

A Geological Field Guide to the Lesmurdie Falls – Gooseberry Hill Area



By John A Bunting

Lesmurdie – Gooseberry Hill – Field Guide

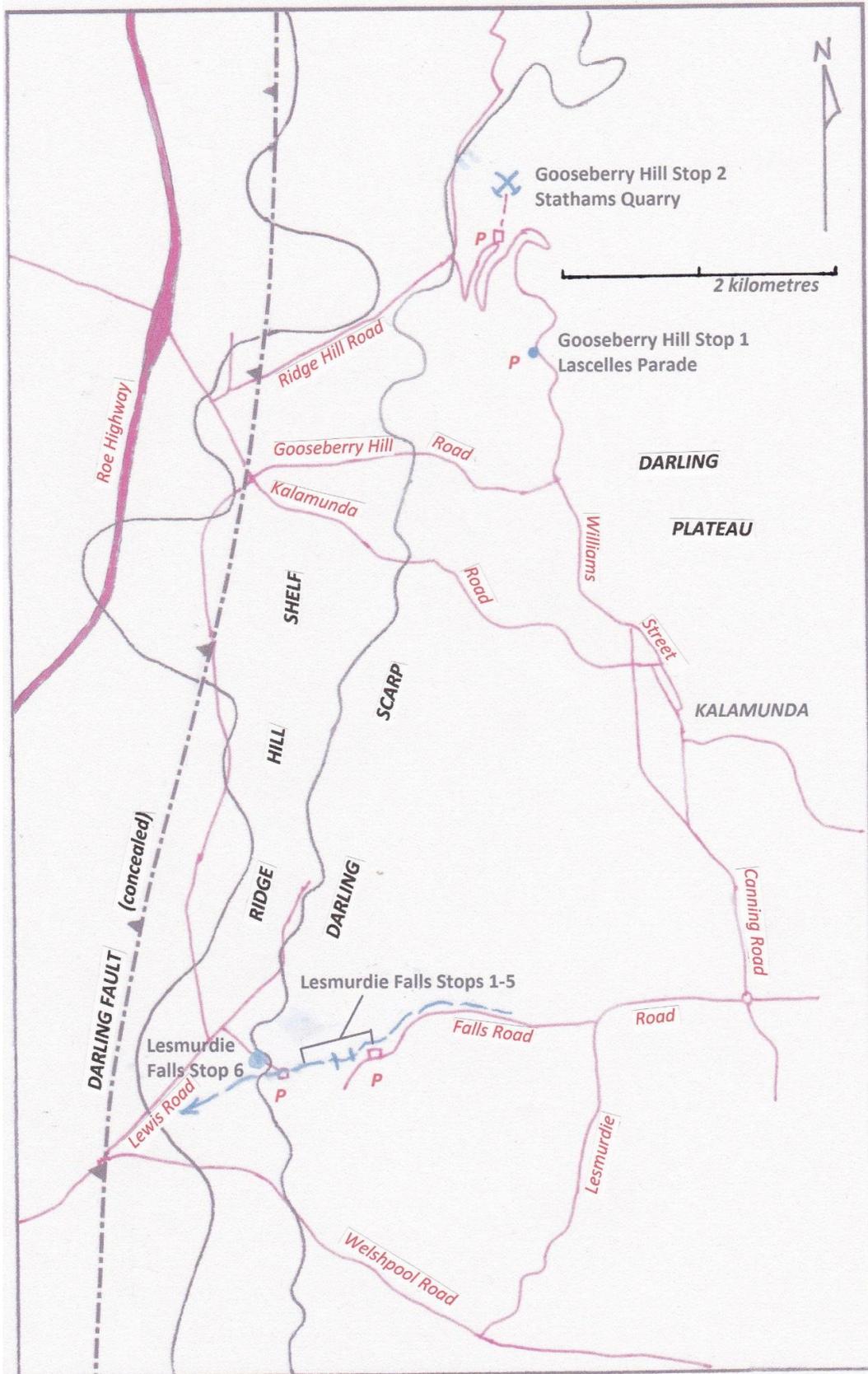


Figure 1: Location, access and main geological features of Lesmurdie-Gooseberry Hill

INTRODUCTION

This field guide describes the geology of the Darling Scarp at two localities – Lesmurdie Falls and Gooseberry Hill (Figure 1). While intended for use by teachers of the upper-school Earth and Environmental Science curriculum in Western Australian high schools, the guide should also be of interest to other teachers and the general public. Criteria for choosing the localities therefore had to include access and safety considerations as well as illustrating various aspects of geology and the environment. The aim is to give sufficient information to allow teachers to take students into the field without specialist geoscientific help or local knowledge, although some basic geological knowledge is assumed.

The guide was compiled by John Bunting for Earth Science Western Australia (ESWA) as a contribution to CONSTAWA 2013 at Mazenod College. Other localities along the Darling Scarp and coastal areas are described in “A Field Guide to Perth and Surrounds”, also by John Bunting, and published by ESWA in 2011 (see www.earthsciencewa.com.au)

ACCESS AND SAFETY

The localities described here are accessible to the public, with all stops being in National Parks or public road reserves. Safety issues are mentioned in the appropriate sections below, but these are guidelines only. Anyone visiting the localities should note that safety depends on personal circumstances and current conditions (weather, state of tracks etc), and you must be responsible for your own safety.

GENERAL GEOLOGY

The Lesmurdie Falls and Gooseberry Hill localities are at the western edge of the Darling Plateau, where crystalline bedrock of the Yilgarn Craton consists of Archean metamorphic rocks 2800-2650 million years old that were intruded by large volumes of granitic magma 2600 million years ago. Dolerite dykes intruded the granite at about 1200 million years. The intrusion, crystallization and metamorphism of these rocks took place many kilometres below the Earth’s surface, but uplift and erosion over a few hundred million years has exposed the crystalline rocks at the surface.

In this part of the Darling Plateau the crystalline basement has suffered a prolonged period of lateritic weathering over the last several million years. The most obvious manifestation of this is the hard orange-brown lateritic duricrust that underlies the thin sandy soil and pea gravel. Between the duricrust and the underlying fresh bedrock are various zones of weathered rock that form a laterite profile ranging from a few metres to over 40 metres thick. The weathering process takes place under

the ground surface and is related to the movement of oxidising groundwater. Weathering proceeds downwards, so the most-weathered material is near the top. Recent erosion along the Darling Scarp has revealed the fresh bedrock.

The Darling Scarp forms the western edge of the Darling Plateau (Figure 1) and separates it from the Swan Coastal Plain. At the foot of the scarp, on the gently sloping Ridge Hill Shelf, unconsolidated colluvial and alluvial deposits derived from erosion along the scarp overlie two sedimentary formations. The Ridge Hill Sandstone (possibly Early Pleistocene, 1,810-750 thousand years) is a shoreline deposit consisting of sandstone and minor conglomerate. It occurs at elevations between 70 m and 90 m above sea level. Sandstone outcrop in a small road cutting near the bottom car park may be Ridge Hill Sandstone. The younger Middle Pleistocene Yoganup Formation consists of partly consolidated shoreline and dune sands with minor conglomerate, at elevations of 25 m to 45 m above sea level. Both formations are now oxidised and contain layers of heavy minerals.

Somewhere beneath the Ridge Hill Shelf is the **Darling Fault***. Although not exposed, its position has been determined by various geophysical methods such as seismic, magnetic and gravity surveys.

** The **Darling Fault** is one of the major structures of the Earth's crust. It can be traced from the south coast near Point D'Entrecasteaux northwards for about 1000 km. Downthrow on the western side of the fault has resulted in up to 15 km thickness of sediments being deposited in the Perth Basin, whereas to the east the upthrow side exposes Archean granite and metamorphic rocks of the Yilgarn Craton. The fault probably started in the Silurian, about 430 million years ago. Most of the movement probably occurred in the Triassic to early Cretaceous (230-140 million years ago) with only minor movement since then. No fault movement has occurred in historic times. The surface expression of the fault is the **Darling Scarp**, which in the Perth area is about 100m high.*

The Phanerozoic Darling Fault (younger than 540 million years) may in part be the reactivation of an even older structure representing the collision of a Proterozoic continent with the Yilgarn Craton. These Proterozoic rocks – mainly metamorphosed igneous and sedimentary rocks – constitute the Pinjarra Orogen, which is exposed in the Leeuwin and Northampton Blocks but also underlies the Perth Basin.

The Swan Coastal Plain stretches from the foot of the Darling Scarp westward to the Indian Ocean. The exposed sediments include various alluvial deposits, wind-blown dune sands, the intervening swale deposits, and the calcified dunes of the Tamala Limestone.

LESMURDIE FALLS

What will we see?

- Views of the Darling Scarp and Swan Coastal Plain
- Two different Archean granites
- Dolerite dykes with chilled margins (Proterozoic)
- Granite tors, joints and weathering
- Controls on watercourse and waterfalls
- Soil profile
- Ridge Hill Sandstone (Early Pleistocene)

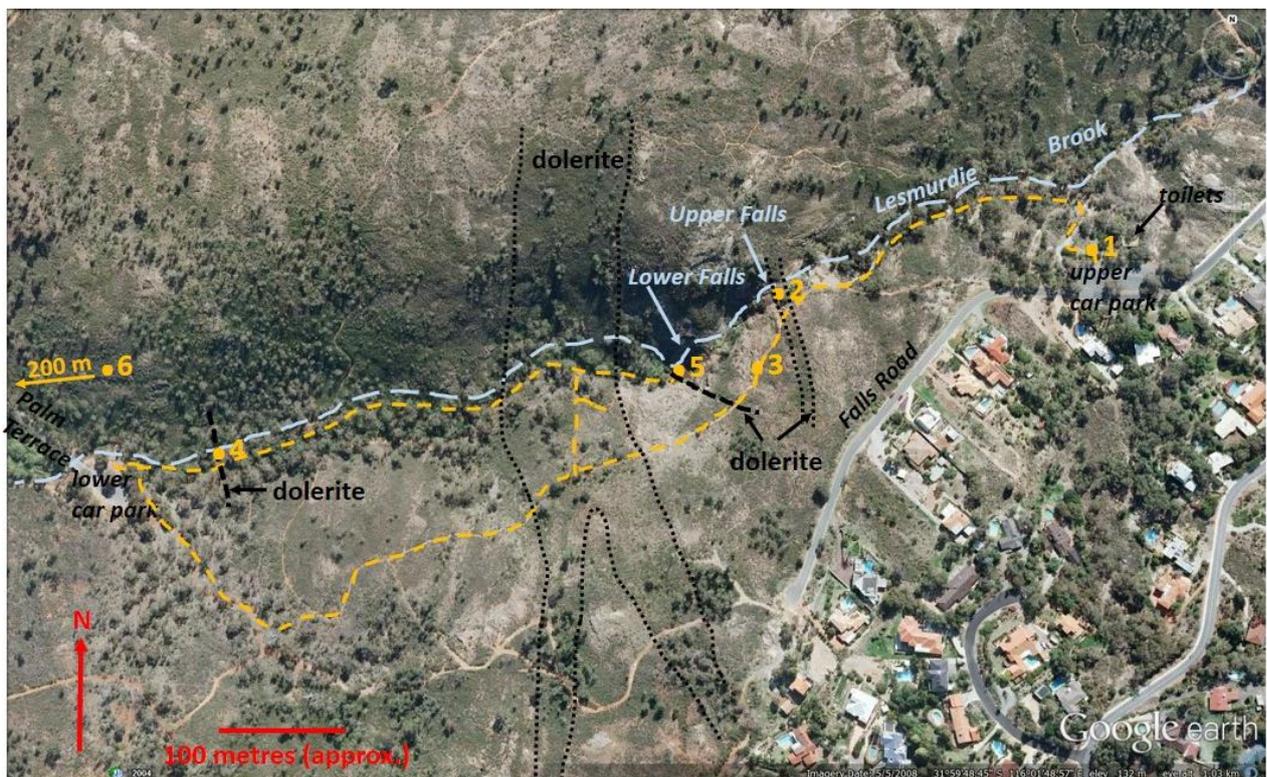


Figure 2: Location and excursion stops on Google Earth image showing some dolerite dykes

(Taken from Google earth 2013 Whereis © Sensis Proprietary Limited)

Location and access: From Kalamunda, drive south along Canning Road to the roundabout at Lesmurdie Road and turn right. After 1.1 km turn right into Falls Road. From Welshpool Road, turn north into Lesmurdie Road, follow it for 2.8 km then turn left into Falls Road. The car park at Lesmurdie Falls is 1.9 km along Falls Road (Figure 2). Access to the top of Lesmurdie Falls by

wheelchair is good, but the tracks from there down to the lower car park, into the lower Falls, and especially the climb back to the upper car park, require a reasonable amount of fitness and mobility.

If you have transport with a driver who will not be going on the walk the driver could pick you up at the bottom car park at the end of Palm Terrace. Ask the driver to return to Welshpool Road (reverse the directions, above), turn right and drive several kilometres down the scarp. Turn right at Lewis Road (the first turn on the right after reaching the bottom of the hill) and after 1.4 km turn right into Palm Terrace.

Safety: In the area of the falls the rocks and sloping areas are slippery and dangerous. Stay on the recognised footpaths. The walk to the base of the lower Falls may be dangerous and even impossible if the creek is in flood.

Timing: Allow at least 30 minutes each for the top and bottom of the falls, plus 15 minutes for the walk down from top to bottom. If you don't have transport picking you up at the bottom the time to walk back to the top car park will depend on your level of fitness!

Stop 1: Top car park information board

Walk down the few metres from the car park to the information board. Facing the car park is an aerial view of the Lesmurdie Falls area showing various walks. The excursion described here follows approximately the blue dotted route. On the far side of the board two posters explain the generalized geological history of the area and the origins of the Darling Fault.

Walk down the path past the picnic tables and along the south side of the creek towards the Falls.

Stop 2: Lesmurdie Falls – upper platform

As you walk down to the creek (Lesmurdie Brook) note the change of soil from the colluvium (scree) of lateritic gravel and weathered granite fragments to the thin alluvium of the valley floor. This alluvium, being wetter and richer in nutrients, supports much denser and more prolific vegetation than the barren colluvial soil. About 30 metres before the platform a short track leads to a pool on Lesmurdie Brook. Most of the granite surrounding the pool has widely spaced joints, but on the far side of the pool there is a zone about a metre wide of closely spaced vertical joints trending about

southwest (Figure 3). Such closely spaced joints would be more susceptible to erosion exploitable by the running water than the more massive granite. If extensive, the joints could explain why the brook and its valley are here.



Figure 3: Stop 2 – Pool above the Falls showing closely spaced joints in granite

Continue towards the platform over the top of the falls. On the left (south) side of the path near the entrance to the platform is an outcrop of dolerite. The dolerite is a dyke about 10 metres wide (you can see the approximate contacts with the older granite) trending NNW across the creek. Walk onto the platform and look over the far end, where the same dolerite dyke is exposed in contact with granite to the west. Figure 4 shows the dolerite (dark) to the right and granite (light) to the left. In the bed of the creek black algal staining makes it difficult to distinguish dolerite from granite. The staining is caused by algae growing in the wet seasons and drying out in summer.

The north-south-trending dolerite dyke is more resistant to physical erosion than the granite* and it may have formed a resistant bar that dammed the water in the creek. Below the dolerite the less resistant granite was easily eroded to form the waterfall.



Figure 4: Stop 2 – From upper platform, dolerite (dark) on right, granite (pale) on left

** A distinction must be made between the physical erosion of rocks and chemical weathering. In its fresh state dolerite can be more resistant to physical erosion compared to granite. It will therefore stand out as outcrop or as a bar in a watercourse. However the dark Fe and Mg-rich minerals in dolerite are more susceptible to chemical weathering such as occurs in a lateritic deep-weathering profile or even under a soil cover. Thus over much of the Darling Scarp the dolerite dykes have chemically weathered to a reddish soil in low points in the topography.*

Stop 3: Middle Platform

Walk down the path for a hundred metres or so to the second platform, from which there is a good view back to the Falls (Figure 5). The view down the valley to the west is spectacular (Figure 6). We can see the undulating valleys and ridges of the Darling Scarp and in the distance the Swan Coastal

Plain. Some granite outcrops are visible, and somewhere beyond the last of these the unexposed Darling Fault is obscured by the marine and colluvial/alluvial sediments of the Ridge Hill Shelf.



Figure 5: Stop 3 – View of the Upper Falls from the middle platform. The “stepped” arrangement is probably caused by joints in the granite.



Figure 6: Stop 3 – View from the middle platform showing change from the valleys and ridges of the Darling Scarp to the flat Swan Coastal Plain beyond the concealed Darling Fault.

Beyond this on the Swan Coastal Plain is the Pinjarra Plain where alluvial fans near the Ridge Hill Shelf merge with floodplain deposits in the Swan Valley.

In the middle distance are the fossil coastal dunes of the Bassendean Dune System. Quartz sand in the dunes is interspersed with swamp deposits and alluvium in the swales – the low-lying depressions between the dunes. The Bassendean Dune System formed during a period of high sea level during an interglacial period that started 240,000 years ago and lasted about 100,000 years. On the horizon beyond the city (top right in Figure 6) are the low hills of the Spearwood Dune System. This also formed as a series of coastal dunes interspersed with swales and lagoons on a prograding shoreline (i.e. retreating), which means that the dunes are progressively younger to the west. The shelly quartz sand of the dunes has been lithified to form the dune-bedded calcarenite of the Tamala Limestone that now forms the main ridges of the dune system.

There are now several choices. If you have a driver who has gone to the Palm Terrace car park, or if you are prepared to walk down and then return up the hill, follow the path down to the bottom car park and turn right onto the rough path that leads along the south side of Lesmurdie Brook to the bottom of the Falls. Alternatively return to the top car park and either drive to the bottom car park at the southeast end of Palm Terrace or leave the rest of the excursion for another day.

Stop 3-Stop 4: The path to the valley floor

As you walk down the path along the side of the valley there are several interesting features. About 30m from the platform look for a small gap in the granite outcrop on the left, where a weathered dolerite dyke is exposed. The dyke is only 1m wide, and we will see it again at the bottom of the falls.

About 20-30m further on there is no rock exposed but the left side of the path shows a good cross-section of the rather barren soil that covers the granite. This shows a typical soil profile (Figure 7) with:

- **O Horizon** – a thin surface layer of humus-rich soil in which the plants are growing;
- **A Horizon** – a layer of soil, about 50 cm thick, that is moderately rich in humus but increasingly leached downwards, giving a change from darker to paler brown (but note that some of the darker colour in Figure 7 is caused by moisture);
- **B Horizon** – sandy colluvial soil with coarser rock fragments (below the scale bar) and a yellower colour caused by precipitation of iron oxides leached from the overlying A Horizon.



Figure 7: Soil profile alongside the path about 60m from the middle platform.

The path continues over outcropping granite for another 50m or so until the rock type and vegetation change. The rock is now dolerite, and although it appears to be more-or-less continuous for about 100m, the aerial view (Figure 2) suggests that there may be several closely spaced dykes. Look for variation in the dolerite – finer grained near the edges (see box, below), with some coarser grained near the centre of the bigger dykes. Look also for dolerite with coarse dark crystals (pyroxene) set in a finer grained groundmass. Two other features of interest in this wide zone of dolerite. Wandoo, the large eucalypts with white bark, seem to relish the iron-rich soils over the dolerite. If you look to the north on the opposite side of the valley you can see where the more easily weathered dolerite forms a low area on the horizon, with a large wandoo in the middle of it.

Continue to the bottom of the valley. At the car park (Palm Terrace) turn right and take the path upstream along the south bank of Lesmurdie Brook. Stop 4 is about 80 metres from the end of the car park.

Stop 4: Dolerite bar

An outcrop of fresh dolerite here has created a resistant bar (Figure 8), just like the one at the upper platform above the Falls (Stop 2). Although there would be a small cascade when the creek is flowing there is no waterfall because we are now close to the base of the scarp near the eastern edge of the gently sloping Ridge Hill Shelf. The Darling Fault, although not exposed, is interpreted to be about a kilometre west of the car park.



Figure 8: Stop 4 – Dolerite bar about 80 metres upstream from the lower car park.

Continue upstream for about 350 metres to the base of the waterfall. The last 50 metre or so is a bit of a scramble over outcrop and fallen rock that may be difficult and slippery, especially during and after rain.

Stop 5: Bottom of the Lower Falls

Lesmurdie Falls are effectively two waterfalls. From platforms near the top we could see the Upper Falls. At Stop 5 we can inspect the base of the Lower Falls. How much is visible here will depend very much on how much water is flowing over the Falls. If it is in flood, don't approach too closely. If it is not in flood (sometimes the flow stops completely) do not attempt to climb up the rocks at the base of the cliff.

The rock here is mostly medium-grained granite. As at Stop 2, the black algal coating makes much of it look like dolerite. There may be some dolerite controlling the Lower Falls, but it is too dangerous to confirm this. But, look to the right of the Falls. In the cliff there is a narrow dolerite dyke about 2 metres wide (Figure 9a). If you can get close enough (approach with caution) you can see that the fine-grained dolerite is even finer at the contact with the granite (Figure 9b). This is a chilled contact.*



Figure 9a: Stop 5 – Dolerite dyke near Lower Falls.

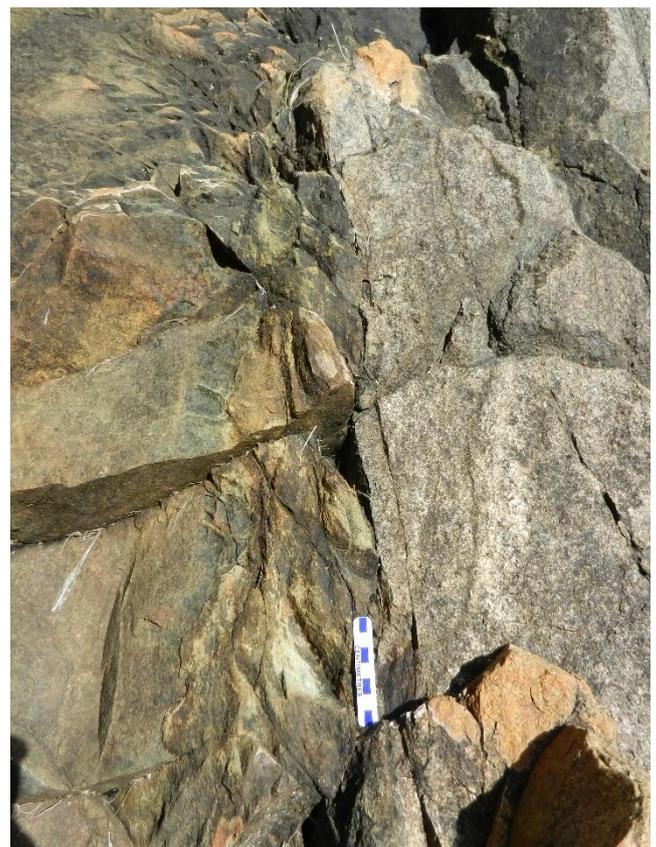


Figure 9b: Western contact of dyke (right contact in Figure 10) showing chilled margin* of intrusive dolerite (left of scale) against granite.

** The finer grainsize of a chilled margin is caused by the dolerite magma cooling and crystallizing more quickly against the relatively cool host rock. In the centre of the intrusive body the magma cooled more slowly resulting in bigger crystals and a coarser grainsize. If the dyke had been much bigger the grainsize in the centre may have been even coarser and the rock would be described as a gabbro. Gabbro, dolerite and basalt are essentially derived from the same type of magma – gabbro forming large plutonic igneous bodies deep in the crust, dolerite usually in higher-level hypabyssal intrusions such as dykes and sills, and basalt extruding at the surface as lava flows.*

Walk back along the path towards the Palm Terrace car park. About 50 metres from the bottom of the Falls notice the granite outcrop on the left (south) side of the path. There is a sharp contact between medium-grained granite on the left and coarse-grained granite on the right (Figure 10). We can't tell the age relationships here, but elsewhere along the Darling Scarp the medium-grained granite typically intrudes the coarse-grained granite (e.g. at Stathams Quarry).



Figure 10: Contact between coarse-grained granite, below scale, and medium-grained granite, near path 50 metres below the Lower Falls.

About 40 metres from the granite contact a path to the left (south) takes you to the Lions Lookout with a great view of the Lower Falls. From that path a steep and difficult path takes you up the valley side and back to the Falls Road car park. Alternatively return the easier but longer way by retracing your route via the lower (Palm Terrace) car park. To visit Stop 6 return to the Palm Terrace car park and walk (or drive if you left a car in the car park) along Palm Terrace for about 250 metres to the junction with Waterfall Road.

Stop 6: Ridge Hill Sandstone

OK, this doesn't look very exciting but this outcrop of sandstone (Figure 11) might be one of the few outcrops of the Ridge Hill Sandstone along this part of the scarp. The sandstone is quartz rich, medium grained, moderately sorted, ferruginized and shows no bedding or fossils. It contains a small percentage of heavy mineral grains (tiny dark grains, visible with a 10x hand lens) that are probably ilmenite – an iron-titanium oxide mineral. This supports the published interpretation that the sandstone originated as a beach or shoreline sand deposit. The elevation (from Google Earth) of this outcrop at 70 metres above sea level, which is typical of the lower part of the Ridge Hill Sandstone. All of this means that if you were here during the Early Pleistocene, about 1810-750 thousand years ago, you would have been on a pleasant sandy beach at the foot of the Darling Scarp.



Figure 11: Stop 6 – Ridge Hill Sandstone at the junction of Palm Terrace and Waterfall Road.



Lesmurdie – Gooseberry Hill – Field Guide

This completes the Lesmurdie Falls excursion. Walk back to the Palm Terrace car park and retrace your steps to the upper car park or, by car, continue along Palm Terrace to Lewis Road. Turn left to get to Welshpool Road and the Roe Highway.

GOOSEBERRY HILL

What will we see?

- Views of the Darling Scarp and Swan Coastal Plain
- Deeply weathered dolerite and granite
- Mica schist
- Three phases of granite intrusion
- Granitic pegmatite veins
- Dolerite dykes with chilled margins
- Granite tors, joints and weathering
- Rehabilitation of old railway line and quarry

Location and access: From Kalamunda drive north along William Street (Figure 1), which becomes Lascelles Parade. About 1.2 km after the junction with Gooseberry Hill Road there is a gravel parking area on the left (west side) and a road cutting on the right – this is **Stop 1** (MGA 410180E 6065140N). Continue along Lascelles Parade until it becomes the Zig Zag Scenic Drive, (one-way after the first hairpin). At the 3rd hairpin, 3 km from Stop 1, stop in the gravel car park (MGA 409920E 6466080N). **Stop 2**, Stathams Quarry, is about 300m along the track from the gate at the end of the car park. Wheelchair access is fine at Stop 1 and possibly along the track to the top of the quarry, but getting down to the quarry requires a reasonable amount of fitness and mobility.

Safety: The only real safety concern at Stop 1 is traffic on the road. Although not busy, the stop is on a sweeping curve that could be dangerous if a vehicle is speeding. Stop 2 is at Stathams Quarry with all the dangers that this entails. Don't stand near the edge at the top of the quarry. Don't get too close to the cliffs in the quarry. Be careful on the potentially unstable blocks of fallen rock. And obey the signs at the fenced-off areas.

Timing: Allow about 15 minutes at Stop 1, and at least an hour at the quarry.

General geology: (See INTRODUCTION)

Stop 1: Lascelles Parade

The view to the west is spectacular (Figure 12). We can see the undulating valleys and ridges of the Darling Scarp and in the distance the Swan Coastal Plain. Some granite outcrops are visible, and somewhere beyond the last of these the unexposed Darling Fault is obscured by the marine and colluvial/alluvial sediments of the Ridge Hill Shelf. Beyond this on the Swan Coastal Plain is the Pinjarra Plain where alluvial fans near the Ridge Hill Shelf merge with floodplain deposits in the Swan Valley. Unconsolidated clay and loam and the underlying fluvial clay, silt, sandstone and conglomerate of the Guildford Formation have been cut into by the Swan River to form a series of river terraces.

In the middle distance are the fossil coastal dunes of the Bassendean Dune System. Quartz sand in the dunes is interspersed with swamp deposits and alluvium in the swales – the low-lying depressions between the dunes. The Bassendean Dune System formed during a period of high sea level during an interglacial period that started 240,000 years ago and lasted about 100,000 years. On the horizon beyond the city are the low hills of the Spearwood Dune System. This also formed as a series of coastal dunes interspersed with swales and lagoons on a prograding shoreline (i.e. retreating), which means that the dunes are progressively younger to the west. The shelly quartz sand of the dunes has been lithified to form the dune-bedded calcarenite of the Tamala Limestone that now forms the main ridges of the dune system.



Figure 12: Stop 1 – View over the Darling Scarp to the Swan Coastal Plain

Now turn around and look at the east side of the road. The cutting is in deeply weathered Precambrian basement rocks, the northern two thirds of which is in weathered dolerite. The original hard, dark rock has been leached by groundwater, with the original mafic minerals (pyroxene and/or amphibole) and plagioclase feldspar oxidized to clay and iron/aluminium oxide minerals. In the main part of the cliff the rock is pinkish brown or buff, and some original texture is preserved (Figure 13). There even seems to be some preservation of the spheroidal, onion-skin weathering that is typical of slightly weathered dolerite. This is the saprolite zone of the weathering profile. At some depth below road level the rock would be less weathered with some of the original minerals preserved in the saprock zone, which passes down into fresh rock.

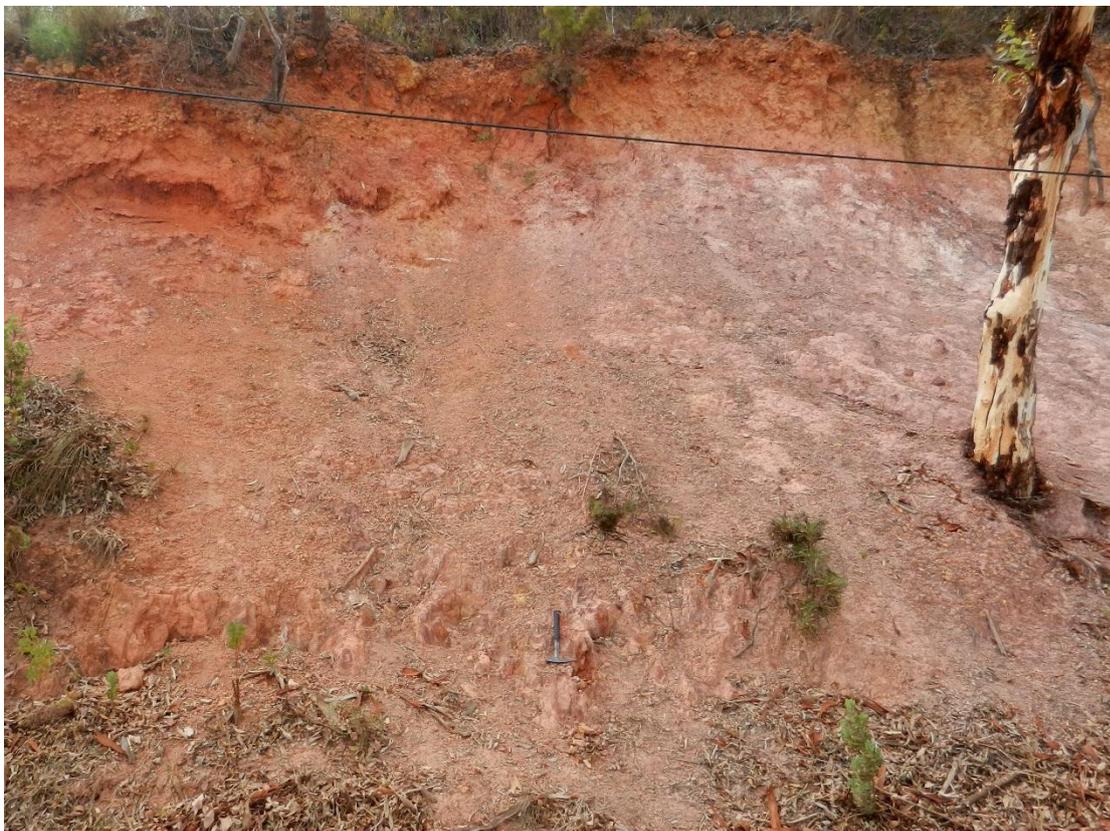


Figure 13: Stop 2 – Weathered dolerite in road cutting

At about eye level and upwards there are patches of white leached rock that are part of the mottled zone. Near the top of the cutting there is a zone of buff-coloured rock about 1 to 2 metres thick. Here there are no original textures preserved and the lateritic rock consists almost entirely of iron and aluminium hydroxide minerals. This is the zone that is mined as bauxite further south. The top half metre or so is transported material that consists of laterite fragments in sandy soil.

The southern half of the cutting is in weathered granite. You can see, or feel if you rub material between your fingers, the gritty grains of quartz that, unlike the feldspar in the granite, are resistant to weathering. The white/pink/red-brown mottling is more complex here, perhaps reflecting variations in the pre-weathering granite. Look also for a band of weathered quartz-mica schist, about 2 metres wide, within the weathered granite (Figure 14). The schistosity trends about 280 degrees, with a steep northerly dip. This is probably a shear zone in the granite, although it could be a sliver of metamorphosed sedimentary rock caught up in the granite.



Figure 14: Stop 2 – Weathered granite and mica schist (above the hammer), southern end of road cutting

Continue driving down Lascelles Parade and the Zig Zag Scenic Drive to the car park on the third hairpin bend (Figure 1). From there walk about 300m to a point 50m past a gate and fence from where steps and a path to the left lead down to the quarry.

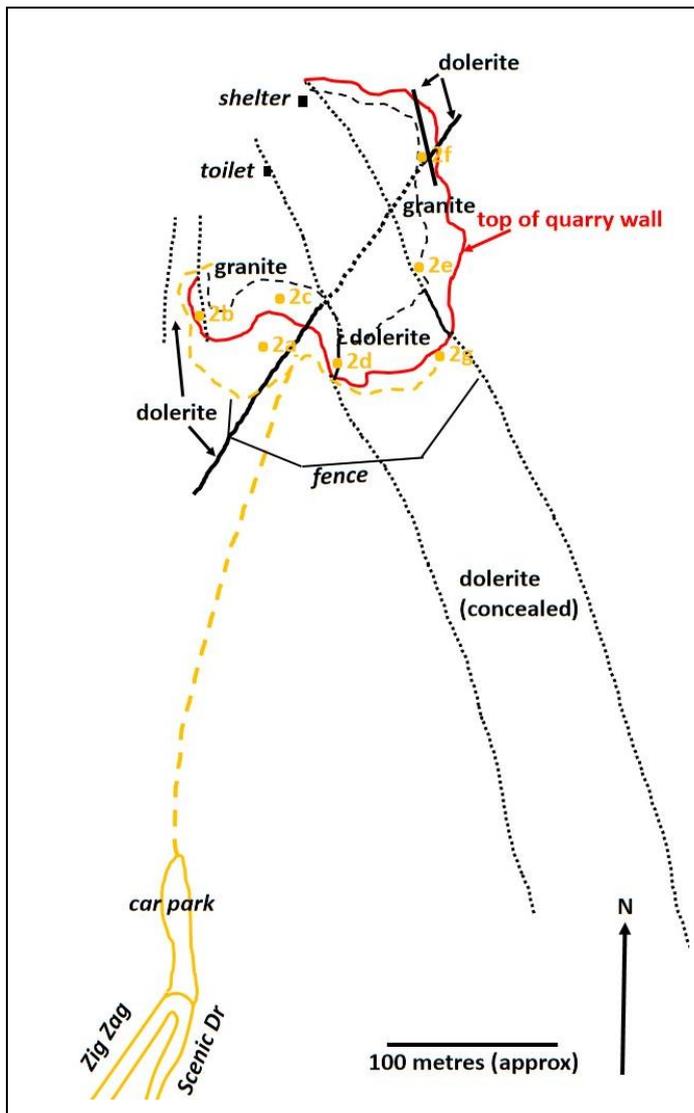


Figure 15: Sketch map of Stathams Quarry showing simplified geology and excursion stops.

Stop 2: Stathams Quarry

Stathams Quarry (Figure 15) exhibits five main rock types, four of them granitic (including the pegmatite), illustrating the complex nature of multiple intrusions.

1. An early phase of gneissic granite is coarse grained and porphyritic, i.e. with large crystals (phenocrysts) set in a finer (but in this case still coarse) groundmass. The phenocrysts are microcline (potassium-rich alkali feldspar) set in a groundmass of quartz, plagioclase feldspar, microcline and biotite (a dark mica). Metamorphism and deformation of the granite has produced an alignment of the microcline phenocrysts and streakiness in biotite-rich layers to impart a gneissic foliation.
2. Rare veins of finer-grained grey granite have intruded the coarse-grained granite. These veins are sub-parallel to, but cut across, the gneissic foliation in the earlier granite.
3. Later veins and irregular bodies of medium-grained grey granite have cut both the earlier granites at high angles. This latest phase of grey granite contains xenoliths of the earlier coarse-grained granite, and appears to post-date the gentle folding.
4. Pegmatite veins have intruded all other granitic phases, although they could be related to the latest grey granite (type 4 above). The pegmatite is a very coarse-grained granitic rock consisting of microcline, quartz, minor plagioclase and minor muscovite (white mica). Pegmatite formed in the volatile-rich late stages of magma crystallization.
5. Dolerite dykes have intruded the granite. Dolerite is a dark rock consisting of pyroxene (now altered to amphibole) and plagioclase. Pyroxene and amphibole are silicate minerals rich in magnesium, iron and calcium. Plagioclase here is calcium-rich (compared to the more sodium-rich varieties in the granite) and is partly altered to greenish epidote. Dykes are narrow bodies of igneous rock formed when magma intrudes vertically (or nearly so) into older rocks. In the quarry there is a large dyke about 80 m wide and a small one about 3 m wide (Figure 6). A third dyke is partly exposed on the southwestern wall of the quarry. Because it is hard wearing and denser than granite, fresh dolerite was one of the main reasons for the existence of the quarry. However dolerite is more susceptible to chemical weathering than granite and therefore in the landscape the dolerite dykes commonly form low areas of reddish iron-rich soil. These areas support denser vegetation and therefore show up from the air as lines of green (Figure 16).

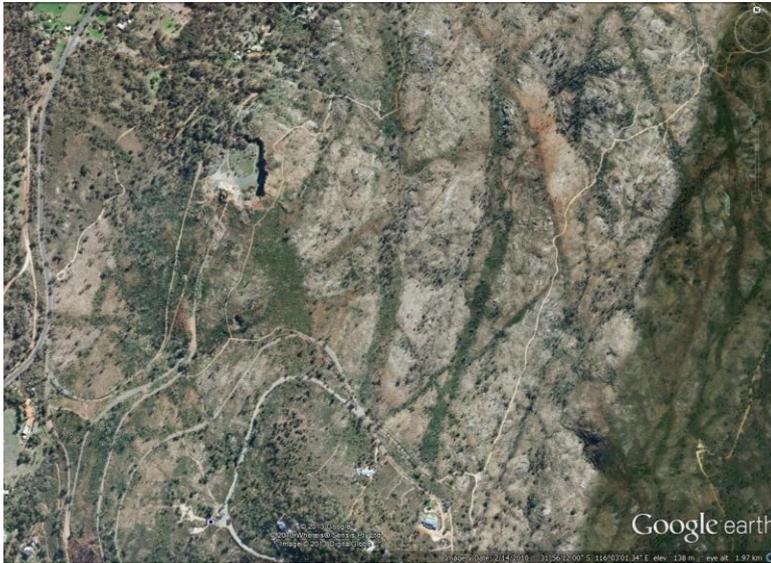


Figure 16: Google Earth image showing Stathams Quarry (top left) and complex pattern of dolerite dykes with the green vegetation anomaly. The biggest dyke runs SSE from the quarry. (Taken from Google earth 2013 Whereis © Sensis Proprietary Limited)

Some suggested stops within the quarry are shown on Figure 15. Before descending to the quarry floor note the large granite rocks that form tors, formed by weathering of joints in the granite (**Stop 2a**). Here we can see several sets of joints in different directions, some vertical, giving a rectangular pattern, and some nearly horizontal. Joints are cracks in the rock formed by stresses in the Earth's crust. Note the exfoliation of the granite (Figure 17) that contributes to the spheroidal weathering to shape the tors.



Figure 17: Stop 2a – Granite tors showing exfoliation where a thin skin of rock has spalled off.

At **Stop 2b**, as you reach the valley floor, look for the darker dolerite that forms the SW wall of the quarry. The wall in front of you is in the older coarse-grained granite. Near the top of the wall the granite is weathered (oxidised) to a yellowish saprock. Note how some corestones have escaped weathering; indeed the granite tors themselves appear to be on top of weathered rock and may be gigantic corestones. As you walk along the base of the wall (outside the fence!) look up to see irregular veins of the later medium-grained grey granite.

Before going on to Stop 2c it is useful to walk to the centre of the quarry floor and look south for the view shown in Figure 18. Look for the large dolerite dyke (the dark rock) about 80 m wide and the smaller dyke off to the right (west). At the top of the quarry wall, both the granite and the dolerite have been affected by deep weathering. The granite becomes paler as the feldspar is weathered (saprock), then becomes cream-coloured as the feldspar is completely replaced by clay minerals (mainly kaolin). Some blocks of granite survive the weathering as core stones. The dolerite partly weathers to a greenish brown saprock as the minerals start to break down, then becomes a dark reddish brown saprolite. Note the land surface above the smaller dolerite dyke, where the softer weathering products of the dolerite have eroded more easily than the more resistive granite. Granitic rocks can be seen as surface outcrop, but often the only evidence for a dolerite dyke is a linear zone of darker reddish soil.



Figure 18: South wall of Stathams Quarry showing large and small dolerite dykes, sheared eastern contact of main dolerite and Stops 2c-e.

Walk back to the southern quarry wall where **Stop 2c** is a good place to see cross-cutting relationships (Figure 19). The older coarse-grained granite (1), with streaky vertical foliation, is cut by a 30 cm vein of grey granite (2), which is intruded by an irregular blob of medium-grained grey granite (3). Look for terminations of foliation and contacts against the younger intrusions. Note also the near vertical dark lines which mark late joints and faults where the joint/fault planes contain some recrystallized mafic minerals. The dark wall at the right of Figure 7 is where granite blocks have fallen from one side of a joint or fault. Examples of various granite types can be seen in the loose blocks near the base of the quarry wall.



Figure 19: Stop 2c – Three phases of granite intrusion and, on right, an exposed joint surface



Figure 20a: Stop 2d – Western contact of main dolerite (left) with granite (right). The quarry wall is the exhumed contact.

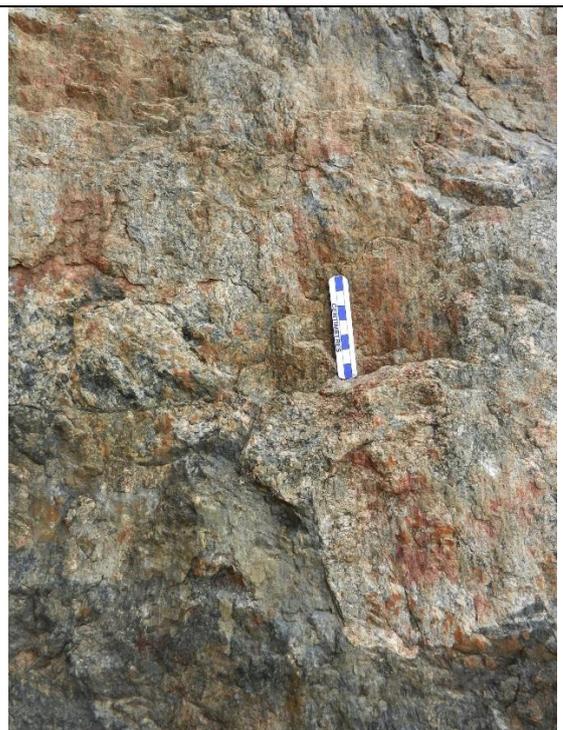


Figure 20b: Detail from lower right corner of Figure 22a showing nearly vertical slickensides (faint grooves parallel to scale).

Stop 2d (Figure 20a) is the western contact of the large dolerite dyke visible in Figure 18. The huge east-facing wall is the granitic side of the contact, revealed during the quarrying activity when the

more useful dolerite was removed. Steeply north-plunging grooves in the granite on the wall (Figure 20b) are slickensides, caused by the granite and dolerite moving against each other – proof that there has been some shearing of the contact. Note that the dolerite near the contact is fine grained at the chilled margin of the dyke*. As you walk towards the centre of the dolerite note how the grain size becomes coarser and the texture somewhat blotchy on a scale of a few millimetres. The blotchy texture may be an indication of an original porphyritic texture with small pyroxene phenocrysts, now partly destroyed by alteration to amphibole.

** The finer grainsize of a chilled margin is caused by the dolerite magma cooling and crystallizing more quickly against the relatively cool host rock whereas in the centre of the intrusive body the magma cooled more slowly. If the dyke had been bigger the texture may have been even coarser and the rock would be described as a gabbro. Gabbro, dolerite and basalt are essentially derived from the same type of magma – gabbro forming large plutonic bodies deep in the crust, dolerite usually in higher-level hypabyssal intrusions such as dykes and sills, and basalt extruding at the surface as lava flows.*

At **Stop 2e** you have crossed the eastern margin of the large dolerite dyke and are back in coarse-grained gneissic granite. Here, in a large fallen block, there is a good example of a late pegmatite vein (Figure 21) that has split into two smaller veins. Note the large phenocrysts of microcline (potassium-rich feldspar) that define the porphyritic texture of the granite – there is a good example about 7 cm above the scale bar, just to the left of the pegmatite. Other pegmatite veins can be seen high in the quarry wall.



Figure 21: Stop 2e –
Pegmatite vein in coarse-
grained porphyritic
granite

Continue north along the east wall of the quarry. At **Stop 2f** there is a complex arrangement of narrow, near-vertical dolerite dykes. One of them (dyke 1 in Figure 24) trends NNW, almost parallel to the quarry wall, and is set into a cleft. Dyke 2 trends NNE and is probably the extension of the narrow dyke seen in the south wall of the quarry (Figure 20). The area where they join is complex and we cannot see any clear evidence for which dyke is the earlier.



Figure 22: Stop 2f – Twin dykes at NE corner of quarry

Return to the southwestern corner of the quarry and climb back up the steps. If you have time walk along the path around the top of the quarry, past the large granite tors. **DO NOT WALK CLOSE TO THE EDGE OF THE QUARRY, AND DO NOT ATTEMPT THIS IN RAIN, STRONG WINDS OR POOR VISIBILITY.** At **Stop 2g** there is a good view of the weathering profile above the granite and dolerite, and of the abutment at the western margin of the main dolerite (Figure 23). Note the irregular contact between the fresh greyish rock and the cream/buff saprock zone (where some of the original mineralogy is preserved), and above that the yellow/rust-coloured saprolite zone (where the feldspar has weathered to clay, but some texture is preserved). The profile is then truncated by a dark reddish-brown layer that is probably transported material. The very topmost layer has been disturbed by the quarrying activities.



Figure 23: Stop 2g – Weathering of granite at top of quarry wall, near contact with main dolerite (left)

*Return south to the car park. Remember that you must continue driving **down** the Zig Zag Scenic Drive, which is one-way. At the bottom, turn left on to Ridge Hill Road to return to Kalamunda Road (via a left turn at Midland Road at the end of Ridge Hill Road). Turning right at Ridge Hill Road will take you to Great Eastern Highway at Greenmount via Scott Street.*