
U3A Field excursion 2025
SE South Australia

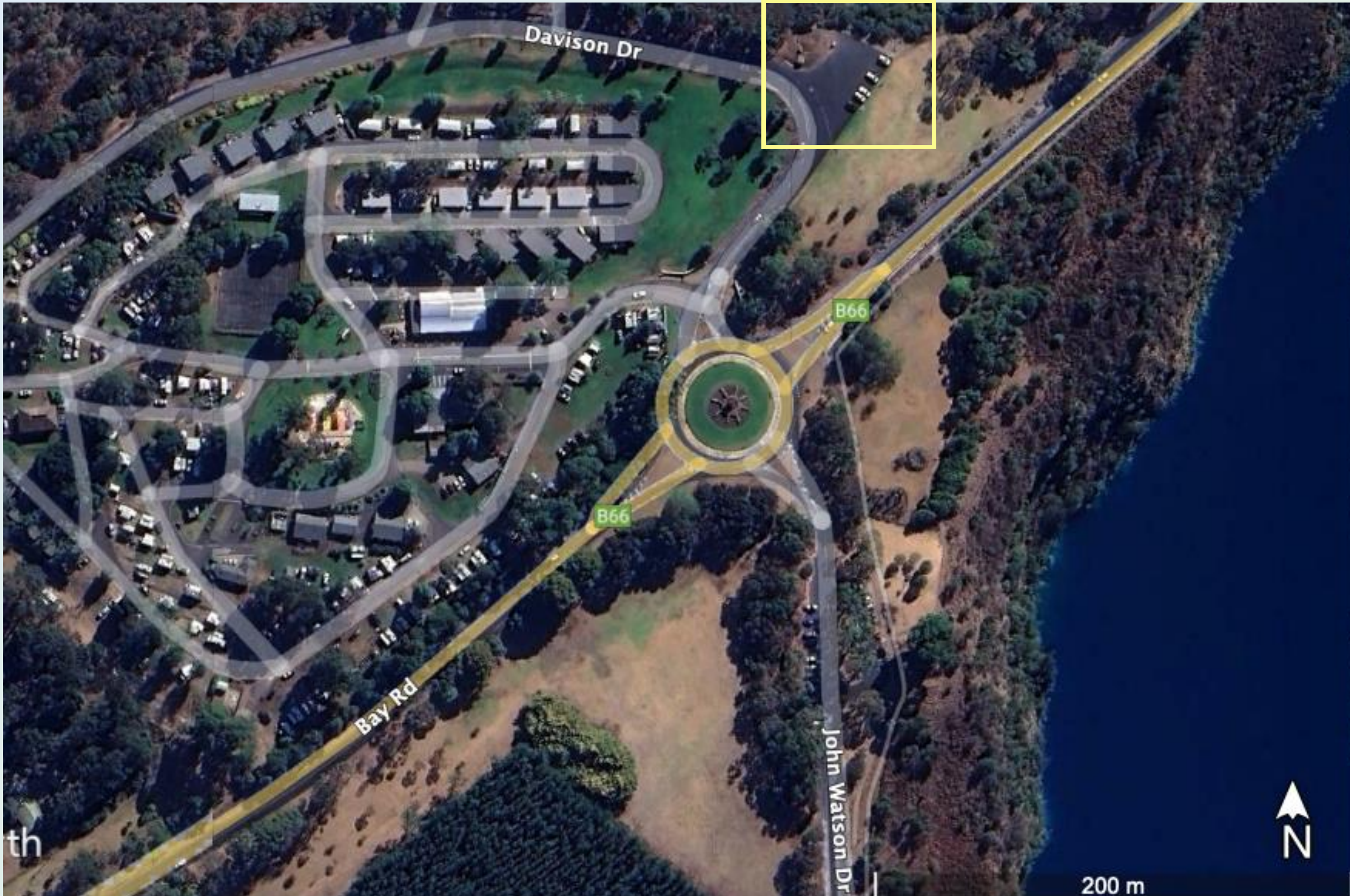
For those people attending the Mount Gambier excursion, these are the dates for the excursion:

- Overnight Naracoorte Sunday 9th November
- Overnight Mount Gambier 10th, 11th, 12th

U3A Mount Gambier Geology excursion

Day 1 Sunday November 9th	Drive to Naracoorte
	Overnight Naracoorte
Day 2 Monday November 10th	9.00 am and 9.30am Victoria cave tours Naracoorte
	Drive to Mount Gambier Blue Lake viewing
	3pm/5pm Short talks on Blue Lake crater wall
	Overnight Mount Gambier
Day 3 Tuesday November 11th	10am Umpherston cenote
	12noon Mt Schank
	Port MacDonnell,
	Mt Gambier volcanic complex or alternative sites*
	Overnight Mount Gambier
Day 4 Wednesday November 12th	10am Tantanoola Cave
	Discovery centre at 2pm Ridddoch Arts & Cultural centre volcano movie
	Overnight Mount Gambier
Day 5 Thursday November 13th	Journey homeward

*Alternative or additional site visits: Lake Leake (birdwatching), Hells Hole, Engelbrecht cave, Honan Mint trail, Caroline sinkhole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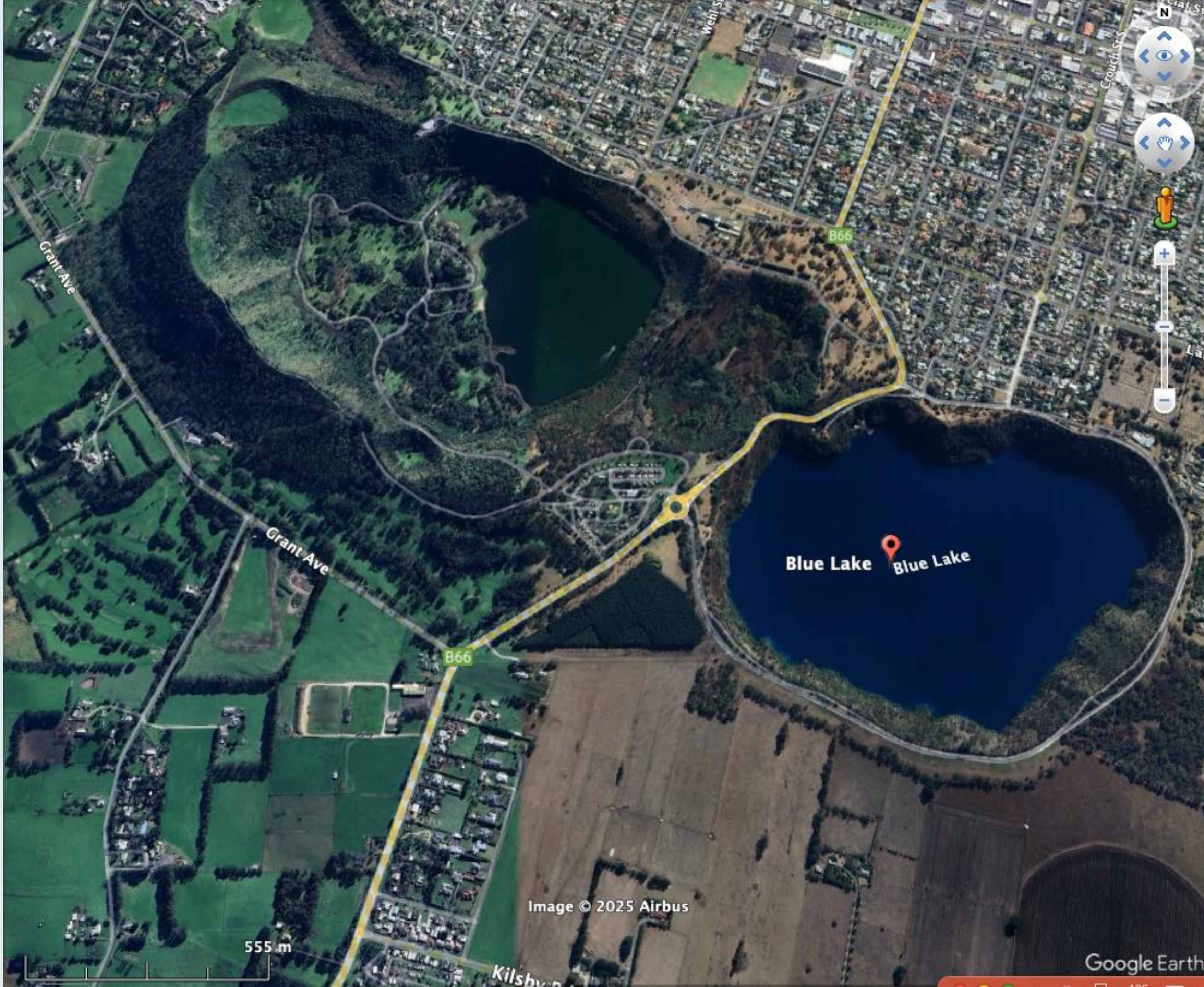

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Introduction

- The southeastern corner of South Australia contains two major types of geological features:

    (1) cavernous limestones

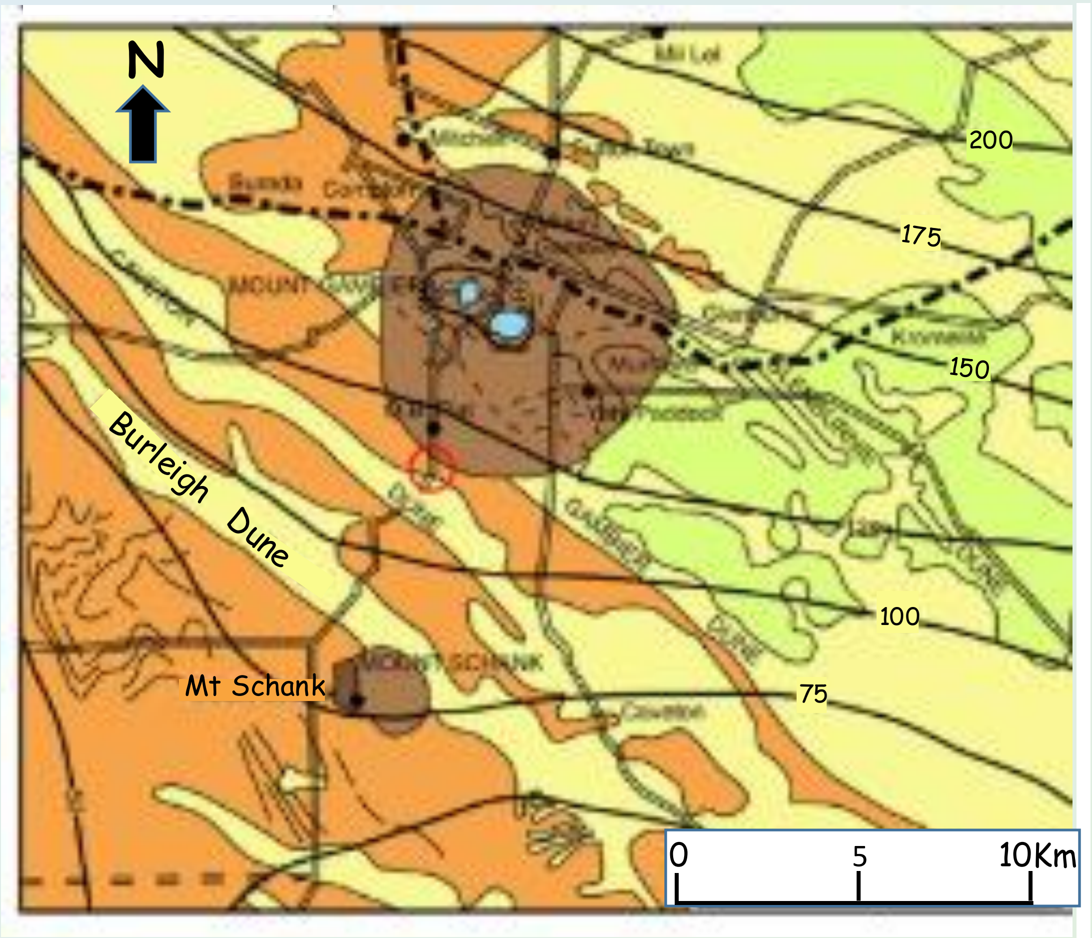
    (2) basaltic volcanoes and maars

- limestone underlies much of the southeast corner of SA extending into southwestern Victoria
- superimposed on the limestone are younger volcanoes and maars
- volcanic activity took place comparatively recently in geological terms
- Mt Schank near Mount Gambier is the youngest volcano on the Australian mainland (~4,300 years)

Regional geology

- Mount Gambier lies within the limestone coast in the Gambier Basin Province of South Aust.
- the Palaeogene-Neogene basin developed during the rifting and early phase separation of Australia and Antarctica
- a karstified upper surface of Late Eocene (~35Ma) to Middle Miocene (~15Ma) Mount Gambier Limestone is exposed in Mount Gambier area → regional uplift
- regional warping of Gambier Limestone associated with emplacements of igneous intrusions associated with Holocene-Pleistocene volcanoes

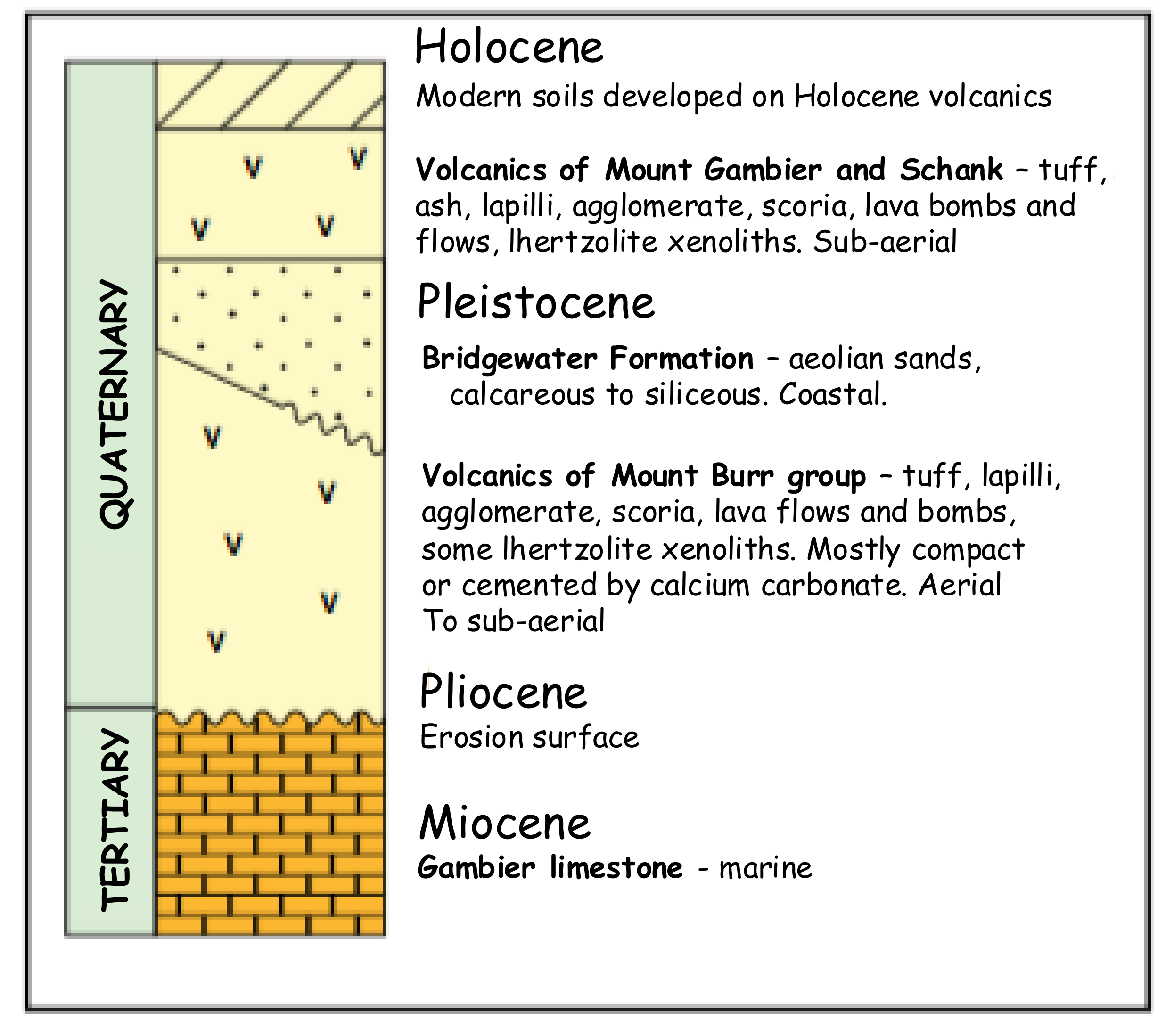
Mount Gambier district geology volcanism



LEGEND

Lakes	Basalts, scoria
Ash, lapilli, lava bombs	Aeolionites, beach sands
Deep flat-lying sands	Gambier Limestone

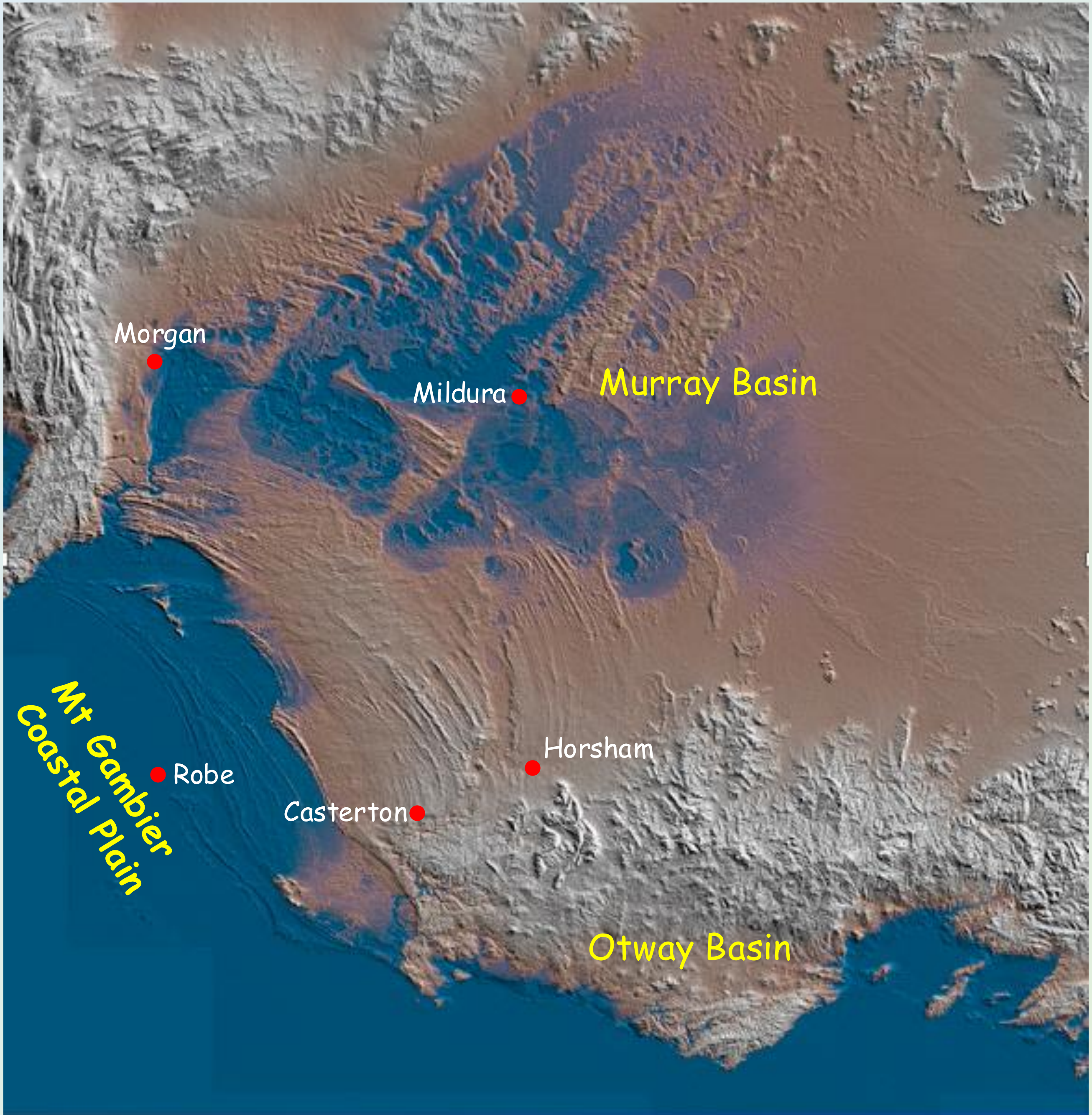
Stratigraphy of southeastern South Australia



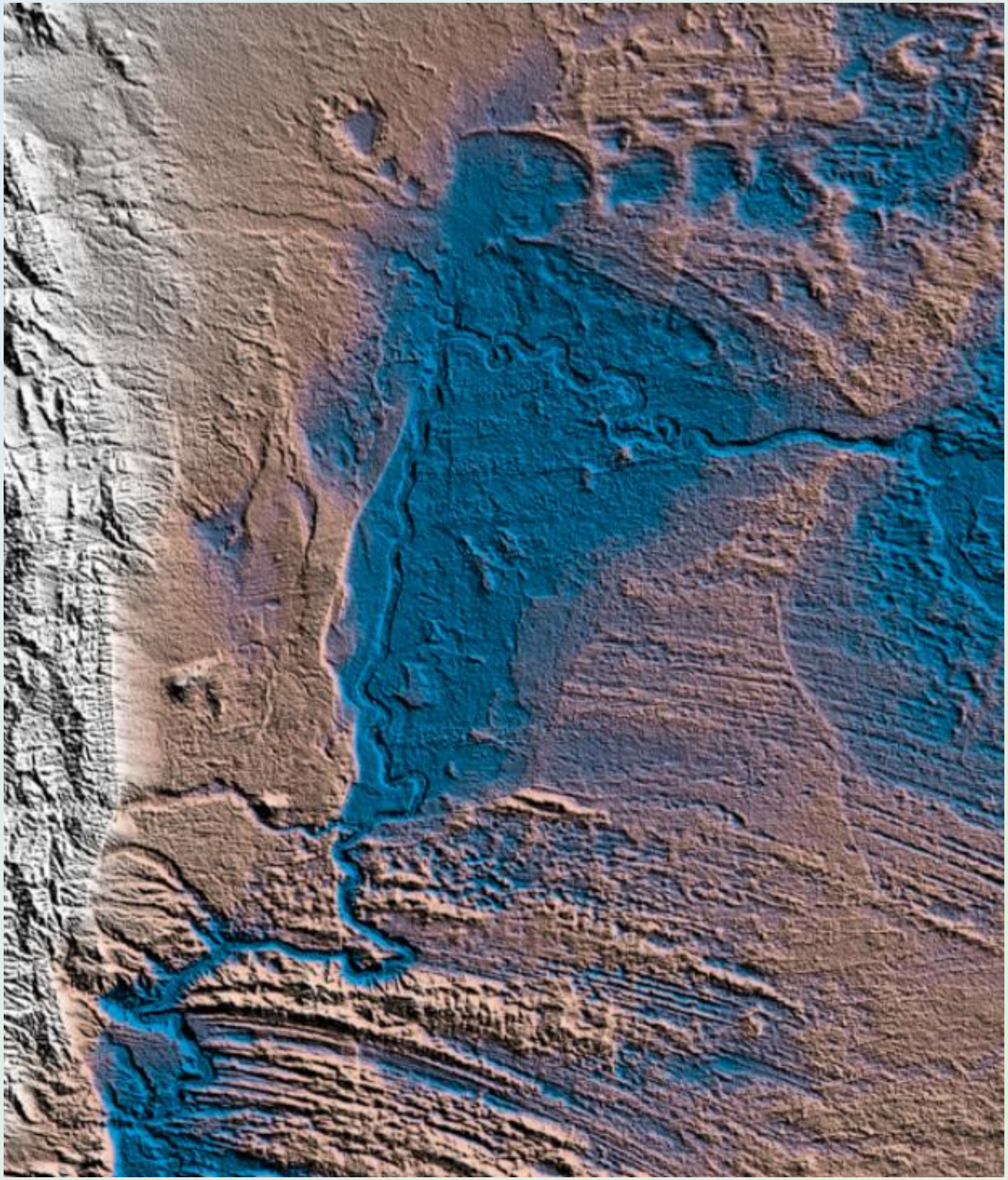
Murray Basin

- Murray Basin underlies riverine plains in NSW, Vic and Sth Aust.
  → formed in Palaeocene (<60 Ma) during rifting of Australia from Antarctica → sinking of oceanic crust (~200m deep 2,500km wide)
- a shallow sea invaded the basin depositing fossiliferous limestones
- sea levels rose and retreated several times 25 - 2.5 Ma → sea level reached peak ~6Ma → marine transgression created Murravian Gulf
- coastal sediments deposited in sheets as coastline prograded SW
- streams and rivers entered basin from eastern highlands → spread out over the plains → depositing sands and gravels

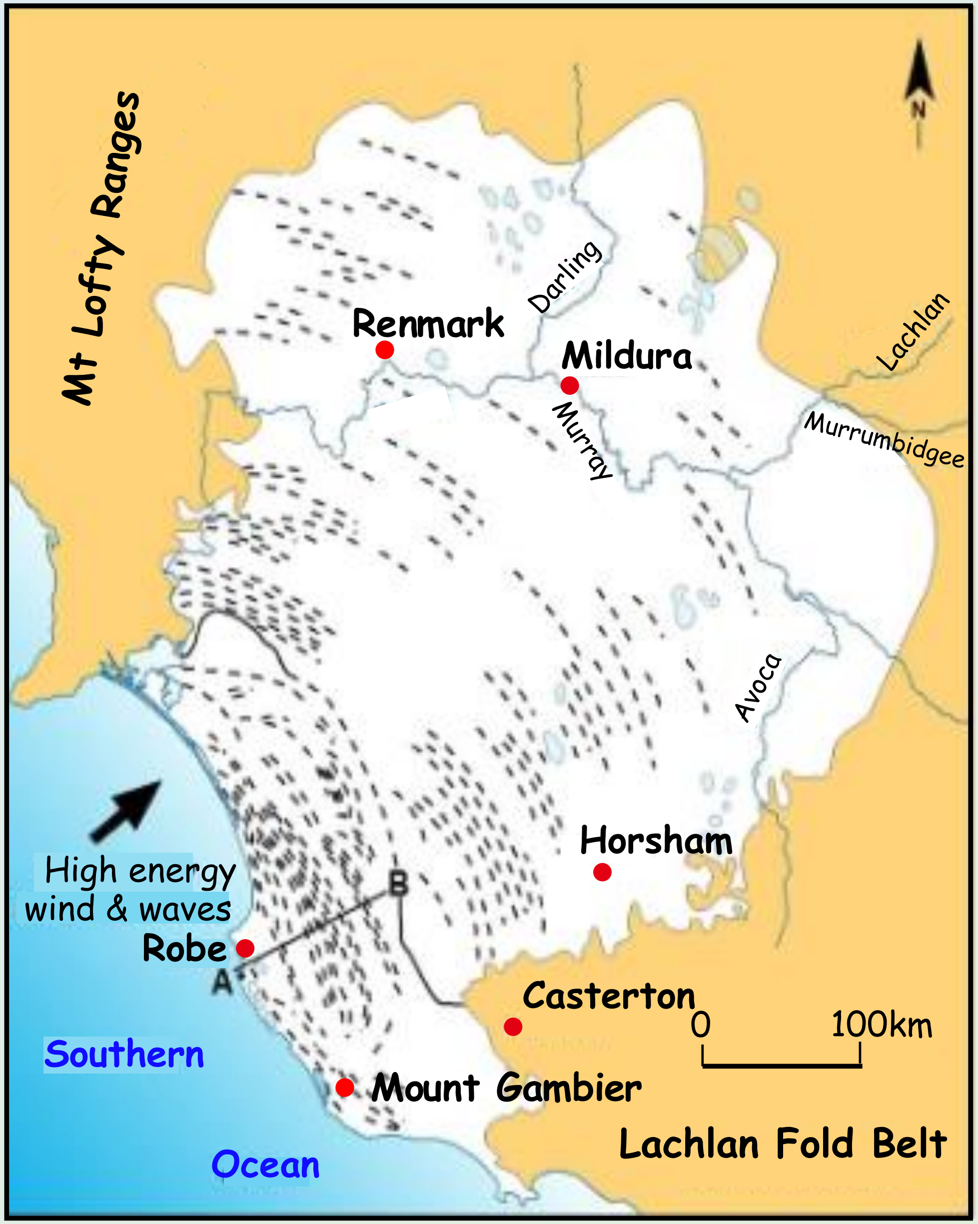
SRTM image of the Murray Basin



Murray River deflection



Murray Basin strandlines



Murray Basin strandlines

- Strand lines in the Murray Basin are ancient elevated shorelines representing past coastlines from Late Miocene to Early Pliocene periods (7.2 -3.5Ma)
- these ancient shorelines formed as sea levels fell
- the strandlines are composed of fossil beach sands
- strand lines → important for heavy mineral sand deposits*
- heavy mineral sand deposits form through wave and wind sorting
- strand lines → valuable record of past sea level changes and climate conditions

Gambier limestone

- Gambier Limestone → Major fossiliferous carbonate varying in thickness up to 400m offshore, deposited ~35-15Ma
- Naracoorte Limestone is a member of the Mount Gambier Limestone occurring in northern part of Gambier Basin → 6m thick, rubbly, highly fossiliferous, leached
- Naracoorte Limestone → abundant casts and moulds of molluscs and echinoids
- in Naracoorte area, member is of Early-Miocene age (~24-18Ma)
- rubbly appearance results from solution processes → commenced in Middle to Late Miocene

Karst features in Gambier Limestone

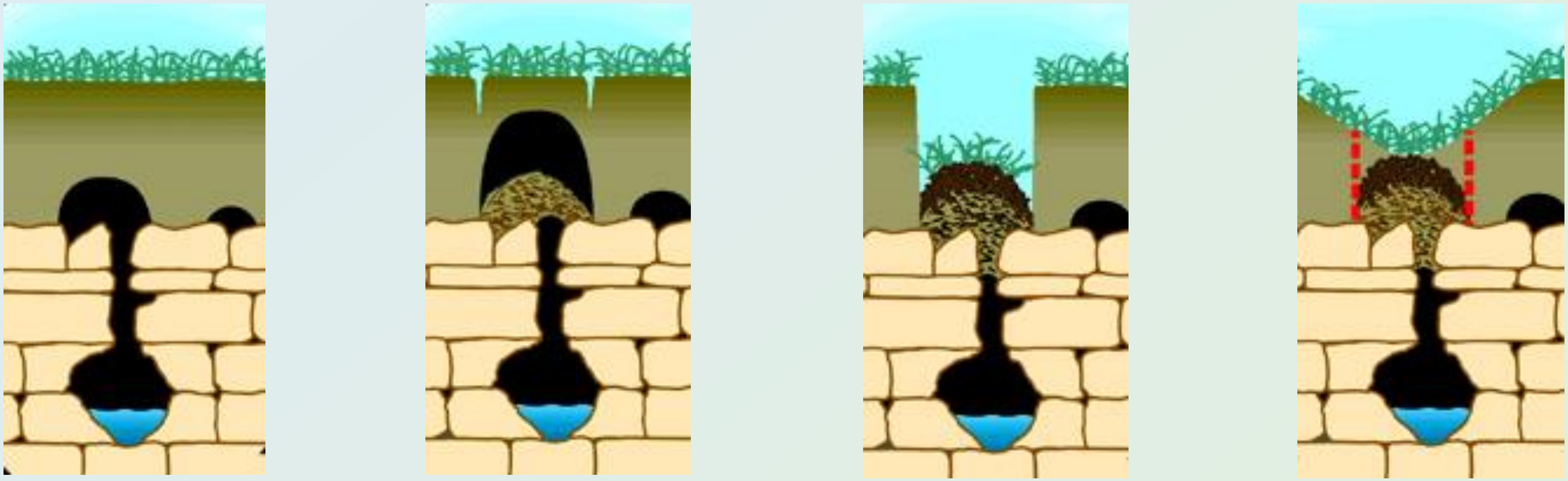
- Spectacular developed karst features are located near Naracoorte and SW of Mount Gambier*
- the region hosts two carbonate rock units, the Gambier Limestone (Miocene) and the Bridgewater Formation calcarenites (Pleistocene)
- karst in Gambier Limestone is more spectacular and extensive and includes cenotes, complex, joint-controlled cave systems and dolines
- depth to which karst features are developed → increases towards the coast with thickening Gambier Limestone and lower sea levels and water table levels during the Pleistocene glacial periods

Sinkholes

- Sinkholes → depressions or cavities that form in the ground
- most sinkholes are formed by karst processes with dissolution of carbonate rocks by circulating, weakly acidic groundwater*
- as carbonates dissolve, spaces and caverns develop underground
- sinkholes are usually circular and vary in size from tens to hundreds of metres in diameter and depth
- there are two main types of sinkhole, dolines and cenotes

Formation of doline

Doline → naturally occurring bowl-like depression → there are a number of stages recognised in formation of doline

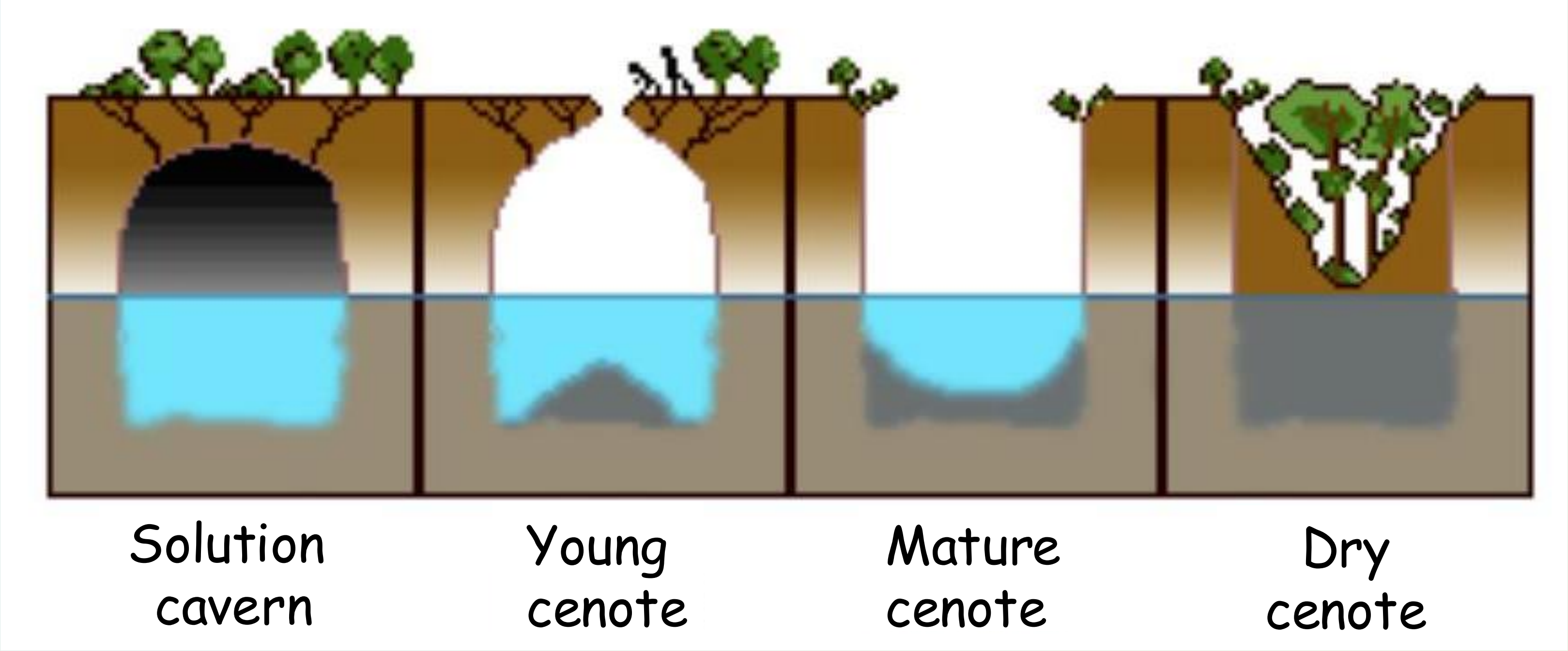


1. 2. 3. 4.

1. Soil falls into crevice and is transported away by water
2. Further collapse of soil causes cracks to develop at surface
3. Soil roof collapses into developing sinkhole
4. Erosion by water smooths sharp edges → bowl shaped depression

Cenote

A cenote is a sinkhole formed by the collapse of limestone bedrock that exposes underground water. These subterranean systems are connected by flooded cave networks and can range from fully enclosed caves to open air natural pools



Cenote

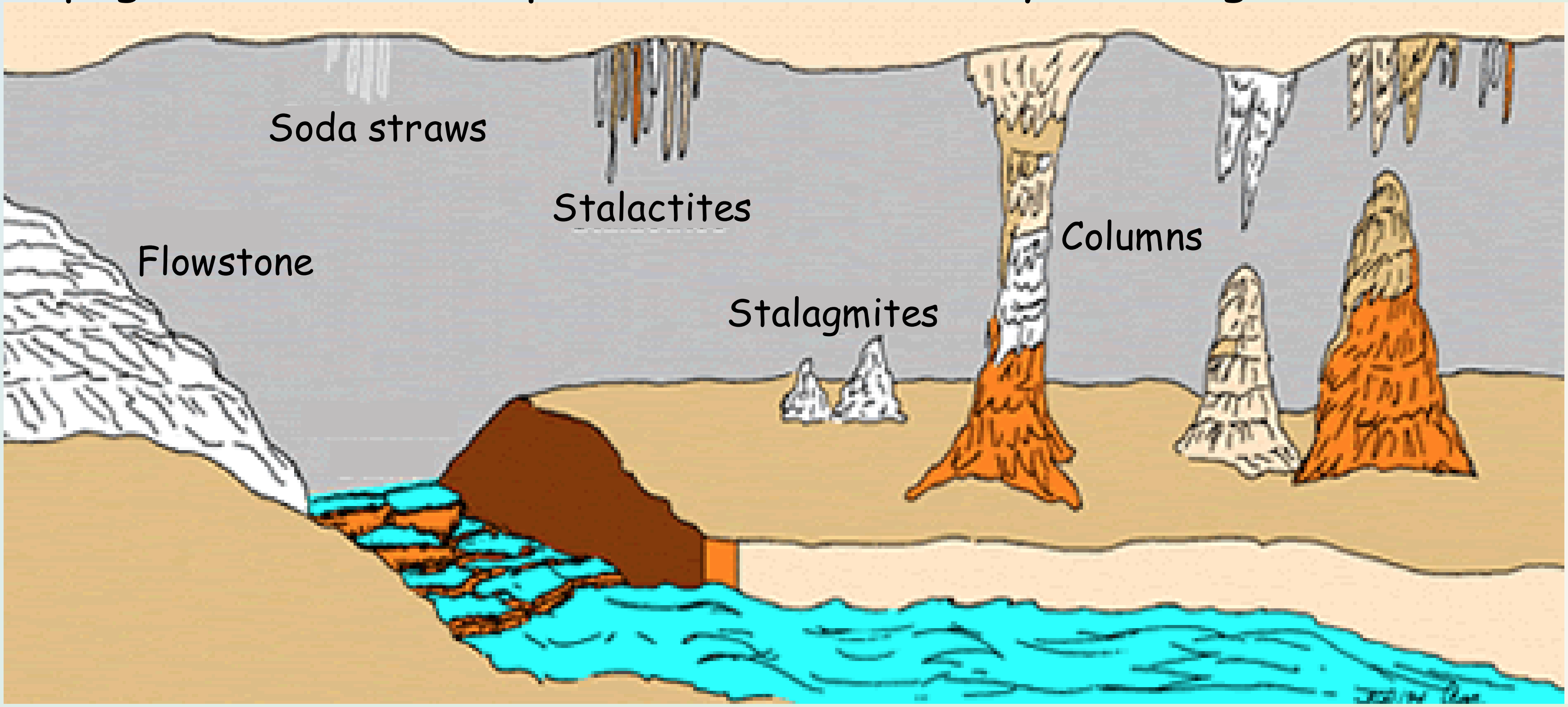
Oxman cenote, Mexico

Limestone caves

- Limestone → chemical and/or organic sedimentary rock containing >50% $CaCO_3$
- limestones form in shallow marine environments where evaporation rates are high and/or where the remains of marine invertebrates and calcareous algae accumulate
- when uplifted from sea → fractures develop → allow penetration by groundwater → dissolves $CaCO_3$ → precipitates it elsewhere
- caves form in limestones with low permeability → water restricted to flow along planes of weakness (joints, fractures)
- humid cave environment → ideal for chemical deposition of speleotherms (stalactites, stalagmites etc.)

Speleotherms

- Speleotherms → geological structures that form most commonly in calcareous caves due to carbonate dissolution and re-precipitation
- many factors impact the shape and colour of speleotherms including chemical composition of rock and water, water flow direction, seepage rate, cave temperature and humidity, above ground climate



Formation conditions for speleotherms

(1) Rainwater reacts with CO_2 in the atmosphere and with soil to form weak carbonic acid

$$H_2O + CO_2 \rightarrow \underset{\text{carbonic acid}}{H_2CO_3}$$

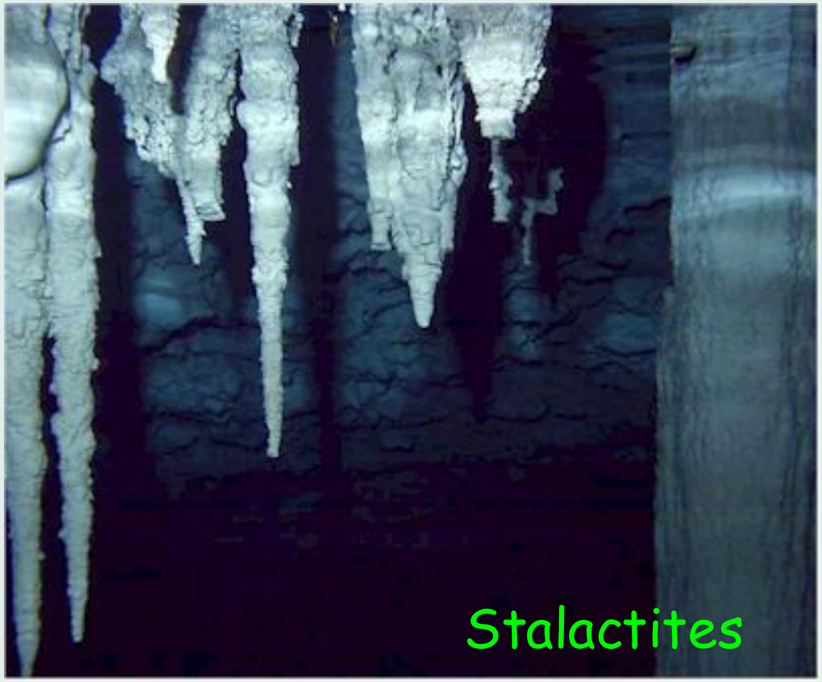
(2) as the acid passes through limestone bedrock it dissolves bedrock

$$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + \underset{\text{bicarbonate ion}}{2HCO_3^-}$$

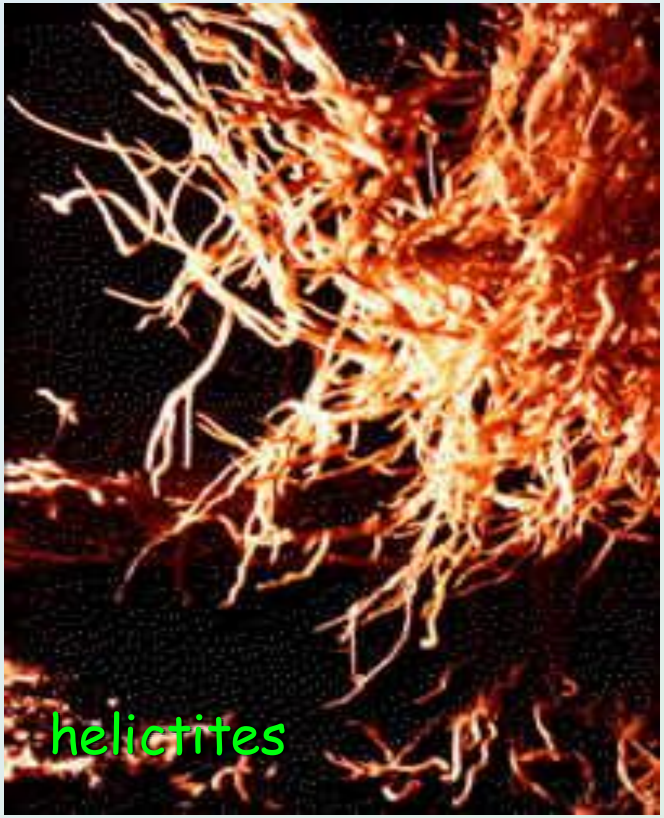
(3) When the solution reaches the cave, the lower pCO_2 in the cave drives the precipitation of $CaCO_3$

$$Ca^{2+} + 2H_2CO_3 \rightarrow CaCO_3 + H_2O + CO_2 + 2H^+$$

Common types of speleothems



Common types of speleothems



Naracoorte caves complex

- Naracoorte caves → usually hosted by Tertiary limestones although some are partly within Pleistocene calcarenites
- the area is underlain by thick limestone of Palaeogene to Neogene age (~35-15Ma)
- caves formed along Kanawinka fault zone → fractured limestone → aided groundwater dissolution
- doline to horizontal passage solution and collapse → formed caves
- caves preserve palaeoenvironmental history spanning ~500Ka years

Victoria cave, Naracoorte

- Victoria Fossil Cave contains largest bone-bed deposits in the world with ~200,000m^3 of fossiliferous mud, sand and clay
- Victoria cave → acted as repository for animal skeletal remains derived from doline traps and animal lairs
- fossil remains include delicate bones of small frogs, small marsupials, birds, bats, extinct browsing kangaroos, emu-like animals, diprotodons*, thylacines, marsupial lions, emus, snakes
- ages of fossils → >150,000 to 18,000years

Victoria Fossil Cave, Naracoorte

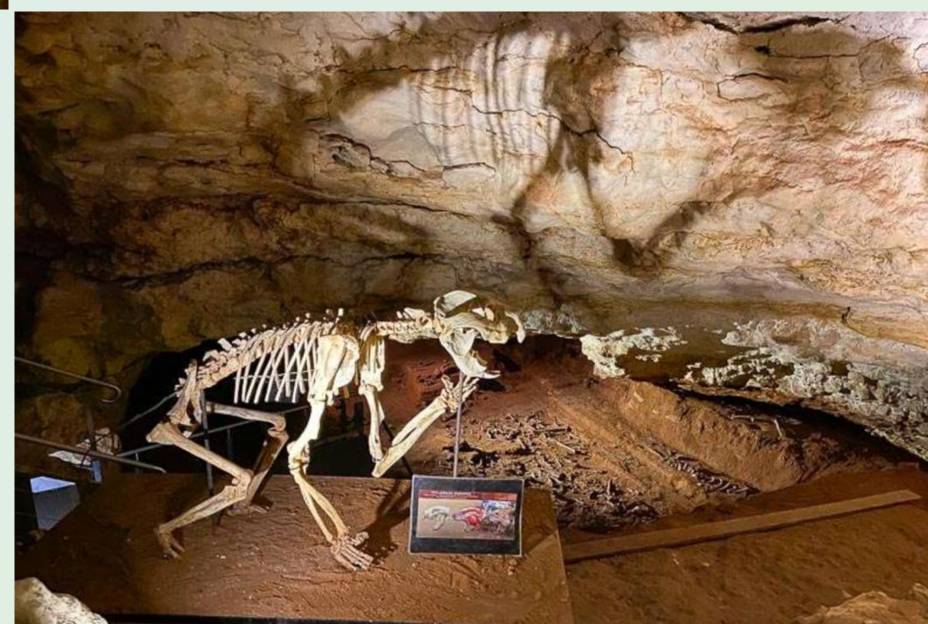
- Victoria Fossil Cave contains a number of chambers with exposed speleotherms
- the fossil chamber contains tens of thousands of fossil bones accumulated over 300,000 years
- opening in ceiling of chamber acted as a natural pitfall trap
- over 30 years of excavation and research, more than 5,000 catalogued specimens have been excavated from only 4% of bone-rich sediments
- from the fossil bed, specimens representing 93 vertebrate species have been recovered

Victoria Fossil Cave, Naracoorte

Speleotherms, Victoria Cave

Skeleton of marsupial lion,

Victoria Fossil Cave, Naracoorte

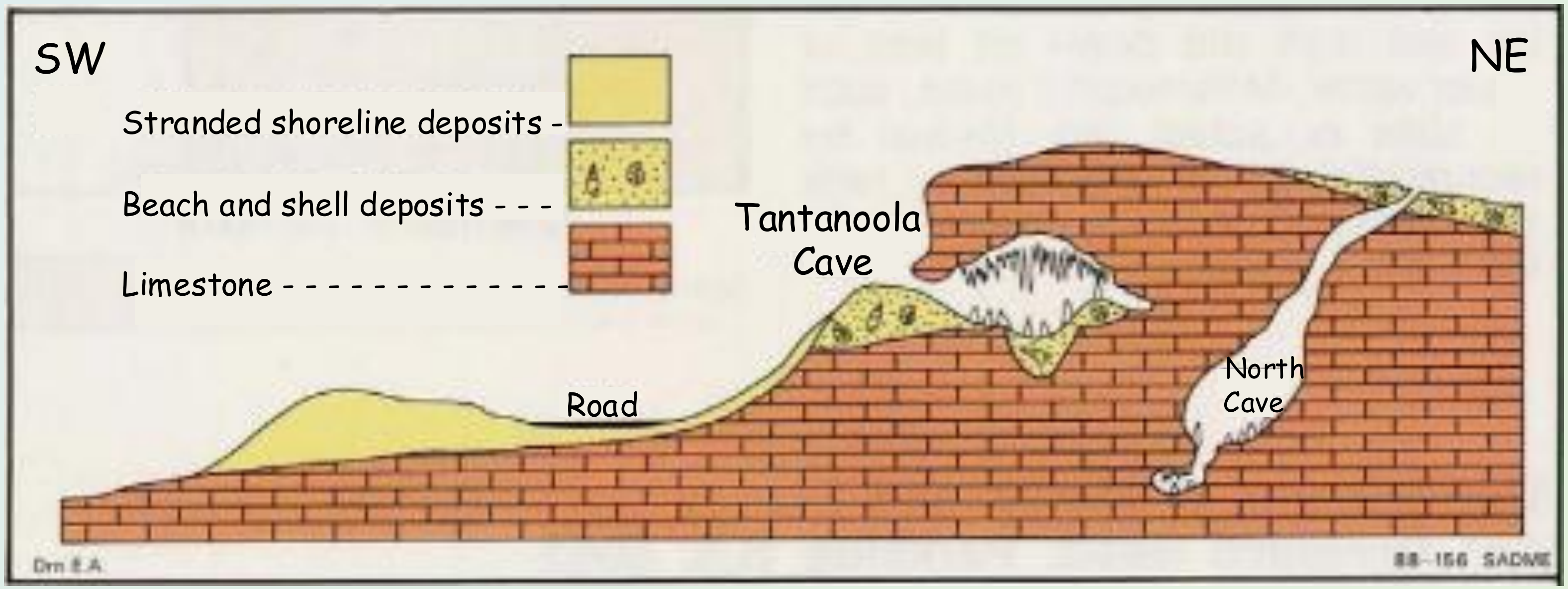


Mount Gambier area limestone caves

- There are numerous caves in the Mount Gambier area e.g. Umpherston, Engelbrecht, Tantanoola, Mitchell*
- these caves commonly intersect the watertable
- there are dozens of cenotes in the area, three examples being Little Blue Lake, Umpherston and Hells Hole
- depth to which karst features have developed increases towards coast due to increase in thickness of Gambier Limestone and lower sea levels during the Pleistocene glacial periods

Tantanoola cave

- The Tantanoola cave complex is located along a dolomitic karst ridge featuring the only pink dolostone in South Aust.
- in the cave there is a variety of speleotherms including, curtains, helictites, flowstones, straws, stalactites and stalagmites
- the pink colour of the dolomite is related to iron derived from local volcanism



Tantanoola cave

Phreatic and phreatomagmatic eruptions

- Phreatic eruption eruptions occur where magma heats groundwater or surface water resulting in an explosion of steam, ash, rock and volcanic bombs

- phreatomagmatic eruptions involve direct interaction between water and magma → produce explosions of magma clasts e.g. pumice, volcanic bombs and magma mixed with other materials

Phreatomagmatic eruption, Solomon Islands

Phreatomagmatic eruption Taal, Philipinnes

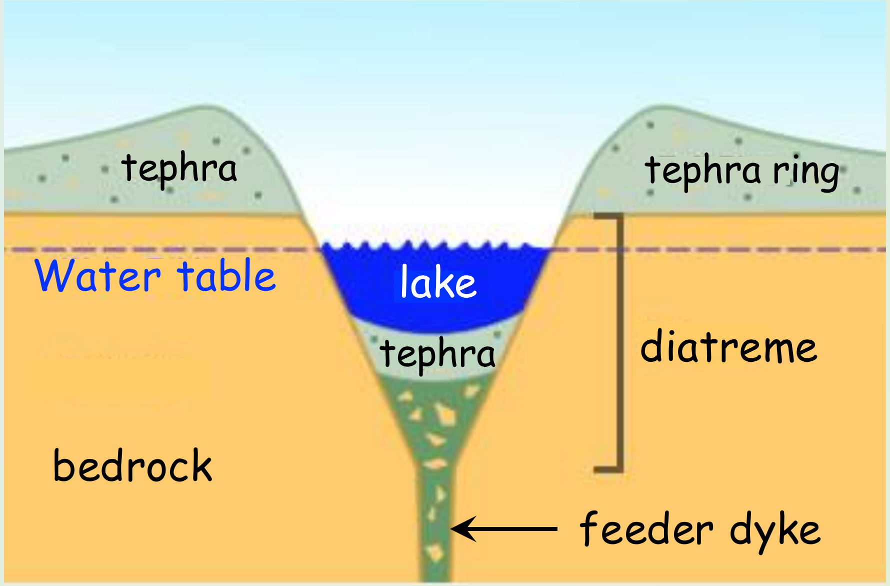
Diatremes

- Diatreme → volcanic pipe punched through the crust by a powerful, steam-driven explosion
- formed by phreatic or phreatomagmatic explosions when magma encounters and flashes groundwater to steam
- resulting explosion creates broad, shallow crater at surface (maar)
- explosion fills pipe-like conduit with a mixture of volcanic and shattered wallrock fragments
- diatremes can transport valuable minerals like diamonds from deep within the Earth's mantle to the surface

Maar

- Broad low relief, volcanic crater surrounded by low rims of mixed loose rock fragments, cinders and volcanic ash (tephra)
- produced by explosive eruptions where basalt magma has heated or, come into contact with groundwater (phreatic, phreatomagmatic eruptions)
- e.g. Tower Hill, Western Victoria

Cross-sectional view through a maar showing the diatreme, ring of tephra surrounding the crater and the water table forming a lake within the crater

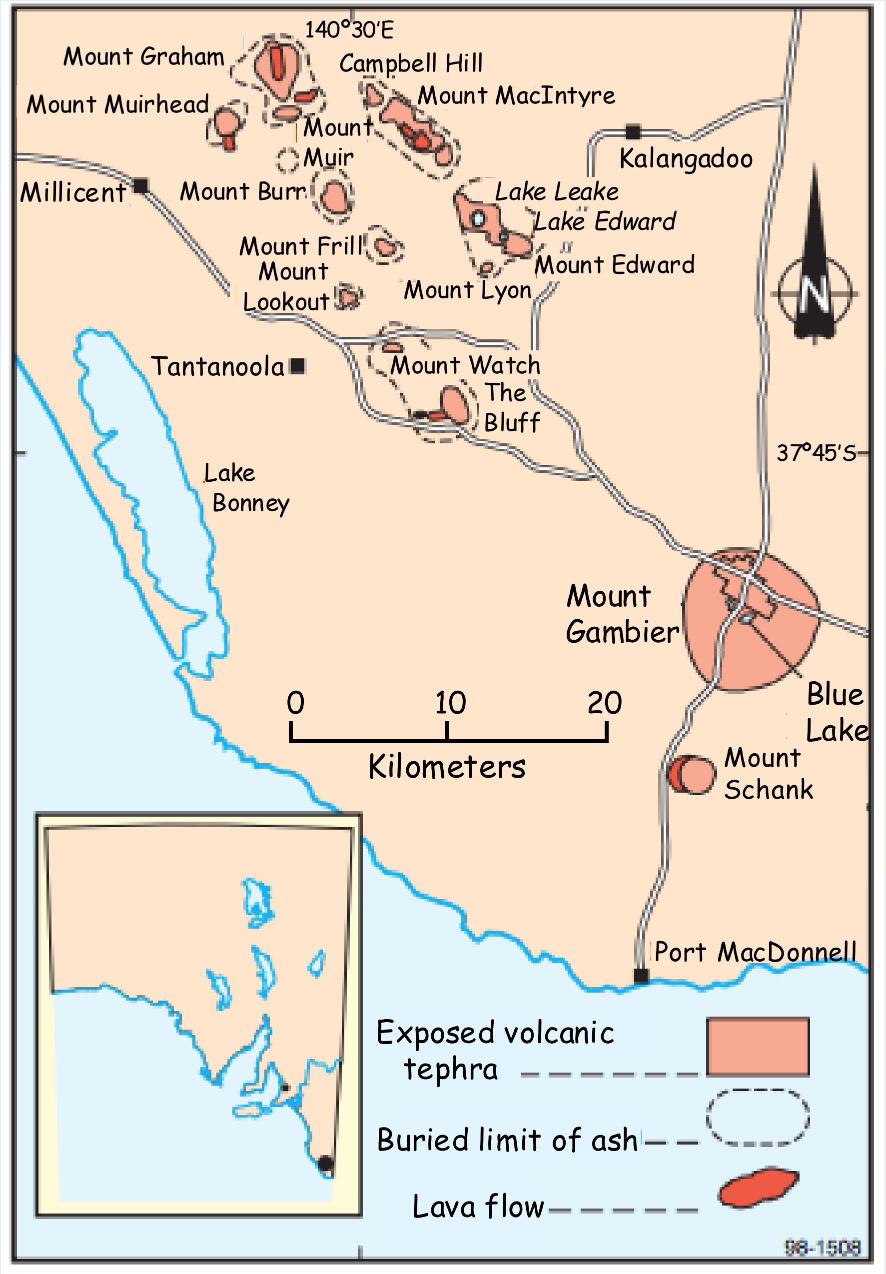


Diamond Head maar, O'ahu, Hawaii

Quaternary volcanics in SE South Australia

- Volcanics in in SE South Australia comprise two distinct groups that constitute a western extension of Late Tertiary to Quaternary Newer Volcanics in Victoria (includes >400 volcanic features)
- older (northern) Mt Burr group includes 15 fissure controlled centres with basaltic lava flows, composite domes*, cones and maars
- SE of Mt Burr lies the second group of volcanoes consisting of Mt Schank and Mt Gambier
- the second group overlie the Bridgewater Fm and are younger than Mt Burr group → mid-Holocene
- Mount Gambier and Schank formed by phreatomagmatic explosions

Mount Gambier and Mt Burr groups of Quaternary volcanics



Mount Gambier and Mt Burr groups of Quaternary volcanics

- Volcanic centres NW of Mount Gambier and Mt Schank, that formed the Mt Burr Group began erupting in the Early Pleistocene period ~1Ma and ceased ~20Ka
- 15 volcanoes make up the Mt Burr volcanic group, the volcanoes are all basaltic and include lava flows, cones and tuff rings
- the Mt Burr volcanic deposits have been modified by erosion and partly covered by fossil beach, sand drift
- a later phase consists of Mount Gambier and Mt Schank volcanoes whose shapes are still quite fresh and only slightly affected by erosion

Mount Gambier volcanic complex

- Initial eruptions occurred at two sites, one at the end of present day complex, the other near Leg of Mutton crater
- these phreatic eruptions commenced ~5,000 and as late as 4,300years ago
- small low maars quickly formed blanketing surrounding area in up to 2m of ash and lapilli*
- lava flowed from fissure (W part of complex) and a vent (Leg of Mutton crater area) but small flows did not coalesce
- a small scoria cone developed adjacent to and partly over the western flow
- during first period, eruptions passed from mildly phreatic and passive to weakly explosive cone building

Mount Gambier volcanics

- Activity ceased for up to 300years allowing complete lava crystallisation and cessation of flows to occur
- groundwater interaction with several ascending magma columns → phreatomagmatic explosions → evacuating large maar craters
- Blue Lake and Valley Lake formed as a result of phreatomagmatic explosions
- activity climaxed with lava fountaining in Brownes Lake and steam emissions from blowholes within and outside complex

Mount Gambier eruptive history

(1) Radiocarbon dating places the Mount Gambier eruptions as late as 4,300 to 4,000 years ago → youngest volcanic feature on the Australian mainland

(2) eruptive history began with the phreatic formation of small maars and widespread ash followed by basaltic eruptions

(3) later groundwater mixing with magma led to explosive phreatomagmatic activity and the formation of crater lakes. Lava bombs up to several tonnes were ejected

(4) volcanism persisted for approximately 200-300years transitioning from explosive events to steam venting

Mount Gambier volcanic complex

Aerial photograph of Mount Gambier volcanic complex looking north

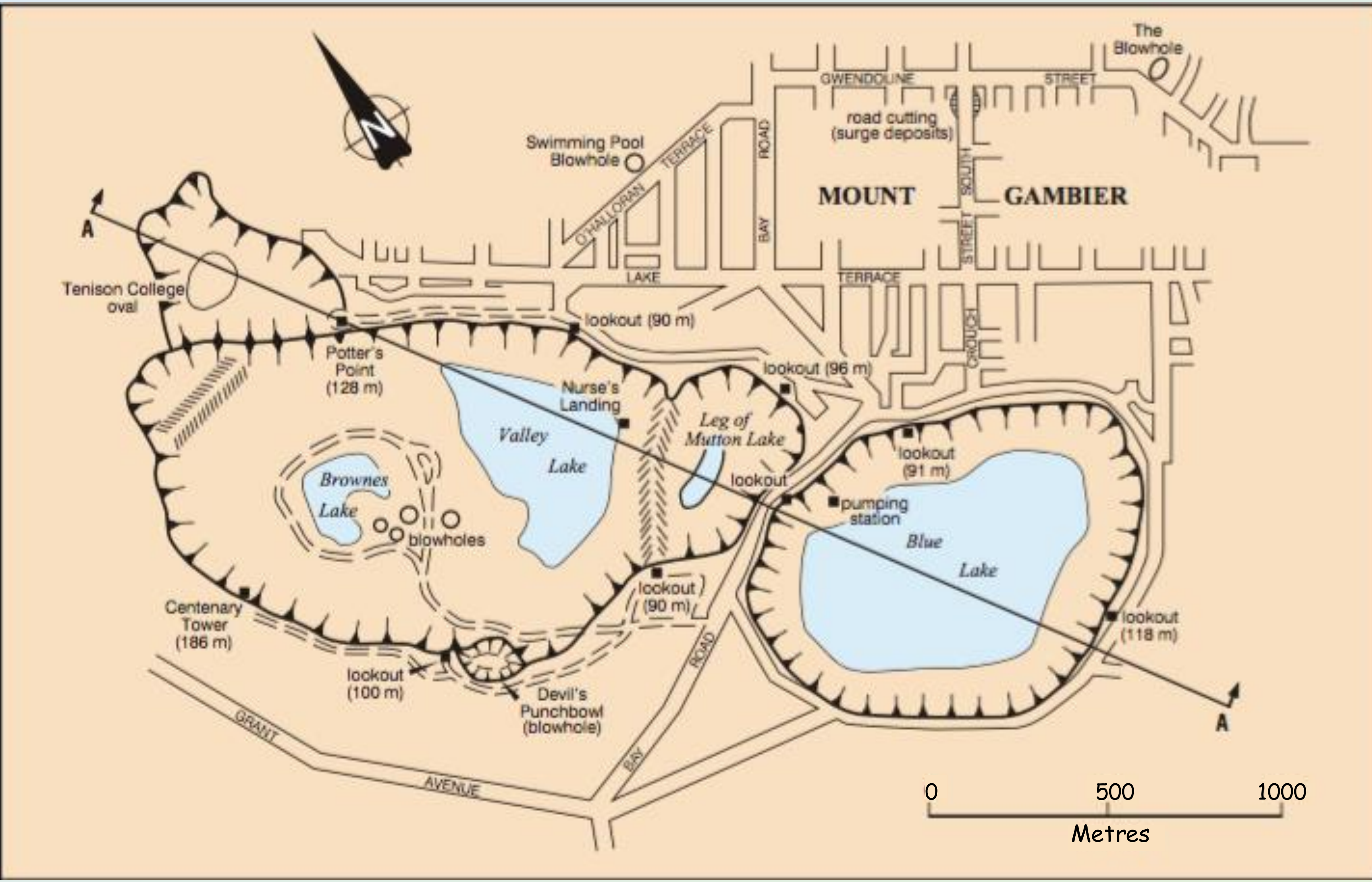
Blue Lake crater wall

Blue Lake crater wall

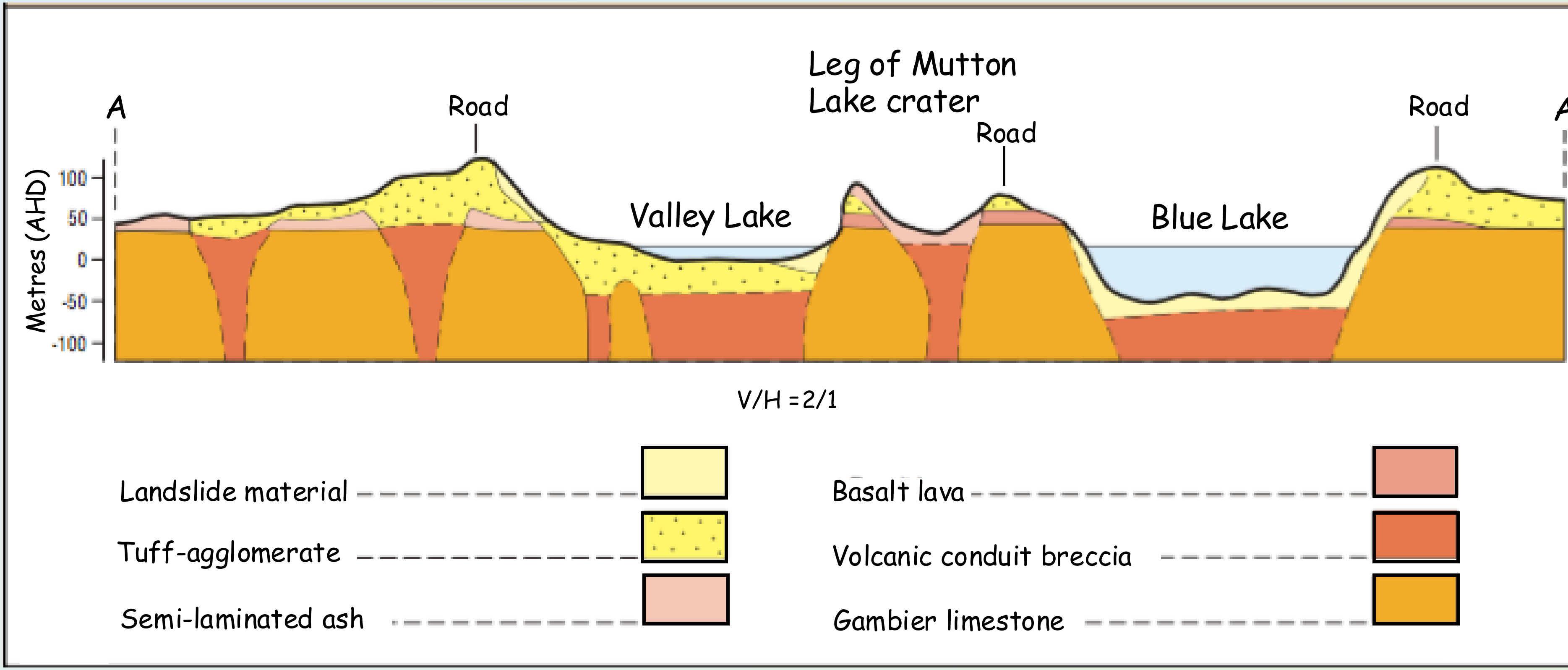
Volcanic ash and

agglomerate deposits

Mount Gambier crater map



Diagramatic cross-section through Mount Gambier craters



Mount Schank volcanics

- Mt Schank → hybrid maar-cone structure formed chiefly by phreatomagmatic explosions
- Tl age date → 4,930± 540yrs BP
- eruptions commenced from 1.2km fissure in Gambier limestone
- magma supply rapidly increased allowing lava to flow freely from fissure while small scoria cones built up along its length
- flow moved eastwards and southwards to cover an area of ~300,000m^2 with average thickness 3.5m

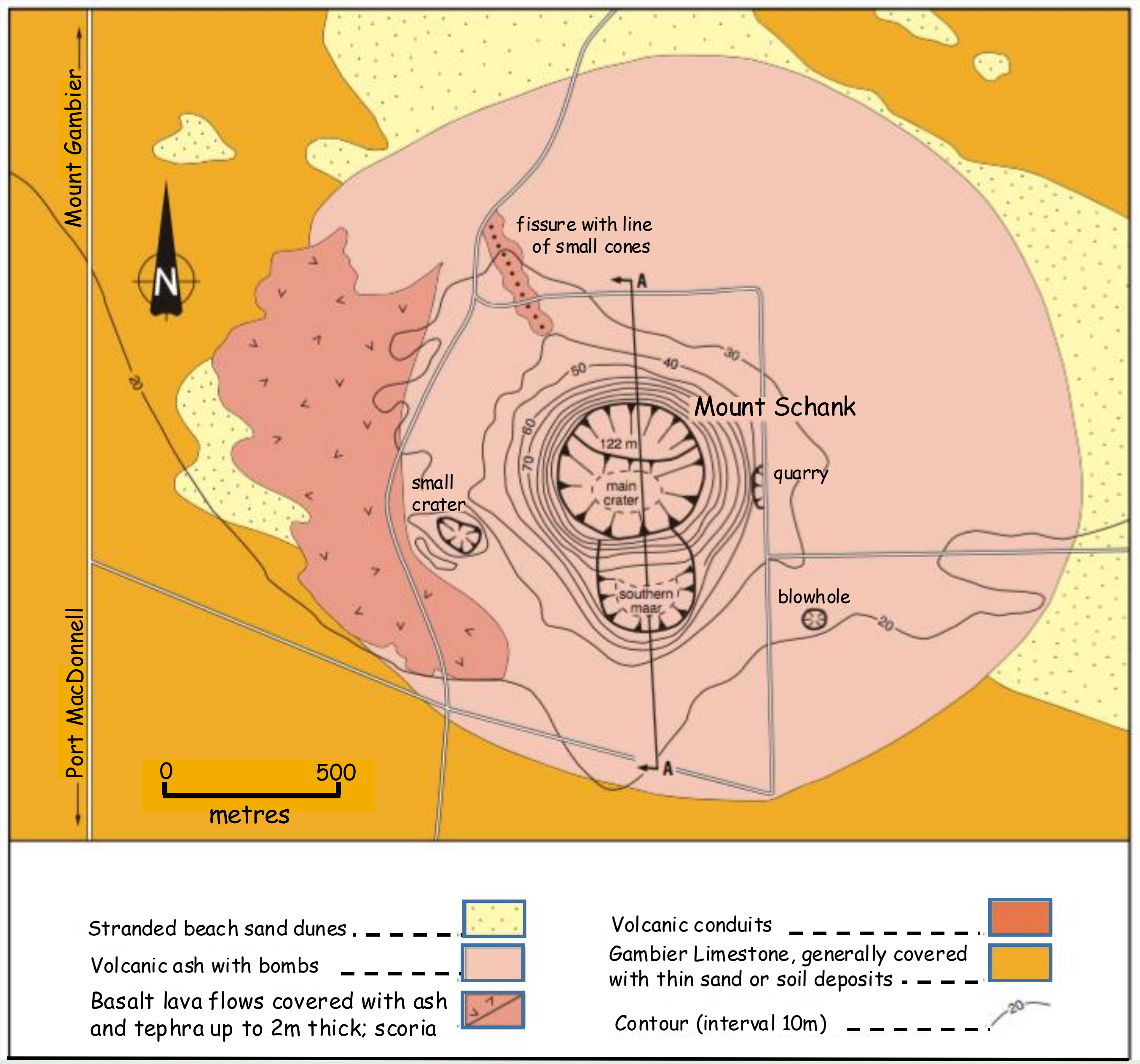
Mount Schank volcanics

- Eruptive activity contracted to centre and southern end of the fissure where first a small scoria cone and small maar were constructed
- these indicate more groundwater access to magma at southern end of fracture
- when activity at these two sites ceased, a final vent opened up between them, resulting in large main crater seen today
- major vent-clearing phreatomagmatic explosions during this eruption resulted in a broad cone with both maar and cone crater characteristics.

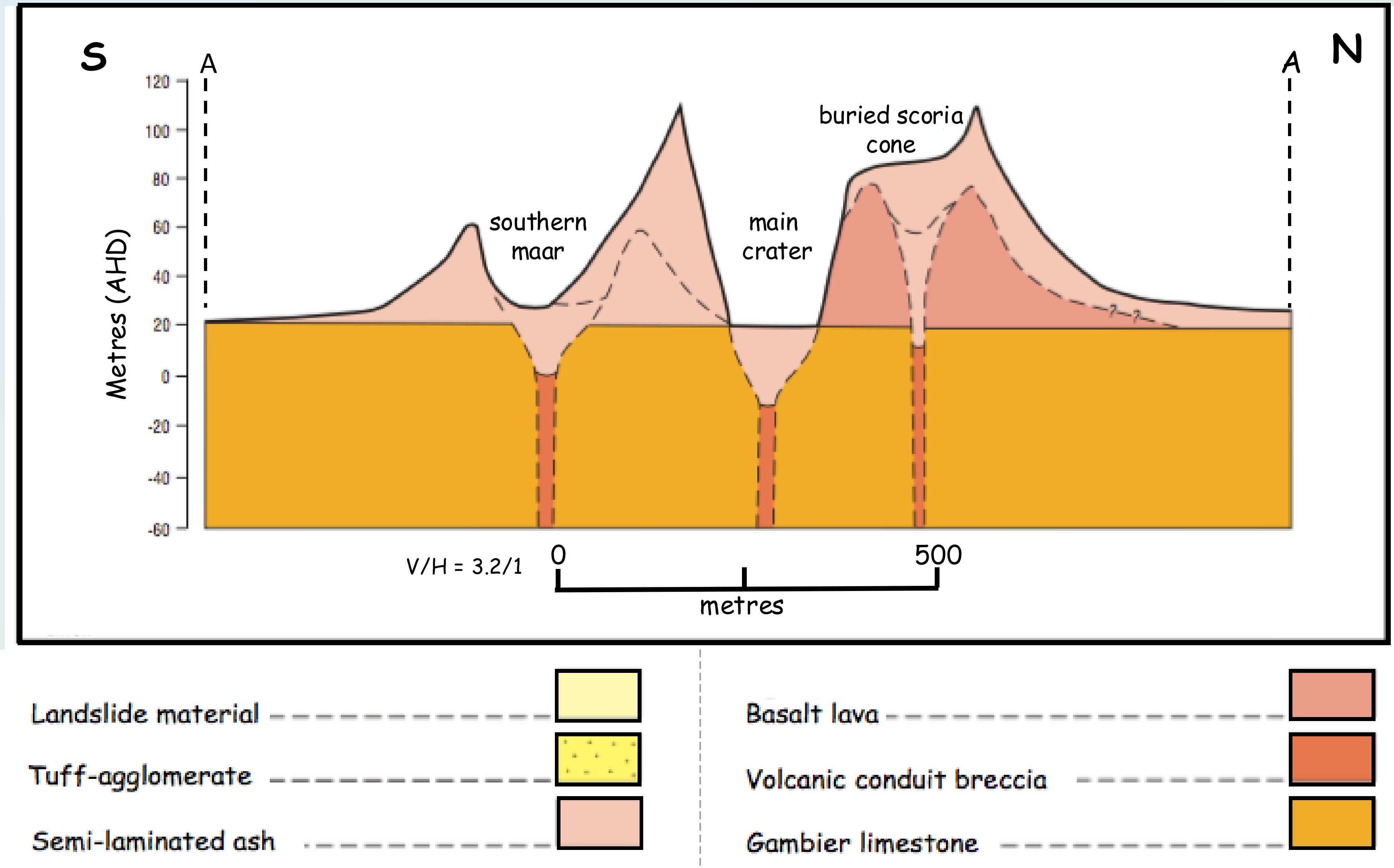
Mount Schank

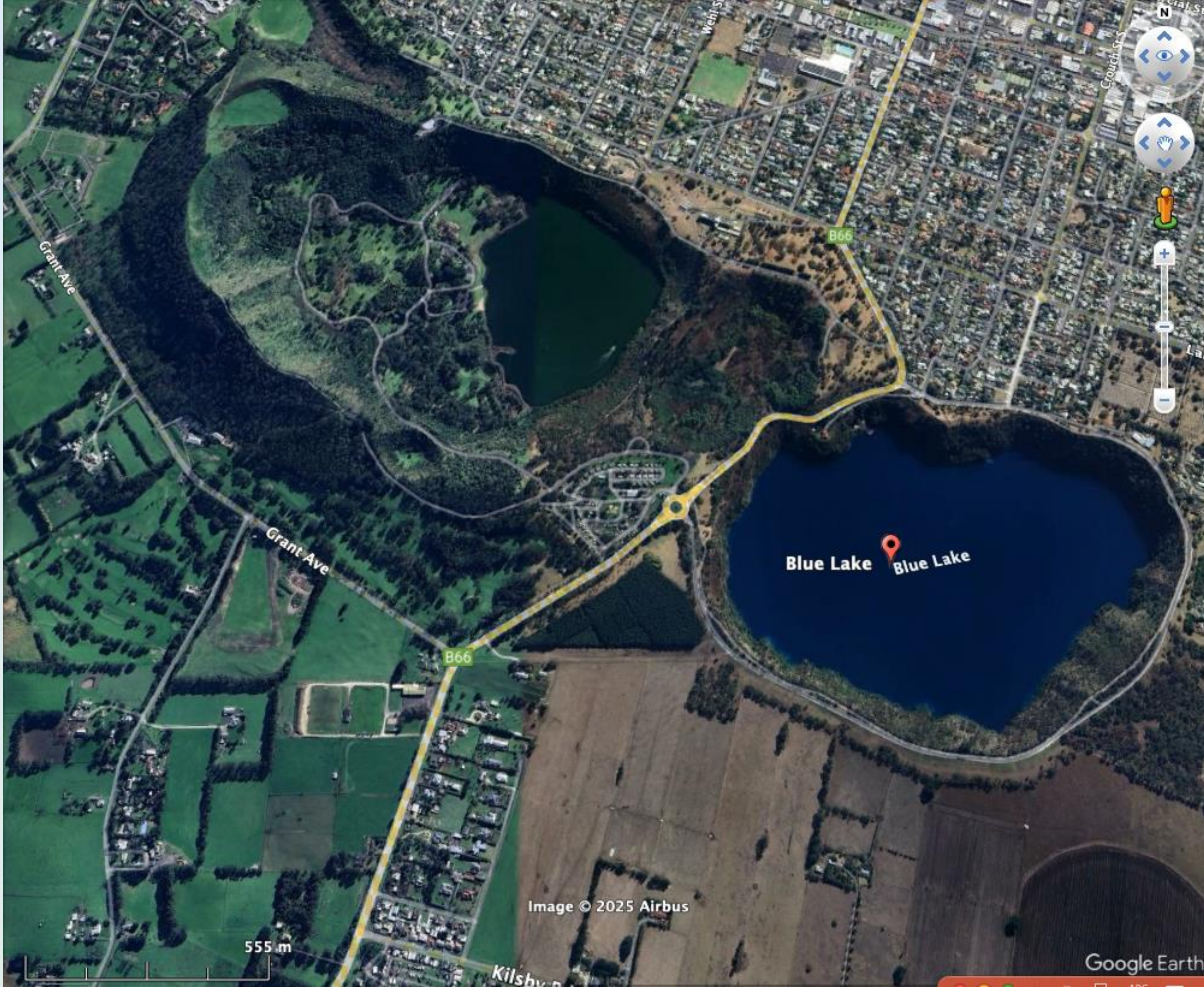
Mount Schank differs from the craters at Mount Gambier in that its floor lies at the level of the surrounding plain

Mount Schank



Mt Schank vertical cross-section

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