SOME GEOLOGICAL HIGHLIGHTS OF THE CENTRAL WEST CYCLING TRAIL IN THE DUNEDOO-MENDOORAN-COBBORA AREA

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INTRODUCTION

The Central West Cycling Trail (https://centralwestcycletrail.com.au) comprises a network of back roads and tracks passing through Mudgee, Gulgong, Dunedoo, Mendooran, Ballimore, Dubbo, Geurie, Wellington and Goolma in central NSW. The countryside traversed by the trails is gently rolling, and typical of scenic and peaceful inland eastern Australia.

The cycling route in the Dunedoo-Mendooran-Cobbora area represents an area of interesting landforms and geology. It straddles part of the southern edge of the major, regional-scale sedimentary basins which comprise much of eastern and central Australia, including the Gunnedah Basin and the younger Great Australian (Artesian) Basin. The basins overlie the much older Lachlan Orogen, which contrasts strongly in rock types and landforms. Large areas of fertile, flat floodplains border major watercourses, and in some cases show characteristics which suggest their derivation from distant (rather than local) sites.

The cycle trails were visited in October 2023 when easily accessible geological sites were examined for their educational potential. Local outdoor enthusiast Sharon Nott generously provided logistical support and guidance on site locations.

GEOLOGICAL SETTING

A simplified geological map of the area (Map 1) and accompanying geological time-space diagram (Table 1) illustrate the main geological units traversed by the cycle trails, and place them in a stratigraphic and time framework. The area essentially comprises an ancient 419 - 467 million year old metamorphosed and folded "basement" which is intruded by granites and overlain by much younger sedimentary basins. These are in turn locally overlain by relatively young basaltic lavas, and finally by very recent floodplain and watercourse sediments.

The Oldest Rocks - The Lachlan Orogen

The Lachlan Orogen (previously *Lachlan Fold Belt*) is a broad, north-trending belt of deep-water marine sedimentary rocks, a variety of volcanic rocks, and voluminous granitic intrusions extending from Tasmania to northern NSW (Figure 1, Table 1). It originated as part of the plate margin of the supercontinent Gondwana 545 - 365 million years ago (Figure 2). Its rocks were multiply deformed and metamorphosed in two major events about 440–430 and 400–380 million years ago. Deformation produced folds, faults and foliations in certain rock types, and locally resulted in the introduction of gold-bearing quartz veins. The final deformational event raised all of the Lachlan Orogen above sea level and commenced a prolonged episode of deep erosion.

The Orogen is overlain by the Sydney-Gunnedah Basins to the east, the Great Australian Basin to the north, and the Murray-Darling Basin in the west.

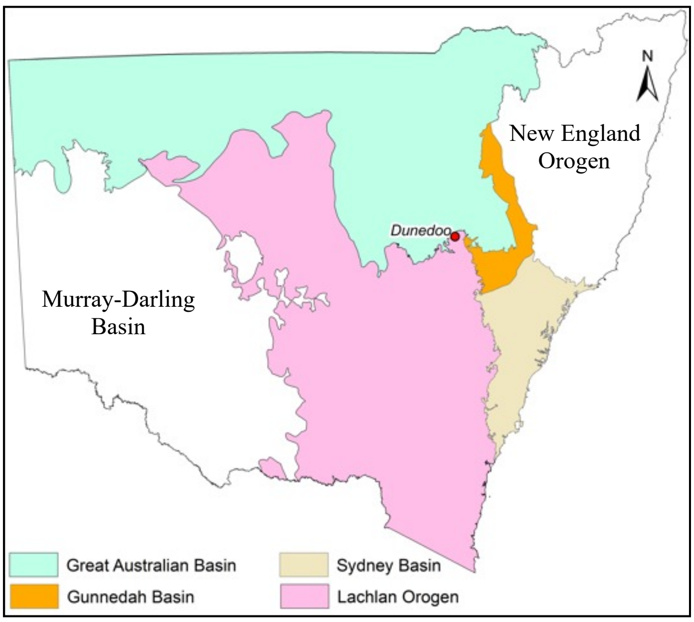
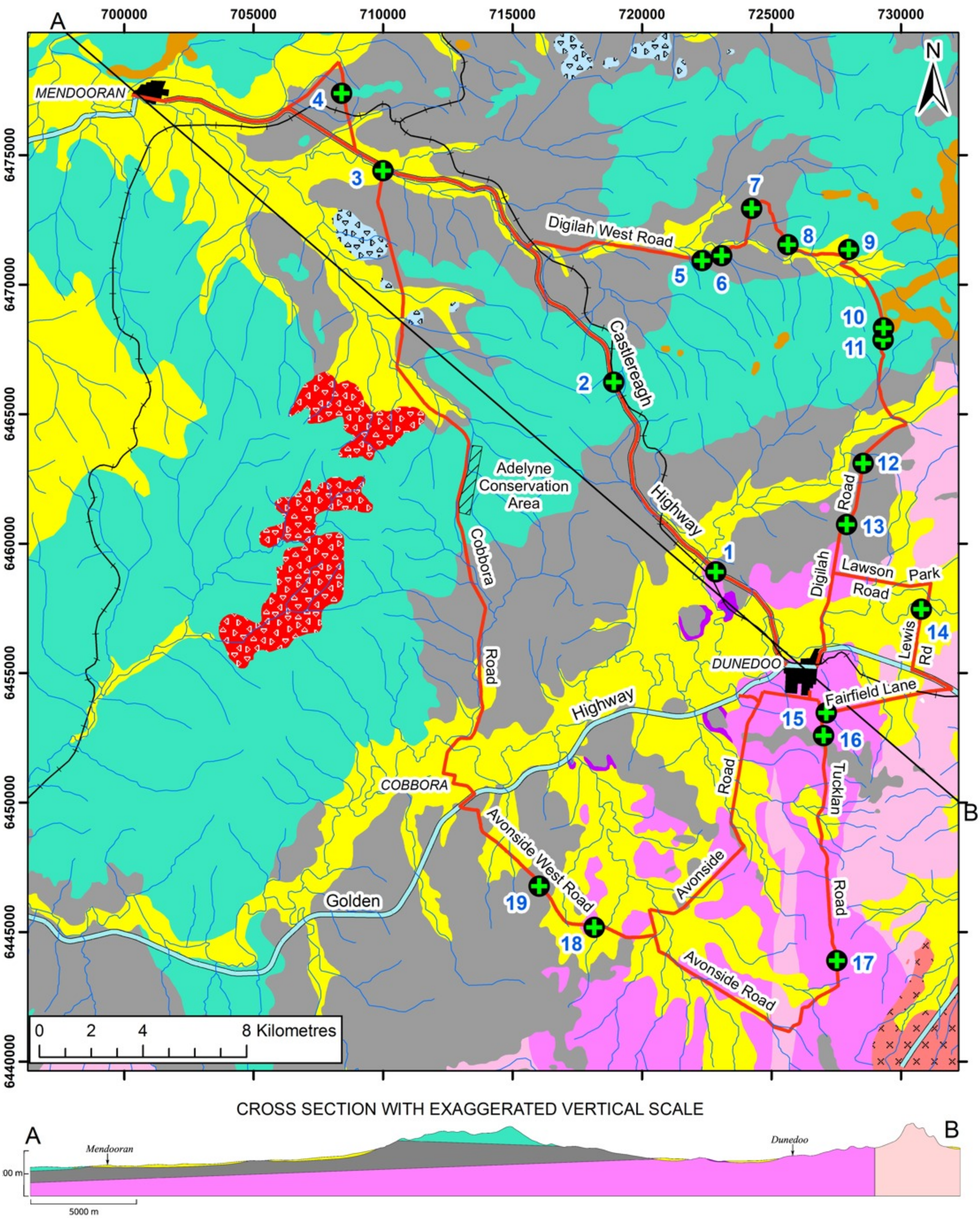


Figure 1. The outcrop extent of the Lachlan Orogen, Sydney-Gunnedah and Great Australian Basins in NSW.



Map 1. Simplified geological map of the Dunedoo-Mendooran-Cobbora area. Routes of the Central West Cycling Trail are shown in red, with several potential additional routes added to visit sites of geological or scenic significance. The map legend is shown on the following page. Geological sites described in text are shown as green crosses with reference numbers.

- 9 Geological site with number
- Watercourses
- Railways
- Geological routes described herein
- Highways
- Standard road and track
- Towns

CENOZOIC	Watercourse sand and gravel, floodplain silt and (modern unconsolidated sediments)
MIOCENE-EOCENE	Basaltic lavas

GREAT AUSTRALIAN BASIN

MIDDLE JURASSIC	Quartz sandstone, siltstone, minor conglomerate (sedimentary rocks)
EARLY JURASSIC	Dolerite, basalt, trachyte (volcanic rocks)
	Doleritic and syenitic sills and dykes (intrusive igneous rocks)

GUNNEDAH BASIN

TRIASSIC	Sandstone, siltstone, conglomerate (sedimentary rocks)
PERMIAN	Rhyolitic to dacitic tuff, lava and sandstone

LACHLAN OROGEN

CARBONIFEROUS	Granitic and monzonitic intrusions (intrusive igneous rocks)
SILURIAN	Rhyolite, conglomerate, sandstone, shale, limest (volcanic and sedimentary rocks)
LATE ORDOVICIAN	Chert, siltstone, limestone, rare basalt, phyllite (sedimentary and volcanic rocks)

Reference for Map 1

ERA	PERIOD	AGE (Millions of years ago)	GEOLOGICAL FEATURE	LITHOLOGIES	GEOLOGICAL PROCESSES	SITE NUMBER
CENOZOIC	Holocene-Pleistocene	0 - 30	Watercourses, floodplains	Sand, gravel, silt	Widespread erosion, local alluvial deposition	3, 14
	Oligocene-Eocene	28 - 38	Liverpool Range Volcanics	Olivine basalt	Eruption of basalts from fissures	
					Erosion	
MESOZOIC	Middle Jurassic	152 - 191	Great Australian Basin (Surat Basin)	Quartz sandstone, siltstone, conglomerate	Shallow lakes and floodplains cut by braided stream channels carrying gravel, sand and silt	1, 2, 4, 10, 11
					Erosion	
	Middle Triassic	237 - 259	Gunnedah Basin	Sandstone, siltstone, conglomerate, coal	Coastal lakes, streams, alluvial fans and deltas	1, 5, 6, 7, 12, 13, 15, 18
PALAEOZOIC	Late Permian					
	Early to Middle Permian			None preserved locally	Glaciation wanes due to global warming. Erosion	
	Carboniferous	299 - 358	Lachlan Orogen	Granite, monzonite	Granitic intrusions at depth. Surface glaciation	
	Devonian			None preserved locally	Shallow ocean covered region. Mountain building event folded rocks and introduced gold-bearing veins	
	Silurian	419 - 431		Conglomerate, siltstone, limestone, lavas	Shallow equatorial seas with local eruptive areas	
					Uplift and erosion	
	Ordovician	445 - 467		Chert, siltstone, phyllite, lava	Deep sea deposition with local volcanic island belt	1, 15, 16, 17

Table 1. A summary of major geological features in the area.

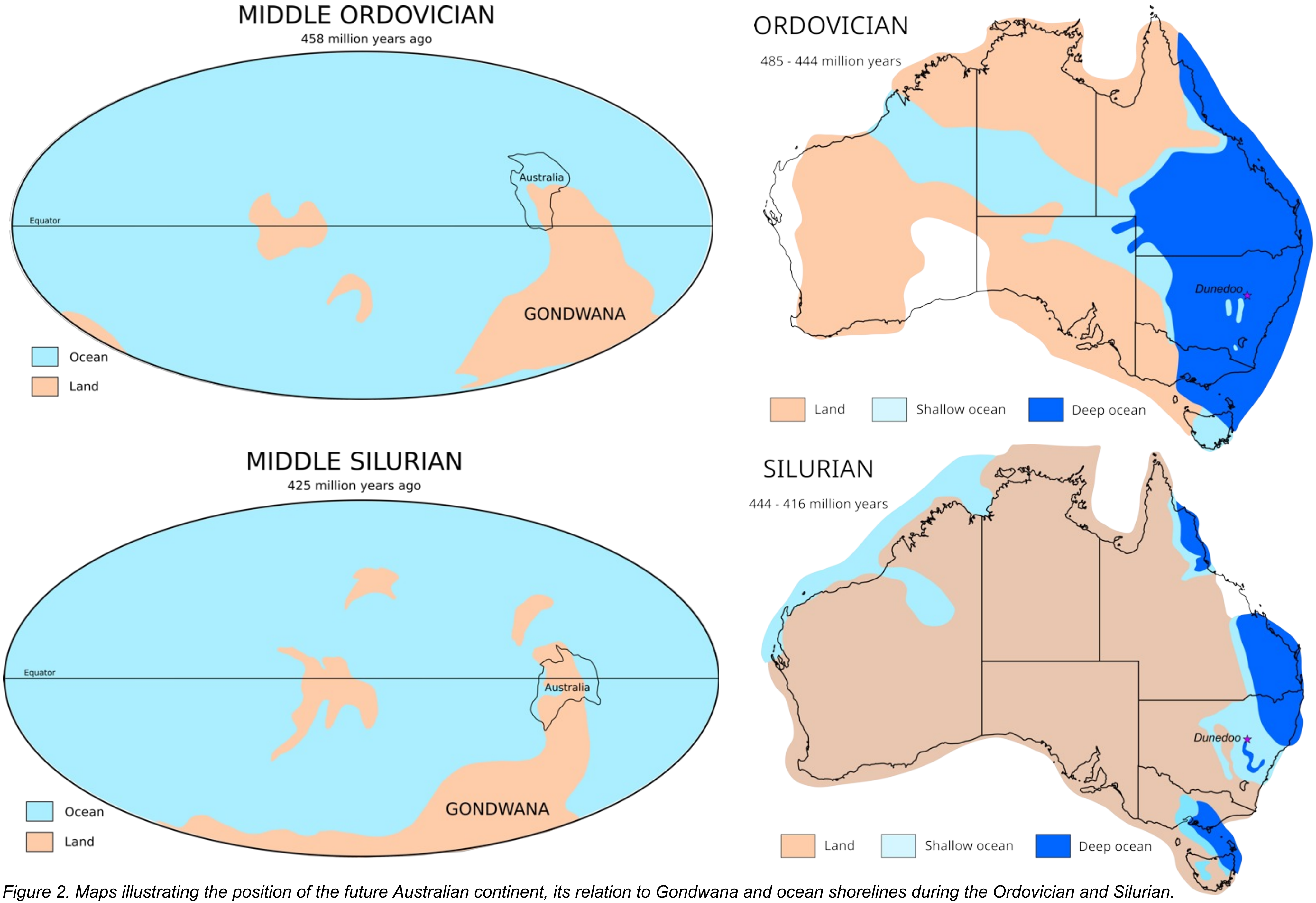


Figure 2. Maps illustrating the position of the future Australian continent, its relation to Gondwana and ocean shorelines during the Ordovician and Silurian.

The Gunnedah Basin

The Gunnedah Basin is a Permian and Triassic sedimentary basin in NSW, covering approximately 15,000 square kilometres (Figure 1, Table 1). It is the northern extent of the on- and offshore Sydney Basin from which it is separated by structures in the Liverpool Range area.

The basin overlies the Lachlan Orogen along an erosional contact. It began forming in the Early Permian about 259 million years ago (Figure 3) when the eastern Australian crust commenced sagging due to tension caused by tectonic plate movement, accelerating during the mid Permian and allowing ocean waters to extend inland. Sedimentary material deposited in the basin was initially derived from erosion of local Lachlan Orogen rocks, in places producing lakes and deltas in which organic material concentrated as future coal deposits. Uplift of the New England region in the Late Permian drove the shoreline back and resulted in a rapid influx of sediment from the highlands, including gravels deposited from braided streams. As the New England region was eroded downward, the basin received abundant sediment deposited from meandering stream systems, producing swampy areas and additional future coal seams. The depositional life of the basin ended in the middle Triassic when it was uplifted by regional-scale faulting after which erosional processes commenced.

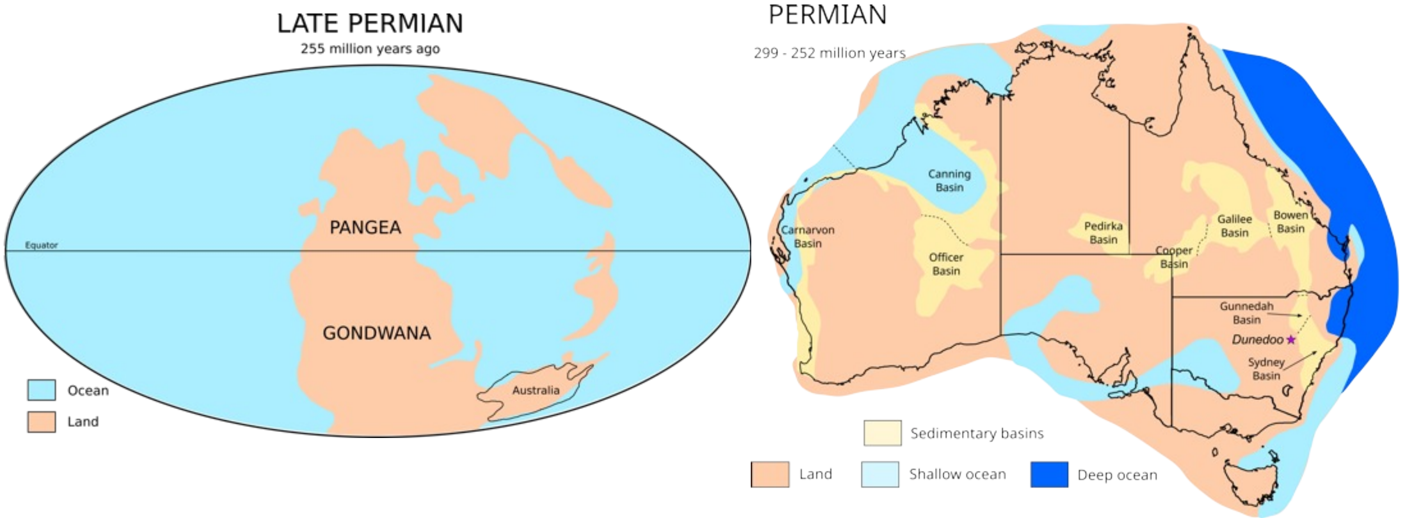


Figure 3. Maps showing the future Australian continent and its relationship to Gondwana and marine shorelines during the Permian.

The Gunnedah Basin comprises groups of rocks which represent their depositional environments and compositions. These are known as *stratigraphic units*. Each stratigraphic unit is given a formal name so that it can be referred to on maps and in publications. Their temporal and spatial relationships are depicted in diagrams known as stratigraphic columns. The stratigraphic units present in the Gunnedah Basin in the Dunedoo-Mendooran area are shown in a stratigraphic column in Table 2.

The Great Australian (Artesian) Basin: The Surat Basin

The enormous Great Australian Basin system (Table 1) covers more than 1.7 million square kilometres of Queensland, New South Wales, South Australia and the Northern Territory. It contains a vast volume of underground water and is the largest groundwater basin in Australia. It is composed of a number of individual basins, with the Early Jurassic to Early Cretaceous Surat Basin being the eastern-most in NSW (Figure 4) and being a major geological feature in the Dunedoo-Mendooran area.

Deposition in the basin commenced about 190 million years ago with the onset of a period of subsidence of much of eastern Australia. During the early stages, deposition was mostly associated with streams and lakes, while by the Middle Jurassic coal swamp environments predominated over much of the basin. Towards the end of the Middle Jurassic, deposition from stream systems again predominated and continued until the earliest Cretaceous, about 145 million years ago. A global sea level rise followed, depositing shallow marine sediments and reaching its peak about 120 million years ago. A drop in sea levels resulted in stream and lake sedimentation before this ceased about 115 million years ago. Erosion followed, with most younger strata removed in the Dunedoo-Mendooran area, with only rocks of Jurassic age preserved. These rocks are sandstone-rich and represent ideal basin recharge aquifers.

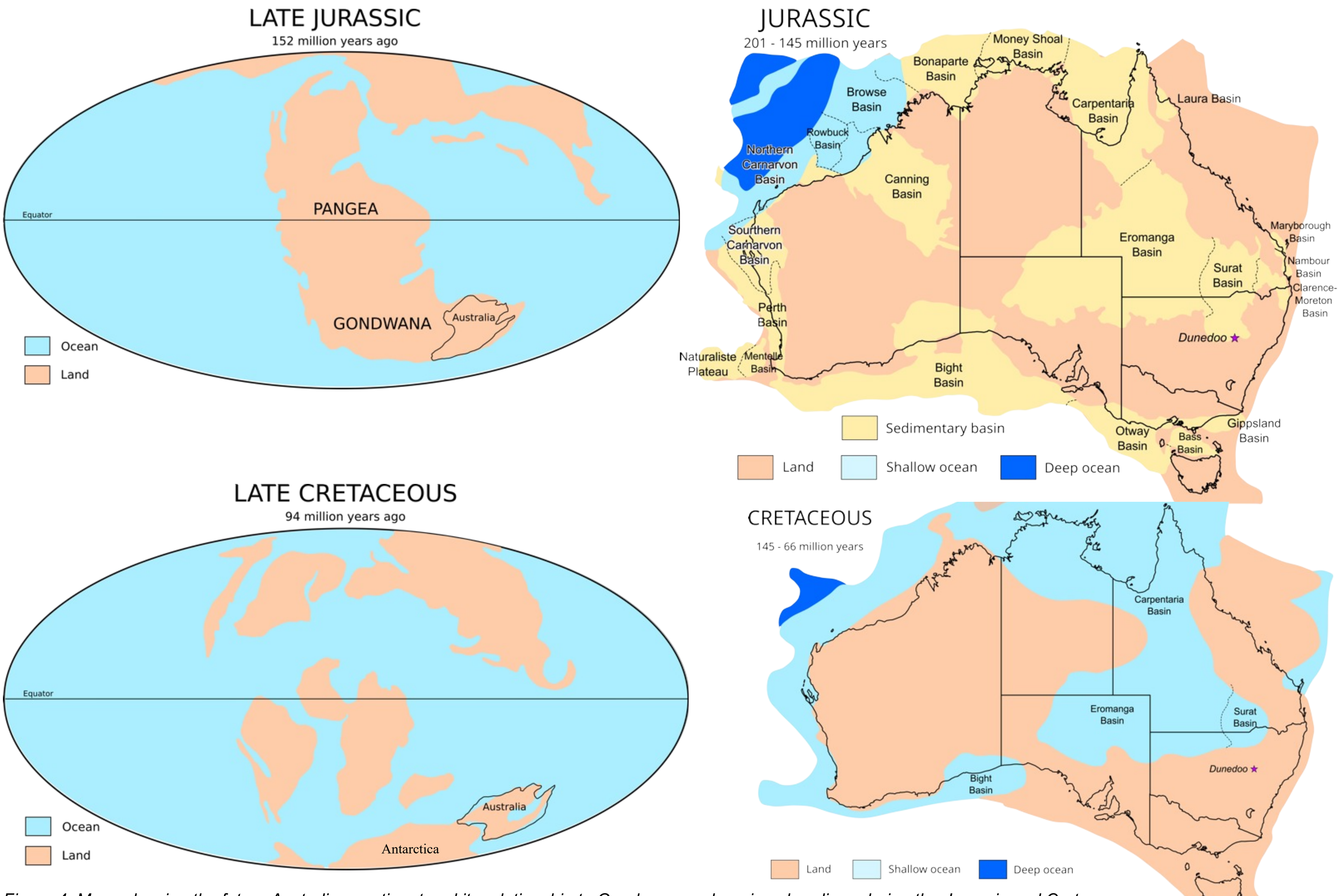


Figure 4. Maps showing the future Australian continent and its relationship to Gondwana and marine shorelines during the Jurassic and Cretaceous

The Surat Basin commenced deposition about 45 million years after erosion commenced of the Gunnedah Basin rocks. The initial gravels and pebbly sands laid down in the Dunedoo-Mendooran area are made up of material derived from both the Gunnedah Basin and Lachlan Orogen. Cross sections produced across the Gunnedah Basin and Surat Basin rocks show the evident infilling of the eroded topography cut into the Gunnedah Basin by Surat Basin material (shown in cross section on Map 1, and discussed below).

Similarly to the Gunnedah Basin, the Surat Basin is subdivided by stratigraphic units. Those present in the Dunedoo-Mendooran area are shown in Table 2.

Liverpool Range Volcanics

The Liverpool Range Volcanics (Table 1) represent the largest Cenozoic volcanic province in NSW. The present extent of the lava field represents an erupted volume of 4,000 – 6,000 cubic kilometres. The regional distribution of lava types indicates two distinct rock type groups: an older eastern suite of Late Eocene age (40.3-37.7 million years) and a western suite of Oligocene age (35.1-32.3 million years). Rocks of the western suite are present between Dunedoo and Mendooran. These rocks lie spatially between the Warrumbungle volcano to the north, and the Canobolas volcano to the south and show an eruptive age intermediate between rocks derived from both volcanoes. The Warrumbungle, Liverpool Range and Canobolas lavas are related to hot spot volcanism (i.e. a process whereby eruptions are related to the northward movement of the Australian continent across a fixed mantle thermal plume), however the Liverpool Range lavas were erupted from fissures rather than volcanoes. The chief rock type present regionally is olivine basalt.

Cenozoic Watercourses and Floodplains

The Cenozoic era throughout most of Australia is characterised by extensive erosion, with most deposition occurring in floodplains, lakes, and major internal drainage basins such as the 60 million year old Lake Eyre basin. Broad floodplains border the Talbragar River at Dunedoo and the Castlereagh River at Mendooran. These rivers are both mature meandering streams which have transported silt from their eroding, elevated headwaters over millions of years, depositing the silt and mud outside of their channels in flood conditions.

BASIN	MILLION YEARS AGO	AGE	STRATIGRAPHIC UNIT	ROCK TYPES	DEPOSITIONAL ENVIRONMENT
Great Australian Basin - Surat Basin	152	Mid-Late Jurassic	Pilliga Sandstone	Sandstone, minor siltstone	Braided stream
		Early-mid Jurassic	Purlawaugh Formation	Sandstone, siltstone, mudstone, coal	Floodplain, meandering stream
	220	Erosion			
Gunnedah Basin	237	Mid Triassic	Napperby Formation	Sandstone, siltstone, claystone, coal, conglomerate	Delta Lake
		Early Triassic	Digby Formation	Conglomerate	Alluvial fan
	247	Erosion			
	255 259	Late Permian	Black Jack Group	Sandstone, siltstone, claystone, coal	Lakes, peat swamp River, floodplain Marine delta

Table 2. Stratigraphic columns for the Surat and Gunnedah basins in the Dunedoo-Mendooran area.

THE CYCLING TRAILS AND GEOLOGY

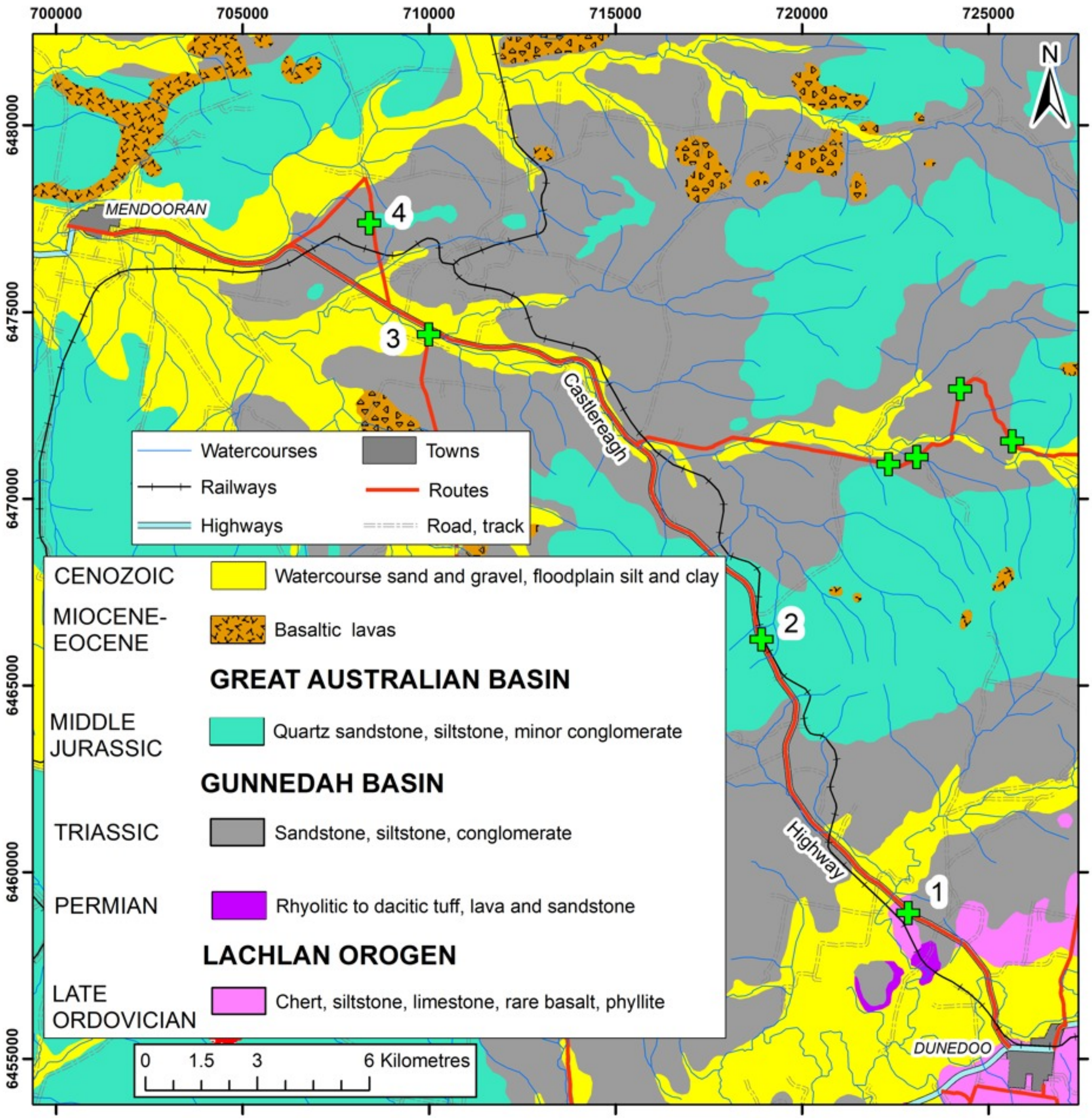
For descriptive purposes the cycling trails shown in Map 1 have been subdivided into individual sections or loops, some of which can be easily combined for continuous routes to and from Dunedoo:

- Dunedoo to Mendooran via Castlereagh Highway
- Digilah Road - Digilah West Road
- Lawson Park Road - Lewis Road - Tucklan Road - Avonside Road - Avonside West Road
- Cobbora Road

Dunedoo to Mendooran via Castlereagh Highway

This is a 2 lane, relatively wide sealed road which can carry moderate traffic at times. The route description assumes commencing at Dunedoo (see Map 2, below).

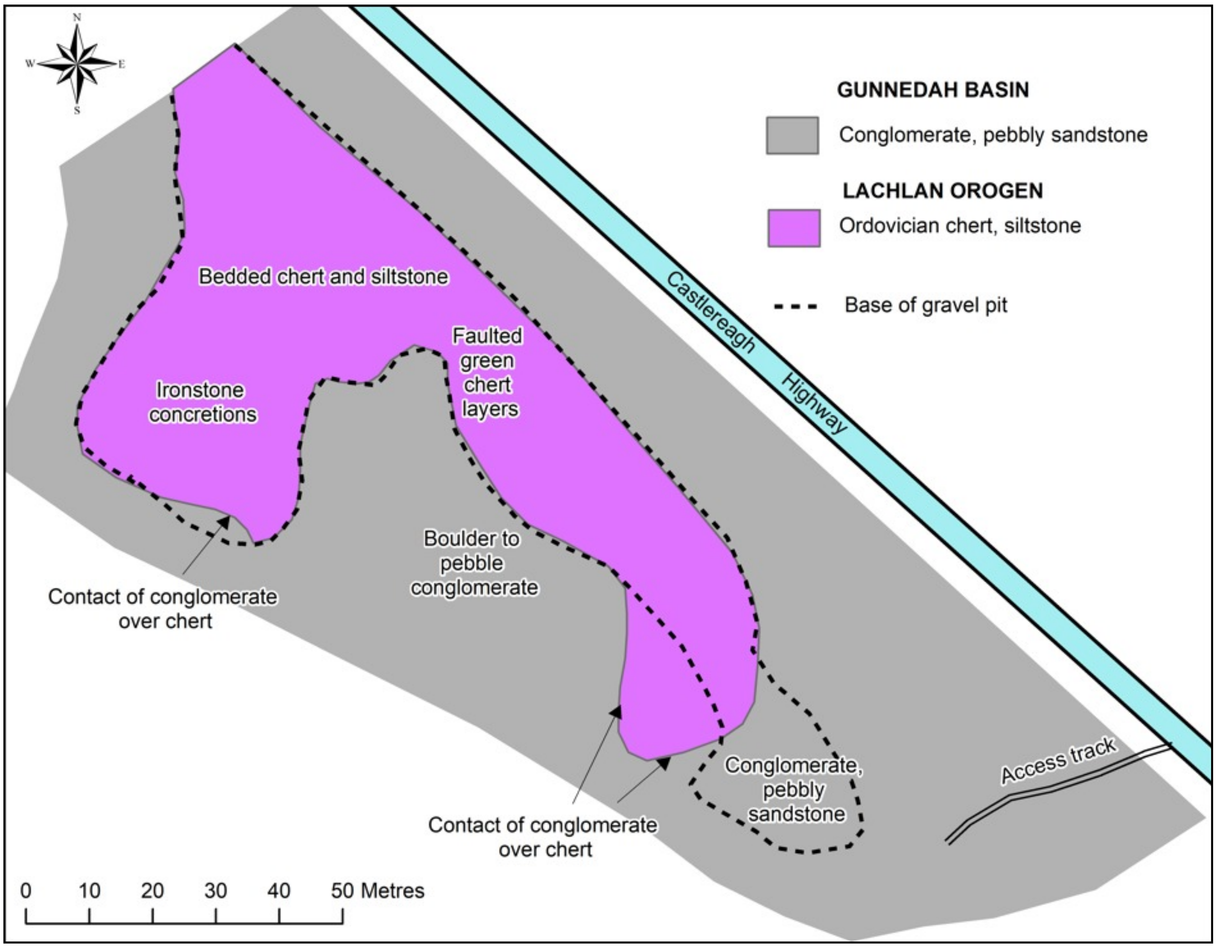
The first 3.3 km of the route passes over the flat Talbragar River floodplain. The road begins rising onto a hill composed of Ordovician chert and siltstone with thick, sheet-like Gunnedah Basin sandstone beds showing prominently on the hilltop. These rocks can be examined in an abandoned roadside gravel pit (Site 1) 5 km from the intersection of the Golden and Castlereagh Highways.



Map 2. Simplified geological map of the Dunedoo-Mendooran route via the Castlereagh Highway.

Site 1. Contact between the Gunnedah Basin and Ordovician basement rocks. Grid reference 722790E 6458950N (GDA 94, MGA Zone 55)

The gravel pit occurs amongst woodland on the western side of the highway (Map 3). The former access track provides suitable off-road parking.



Map 3. Geological plan of gravel pit at Site 1.

The gravel pit has been excavated through conglomerate and pebbly sandstone of the Gunnedah Basin into the underlying chert and siltstone of the Lachlan Orogen. Map 3 shows the geology of the pit site, and the outline of the pit base. A number of sites about the pit allow you to place your hands on Lachlan Orogen and Gunnedah Basin rocks, spanning a time gap of nearly 200 million years! The conglomerate and pebbly sandstone was deposited by streams carrying abundant coarse and bouldery gravel and sand, much of which was derived from eroding the underlying cherts and siltstones. These were the first rocks formed in the Gunnedah Basin when parts of eastern Australia began subsiding whilst other areas remained elevated, thereby creating a topographic gradient which produced fast flowing streams.

By examining the chert and siltstone in the base of the pit, and comparing those rocks to the pebbles in the conglomerate, it can be seen that they are nearly identical. Note in particular the sparse green chert pebbles which match the layers of green chert found in the centre of the pit area. The pebbles are a mix of well rounded and angular shapes (Photo 1), showing that some have been exposed to alluvial processes for a long period of time, whereas others have been eroded and buried rapidly.

The cherts and siltstones are bleached (Photo 2) from a long period of deep weathering in the groundwater table, during which most soluble minerals were removed. As part of this process, it is common for iron oxides to deposit in places as infillings of fractures and as *concretions*. *Concretions* are formed when a dissolved mineral (iron oxide, calcium carbonate or silica) precipitates about a nucleus, forming a concentrically zoned body. Iron oxide concretions are common in one part of the pit (see Map 3, Photo 3).

Small-scale faults are very common in the Earth's crust, particularly in rocks which have undergone multiple deformations as have the Lachlan Orogen rocks. A number of distinctive, green chert beds (Map 3,

Photo 1. Conglomerate composed of angular chert and siltstone pebbles.

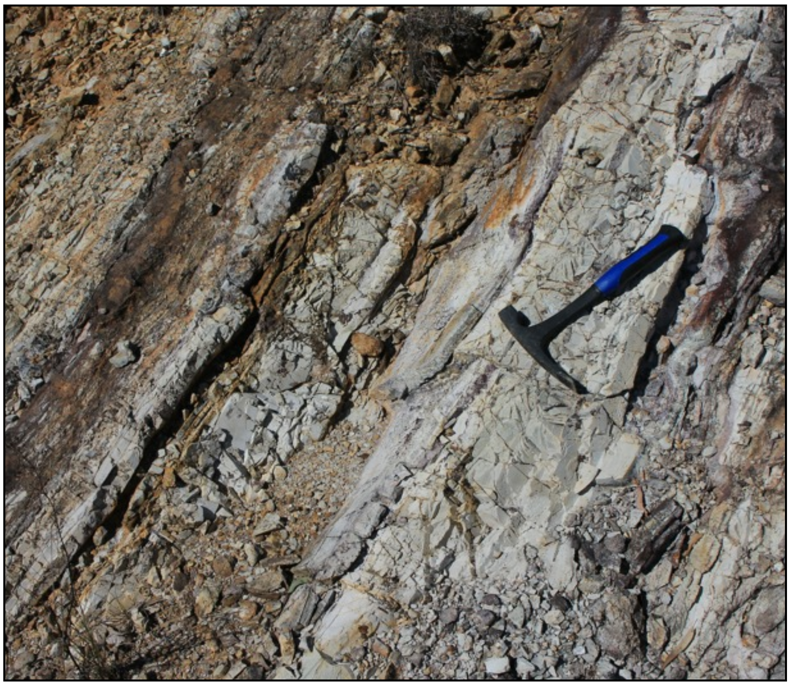


Photo 2. Bedded bleached chert and siltstone with weathering-derived iron oxide accumulations.

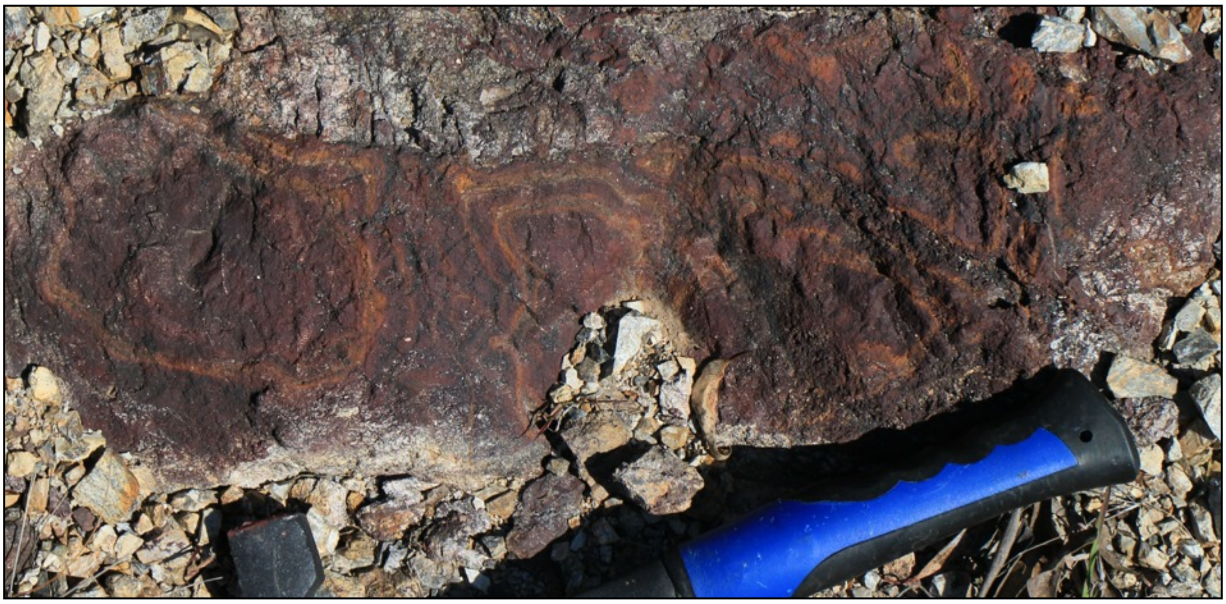


Photo 3. Concentrically zoned iron oxide concretions

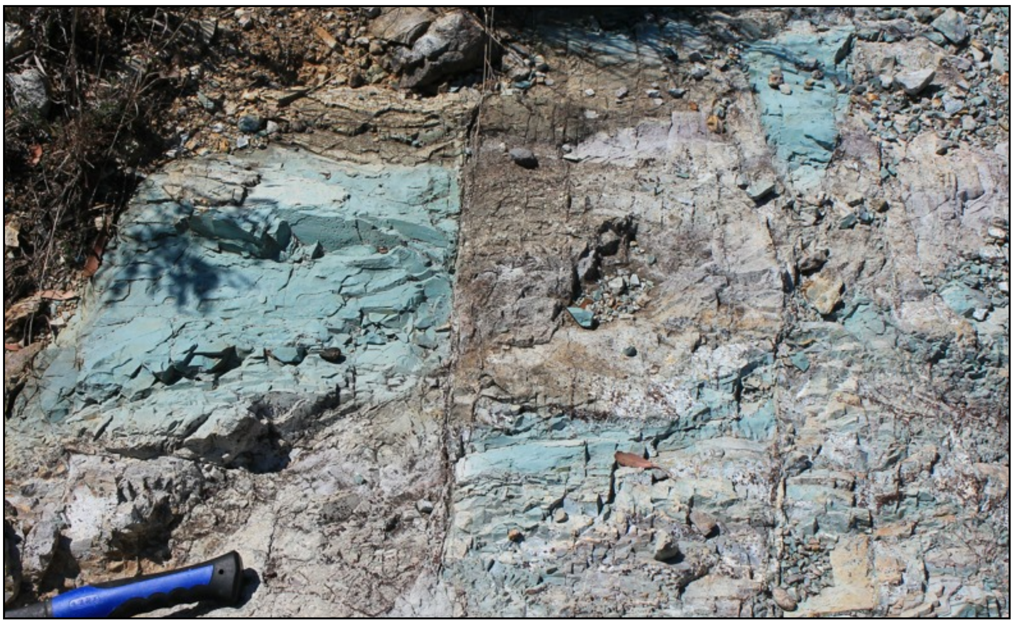


Photo 4. Pale green chert beds truncated and offset by fault planes running from top to bottom of photo.

Photo 4) show complex fault offset patterns, with relative displacement across the fault planes of a few centimetres to tens of centimetres. The offsets directions are not consistent, as can be determined by attempting to match the green chert beds on either side of the fault planes.

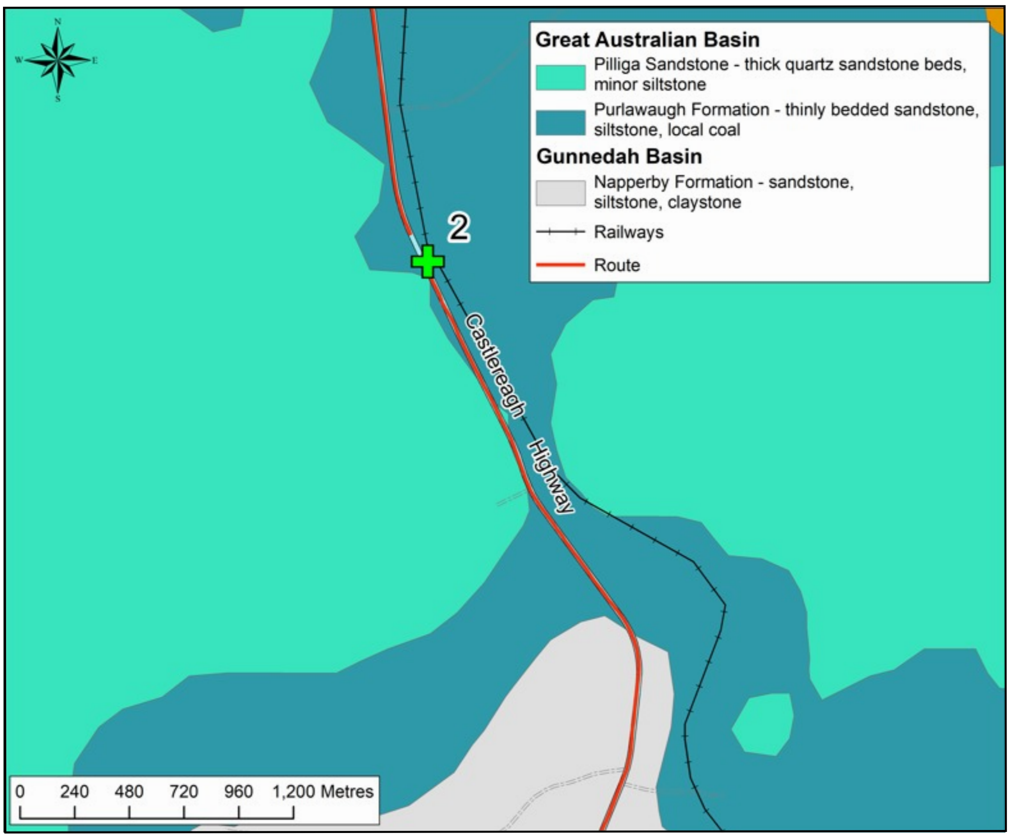
Continuing north along the highway: the road passes across the Munbedah Creek floodplain and commences a slow ascent through Gunnedah Basin rocks. These aren't well exposed, with a few small road cuttings showing sandstones and siltstones. The road begins a steeper ascent, having passed through the more erosion resistant quartz sandstones of the Surat Basin. At the crest of the ascent, a tall and steep road cutting with a falling rock barrier represents Site 2 (see Map 2). A convenient parking place occurs on the eastern side of the road.

Site 2. The lowermost geological unit of the Surat Basin. Grid reference 718910E 6466230N (GDA 94, MGA Zone 55).

In the area covered by this guide the Surat Basin comprises two distinct rock groupings: the *Purlawaugh Formation*, and the *Pilliga Sandstone* (Table 2). These *stratigraphic units* occur widely throughout the entire basin, and demonstrate a generally consistent set of evolving depositional conditions over a large area.

Photo 5. Weathered thin silty sandstone and siltstone beds of the Purlawaugh Formation. The thick sandstone at the top of the cutting is more representative of the Pilliga Sandstone.

Site 2 shows a representative section of the Purlawaugh Formation (Map 4), the earliest sedimentary rocks deposited in the Surat Basin. The rocks observable in the road cutting comprise alternating thin layers (i.e. *beds*) of weathered and bleached silty quartz-rich sandstone and siltstone (Photo 5). These were deposited in and adjacent to meandering fresh water streams and in lakes and floodplains. Elsewhere, this part of the formation may contain more shale and mudstone, and thin coal. The lowermost parts of this formation are commonly conglomerate-bearing. South of this area, towards Gulgong, the Talbragar Fish Fossil bed occurs in this formation.



Map 4. Geological map of the region about Site 2.

The crest of the hill above the cutting is capped by Pilliga Sandstone (Map 4). The thick sandstone layer visible at the top of the cutting may be the earliest trace of that unit, which will be examined at Site 4.

Continuing north along the highway the topography gradually descends back through poorly outcropping Gunnedah Basin rocks (Map 2), then along the floodplain bordering Merrygoen Creek. About 27.6 km from the Golden Highway intersection the turn off to Cobbora Road is reached. Proceed down this road for 140 m to the Merrygoen Creek crossing and walk to the first gravel bar west of the crossing. This is Site 3.

Site 3. Ironstone concretions in creek gravels. Grid reference: 710010E 6474410N (GDA 94, MGA Zone 55).

Merrygoen Creek passes through areas of weathered rocks containing fracture-fills and concretions of dark brown to red iron oxides. These heavy rocks are sorted by flowing creek water into gravel bars containing an abundance of concretions (Photo 6). Searching the nearby gravel bars can result in the discovery of unique and interesting ironstone specimens.

Photo 6. Gravel bar containing abundant ironstone pebbles and concretion fragments.

Photo 7. Creek bank showing previous creek deposits, including the creek bed and floodplain.

A section through the creek bank provides an example of the prior history of Merrygoen Creek (Photo 7). The bank mainly contains sand and silt, with a long layer of gravel passing through the middle of the section. The gravel represents the previous bed of the creek which has repeatedly meandered back and forth across the floodplain. When the creek bed changes its course the previous bed is infilled with finer-grained sediment resulting from flood events. The watercourse bank wall shows the gravelly creek bed cutting downward into previous floodplain sand, then being infilled by sand passing upward into silt as the old channel was filled by floodplain material. The present channel has cut downward through numerous generations of prior channels and floodplains, suggesting that this part of Australia is slowly elevating.

Return to the highway and continue west for 1.4 km to Beni Road. Turn into this road and proceed across the railway crossing, gradually ascending through poorly outcropping Gunnedah Basin rocks for 2.2 km from the intersection with the Castlereagh Highway. Enter the deserted gravel pit on the west side of the road on the crest of the hill - Site 4.

Site 4. Pilliga Sandstone. Grid reference: 709470E 6477525N (GDA 94, MGA Zone 55).

The Pilliga Sandstone is the youngest portion of the Surat basin preserved in the region. It typically forms undulating plateaus, and caps most of the topographically higher terrain in the region. Its bouldery outcrops and thin, poor quality sandy soils downgrades its value as farming or grazing land, resulting in large areas remaining thickly vegetated.

This regionally extensive, thickly-bedded, sandstone-dominated unit also contains minor pebbly sandstone, conglomerate, siltstone and mudstone. It is the product of high-energy, rapidly-flowing braided streams transporting an abundance of sediment. The Pilliga Sandstone represents a change in depositional environment from the lower energy regime of the Purlawaugh Formation. In places the Pilliga Sandstone has eroded into and stripped away the Purlawaugh Formation and parts of the Gunnedah Basin.

Site 4 shows the thick, coarse-grained quartz sandstones typifying Pilliga Sandstone (Photo 9). Quartz pebble conglomerate is present in places (Photo 8). The sedimentary rocks are composed almost entirely of quartz, a mineral which survives chemical weathering processes after other mineral and rock grains have been destroyed. The presence of so much quartz confirms that the region had been subjected to a very long period of prolonged weathering and erosion, such as occurs in arid zone Australia today.

Photo 8. Quartz pebble conglomerate layer within quartz sandstone of the Pilliga Sandstone.

Photo 9. Thick beds of quartz sandstone typical of the Pilliga Sandstone.

After examining Site 4, return to Beni Road and turn north, travelling for 1.2 km to the intersection with Dennykymine Road. Turn west along that road following the Castlereagh River floodplain to the intersection with the Castlereagh Highway. Turning right will take you into the old Australiana village of Mendooran, built on the banks overlooking the Castlereagh River.

Digilah Road - Digilah West Road

This route runs from Dunedoo to Digilah Road and then along Digilah West Road to the Castlereagh Highway, a distance of 50.5 km from the Digilah Road-Golden Highway intersection. The road passes across rocks of the Gunnedah and Surat Basins, the Liverpool Range Volcanics, and various floodplains (Map 5). The route is described from south to north, from the start of Digilah Road.

The road passes across the Talbragar River and its broad floodplain before slowly ascending through areas of very poorly outcropping Lachlan Orogen rocks, then poorly exposed Gunnedah Basin strata. The approaching low hills about 4.8 km from the start of the road represent prominently outcropping Gunnedah Basin rocks which are examined at Site 13.

Site 13. Rock types of the Gunnedah Basin. Grid reference: 727930E 6460770N.

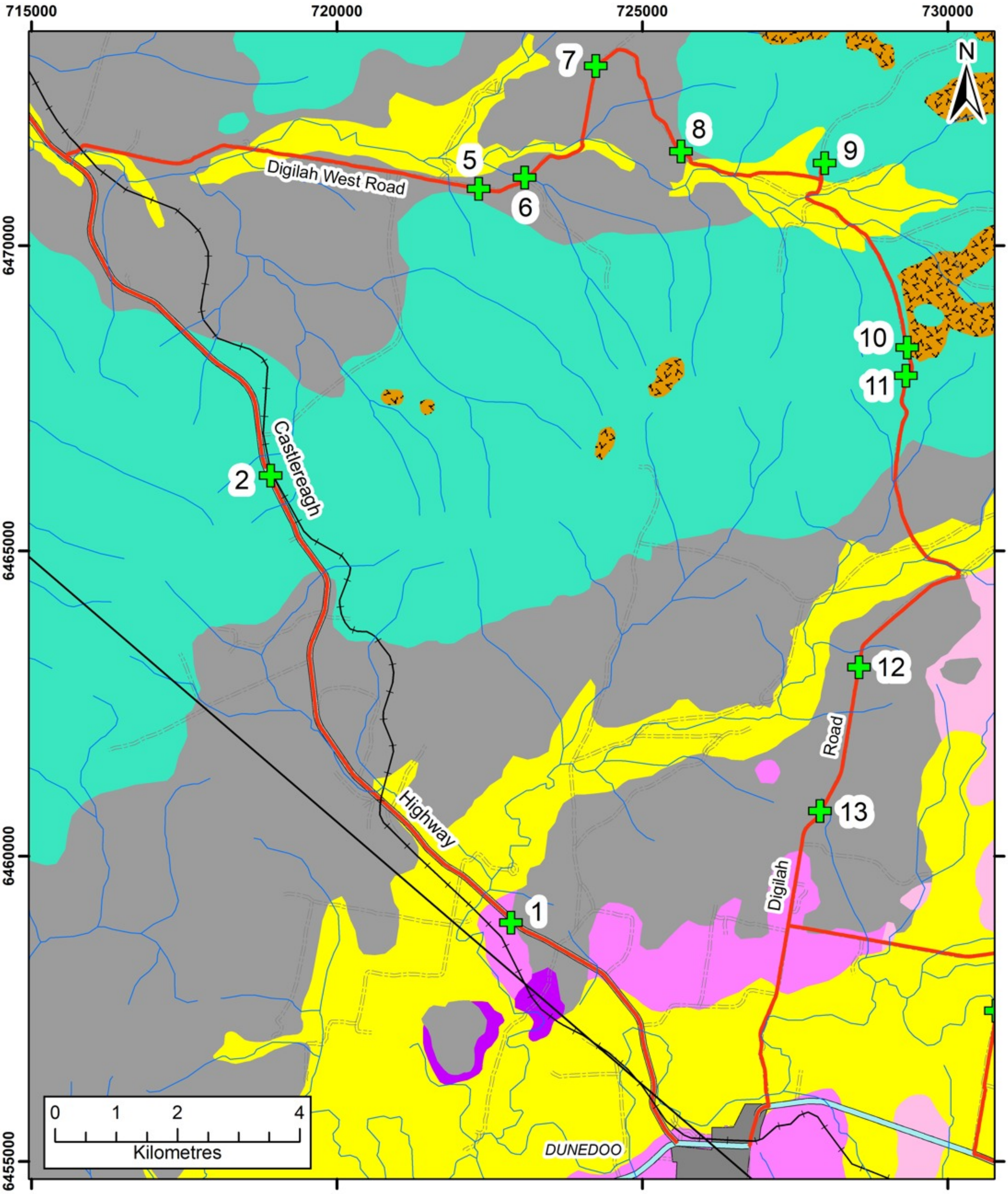
This site is located on the side of a small hill with prominent, low outcrop (Photo 10). A wire fence marks the boundary of private land, so please don't venture beyond it.

The site comprises rocks of two stratigraphic units from the Gunnedah Basin (Map 6, Table 2):

- Black Jack Group - siltstone with woody carbonaceous and coaly fossils, overlain by
- Digby Formation - pebble and cobble conglomerate

Photo 10. Outcrop at Site 13, showing fence. Fossiliferous, carbonaceous siltstones in foreground, conglomerate on hill top.

Black Jack group occupies most of the accessible outcrop area. The main rock type here is grey, carbonaceous siltstone with horizontal layering (Photo 10). Carbonised woody plant remains are common in certain layers, particularly just below the fence (Photo 12). Large, flattened logs occur in places, lying horizontally within the enclosing siltstone (Photo 11). Black, coalified fragments of woody material occur locally in the carbonaceous layers.



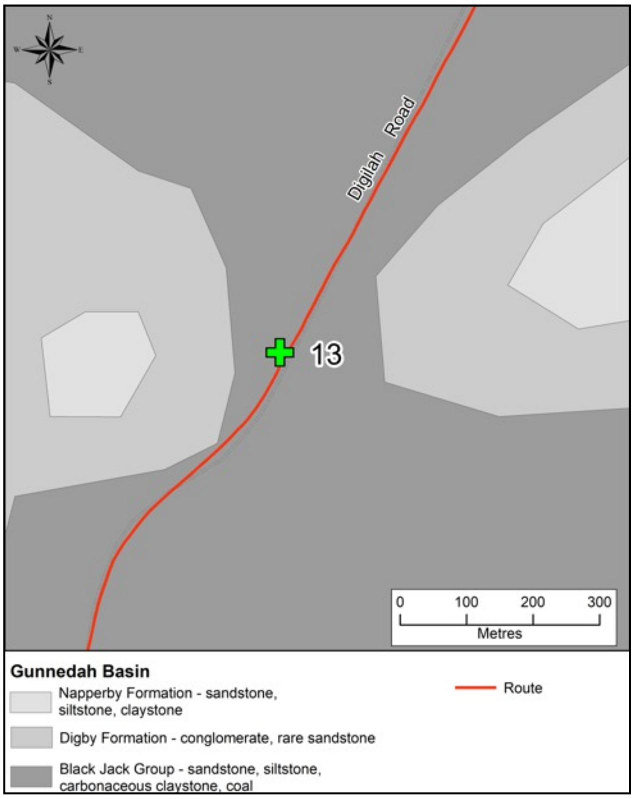
Map 5. Simplified geological map showing the route and geological sites of the Digilah and Digilah West Roads. Legend as for Map 1.

The top of the hill is capped with a thick layer of pebble and cobble conglomerate, representing the Digby Formation Map 6, Photo 13). Although it's not possible to examine the outcrop, boulders have rolled down slope through the fence, and the ground is strewn with well rounded pebbles derived from the conglomerate.

The rocks of the Black Jack Group were deposited from major river systems, initially in a brackish delta plain environment and then beyond tidal reach in an upper delta plain environment. Sediment was supplied largely by rivers draining from the rising country of the New England area, but sand and gravel was also contributed by rivers from the Lachlan Orogen to the south and west. Extensive coal deposits occur throughout the Black Jack Group with the principal seam, both in thickness and extent being the *Hoskissons Seam*. The rocks present at Site 13 are of floodplain and possible peat swamp origin.

The conglomerates of the Triassic Digby Formation are high energy alluvial fan deposits laid down over the Black Jack Group after a long period of erosion. This formation resulted from further uplift of the New England region, the increased elevation producing high energy braided streams carrying abundant coarse gravel and sand. Consider that the pebbles present in the conglomerate were washed off the New England region and transported here by rivers about 250 million years ago!

It is significant that the Black Jack Group is the oldest part of the Gunnedah Basin present in the Dunedoo region. This unit was deposited near the end of the Late Permian, about 250-259 million years ago. The oldest rocks elsewhere in the basin were deposited from about 275 million years, indicating that the basin did not expand to the Dunedoo region until about 16 million years after it began filling.



Map 6. Geological map of the Site 13 area.

Continue along Digilah Road passing through poorly outcropping Black Jack Group with low hills capped by Digby Formation in the distance. After about 2.5 km abundant small sandstone blocks are apparent on the eastern side of the road. These are hard, silicified siltstone which can contain leaf and woody stem fossils of the Permian plant *Glossopteris*. A stop at Site 12 gives an opportunity to search for fossils.

Photo 11. Flattened, partly coalified carbonaceous log in siltstone.

Photo 12. Carbonaceous siltstone with abundant woody plant remains.

Photo 13. Bouldery outcrop of conglomerate along hill top. Individual rounded pebbles and boulders of conglomerate occur down-slope of the outcrop.

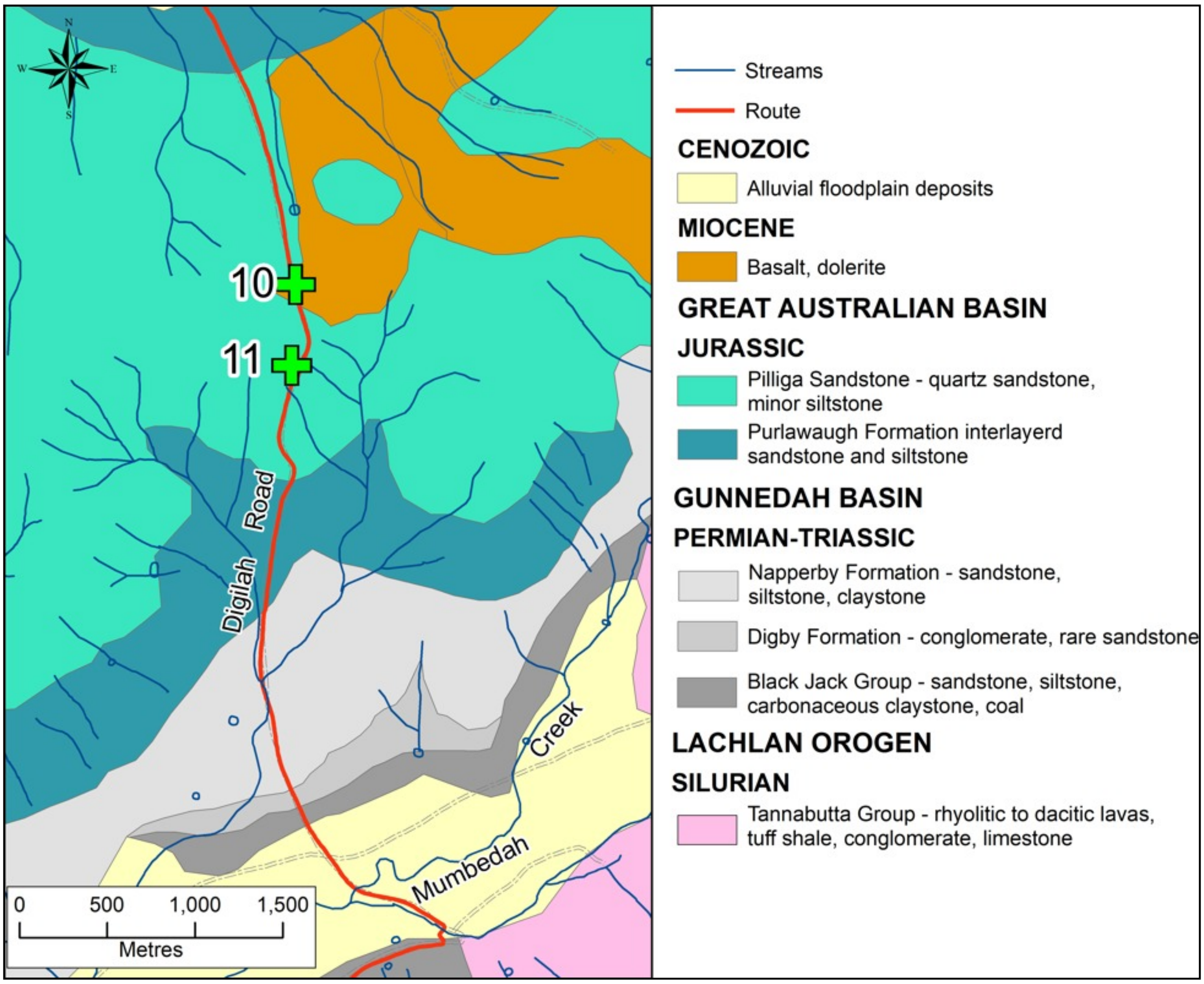
Site 12. Gunnedah Basin siltstones containing Glossopteris. Grid reference: 7285450E 6463100N.

Glossopteris was a deciduous, seed-bearing tree which was the dominant lowland vegetation at high latitudes across Gondwana during the Permian. It first appeared at the beginning of the Permian about 299 million years ago, and became extinct during the mass extinction event at the end of the Permian. It was probably the major contributor of vegetation to Permian coal swamps.

The siltstones along the road side here are very tough and require a hammer to split. However, any road cutting through Permian rocks in this region has the potential to reveal good specimens of this relatively common fossil.

Photo 14. Glossopteris in silicified siltstone.

Continue along Digilah Road. The geological map of this route (Map 5) shows that Lachlan Orogen rocks are present at short distances to the east and south, suggesting that the preserved thickness of the Gunnedah Basin here is relatively thin. The road crosses the broad Mumbedah Creek floodplain before beginning an ascent through Gunnedah Basin rocks and lowermost Surat Basin, then as the road steepens up the more erosion-resistant Pilliga Sandstone described previously at Site 4 is entered. Before the crest of the ridge is reached a large roadside pit is encountered. This is Site 11.



Map 7. Geological map of Sites 10 and 11.

Site 11. Pilliga Sandstone with cross-bedding. Grid reference: 729290E 6467880N.

This bulldozed pit shows the general characteristics of the Pilliga Sandstone (Photo 15), and includes some thin, grey siltstone and mudstone beds (Photo 16). Cross bedding will be discussed and described at Site 8, where multiple examples of these sedimentary structures are easily examined. Cross beds are planar structures developed at an angle to the main bedding planes. This is evident in Photo 15 and enhanced in the accompanying interpretative diagram. Cross bedding is formed by sand cascading down the front of a moving sand body, both in water and in air. It can be used to indicate the direction of the current which produced the structure.

The sandstone beds at this site are very thick, commonly a metre or more. The cross beds confirm that the individual sand beds were produced by a migrating mass of sand down stream. In photo 16, the current was moving from left to right. The thick beds indicate that large masses of sand were being transported by a fast moving body of water. Studies of these rocks throughout the Surat basin have indicated that the streams were braided, consisting of a network of many sinuous and bifurcating branches within the main channel. They are a product of fast water flow and steep gradients, with a high load of sediment moving along the bottom. They are often found around mountainous regions with glaciers, or in areas with sparse vegetation.

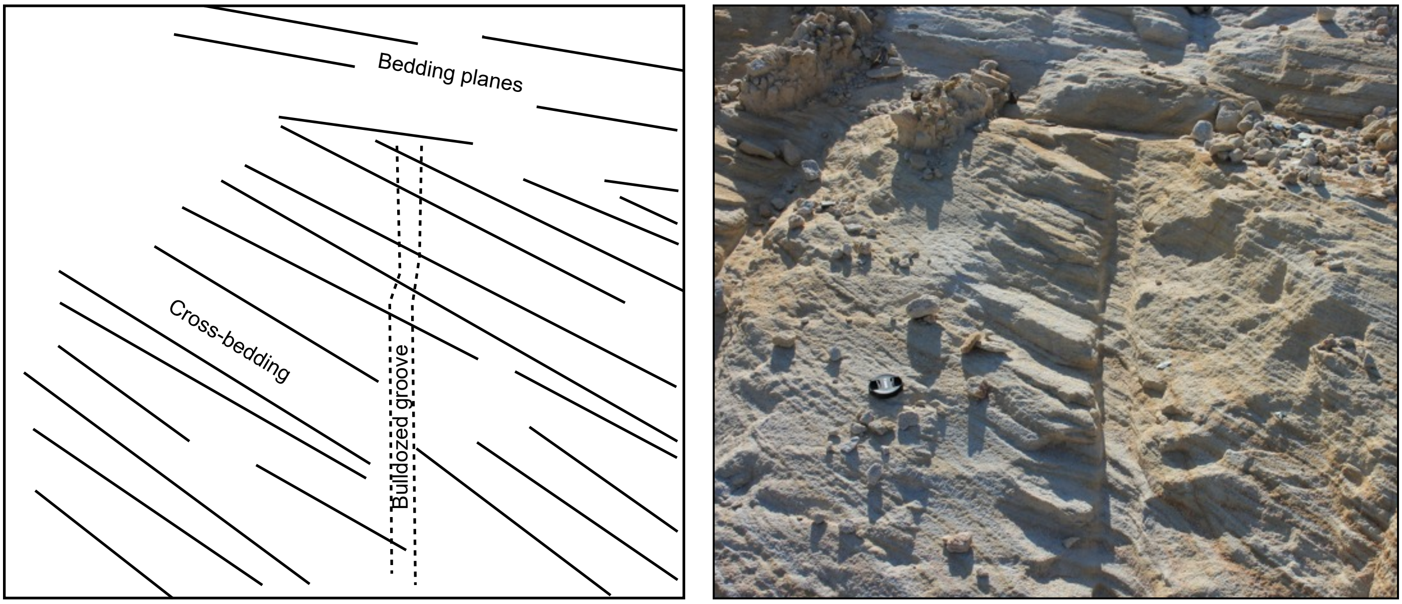


Photo 15. Image of cross bedded sandstone with interpretative diagram.

Photo 16. Thin siltstone layers within white sandstone.

The thin silty layers represent areas to the side of the main channel which received overflow during flood episodes.

Continue up hill to the crest of the ridge. A road cutting through black soil is Site 10.

Site 10. Miocene basaltic lava. Grid reference: 729320E 6468325N.

This site is one of the few available in the region to examine the products of Miocene hot spot volcanism which produced much of the young basaltic lavas throughout eastern Australia (Map 7).

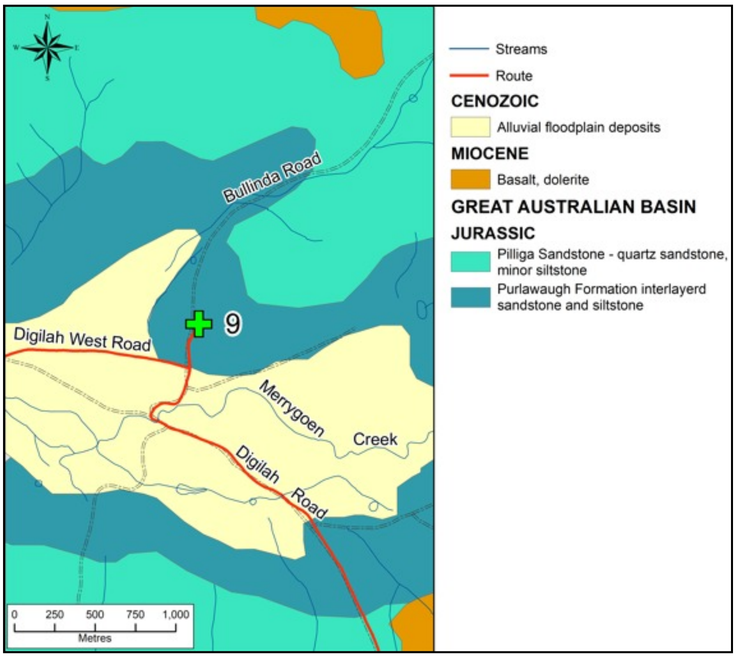
The lava forms the crest of the ridge. It has weathered to produce fertile black and red clayey soil throughout which small fragments of basalt are preserved. The basalt is fine-grained, with freshly broken surfaces showing small crystals of green *olivine* and white *feldspar* visible against the black *pyroxene*-rich rock.

These lavas are scattered remnants of the previously very widespread Liverpool Range Volcanics. They were erupted from fissures from 32 to 35 million years ago. They generally occur along ridge crests as their resistance to erosion helps preserve the topography whilst softer rocks erode away around them.

Continue down hill through Surat Basin rocks and onto the extensive Merrygoen Creek floodplain. Continue past the intersection with Digilah West Road on Bullinda Road up hill for 270 m and stop by the roadside pit. This is Site 9.

Site 9. Gravel pit in Purlawaugh Formation. Grid reference: 727980E 6471350N.

This site shows many of the characteristic features of Purlawaugh Formation, the lowermost geological unit of the Surat Basin in this region. It was previously described at Site 2. The overlying Pilliga Sandstone examined at Site 11 occurs at the top of this ridge (Map 8).



Map 8. Geological map of the Site 9 area.

The rocks here are interlayered silty quartz sandstones and siltstones showing common cross bedding (Photo 17). The individual beds are much thinner and siltstone is more abundant than the Pilliga Sandstone. A bulldozed block of orange sandstone shows abundant rip up clasts of white claystone (Photo 18). *Rip up clasts* are fragments of an underlying sediment which were torn up by a strong water current and incorporated in the newly deposited sediment. In this case it was a clay layer which was torn up, the sticky clay holding together long enough to be redeposited as fragments rather than being completely destroyed. It is a further confirmation on the high water velocities present during deposition of this unit.


Photo 17. Cross bedded quartz sandstones.

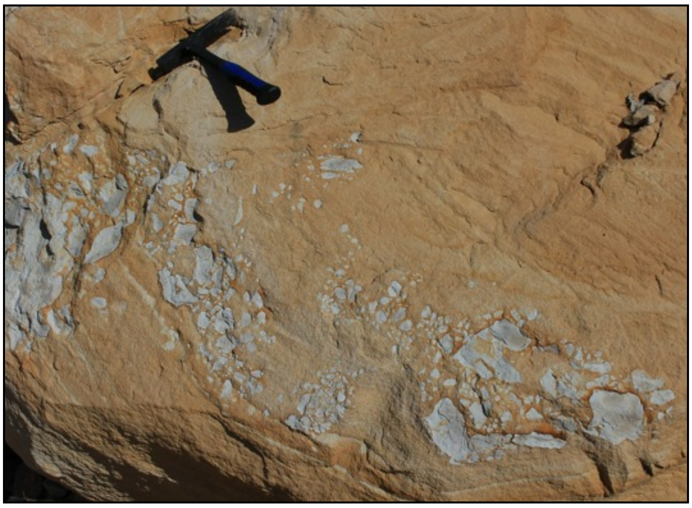


Photo 18. Rip up clasts of mudstone in sandstone block.

Note how the crossbeds all show a similar orientation of their dipping surfaces. This demonstrates a consistent current direction with no significant meandering of the channel in which the sandstones were deposited. Close inspection of broken surfaces of sandstone will also show the presence of small silvery grains of white mica (*muscovite*).

Return to the previous intersection, and turn west into Digilah West Road. Follow this for 2.4 km, passing along the Merrygoen Creek floodplain, then beginning a slow ascent through poorly exposed Gunnedah Basin rocks with a heavily timbered ridge visible close to the eastern side of the road. A number of very large, angular boulders of sandstone are visible on the flanks of the ridge. This is Site 8.

Site 8. Boulders of cross bedded Pilliga Sandstone. Grid reference: 725640E 6471545N.

Numerous huge boulders of Pilliga Sandstone have rolled down hill from their outcrop beneath thick tree cover (Photo 19). One boulder can be observed on the road side of the boundary fence (Photo 20). Please don't cross the fence.

Photo 19. View of large boulders of Pilliga Sandstone with ridge of outcrop in background.

This spectacular boulder has rolled into a position approximating its original orientation! It is composed of numerous sandstone beds showing well developed cross bedding with similar dip directions. Figure 1 shows the mechanism for producing cross bedding in water or air, whereby the current transports sand ripples through a process of erosion on the upstream side of the ripple crest, and deposition on the downstream side. Small variations in grainsize and composition of the sand highlights the successive crossbeds which have been enhanced by erosion, producing the effects seen in the large boulder.

Water or air currents cause ripples to move by erosion and redeposition

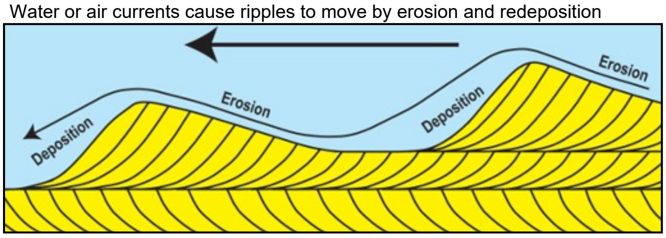


Figure 1. Mechanism for production of cross beds.

Continue along the road for about 2.5 km to an area of abundant low outcrop on a bend. This is Site 7.

Photo 20. Large boulder of Pilliga Sandstone showing repeated crossbedded layers.

Site 7. Pebbly sandstone in Gunnedah Basin rocks. Grid reference: 724240E 6472940N.

This site examines some conglomeratic rocks (Photo 21) from the Napperby Formation (Map 9), the youngest rocks preserved in this area of the Gunnedah Basin. This geological unit overlies the conglomeratic Digby Formation examined at Site 13 (see Map 6) and is overlain by the Purlawaugh Formation along an erosional boundary with a time gap of about 45 million years.

The Napperby Formation is rarely found in outcrop due to its thinly layered, clay-rich sandstones and siltstones. Conglomerates are uncommon. It was deposited during the Triassic in non-marine, deltaic and lake environments.

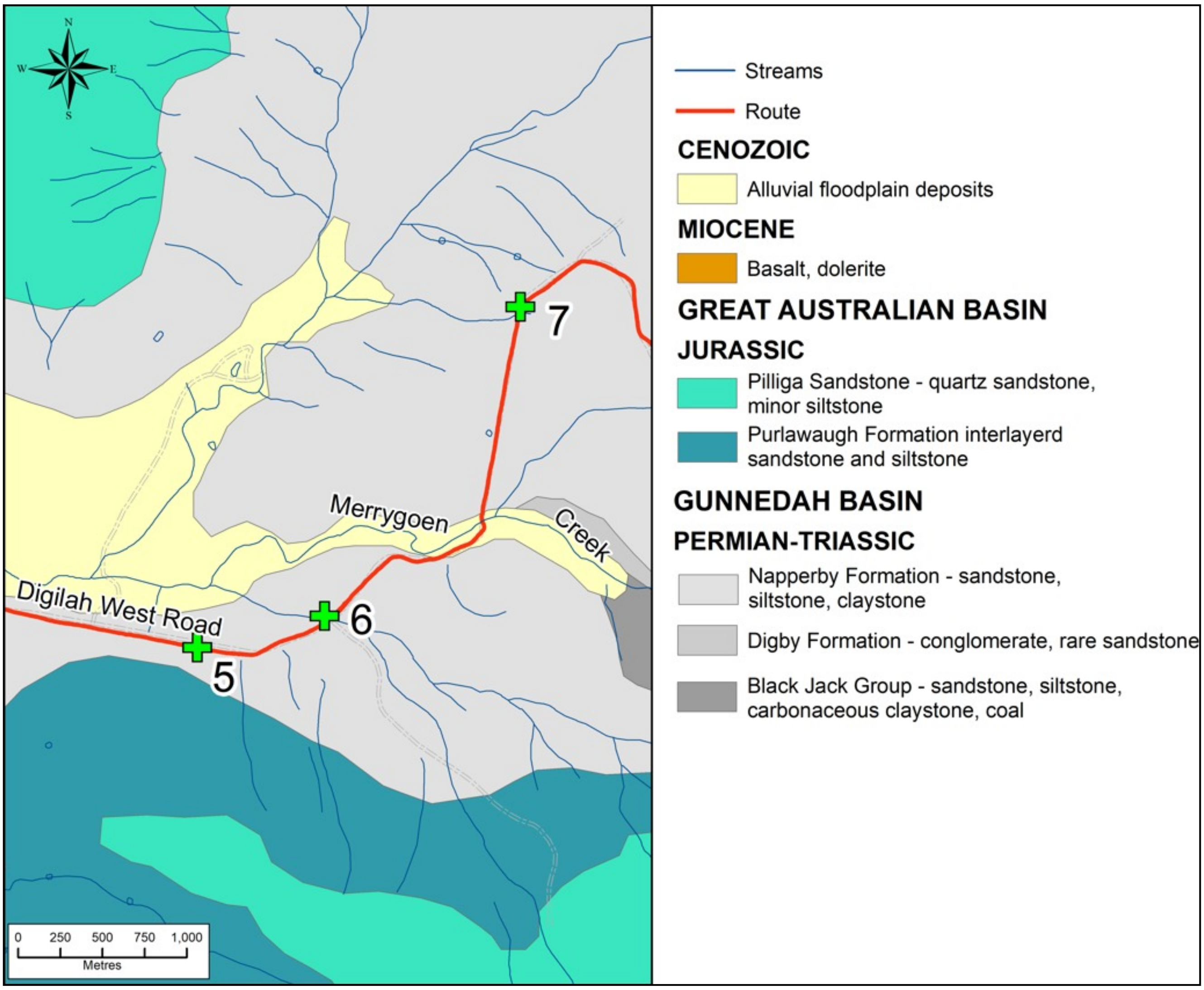
The conglomerate outcropping at this site is very unusual. It is composed of abundant sand enclosing angular fragments of chert, probably derived from Ordovician Lachlan Orogen rocks. It is likely that during the deposition of the original gravel, this area was on the flank of elevated Ordovician rocks which were shedding stony material down-slope. The gravel was not deposited in a creek which would have rounded the pebbles and sorted grainsizes, but was rapidly covered and preserved. The conglomerate resembles similar rocks at Site 1 which are deposited directly on the Ordovician basement. Perhaps a similar situation exists here, with the Ordovician rocks currently shallowly buried.

Photo 21. Napperby Formation conglomerate.

Continue along the road for nearly 2.5 km, crossing Merrygoen Creek and stopping near the bridge over steep-sided creek with a homestead near the western bank. Site 6 (Map 9) is located in the creek bed, which is best accessed from the eastern side of the bridge on the northern side of the road.

Site 6. Napperby Formation sandstones with abundant spectacular ironstone concretions. Grid reference: 723075E 6471110N.

The creek bed reveals many outcrops of Napperby Formation including micaceous quartz sandstone, some showing cross beds. Ironstone concretions are abundant, both as blocks and fragments transported by the watercourse, and as specimens in their original position.



Map 9. Geological map showing sites 5, 6 and 7.


Photos 22, 23. Iron oxide concretions from Site 6, showing concentric internal layering.

Most concretions show attractive concentric layering (Photos 22, 23) produced during repeated growth stages of the concretion, probably over thousands of years. These have grown in fractures within the sandstone where groundwater carrying dissolved iron oxide initially precipitated it about a suitable object. Successive influxes of groundwater carried additional iron oxide into the fracture which precipitated about the rim of the earlier oxide. Various impurities such as clay, and differing concentrations of iron oxide and water temperatures and duration of immersion produced layers of different composition and thickness.

Continue along the road for 850 m, stopping at the top of a low rise before it descends to the west. Low outcrops and abundant quartz pebbles mark Site 5.

Site 5. Conglomerate and sandstone of Napperby Formation. Grid reference: 722300E 6470930N.

This site shows a quartz pebble conglomerate which corresponds significantly with the chert-rich conglomerate of Site 7. The conglomerate doesn't outcrop prominently. It is mainly composed of rounded pebbles and cobbles of white vein quartz (Photo 24). The ground is covered with pebbles eroded from the conglomerate. Sandstone is abundant to the east along the road edge. An example of fossil mud cracks in siltstone was observed (Photo 25), indicating that these rocks were at times subjected to wetting and drying events.

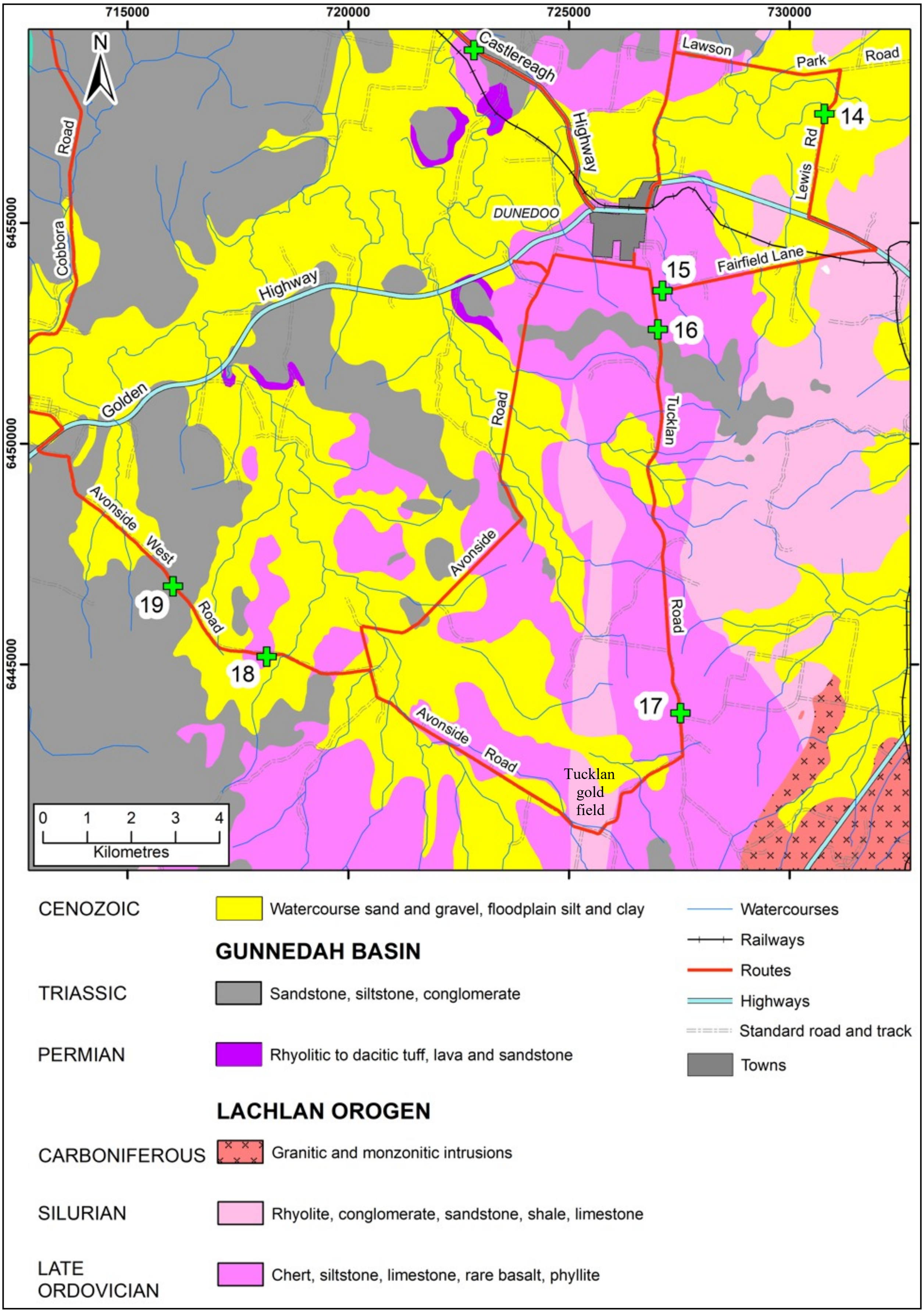
Photo 24. Quartz pebble conglomerate from Napperby Formation.

Photo 25. Fossil mud cracks in siltstone from Napperby Formation.

The road continues to the Castlereagh Highway through country with very poorly exposed Gunnedah Basin rocks and floodplains bordering Merrygoen Creek. No significant outcrops occur along this section of road.

Lawson Park Road - Lewis Road - Fairfield Lane - Tucklan Road - Avonside Road Loop

This potential loop route is described in the order listed in the above heading, providing a circuit starting and ending at Dunedoo. The geology examined along the route includes a detailed look at the composition and origin of the Talbragar River floodplain, some different examples of rocks comprising the Ordovician and Silurian components of the Lachlan Orogen, and interesting rocks in the Gunnedah Basin (see Map 10).



Map 10. Simplified geology of the Lawson Park Lane to Avonside Road route.

Travel from Dunedoo eastward onto the Golden Highway, and turn into Digilah Road. Travel across the Talbragar River floodplain for 3 km to the intersection with Lawson Park Road. Turn right into this road and proceed for 3.8 km to the intersection with Lewis Road, a narrow gravel road on the right. Follow Lewis Road for 1 km, crossing the Talbragar River. Park on the southern side of the bridge.

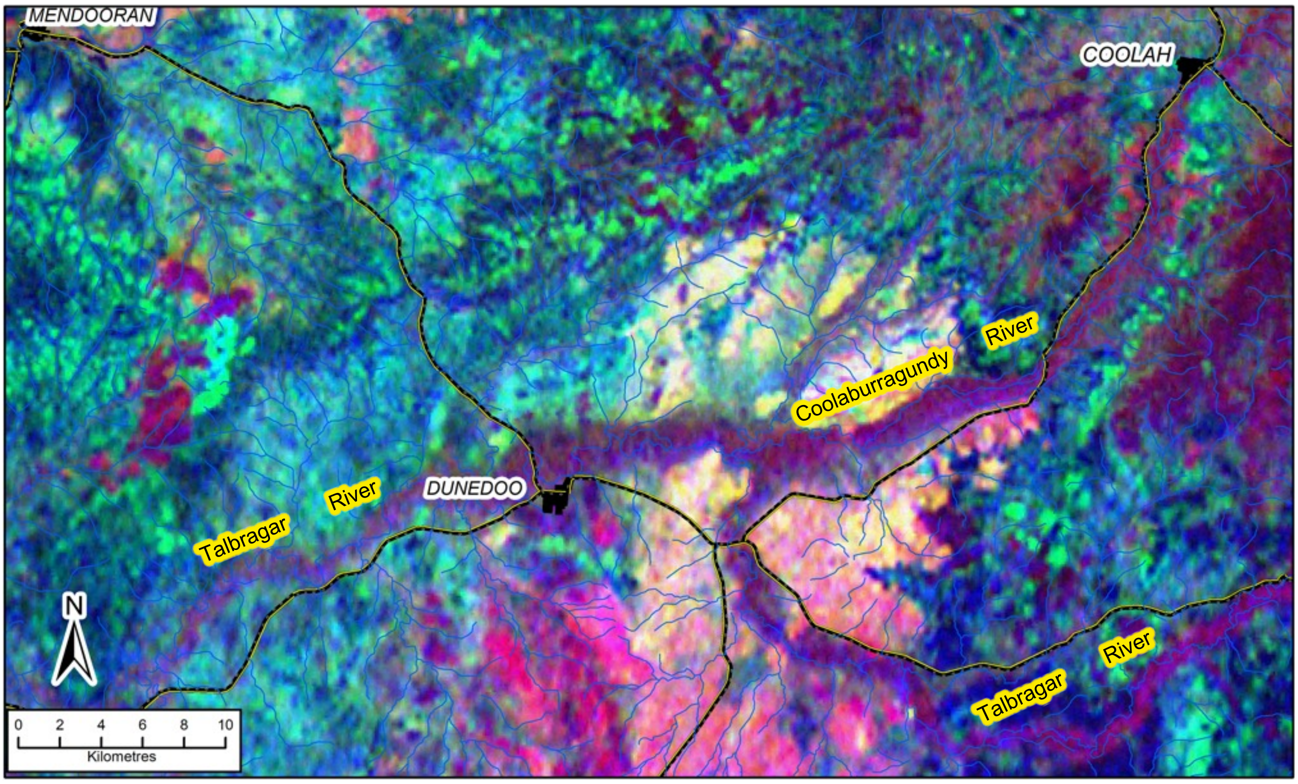
Site 14. The Talbragar River floodplain: not just a boring area of black soil. Grid reference: 730790E 6457450N.

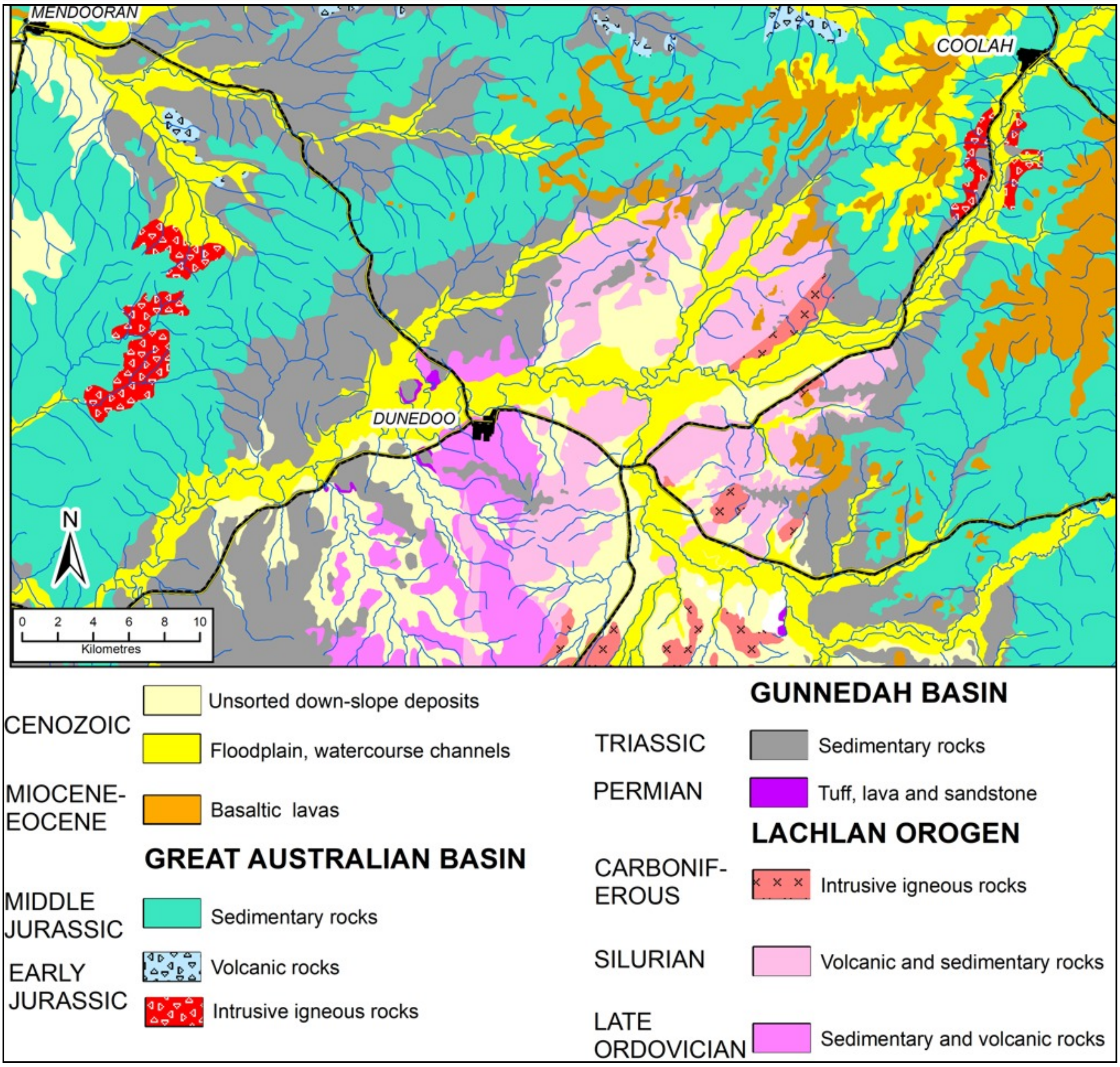
The Talbragar River floodplain (Map 11) is a broad, flat area of farmed and irrigated land bordering the Talbragar River. The river meanders through the floodplain, which is up to 2 km wide in places. A satellite image (Figure 2) shows the complex agricultural features developed on the floodplain, including ploughed paddocks and circular features resulting from cultivation for centre-pivot boom spray irrigation. As well as these man-made features, the river's prolonged history of migrating meanders and flood events is shown as cut-off and abandoned meanders, and flood channels leading off the active river channel and rejoining it further downstream.

Figure 2. Satellite image of the Talbragar River floodplain near Dunedoo.

The Talbragar River floodplain has resulted from millions of years of lateral movement of the river as it carved through bedrock, then began infilling it with river channel sediment, and over-bank silt and clay during major flood events. Site 14, on the river bank, demonstrates the composition of the floodplain as massive black clayey soil. This thick black soil has been transported down stream by the Talbragar River and its upstream tributary the Coolaburragundy River. Both rivers are sourced from the Liverpool Ranges about 70 km northeast of Dunedoo, which is dominated by a large region of basalt outcrops (Liverpool Range Volcanics as examined at Site 10). Millions of years of weathering and erosion of the basalt has released vast quantities of rich black soil into the drainage system, resulting in the rich floodplains along both rivers.

Map 11 shows the simplified geology of this region with a radiometric image of the equivalent area. The radiometric image is a depiction of the gamma rays produced by the naturally occurring isotopes of potassium, thorium and uranium which are present in most rocks. The gamma rays were recorded in an aerial survey and the image produced from that data for use by researchers. The gamma rays are derived from outcrops and soil, with virtually no depth penetration below a few centimetres. Bright colours





Map 11. Radiometric image (top) and corresponding simplified geological map of the region.

represent high concentrations of isotopes, dark colours low concentrations, and the variation in colours represent the relative proportions of the three isotopes.

By comparing the geological map to the radiometric image some interpretations can be made:

1. Note the strong relationship between distinctive colours in the radiometric image and mapped geological units. In particular, the Silurian portion of the Lachlan Orogen is distinctly and uniquely bright, parts of the Surat Basin (particularly Pilliga Sandstone) are distinctively bright green, and the basalts show as dark pinkish-red, the same colour as the floodplains of the Talbragar and Coolaburragundy Rivers.

2. Note how the Castlereagh River and Merrygoen Creek floodplains near Mendooran are not distinctively different from the surrounding outcrops. This is because their sediment is derived from rocks present in the local geology.

3. The radiometric characteristics of the Talbragar River floodplain change significantly west of Dunedoo. This relates to dilution of the basaltic clay sediment with locally sourced materials.

To visit Site 15, continue along Lewis Road to the Golden Highway, turn left and travel along the highway for 1.7 km to the junction with Fairfield Lane. The lane passes through floodplain and poorly exposed Ordovician Lachlan Orogen rocks. Site 15 is a long road cutting near the intersection with Tucklan Road.

Site 15. Folded Ordovician cherts and siltstones. Grid reference: 727110E 6453450N.

The road cutting on the eastern edge of the road shows tightly folded layers of creamy-white cherts of the Lachlan Orogen (Photo 26). The geometry of the folds can be traced by tracing the path of individual layers on the outcrop, and noting the variability in the orientation of layers across the entire outcrop width.

Photo 26. Folded Ordovician cherts.

The folds may result from tectonic processes, or from deformation of the original sediment whilst soft. Soft sediment fold structures are very common in deep sea sediments due to combinations of compaction and seismicity.

Turn left on to Tucklan Road and travel for 800 m to the hill crest, where low road cuttings show outcrops to be examined as Site 16.

Site 16. Basal Gunnedah Basin on cherty Ordovician. Grid reference: 727020E 6452590N.

This site shares a similar geological relationship to that in Site 1: angular conglomerate of the Gunnedah Basin (Black Jack Group - Map 11, Table 2) directly overlying Ordovician cherty rocks of the Lachlan Orogen. This conglomerate may represent original gravelly soil sitting in its original position prior to the

Photo 27. Site 16, with an elevated area of Gunnedah Basin rocks shown through the fence in distance.

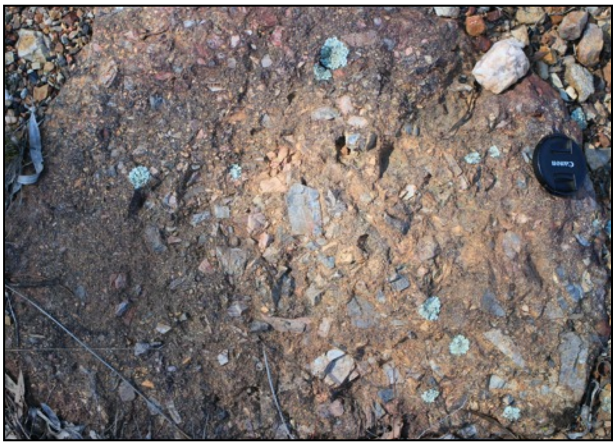


Photo 28. Angular chert fragments throughout conglomerate at base of Gunnedah Basin.

later sandstones and siltstones depositing over the top. The conglomerate shows large, angular blocks of chert mixed with abundant sand. It is obvious from the angularity of the blocks that they have not undergone any significant degree of alluvial rounding.

Most of the Gunnedah Basin rocks have been eroded away south of Dunedoo (Map 11), with only remnants present along hill tops as is the case here. The original extent of the local Gunnedah Basin would not have extended much further south than Dunedoo, with the basin deepening and thickening to the north and east. This area was probably a topographically high area during the Permian and Triassic, caused by the erosion-resistant, hill-forming rocks of the Lachlan Orogen present in a belt south of Dunedoo.

Continue south along Tucklan Road for 8.7 km through undulating country with poorly exposed Lachlan Orogen rocks. A steep road cutting on the western side of the road represents Site 17.

Site 17. Cleaved and folded siltstones of Ordovician Lachlan Orogen. Grid reference: 727510E 6443890N.

This site shows a representative example of the non-cherty rocks in the local Ordovician Lachlan Orogen. These rocks are siltstones which have been deformed, folded and faulted. A persistent, close-spaced fracture in the rocks is a *cleavage*, produced when clayey and silty rocks are folded. The siltstones were deposited in a very deep ocean.

Photo 29. Folded, faulted and cleaved siltstones with iron oxide fracture-fills.

Photo 30. Cleaved weathered siltstones with iron oxide joint-fills.

Deep weathering of these rocks has caused some degree of bleaching and mottling, produced by groundwater dissolving iron, then reprecipitating it in fractures and porous rocks as the water table periodically or seasonally lowered. This process took place many millions of years ago when these rocks were buried for at least tens of metres.

Continue south along Tucklan Road for 970 m until the turnoff to Avonside Road is reached. Turn right into this road. After a distance of 2.3 km a hill is ascended with a house ("*Giraween*") on the left and a forested hill on the right. The Tucklan gold field extends along the crest and flanks of the hill to the north, which is a fault-bounded block of Silurian volcanic and sedimentary rocks (Map 10). Gold was recovered from quartz veins in an open cut and several shafts along the ridge, and alluvial gold was worked along the flanks and base of the hill. There are no substantial workings preserved, and nothing visible from the road of this significant mining.

Continue down hill, following Avonside Road for 6.9 km through poorly exposed Ordovician Lachlan Orogen rocks and floodplains to the intersection with Avonside West Road. Turn left into this road and proceed for 2.5 km where a very large gravel pit is evident on the south of the road. This is Site 18.

Site 18. Folded Ordovician phyllites with quartz veins. Grid reference: 718150E 6445160N.

This gravel pit has exposed some metamorphic rock types showing well-developed, multiple generations of folds and some interesting pyrite-bearing blue-grey quartz veins. The metamorphic rocks are silvery coloured due to abundant white mica which occurs as aligned, fine-grained masses referred to as a *schistosity*. These rocks are *phyllites*, strongly metamorphosed siltstones, shales or mudstones which have been subjected to intense stresses in the Earth's crust associated with mountain building processes. Some of these rocks show very tight folds (Photo 31) and chevron folds (Photo 32). The chevron folds (so named for their repeated V-shapes) are superimposed on the tight folds, and represent a second deformational event.

Narrow quartz, quartz-pyrite and quartz-iron oxide veins occur in places throughout the pit. Some of these show a blue-grey colour, indicative of being subjected to stress, probably resulting from a mountain-building event. Veins similar to these were worked at the Tucklan gold field and in most east Australian gold fields. The veins would have formed during the first major deformation due to heat from compression deep within the crust and circulating hot fluids. Minute amounts of gold within the rocks pass into solution and are concentrated in the veins. As the veins near the Earth's surface and enter the weathering zone, the gold is once more slowly dissolved and redeposited within rocks in the water table. This weathering-related gold (*supergene gold*) has produced the historically rich, shallow gold deposits throughout Australia, and created large nuggets. Are the veins from this pit gold-bearing? That's a mystery, as there is no official record of them being assayed.

Continue west along Avonside West Road for 2.8 km, crossing the floodplain and ascending a hill. Prominent outcrops on the crest are discussed as Site 19.

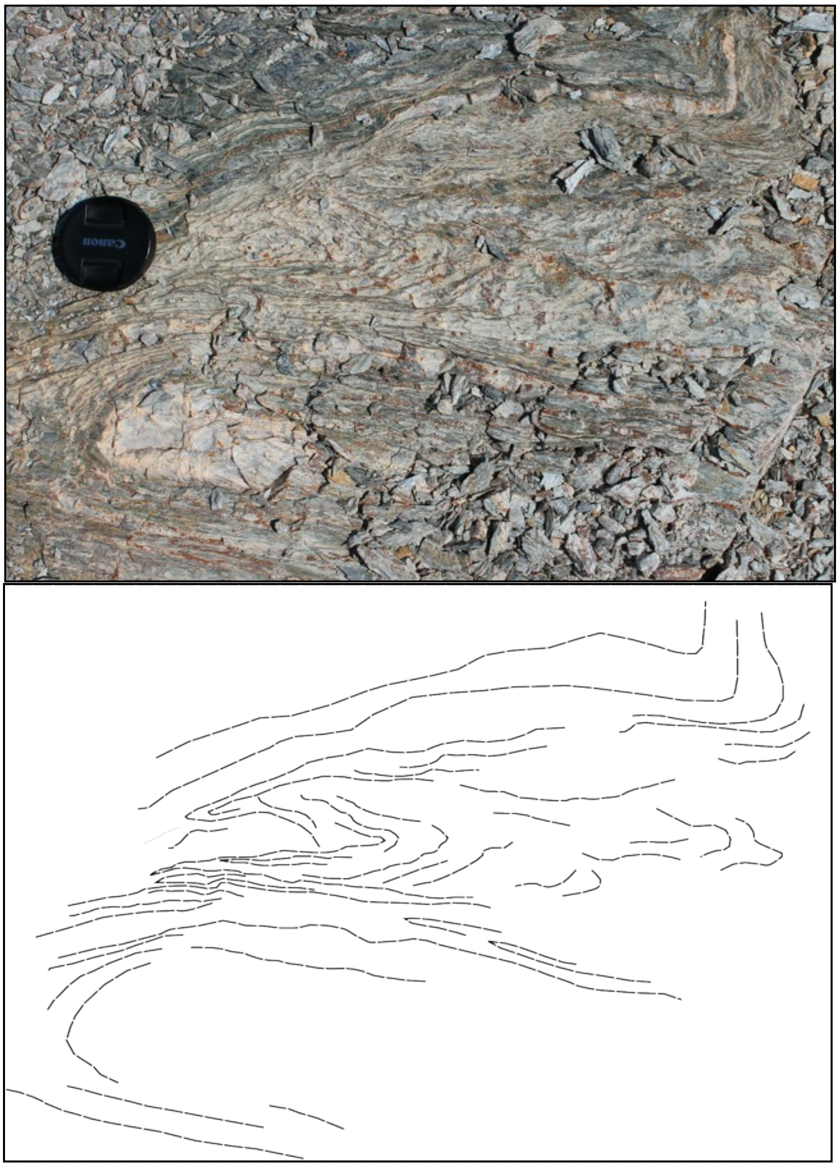


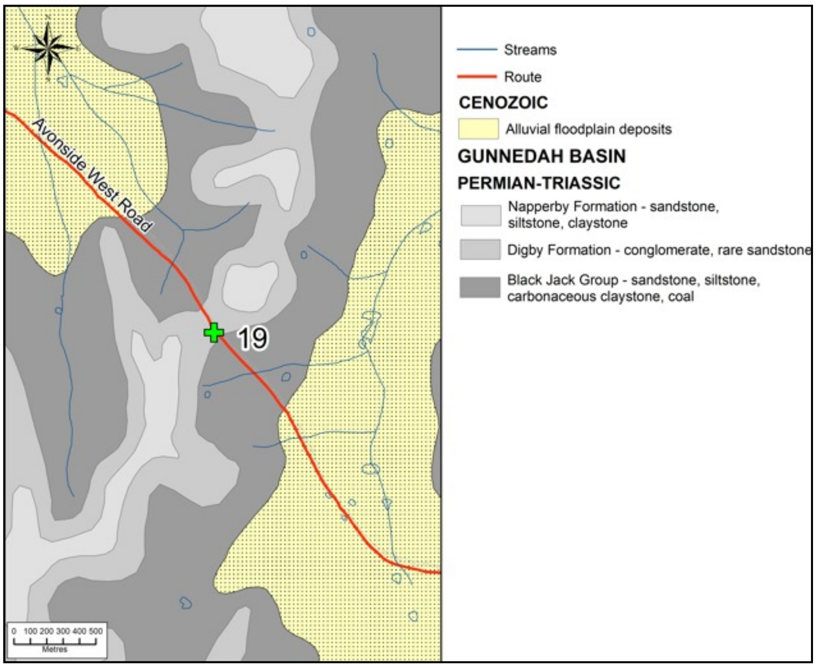
Photo 31. Tight folds in phyllite, with interpretation diagram.

Photo 32. Chevron folds in phyllite.

Site 19. Pebble conglomerate in Digby Formation, Gunnedah Basin. Grid reference: 716030E 6446770N.

The Digby Formation was discussed at Site 13 (page 15), but could not be directly observed. Site 19 is an ideal location to examine the characteristics of this significant unit of the Gunnedah Basin.

The conglomerate comprises well-rounded pebbles of quartz, chert and jasper (Photo 33). This represents material transported hundreds of kilometres from the New England region during the Early Triassic. The pebble material is of Silurian to Carboniferous age and is common throughout the New England region. It is of a similar origin to the Ordovician cherts in the nearby Lachlan Orogen.



Map 12. Geological map of the Site 19 area.

There are no additional sites along this road, so a return to Avonside Road is recommended. This quiet road can be followed directly back to Dunedoo.

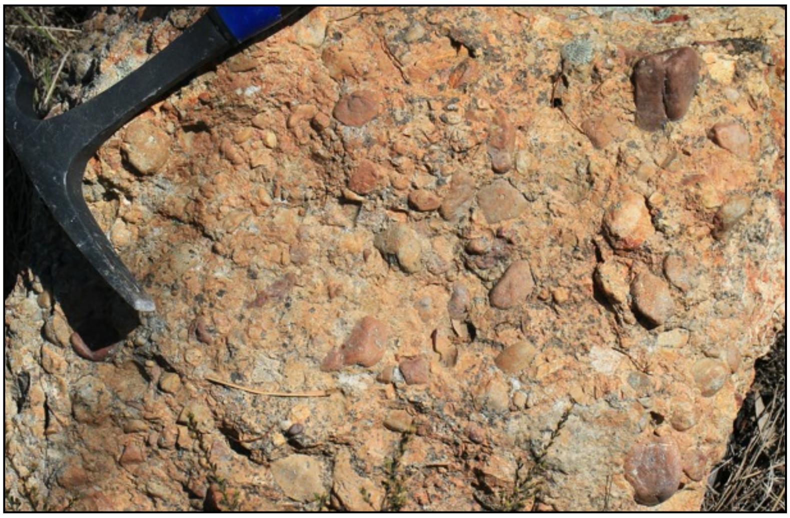


Photo 13. Digby Formation conglomerate

Cobbora Road Cycling Route

No specific geological sites have been identified along this pleasant and relatively quiet road. The geology of this route is shown on Map 1, and includes floodplains, Gunnedah Basin and Surat Basin. The road climbs gradually to a plateau developed on Surat Basin rocks, where the Adelyne Conservation Area is accessible on the eastern side of the road. Although there are no formal cycling or walking tracks in the Conservation Area, a walk up the tall hill accessible through the entrance gate presents a good opportunity to examine the Pilliga Sandstone on the hill crest, and admire the enormous ironbark trees populating this landform. The view through the trees also provides a view of the distant Warrumbungle Range.

This concludes the geological guide. We hope you have derived an insight into the local geology and its long and varied history. This was encouraged and supported by Sharon Nott of Dunedoo whose hospitality, friendliness and enthusiasm is gratefully acknowledged. The welcoming and hospitable folk at the Dunedoo Museum and Library, and the hosts at Cobbora Station also helped make our stay and activities memorable for all the right reasons.