BRACHINA GORGE

Geological trail

A snapshot of geological time in the Flinders Ranges National Park in South Australia

South Australian Division

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Compiled by MN Hiern
for the Geological Field Guide Sub-committee
October 2015

Based on original text by GW Krieg
for Geological Heritage Site FR 41 of the
Geological Heritage Sub-committee
February 2014

These notes supplement the track-side signs describing the geological features seen along the trail and the descriptive panels in the information booths at the eastern and western ends of the trail.

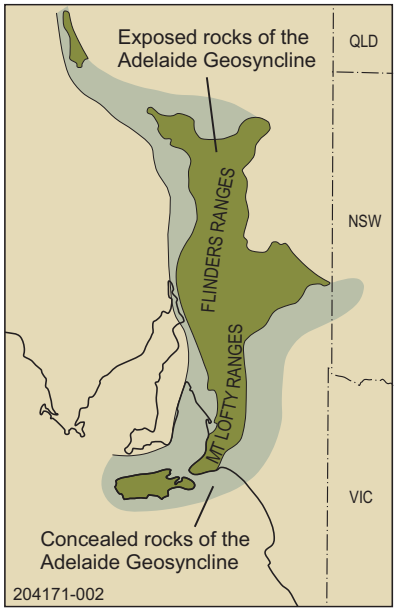
Cover photo: *View south of succession of dipping (40–45° W) sandstone ridges with red Bonney Sandstone on the left (beginning above the vehicle) overlain by hard, pale Rawnsley Quartzite further away (top right). View point at GR 0268574 mE, 6530091 mN. (Photo 409145 courtesy Department of State Development)*

Job number 204171

The Brachina Gorge Geological Trail

Regional setting

One of the best records in the world of sedimentary deposition in the period of geological time between about 800 million and 500 million years ago is exposed in the Flinders Ranges, Mount Lofty Ranges and the Olary region in South Australia.



Sandy and silty sediments derived from erosion of older rocks of the Gawler Craton in the hinterland to the west, and island masses of this basement rock rising from an undersea ridge over 200 km to the east, were deposited into an extensive marine basin called the Adelaide Geosyncline in which the seafloor was slowly subsiding along a series of elongated north-south step or graben faults.

During the 300 million years of continuing but intermittent subsidence of the basin floor, a thick pile of sediment accumulated in the geosyncline. This sequence was then compressed and hardened by deep burial and later folded into a high mountain range by a new regime of earth movements.

Subsequent erosion has reduced these highlands to their present form and deposited huge amounts of sediment to the east into younger sedimentary basins formed by later crustal down warping.

Excellent exposures of rocks deposited in the Adelaide Geosyncline between about 650 and 500 million years ago can be seen in Brachina Gorge, particularly on the southern wall.

Here the sequence dips at moderate angles to the west except at the western end of the trail where the rocks have been buckled by faulting.

Much younger flat-lying sediments deposited in the Pleistocene Epoch between about 35 000 and 18 000 years ago can be seen midway along the trail.

A plaque describing a site of international geological significance, marking the base of the Ediacaran Period of geological time, was placed in 2005 on the southern bank of Enorama Creek, 500 m east of the Enorama Campsite. This records a major change, which began about 635 million years ago, in the evolution from simple single-celled life forms to more complex multi-cellular organisms.

Evidence of other significant events in the geological history of the rocks in the Brachina Gorge includes;

- depositional structures in the sandy and silty sediments eroded from adjacent hinterlands, such as cross bedding and mud cracks, resulting from varying conditions of water depth and temperature during deposition.

- dumping of glacial till in the melt water of a world wide period of continental glaciation.
- precipitation of ironstone, limestone and dolomite in the sea by chemical and biological action.
- debris from the impact of a large meteorite which fell near Lake Acraman in the Gawler Ranges about 300 km to the west.
- some of the very earliest life forms which existed before the world renowned Ediacaran fauna.

It should be noted that recent research has modified the estimates of the ages of beds in this rock sequence quoted in these notes from those appearing on the trail signs.

Geological names

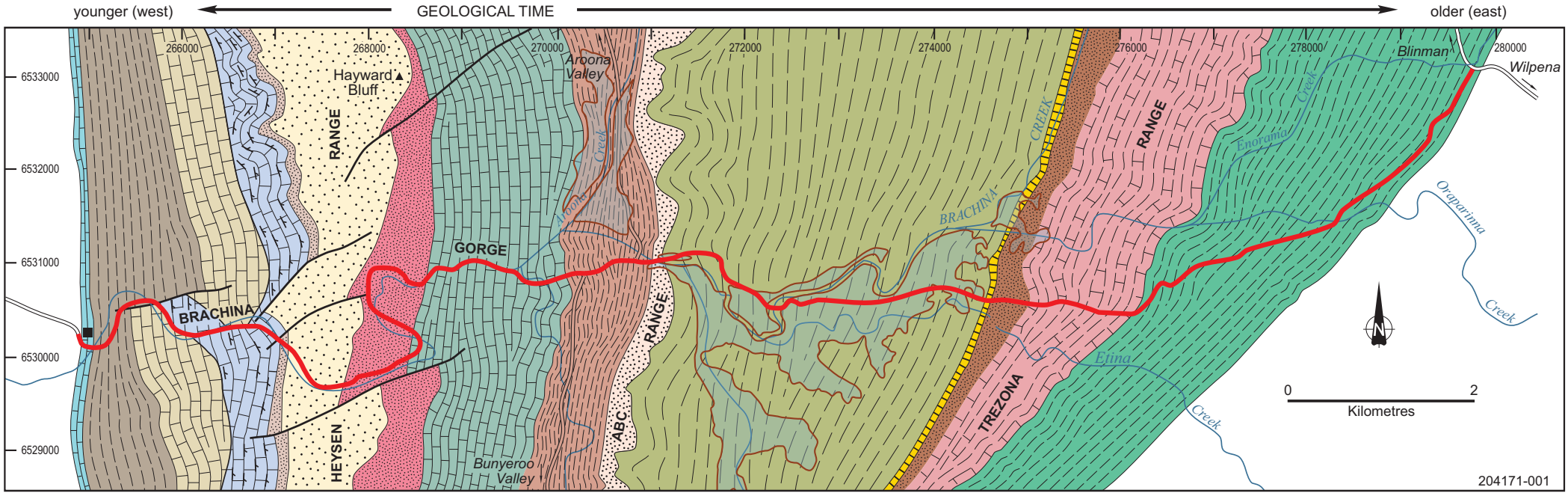
Geologists use an international convention for identifying masses of rock which have clear cut boundaries and can be mapped on a regional scale.

This consists of the geographical name of the place where the rock unit was first described, combined with the geological name for the type of rock.

These are called stratigraphic units and are applied to beds of sedimentary rocks, such as Enorama Shale, masses of igneous rocks like the Gawler Range Volcanics and metamorphic rocks referred to as Tapley Hill Slate.

Sequences of alternating thin (1–3 m) interbeds of, for example, sandstone and shale, are called Formations.

A glossary of terms used in the site descriptions is included in these notes.



Cambrian age rocks

- Wirrealpa Limestone
- Billy Creek Formation
- Wilkawillina Limestone
- Woodendinna Dolomite
- Parachilna Formation

Precambrian rocks

- Rawnsley Quartzite
- Bonney Sandstone
- Wonoka Formation
- Bunyeroo Formation
- ABC Range Quartzite

- Brachina Formation
- Nuccaleena Formation
- Elatina Formation
- Trezona Formation
- Enorama Shale

Other features

- Pleistocene wetland
- Geological fault
- Brachina Trail

Signage on the trail

A series of track-side signs have been placed in the approximate position of where the boundary between a younger (overlying) sedimentary bed and an older (underlying) bed crosses the track.

For example, in the left hand image below, the viewer is looking west from the base of the Wonoka Formation and the right hand image of the other side of the same sign looking east, is from the top of the older Bunyeroo Formation.

Both signs indicate that, on the basis of the best research available at the time, the contact between the two units is estimated to be between 570 and 580 million years old.

Sign looking west on the base of the Wonoka Formation. (Photo courtesy MN Hiern)

Sign looking east on the top of the underlying Bunyeroo Formation. (Photo courtesy MN Hiern)

Access

A graded track through the gorge can be travelled with care in most two-wheel-drive vehicles (if not fitted with low profile tyres) except after rain, particularly at the Slippery Dip creek bank ramp (Site 7 on the trail map).

All vehicles require a Park Pass obtainable from the Wilpena Pound Visitor Centre or from self-registration roadside booths within the Park.

Camping is permitted in designated campsites for which a camping permit is required. Camp fires are allowed in designated places.

Walks along the trail, or on the tracks taking off from it, are of gentle grade but can, in places, be rough and stony under foot. The cooler months of April to October are the best time for walking.

Rainwater tanks have been installed at some campsites for visitor use but it is recommended by the National Parks and Wildlife Service that visitors carry their own supply of water. Running creek water is sometimes available but should be boiled before drinking.

All but a few of the sites of interest are adjacent to the trail, most being on the southern side.

Intending visitors should check the website http://www.environment.sa.gov.au/parks/Find_a_Park for details of accommodation, camping, activities, fees etc. in the Flinders Ranges National Park.

Site descriptions and photographs

Site numbers begin at the eastern end of the trail at the turn-off from the Flinders Ranges Way to Blinman, 33 km north of the Wilpena Tourist Resort.

It was noted earlier that estimated geological ages in this brochure are based on more recent evidence to that used for the trackside signs.

Information booth at the eastern end of Brachina Gorge Geological Trail. (Photo courtesy MN Hiern)

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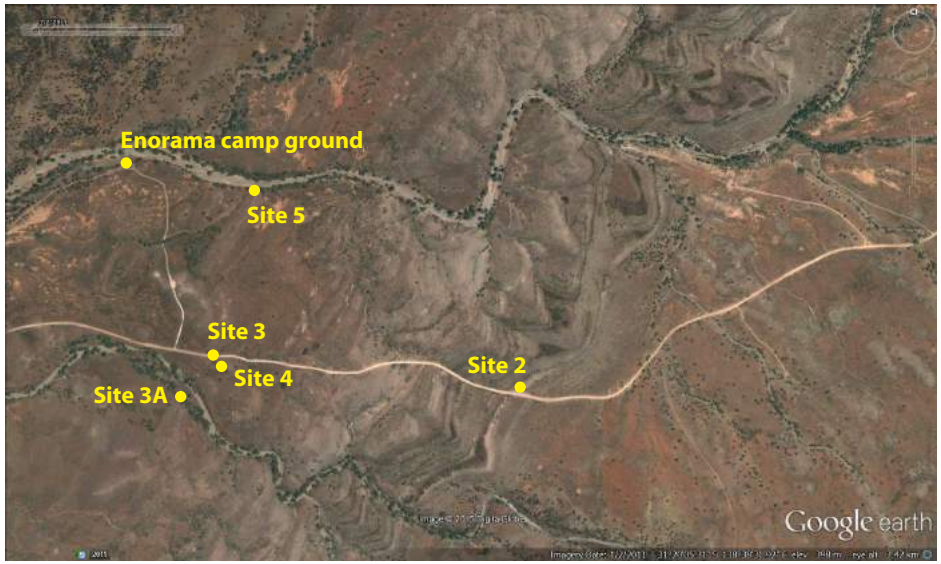
Site 1 Enorama Shale

Grid reference
279647 mE, 6533080 mN

Grey green thinly bedded shale is well exposed in the banks of the Enorama Creek near the Flinders Ranges Way road crossing. Deposited between about 650–645 million years ago in deep quiet water where the finer sediments could slowly settle.

Enorama Shale. (Photo courtesy MN Hiern)



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Site 2 Trezona Formation

Grid reference
275867 mE, 6530504 mN

A sequence of interbedded siltstone with harder reddish limestone bands which form distinctive banded hill slopes in the landscape at the eastern end of the trail and along the main road to Blinman to the north.

Contains stromatolite fossils in the harder limestone interbeds which appear as humps with internal hemi-spherical layering. These are formed as microbial or algal mats and are some of the earliest expressions of life on Earth which first appeared in the geological record about 3500 million years ago. Those here are thought to have lived between about 645 to 640 million years ago.

Banded hill slopes in Trezona Formation, Brachina Gorge trail. (Photo courtesy MN Hiern)

Trezona Formation: Section view of a stromatolite showing fine laminar internal layering and lobate columnar form. (Photo 409130 courtesy Department of State Development)

Sites 3 and 3A Elatina Formation

Site 3 Grid reference
274675 mE, 6530571 mN

Site 3A Grid reference
274598 mE, 6530446 mN

Reddish feldspathic sandstone and siltstone containing pebbles and boulders of a variety of rock types, many of which are smoothed and scratched, indicating a glacial origin. Referred to as tillite, a consolidated glacial till.

In this period of geological time from about 640 to 635 million years ago, there were extensive global ice-caps with glaciers moving towards the ocean and dumping an assortment of rocks plucked from the glacier floor into the sea as the ice melted.

Walking trail to the south to view outcrops along creeks, particularly Site 3A in the southern bank of the main Etina Creek channel.

Glacial tillite of Elatina Formation in tributary creek.

Site 3A on the south bank of Etina Creek.

(Photos courtesy MN Hiern)

Site 4 Nuccaleena Formation

Grid reference
274674 mE, 6530602 mN

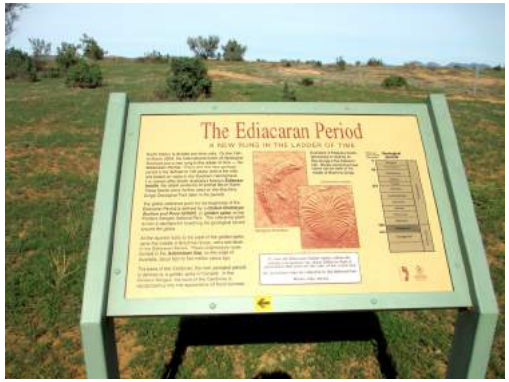
A thin bed of buff to pale pink coloured dolomite (magnesian limestone) deposited in warm shallow water pools over a wide area of the Flinders Ranges after the sea level rose at the end of the glacial conditions of Elatina time.

Thought to have been deposited about 635 million years ago at the beginning of the Ediacaran Period of geological time.

Enorama camp ground

Grid reference
274342 mE, 6531303 mN

Take the track north to the Enorama camp ground and view the descriptive sign, then walk 500 m to the east along Enorama Creek or overland on the Trezona Hike to the base of the Nuccaleena Formation in the south bank of the creek.



Ediacaran Period sign at the Enorama camp ground.

(Photos courtesy MN Hiern)

Site 5 Global Stratotype Section and Point (GSSP)

Grid reference
274846 mE, 6531252 mN

GSSP in Enorama Creek with brass plaque at the base of the Nuccalenna Formation overlying pinkish Elatina Formation with erratics. (Photo courtesy MN Hiern)

Here, as recorded on the Geo-site Golden Spike marker post, a brass plaque "*marks the start of the Ediacaran Period of geological time, as the Earth warmed following glaciation. Multi-celled organisms became widespread in maritime environments. The brass disc indicates its location where pink Elatina Formation glacial tillite is overlain by buff Nuccaleena Formation dolomite*".

This site in Enorama Creek was selected in 2005 when the base of the Nuccaleena Formation was adopted as the beginning of a new Period of geological time by the International Commission on Stratigraphy Working Group on the Terminal Proterozoic Period.

For further reading see Preiss, Wolfgang 2005. Global Stratotype for the Ediacaran System and Period. *MESA Journal* 37; 20-25.

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Site 6 Pleistocene wetland terrace

Grid reference
273061 mE, 6530628 mN

Erosion from overland sheet flow of Pleistocene wetland terrace sequence. (Photo courtesy MN Hiern)

To the west of the Trezona turn-off is an extensive plain which contrasts sharply with the typical rugged landforms of the Flinders Ranges.

It is underlain by a much younger flat-lying sequence of unconsolidated sediments deposited in a wetland between 35 000 and 18 000 years ago.

Microfossils of snails and ostracods (shrimp-like animals with a protective shell) and eggshell fragments of the extinct giant flightless (emu-like) bird *Genyornis* have been found in these sediments.

For further reading see Williams, MAJ, Nitschke, N and Chor, C 2006. Complex geomorphic response to late Pleistocene climatic changes in the arid Flinders Ranges of South Australia. *Geomorphologie* 4; 249-258, and earlier researchers on the unusual climatic conditions associated with this Pleistocene sequence.

Site 7 Pleistocene section, unconformity and Brachina Formation

Grid reference
272297 mE, 6530489 m N

Pleistocene sequence and the Slippery Dip creek crossing. (Photo courtesy MN Hiern)

At the Slippery Dip, so called because of the condition of the track after rain on the ramp at the Enorama Creek crossing, thinly bedded silty and clayey Pleistocene age sands can be seen unconformably (see glossary) overlying folded Brachina Formation.

North of the track, a brown former soil horizon (palaeosol) with organic matter, about 15 cm thick, is visible

in the creek bank near the top of the Pleistocene sequence.

Brachina Formation grades upwards from an olive-green mica-rich siltstone to a reddish-brown laminated siltstone overlain by interbedded sandstone and siltstone displaying cross bedding and ripple marks.

Estimated to have been deposited around 630 to 620 million years ago in a sea of moderate depth which became progressively shallower as indicated by the upwards coarsening grain size and current bedding in the sandstone beds.

Part of the Brachina Formation sequence can be seen in the southern bank of the creek beneath the unconformity.

Note that the track-side sign (below) does not refer to the Pleistocene sequence or the unconformity with the underlying Brachina Formation.

At the Slippery dip, Brachina Formation overlain unconformably by very much younger Pleistocene unconsolidated sediments. (Photo courtesy MN Hiern)

Google Earth image © 2015 CNES / Astrium.

Site 8 ABC Range Quartzite
Grid reference
271386 mE, 6531023 mN

A 70 m thick bed of clean sand, now cemented to quartzite, displaying heavy mineral banding and sedimentary structures such as cross bedding and ripple marks. Mud cracks can be seen in clay bands within the sandstone.

Estimated to have been deposited between 620 and 610 million years ago in a large deltaic complex regularly swept by tidal currents.

ABC Quartzite looking south. (Photo courtesy MN Hiern)

ABC Quartzite, so named because the serrated peaks could be notionally labelled by the letters of the alphabet. (Photo courtesy MN Hiern)

Cross bedding in ABC Range quartzite at Blower Waterhole similar to that seen in Brachina Gorge. (Photo 047458 courtesy Department of State Development)

Site 9 Bunyeroo Formation

Grid reference
276962 mE, 6531205 mN

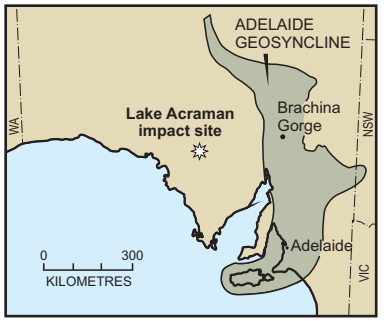
Reddish-brown passing up to grey-green shale and siltstone which, being soft, has been eroded to form the Aroona Valley.

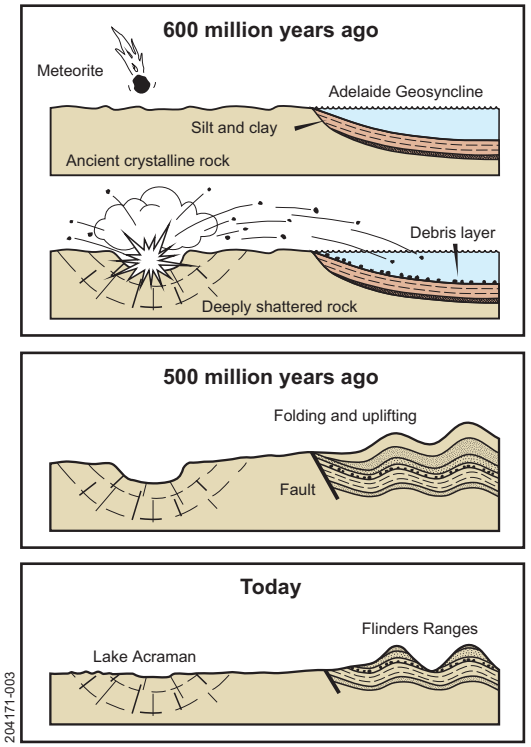
As described in the trackside information plate at the Aroona Valley lookout, the Bunyeroo Formation contains a thin (10–30 mm) unusual layer containing abundant fragments of a distinctive red porphyritic rock, called the Gawler Range Volcanics,

Reddish shale of the Bunyeroo Formation. (Photo courtesy MN Hiern)

which is about 1000 million years older and found only about 300 km to the west in the Gawler Ranges on Eyre Peninsula.

This layer is interpreted to be fallout from the impact of the giant meteorite which crashed onto Eyre Peninsula at Lake Acraman about 600 million years ago throwing vast quantities of Gawler Range Volcanics debris into the atmosphere for hundreds of kilometres around.





Site 10 Wonoka Formation

Grid reference
269671 mE, 6530801 mN

Laminated calcareous siltstone and limestone sequence with some thin, fine-grained sandstone interbeds, estimated to be around 590 to 570 million years old.

Limestone beds in the upper part show fine lamination and may contain spherical carbonate grains called oolites.

Wonoka Formation. (Photo courtesy MN Hiern)

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Site 11 Bonney Sandsone

Grid reference
268535 mE, 6530745 mN

Consists of cyclic sequences, each 20 to 30 metres thick, of red micaceous siltstone and red medium-grained sandstone with cross-bedding, ripple marks, mudclasts and mud cracks.

Has an estimated age from 570 to 560 million years ago.

Bonney Sandstone. (Photo courtesy MN Hiern)

Site 12 Rawnsley Quartzite

Grid reference
268080 mE, 6529811 mN

This hard, white, well-cemented sandstone, estimated to be 560 to 550 million years old, forms the spectacular high ridges in this part of the Flinders Ranges, including Wilpena Pound.

About 400 m thick and weathering to an orange colour near the surface, it was deposited in a quiet shallow sea and displays many sedimentary structures, including cross-bedding and ripple marks.

The middle part of Rawnsley Quartzite is called the Ediacara Member in which the internationally significant Ediacaran assemblage of soft-bodied multicellular fossils are found in several places in the Flinders Ranges.

Pinkish Bonney Sandstone overlain by white grading up to orange Rawnsley Quartzite. (Photos courtesy MN Hiern)

Site 13 Parachilna Formation

Grid reference
267120 mE, 6530159 mN

This sequence of sandstone and siltstone with thin interbedded limestone marks the end of the Ediacaran Period, about 542 million years ago, and the beginning of the Cambrian Period of geological time in the Adelaide Geosyncline.

Abundant worm burrow remains can be seen in a pink sandstone on the

Worm burrows in pink sandstone in tributary creek to Brachina Gorge. (Photo courtesy N Langsford)

path about 20 m south of the trail but the animals responsible for these structures had no hard parts suitable for preservation.

Better burrows and an unconformable contact between the Parachilna Formation and the underlying Rawnsley Quartzite can be seen further up the tributary creek to the south.

Small shelly fossils first appear in the rock record at this time and were later followed by a profusion of animals such as the beetle-like trilobites and sponge-like archaeocyathids which can be seen in overlying beds of the Cambrian sequence such as the Wilkawilinna and Wirrealpa Limestones.

Woodendinna Dolomite

This 300m thick dolomitic mudstone deposited between the Parachilna Formation (Site 13) and the Wilkawillina Limestone (Site 14) is poorly exposed only on the steep upper southern slopes of the gorge near Teamsters' Campsite and has not been signposted.

Site 14 Wilkawillina Limestone
Grid reference
266588 mE, 6530301 mN

A light to dark-grey limestone bed containing abundant coral-like archaeocyatha fossils which can be seen in the large white mass of rock in the creek bed about 100 m west of the track side sign.

Note that the interpretive sign referred to on the descriptive plate appears to have been lost.

Wilkawillinna Limestone with creek bed outcrop of whitish limestone showing abundant archaeocyatha fossils. (Photos courtesy MN Hiern)

Google Earth image © 2015 CNES / Astrium.

Sites 15 and 15A
Billy Creek Formation
Site 15 Grid reference
265523 mE, 6530617 mN
Site 15A Grid reference
266622 mE, 6529963 mN

A soft, easily eroded red siltstone has not been signposted here possibly because it is only poorly exposed on the southern side of the gorge where it is deeply weathered and displaced by faulting.

This formation can also be seen with interbedded volcanic rocks in a small rise 400 m to the east at Site 15A.

Weathered Billy Creek Formation underlying Wirrealpa Limestone near Site 15. (Photo courtesy MN Hiern)

Elsewhere in the Brachina area it displays halite (salt) casts and dessication cracks indicating hypersaline evaporative lagoonal conditions of deposition.

Estimated to have been deposited between 520 and 515 million years ago.

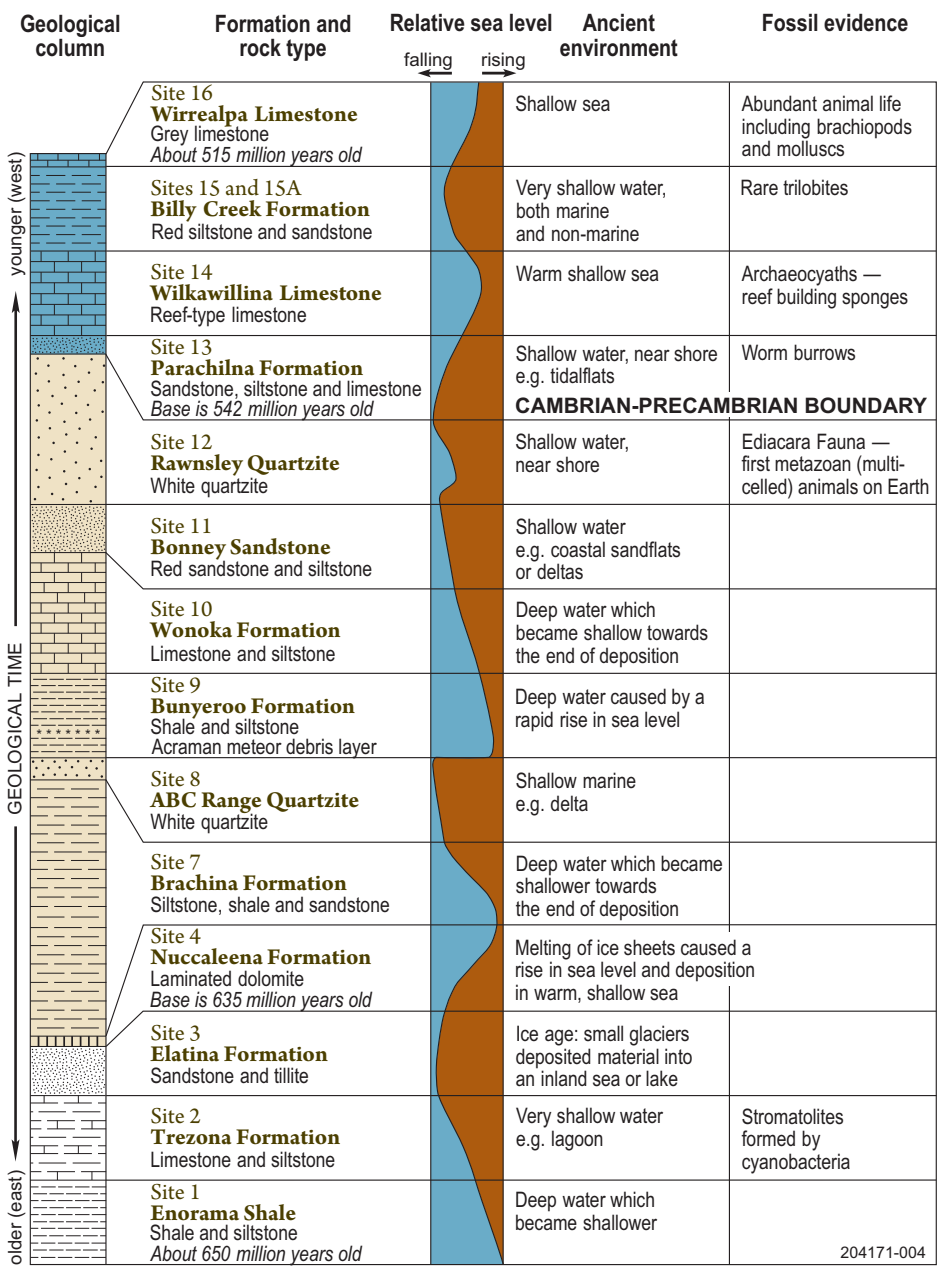
Site 16 Wirrealpa Limestone
Grid reference
265028 mE, 6530266 mN

Buff to light-grey limestone between 515 to 510 million years old, exposed in the creek bank below the parking area at the information booth, which contains trilobite, brachiopod (lamp shells) and stromatolite fossils.

Wirrealpa Limestone in the creek bank below the western information booth. (Photo 409153 courtesy Department of State Development)

Western end and information booth of the Brachina Gorge Geological Trail. (Photo courtesy MN Hiern)

Cambrian and Precambrian environments in Brachina Gorge



Glossary of geological terms used in the site descriptions

bedding the stratification in sediments (and sedimentary rocks) formed by the original deposition of successive layers of sediment.

bedding plane the surface that separates two adjacent layers in a sedimentary rock.

clast a fragment of rock of any shape or size (up to large boulder size).

cross bedding (current bedding) beds within a formation oriented at an angle to the main bedding.

conglomerate a sedimentary rock composed of pebble to boulder sized clasts in a matrix of finer sediment all bound together with natural cement. Thus, pebble conglomerate, boulder conglomerate etc.

dolomite a sedimentary rock composed of calcium magnesium carbonate. Similar to limestone.

Era a broad subdivision of geological time. For example the Palaeozoic Era extends from 542 million years ago to 251 million years ago, a time interval of 291 million years.

Epoch a fine subdivision of geological time, specifically a subdivision of a geological Period.

formation a discrete body of rock of regional extent (10s to 100s of kilometres) distinguishable from the adjoining rocks. Often said to be a mappable unit. For example in the Flinders Ranges a ridge would be a formation of hard rock and an adjacent valley a separate formation of soft rock.

Formation part of the formal, proper name given to a formation (e.g. Brachina Formation).

fossil any feature in a sedimentary rock preserving evidence of past life (e.g. plant and animal remains and traces) or past environments (e.g. mud cracks, salt casts, raindrop impressions).

geological heritage the geological component of our natural heritage.

geological heritage site a particular rock outcrop or larger area of rock in which the displayed geological features are of such outstanding value as to warrant preservation. A site may, for example, be as small as a quarry face or as large as Wilpena Pound.

geological monument a former term for (and synonymous with) geological heritage site. Still occasionally used.

Global Stratotype Section and Point (GSSP) a specifically designated sedimentary rock section and point which, by international agreement, defines a particular formally named interval of geological time (e.g. Ediacaran Period). The Point marks the base of the section and is sometimes informally referred to as 'the Golden Spike'.

loess silt and fine sand deposited chiefly by the wind.

limestone a sedimentary rock composed mainly of calcium carbonate.

periglacial refers to an area or conditions adjacent to a glacier.

Period a defined and named interval of geological time. For example, the Ediacaran Period extending from 635 million years ago to 542 million years ago.

Pleistocene a formally defined Epoch of geological time extending from 2.6 million years ago to 11 500 years ago. Thus, Pleistocene Epoch.

sandstone a sedimentary rock composed of sand grains bound together with natural cement.

sedimentary rock a rock composed of hardened sediment (grains naturally cemented together).

shale a fine-grained (clay sized grains) sedimentary rock which splits readily along its bedding planes.

siltstone a sedimentary rock intermediate in grain size between shale and sandstone.

stromatolite hump like or columnar structures formed by colonies of algae precipitating laminae of limestone during the original deposition in warm, shallow seas causing progressive upwards growth.

unconformity a surface separating younger and older rocks representing a period of erosion or non-deposition.

Be prepared when bushwalking

- wear sturdy shoes, hat and sunscreen
- carry sufficient food and drinking water
- keep to the defined walking trail
- weather conditions can change quickly; ensure you have appropriate wet weather clothing.

Acknowledgment

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