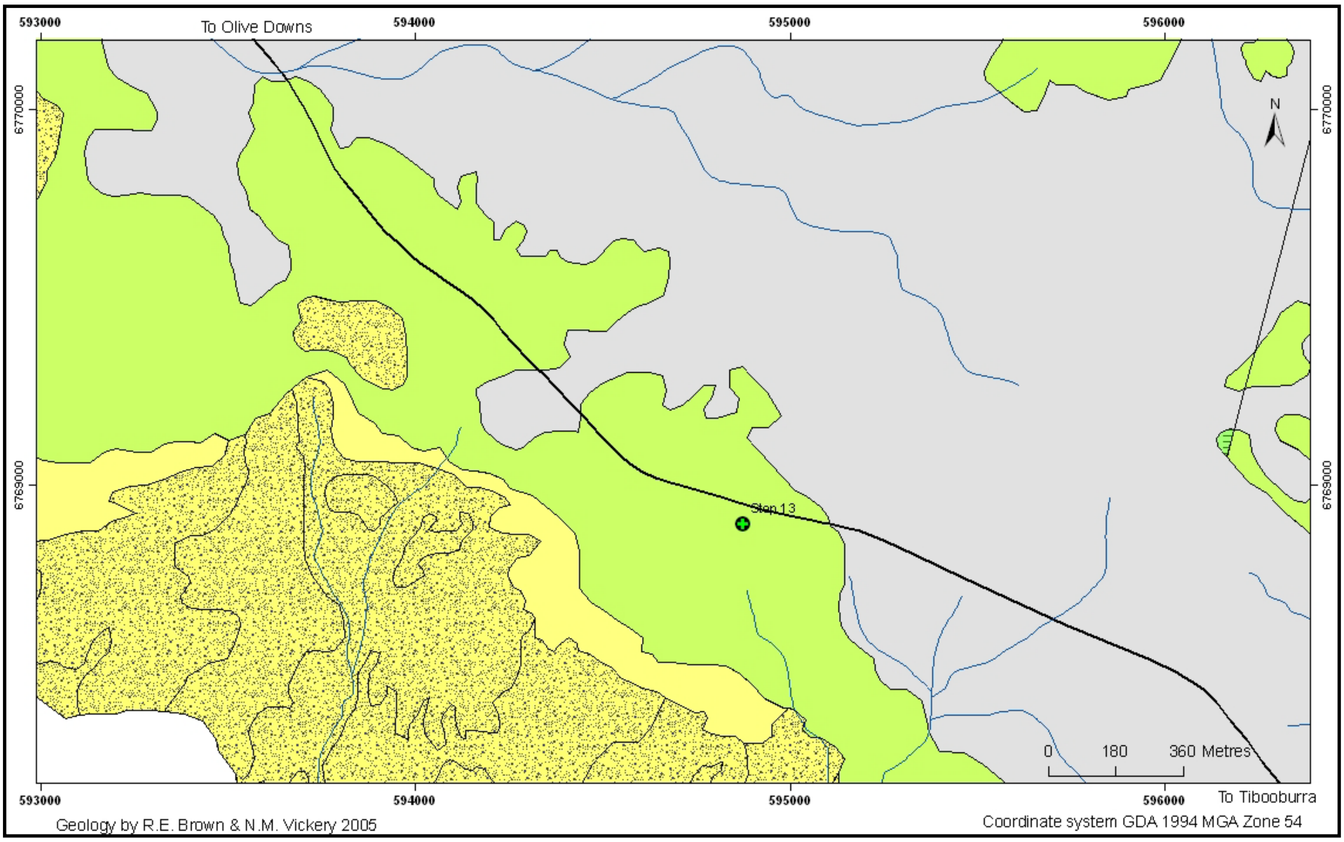
Recent cable trench excavations along the Silver City Highway north of Tibooburra have enabled a rare glimpse of fresh Cretaceous sedimentary rocks. At this locality the Coreena member sandstone is well bedded and contains abundant grazing trails left by seafloor-dwelling organisms. Please do not damage or remove any rock material. This rock was deposited in a shallow marine sea where shelly and soft bodied creatures would be expected in abundance. Explore the outcrops to the west of the road, noting the organism traces. Although shelly fossil remains have not been observed here, they occur abundantly in other localities, generally in calcareous mudstones which occur between the large sandstone beds.

Photo 10. Sinuous organism grazing trails along bedding plains in Cretaceous calcareous sandstone.

To proceed to Stop 13, continue along the highway for about 6.4 km, stopping on the crest of a low rise with abundant outcrop on the south side of the road.

Stop 13. Cretaceous marine sandstone. Grid reference MGA 594878 6768896, AMG 594756 6768719. See Map 11.

At this location, the best outcrop is to the west of the road on the small, but prominent rise. Outcrop here is similar to Stop 12, comprising sandstone deposited near the sea margin. Excavated boulders near the road edge will give you a rare view of the fresh, pale grey to pale blue sedimentary rock. However, exploring further to the southwest will give you an appreciation of how the rock was deposited.



Map 11. Simplified geological map of the area about Stop 13. For key to units, see reference on page 3.

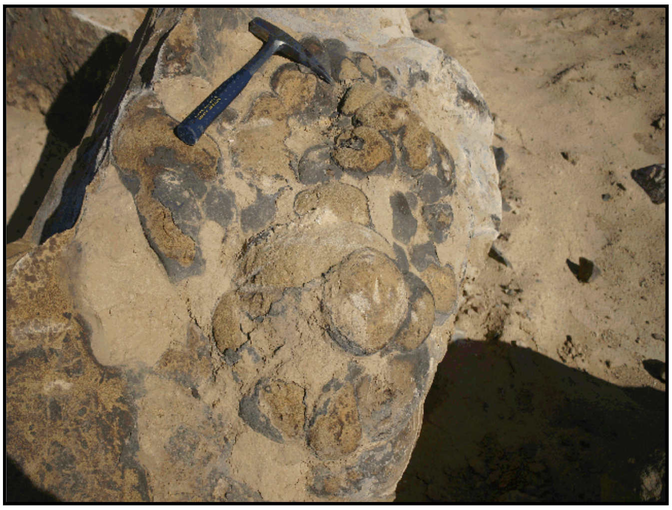


Photo 11. Spherical concretions such as these are common in many outcrops of the Coreena member.

Photo 12. Low, blocky outcrops of Coreena member sandstone. Note the green-brown exterior surface, due to the chemical weathering of glauconite.

Near the road side some of the excavated boulders show relatively fresh concretions similar to those examined at Stop 10. These concretions have not been eroded from the rock and are less distinct in outline. The fresh surfaces also show tabular blocks of mudstone which were incorporated into the sandstone when it was being deposited. The mudstone was deposited and subsequently ripped up, possibly by wave or current action. It was then intermixed with sand which was being transported by the same processes.

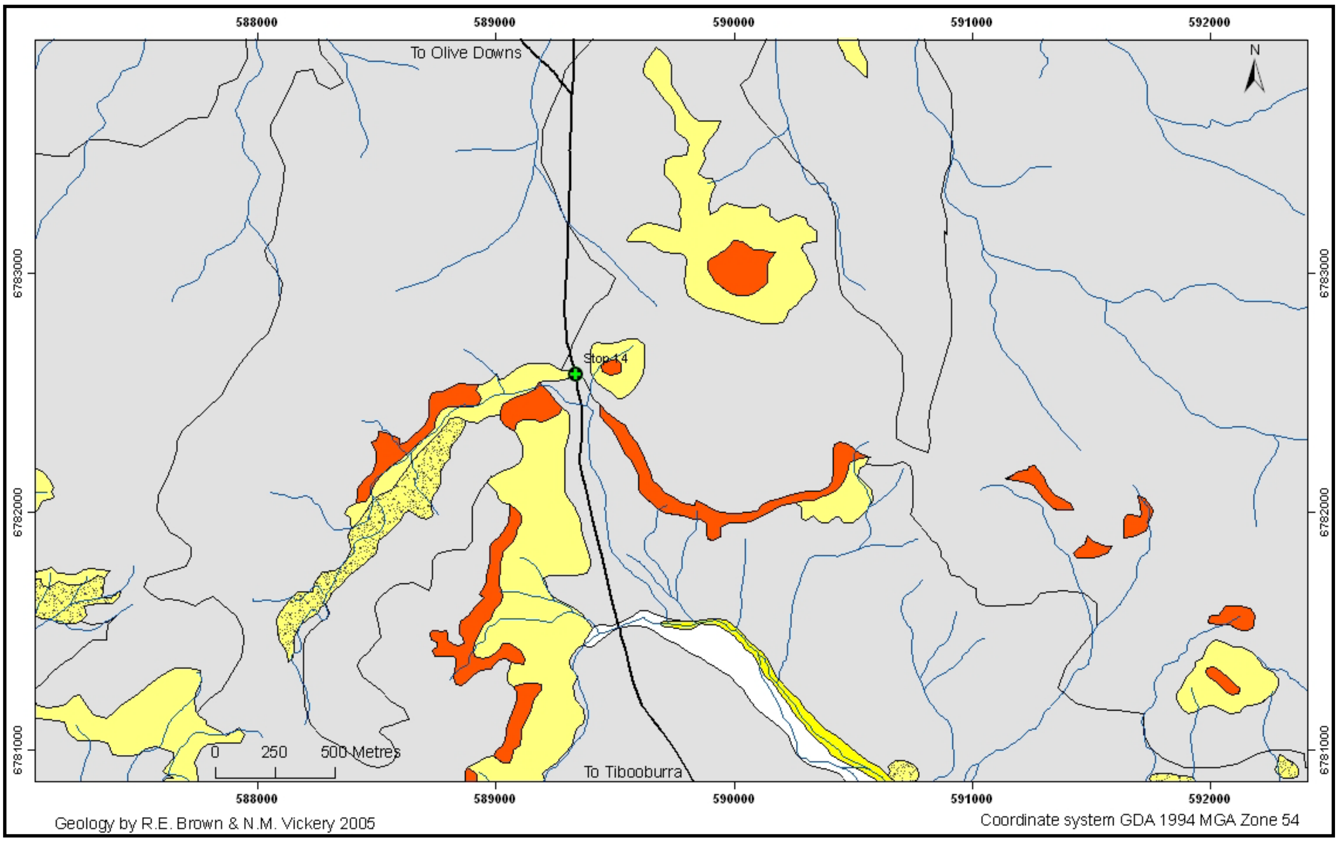
Prominent outcrops of well bedded sandstone and minor mudstone occur further to the southwest. Some of these rocks gently slope to the north and northwest, away from the Tibooburra Inlier and the centre of the Tibooburra dome. On some of the bedding surfaces at this location you will see more grazing trails. The dark green-brown colour of these outcrops (Photo 12) contrasts strongly with the pale blue grey fresh rock. This is due to the concentration of iron rich compounds during the weathering process. Some of this iron was produced from the chemical break down of glauconite (see Stop 9) which is abundant in these marine sandstones.

To proceed to Stop 14 continue along the highway for about 15.6 km. Along the way you will pass across low, rolling hills generally covered by silcrete gibbers. Small outcrops of Cretaceous sandstone will be seen sparsely on the hills. Most of these are similar to what was observed at Stops 12 and 13. A walk about the gibbers plain here may reveal occasional well rounded boulders of tough, very hard, commonly quartz veined, unusual rocks. These are ice rafted glacial boulders (*glacial erratics*) which were transported by pack ice across the Cretaceous sea and dropped onto the sea floor after thawing. The boulders can be rarely observed within outcrops of the Cretaceous sedimentary rocks from which they have eroded, remaining on the ground surface amongst the gibbers.

Stop 14. Silcrete-capped cordillos. Grid reference MGA 589339 6782581, AMG 589217 6782404. See Map 12.

At this location the Silver City Highway cuts the Grey Range. Drive to the top of the mesa and park on the side of the road. From this point you will

Photo 13. Silcrete-capped cordillos. Note the typical scree of white, weathered Cretaceous rocks beneath the silcrete as examined at Stop 2.



Map 12. Simplified geological map of the area about Stop 14. For key to units, see reference on page 3.

see spectacular *jump-ups* (cordillo escarpments), so unique to the Corner Country. The cordillos are capped by silcrete, the upper surface of which can be seen sloping at a low angle away from Tibooburra. This demonstrates that we are on the opposite flank of the Tibooburra dome from Stop 8, where the silcrete layer could be seen sloping to the east.

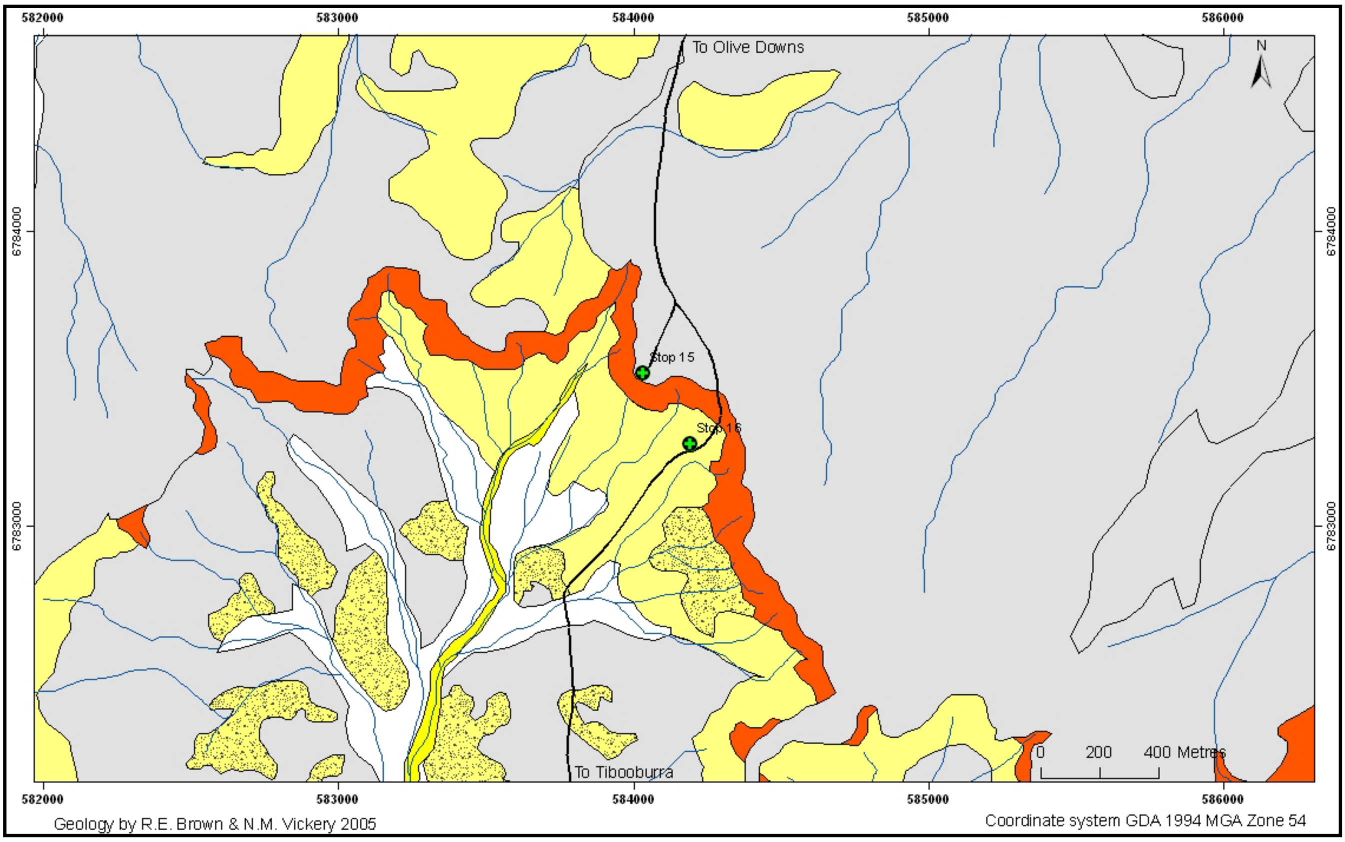
Many cordillo escarpments show a white scree slope extending down slope from the base of the silcrete layer (Photo 13). This white rock is deeply weathered Cretaceous sedimentary rock, similar to that examined at Stop 2. This demonstrates the regionally widespread weathering surface and unconformity which is developed beneath the silcrete.

To proceed to Stop 15, continue along the highway, then take the turnoff to Olive Downs. About 500 m before reaching Olive Downs homestead, turn onto the road heading south. Proceed along this for about 2.5 km. Turn onto the track which leads to the Olive Downs lookout and follow it to the end.

Stop 15. Olive Downs Lookout. Grid reference MGA 584033 6783519, AMG 583911 6783342. See Map 13.

This is a spectacular location from which we can observe many geological features. The most prominent feature of course, is the jump-ups, preserved by the hard, resistant capping of Cordillo Silcrete. Once again you will notice the bleached layer below the cream to orange/brown silcrete cap (Photo 14). The bleached surface is irregular and on the margins of the mesas to the southwest, there is a distinct layering. These bleached rocks are highly weathered Cretaceous sedimentary rocks and the layering is bedding. They were strongly weathered and bleached before the younger, Tertiary Eyre Formation was deposited on them, and then preserved by the later silcrete alteration of the Eyre Formation. The jump-ups therefore record a prolonged geological history consisting of:

1. Deposition of sand, silt and clay during the Cretaceous in a shallow marine to freshwater environment
2. Uplift and erosion of these sediments about the uplifting Tibooburra dome
3. Deposition of sands (the Eyre Formation) by extensive river systems during the Tertiary period
4. Formation of silcrete by silica replacement of the Eyre Formation
5. Continued uplift and erosion on the Tibooburra dome.



Map 13. Simplified geological map of the area about Stops 15 and 16. For key to units, see reference on page 3.

Photo 14. A silcrete-capped cordillo underlain by bleached Cretaceous sedimentary rocks. Note the layering within the Cretaceous rocks and the slope of the silcrete surface away from the Tibooburra dome.

Photo 15. View of gibber plain below showing a well developed alluvial fan of bleached Cretaceous rock, and areas of brown ironstone produced by weathering of the underlying Cretaceous rocks.

By examining the plain to the southwest you can see jumps-ups to the east and west forming the Grey Range with a large, flat alluvial system in the foreground. Note the network of dry creeks and the characteristics of the material that is being washed into them. The creek beds are pale due to the weathered Cretaceous sedimentary rocks eroding from the margins of the jump-ups. You'll also note areas with a veneer of dark chocolate brown material. This is a common feature and is made up of iron oxide rock which generally accompanies the unconformity between the Cretaceous and Tertiary sedimentary rocks. The pale orange brown plains are composed of silcrete gibbers derived from the erosion of the Cordillo Silcrete.

To proceed to Stop 16, return to the road and turn southward. Continue for about 500 m.

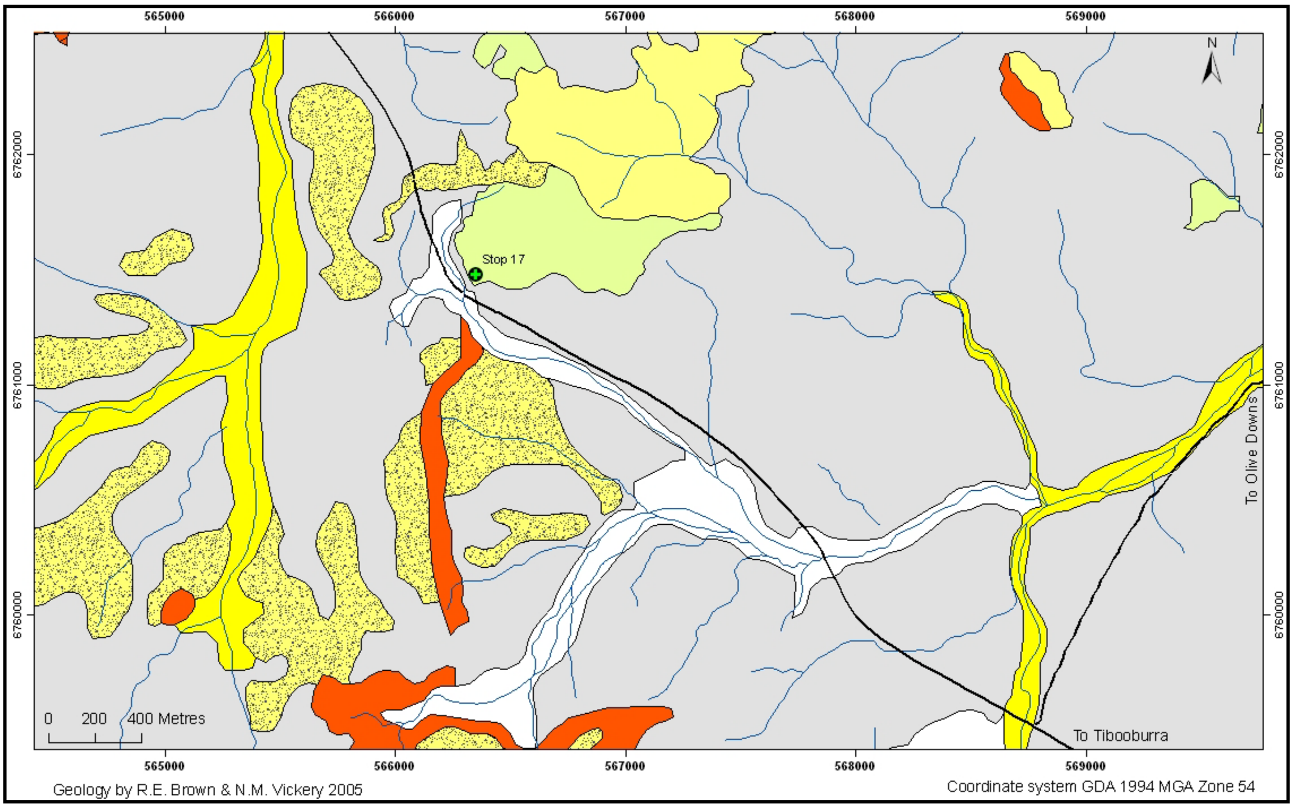
Stop 16. Base of escarpment. Grid reference MGA 584193 6783280, AMG 584071 6783103. See Map 13.

From the foot of the escarpment you can get a good look at the slightly inclined layering of the strongly bleached Cretaceous sedimentary rocks, and the overlying orange/brown Cordillo Silcrete. Towards the lookout the escarpment has been deeply incised into the soft, strongly weathered Cretaceous rocks. The abundant gibbers of resistant, hard silcrete on the ground about you have been formed by the erosion and retreat of the cordillo escarpment.

Photo 16. Cordillo escarpment capped by silcrete and underlain by bleached, weathered Cretaceous rock.

To proceed to Stop 17, continue southward along the road. At 5.9 km you will encounter an intersection – take the road to the southwest and follow this until it intersects the Cameron Corner Road about 25.2 km further. At this intersection turn west and continue for 3.2 km. Along the route you will observe many cordillo escarpments and parallel an attractive gum-lined watercourse.

Stop 17. Low, brown silcrete escarpment. Grid reference MGA 566351 6761481, AMG 566228 6761304. See Map 14.



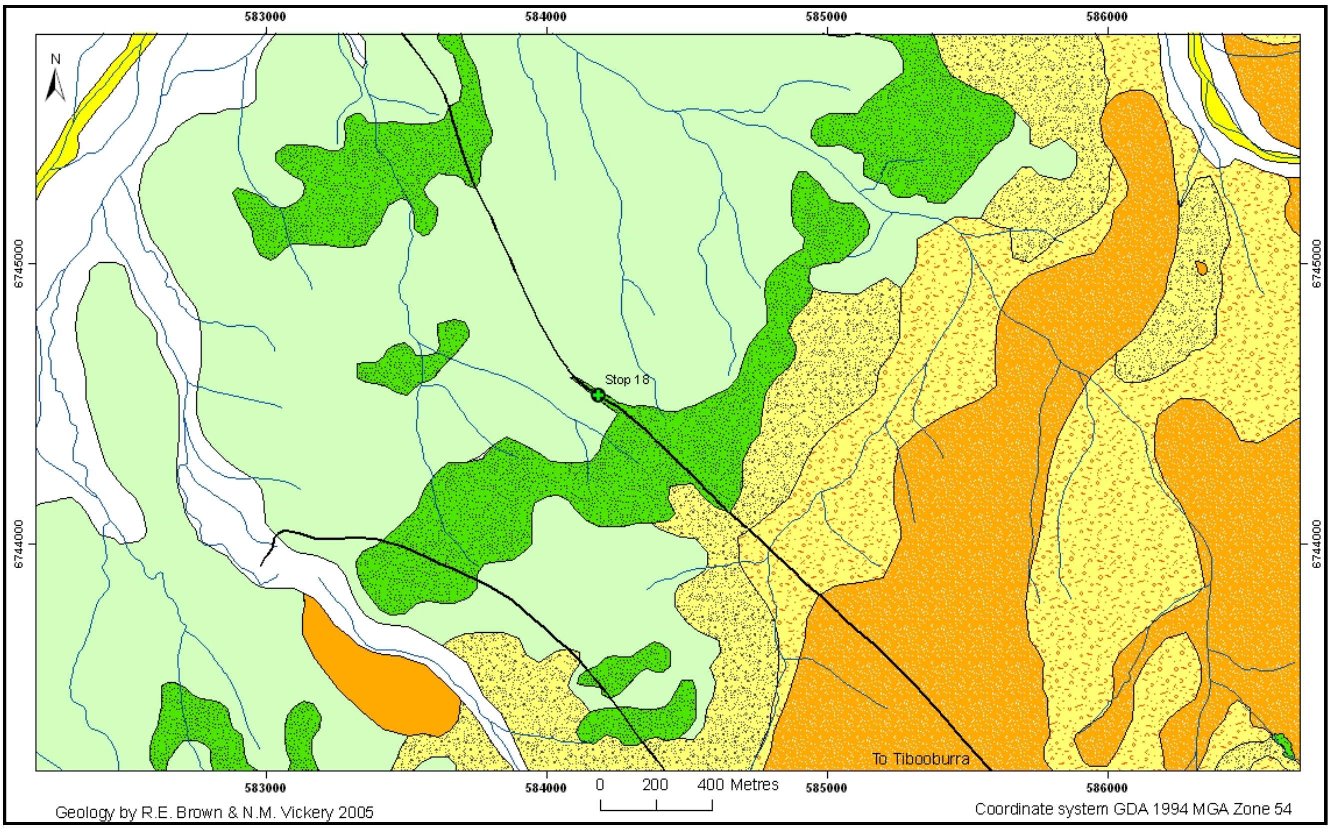
Map 14. Simplified geological map of the area about Stop 17. For key to units, see reference on page 3.

Here the Cameron Corner road intersects the Grey Range. Note the difference between this locality and the previous one, where we intersected the Grey Range to the north. Here the jump-ups are much more subdued. The tops of the mesas comprise earthy orange brown silcrete. If you look around the hills, you will see small columns of tough rock which are blocky and comprise coarse fragments of the same material. This silcrete is probably equivalent to the pebbly silcrete examined at Stop 7 on the opposite flank of the Tibooburra dome.

To proceed to Stop 18, return to the east along this road towards Tibooburra for about 25.3 km, stopping near the top of the low outcrop-covered hill. As you head back towards Tibooburra, you are going down sequence within the Cretaceous rocks, that is, from youngest rocks (away) to oldest rocks near Tibooburra.

Photo 17. Brown, pebbly silcrete capping a low escarpment.

Stop 18. Pebbly Cretaceous sandstone. Grid reference MGA 584186 6744530, AMG 584064 6744353. See Map 15.



Map 15. Simplified geological map of the area about Stop 18. For key to units, see reference on page 3

At Stop 18 you will see rocks of the Cadna-owie Formation, which are older than the Coreena member that we saw in stops 12 and 13 (see reference, page 4). The Cadna-owie Formation contains a distinctive, quartz pebble marker bed which is exposed at this site, forming a small rise. Distinctive units such as this are valuable to geologists as they form a unique rock type amongst otherwise similar rocks, and can therefore be used in correlations throughout the region. This unit mainly comprises pebbles of white and blue quartz (Photo 18). The quartz is derived originally from quartz veins within the Cambrian rocks in the Tibooburra inlier (see Tibooburra inlier tour). The quartz pebbles are supported by a sandy matrix with a calcium carbonate cement. Minor rounded rock fragments are also present within this rock and these are probably Cambrian rocks from the Tibooburra inlier. The Cadna-owie Formation and its distinctive conglomerate were deposited in a shallow marine environment, and organism grazing trails occur on some bedding planes.

This is the completion of the tour. To return to Tibooburra, follow this road to the east. We hope that you have learned something about the rocks of this area, and have enjoyed the magnificent arid zone scenery of this part of Australia. We welcome any feedback you wish to contribute to improve this tour.

Photo 18. The distinctive quartz pebble conglomerate marker bed within the Cretaceous Cadna-owie Formation.