**Stop 1: View looking east to Guildford Plateau – overview of local geology**

1. We'll be looking at nearly ½ billion years of earth history – and the aim today is to see how events over that time have combined to create the landforms we see in south Muckleford. We're standing on very ancient rocks but if we look east, we see one of the youngest landscape types in Victoria – a volcanic plain called the Guildford Plateau. This highlights the surprising thing about Central & Western Victoria – we have some of the youngest landscape forming events in Australia due to volcanism in the last 4.5 million years.
2. We're standing on Ordovician sedimentary rocks formed in a deep ocean off the 'east' coast of Gondwana. These sandstone and mudstone layers are up to 480 million years old.
3. Folding of Ordovician occurred about 445 Ma and the edges of the upturned layers can be seen forming the north-south ridges of local hills. These ridges control the local drainage pattern. (*Ma= millions of years before the present*)
4. If we look east we see the flat Guilford plateau – this was formed by basalt lava flows ~ 3 Ma. The basalt had a low viscosity and was fast moving.
5. To understand why basalt is here, and how it spread, we need to go back about 60 Ma to the Palaeocene (66–56 Ma) – this is when the ancient Loddon River was forming. At this time the separation of Australia and Antarctica caused uplift (of the Dividing Range) and initiated streams like the Loddon river. The Loddon was kick-started during a period of intense rainfall & rapid erosion called the PETM (precisely 56 Ma).
6. Basalt flowed down the ancient Loddon valley & diverted the Loddon forcing it to flow along the southern margin of the plateau. The Muckleford Creek and Campbells Creek were similarly affected. The Muckleford Creek was forced to flow along the west edge of the lava plain. It is probable that temporary lakes formed along Muckleford and Campbells creeks after being disrupted by the lava?
7. Apart from the ancient bedrock and the volcanism, major faults, like the Muckleford Fault, (just 600 metres to our east) extend down of tens of kilometres. The fault has periodically moved over time leading to changes in the landscape. This especially affected the course of streams – the north-south orientation of Muckleford Creek appears to be controlled by the Muckleford Fault.

**Stop 2: Effects of Muckleford Fault in the ancient bedrock – cleavage in a high strain zone**

1. The Ordovician sedimentary rocks (that formed in that the old ocean) were squashed by a tectonic plate to our east – this caused the rocks to become folded into a series of anticlines and synclines.
2. Eventually large faults cut through the folds, like the Muckleford Fault. The Muckleford Fault is a thrust fault (a fault formed by compression).
3. The Muckleford Fault was identified by Wm Harris and D.E. Thomas in the 1930s using graptolite fossils.
4. In the 1980s we started to look at faults differently, asking, how do faults affect the surrounding rocks, especially the rocks on the west-sides of faults (hanging wall). *Note that major faults in Victoria are mostly west-sloping (or in geologists lingo, 'west-dipping'). The hangingwall of a west-dipping fault is on the west side of the fault.*
5. The hangingwall rocks along the Muckleford Fault became highly strained during the 445 Ma event. Why should high strain be constrained to the hangingwall? – because the HW of a thrust fault is the active block moving up and over a relatively stationary footwall block, on the east side.

6. At this stop, the most obvious effect of this high strain, is a very strong and closely-spaced cleavage that has developed at an angle to the original bedding. Cleavage is formed by mica-like minerals regrowing and re-aligning their platy mineral fabric perpendicular to the stress direction during the 445 Ma event (east-west in this case)

**Stop 3: Land-slide or debris avalanche.**

1. At stop 3 we had morning tea on a landslide or debris avalanche – note the large boulders on the north flank of the deposit.

2. This land-slide has many of the typical features of classic land-slides such as the head scarp – best seen in the LiDAR images.

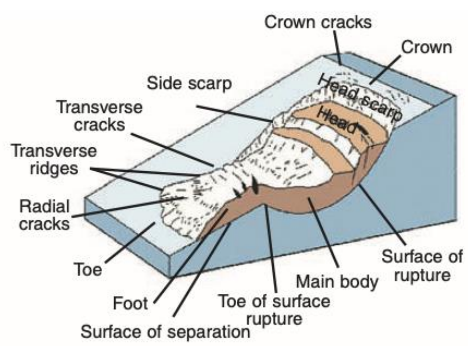


*Fig. 1: Simplified block diagram of a typical, but idealised landslide showing commonly used technical names given the various parts of the landslide (from Highland, 2004, based on Varnes, 1978). Definitions are provided in the glossary of terms.*

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3. Side scarps can be seen on the north and south margins of this land-slide
4. There is evidence that the debris originally spread to the east side of Muckleford Creek and the deposit would have been much larger when brand new. Since then, the Muckleford Ck has re-asserted its authority by cutting through the deposit's eastern side. A small upstream dam may have formed temporarily before the creek was able to cut through.
5. What caused this land-slide? We are just 350 metres west of the Muckleford Fault.
It's quite possible that the landslide was triggered by movement along this fault in recent times.
6. Over the last 50 years 727 seismic events (tremors), of various magnitudes, related to the Muckleford Fault, have been by recorded (pers comm Gary Gibson, 2015)
7. A 2.7 magnitude tremor associated with the Muckleford Fault was recorded near Lockwood on 25th June 2015.

**Stop 4: Frenchmans Tunnel**

1. In 1864 Francois Monier and mates tunneled 213m under the basalt in their search for gold-bearing gravels buried the basalt lava
2. It is safer and cheaper to drive in bedrock as the rock is stronger & therefore needs less timber support.
3. Eventually the company that took over this area (c1865) had enormous water problems. Fine sand became liquified & filled tunnels. One report mentions a water flow of 15,000 gallons per hour.
4. What about the origin of the gravels? The lava completely buried any river sediments that had accumulated in the ancient Loddon River valley. This sediment contained gold and became the target of early miners, but to get it, they had to drive tunnels under the basalt.
5. The ancient rivers were very high energy streams compared to the modern Loddon and we can tell this by the large size of pebbles, cobbles and boulders.

6. Ross Cayley talked about his new idea regarding the evolution of major streams like the Loddon valley. He thinks that broad U-shaped glacial valleys in the early Permian (between 299 & 294 Ma) were later exploited by rivers like the Loddon at about 60 Ma. However, the Loddon probably didn't flow into an old Permian valley until it reached somewhere past Newstead.

**Stop 5: Plunkett's Tunnel**

1. This is another 1860s operation that drove their tunnel into the bedrock for safety – they then probably rose up to mine the gold-bearing gravels. The large size of the mullock heaps suggests mining was extensive. There are pebbles and cobbles scattered amongst the mullock showing they reached the gold-bearing gravels.
2. Looking south to the edge of the plateau we see basalt cooling columns, or columnar jointing. When basalt cools a series of systematic cracks or joints are formed perpendicular to the cooling surface. As the basalt cools it contracts and forms tensile cracks. Individual columns are most commonly six-sided.
3. Fossil pollens and spores from a borehole that penetrated the ancient river sediments shows that at about 25 Ma the valleys were dominated by Nothofagus forests which included Podcarps (ancient conifers) and ferns. This was a southern cool-climate rainforest environment.