Monaro Geology and Soil Tour

2019 - Cooma - Adaminaby

South East Local Land Services
24 May 2019

Background

The inaugural Monaro Geology and Soil Tour, held in 2017 was a joint trip held with local land managers and visiting soil scientists from across NSW from the Soil Knowledge Network (SKN) with a focus on the geology and soils of the central Monaro region. On the back of this successful first tour, the 2018 tour was expanded and took in the geology and soils of the southern Monaro from Cooma to Bombala and out to Delegate.

For this, our third tour we head west to highlight the geological and associated soil features of the landscapes from Cooma to Adaminaby and returning via Middlingbank. Our previous guest speakers geologist, Dr. Leah Moore (University of Canberra, Institute for Applied Ecology) and Certified Professional Soil Scientist, Mr Peter Fogarty (SKN) have both returned for another journey. Both are highly experienced in their fields and are a great source of information for this trip!

Many of the participants in this year's tour have joined us on previous tours and have a good idea about the fascinating geology and soils that exist across the Monaro. South East Local Land Services welcomes everyone along for the 2019 tour which promises to be just as captivating and mind-boggling as our previous tours!

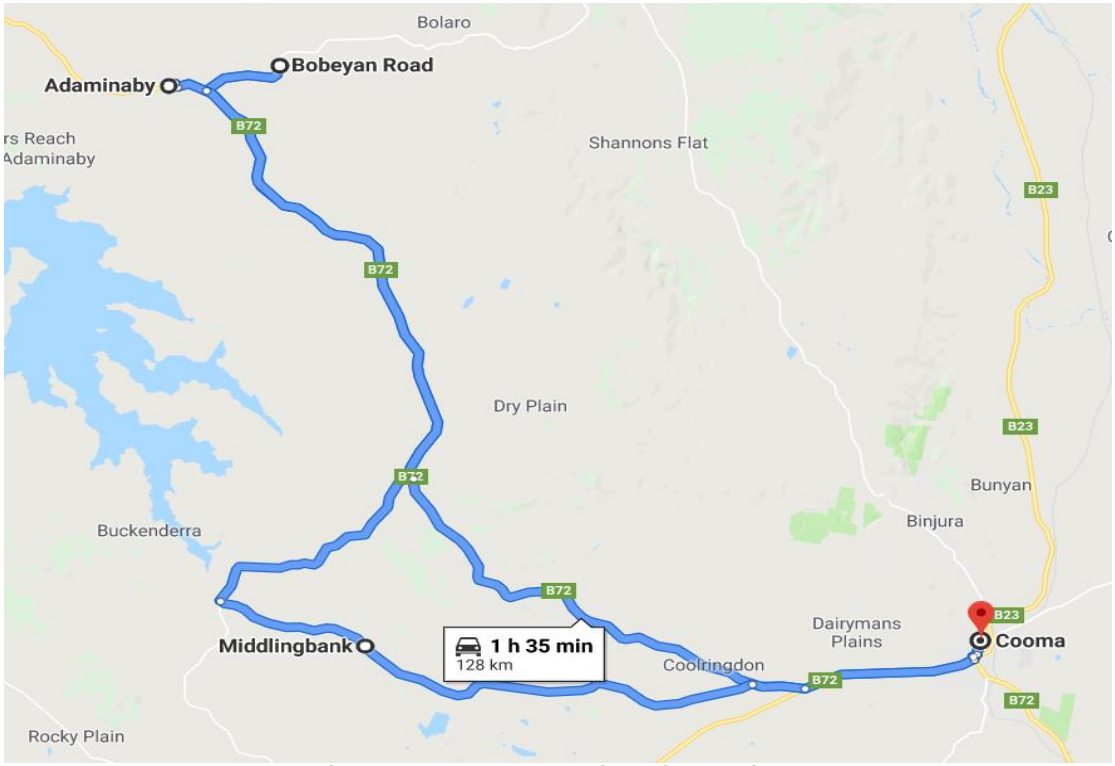

Figure 1. 2019 Tour map (google maps)

Follow us on today's trip and find out about geological information wherever you are in the future. NSW Geology Phone Maps is available on Android and Apple.
https://www.geoscience.nsw.gov.au/phonemaps/

The 2019 Tour

The tour will include the following highlights and stops:

1) Wambrook Hill geology
2) Adaminaby – Morning Tea
3) Ordovician sediment profile - Bobeyan Road
4) Exposed geology, fault line and alluvial soils
5) Adaminaby – Lunch
6) Stradbroke Road - Ordovician sediments and silcrete
7) Lit-par-lit formation and granite soil profile - Middlingbank
8) Monaro basalts - Slacks Creek Road

Soils Of The Area

The soil types across the Adaminaby region are just as variable as their parent geology. The cation exchange capacity (CEC) of soils gives us an insight into a soils potential fertility and its ability to support agricultural production. A higher CEC means potentially a more fertile soil and the Adaminaby area has a wide range of soil CECs (table 1). The inherent fertility ranges from medium to low across the Adaminaby region.

Soil acidity is one characteristic that is more prevalent in this area than in other parts of the Monaro. Soil acidity can result from the soil formation process (is geologically based), or be agriculturally induced. In this region the soil acidity is more related to the soils formation and its parent geology. Soil acidity is a concern as it can inhibit legume nodulation and N-fixation. It is also often related to high aluminium levels in soil which is can be toxic to plants and will limit pasture growth or prevent the establishment of some pasture species.

	pH (CaCl2)	CEC	Al%	Comments
Alluvial	4.8	6.0	<1%	Surrounded by Ordovician metasediment
Alluvial	4.9	14.5	<1%	Surrounded by Silurian sediment and granite
Granite	5.1	11.8	<1%	Silurian granite
Sandstone/ mudstone	**4.3**	3.8	**23%**	Ordovician metasediment
Shale	5.2	7.1	<1%	Silurian sediment
Basalt	4.8-6.5	10-40	<1%	Range for Monaro volcanic region

Table 1. Soil test results (0-10cm) from different soil types around Adaminaby.

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:

- Quaternary period (1 – 2.5 million years ago) – alluvial soils along Murrumbidgee River corridor
- Paleogene (early Tertiary) period (23-56 million years ago) – Monaro basalts
- Silurian periods (393-427 million years old) – intrusive granites and sediments
- Ordovician period (458-480 million years ago) – sediment sandstones, mudstones and shales

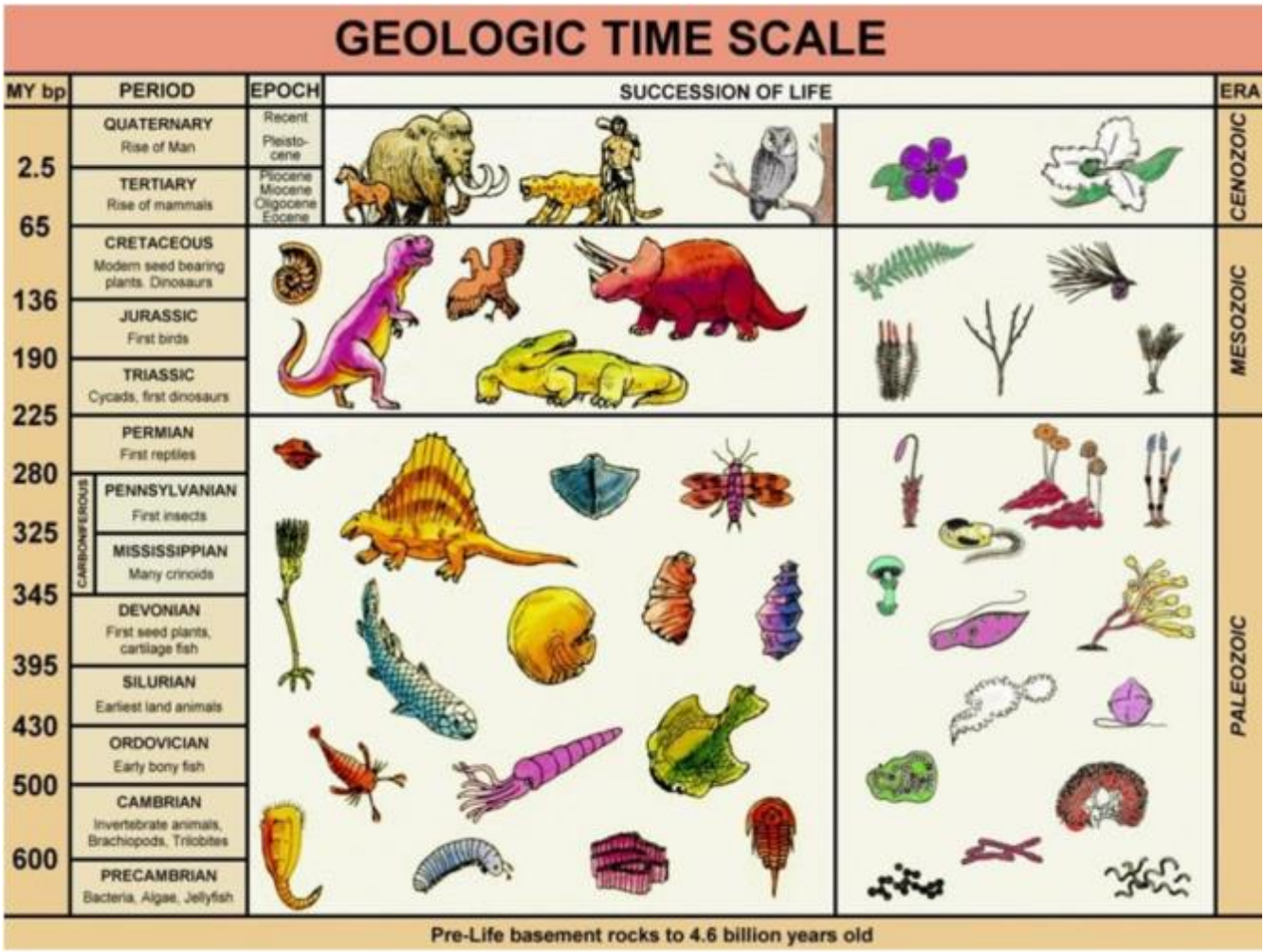

Figure 2. The geological time scale. Source: https://courses.lumenlearning.com/cuny-lehman-geo/chapter/the-geologic-time-scale/

1) Wambrook Hill

This road cutting provides a great example of a contact point between two very different geologies and soil types. On the western side is the Monaro volcanic basalt (Paleogene period: 27-30 million years old). On the eastern side are fine sandstone and siltstone sediments of the Yalmy Group (Silurian period 427-443 million years old). These are draped by an angular cobble conglomerate (blocks about fist size) called a fanglomerate deposit. In the modern landscape this would be the kind of material that forms an alluvial fan on the margins of a steep slope.

Australian Soil Classification: Ferrosol (basalt); Tenosol (siltstone)
Land and Soil Capability Class: 4, moderate to severe limitations (basalt); 5, severe limitations (siltstone).

Figure 3. Wambrook Hill road cutting (Photo: J. Powells).

The basalt lava on the western side of this cutting flowed down a valley in the landscape developed in the Yalmy sandstone landscape. This is one of the most north-westerly flows of volcanic basalt from the Monaro Province. The lavas here are a very special kind of basalt called Ankaramite, which has a lot of the iron and magnesium bearing mineral pyroxene (augite) in its makeup. The cutting allows us to see the weathering of these basalt deposits with basalt rock clearly exposed to depth. Soils derived from this volcanic geology are generally more inherently fertile and have a high available water capacity. As such they are more agriculturally productive than the neighbouring sediment derived soils.

The Silurian sediment (fine sandstone) on the easterly side of the cutting is very representative of the sedimentary soils in the local region. The sediment folds are very noticeable and the colours indicative of the dominant minerals (quartz and kaolinite clay) in

the rock. Weathering profiles have developed on the sandstone and the fanglomerate deposits. The tenosol soils developed here are shallow, stony and light textured. They have low fertility and water holding capacity, and have typically strongly acidic pH.

This location illustrates the concept of inversion of topography where the lavas that originally flowed down the valley now form the crest of the hill. This is because they are more resistant that the older, more weathered surrounding rocks that have been preferentially eroded.

2) Ordovician Metasediment Profile - Bobeyan Road

This road cutting provides a great example of an Ordovician sedimentary geology (alternating sandstone and mudstone) of the Adaminaby Formation (458-480 million years ago) and its associated soil profile. The site also has residual deposits of ferricrete, a hard, erosion-resistant layer of rock, formed due to weathering, which is high in iron (giving it a red, ferrous colour).

Australian Soil Classification: Tenosol
Tenosols are soils with properties including shallow total depth, moderate to high content of stone and gravel and acidic pH. They are infertile, and the gravel and stone content significantly reduces water holding capacity.
Land and Soil Capability Class: 5, severe limitations.

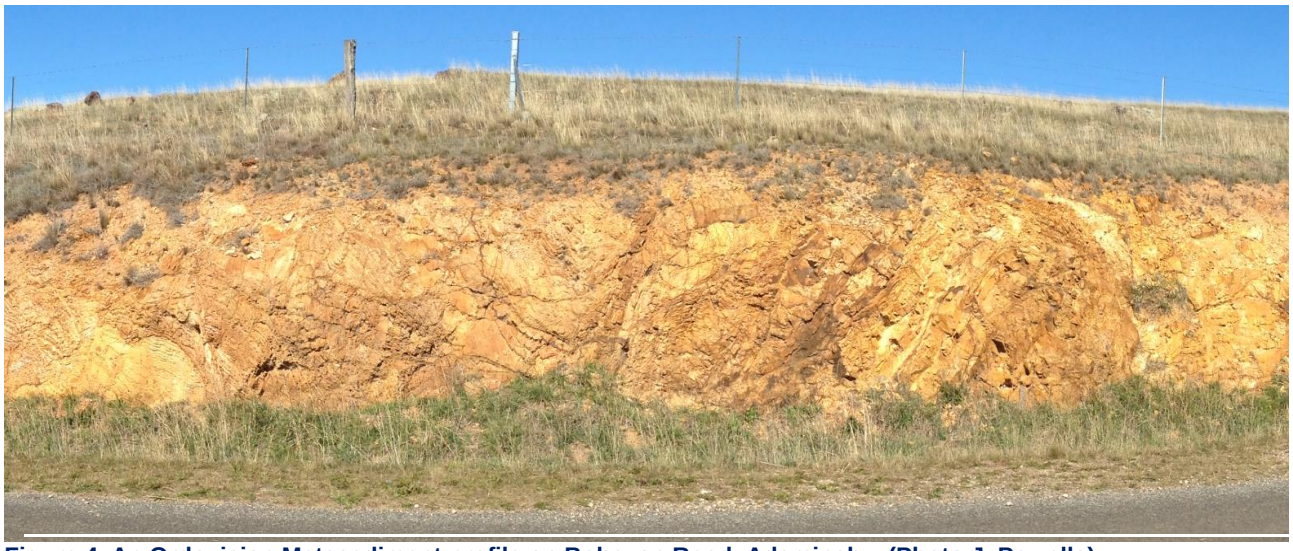

Figure 4. An Ordovician Metasediment profile on Bobeyan Road, Adaminaby. (Photo J. Powells)

The alternating sandstones and mudstones that formed original bedding can be traced across the outcrop even though the sequence has been intensely folded. This ancient rock succession has been subjected to multiple deformational events associated with movement on regional and local faults.

3) Exposed Geology and Fault Line – Bobeyan Road

This site at the corner of Bobeyan Road and Kingston Road is where one of Adaminaby's numerous fault lines is visible and at this location, intersects with the Murrumbidgee River.

Australian Soil Classification: Tenosol
Land and Soil Capability Class: 5, severe limitations.

Figure 5. An exposed fault line and sandstone/ mudstone geology at the corner of Bobeyan Road and Kingston Road, Adaminaby. (Photo. J. Powells)

The geology here is the same as our last site, Ordovician metasediments (alternating sandstone and mudstone) from 458-480 million years ago. The variation in colour and presentation of this cutting is preferential flow of water along the fractures associated with shattering caused by movement on the fault.

The land manager at this location has commented that livestock are often seen licking the exposed rock face. This is not uncommon due to the high concentration of salt in the rock which livestock are attracted too; it's just like a giant salt lick!

This type of geology combined with high rainfall can result in these salts becoming mobilised and running from the rock and soils to produce saline runoff (salty water). Adaminaby has around 690mm rainfall per year (long term range 300-1150mm, 1887-2018) which often results in increased salt levels being recorded in the Murrumbidgee River.

Adjacent to this site lies the Murrumbidgee River and the Quaternary (<2.5 million years old) alluvial deposits. Soils here are a combination of silt, sand and gravel that have been deposited by the river from the weathering and erosion of upstream geologies. Soils formed in this way can be highly variable in fertility and in physical characteristics. Drainage on floodplains is highly variable, and fertility reflects the source geology of the sediments.

Interestingly, upstream from this site, the Murrumbidgee River does not follow this line of alluvial soil which heads back towards the Adaminaby township. The fault line at this site has redirected the river which follows the fault line in a north-west direction back up the valley towards Yaouk.

4) Adaminaby Township

Adaminaby sits in between 2 fault lines, the Adaminaby Thrust to the west and the Cotter Fault to the east. 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.

These 2 faults at Adaminaby provide clear distinctions between the geology and soils of this area (figure 6) with Silurian granodiorite (granite) to the west (pink), Silurian sediments (shale) in the middle (dark purple) and Ordovician sediments (sandstone/mudstone) to the east (light purple). The town also sits on a small residual Quaternary alluvial deposit, despite the river no longer being present (caused by the faulting discussed at the last stop).

Adaminaby is also home to the Big Trout and is our lunch stop for this trip.

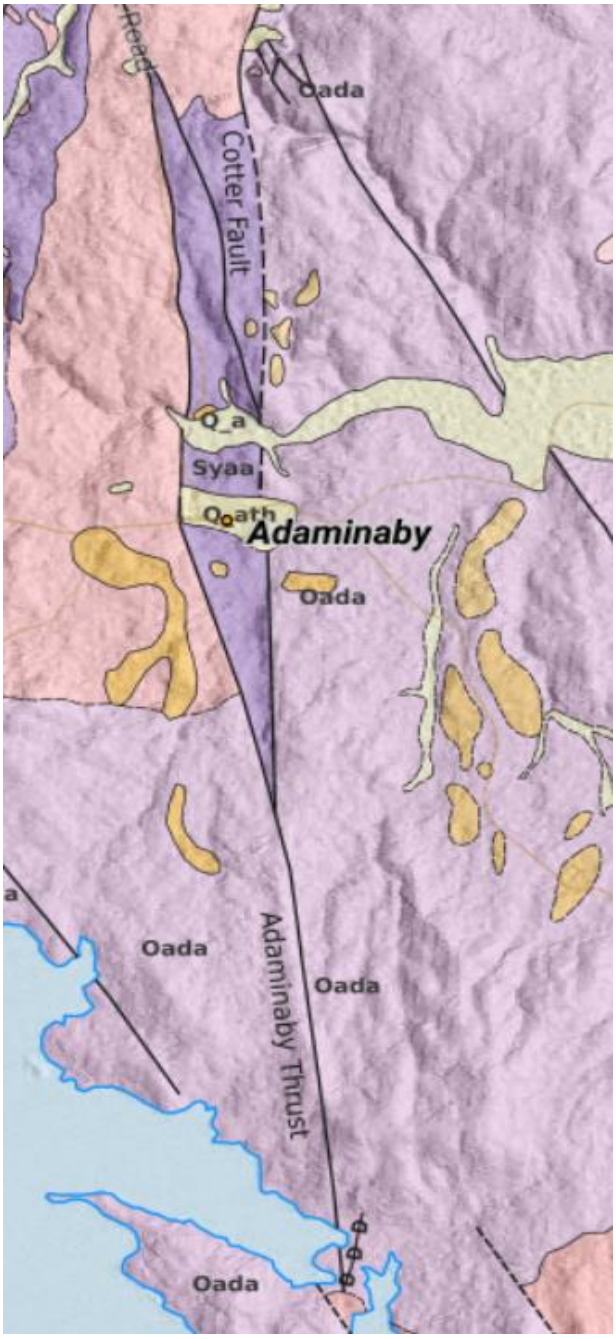

Figure 6. Adaminaby sits between 2 fault lines.

Figure 7. The Big Trout, Adaminaby

5) Stradbroke Road

The road cutting at this site is a classic example of a deeply weathered profile formed on Ordovician metasediments (458-480 million years old) of the Adaminaby area.

Australian Soil Classification: Dermosol

Land and Soil Capability Class: 5, severe limitations.

The contemporary soil profile has formed in the reddish material (figure 8), which is a moderately structured clay loam (white arrow).

The underlying layers of gravel and kaolinized fine sediments are buried soils, sometimes termed Paleosols (yellow arrow).

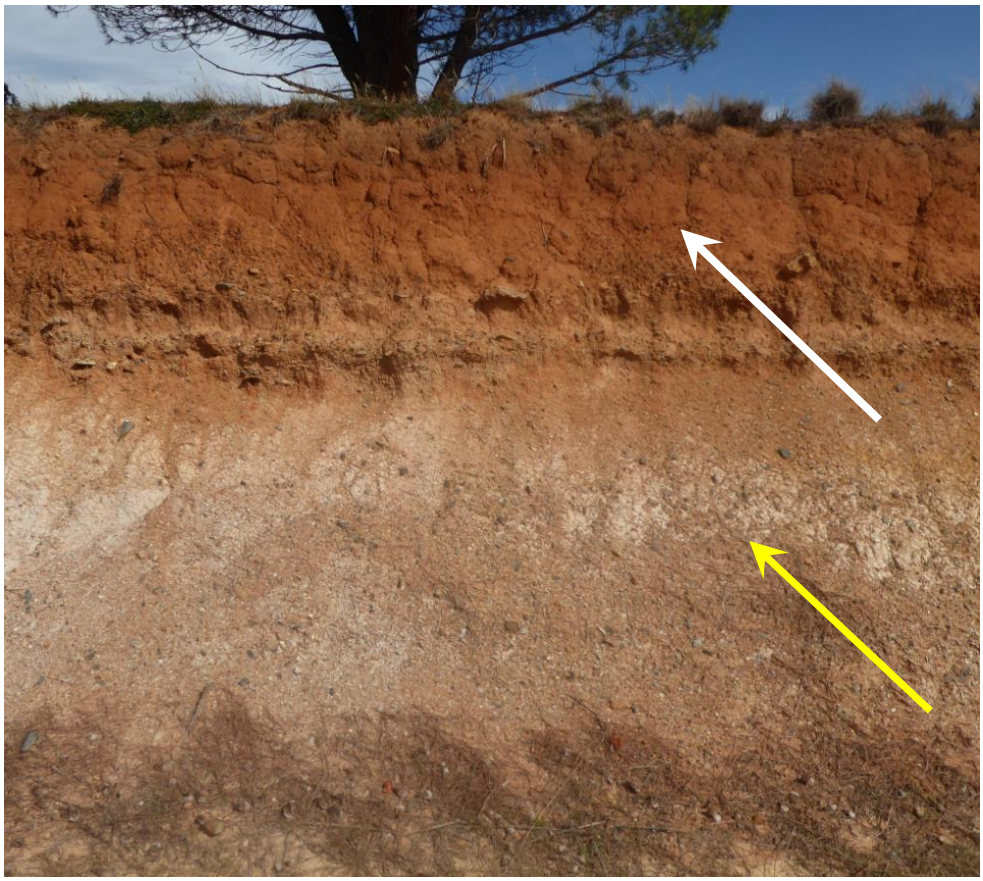

Figure 8. A Dermosol soil profile near Stradbroke Road, Adaminaby.

Either side of the highway and to the east of Stradbroke Road lie outcrops of silcrete which are often appear shining across the landscape. These exposures have been carefully mapped and are believed to trace the path of a former complex of streamlines with dominant flow to the north. These quartz-rich stream gravels were originally

Figure 9. Exposed silcrete around Stradbroke Road, Adaminaby.

formed in the landscape developed on the Ordovician metasedimentary rocks. Paleogene (27-30 million year old) basalts flowed down the valleys covering the stream sediments. Water carrying silica dissolved from the overlying weathering rocks was precipitated as a cement in the stream gravels forming the silcrete (siliceous duricrust). This then became the most resistant material in the landscape and subsequent erosion left the silcretes high in the landscape – another example of inversion of topography.

6) Middlingbank Lit-Par-Lit Formation and Granite Soil Profile

At this site we can see both Silurian granodiorites (granitic rocks) (393-427 million years old) and Ordovician sediments (sandstone) (458-480 million years old).

Australian Soil Classification: Kurosol
Land and Soil Capability Class: 6, Very severe limitations

Figure 10. Lit-par-lit formation on Middlingbank Road.

This road cutting provides an example of lit-par-lit formation. Pronounced "*lee-par-lee*" it is French for "bed-by-bed" and refers to the penetration of fingers of granodiorite up along the weaker layers in the bedded sediment.

This is a relatively rare feature to see in outcrop as it perfectly captures the moment in time when the granite intruded the enclosing sedimentary rock. This process likely happened at about 10km or more below the land surface. The intruding hot granodiorite magma contact metamorphoses (bakes) the sediments in the immediate area making them more resistant to erosion.

These hard baked zones are called 'roof pendants' because they formed the 'roof' of the granodiorite magma chamber. The crest of this hill and few others in this area form prominent peaks for this reason. Typically they have trees on them as the hard rocky land is less productive that the weathered granite forming the flanks of the hills.

Figure 11. The alternating sandstone, granite, sandstone, granite can be clearly seen.

The Kurosol soils here are texture contrast soils with a light textured topsoil overlying a clay subsoil. On granite the subsoils are typically a sandy-clay which is well structured. They are more favourable agriculturally than the soils formed on the sediments as they have a higher water holding capacity although fertility is relatively low. They are also acidic (Kurosols have subsoil pH <5.5w).

7) Monaro Basalts

The Monaro basalts are Paleogene volcanic basalts formed between 23 and 56 million years ago.

Australian Soil Classification: Ferrosol
Land and Soil Capability Class: 4, moderate to severe limitations.

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.

Monaro basalts are quite young (geologically speaking) and are still breaking down or weathering and thus the soils from these rocks contain more corestones (large rocks) in their profiles than other basalt derived soil. This rock type also forms the

Figure 12. Basalt corestones are visible in cuttings along Slacks Creek Road.

substrate for deeper clay-rich soils that have the capacity to exchange cations, and hence are generally more agriculturally productive.

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 12).

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.

8) The Cooma Landscape

As we head back into Cooma further along Slack Creek Road, the tour enters open basalt 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.

Figure 13. The remnant Monaro volcanic plugs, “The Brothers”

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 (figure 13). 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 14) 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.

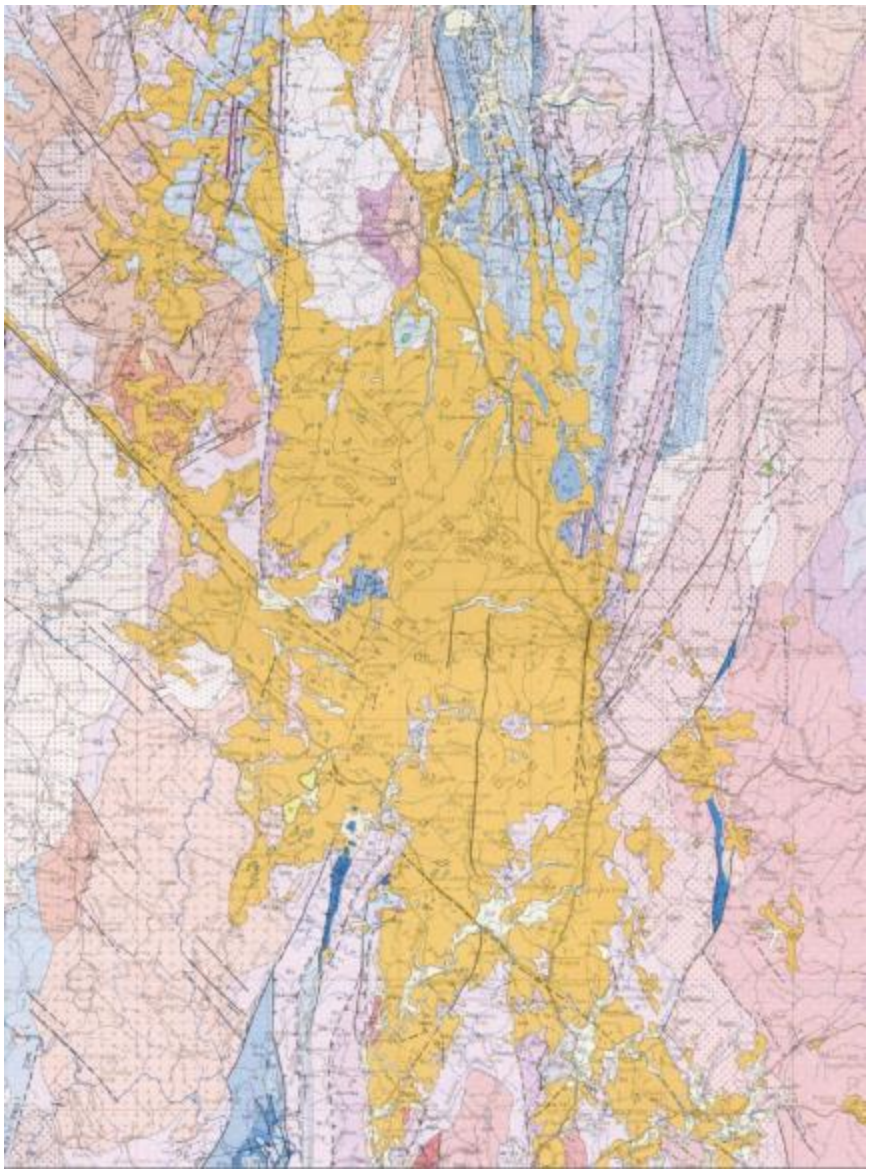

Figure 14. The volcanic basalt soils of the Monaro (orange) spread from north west of Cooma to north east of Bombala.

More Soil and Geology Information

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

NSW Geology Phone Maps - https://www.geoscience.nsw.gov.au/phonemaps/

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

Geology of the Koscuisko National Park 1:250,000 Geological Map: https://d28rz98at9flks.cloudfront.net/22815/kusciusko_hi.pdf

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

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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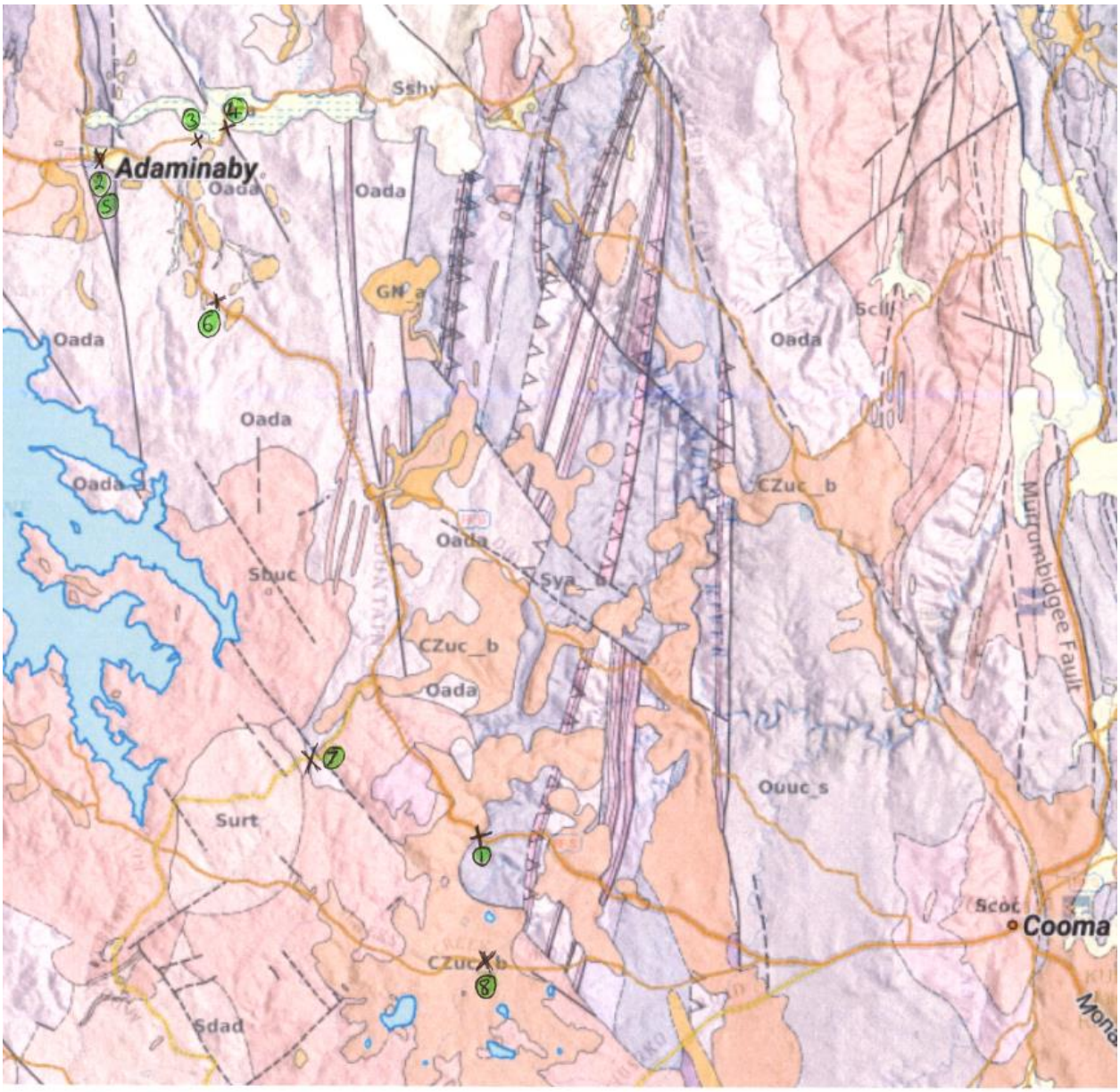
SELLS would also like to thank our guest speakers Dr. Leah Moore (University of Canberra, Institute for Applied Ecology) and Peter Fogarty (Soil Knowledge Network) for their enthusiasm and willingness to share their knowledge!

2019 Tour Map



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