

GEOLOGICAL TOUR OF THE TIBOOBURRA INLIER AREA

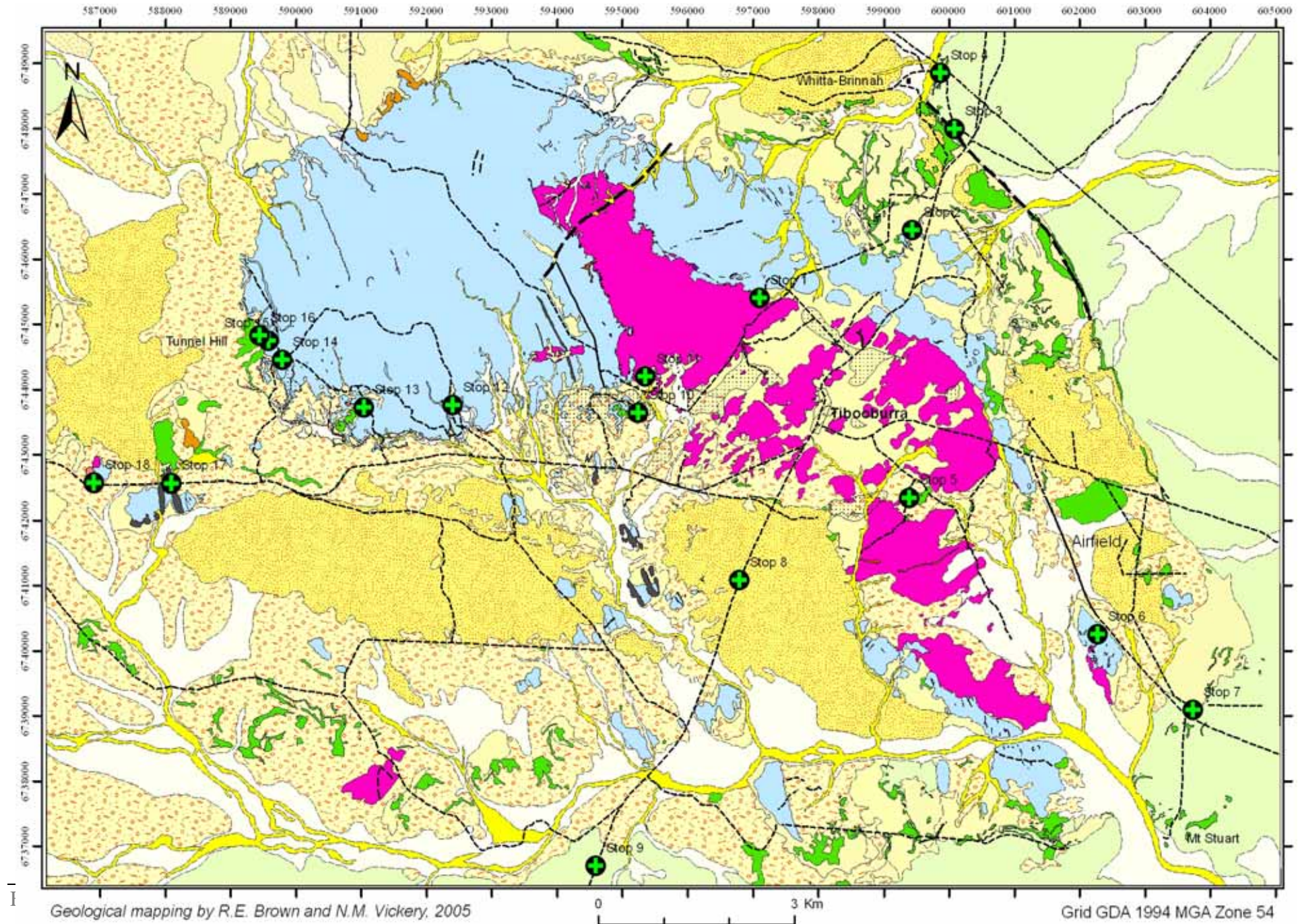
The village of Tibooburra is situated in the far northwest corner of New South Wales. Tibooburra owes its origin to the discovery of alluvial gold during the 1880s at the foot of the low ridges mainly to the west of the town. The gold was probably sourced from quartz reefs which were eroded away millions of years ago. The reefs would have been present in the ancient rocks which make up the ridges. These ancient rocks are surrounded and overlain by much younger rocks. In geological terms an area of older rocks which appear from beneath younger strata is known as an *inlier*.

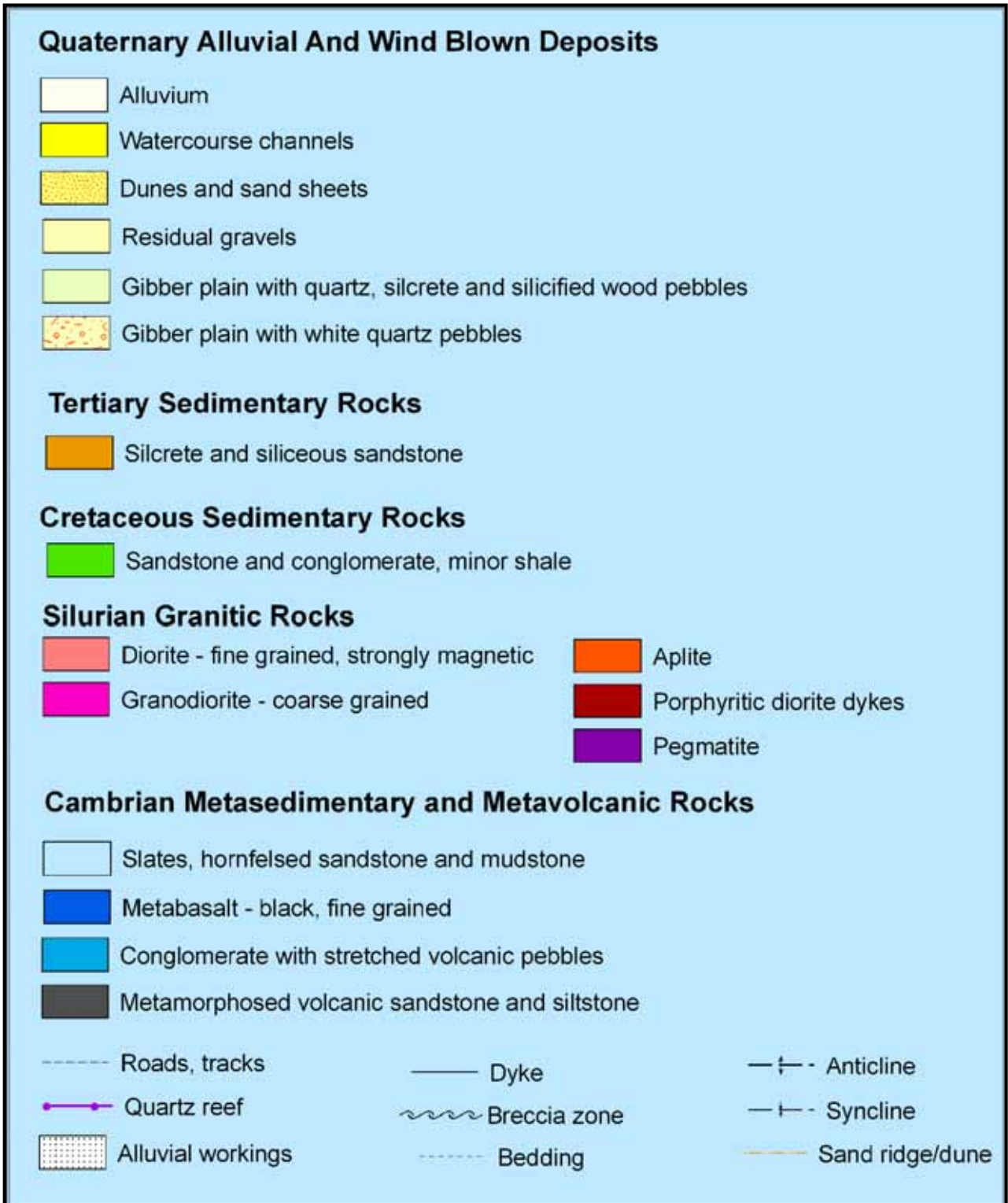
This geological tour is aimed at showing you some of the interesting ancient rocks which make up the Tibooburra inlier. You will also examine some of the younger rocks and the significant geological units which make up the youngest parts of the landscape, and placing everything into a geological time frame. From the 496 million year old sedimentary and volcanic rocks, through the 421 million year old granitic rocks to the gibber plains and sand dunes, the Tibooburra area holds a fascinating, varied and dramatic geological history.

Most of the stops on this tour can be visited by conventional two wheel drive vehicle. Some will require four wheel drive, and these are appropriately noted. A few will also require short walks up to 400 metres. 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.

The stops are situated in private land, the Sturt National Park, and the Tibooburra Common. Please only drive on formed roads and tracks, and don't travel on tracks where access is prohibited (mainly in the National Park). Some outcrops are unique so please don't damage them.

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





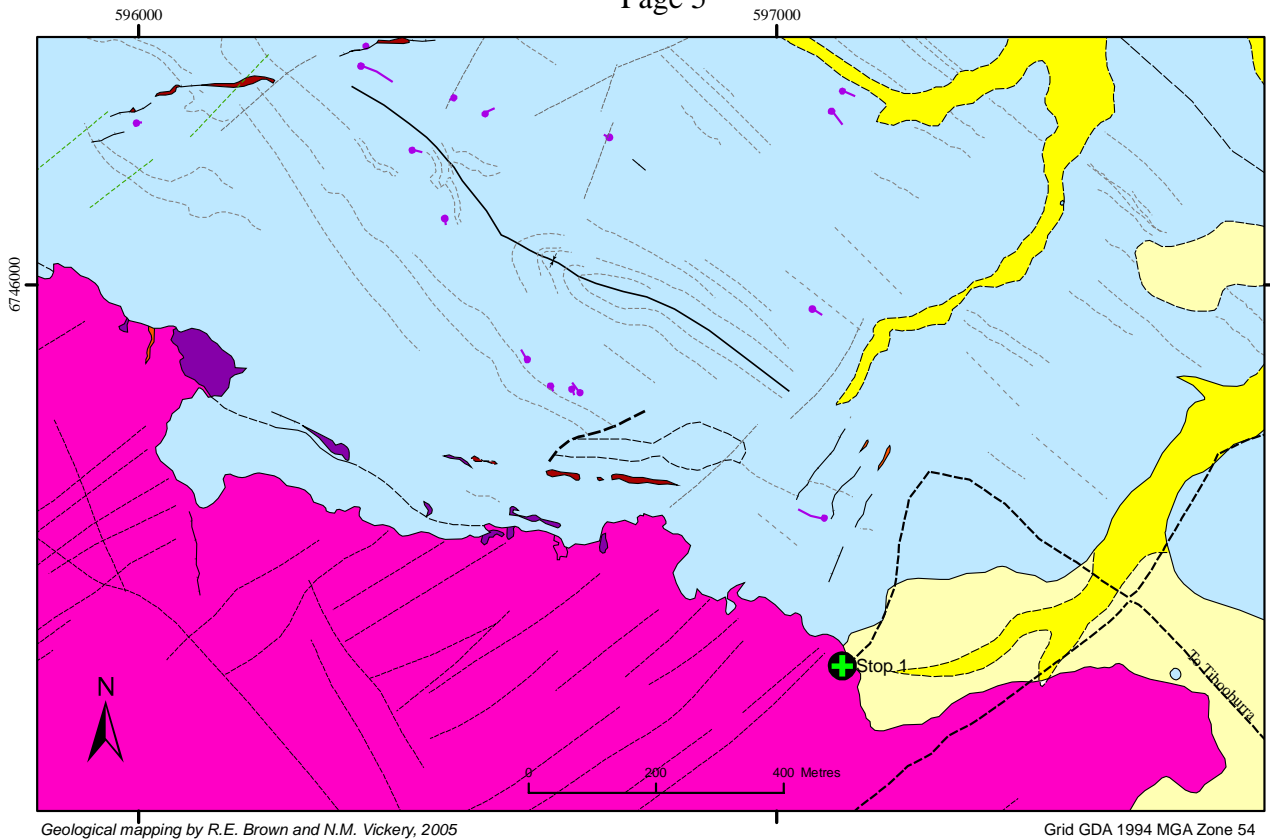
SIMPLIFIED GEOLOGICAL HISTORY OF THE TIBOOBURRA REGION

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. Dead Horse Gully camping area. Grid reference MGA 597102 6745403, AMG 596980 6745226. Granite margin walk.

The National Parks and Wildlife Service have developed a walking track from this site. Using a combination of that track and the accompanying geological map you can examine the characteristics of the *Tibooburra Granodiorite*, its accompanying aplitic, pegmatitic and dioritic intrusions, the irregular margins of the granodiorite body, and the metamorphosed (i.e recrystallised and altered) sedimentary rocks which were intruded by the granodiorite.

The rocks to be seen on this walk include a variety of folded Late Cambrian sedimentary rocks (pale blue on map), the main granodiorite intrusion and a range of smaller intrusions which have accompanied the granodiorite. We can examine some of the features in the sedimentary rocks which demonstrate that they have been strongly heated and recrystallised by the granodiorite during its intrusion.



Map 1. Geological map of the Stop 1 area. For key to geological units, see page 3.

The Tibooburra Granodiorite is the main rock type present in the Tibooburra village area. It forms prominent tors which are resistant to weathering and erosion. The granodiorite is made up of common minerals including quartz, feldspar, black flakes of biotite and black hornblende. It commonly includes small to large, dark coloured blocks of a different igneous rock type which are known as *enclaves* (Photo 1). These enclaves are remnants of the original rocks from which the granodiorite was produced. The granodiorite was formed deep in the crust from the melting of rocks under intense heat and



Photo 1. A tor of Tibooburra Granodiorite cut by a narrow aplite dyke. Note the presence of dark blocks or *enclaves* within the granodiorite. Also note the typical *onion skin* weathering of the tor.



Photo 2. Outcrop of dacite dyke. Note the large, white feldspar crystals in this otherwise dark rock.

pressure. The melted rock mass moved towards the surface as an *intrusion* and probably ceased its movement many kilometres below ground level. During this time the heat from the granodiorite effected the rocks around it (the process of *metamorphism*), producing new minerals and generally toughening the rocks into blocky *hornfels*. Microscopic zircon crystals were separated from the granodiorite and used for age dating the time of crystallisation at 421 million years ago (i.e. the *Silurian* period).



Photo 3. Aplite comprising fine grained feldspar and quartz.



Photo 4. Pegmatite comprising yellow feldspar, white quartz, mica and black tourmaline.



Photo 5. Spotted hornfels showing distinctive cordierite spots.

During the long, slow cooling process whilst the granodiorite was becoming crystalline, some of the remaining molten material was squeezed out from the crystalline rock to form dykes of diorite, aplite and pegmatite. Most of these occur within the margins of the granodiorite and in the nearby metamorphic rocks (see Map 1). Several narrow bodies of diorite can be observed on the walk, always within the metamorphic rocks. The diorites are dark coloured and contain large feldspar crystals (Photo 2). Dykes and small bodies of aplite and pegmatite occur both within the edges of the granodiorite and in the metamorphic rocks. You should encounter a number of these rock types on the walk. Aplite is a fine grained, white to pale yellow rock made up of quartz and feldspar (Photo 3). Pegmatite is a very coarse grained white to yellow rock made up of large feldspar crystals, quartz, muscovite mica and locally, aggregates of black tourmaline (Photo 4).

The metamorphosed sedimentary rocks were deposited deep in the ocean during the *Cambrian* period. Microscopic zircons separated from a volcanic rock were used to determine an age of crystallisation of 496 million years ago. We know that the rocks were deposited in a deep sea from the original structures preserved within them, all of which indicate deposition deeper than a modern continental shelf (i.e. much greater than 200 metres). Periodic seismic

activity probably triggered submarine avalanches from the continental shelf, resulting in the production of rare conglomerates (see Stop 12) and volcanic sandstones (see Stop 17). The sedimentary rocks have been significantly metamorphosed by the granodiorite, with metamorphic effects diminishing away from the intrusion. Some of the most obvious metamorphic effects are the production of prominently outcropping hornfelses, commonly with salmon-coloured sandstones (Photo 5), and the production of *spotted hornfelses*, the spotting being due to the presence of the metamorphic mineral *cordierite*.

To travel to Stop 2 return to the main road and turn left. Proceed for about 2.2 km north.

Stop 2. Escarpment and unconformity. Grid reference MGA 599447 6746442, AMG 599325 6746265.



Map 2. Geological map of the Stop 2 area. For key to geological units, see page 3

This site allows you to examine the contact between the sedimentary rocks of Cretaceous age (shown in green, see legend page 3, and geological history table page 4) and the Cambrian metamorphic rocks (shown in pale blue) we were introduced to in Stop 1. We will also have the opportunity to examine some of the fascinating ironstone *concretions* that are generally present near this contact.

From the foot of the escarpment on the western side of the road we find Cambrian slates which show evidence of prolonged weathering in a wet environment. This is indicated by the crumbly and often bleached character of the slates. This weathering took place during and before the deposition of the Cretaceous sedimentary rocks which crop out near the top of the escarpment. From the geological history of the region (page 4) we know that there was a period of more than 300 million years between the deposition of the Cambrian rocks and the time of deposition of the Cretaceous strata in what is known as the *Eromanga Basin*. During the Jurassic and Cretaceous it is apparent that there was an abundance of groundwater to produce deep, widespread weathering of the older rocks, conditions very much different to those about Tibooburra today. Also note that the Cambrian rocks are somewhat different here to those seen at Stop 1. This is partially due to the distance we have travelled from the Tibooburra Granodiorite, whose metamorphic effects have not been influential here.

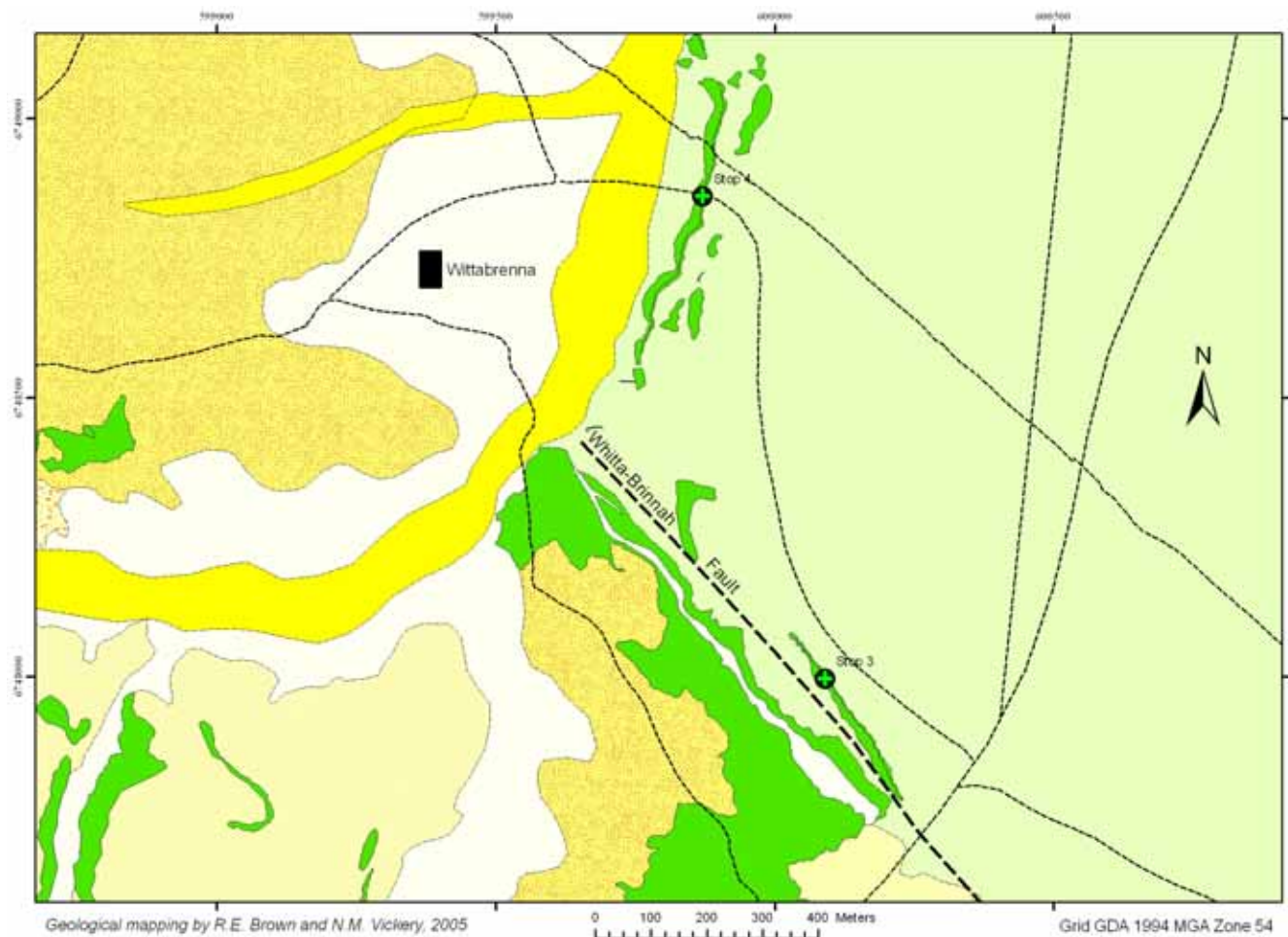
As you climb the escarpment you will find fragments of rusty brown ironstone concretions. The concretions are rocks which have formed by movement of groundwater along fractures, faults and other cracks in the metamorphic rocks. Some concretions have formed in the Cretaceous sedimentary rocks, and these are generally thicker and commonly have internal, open voids. Rarely you may encounter somewhat rounded, smooth concretions which have an internal rattle when shaken. These can be found in a number of localities throughout the region, and are locally known as *rattle rocks*. At

this site most rattle rocks occur on the top of the escarpment, near its edge.

Toward the top of the escarpment the lowermost Cretaceous rocks are exposed. These are sandstones and conglomerates. The contact between the Cretaceous and Cambrian rocks is known as an *unconformity*. The unconformity represents the local Cretaceous land surface upon which creeks and rivers transported and deposited sand and gravel 145 million years ago, and which was subsequently buried by marine sands as the sea level rose. We will examine some of those marine rocks in the next two stops.

To travel to Stop 3, continue north along the main road for about 1.7 km to the Whitta-Brinnah track on the left of the road. Proceed along the track for about 260 m.

Stop 3. An example of young fault movement. Grid reference MGA 600091 6747994, AMG 599969 6747817, access track to Whitta-Brinnah homestead.



Map 3. Geological map of the Stops 3 and 4 area. For key to geological units, see page 3

This site provides evidence for relatively recent fault movement in the region. We know that there are a number of major faults in the Tibooburra-Milparinka area which show evidence for repeated movement since the Cretaceous. This evidence includes greatly tilted Cretaceous rocks, successively elevated erosion terraces along the fault escarpments (where present), and veins emplaced adjacent to the faults within Cretaceous rocks. At this stop we will view some tilted Cretaceous sandstones.

As you will come to appreciate from examining Cretaceous rocks in subsequent stops, the Cretaceous strata generally preserve their original horizontal character. As we will demonstrate on the regional geological tour, most Cretaceous rocks in fact are inclined very slightly away from the Tibooburra inlier. However, when we find Cretaceous rocks with a relatively steep incline we can assume that fault movement has been responsible for the tilting. By mapping out the occurrence of tilting and other fault indicators such as veining and intense fracturing, we can deduce the orientation and approximate position of the fault.

At this locality we can observe moderately steeply inclined Cretaceous sandstones. This inclination is known as the *dip* of these rocks. The sandstones dip at about 45 degrees. We have plotted the probable position of the fault on the geological map shown in Map 3.

To proceed to Stop 4, continue along the track for about 900 metres. Stop where the sandstone outcrops cross the track.

Stop 4. Typical marine Cretaceous sandstone and conglomerate. Grid reference MGA 599871 6748861, AMG 599749 6748684, access track to Whitta-Brinnah homestead.

After the initial period of deposition on land during the Cretaceous, the area was largely submerged



Photo 6. Cretaceous marine sandstone and quartz-pebble conglomerate. Note the uniformly fine grained sand, and the presence of calcium carbonate cement.



Photo 7. Cretaceous marine sandstone and quartz-pebble conglomerate with a large ice rafted pebble.

beneath a shallow marine sea. As we will see at Stop 15, the sediments deposited on land comprised distinctive, fine to coarse grained gravels and pebble-rich sands. By contrast, the sediments deposited in the ocean were much like we see on our beaches: fine grained sands with rare gravels (Photo 6).

At this site you can examine sandstones typical of the influence of the early marine sea. Note the relatively even grainsize range of the sand grains. This is known as a *well sorted* sandstone, meaning that the sand was deposited in an environment which concentrated grains of a similar size. A shallow marine environment typically produces well sorted sediments. On the other hand, many non-marine (land) environments produce poorly sorted sands and

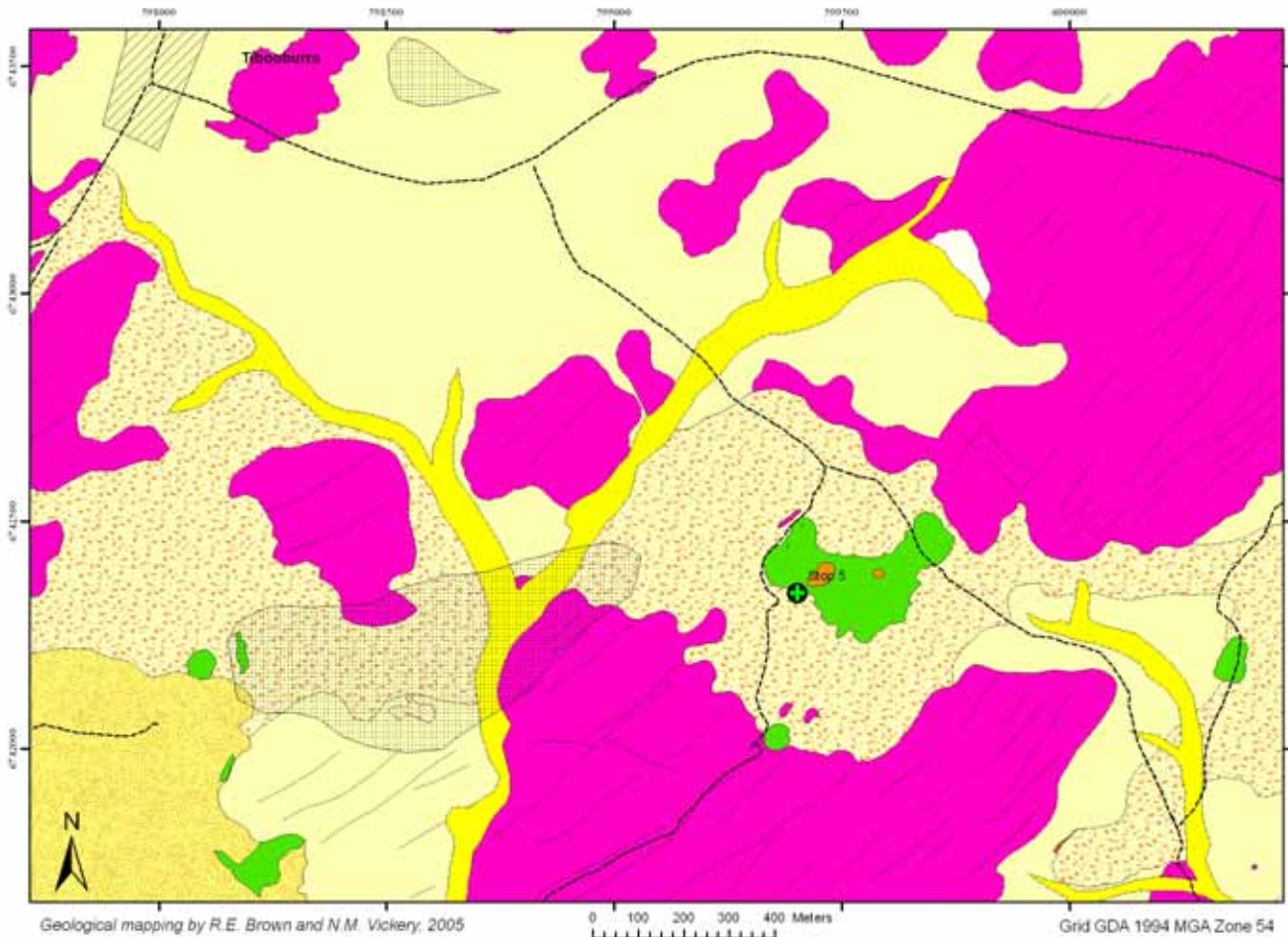
gravels, such as we will see at Stop 15. You can observe this in the sandy creeks about Tibooburra, where in most parts of the creeks there are various mixtures of sand and gravel-size materials.

During the early part of the Cretaceous the region was experiencing polar conditions, with glaciers active in South Australia and possibly New South Wales. Drifting ice was common, carrying glacial outwash and other trapped sediment. As the ice melted the encased sand, gravel and boulders dropped to the sea floor where they were buried. Erosion has revealed some of the ice rafted cobbles and boulders (Photo 7). They are identifiable because the rock types are noticeably foreign to this region and are much coarser than the

surrounding sand or gravel. Some rock types have been correlated with similar rocks in the Cobar region, suggesting ice rafting over many hundreds of kilometres! If you carefully search around this site, particularly walking over the quartz pebble gibber plain, you may find some of these ice rafted rocks which appear as unusual, often dark coloured, large cobbles and boulders.

To travel to Stop 5, return to Tibooburra and turn on to the Wanaaring Road. Travel along this road for about 900 metres. A dirt track, which is not suitable for some conventional vehicles, is evident on the southern side of the road. Travel along this track for 1.3 km (see Map 4). Stop at the foot of the abrupt hill.

Stop 5. A different unconformity – Tertiary strata overlying Cretaceous rocks. Grid reference MGA 599401 6742340, AMG 599279 6742163.



Map 4. Geological map of the area about Stop 5. For key to geological units, see page 3.

The Tibooburra region includes several major unconformities. The Cretaceous-Cambrian unconformity was viewed at Stop 2. At this stop we will examine one example of the unconformity between rocks of the Tertiary and Cretaceous periods. Another example of this unconformity will be viewed on the Tibooburra region excursion.

Following the retreat of the Cretaceous ocean from this part of the continent, the region has been subjected to land-based depositional processes (see table, page 4). In some places large thicknesses of the Eromanga Basin Cretaceous rocks were eroded during the 40 million years preceding the development of the next major depositional basin, the *Lake Eyre Basin*. Sedimentation commenced in the lake Eyre Basin about 60 million years ago, at a time when most of the continent was experiencing tropical conditions involving high temperatures and wet conditions. This environment resulted in deep weathering of the surface rocks, associated with large rates of erosion from the basin margins, and consequently large amounts of sediment deposited in the basin. Exposure of the sandy and gravelly rocks to large groundwater movements resulted in the precipitation of large amounts of quartz (the process of *silicification*) in some rocks to produce *silcretes*. Silcrete will be examined in the Tibooburra region excursion.

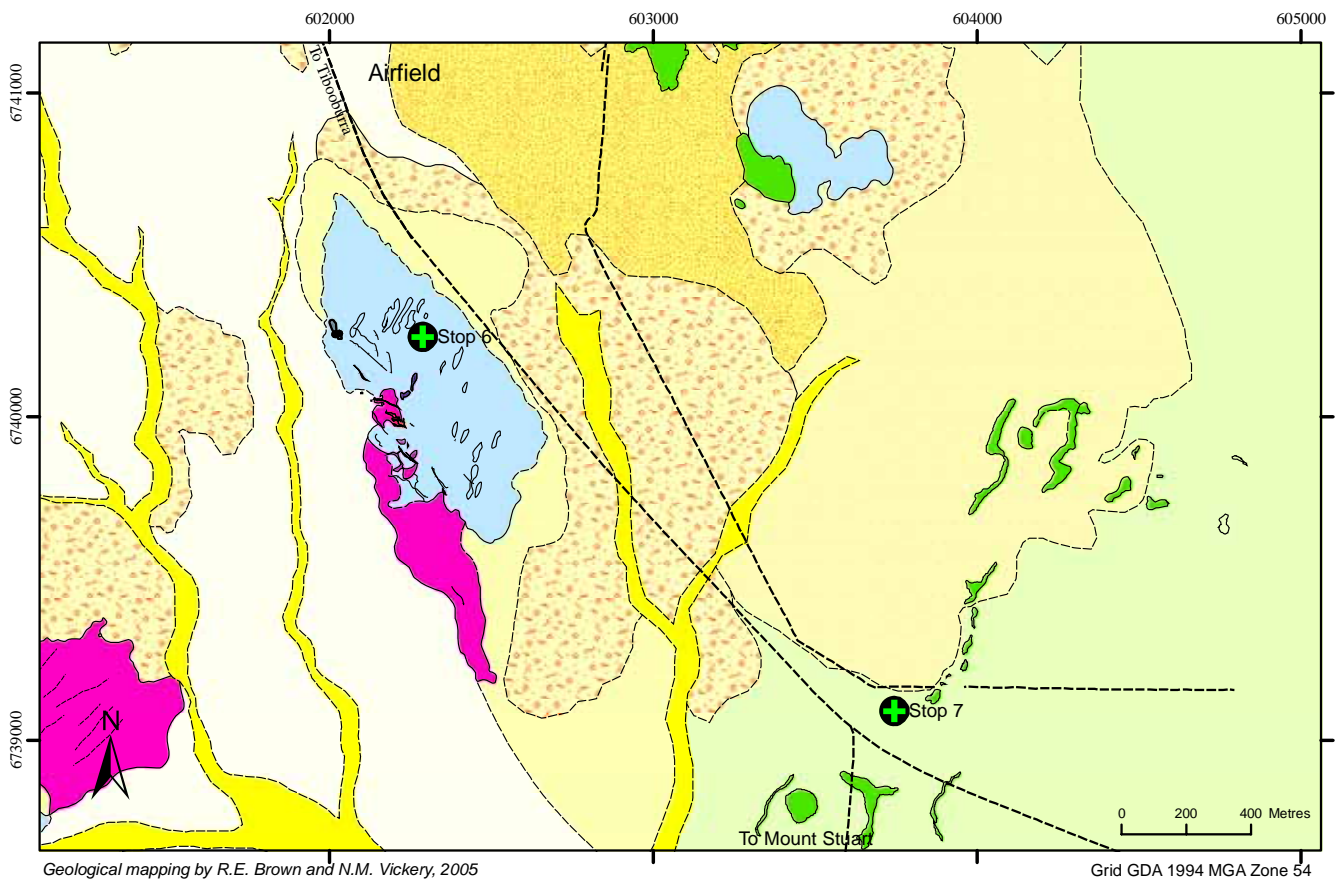
At this site we can examine the weathered Cretaceous sandstone and conglomerate at the foot of the hill. Fossil plant remains are present in the sandstone. **Please don't damage these – allow others to see these relics of the past.** About half way up the hill there is a subtle change in the rocks, marked by the presence of a distinctive quartz pebble conglomerate. The conglomerate represents the base of the Tertiary strata. The depositional break at the base of the conglomerate represents about 40 million years! The sandstone above this is relatively tough and has been silicified. The process of

silicification was insufficient to convert the rock to silcrete. You will agree that the unconformity here is not easy to distinguish. We will examine another example on the regional excursion where the contrast of rocks across the unconformity is strikingly obvious.

Whilst at this locality you will note that there are old alluvial gold workings nearby to the south and southwest. The gold produced there was eroded from sandstone and conglomerate similar to that at the foot of the hill. There are probably low concentrations of gold in these rocks, far too low to warrant working. However, once the gold is eroded from the rocks, the action of running water concentrates the gold into deposits worthy of mining, such as has occurred locally.

To travel to Stop 6, return to the Wanaaring Road and turn right. Proceed for about 5.5 km and stop at the foot of the hill at the southern end of the airfield.

Stop 6. Unusual metamorphosed sandstones close to granodiorite margin. Grid reference MGA 602286 6740249, AMG 602164 6740072.



Map 5. Geological map of the area about Stops 6 and 7. For key to geological units, see page 3.

The rocks present here comprise metamorphosed Cambrian sandstones and mudstones which have been converted to *hornfels*. The metamorphosed sandstones are easily recognisable as they form prominent, dark chocolate brown pods on the hillside. They dominate the sedimentary sequence at this location. These rocks also show original bedding. In places you will observe a spotted texture which is produced by formation of the mineral *cordierite* as a result of heat produced during intrusion of the nearby Tibooburra Granodiorite (see Map 5). Between the pods of sandstone are metamorphosed mudstones which were cleaved during the major crustal folding event which took place during the Silurian period (see table, page 4). These rocks on close inspection preserve fine bedding features referred to as *laminae*.

Walk over the hill to look at the western side. You'll find the contact of the Tibooburra Granodiorite at the base of the hill. Dykes of aplite and pegmatite, similar to those seen at Stop 1 have intruded into the Tibooburra Granodiorite and into the Cambrian metamorphic rocks. At this location you will note that there is a complex relationship between these rocks and the sediments that they have



Photo 8. Metamorphosed sandstones and mudstones (*hornfels*) intruded by pale coloured dykes of aplite and pegmatite.

intruded. Examine the irregular trend of the dykes and notice how they have affected the sediments.

To precede to Stop 7, continue east along the Wanaaring Road to the Mount Stuart turnoff (1.8 km). Park off the northern side of the road at the top of the low hill.

Stop 7. Cretaceous sandstones showing biological traces. Grid reference MGA 603744 6739091, AMG 603622 6738914.

Much like today's shallow marine sediments, the Cretaceous marine sandstones were used by burrowing organisms as a source of safety and food. Cretaceous marine creatures are preserved locally throughout the region as abundant shelly fossils. However, in most places we are aware of their activity by the burrows and tracks left in the sand and mud. We will examine some of these biological traces at this locality.

Following the Map 5 map as a guide, walk to the north and cross the wire fence. Look for the low sandstone outcrops. Some of these sandstones preserve abundant vertical burrows, probably made by ocean worms (Photo 9). Vertical burrows are an indication of strong current or wave activity as may be encountered on or to the seaward of a beach. Most sandstones show evidence on the tops of bedding planes of organism grazing or travelling (Photo 10). Examine the outcrops carefully and you will probably find both varieties of organic traces.



Photo 9. Vertical worm burrows in sandstone, shown from the top of the bed.



Photo 10. Grazing trails along the top of a sandstone bed.

To travel to Stop 8, return to Tibooburra and turn left onto the highway toward Broken Hill. Travel south from the intersection for about 2.6 km.

Stop 8. Wind blown sand sheet. Grid reference MGA 596793 6741084, AMG 596671 6740907.

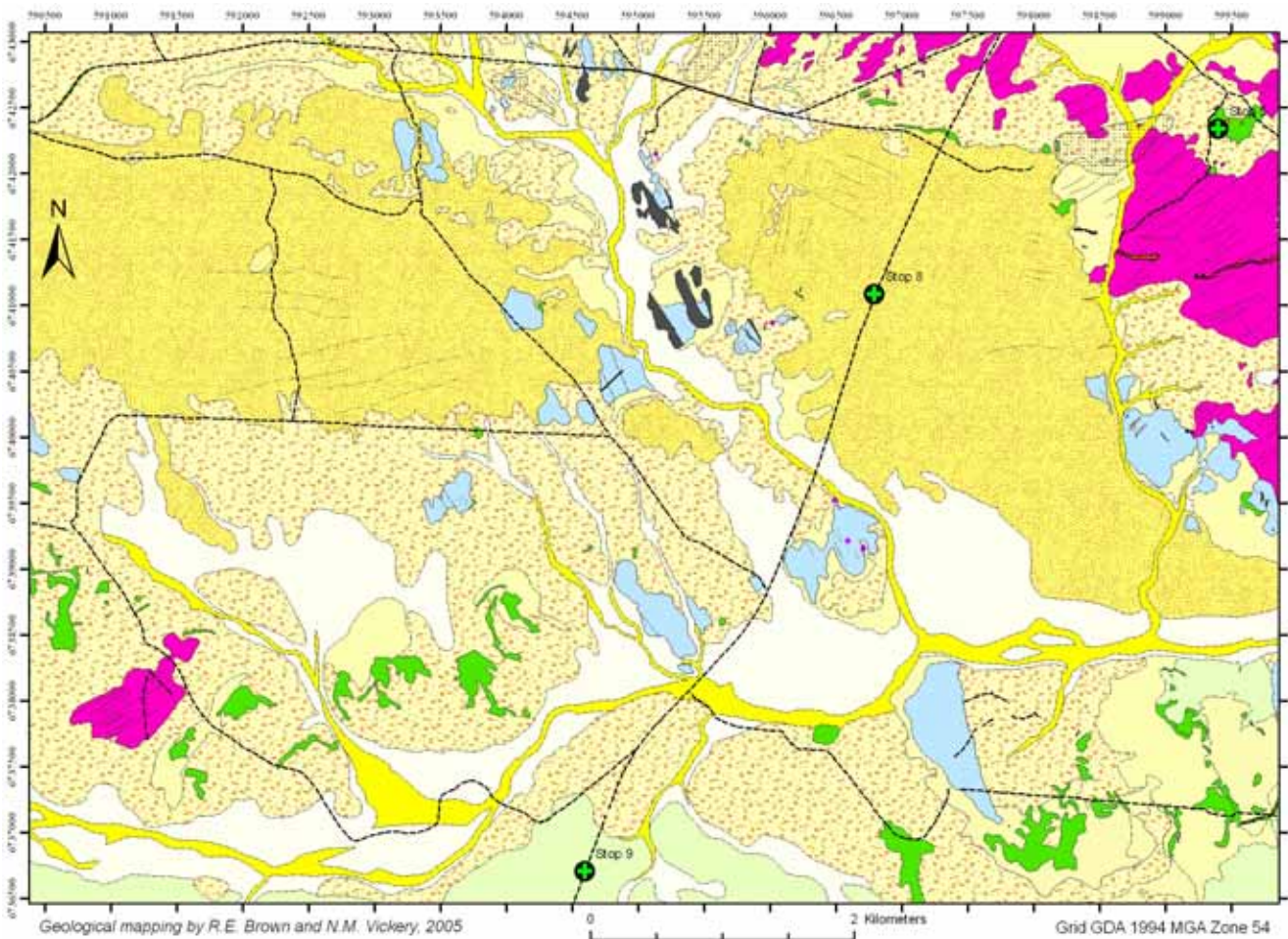
One of the most significant means of transporting sediment in arid Australia is wind. The Tibooorra region shows an abundance of products resulting from wind transport (known as *aeolian* products) which has taken place over many thousands of years. These products include sand sheets and sand dunes. Dunes are only developed in a few places close to Tibooorra. The regional tour visits some dunes and excellent examples are passed through when driving to Cameron Corner. Most of the aeolian products about the inlier are sand sheets.



Photo 11. A typical low sand dune preserved within a sand sheet area. Note the red colour and abundance of vegetation.

Sand sheets are distinctive features in the landscape due to their red colour and richly diverse plant growth (Photo 11). The aeolian sand is a rich nutrient source and also stores moisture reasonably well. The best displays of wildflowers following spring rains are to be found upon dunes and sand sheets. The relative abundance of plants has helped stabilise the dunes, preventing their movement and to some degree preserving their shape and size.

The main period of sand dune and sheet development was many thousands of years ago. At that time the prevailing wind directions were from the south, whereas today's are from the west.



Map 6. Geological map of the Stops 8 and 9 area. Note the orientation of dune crests within the sand sheet areas (dark grey broken lines). For key to geological units, see page 3.

These differences in wind direction are preserved in the dunes. This can be seen in Map 6, where the remnants of dune crests have been mapped as grey, broken lines. You will note that most crests are orientated approximately east-west, indicating wind flow from the north or south. Note that about 800 m west of Stop 8 there are dunes at the edge of the sand sheet with a north-south orientation. These dunes are more recent and represent our prevailing westerly wind directions. This remodelling of the older dunes on the western edge of dune fields is common throughout the region.

Examine the fine character of the dune sand. It is much finer than typical beach dune sand.

To travel to Stop 9 continue south along the highway for another 5 km. At about 4.6 km you should observe a change in the gibber plain from white quartz gibbers to a darker mixture of gibbers.

Stop 9. Gibber plain with petrified wood. Grid reference MGA 594594 6736702, AMG 596671 6736525.

Much of inland Australia is covered with gibbers – well rounded pebbles, cobbles and boulders of weathering resistant rock types. The most common types of gibbers are silcrete, a hard, siliceous rock derived from the erosion of the very widespread silcrete beds occurring throughout inland Australia. There is a roughly concentric ring of different gibber types occurring about the Tibooburra inlier. These are: quartz pebble gibbers (innermost), mixed silcrete-quartz pebble-petrified wood, and silcrete (outermost).

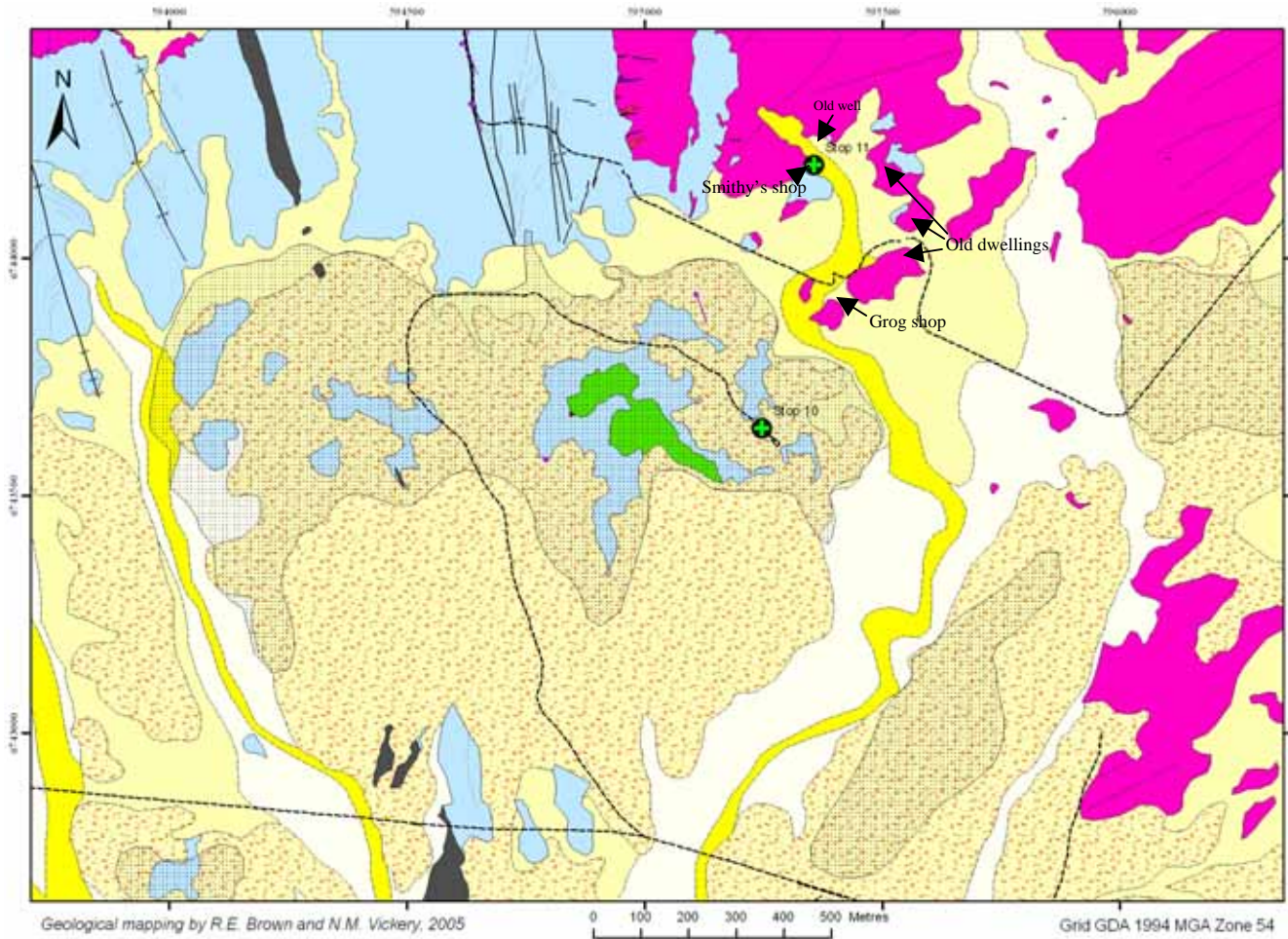
As you drove from Stop 8 you may have noticed the abundant quartz pebble gibbers covering the ground. We will examine these near their source rocks at Stop 15. The quartz pebbles are derived from the erosion of the oldest Cretaceous sedimentary rocks, which are exposed close to the edges of the inlier. Moving further from the inlier, silcrete pebbles become more abundant until they are almost the only rock type present. A transitional area of intermixed quartz, silcrete and minor petrified wood (which you entered about 400 m to the north), represents the influence of some of the oldest Cretaceous rocks which locally contain fossil wood logs as well as quartz pebbles. At this stop we will examine this transitional gibber plain.

The gibber types present here include white quartz, rusty pink to grey silcrete, and scatterings of minor grey petrified wood. Rare black chert pebbles and small, honey coloured agate can also be found. Some of the silcrete pebbles display a thin brown to black veneer. This is known as *desert varnish*, a hard coating of wind blown clay which has been cemented by lesser iron and manganese oxides. The soil beneath the gibbers is rich in clay and gypsum. After rain the clay swells and puffs up the soil surface, resulting in a soft crust. Despite the swelling, vehicle tracks compress the soil too much for swelling to take place. As a result it is possible for vehicle tracks to remain visible for many decades.

To travel to Stop 10, return to the Cameron Corner Road intersection (about 6.2 km) and turn left. Proceed for about 2.4 km and turn right onto the track. This may not be suitable for some conventional vehicles. Follow the track to its end, about 2.1 km.

Stop 10. Easter Monday gold workings. Grid reference MGA 595247 6743641, AMG 595125 6743464.

The Easter Monday diggings are some of the major historical hand mining workings in the Tibooburra region. Gold was mined here from both the oldest Cretaceous conglomerate, and from soil and alluvium. The original gold-bearing quartz reefs, which were probably within the Cambrian metamorphic rocks, were eroded prior to and during the Cretaceous. Gold from these reefs was concentrated by streams into gravels and sands which have since been converted into sandstones and conglomerates. Erosion of those sedimentary rocks has released the gold into modern soils and creek deposits.



Map 7. Geological map of the area about Stops 10 and 11. For key to geological units, see page 3.



Photo 12. Gold diggings in Cretaceous conglomerate, Easter Monday area.



Photo 13. Cretaceous conglomerate viewed in a pit wall. Notice the abundant quartz pebbles, and fragments of Cambrian rocks.

The Cretaceous conglomerate which produced some of the gold from here can be seen on the top of the low hill to the south (see Map 7 and Photos 12 and 13). The miners worked the very base of the conglomerate, scraping the conglomerate from where it lies upon the metamorphic rocks. They also worked the soils down slope from here, and their raked heaps can still be seen. The miners were mainly interested in the coarser, nuggety gold, as their primitive separation devices were inadequate for recovering finer gold. After the infrequent rains, some separation using water trapped in small, local dams would have resulted in improved gold recovery. This area remains a very popular and rewarding centre for fossickers equipped with metal detectors. There is undoubtedly much fine gold

remaining which was not sought after by the original miners, and which is too fine for metal detectors to identify.

The miners lived virtually where they worked. Remains of some of their very primitive dwellings will be examined between here and Stop 11. This will entail a walk of more than 1 km return, so carry adequate water and appropriate clothing and footwear. The unique dwellings occur amongst the large granite boulders on the northern side of the National Park fence. Proceed to the large creek, and generally follow it upstream.

Stop 11. Old miners' dwellings. Grid reference MGA 595356 6744195, AMG 595234 6744018.

The early gold miners lived a hard, meagre, subsistence existence with poor rations, little water and very basic shelter. Many lived amongst the granite boulders, where the large tors provided some shelter and sufficient loose rocks to construct a dwelling. Drinking water availability was a constant problem. Wells and earthen tanks (dams) provided the miners with this essential commodity. Alcoholic beverages were available from the licensed hotels in or grog shops.

The walk from Stop 10 to Stop 11 (see Map 7) will show you the remains of dwellings, a grog shop, a blacksmith's shop, and a well. You will have a walk of at least 1 km through relatively flat terrain. Walk northwards from Easter Monday towards the tree-lined creek bed. On the eastern bank of the creek where the creek encounters the boundary fence of the National Park are the remains of a grog shop. Broken bottles and old cans are abundant.

Cross the fence into the National Park. If you remain on the eastern side of the creek and generally search amongst the large granodiorite boulders you will find a large number of derelict dwellings (see Photo 14). These take the form of a low (less than half a metre), rectangular line of rocks with a small opening for a doorway. Inevitably one short end of the structure is a large boulder. In many cases broken bottles and cans occur with each structure. It is likely that these were nothing more than low stone walls with a canvas roof, beneath which the miner slept. The boulders and stone walls gave some protection from the relentless winds which are a frequent phenomenon in the arid zone. Please don't disturb the structures – they represent a significant part of our cultural and mining heritage.

An old well with remains of a windlass occurs on the eastern bank of the creek near where the rocky hill is cut by the creek (see Map 7). This well must have been a major supplier of drinking water to the local miners.

Cross the creek and head back downstream. Close to the bank, amongst the boulders you will find the remains of the smithy's workshop (Photo 15). The old forge is apparent, the dwelling chimney, old broken bottles and cans and wire netting animal pens. The ground is strewn with old iron discarded by the blacksmith. The smithy would have been indispensable for producing and



Photo 14. Old miner's dwelling, comprising low walls of stacked granodiorite blocks.

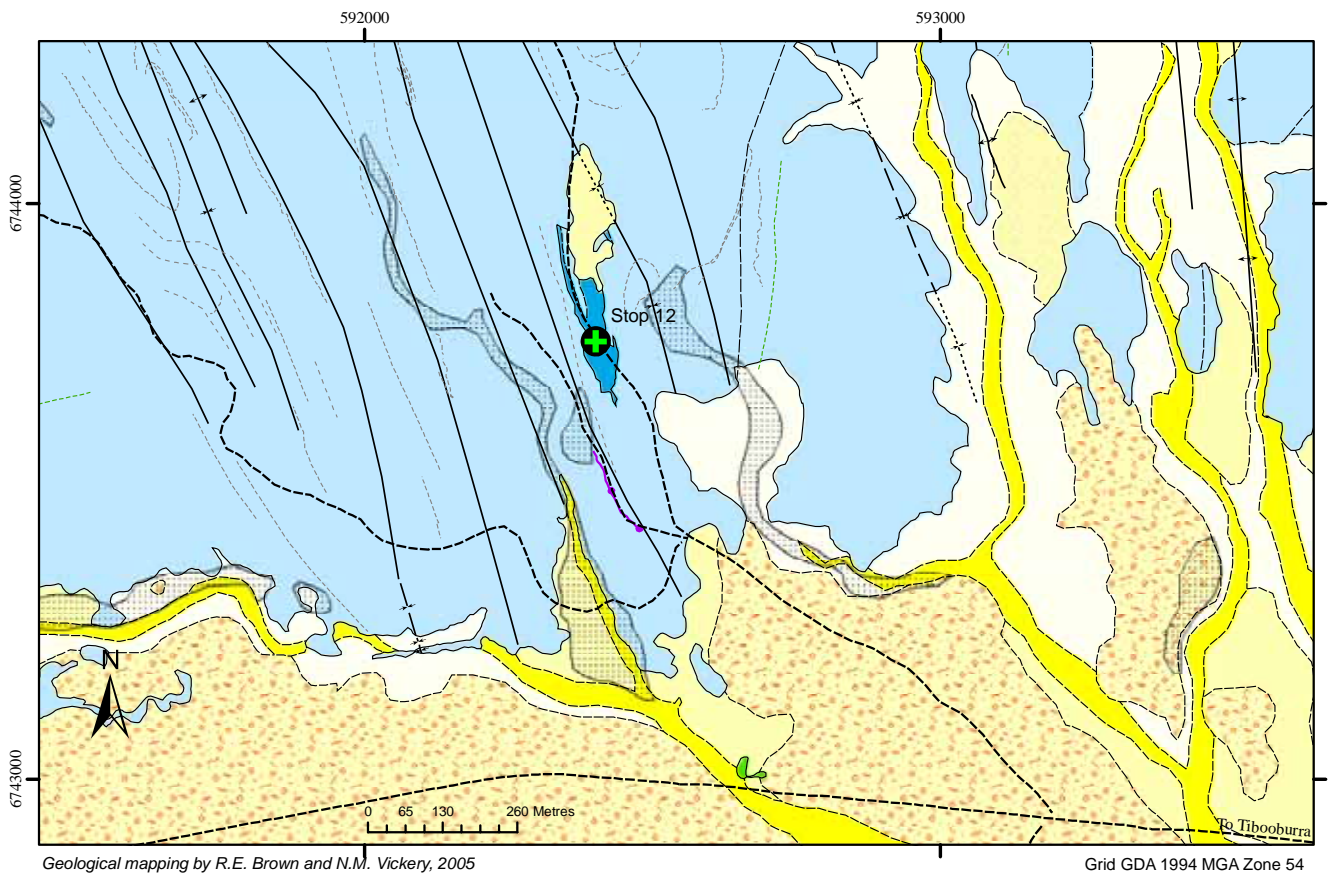


Photo 15. Remains of a blacksmith's workshop and dwelling. Remains of forge by the author.

maintaining the miners' iron equipment. Note the remains of an old gold sorting implement.

To travel to Stop 12, return to the Cameron Corner road and turn right. Proceed for about 1.8 km along the road then take the small track to the right (see Map 8). Follow this track for about 1.2 km.

Stop 12. Conglomerate with stretched pebbles. Grid reference MGA 592402 6743762, AMG 592280 6743585. Map 8.



Map 8. Geological map of the area about Stop 12. For key to geological units, see page 3.

Pebbly rocks (*conglomerates*) are rare in the Tibooburra inlier. Stop 12 examines one of the few outcrops of Cambrian conglomerate and shows the effects of high pressures on the rock. The main outcrops are on the western side of the track.

This conglomerate is composed of volcanic pebbles set in what was sand and mud (Photo 16). Intense pressure during the Silurian (see table, page 4) has folded the Cambrian rocks throughout the inlier before the intrusion of the granodiorite. These high pressures also imparted a slaty cleavage to the rocks, and stretched and flattened the pebbles in this conglomerate. The conglomerate also shows a slaty cleavage which appears here as a north-south trending, closely spaced fracturing. Note how the pebbles are much more elongate than the pebbles you will find in nearby Cretaceous rocks, or on the gibbers plains. You will also note that the conglomerate pebbles are flattened.

Geoscientists can obtain an approximation of the stresses which acted upon these rocks by measuring the changes in elongation

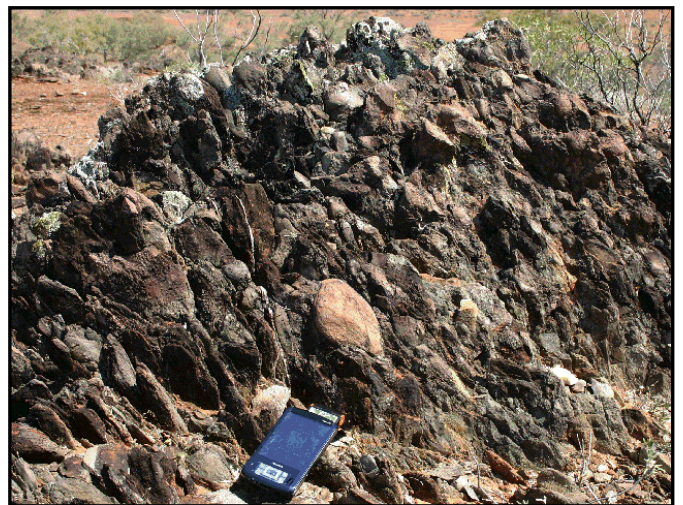


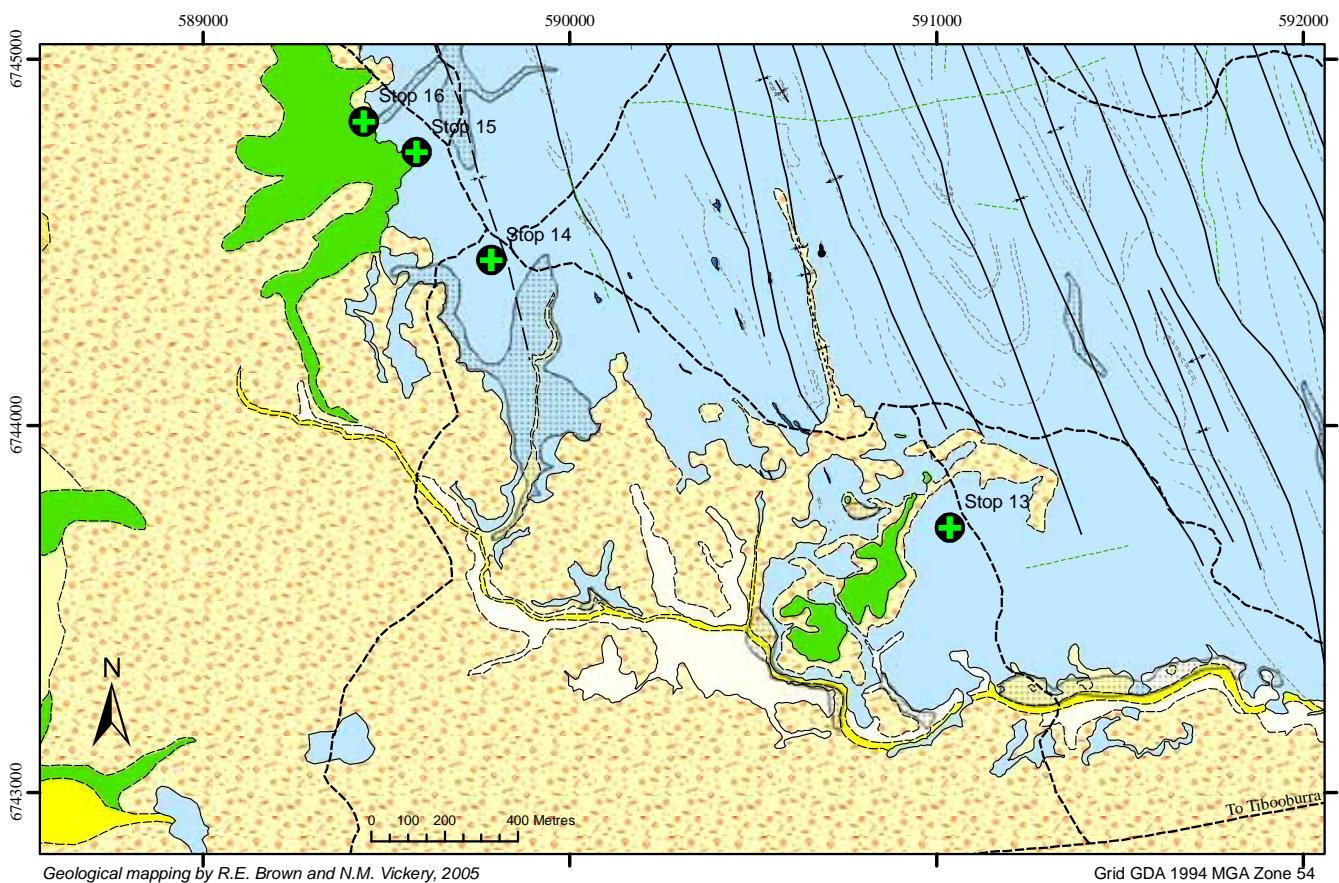
Photo 16. Cambrian conglomerate with stretched pebbles

and flattening of the pebbles. Natural pebble-forming processes create pebbles with a remarkably consistent mathematical relationship between their length and breadth. Examine a range of pebbles from the gibber plains and you will agree! Pressures within the earth's crust stretch and thin the pebbles, thereby altering the consistent ratio of length and breadth. From documented experimental work we can approximate the pressures which are responsible for modifying these pebbles.

The pebbles are mainly comprised of volcanic rocks. There are no similar volcanic rock types present within the Tibooburra inlier, and it is assumed that the pebbles were derived from distant land which was experiencing volcanic activity. The presence of volcanic muds and sands (Stop 17) supports this conclusion.

To travel to Stop 13 return to the Cameron Corner road and turn right. Travel for approximately 1.8 km and turn right onto the small track. **This track requires four wheel drive to cross a sandy creek, and high clearance.** Proceed along the track for about 1 km.

Stop 13. Unusual mound in Cambrian rocks. Grid reference MGA 591036 6743722, AMG 590914 6743545. Map 9. *To reach Stops 13 to 16 you will require a 4WD vehicle.*



Map 9. Geological map of the area about Stops 13-16. For key to geological units, see page 3.

This stop examines an unusual and perplexing landform. A hemispherical, mound-like feature is developed in slaty Cambrian rocks in close proximity to outcrops of the oldest Cretaceous rocks (see Map 9, Photo 17). Several similar landforms are present in the Cambrian rocks about Tibooburra, in all cases immediately adjacent to Cretaceous outcrops.

The most reasonable explanation for these smooth, well rounded landforms is that they represent a part of the pre-Cretaceous land surface which has been exposed by the erosion of the overlying Cretaceous rocks. This may have been a feature formed by erosion of the soft slates by the watercourses which deposited the conglomerates and sandstones to be visited in Stop 15.

Another, larger mound-like feature near Tibooburra village has been described by local townspeople as a growing landform which has risen from the flat surface over several decades. Although there is no evidence to substantiate this assertion, it is intriguing to consider that the mounds are currently growing, almost like the top of a bubble. If this is correct, then it may be attributable to local pressures within the slates, forcing small areas of weathered slates upward in the form of domes. There may be analogies for this phenomenon elsewhere in the world, but we are not aware of them.



Photo 17. Mound-like feature in Cambrian slates.

Continue along the track for about 700 metres, negotiating the creek bed. Just beyond the creek the track passes over several dyke-like bodies of black metabasalt (see map, Map 9). These metabasalts are uncommon in the Cambrian rocks. They have intruded the sedimentary rocks before they were folded, as a number of the basalts are themselves folded.

Continue along the track for 1 km to Stop 14.

Stop 14. Ironstone-mantled hill. Grid reference MGA 589785 6744454, AMG 589663 6744277.

The oldest Cretaceous sedimentary rocks were deposited upon Cambrian metamorphic rocks which had been subjected to many millions of years of weathering and erosion. The local Cretaceous land surface was undulating to flat, with well rounded landforms. We see evidence for the character of the Cretaceous land surface in many places, particularly along the western side of the Tibooburra inlier where the Cretaceous rocks have only recently (in a geological time-frame) been removed by erosion. Stop 14 and along the track to Stop 15 shows some of the features of that land surface.

As we saw at Stop 2, the unconformity between the Cambrian and Cretaceous rocks is accompanied by abundant ironstone. This is partially because the unconformity was a zone of significant groundwater movement which resulted in the precipitation of iron oxides in cracks and pore spaces in the rocks. As the relatively soft Cretaceous rocks have been eroded away, the weathering-resistant ironstone within the rocks about the unconformity has dropped onto the ground surface along with the white quartz pebbles from the sandstones and conglomerates. The ironstone and quartz pebbles act as armour against further erosion, preserving the pre-Cretaceous land surface. In time the quartz pebbles are dispersed by gravity (they roll down slopes during heavy rainfall), leaving an abundance of ironstone (see Photo 18). Eventually even the tough ironstone is broken down into smaller, easily moved fragments which are washed or blown away, leaving the old pre-Cretaceous land surface open to reshaping by erosional forces.



Photo 18. Smoothly rounded, ironstone-mantled hill.

Notice at this stop that the ironstone-mantled hill has very little remaining quartz pebbles. Some quartz occurs as an apron about the base of the hill, but most has been washed away. The ironstone is preserving the original depositional surface. It is sobering to consider that you are walking over a land surface which was much the same shape as we see here about 145 million years ago!

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As we drive from here to Stop 15 and then to Stop 16 we are driving along that ancient land surface, with only a few deep gullies destroying its original form. Notice that as we get closer to the outcropping Cretaceous rocks the amount of white quartz pebbles increase, probably because there has been less time for their dispersal than in areas further away.

Continue along the track, moving up the hill to the prominent bluff which marks Stop 15 (see Map 9).

Stop 15. Cretaceous conglomerate and sandstone. Grid reference MGA 589581 6744748, AMG 589459 6744571.

Following a prolonged period of erosion with little widespread deposition a major sedimentary basin opened up during the Cretaceous throughout inland Australia. This basin is known as the *Eromanga Basin*. The first rocks deposited in this basin were formed on land by extensive rivers similar to those throughout arid southwestern Queensland today. These rocks show characteristics diagnostic of those rivers, including a wide range and mixture of grain sizes, and very irregular internal structures. These earliest sandstones and conglomerates sourced their sand and gravel from the erosion of nearby Cambrian metamorphic rocks. The abundant quartz veins (some of which were gold-bearing) throughout the Cambrian rocks were eroded into the creeks, resulting in common white quartz pebbles and boulders (Photo 19), and local concentrations of alluvial gold.

At this stop you can examine those oldest Cretaceous sedimentary rocks. You can also see how the erosion of those rocks has resulted in the formation of the white quartz gibber plains which encircle the Tibooburra inlier.



Photo 19. Cretaceous conglomerate and pebbly sandstone. Note the abundant quartz pebbles.



Photo 20. Iron stained Cretaceous sandstone and conglomerate.

The cliff exposures of sandstone and conglomerate display the characteristics of sands and gravels deposited in a perennial river system. Note the wide range of fragment sizes (Photos 19 and 20) and the very irregular bed surfaces within the rocks. These indicate short periods of rapid water flow with frequent migration of the watercourse laterally. You would expect this in a very wide, gravelly and sandy river channel through which ran a network of small, bifurcating watercourses. As you ascend the ridge conglomerates become less abundant and sandstones and finer grained rocks are more common suggesting that the source of the sand and gravel was eroding downward, with lower slopes and less energetic rivers resulting. Also note the brown iron oxides present in the sandstones. These iron oxides and the quartz pebbles erode from the rocks to armour the pre-Cretaceous land surface being exposed from beneath the Cretaceous rocks.

It is also worth examining the white quartz gibber surface which spreads outward from the eroding Cretaceous rocks (Photo 21). Note the wide size range of the quartz, with some huge boulders present in places. Note how the quartz is well rounded, indicating a prolonged period of tumbling within creeks and rivers after the quartz was eroded from the Cambrian rocks. Many gold nuggets have been



Photo 21. White quartz gibbers eroding from Cretaceous sandstone and conglomerate.

recovered from this gibber plain, confirming that alluvial gold is present in the lowermost Cretaceous conglomerates and sandstones.

To travel to Stop 16, return by vehicle to the foot of the hill and follow the track which leads around the escarpment (the left fork). Alternatively it is an easy stroll of about 170 metres from Stop 15 along the foot of the escarpment to Stop 16. Stop 16 is situated at the foot of the escarpment at the head of a major gully.

Stop 16. The Tunnel Hill adit. Grid reference MGA 589438 6744832, AMG 589316 6744655.

Most gold mining in the Tibooburra area either took place in alluvial gravels closely associated with the lowermost Cretaceous conglomerates, or as in the case of parts of the Easter Monday area (Stop 10), within those conglomerates. Realising that rich gold was to be found in some places along the unconformity between the Cretaceous and Cambrian rocks, an attempt was made during the 1800s by a group of enterprising miners to drive a tunnel (known in mining terminology as an *adit*) along the unconformity in an attempt to discover high grade alluvial gold resources. Historical accounts, and more recent resampling of the adit suggest that small amounts of gold were encountered.

This stop will acquaint you with the adit, the entrance of which has now fallen in. The large dumps at the adit portal demonstrate the nature of the rocks passed through in the search for gold. Note that there is evidence that the gully draining from the foot of the escarpment here was worked for gold. The heaps of gravel deposited along the flanks of the gully demonstrate that the gully was excavated, sieved, and the remaining material either washed or dry blown to recover the gold. Most gullies in this area have undergone similar treatment.

To travel to Stop 17, return to the Cameron Corner Road, turn right, and proceed for about 3.5 km. Along the way, observe the broad expanse of quartz gibbers which have shed from the Cretaceous conglomerates adjacent to the inlier.

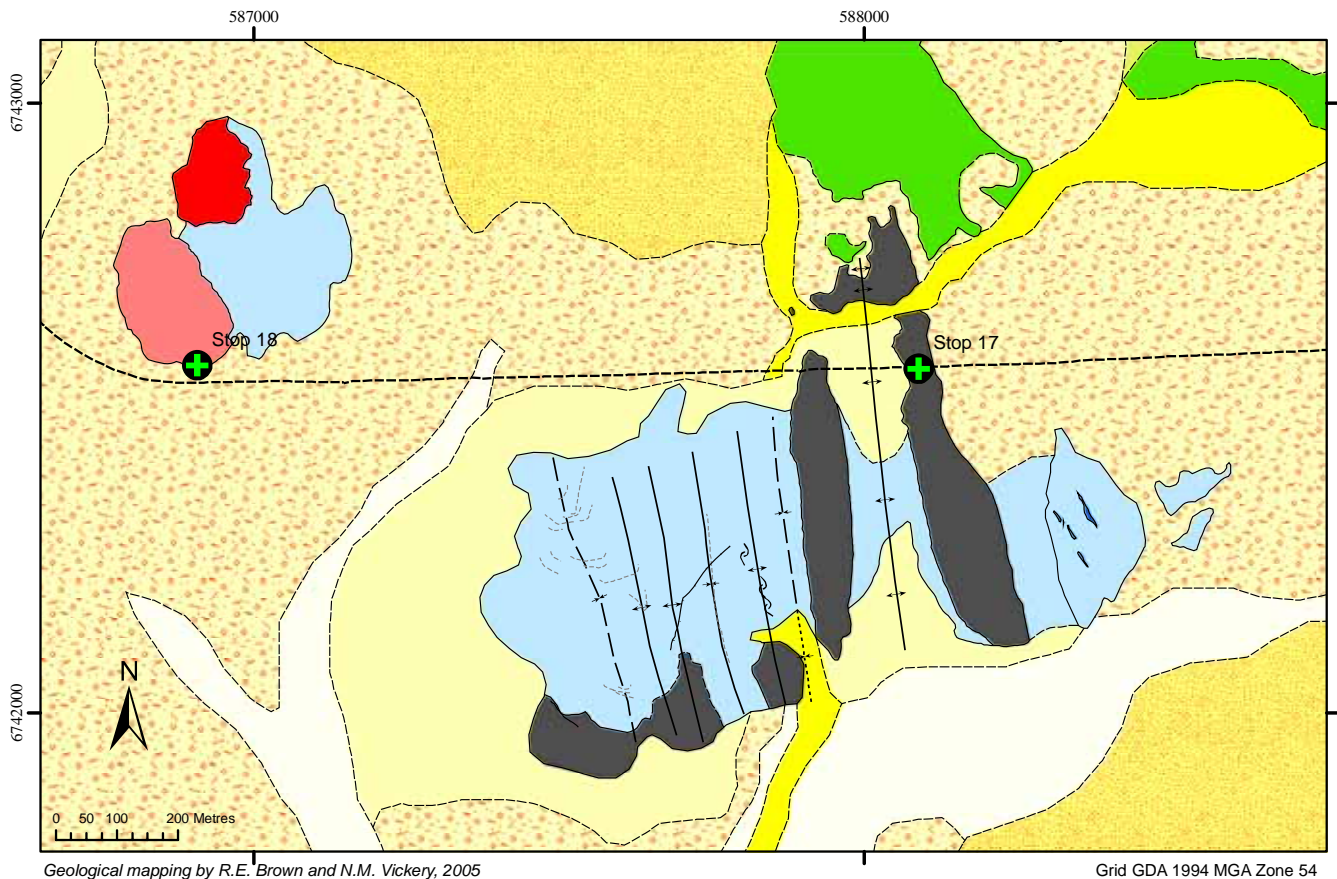
Stop 17. Volcanic sandstone. Grid reference MGA 588089 6742565, AMG 587967 6742388. Map 10.

A number of very significant sandstones of volcanic origin occur throughout the Cambrian metamorphic rocks of the Tibooburra inlier. These volcanic rocks are very distinctive in outcrop. They are of great importance in understanding the origin of the Cambrian rocks by providing the means to acquire an age date. The distinctive and unique character of these rocks also makes them useful for mapping the large folds within the Cambrian rocks.

The volcanic rocks can be examined at Stop 17. They are typically very hard, show pale coloured external surfaces (Photo 22) and are grey on freshly fractured surfaces. Their composition is similar to that of a granite, which in geological terminology is *rhyolite*.



Photo 22. Pale coloured Cambrian volcanic sandstone with prominent laminae. These rocks provide microscopic zircons for age dating.



Map 10. Geological map of the area about Stops 17-18. For key to geological units, see page 3.

From examination of these rocks in outcrop and in the laboratory we know that they have been deposited amongst the non-volcanic Cambrian sedimentary rocks by a process of slumping down what was possibly the continental slope. Slumping was probably initiated by seismic activity (earthquakes). The unique volcanic sand was derived from an area undergoing volcanic activity. This may have been the same area as that which produced the stretched pebble conglomerate visited at Stop 12. Microscopic zircons are present in the volcanic sand. Some of these were formed during the volcanic event which produced the sand or ash. These age of crystallisation of the zircons can be determined by laboratories to within a few million years accuracy using the *SHRIMP technique*. Dates of 496 million years have been obtained for the zircons in these rocks, indicating that the rocks were deposited during, or slightly after that Cambrian date.

Map 10 illustrates the complex folding which is present in the immediate area as defined by the outcrop distribution of the volcanic sandstone (dark grey unit). There are few other indicators in these rocks to suggest that folds such as these are present.

To travel to Stop 18, continue along the Cameron Corner road for about 1.2 km and park at the foot of the low hill.

Stop 18. Diorite and granodiorite intrusions. Grid reference MGA 586906 6742570, AMG 586784 6742393. Map 10.

Although the Tibooburra Granodiorite is the largest outcropping intrusion in the region there are two other intrusive bodies with only small outcrop areas but which are of similar size beneath the surface cover of soil and Cretaceous rocks. Magnetic data collected across the region provides strong evidence for the size of these other bodies (see Figure 1).

Stop 18 demonstrates the rock types present in one of these other, largely concealed intrusions. Two major rock types are present (see map 10). Black, fine to medium grained diorite occurs on the edge of the road, extending up to the crest of the hill. Granodiorite, exposed as large tors and boulders, occurs on the northern end of the ridge.



Photo 23. Outcrop of the diorite intrusion.



Photo 24. Prominent outcrop of the diorite, showing abundant narrow veins and dykes of contrasting composition.

The diorite is a black to dark green, finely crystalline rock (Photo 23). It is strongly magnetic and includes zircons which have enabled a determination of the age of crystallisation as 421 million years (Silurian). This age is identical to that of the Tibooburra Granodiorite. Recent computer modelling of the magnetic data across this area has demonstrated that this intrusion is an offshoot from a major magma chamber about 2 kilometres deep. The Tibooburra Granodiorite is a similar offshoot from this chamber. Consequently, it would be expected that the two outcropping intrusions would share similar ages and rock types.

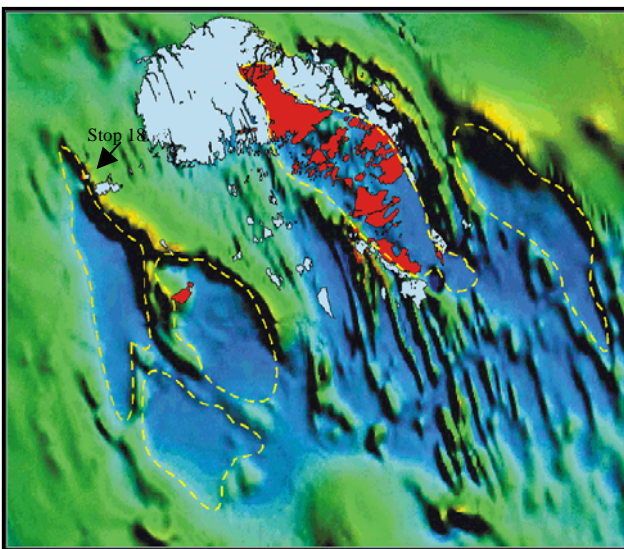


Figure 1. Magnetic image of the Tibooburra area, showing outcrop of granodiorite in red and Cambrian rocks in grey. Dark blue corresponds with areas of low magnetic response, such as granodiorite. Shallowly buried intrusions are outlined in yellow. Stop 18 is indicated.

The granodiorite outcropping at the northern end of the ridge is similar to the Tibooburra Granodiorite. It includes small areas which are strongly magnetic, and narrow dykes of different composition.

The Cambrian metamorphosed sedimentary rocks adjacent to the intrusive rocks have been metamorphosed by the intrusion. Hornfels textures are apparent. Metamorphosed sandstones are abundant, exhibiting their typical prominent, blocky character, and reddish colour.

Cretaceous rocks can be observed about the edges of the hill. The Cretaceous rocks are fine grained sandstones with calcium carbonate cement. They are interpreted to have been sands deposited in a marine environment. This is in contrast to the sandstone and conglomerate present on bedrock at Stop 15. It is possible that the initial river-deposited sands and gravels have been reworked and modified in this area by waves and currents associated with the incoming Cretaceous sea, resulting in the well sorted sandstones we see here today.

This completes the Tibooburra inlier tour. We hope that you have enjoyed the experience, and have learned something from it. We would be pleased to respond to your critical comments or queries.