Geology and Soil Tour of the Southern Monaro

South East Local Land Services
23 June 2018

Background

On the back of last years successful tour with the Soil Knowledge Network (SKN), this tour has been planned to highlight the some of the geological and associated soil features of the landscapes across the southern Monaro region.

Our guest speakers for this trip are geologist Dr. Leah Moore (University of Canberra, Institute for Applied Ecology) and Certified Professional Soil Scientist Mr Peter Fogarty (Soil Knowledge Network). Both are highly experienced in their fields and a great source of information for this trip!

There are two legs in this tour, the first running from Cooma to Bombala (Figure 1).

The second leg runs from Bombala to Delegate, back to Bombala then briefly out the Cathcart Road (Figure 2).

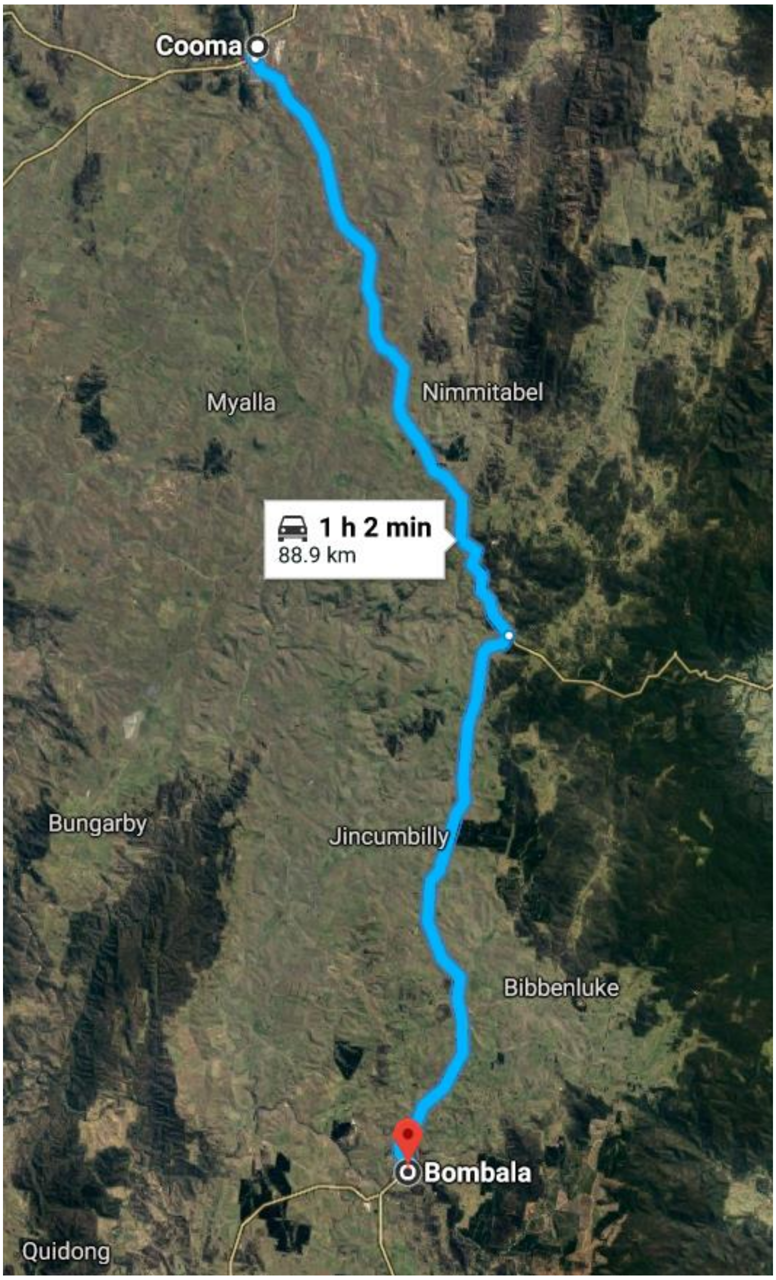

Figure 1. Cooma to Bombala Tour Leg (google maps)

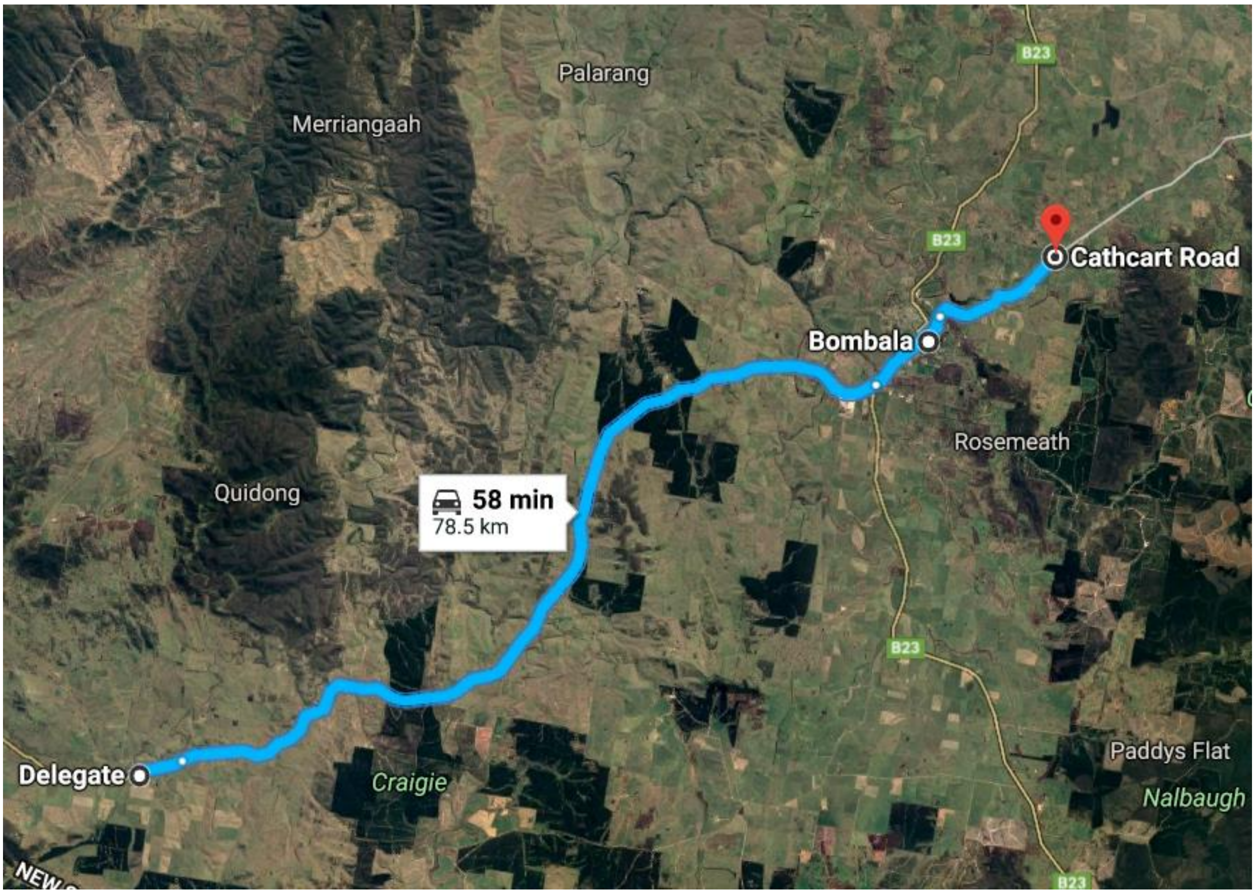

Figure 2. Bombala: Delegate: Cathcart Road Tour Leg (google maps)

The tour

The tour will include the following highlights and stops:

1) The Brothers
2) Holts Flat – Monaro Basalts
3) Ando – Monaro Lakes

Bombala Park – Morning Tea

4) Ashton Creek – sandstone & mudstone
5) Bakers Creek soil profiles
6) Irondoon Thrust

Delegate River, Delegate Caravan Park – Lunch

7) Saucy Creek - Granite formations
8) Cathcart Road – Brown Mountain basalts

A Long Geological History

The geological time scale is a long and important one for us to understand. The geology of the Monaro covers several key geological periods which will be highlighted today including:

- Ordovician period (488-444 million years ago) – sandstones, mudstones and shales
- Silurian and Devonian periods (444-359 million years ago) – Bombala intrusive granites
- Paleogene (early Tertiary) period (65-23 million years ago) – Monaro and Brown Mountain basalts

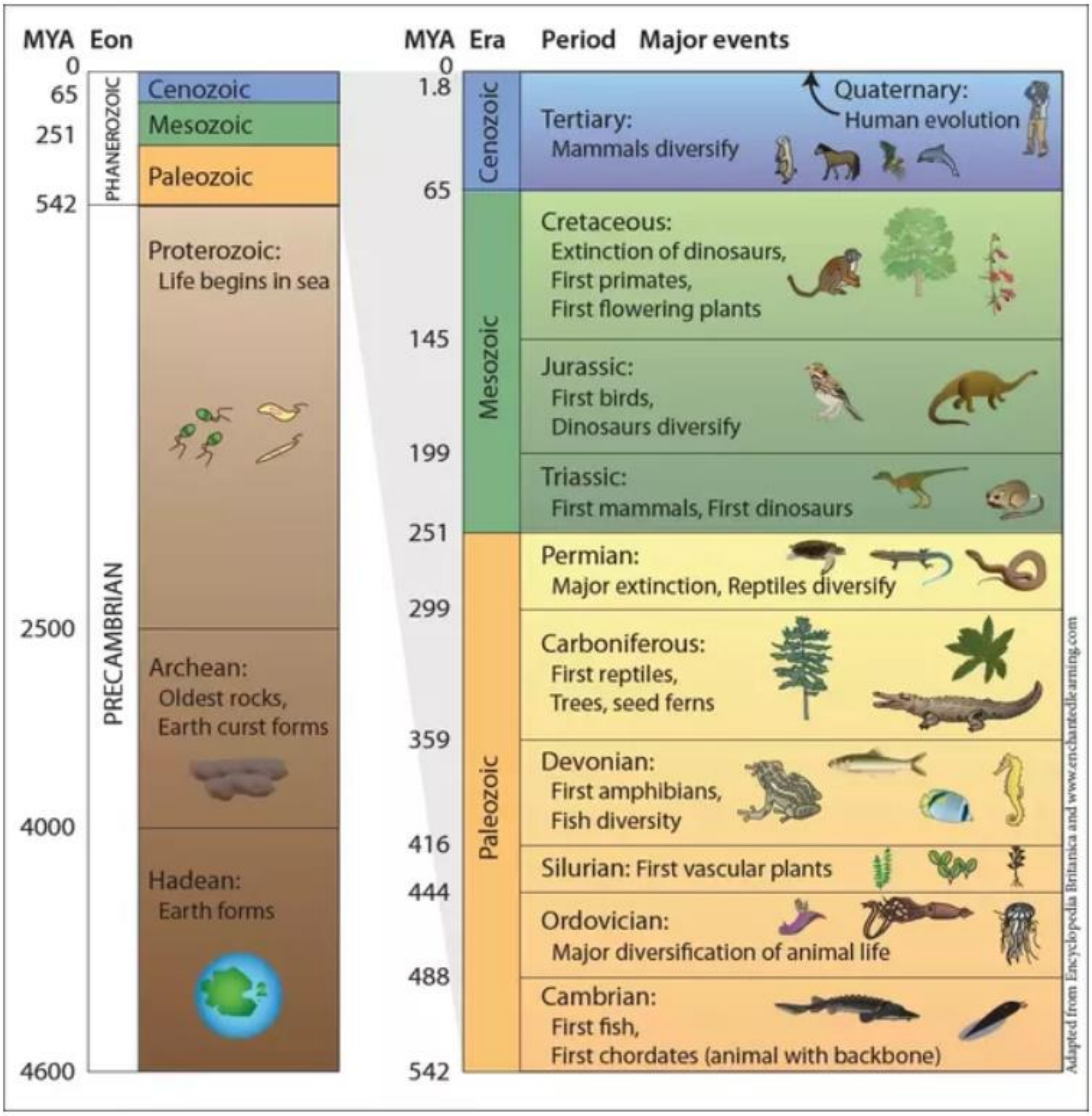

Figure 3. The geological time scale (http://www.ias4sure.com/wikiias/prelims/geological-time-scale/).

1) The Brothers

Australian Soil Classification: Ferrosol
Great Soil Group: Chocolate Soil
Land and Soil Capability Class: 4 Moderate to severe limitations
Inherent Soil Fertility: 4 Moderately High

Figure 4. The remnant Monaro volcanic plugs, "The Brothers"

As we head south from Cooma the tour enters open farming country. This soil landscape is known as "Maneroo" and is characterised by basalt soils of varying depth, many with shrink-swell capabilities which makes the establishment of trees a challenging one.

The Maneroo soil landscape can be identified in this area as undulating land with flat-topped hills and numerous lakes. The vegetation through this area was once all native grassland, with many areas sown to introduced pasture species as the Monaro region was settled and farming of these more fertile soils increased.

Within the Maneroo soil landscape, lies one of the most prominent features of the Monaro, The Brothers. It is mapped as Brothers soil landscape and comprises stony shallow ferrosols. The peaks are volcanic plugs, that is, they are the remains of the internal cores of the volcanoes that have since weathered/ eroded over time. The highest peak of the brothers is South Brother at 1120m.

Approximately 65 eruptive volcanic sites have been mapped in the Monaro region ranging in age from 54 to 34 million years old. The lava that flowed from around 35 eruptive events filled the surrounding valleys. The basalt plains visible today (Figure 4,5) are the remains of the valley floor lavas as the slopes and peaks of the original volcanoes have been largely eroded.

In the central Monaro the aggregate thickness of the layered lava flows, interbasaltic sediments, duricrusts and paleosols is up to 400m. In addition there are multiple intrusive plugs that form resistant features in the landscape, commonly at points of intersection of regional faults. These plugs were once magma conduits beneath volcanoes now eroded from the landscape.

The Brothers are remnant plugs that preserve a slightly coarser (porphyritic) textured rock compared with surrounding the lava-forming basalt (fine texture; cooled rapidly). The conical shape of the hills forms when blocks of eroded rock tumble from the resistant plugs to form aprons around the central cores. Weathering and development of soil on this colluvial pile results in the modern low hill landscape observed.

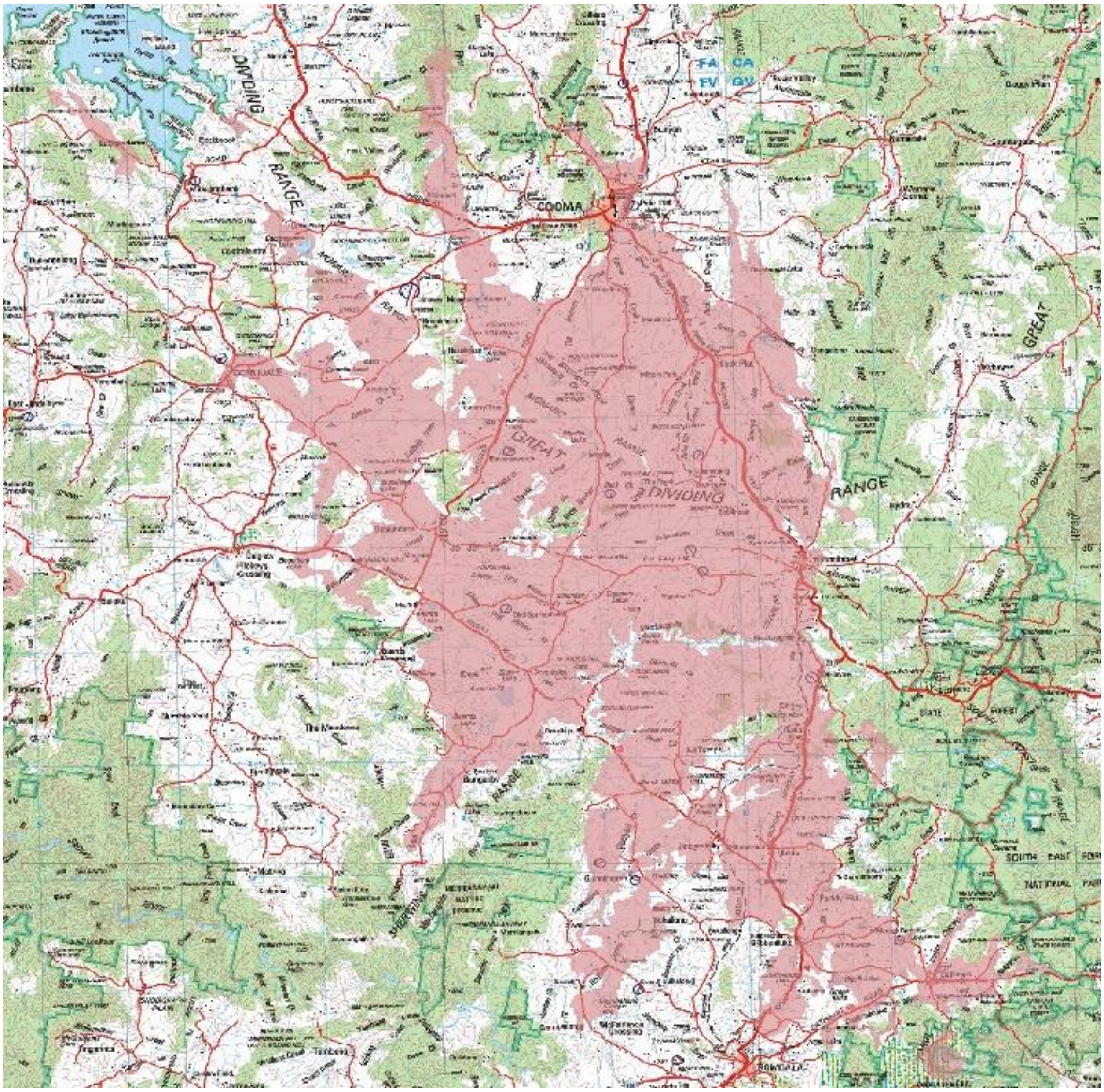

Figure 5. The volcanic basalt soils of the Monaro (red) spread from north west of Cooma to north east of Bombala.

2) Inland Lakes, Snowy River Way: Monaro Highway

Australian Soil Classification: Ferrosol
Great Soil Group: Chocolate Soil
Land and Soil Capability Class: 4, Moderate to severe limitations
Inherent Soil Fertility: Moderately-High

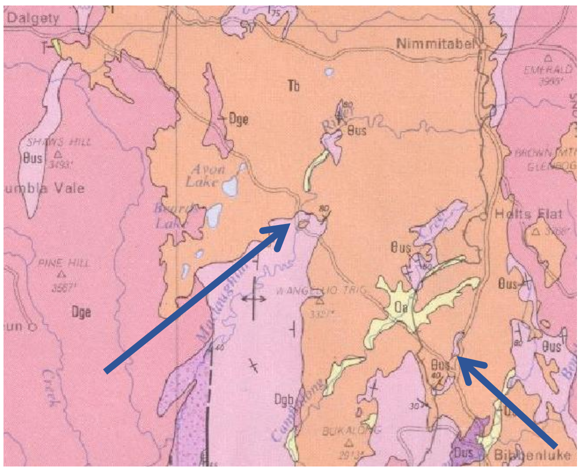

Figure 6. Monaro 1:500 000 Geological Map

Monaro lakes form in geomorphic depressions (basins) where water accumulates. They occur on basalt geology (Figure 6, orange) often with older adjacent or underlying granite (dark pink) or metasediments (light pink). The swelling clay soils are formed from weathered basalt and when saturated swell and block water infiltration, thus allowing the water to sit on the soil surface in the depression (Figure 7).

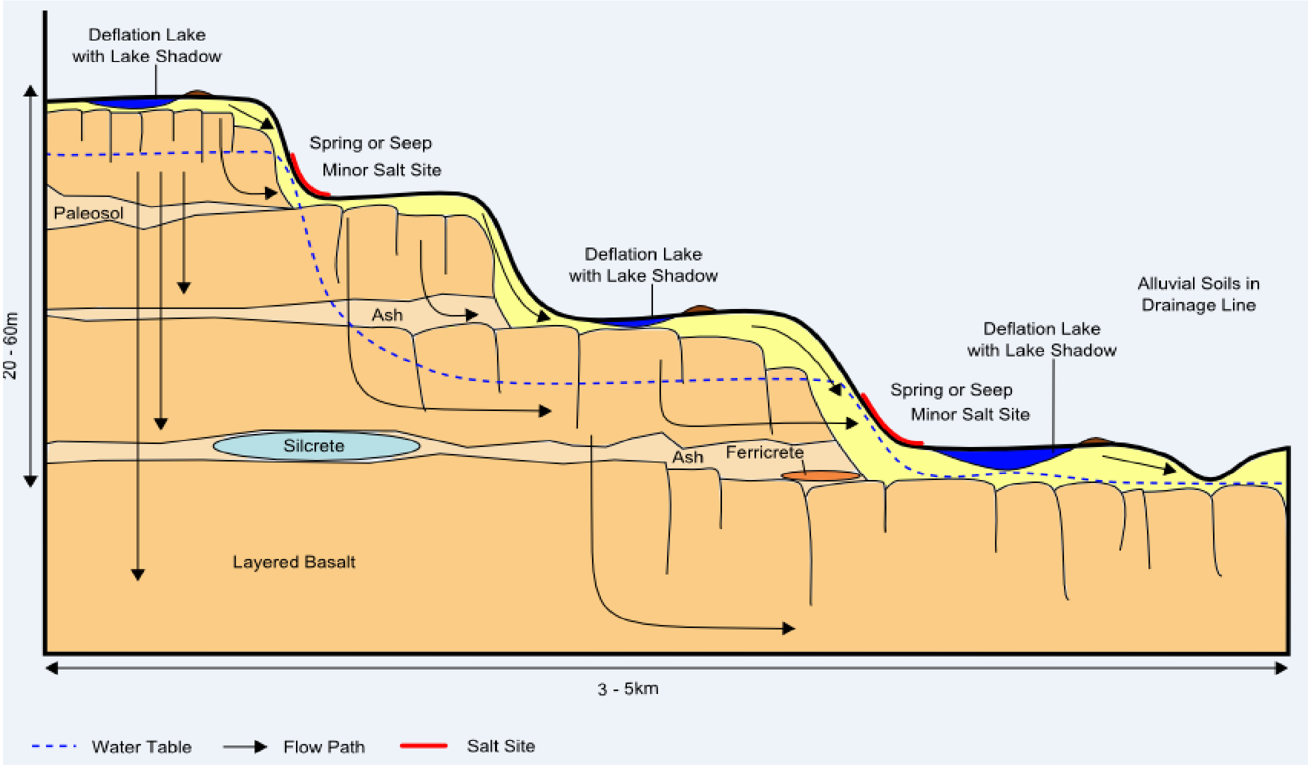

Figure 7. Geological formation of the Monaro Lakes (Moore & Cowood 2018).

3) Holts Flat

Australian Soil Classification: Ferrosol
Great Soil Group: Chocolate Soil
Land and Soil Capability Class: 4, Moderate to severe limitations
Inherent Soil Fertility: Moderately-High

The roadside cutting at this stop shows a good example of a physical and chemical breakdown of the basalt which is the parent rock for the ferrosol soil.

When basalt lavas first cool and contract, the rock becomes internally jointed, forming cooling columns that have a hexagonal prism shape. When these weather they form an arrangement of stacked corestones (Figure 8,9).

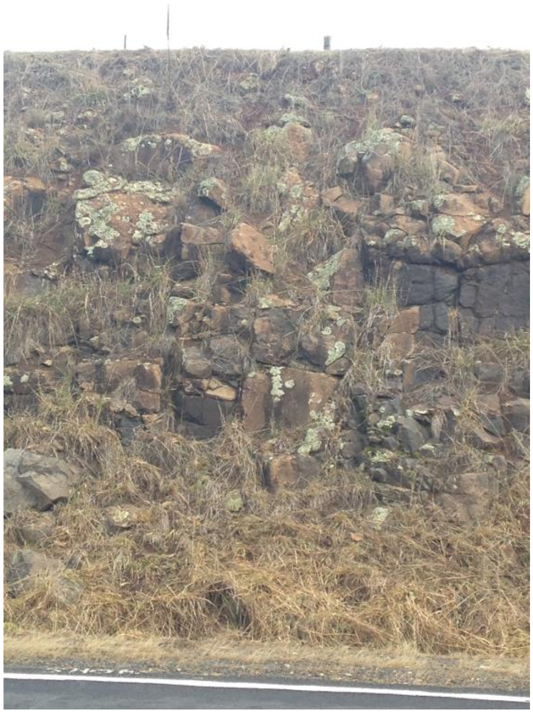

Figure 8. Roadside cutting showing basalt corestones near Holts Flat.

Figure 9. Basalt rock columns on Maffra Road, at Ravensworth TSR.

Corestones form during rock weathering when water percolates down through joints in the rock and chemically alter the corners and edges of the blocks more readily than the faces.

The result is the formation of spheroidal corestones, and this is why the process is known as spheroidal weathering. Because these corestones weather from the outside inward, some preserve layers of weathering rinds around a fresh rock core, commonly referred to as an onion-skin weathering.

This rock type forms the substrate for clay-rich soils but the depth of weathering and stage of soil formation differs with the age of the rock (older typically more weathered), position in the landscape and rainfall zone.

Bombala – Delegate – Cathcart Road Tour Leg

4) Sandstone & Mudstone Folds

Australian Soil Classification: Tenosols and shallow Red Chromosols
Great Soil Group: Lithosols and shallow Red Podzolics
Land and Soil Capability Class: 4 Moderate to severe limitations
Inherent Soil Fertility: Low

This stop highlights the stratigraphic hierarchy level known as the Adaminaby group (late Ordovician period, 490-440 million years ago) comprising of siltstone, sandstone, shale and mudstones.

The interbedded sandstone and mudstone sediments we see at this site are the oldest we see in the Monaro South area. They are found throughout south-east Australia and commonly form the basement rocks.

This means that this rock sequence was emplaced before the others, so all of the other rock types we see in the local landscape

Figure 10. Roadside cutting near Ashton Creek showing interbedded sandstone/ shale/ sandstone

have either been intruded into these rocks well below the land surface (granitic rocks), or erupted onto the ancient land surface (volcanic rocks) or formed at the surface more recently (e.g. slope sediments and river gravels).

The interbedded sandstones and mudstones have been buried, folded, faulted and uplifted over hundreds of millions of years, so sometimes are slightly metamorphosed. For this reason they can look a little different in different locations. For example they may be a little harder and greyer in colour and look a little more platey.

In order to encompass this variability when we describe this sequence of rocks we sometimes refer to them as the Ordovician meta-sediments. These materials form the substrate for sandy soils with variable clay content that commonly include remnant sandstone and mudstone rock fragments.

5) Bakers Creek

Australian Soil Classification: Rudosol

Great Soil Group: Alluvial Soil

Land and Soil Capability Class: 5 (?)

Inherent Soil Fertility: Moderate but constrained by poor drainage and flooding

The channel network in many Southern Tablelands catchments has been incised to form deep channels and gullies. This occurred following European settlement as a result of dramatic changes to the runoff regime and changes to the protective vegetation cover.

Figure 11. Active erosion visible along Bakers Creek

While the phase of maximum channel incision has now passed, many drainage systems display sections of active streambank and gully erosion. These sites are often significant sources of sediment to the catchment. On the upside, the exposed channel walls provide an insight into previous environmental conditions during which alluvial deposition was a major land forming process (Figure 11).

When the rocks present in the Monaro South landscape weather and are eroded, sediments are redeposited in the landscape as colluvial (slope), alluvial (stream) and lacustrine (lake) sediments. These materials form the substrate for gravelly, sandy and clayey soils depending on landscape setting (e.g. floodplain materials are often finer grained) and proximity to source.

The secondary mineral assemblage (clays, iron oxides etc.) impart particular properties to the soil. For example, the presence of dispersive clays in the soil may enhance erosion, as seen along some streamlines in the Monaro South area.

6) Irondoon Thrust

A thrust fault occurs when a region of the Earth's crust is subjected to a compressional force and the rocks on one side of the fault plane are 'thrust' over the rocks on the other side. This characteristically results in the formation of an almost linear (or slightly curved) ridgeline where the rocks have been uplifted.

The Irondoon Thrust (Figure 12) has formed due to ESE-WNW compressional forces pushing Ordovician meta-sedimentary rocks up and westward over younger Silurian rocks. Structural modifications of the landscape on this scale may result in distinct changes in the underlying geology, and hence soil type, over short distances.

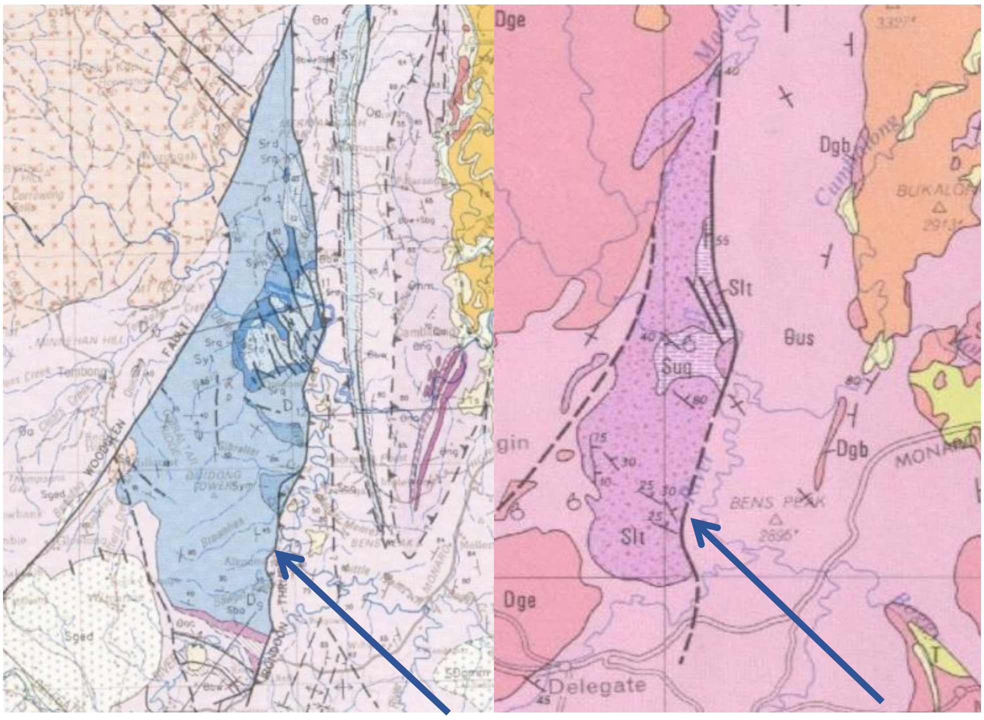

Figure 12. The Irondoon thrust features prominently on geological maps of the area.

The Adaminaby group on the right hand side of the thrust comprising of siltstone, sandstone, shale and mudstones (late Ordovician period)
Australian Soil Classification: Kandosol,
Great Soil Group: Red Earth, less fertile
Land and Soil Capability Class: 6, Very severe limitations,
Inherent Soil Fertility: Moderately low.

The Tombong formation on the left of the thrust comprising of a sandstone, siltstone complex (Silurian period sediments)
Australian Soil Classification: Kurosol
Great Soil Group: Yellow Podzolic, less fertile
Land and Soil Capability Class: 5, Severe limitations,
Inherent Soil Fertility: Moderately low.

7) Saucy Creek - Granite formations

Figure 13. An example of deeply weathered Bemboka granodiorite near Saucy Creek

Australian Soil Classification: Kurosol
Great Soil Group: Yellow Podzolic, less fertile
Land and Soil Capability Class: 6, Very severe limitations,
Inherent Soil Fertility: Moderately-Low

At this location there is a deep weathering profile formed on the Siluro-Devonian Bemboka granodiorite (Figure 13).

The clayey weathered rock that still retains the primary texture of the rock (mineral shapes) is referred to as saprolite. In the upper parts of the profile pedogenic (soil forming) processes modify the texture we see due to bioturbation (disruption by organisms), addition of organic material (humus) and physical and chemical changes in the minerals and rock fragments present. With time this would result in the formation of soil horizons. At this location these soils form the substrate for granular quartz-bearing clayey soils with relatively low cation exchange capacity (CEC).

Figure 14. Cross-cutting dykes visible in the road cutting near Saucy Creek.

Some primary features like quartz veins and cross-cutting dykes are clearly disrupted in the pedogenic zone as a result of the soil-forming processes (Figure 14).

8) Cathcart Road

Australian Soil Classification: Ferrosol
Great Soil Group: Kraznozem
Land and Soil Capability Class: 5, Severe limitations
Inherent Soil Fertility: Moderately high

Here we see an example of a basalt outcrop, part of the Brown Mountain basalts. Basalt soils are our youngest soils however there is an age range within the basalts in our region.

The basalts at this site are older than the Monaro basalt soils (stop 3, Holts Flat). Monaro basalts are still breaking down or weathering and thus the soils from these rocks contain more corestones (large rocks) in their profiles.

Brown Mountain basalts being older are more weathered and hence less rocky. This rock type also forms the substrate for deeper clay-rich soils that have the capacity to exchange cations, and hence are generally more productive.

Unlike the Monaro basalt region, Brown Mountain basalts are typically exposed to higher rainfall in the south-east as this area is partially influenced by orographic rainfall from the coast.

More information

Soils Knowledge Network - http://www.nswskn.com/

eSPADE - http://www.environment.nsw.gov.au/eSpade2WebApp#

eSPADE is the go-to website for local soil landscape information. Much of the information provided in this handout including Australian Soil Classifications, Soil Landscape and geological information was all sourced from this site.

Bega-Mallacoota 1:250,000 Geological Map:
http://gmaps.geoscience.nsw.gov.au/250K/BegaMallacoota/

NSW Government, Planning & Environment (1971). Monaro 1:500 000 Geological Map - https://www.resourcesandenergy.nsw.gov.au/miners-and-explorers/geoscience-information/products-and-data/maps/geological-maps/1-500-000/monaro-500k-geological-map

Australian Soil Club – Soil classifications and their characteristics: http://www.soil.org.au/soil-types.htm

Geological sites of NSW – The Monaro Plain - http://www.geomaps.com.au/scripts/monaroplain.php

Deakin University – Soil and Rocks. https://blogs.deakin.edu.au/sci-enviro-ed/wp-content/uploads/sites/40/2014/04/rocks-soil.pdf

Acknowledgments:

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