Geological Tours of the Tamworth District

The Tamworth district occurs across one of eastern New South Wales' most significant crustal fractures, the Peel Fault. This major fault is developed for several hundred kilometres from Forster on the coast, to Warialda in the north. The Peel Fault has been active for more than 350 million years. Its presence is marked by a dramatic change in the rock types on either side, sometimes by the presence of serpentinite (serpentine), and by a prominent escarpment.

In the Tamworth area, the rocks occurring on the eastern side of the Peel Fault include sedimentary and volcanic deposits which formed far from land in a deep ocean. These were deposited during the Ordovician to the Carboniferous periods (see figure 1), between nearly 300 million to more than 400 million years ago. Following their deposition they were uplifted and extensively folded and faulted. Some of these rocks will be examined on one of the drives presented below. These ancient rocks were intruded during the Permian and Triassic periods (about 200 to 250 million years ago) by large masses of granite. Numerous varieties of these granitic rocks are well exposed along the New England Highway between Moonbi and Uralla.

Locally, the rocks occurring on the western side of the Peel Fault include sedimentary deposits which formed in a shallowing ocean relatively close to land. Volcanic island chains erupted large masses of volcanic ash and lava which were incorporated into the ocean both as grains, pebbles and boulders, and in places as large blocks. The warm, shallow tropical waters were suitable for primitive reef formation, resulting in the deposition of limestones. Most rocks were deposited during the Devonian and Carboniferous periods about 300 to 350 million years ago. However, a few remnants of much older rocks are preserved near Chaffey Dam (see map), indicating that gravels, sands and silts were being deposited here during the Ordovician period, more than 400 million years ago. Late in the Carboniferous period the shallowing ocean had retreated eastward, resulting in the deposition of sedimentary rocks and volcanics on land. These land-formed rocks were laid down during a period of glacial activity. They form the ridges visible to the southwest of Tamworth in the Currabubula area. At the end of the Carboniferous the rocks were uplifted and folded during the first of several periods of similar deformation.

The two geological drives presented here are designed to acquaint the user with some of the major, and most significant aspects of the geology of this area. The stop localities have been chosen to provide good rock exposures and accessible roadside parking. The accompanying notes place each stop into geological perspective, and in some cases demonstrate other interesting geological features. Please don't damage unique rock exposures. Other road cuttings and other rock exposures along the routes which are not described in the notes may also be sources of interesting and unique rocks and geological features. **Be aware of the dangers of standing on busy roadsides – be vigilant, safety conscious and courteous to motorists**.

GEOLOGICAL TOUR 1 – OXLEY HIGHWAY: TAMWORTH TO KEEPIT DAM AREA VIA SOMERTON

This drive follows the Oxley Highway from Tamworth to the Keepit Dam turnoff, then continues for several kilometres further along the highway towards Gunnedah. The drive demonstrates the character of the rocks which formed in the Devonian to Carboniferous ocean about 300 to 350 million years ago. By driving from east to west we are generally passing backwards in time, and are driving toward the ancient Devonian volcanic island chain.

Stop 1. Road cuttings by abandoned roadside open cut pit. Parking available in entrance to pit. AMG grid reference 290774E 6565278N GDA grid reference 290881E 6565468N.

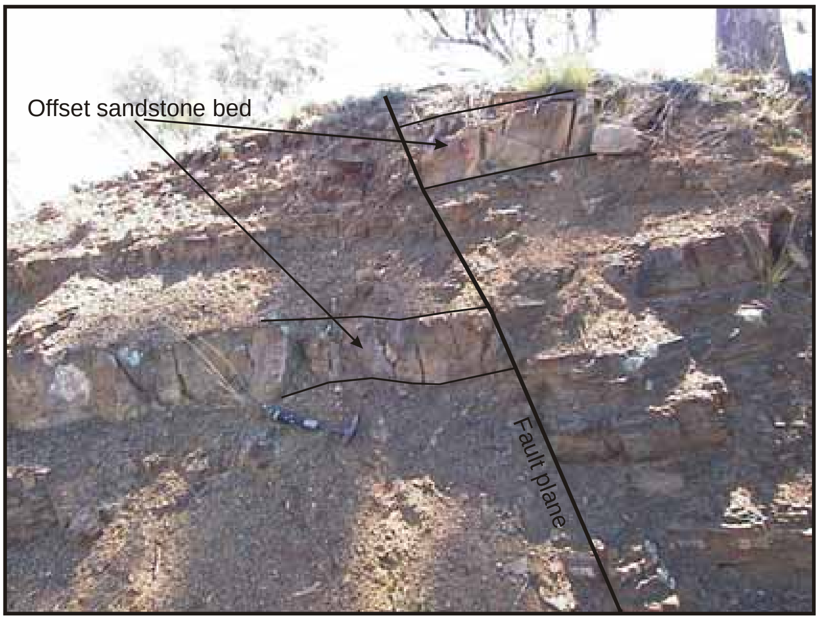


Photo 1. West dipping mudstone and sandstone offset by fault

The road cuttings reveal shallowly west-dipping bedded mudstones (dark grey, flaggy, cleavable rocks) and a few sandstone beds (coarser grained, less well layered). These rocks were probably laid down in less than 200 metres of ocean water below wave activity. A modern analogue may be the continental shelf off eastern Australia. The low angle, western dips represent regional-scale folding of the rocks, with most rocks along the highway dipping westward until the core (axis) of the fold is passed near the Keepit Dam turnoff. To the west of the fold axis the rocks dip eastward.
A number of narrow, white quartz and calcite (calcium carbonate) veins cut the rocks. Calcite is softer than quartz and can be scratched by a steel object. The veins have formed in cracks and fractures formed as a result of local faulting. Several faults are visible in the cuttings. Note the fault in the cutting near the eastern end of the entrance to the parking area (Photo 1). A sandstone bed has been displaced by the almost vertical fault plane. Note how the quartz and calcite veins are approximately parallel to the fault plane. Another fault is evident in the cutting at the opposite end of the parking area. Movement along this fault has resulted in downward dragging of the bedded rocks, evident as an abrupt steepening of the rocks, then a return to their normal, low angle westward dip as the fault plane is crossed.

Small faults such as these are very common throughout the region. You will observe more faults and some of their features in subsequent stops, and particularly in Drive 2.
Most road cuttings between here and Stop 2 show no fresh rock outcrop. Some show old river gravels in the present soil profile. These gravels are described in Stop 3

Stop 2. Road cutting on the south side of the highway. AMG grid reference 276380E 6572060N, GDA grid reference 276486E 6572250N. Photo 2.

Pebbly conglomerate and sandstone outcrop here. These were deposited during the Early Carboniferous about 300 million years ago. The pebbles were probably rounded on land in river systems and were carried out to sea by floods or other catastrophic processes. The pebble types tell us something of the source landmass, with coarse and fine-grained volcanic rock types indicating active land-based volcanoes.

Photo 2. Volcanic pebbles in sandstone.

Stop 3. Road cutting on south side of the highway. AMG grid reference 268680E 6574341N, GDA grid reference 268787E 6574531N. Photo 3.

Westerly dipping mudstones are exposed in both walls of the cutting. These are capped by a thick cover of coarse river gravels. The mudstones represent the dominant, silty form of sediment deposited on the floor of the Devonian and Early Carboniferous ocean. Note that the rocks continue to dip westward toward the fold axis.

Photo 3. Westerly dipping mudstones overlain by river gravels.

The river gravels demonstrate the extent of natural erosion of the landscape during the past few million years. Although the precise age of deposition of the gravels is unknown it is likely that it occurred somewhere during the past 30 million years. The probable river responsible for depositing the gravels would have been the ancestor of the present Peel River which flows to the west several kilometres north of here. The pebbles present in the road cutting gravels are identical in type to those visible in the Peel River at Somerton.

Stop 4. Road cutting with parking on south side of the road. AMG grid reference 266800E 6574012N, GDA grid reference 266907E 6574202N. Photo 4.

The dominant mudstones of the Early Carboniferous ocean were locally inundated by sand and gravel from the nearby landmass to the west. The shallow, tropical ocean produced local reefs and an abundance of calcium carbonate-rich silt and sand. Ocean floor dwelling species such as *crinoids* (an ancient sea lily and a relative of modern star fish and sea urchins) are abundant and have been replaced by calcium carbonate. Their tube-like stems are visible in blocks of limestone exposed near the western, top end of the cutting, and in blocks which have rolled to the bottom of the cutting (see photo 4). These fossils are about 300 million years old.

An artist's impression of long stemmed crinoids filtering food from their ancient ocean. The tough stems are most commonly preserved, whereas the soft, fleshy top of the creature was usually lost.

Stop 5. Turn off to Keepit Dam. Stop at "River Glen" front gate area, Keepit Dam road. AMG grid reference 264045E 6573288N, GDA grid reference 264152E 6573478N. Photo 5.

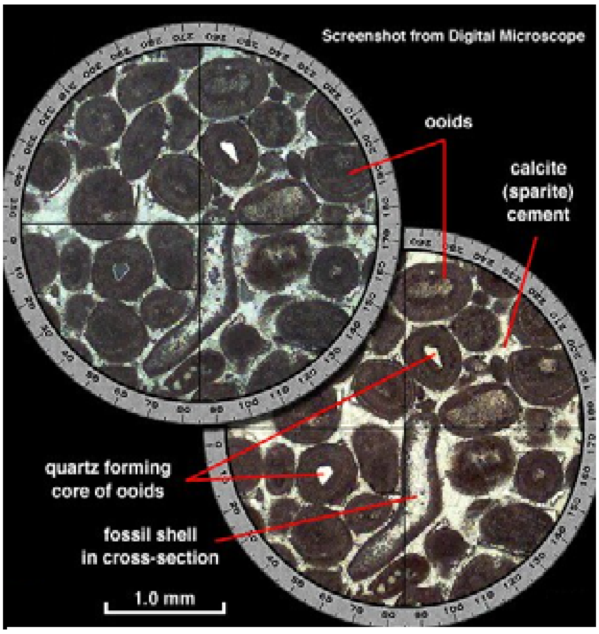
The warm, shallow, Early Carboniferous ocean in places resembled the present tropical seas surrounding the Bahamas. In those waters, an abundance of calcium carbonate derived from reef organisms is present as sand and mud, and is also dissolved in the ocean water. Some of the calcium carbonate crystallises on sand grains or shell fragments and is rounded into small spheres by strongly oscillating currents, possibly in an area of high tidal activity. The tapioca-like spheres resulting from this process are known as *ooids*.

Photo 5. Block of crinoid-rich limestone.

They would locally have formed thick, dune-like accumulations. These are preserved in a limestone bed exposed as blocks on the eastern side of the road, opposite the “River Glen” front gate (see photo 5).

The *oolitic* (i.e. ooid-rich) limestone present here occurs within a thick sandstone bed which outcrops on the western side of the road. The limestone occurs as one or more beds several metres thick which outcrop continuously for many tens of kilometres throughout the region. The limestone is composed of abundant ooids, broken shelly fossils and *crinoid* stems. This limestone is significant to geologists as it represents a unique *marker bed* throughout the rocks of this region.

Return to the Oxley Highway and turn toward Gunnedah.



A microscope view of an oolitic limestone.

Stop 6. Parking area, Oxley Highway. AMG grid reference 263964E 6572547N, GDA grid reference 264071E 6572737N. Photo 6.

The road cutting on the opposite side of the road is composed of easterly-dipping mudstones. The easterly dip demonstrates that we have crossed the axis of the major, regionally extensive fold (see geological map).

It is a short walk of about 100m further west along the highway to Stop 7.


Photo 6. Easterly-dipping mudstones on the western flank of the regional fold.

Stop 7. South side of highway near end of overtaking lane. AMG grid reference 263713E 6572537N, GDA grid reference 263820E 6572727N. Photo 7

Boulders and pebbles of mainly volcanic rocks occur throughout this broad outcrop of Devonian conglomerate and pebbly sandstone. This conglomerate is widespread as a continuous, thick unit throughout the region. It includes varieties that formed within rivers, and some forms that were deposited within the ocean. This indicates that this conglomerate formed upon, and along the flanks of, one of the many volcanic island chains which occurred off shore of the Australian continental landmass more than 300 million years ago.

Photo 7. Abundant volcanic rock pebbles in Devonian conglomerate .

Some extensive conglomerate units such as this are interpreted by geologists to represent significant episodes of instability in the crust. The instability could have been due to a variety of reasons. However, it generally resulted in increased seismic activity (earthquakes), and may have caused uplifting or down warping of the crust. The large masses of conglomerate form from rapid erosion of the uplifted areas.

Stop 8. Road cutting on north of highway, 50m east of "Glengarry" front gate. AMG grid reference 262074E 6571605N, GDA grid reference 262181E 6571795N. Safe parking is available on a track south of the highway.

These are some of the most significant rocks exposed in the Tamworth Belt. This cutting, and several to the west comprise boulder conglomerate and volcanic sandstones with boulders of coarse-grained volcanic rock types. Some of the nearby cuttings show a range of interesting lavas, all of which show features which tell geologists that they were deposited on land. However, the enclosing conglomerates and sandstones show characteristics which indicate deposition in the ocean. Calcite (calcium carbonate) is present as fillings in fractures and in what were gas bubbles in the molten lava.

The tall ridges to the northwest of this stop comprise several huge masses of land-deposited lavas amongst oceanic sediment. The presence of these large blocks of lava indicates that they have slipped off the edge of a steep sided volcanic island into ocean waters tens or hundreds of metres deep. The island mass must have occurred very close to this locality. A major fault passes from north to south through that area, effectively removing any evidence of the volcanic core of this island chain. This fault also marks the western edge of the Tamworth Belt.

The drive from Stop 7 to Stop 8 passes downward into the rock strata. Consequently, the conglomerate observed in Stop 7 is several million years younger than the rocks in Stop 8. Both localities show a different, but constant presence of the volcanic island mass. The significance of the Stop 7 conglomerates is that some of them represent the exposed sedimentary surface of the island. As you return eastward toward Tamworth you are witnessing the rock products of the ocean which deepened away from the western island chain. Initial sandstones and limestones indicate shallow waters close to land, and muds further east represent both increasing distance from land and/or increasingly deep water.

GEOLOGICAL DRIVE 2 –TAMWORTH TO CHAFFEY DAM AREA VIA NUNDLE ROAD

This drive commences in relatively shallow water marine sedimentary rocks of the Tamworth Belt, crosses the Peel Fault into very deep water marine sedimentary and volcanic rocks, and concludes in the oldest rocks present in the region (about 500 million years old).

Stop 1. Road cutting on bend AMG grid reference 310063E 6554290N, GDA grid reference 310169E 6554480N. Care is advised in this cutting. Park on the southern end of the cutting off the edge of the road.

Steeply dipping thick sandstones and thinner mudstones with well-developed bedding surfaces. The rocks outcropping here are the same age (Devonian, about 350 million years old) as the intermixed volcanics, boulder conglomerates and sandstones present in Stop 8 of Tour 1. These sandstones and mudstones were deposited many tens of kilometres from land, and are missing the boulders and other indicators of close proximity to land that their counterparts at Stop 8 show.

The sandstones are composed of large amounts of volcanic sandy material. Thin, white layers in the mudstones are volcanic ash bands, formed by the settling of windborne ash originating from the Devonian volcanic island chain to the west.

Stop 2. Roadside open cut. AMG grid reference 317528E 6546309N, GDA grid reference 317634E 6546499N.

This is the first stop on the eastern side of the Peel Fault (the Central Block, see map), which lies only a few hundred metres to the west of here. These rocks are deep water, marine (oceanic) muddy, silty and clayey sediments. They show little or no bedding, probably due to their deposition as *mass flow* sediments. *Mass flow* sediments were originally deposited as normally bedded clays and silts similar to those examined in Stop 1. Following their deposition, some accumulations of clays and muds on the edge of steep underwater slopes were dislodged by seismic activity. The dislodged sediment flowed down the slope as dense clouds of silt within which all previous bedding was blended and mixed together to form a homogenous mass. Rocks such as this are common in some areas of the Central Block. They contrast strongly with some of the bedded rocks deposited by normal settling of grains which will be viewed in subsequent stops on this tour.

The abundant quartz veining which occurs throughout this outcrop has resulted from fracturing accompanying the nearby Peel Fault. Major faults such as this can cause fracturing in rocks up to kilometres from the fault line. The fractures can be locally very complex, their shapes representing multiple episodes of varying movement along the fault.

Stop 3. Road cutting on east of road. AMG grid reference 319588E 6545278N, GDA grid reference 319694E 6545468N. Park south of the cutting off road.

The cutting shows some excellent outcrop of red and pink jasper and pale yellowish-white chert. These rock types are abundant along the western edge of the Central Block. They are composed of *silica* (essentially quartz) which was deposited on the ocean floor from millions of microscopic organisms whose skeletons are made of silica. The most common of these organisms are the *radiolaria*, roughly spherical, floating creatures which are common in today's oceans. Their dead bodies form thick layers known as *radiolarian ooze* on the deepest floors of the ocean. The radiolarian ooze is eventually converted to rock, forming chert and jasper. Jasper is merely an iron-rich variety of chert. The unique patterns and shapes of some radiolaria enable palaeontologists (fossil experts) to accurately age date the rocks containing the radiolaria. Most cherts and jaspers from this area date from the Silurian to the Devonian, or about 350 to 400 million years old.

You can see the rough, blocky outcrops of chert and jasper on adjacent hillsides. Note that the jasper and chert are bedded. The bedding dips steeply into the road cutting. The rocks east of the Peel Fault have been tightly compressed and folded into many complex folds. They have been generally more deformed than the rocks west of the Peel Fault.

Continue through Dungowan Village, taking the turn off to Nundle.

Stop 4. Road cutting on the edge of Dungowan Village. AMG grid reference 320394E 6544212N, GDA grid reference 320500E 6544402N. Stop near end of cutting furthest from Dungowan. Photos 8 & 9.

This road cutting occurs in altered basalt, white chert, and grey sandstone which are cut by numerous small faults and quartz veins. The basalts outcropping here have been altered by fluids passing through the consolidated rocks. This is common in ancient basaltic rocks. Veins of quartz and green epidote have formed during the alteration (see Photo 8).

Photo 8. Dark grey, altered basalt with numerous veins of quartz and epidote.

Photo 9. Fault plane showing slickensides. The arrow shows the direction of movement of the observer's side of the fault. The slickensides are apparent as shallow grooves running diagonally through the photo, parallel to the arrow.

Many of the old basalts east of the Peel Fault have been formed on the ocean floor by eruptions from long, narrow fissures. Some of the basalts show pillow-shaped structures formed by the basalt extruding into cold seawater and being rapidly chilled. These structures are not visible in this outcrop.

Coarse sandstones composed of angular rock fragments occur in the cutting. These sandstones are devoid of bedding features and were probably formed by mass flow (as in Stop 2).

Many small faults have cut through the rocks in this cutting. The faults are evident as smooth, flat to gently curved surfaces, some of which are coated in vein quartz. Several fault surfaces show *slickensides*. These are grooves formed by movement along the fault (Photo 9). The slickensides represent gouges cut into the rock as both sides of the fault moved against one another. By running your hand along the slickensides you can feel that movement in one direction is smooth, whilst it is rougher in the opposite direction. The direction of easy movement of your hand is the direction that the side of the fault closest to you last moved in. Try this technique on some of the faults in the cutting. Do all faults here have the same direction and relative sense of movement?

Most road cuttings between here and Stop 5 show variations of Stops 2 to 4. Any cutting could reward you with some colourful jasper, interesting faults, or different combinations of sedimentary and volcanic rock types.

Stop 5. Chaffey Dam visitors' area parking. AMG grid reference 322840E 6529985N, GDA grid reference 322946E 6530175N.

The road cutting shows an excellent collection of very deep-water oceanic sedimentary rocks, numerous small, vertical faults and many small folds. The rocks include claystones and *siliceous* mudstones. The *siliceous* (silica, or quartz-rich) rocks are probably rich in radiolaria, similar to the cherts and jaspers of Stop 3. These rocks were deposited during the Silurian and Devonian periods, about 350 to 400 million years ago. They are representative of the type of sediments which are depositing in the deepest portions of our oceans today, at depths up to about 5 kilometres.

Note the black to blue-black staining on many of the rocks. This colour is due to the presence of manganese oxides. These minerals are common in these deep oceanic rocks throughout the region. The manganese oxides formed from underwater volcanic activity which introduces large amounts of minerals, particularly manganese, into the seawater. The manganese permeates many of the rocks about the volcanic fissures, and forms thin layers. In some places thick accumulations of manganese oxide up to many metres thick have been mined for this useful mineral. One of its most familiar uses is for the manufacture of the black, rod-like cores of dry cell batteries.

Examine the numerous small folds visible throughout the cutting. Folds such as these occur throughout the region east of the Peel Fault, and range in size from smaller than these to many which are kilometres long and wide. They were formed during several periods of *tectonic activity* during which the rocks are moved, folded and faulted as part of our continent's evolution.

Stop 6. Serpentinite (serpentine) in road cutting. AMG grid reference 323089E 6528218N, GDA grid reference 323195E 6528408N.

This and the next road cutting show serpentinite faulted against sedimentary rocks of the Central Block. The Peel Fault lies with metres of here to the east. Serpentinite such as this has been faulted up along the Peel Fault for most of its length, and makes an excellent marker for the fault's presence. Note how the character of the serpentinite varies along the cutting and to the next. The first outcrops are slaty and fractured, whilst those further along the cuttings are less deformed. The slaty serpentinite is probably close to the plane of the Peel Fault.

Serpentinite is a relatively rare rock in eastern Australia. It was once part of the thin crust and upper mantle which was present beneath the deepest region of the oceans during the Cambrian period, about 500 million years ago. Over millions of years those ancient rocks, which were composed of a range of unusual rock types, were folded, altered and in some cases melted. The serpentinite we see in these cuttings bear no resemblance to their original rock types. These soft, talc-like rocks react to the earth's pressures by flowing like toothpaste squeezed from a tube, oozing its way upward along major fractures such as the Peel Fault.

Continue along the road, take the Nundle turnoff, then after several kilometres take the Western Foreshores turnoff. Along the way, note the serpentinite in other cuttings, and observe that we have crossed the Peel fault and have returned to the Tamworth Belt on the western side of the fault.

Stop 7. Road cutting near houses. AMG grid reference 320170E 6527777N, GDA grid reference 320276E 6527967N. Photo 10.

This cutting shows steeply dipping, bedded siliceous siltstones and mudstones of the Tamworth Belt. Numerous *graded beds* are present (see Photo 10. Graded beds are a product of sand, silt and clay being rapidly dropped into still water. The coarser and heavier mineral grains settle to the bottom of the bed, whilst the finer and lighter minerals settle last. This is apparent in Photo 10 where the bottoms of the beds are defined by yellow silt and the tops by white to grey clay. Note how there is a complete gradation from the yellow silt to the clay; hence the term *graded bed*. Graded beds are a useful indicator for confirming that the beds have not been turned upside down by folds. In this cutting, it is apparent that the beds are not overturned. See how many variations on these graded beds you can observe throughout the cutting.

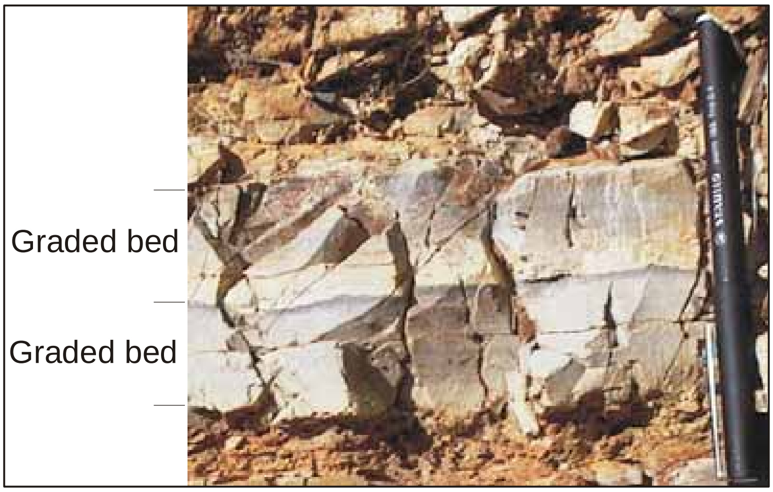


Photo 10. Graded beds in siltstone and claystone. Note the gradation from coarser, yellowish base, to grey-white finer top.

These rocks were formed in relatively shallow oceanic waters during the Devonian period about 350 million years ago.

Stop 8. Road cutting in mudstone and siltstone. AMG grid reference 320687E 6529283N, GDA grid reference 320793E 6529473N.

The rocks in this cutting are of the same age as those viewed at the previous stop. Graded beds are common here. Note how the rocks dip steeply, whereas those at Stop 7 dipped shallowly. This significant change in dip probably has been caused by major faults in the proximity.

The cutting also includes some distinctively green mudstones. These are unique to this group of rocks and are considered a diagnostic feature of this group throughout the region.

Stop 9. Road cuttings in conglomerate. AMG grid reference 320357E 6529788N, GDA grid reference 320463E 6529978N. Photo 11.

Photo 11. Pebbles and boulders of granite, limestone and volcanic rocks in Ordovician conglomerate.

The conglomerate exposed in the road cuttings on either side of the road is one of the oldest and most unique rocks in the region. The pebbles and mud which comprise the conglomerate were deposited in an oceanic canyon during the Ordovician period, more than 400 million years ago. The canyon was a major feature along which sediment was funnelled from the shallow ocean closer to the Ordovician shoreline, to the deep ocean beyond the continental shelf.

The variety of rock types present as pebbles in the conglomerate supply an insight into the landmass which supplied the pebbles (see Photo 11). Volcanic rock types from surface eruptions, granites which crystallised deep under ground and limestones from close to shore indicate that the closest land was in tropical or subtropical waters and was volcanic in character. No granites of Ordovician or older age are known from the region, but are common hundreds of kilometres west of here. The granite pebbles may have been transported long distances, or more likely the granite-bearing land has been shifted by faults and is now deeply buried by younger rocks nearby.

These conglomerates are only found in a small region along the eastern edge of the Tamworth Belt (see map). They may be more extensive across the region at great depth beneath the younger Tamworth Belt rocks.

Continue back to Tamworth by following the western foreshores road back to Woolomin. Note the abrupt change in rock types when the Peel Fault is crossed once again, with large, wall like beds of jasper becoming evident once more.