FILE NO.: 26404

ASSESSMENT OF HERITAGE VALUE

ARKAROOLA Via Leigh Creek

DESCRIPTION OF THE PLACE

: 11

Located in the north Flinders Ranges, Arkaroola comprises most of the Arkaroola Wilderness Sanctuary and the Mawson Plateau region of the Mount Freeling pastoral lease, and is approximately 600km² in area. The area is widely recognised for its outstanding geological, paleontological, biodiversity, conservation, landscape, wilderness, cultural, educational and tourism values.

Arkaroola is comprised of a variety of landforms, mainly rugged ranges with distinctive granite peaks and ridges, and high ground dissected by deep gorges. Although initially leased as pastoral land, most of the area has not been stocked for over 30 years and is primarily managed for biodiversity conservation and tourism.

The natural fauna and flora of the area was severely damaged by pastoral activity and despite a substantial degree of regeneration, many species remain vulnerable and endangered or threatened, including Spidery Wattle (*Acacia araneosa*), Bell Fruit Tree (*Codonocarpus pyramidalis*), Yellow-footed Rock Wallaby (*Petrogale xanthopus xanthopus*), as well as many other plants, birds and bats.

The unique geology of the area was brought to the attention of Sir Douglas Mawson in the 1920s, and has been the subject of intense research and many world first discoveries regarding formation of the Earth's crust, fossils, radiation, mineralisation and early life forms. The area is world famous for unique minerals, museum quality mineral speciments and minerals which show the evolution of tropical and arid climates in Australia. Due to its geological structure, since the 1850s the area has been the subject of mining and exploration for gold, uranium and other valuable minerals, usually to the detriment of the natural environment and significant habitats.

While the consideration of indigenous heritage values does not form part of this assessment, the Arkaroola area is a significant landscape for the Adnyamathanha people, whose cultural connections with this place remain strong and vibrant.

STATEMENT OF HERITAGE SIGNIFICANCE

The Arkaroola area is of State heritage significance because it is one of the most diverse landscapes in South Australia, with outstanding scientific, environmental, cultural and social values. There is a unique combination of many layers of natural phenomena and the concentration and integration of geological, botanical and zoological values in one region is of exceptional significance.

Arkaroola is one of the few places on earth where the geology and palaeontology of Precambrian and earlier periods in the formation of the Earth's crust can be seen and researched. There are a number of type sections and specifically identified geological monuments which illustrate these geological phenomena, including Mount Gee, Mount Painter, Arkaroola Gorge and The Armchair areas and Paralana Hot Springs.

The work of many nationally and world renowned geological scientists is based on the natural geological laboratory of Arkaroola. These included Sir Douglas Mawson and Dr Reg Sprigg, as well as many others, some of whom are still working in the area, currently most notably Professor Ian Plimer (University of Adelaide), Professor Malcolm Walter (University of New South Wales) and Associate Professor Malcolm Wallace (University of Melbourne).

The natural environment is also highly significant with large areas, particularly Mawson's Plateau, classified as wilderness, potentially of national significance. Based on limited surveys, it is known that the Arkaroola area is home to at least 160 species of birds, bats and fishes and the rare and endangered Yellow-footed Rock-wallaby (*Petrogale xanthopus*), and the habitat of plant species, including the Spidery Wattle (*Acacia araneosa*) and Bell Fruit Tree (*Codonocarpus pyramidalis*) found only in this location.

Tourism, both scientific and environmental is an important function of Arkaroola, and the spectacular scenery can be linked to geology, the evolution of the Earth and major planetary processes as well as the evolution of landscape and development of flora and fauna in the area. This provides an exceptional experience for visitors to the area.

RECOMMENDATION

It is recommended that Arkaroola, via Leigh Creek be provisionally entered in the South Australian Heritage Register as a State Heritage Place.

RELEVANT CRITERIA (Under Section 16 of the Heritage Places Act 1993)

(a) it demonstrates important aspects of the evolution or pattern of the State's history

Not applicable '

(b) it has rare, uncommon or endangered qualities that are of cultural significance Not applicable

(c) it may yield information that will contribute to an understanding of the State's history, including its natural history

The Arkaroola area has high biodiversity value and contains a high abundance of national and state conservation rated and endemic species. The large topographic variation provides a diversity of micro-climates which in turn increases the diversity of species surviving in the area. Some of the area's unique species, such as the Flinders Ranges Purple-spotted Gudgeon and the Spidery Wattle, are found nowhere else in the world.

Areas within and around Arkaroola are identified as having unique and valuable wilderness qualities. The Mawson Plateau in particular is identified as wilderness of potential national significance located within one of the most elevated regions of South Australia.

The area is also recognised for its outstanding geological features and processes reflecting, among others subjects, climate evolution and the origins of life and DNA. Many of these features are unique and of international significance, and contain the type sections for various rock types. The Cambrian- Precambrian boundary is visible within the area. The recently discovered Arkaroola algal reef is a framework containing calcified organisms that may represent the remains of the oldest animals on Earth. No other comparable reefs of that age have yet been discovered. Ediacaran rock formations and fossils can also be found in the area, as well as more common Cambrian and later period fossils and mineralisation. Their high value to science and teaching is recognised in the number of Geological Monuments (Geological Heritage Sites) identified by the Geological Society of Australia within the Arkaroola Gorge, Mount Gee, Mount Painter and Armchair areas. Each of the monuments also provides the opportunity for further valuable scientific research and preserves a geological feature that is of educational and recreational value to visitors to the site.

The range of scientific research which is based on the geology of Arkaroola is far reaching, and it includes astropalaentology. The geomorphology and evolution of life forms demonstrated in the rocks and fossils accessible at Arkaroola reflect the extreme conditions on Earth 3500 to 4000 million years ago. Paralana Springs is a site for current research by NASA to collate information on expected life in similar conditions

on Mars. It is probable that research at Arkaroola will contribute to an understanding of planetary and interplanetary history and the origin of life.

- (d) it is an outstanding representative of a particular class of places of cultural significance
 Not applicable
- (e) it demonstrates a high degree of creative, aesthetic or technical accomplishment or is an outstanding representative of particular construction techniques or design characteristics Not applicable

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 (f) it has strong cultural or spiritual associations for the community or a group within it
Not applicable

(g) it has a special association with the life or work of a person or organisation or an event of historical importance

Sir Douglas Mawson (1882-1958), one of Australia's best known geologists and explorers, frequently visited Arkaroola for its wealth of minerals and geological uniqueness and encouraged his students to participate in these expeditions. Mawson was first appointed lecturer in mineralogy and petrology in the University of Adelaide in 1905 and was a pioneer of the chemical aspects of geology and geochemistry. He identified the first radioactive ore body in South Australia, now known as Radium Hill, and investigated the highly mineralised Precambrian rocks of the Barrier range which extended from the northern Flinders Ranges. After some years involved in Antarctic exploration, which earned him a knighthood, and high level service in the British Ministry of Munitions during the First World War, Mawson returned to the University of Adelaide in 1919. He was appointed Professor of Geology and Mineralogy in 1921. His insistence on geological field work for students was a keystone to the development of a highly successful teaching and research department. His own geological research focussed on the 'Adelaide System' (or Syncline) of Precambrian rocks, especially in the Flinders Ranges. Mawson was acclaimed and awarded many honours during his lifetime and the large number of species and places bearing his name reflect this acclaim.

One of Mawson's students in the late 1930s was Reg Sprigg, who would in turn became a prominent Australian geologist and conservationist. Reginald Claude Sprigg (1919-1994) was the youngest Fellow of the Royal Society, at the age of 17, and completed his Master of Science at the University of Adelaide in 1942. He worked as Assistant Government Geologist in the South Australian Geological Survey after the Second World War and was inspecting abandoned mines in the Ediacaran Hills when he found and correctly identified organic fossils of Precambrian age. This subsequently led to the erection of the Ediacaran Period, the first new geological period in over 100 years. Sprigg was then involved in the establishment of SANTOS and other geological survey companies, and he became General Manager of Beach Petroleum in 1962.

In 1968, Reg Sprigg, with his wife Griselda, purchased the Arkaroola Pastoral Lease and immediately began to destock the lease. By 1978, all stock had been removed. The Sprigg family's intention was to conserve the unique and rare wildlife and landscapes of the area covered by the lease. Arkaroola became one of the first ecotourism ventures in Australia and Sprigg is considered a pioneer of this method of tourism. He has also had minerals and species named after him. Arkaroola also continues to be available to geologists and palaeontologists for research and education, following the example of Mawson.

BRIEF HISTORICAL BACKGROUND

Aboriginal History

The earliest date firmly identified for Aboriginal occupation of the Flinders Ranges is 15000BP but dating techniques being established for rock art analysis suggest at least double this antiquity (based on testing of engravings in the Yunta area). Aboriginal Flinders Ranges societies included Adnyamathanha, Wailpi, Kuyani, Jadliaura and Piladappa and some intermarriage with Antikarinja from Ernabella-Oodnadatta groups. Today most identify as Adnyamathanha. (ie Hills peoples:- *Adnya*- stone, hill; *matha*- group; *nha*- suffix). Aboriginal ochre mines are found through the Flinders Ranges region, the main ones being at Parachilna, Aroona and Bookartoo, and there is an ochre wall in Arkaroola. Ochre was traded throughout the ranges and further afield, to the south-east and to Queensland, with red ochre being especially prized. Ochre was used for rock paintings, decorating weapons and sacred objects and preparing bodies for ceremonies. Also traded were sandstone slabs, quarried in the eastern ranges near Wertaloona, for use as grinding stones for wet-milling grass seed, a staple of the region's diet. Trade between Aboriginal groups extended to the central Simpson Desert and western Lake Eyre Basin.

Exploration, Pastoralism and Mining

Exploration in the early years of Non-Aboriginal settlement of South Australia pushed north into the Flinders Ranges. John Horrocks, and his camel (imported specially from Tenerife), ventured this far north in 1846. The subsequent pastoral occupation of the land in the northern Flinders Ranges was predicated on the continuation of good rain as experienced during the 1840s, 1850s and early 1860s. In 1851, the government introduced 14 year pastoral leases for these unsurveyed outlying areas (wastelands) of the country and the good seasons attracted pastoralists, shepherds and stockmen into the Flinders Ranges, as the saltbush provided stock feed. In 1856, the first formal lease, of Paralana Run, was taken up by brothers William and John Jacob, and in 1857 John McTaggart took up Wooltana.

Official surveys followed the granting of pastoral leases and in 1857, Assistant Surveyor-General W G Goyder and J M Painter undertook government survey work in Northern Flinders from Mount Serle, Oomberatina (Umberatana) and Lake Blanche. Their experiences in the arid conditions led them to recommend the sinking of wells to provide a reliable water source.

The pastoralists were soon followed by prospectors and miners, and in 1857 Chambers and Finke were reportedly mining for copper at the only mine in the northern ranges, near Oratunga. By 1860, the promise of mining riches saw the Great Northern Copper Mining Company of South Australia survey a railway from Port Augusta to its leases in the northern Flinders Ranges. Alfred Frost discovered copper resulting in Yudanamutana mine in 1862. The copper discovered at Blinman was also worked by the Yudanamutana Copper Mining Company.

When drought struck in 1864, a series of extremely dry years saw the decline of activity in the region. Due to government estimates made in good years and high government charges based on these estimates, properties were overstocked. There was no feed for stock or for the animals used to transport goods and ore (donkeys, horses, camels). The fledgling mining workings came to a standstill and the mining camps were depopulated. The high summer temperatures and extreme dust storms continued for the next two years, salt bush was destroyed resulting in high stock losses from lack of feed. The drought conditions also killed native animals resulting in insufficient food for the Aboriginal population and conflict arose between Aborigines and Europeans as there was competition for available water and food.

The drought broke eventually, with the rains in 1867, but the experience led to necessary changes in pastoral practices - fewer shepherds, increased fencing, and introduction of boundary riders. The Government also made necessary changes to pastoral lease conditions, with more sensible tenure arrangements.

The late 1860s and 1870s saw the extension of Thomas Elder's pastoral empire into the northern Flinders and beyond. He and Robert Barr Smith acquired Illawortina, Umberatana and Lyndhurst leases which abutted or included the Gammon Ranges and the high land now included in Arkaroola. Elder was a staunch supporter of the use of camels as a means of transportation in the arid areas of Australia and arranged for their importation, setting up his station at Beltana for camel breeding. Elder's leases (PL2517) in the northern Flinders expired 1896 and the land remained unoccupied until it was taken up as Freeling Heights (PL1465) in 1921 (part of which became Arkaroola (PL2240) in 1962).

By the 1870s, the north of South Australia was becoming relatively less remote. The completion of the Overland Telegraph in 1872 helped to improve communications in far north of South Australia, and construction began on the railway north from Port Augusta in 1878.

The narrow gauge line reached Hawker, on the western side of the Flinders Ranges in 1880 and was extended to Beltana and Copley by 1881. It reached Marree, at the southern edge of Lake Eyre in 1884. This determined the pattern of building of railway links on the western side of the Flinders and roads on the east.

Further extreme drought years were experienced by pastoralists during 1880-81, and the understandable concern about water lead to a more thorough collection of data on wells and water quality was recorded by the government with assistance from pastoralists, and later, mining prospectors. The Australasian Association for the Advancement of Science reported on mineral waters from wells, bores and springs, in which Goyder's earlier analysis of water sources was discussed.

The second wave of mining exploration in the region occurred during the 1890s, again mainly for copper, but some radium ore was discovered at Umberatana between 1886 and 1898. The main prospectors and miners during this time were the brothers Gordon A Greenwood and William B Greenwood, who were able to sell on their mining interests to the Tasmanian Copper Company in 1904 (but they remained as pastoral leaseholders in the region until the 1940s). The Tasmanian Copper Company had established smelters at Blinman in 1902, to treat ore from the northern Flinders Ranges. The company also owned the Yudnamutana mine and several others, but abandoned them by 1908. In 1910 another mining company, the Union Copper Mines, constructed a smelter at Yudnamutana, but it was never fired. The world price for copper had slumped by this stage and as a consequence mining slowed to uneconomic levels and ceased completely after the end of the First World War. All that remains at Yudnamutana now is some evidence of mine shafts and miners' dugouts in the hillside.

Mining and Uranium

William B Greenwood continued prospecting on his lease and found corundum between Mount Pitt and Mount Painter in 1906, and then in 1910 discovered uranium at Mount Painter. Rock samples deposited at the Department of Mines and at the University of Adelaide's Geology Department were analysed by Professor Douglas Mawson and others and carnotite and torbernite (minerals containing radium) were identified. A number of prospecting syndicates operated in the area, including the Radium Extraction Company and the Mount Painter Heights Radium Syndicate. Radium commanded high prices world-wide for use in medicine, as radium bromide. [An as yet unconfirmed anecdote attributes the use of Mount Painter radium in the research of Marie Curie.] However, attempts to extract the radium rich ore were hampered by low concentrations, a shortage of water and difficulties with transportation from the remote area, and the First World War again halted uranium mining operations.

Interest in the potential of the area remained high as the world-wide demand for radium increased substantially during the 1920s. In 1924 Professor Sir Douglas Mawson and a team of geologists from the University of Adelaide undertook a field trip into the northern

Flinders to investigate the radioactive ores around the Mount Painter area. They also examined the hot springs at Paralana, as the Assistant Government Geologist and Deputy Director of Mines, R Lockhart Jack, had noted the location of good quality water there the year before. The Paralana Springs became an additional reason for interest in the area, as it was considered that they may have medicinal properties. The Medical Directors of the Australian Radium Corporation examined Paralana Springs in 1925, after which the company took up mineral leases to the surrounding land, and began mining.

The severe drought conditions of 1926-1929 hampered the establishment of a leaching plant at the mine and the ore extracted had to be transported by camels for the first few miles to a road and then on to the railway at Copley. The ore was sent to the Dry Creek treatment works for extraction and radium bromide and other uranium compounds were produced. The difficulties of transport and the low grade ore again defeated continued mining at Mount Painter, the Australian Radium Corporation suspended operations in the late 1920s and mining in the area ceased in 1932. An additional problem for the company had been the fall in the international price due to the discovery of extensive uranium fields in the Congo in 1924.

Pastoral Lease Rearrangement - Creation of Arkaroola

Between the early 1900s up to 1925, the land which was to become the Arkaroola pastoral lease sat within a number of other leases, which changed hands at different times. The most notable transfers were: 1907, John McTaggart acquired the lease of Paralana Run from the Hawker estate; 1908, William B Greenwood leased Illinawortina (PL1261); 1909, Illinawortina transferred to Union Pastoral Co. Ltd.; 1918, McTaggart family sold Wooltana to A J and P A McBride; 1919, Ilinawortina was transferred to Peter MacDonald Morrison of Balcanoona Station; 1921, Thomas Robinson took up lease of Freeling Heights (PL1465); 1925, Illinawortina was transferred to Roy Thomas of Adelaide.

The actual Arkaroola lease was created in 1937 when it was carved from the poorer country of four adjoining stations - Mount Fitton, Freeling Heights, Illinawortina/Balcanoona and Wooltana. *Arkaroo* was the great serpent who according to myth inhabited the Gammon Ranges and the Arkaroola Creek cut across the new run- hence the name Arkaroola. Gordon A Greenwood, the then lessee of Mount Serle Station is noted as saying: "Arkaroola was not the best sheep or cattle country. It had low carrying capacity, unreliable water sources and was subject to droughts."

Tourism and Research

The first attempt at tourist development in the northern Flinders Ranges was one outcome of the discovery of uranium and a radioactive landscape. In 1926 the Australian Radium Corporation set up a trial camp for a proposed health spa at Paralana Hot Springs under Dr Clyde Fenton, based on the continental model of hot springs and 'taking the waters'. A Dr Martin held a second trial in 1927, when the Governor of South Australia, Sir Tom Bridges, who was staying at Wooltana Station while performing his official duties and opening the

Angorichina Hostel built by Tubercular Soldiers Aid Society, visited Paralana Springs and bathed in the water. He repeated this visit several days later. [Bridges died aged 68, the cause of death is not given in his Australian Dictionary of Biography entry.] With the cessation of mining, no development of the springs occurred for some years, but in 1938 the idea surfaced again and a Paralana Hot Springs Syndicate was formed after scientific interest in the properties of the Springs was reignited. Professor Kerr Grant and physicists from University of Adelaide travelled to Arkaroola to examine the radioactivity and gaseous content in the water at Paralana Springs. And in the same year Sir Douglas Mawson took a group of geology students into the area. Of particular interest is the fact that one of these students was Reg Sprigg, later owner of the Arkaroola lease.

Second World War Exploration for Uranium

The Paralana Hot Springs Syndicate's request to government in 1939 for assistance for establishing a continental style spa at Paralana Springs was ill-timed, as The Second World War was imminent and resources were to be directed elsewhere. In early 1944, the Commonwealth Government responded to an urgent request from the British Government to investigate uranium production in Australia. The exploration program which ensued included the Mount Painter region. The land was removed from provisions of the Mining Act and declared a Reserved Area. Geological surveys were begun, still serviced by camels, and to facilitate aerial photography by the RAAF, an aerodrome was built at Balcanoona. When the ore load was found to be quite low and difficult to access at Mount Painter the investigation was subsequently focussed on the East Painter deposits until the program finished in September 1945. Department of Mines exploration and measurement of uraniferous ore bodies around Mount Painter continued into the 1950s, and this was continued by a number of mining companies in the 1960s.

Pastoral Leases After the Second World War

In 1946 William B Greenwood obtained the Arkaroola lease, and there was one last attempt to promote a spa project at Paralana Springs. Wilpena Pound had been declared a National Pleasure Resort the previous year and tourism to the Flinders Ranges had increased after the Second World War. However, the interest did not extend to Paralana. The Greenwood brothers also held the lease of Freeling Heights, to the west of Arkaroola and Mount Serle to the south. In 1949 Thomas Gordon leased both Arkaroola and Freeling Heights, and then Arkaroola was transferred to a T J Conalon. In 1952, the Arkaroola and Freeling Heights leases were combined into one new lease (PL2240), of 221 square miles which was then held by Cyril Paull Edwards.

Sanctuary Status

The Arkaroola lease was transferred to Reginald Claude Sprigg in 1968. Sprigg and his wife Griselda believed that Arkaroola Station could function as a "Fauna Sanctuary and Historic Reserve, part sheep station, part tourist resort and part wildlife reserve", and to that end

obtained sanctuary status for their land. Arkaroola became a Fauna Sanctuary under the *South Australia Fauna Conservation Act* (1964/65). The classification 'Sanctuary' gives protection under the *National Parks and Wildlife Act* 1972 to a fringe category of land hosting worthy animals and plants.

While mining activity could have some positive outcomes such as additional roads and water supplies, most often the site preparation and other activities, particularly the use of bulldozers, caused rapid damage to the natural environment. Sprigg's intention was to maintain closer cooperation between mining, tourism and sanctuary management. A Policy Document was prepared in 1969 setting out the intended approach to the management of the area. The station was divided into coherent areas for sanctuary with controlled access, fenced in pastoral area, and areas for regeneration of plants and breeding of birds. Eradication of vermin, such as feral goats, cats and foxes, was necessary for successful sanctuary management.

The Arkaroola Policy Document listed the historic features of the sanctuary at this time (1970) which included stone walls constructed by early shepherds between Lady Buxton Mine and Paralana, reputed to have been used to herd wallabies in wallaby drives making the kill easier. W B Greenwood's "broad arrow" in stones together with the figures "98" at the entrance to Radium Creek, opposite Echo Camp was also mentioned. This pointed the way to a prospecting sortie that identified the Mount Painter uranium field. There were also numerous old mine sites noted and the Bolla Bollana Smelter round house and ruined old main smelter and chimney.

The Arkaroola – Mount Painter Sanctuary was seen as an experiment with the aim of "facilitating tourism whilst limiting sheep and wool production in favour of conservation and husbanding of native fauna and flora". Careful management and improved knowledge of the habits and survival needs of the marsupial population was considered essential, as was cooperation between government departments, public institutions and commercial organisations with a variety of interests in the area. Preservation of the frequently unique character of the area was to be ensured with access that allowed for the "enjoyment and edification of a sympathetic public". Between 1968 and 1970 six new bores completed at Arkaroola to improve water supply and assist with feed for stock and marsupials. This led to experiments to determine appropriate grasses for sometimes saline bore water. Sheep were removed from Arkaroola in 1970, with the approval of the Pastoral Board, which oversaw the management of pastoral leases.

The significant landscape of the Flinders Ranges was a well-recognised asset, with the Gammon Ranges and Wilpena National Parks gazetted by 1972. Although at this point the official sanctuary status was withdrawn from Arkaroola, Reg Sprigg continued to manage the place as an important area of natural environment to be conserved appropriately. The eco-tourism facilities and activities were developed, and the Spriggs continued to encourage

ongoing geological and environmental research and associations with educational institutions including the University of Adelaide.

The Geological Society of Australia identified a number of highly significant sites and features on Arkaroola during the survey of geological monuments (also called geological heritage sites) begun in 1976. Most notable of these were the Arkaroola Gorge, Paralana Hot Springs, Mount Painter and Mount Gee, and a number of small sites. [Refer map and description in Geological Society report included as Attachment A as part of this assessment.]

Reg Sprigg died in 1994. In 1996 the official 'sanctuary' status of Arkaroola was reinstated as the Arkaroola Wilderness Sanctuary, and it has continued to function as a world-renown eco-tourist centre, managed by his son and daughter. It also continues to serve as a geological research and education centre.

In 2011, the South Australian government banned mining within an area which encompasses the original Arkaroola lease and a section of the Freeling Heights lease which includes Mawson Plateau.

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See also:

Australian Dictionary of Biography, Entries for Mawson, Bridges, Grant, Elder.

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FILE NO.: 26404

SITE RECORD

ARKAROOLA Via Leigh Creek

FORMER NAME: DESCRIPTION OF PLACE: DATE OF COMPLETION: REGISTER STATUS:

CURRENT USE:

PREVIOUS USE(S):

ARCHITECT:

BUILDER:

SUBJECT INDEXING:

MISCELLANEOUS INDEX: LOCAL GOVERNMENT AREA: LAND DESCRIPTION: Wilderness sanctuary
Not ApplicableDescription:NoDate:28Description:EcDates:PaDates:NoDates:NoDates:NoDates:Category:

Description: Title Type: Volume: Folio: Lot No.: Section: Nominated 28 September 2011 Eco-tourism

Pastoral Lease

Not Applicable

Not Applicable

Landscape Aren (+?

Out of Hundreds GRO 32 2011

LOCATION PLAN

ARKAROOLA Via Leigh Creek



Arkaroola, via Leigh Creek shown arrowed

SITE PLAN

ARKAROOLA Via Leigh Creek



PHOTOGRAPHS

ARKAROOLA Via Leigh Creek



Ridgetop Track



Split Rock

PHOTOGRAPHS (Cont.)

ARKAROOLA Via Leigh Creek



The Armchair



View from Siller's Lookout, Ridgetop Track

FILE NO .: 26404

PHOTOGRAPHS (Cont.)

ARKAROOLA Via Leigh Creek



View from Siller's Lookout

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Siller's Lookout

All Photographs taken by John Barker, DENR (September 2011)

GEOLOGICAL AND MINING HERITAGE OF ARKAROOLA

Report of Geological Heritage Sub-committee, Geological Society of Australia, SA Division

INTRODUCTION

Of all of the extensive Precambrian terrains in South Australia, the Mount Painter Inlier is the most spectacular. (An inlier is defined as a mass of older rocks surrounded by younger rocks.) This is partly because of a variety of geological features in the basement rocks, including a diverse range of mineral occurrences, but more particularly because of the rugged landforms created by deeply incised stream erosion resulting from periodical cycles of uplift and subsidence of the area.

An area of 603.7 km² in the northern Flinders Ranges around Arkaroola was reserved from the operation of the *Mining Act 1971* on 29 July 2011 while an assessment of heritage values was made. This submission, prepared by the Geological Society of Australia, describes the geological setting of the reserved area and the geological and mining heritage features within it.

GEOLOGICAL SETTING

In a regional context, the Mount Painter Inlier and adjacent Mount Babbage Inlier, are located on the north western tip of the Curnamona Province, a Precambrian craton separated from the more extensive Gawler Craton by the Adelaide Geosyncline. While the ages quoted and geological interpretation of the events described herein may change as a result of future research, the geological framework recorded in the following summary is considered adequate for an assessment of heritage values.

As shown in Figure 1 overleaf, at the heart of the Mount Painter Inlier is a central core of metamorphosed and faulted volcanic and sedimentary rocks called the Radium Creek Metamorphics which were deposited around 1600 million years ago around the beginning of the Mesoproterozoic period of geological time.

During a post depositional phase of metamorphism, deformation and igneous activity from about 1570 million to 1550 years ago, the Radium Creek Metamorphics were intruded by what is referred to by some as the 'older granite suite,' which includes such individual bodies described in the geological literature at Yerila, Box Bore, The Amchair, Old Camp, Camel Pad, Golden Pole, Con Bore, Prospect Hill and White Well Granites as well as an unusual grey coloured pink weathering medium to coarse grained intrusive rock hanned the Nooldoonooldoona Trondhjemite.

Intense northeast trending shearing, particularly inception of the Paralana Fault, occurred about 1550 million years ago. Intermittent uplifting and subsiding movements on this and other major faults has continued until the present time and created the highly scenic eastern face of the range rising abruptly from the Lake Frome plains, as well as the rugged landforms within the ranges. An indication of the scale of this uplift is apparent from the presence of older erosional land surfaces lying 1000 metres above the Lake Frome plains in the Freeling Heights area.

Deposition of a thick sedimentary sequence in a large subsiding basin between the Curnamona Province and the Gawler Craton to the west (shown in the inset to Figure 1) called the Adelaide Geosyncline, began in the Neoproterozoic Period about 850 million years ago and continued into the Palaeozoic Cambrian Period until about 500 million years ago. Around 480 million years ago in the Ordovician Period, the geosynclinal and older rocks were metamorphosed and folded during a phase of deep burial and lateral compression called the Delamerian Orogeny.

In the study area, these rocks can be seen in the Arkaroola Gorge and extending into the Vulkathunha-Gammon Range National Park to the south and the pastoral lands to the west. These and the Radium Creek Metamorphics have been displaced by intense shearing in the vicinity of the Paralana Fault but further to the south and west, away from basement core, the Neoproterozoic geosynclinal sediments are only gently folded.

A second phase of igneous activity occurred after the Delamerian Orogeny waned in the late Ordovician about 440 million years ago with intrusion of the British Empire Granite of the 'younger granite suite' north of Freeling Heights. Smaller plugs of granite with estimated ages between 450 and 372 million years occur at The Pinnacles, The Needles and Sitting Bull and others to the south west.

Flat lying bodies of an unusual granitic breccia, called the Radium Ridge Breccias, unconformably overlie the basement rocks over an area of about 10 km² in the Mount Painter-Mount Gee area and a few localities to the north and east. In places these contain uranium minerals and abundant haematite (iron oxide). A site named the Number 6 deposit was mined for radium from underground workings on a small scale for a few years after 1910 by the Radium Extraction Company of South Australia.

Underground exploration and some drilling conducted by the SA Department of Mines between 1946 and 1950 focussed on the East Painter deposits and a large uraniferous body, too low grade to develop at that time, was disclosed.

Extensive exploration, including drilling, was conducted at several prospects between 1967 and 1969 by a private company consortium. One of the access tracks cut for this drilling is the Ridgetop Tour Track, now used by the Arkaroola Village operators for guided tours to give visitors an experience of the outstanding scenic vistas of the ranges.

Further phases of geological mapping and drilling, including non-invasive moving of drilling rigs by helicopter, have been carried out since then without proving a commercially viable orebody.



Drill rig being moved by helicopter, Mount Painter area circa 1990.

Although this status gives no legal protection, it is recognition by geological professionals that such sites display geological features and processes of value for scientific, teaching or public enjoyment. Summaries of these sites are provided below and more detail on them (some of which is now out of date) can be found in a DVD available from Primary Industries and Resources South Australia (PIRSA) titled 'Geological Monuments in South Australia.' Site numbers in the map above are used below and are also the file numbers in the DVD.

FR 1. 1. Arkaroola Gorge; an area of 8000 ha around the Arkaroola Creek with ephemeral stream beds deeply incised into Radium Creek Metamorhics and the overlying Neoproterozoic sedimentary sequence of the Adelaide Geosyncline. Spectacular scenery with value for education, research and outdoor leisure activities. Also listed on the former Register of the National Estate.



Major unconformity between Mount Neill Granite basement and the basal Adelaidean Paralana Quartzite 100 m northeast of Arkaroola Waterhole PIRSA Photo 049582

FR 1. 2. Mount Gee; Called the 'crystal mountain' because of the abundance of quartz varieties including the unusual 'nail hole' quartz.

Has excellent exposures of the Radium Ridge Breccias and Mount Gee Sinter which, as discussed earlier, are considered to have formed at or near a former land surface by upwelling hot water solutions.

FR 1. 3. Mount Painter; rugged capping of MountGee Sinter unconformably overlying a weathered surface of basement Radium Creek Metamorphics.



Easterly view from Mount Gee to Mount Painter with Mount Gee Sinter in the foreground and capping Mount Painter down to the base of the cliffs. PIRSA Photo 49640 FR 7. Corundum Mine; Small hexagonal crystals of corundum and other minerals in metasediments of the Radium Ridge Metamorphics.

FR 10. The Needles; One of several small isolated intrusive bodies of sodic granite postdating the late Cambrian/ Ordovician Delamerian Orogeny.

FR 11. The Pinnacles; One of several small isolated intrusive bodies of sodic granite postdating the late Cambrian/Ordovician Delamerian Orogeny.



The Pinnacles, Arkaroola PIRSA Photo 034364

FR 12. Sitting Bull; One of several small isolated intrusive bodies of sodic granite postdating the late Cambrian/ Ordovician Delamerian Orogeny.

These twelve sites are those which have come to the attention of the Geological Heritage sub-committee. It is likely that future research will identify other features of geological heritage status.

MINING HERITAGE

Discovery of silver-lead minerals at Glen Osmond in the Adelaide foothills in 1839 led to opening of the first base metal mine in Australia in 1841 and established South Australia's pioneering place in the nation's mining heritage. Development of copper deposits at Kapunda in 1844, Burra in 1845 and Moonta in 1859 made South Australia the leading producer of copper in the world during mid 19th century. Part of this Copper Kingdom, as South Australia came to be known, was the heritage of mining methods and customs brought by the Cornish miners and their families when they came to mine the rich South Australian ores. This heritage is celebrated every two years at the Kernewek Lowender Festival in the Copper Triangle, and is said to be the largest Cornish festival outside of Cornwall.

The quest for new deposits of copper spread to the Flinders Ranges in the 1860's and several mines, usually worked from underground shafts and horizontal adits into the rugged hill sides, were opened in the Mount Painter area. Most of these were in the girdle of Adelaidean Neoproterozoic rocks around the basement core. They were usually short lived because the rich near surface secondary orebodies soon passed down into impoverished primary sulphide lodes which were too low grade to work.

Despite their short life, these workings are part of South Australia's rich Cornish cultural and mining heritage through their display of the mining methods of 150 years ago under the severe conditions of the climate and terrain of this area.

Primary Industries and Resources SA, 2010. PIRSA Geothermal Energy. http://www.pir.sa.gov.au/geothermal/prospectivity/geothermal provinces

Robertson, R S, Conor, C C H, Preiss, W V. Crooks, A.F. and Sheard, M J *In:* Cooper, B J and McGeough, M A (Eds), 2006, South Australia mineral explorers guide. Second edn. *South Australia. Department of Primary Industries and Resources. Mineral Exploration Data Package*, 11, Ch. 5 Curnamona Province

Geological Society of Australia, SA Division Geological Heritage Sub-committee 28 September 2011

ATTACHMENT B

ADDITIONAL INFORMATION ON GEOLOGICAL HERITAGE SITES AT ARKAROOLA

Twelve Geological Heritage Sites, formerly called Geological Monuments, have been recognised in the Arkaroola area by the Geological Heritage Sub-Committee of the Geological Society of Australia (SA Division).

Geological Heritage Sites (or Monuments) are defined as geological features and processes that:

- aid in the teaching of science at all educational levels and that are used, especially by the professional community of earth scientists, for research and reference,
- are representative, rare or even unique to science in South Australia, Australia or internationally, and
- are of aesthetic, educational or recreational value to the general public.

The following information on five Geological Heritage Sites, extracted from the Register of the National Estate and from Professor Ian Plimer's 2007 notes (Plimer 2007), expands the information provided by the Geological Heritage Sub-Committee's geological report for Arkaroola, and provides additional detail on the environment at each site.

1. ARKAROOLA GORGE

RNE Citation:

The Arkaroola Creek, flowing from the Gammon Ranges to the south, swings east in the area of Bolla Bollana smelters and becomes unusually and spectacularly sinuous, frequently doubling almost back into itself. Cutting through the resistant quartzites, tillites and granites of Proterozoic age, it forms a number of beautiful waterholes and gorges with sheer rock walls. The surrounding terrain is typically chaotic with serrated quartzite, massive tillite and bulbous granite peaks. The flora, often reflecting the geology, is dominated by several acacia and eucalypt species, yaccas, porcupine grass and after seasonal rains, wildflowers of great beauty.

2. MOUNT GEE

RNE Citation:

Spectacular mass of quartz crystal and vughular, lining the cavities of crush breccias. The controversy and research concerning the age and nature of these breccias and the underlying tillitic beds is of significance to crustal science and geological history, these beds having been assigned to the ancient basement complex (>1400 million years bp) of the Adelaide geosyncline. The quartz is of unusual to rare form, composition, variety and beauty. Fluorescent quartz is common and often associated with uranium minerals, some also rare. This uranium mineralisation is of potential economic importance.

The spectacular Crystal Mountain of Mount Gee protrudes through the chaotic ridge-and-gorge landscape of the red granite highlands around Mount Painter and rises almost 250m from its valleys. Native pine (Callitris columellaris) clothe its slopes. Prominent outcrops of quartz-haematite breccia contain quartz of rare variety and beauty, ghosted, smoky or amethystine, rosetted or stalactitic, or the unique nailhole quartz consisting of radiating crystals in cylindrical masses round central prismatic cavities with shapes typical of gypsum. The uranium minerals present in some vughs are often inter-grown with fluorescent and radioactive quartz.

Plimer 2007:

The rocks and minerals of the Mount Gee area provide a window into past climates, the rate of past climate change, the natural decay of radioactive materials, the trapping of radioactive materials and the stabilisation of tailings, mine waste and reactor waste. In this domain are numerous rare minerals such as kasolite, metatorbenite and clinobisvanite. The rocks, particularly the granites, have yielded an unusual mineralogy, and the area is renowned for the great variety of quartz types, including 'nail hole' quartz, used in teaching to illustrate a number of geological processes.

3. MOUNT PAINTER

RNE Citation:

This rugged isolated peak dominates the central skyline of spectacular high ranges of the region to which it gives its name. The ranges here represent deeply dissected fossil land surface of which Mount Painter is a residual hill, or monadnock and are part of ancient (1,100 million years bp) basement terrain exposed in few regions of the state. Mount Painter itself consists of an intrusive pipe of haematitic granite breccia, age and origin of which are subject of continuing geological debate. In addition, this wild mountain terrain is a haunt of the until recently rare yellow-footed rock wallaby.

The magnificent triangular peak of Mount Painter rises several hundred metres above the mid-Tertiary (about 45 million years bp). Yudnamutana erosion surface uplifted and dissected to form a region of serrated summits, bulbous masses and deep gorges and ravines. The area is essentially in its natural state.

Plimer 2007:

Mount Painter shows topography inversion. It is an ancient gas maar (volcano), preserved in three dimensions. The original crater lake preserves streams of gas bubbles that were trapped when they were ascending, fragments that were blasted up and fell back into the crater lake, and mud sediments from the floor of the crater lake.

4. THE ARMCHAIR

RNE Citation:

This striking armchair-like mountain has resulted from weathering of a relatively unstressed granitic mass of the older granite suite (1400-1645 million years bp), part of the crystalline basement core of the Mount Painter province. As this is one of the few regions in the state where these ancient rocks crop out, they are of great geological interest. In addition, the precipitous walls developed in smooth red granite dyke rock make it a principal target for photographers, bushwalkers and climbers.

The rounded, starkly bald and bare red granite form of The Armchair is a notable landmark within the deep Yudnamutana Creek drainage sub-basin. The main vegetation is porcupine grass, or spinifex with scattered acacias and eucalypts.

Plimer 2007:

The Armchair is a window into the evolution of the landscape of the Mount Painter area. Although the rocks are old they show that the area was once a plain that has undergone a long history of uplift and associated earthquakes, that uplift has distressed the rocks thereby producing a characteristic fracture pattern and the general lack of soils shows that the uplift process is still taking place, in a still geologically active region.

5. PARALANA HOT SPRING

RNE Citation:

Hot Spring associated with Paralana Fault zone. An outstanding natural phenomenon unique in the Flinders Ranges. The source of the heat is controversial and requires further research, but the presence of radon gas, uranium and radium suggests a relationship with the radioactive mineralisation in this province. The site is a tourist attraction.

The Spring occurs in the gravelly bed of Hot Spring or Paralana Creek where it emerges from the rugged hills of the Mount Painter complex and crosses a splinter of the major Paralana Fault. The Spring releases carbon dioxide, hydrogen, helium and radon gases and the water issues at temperatures of sixty-four degrees Celsius (Kerr Grant) to eighty-two degrees Celsius (Sprigg) into a pool. Overflow from the pool drains into a reedy creek with luxuriant river red gums (Eucalyptus camaldulensis) and ti-tree (Melaleuca lanceolata). Radon gas is detected in the waters and atmosphere of The Spring and uranium and radium in water and radium in the sands of the creek.

Although measured levels of radioactivity show that the Spring is not a major health hazard, extended visitor camping at the site should be avoided as a precautionary measure.

Plimer 2007:

The hot springs are a link between local processes, the evolution of life and planetary science. When rain falls onto the Mawson Plateau north of Arkaroola, water moves down through cracked rocks, passing through uranium-rich granite which is naturally decaying and producing heat, helium gas and the radioactive gas, radon. This water then sinks down into the Paralana Fault and is then pumped up the fault to the surface, by constant stress and earth tremors. Thus, decaying uranium heats water up to 56-65°C for the hot springs, one of the few places in the world where this happens. The red rocks at the Springs are a silica-iron oxide rock, jasper, which formed as a precipitate from hot springs in earlier times.

The Springs also contain extremophile life, similar to early life on Earth 3500 to 4000 million years ago. The slime in the Springs is a mat of cyanobacteria that has adapted to the extreme conditions of heat and high radioactivity. More than 50 species of bacteria thrive in this water. These conditions have been the basis of research by NASA to extrapolate information on expected life in similar conditions on Mars.