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Explanatory Notes on the Alroy Geological Sheet

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The Alroy Sheet area is in the south-western part of the Barkly Tableland in the Northern Territory of Australia; it lies between longitudes 135° E. and 136° 30' E., and between latitudes 19° S. and 20° S.

The Sheet area is covered by two sets of vertical air-photographs: one set was taken by the Royal Australian Air Force in 1947, and is at a scale of 1:46,500; the other was taken in 1963 by Adastra, at 1:80,000. In 1959 the Division of National Mapping, Department of National Development, published the Alroy Sheet in the 4-mile planimetric series; this map was compiled from the 1947 photography supplemented by spot photography and ground control, both of which were carried out in 1958. Photo-scale compilations of the separate 1-mile areas are available from the Division of National Mapping; they show all cultural information to 1958. At present no map based on the 1963 photography is available, but a revised edition of the early map was published by National Mapping in 1964 at 1:250,000 scale. During the 1962 geological survey (Randal & Nichols, 1963), on which these Notes are based, new bores and tracks were mapped, and appear on the geological sheet.

The bitumen-sealed Barkly Highway from Mount Isa and Camooweal in Queensland to Tennant Creek on the Stuart Highway bisects the Sheet area from south-east to north-west. A new road leads northwards from the Barkly Highway near Dalmore Downs to Anthony Lagoon and Brunette Downs via Alroy Downs. These two roads provide access to numerous station tracks and stock routes in the area. There are no tracks or development in this Sheet area south of the Barkly Highway.

The areas contains Alroy and Dalmore Downs stations and homesteads, and parts of Brunette Downs, Rockhampton Downs, and Alexandria stations. Other settlements are Frewena Roadhouse and Wonaral Telegraph Station, both located on the Barkly Highway. Cattle movement is mainly along the new Anthony Lagoon road and the South Barkly Stock Route, which connects the Barkly Stock Route at Ranken, to the east, to the Stuart Highway near Banka Banka, to the west.

The climate is monsoonal; the wet season normally lasts from December to March. Temperatures are high throughout the year. The lowest temperatures and humidities are during the dry season, which is influenced by consistent south-easterly winds. Towards the end of the dry season, temperature and humidity...
rise and cloudy days are frequent; wind directions become variable, and ultimately winds from the north-west predominate and usher in the wet season. The average annual rainfall in 1950 to 1962 ranged from about 11½ inches at Wonarah to about 12 inches in the north-west; the Sheet area is the driest part of the Barkly Tableland.

**Previous Investigations**

Until 1962 none of the area had been systematically mapped. However, this and adjoining areas of the Barkly Tableland have been traversed in the past by explorers, and by geologists engaged in regional reconnaissance mapping; and several fossil collections have been made.

A Cambrian fossil was first found on the Barkly Tableland by H. Y. L. Brown (1895) in the adjoining Ranken Sheet area (Randal, 1966b). A. L. Merrotsv. during surveying trins on the Tableland discovered the cast of a trilobite 8 miles east of Aroy Downs homestead. Etheridge (1919) described the fossil as *Psychoparia aloayensis*, but Whitehouse (1939) subsequently assigned it to the new genus *Lyriaspis*.

Woolnough (1912) and Jensen (1914) passed through the area, or close to it, and referred to the Cambrian limestones and the underground water of the Barkly Tableland. In subsequent papers Jensen (1923, 1944) referred to the Cambrian rocks as the Barkly Tableland Series. Ward (1926) visited the area during an investigation of the underground water resources of the Northern Territory.

In 1947 and 1948 Noakes & Traves visited the area in the course of a CSIRO investigation of the Barkly Region. In addition to their report (1954), they have described the geology of the area and listed fossil localities in the files of the Bureau of Mineral Resources. During this survey they referred to the Cambrian rocks as the Barkly Group.

Since 1948, A. A. Ópik has visited the Tableland several times, and has made many fossil collections; his work is reported in a number of unpublished reports and in Ópik and others (1957).

Mapping by the Bureau of Mineral Resources on the adjoining Sheet areas of Tennant Creek (Ivanac, 1954), Brunette Downs, Ranken, and Avon Downs (Randal, 1966a, b, c) is relevant to the Cambrian stratigraphy of this Sheet area. During 1962 the Bureau of Mineral Resources carried out a programme of core-hole drilling in the Georgina Basin (Milligan, 1963); three of these holes—Grg15, 15a, and 17—were drilled in the Aroy Sheet area.

In 1963 Adastra Hunting Geophysics Pty Ltd completed an aeromagnetic survey over the western half for Barkley Oil Company Pty Ltd (Howe & Faessler, 1963), and during the summer of 1964-65 W. L. Sides Pty Ltd drilled Frewena No. 1 Well to 1024 feet for the same company (E. A. Webb, pers. comm.). During 1964 aeromagnetic traverses were flown over the eastern part of the Sheet by the Bureau of Mineral Resources (Wells, Tipper, & Milsom, 1964).
PHYSIOGRAPHY

The entire Sheet area occurs within the Barkly Internal Drainage Basin (Randall, 1962; called Barkly Basin in CSIRO, 1954). The divide separating this Basin from the Georgina River Basin lies to the east, in the Ranken Sheet area, and the divide separating it from the Gulf Fall lies to the north and east, in the Wallhallow, Mount Drummond, and Ranken Sheet areas.

![Fig. 1. Physiography of the Alroy Sheet area](image)

The Barkly Internal Drainage Basin is not a single entity; it consists of a number of bluebush swamps or lakes which are themselves internal drainage centres. The largest of these is Lake Sylvester (including Lake De Burgh), part of which lies in the central north of the Alroy Sheet area (Fig. 1). The Playford River and its tributaries, Buchanan and Desert Creeks, flow into the southern part of the lake. Other major lakes of the Barkly Internal Drainage Basin lie to the north in the adjoining Brunette Downs Sheet area. As well as the major drainage centre, smaller bluebush swamps and claypans occur south and north of the Playford River and north of the Barkly Highway. These act as foci for small gullies and runnels during brief periods of local seasonal flooding. In the far south the Frew River, which rises in the Davenport Ranges, empties into a local internal drainage claypan.
The streams are braided in their lower courses and have broad shallow valley profiles; in their upper reaches they are moderately entrenched with sharp, but not deep, valleys. The major streams rise to the east and north-east in the adjoining Ranken and Mount Drummond Sheet areas.

Besides the internal drainage foci, physiographic features are delineated by the division of the landforms into grass-covered downs and timbered areas (including the so-called 'desert'). A prominent timberline enters the Alroy Sheet area from the east 8 miles north of Wonarah Telegraph Station, and with minor changes in direction strikes north-west to near Alroy Downs homestead; from there it strikes westward to Frewena Roadhouse and thence north-westwards and northwards to Rockhampton Downs homestead and beyond in the Brunette Downs Sheet area. The continuation of this timberline to the east is strongly developed in the Ranken and Avon Downs Sheet areas. This timberline separates the mainly carbonate rocks of the downs country to the north from the timbered and scrubby exposures of shale, siltstone, and chert of the Wonarah Beds and from the areas of Cainozoic travertine, red sandy soil, and sand dunes.

Immediately south of the timberline and east of Frewena the country is moderately well timbered and scrub-covered, with low stony rises; vegetation is mainly box and bloodwood trees with minor shrubs and grasses. South of the Barkly Highway and north-west of Frewena the country is gently undulating, and the vegetation consists mainly of snappy gum, with some Acacia spp. and mallee scrub, particularly in the south. In the central part of the southern area low sanddunes trend north-westerly. The scrublands south of the highway form part of a large semi-desert which extends from near Georgina Downs in the Sandover River Sheet area (Nichols, 1966) north-westward to near Brunchilly and the Stuart Highway in the Helen Springs Sheet area.

The downs country, which forms the remainder of the area, is essentially a grassland with Mitchell grass dominant over Flinders, couch, and blue grasses. The topography is gently undulating, with low gravelly rises supporting various species of eucalypts and acacias, which also occur along some of the watercourses. The drainage is well developed and dendritic; major watercourses are widely spaced because of the low runoff. The downs country is developed mainly on Cambrian and Tertiary carbonate rocks.

Relief is low: Mount Lamb is 880 feet above sea level and rises about 80 feet above the level of the surrounding downs; the hills south-east of Wonarah rise to about 920 feet above sea level. The downs are highest between Kerlingnew Swamp and Desert Creek (between 800 and 825 feet above sea level). The lowest part is Lake Sylvester, which is 630 feet above sea level; and the entire area slopes towards it.

STRATIGRAPHY

The area is covered by extensive superficial deposits with loose blocks of carbonate rocks, and pebbles of chert and pistolithic ironstone gravel. The drillers' terms in the water-bore logs are too vague to be stratigraphically useful, and the
bores from which samples have been examined by geologists are few and too far apart to permit accurate correlation. Consequently the Cambrian rocks are described by the informal term 'Beds'; formations may be recognized if more detailed subsurface information becomes available.

**Proterozoic**

In the section on the map, Proterozoic rocks are shown under the Cambrian rocks; but they do not crop out. By extrapolation from nearby areas, it seems that the Cambrian succession may be underlain by the Warramunga Group (Noakes & Traves, 1954; Ivanac, 1954) in the west, by the Mittiebah Sandstone (Smith & Roberts, 1963) in the north and north-east, and by the Hatches Creek Group in the south and south-west (Smith, Stewart, & Smith, 1961). The depth to magnetic basement is about 800 feet both near Wonarah Telegraph Station (Jewell, 1960) and in the north-east (Wells, Tipper, & Milsom, 1964), and in the west ranges from 500 feet above sea level to 3000 feet below, and is between 650 and 3700 feet below the surface; the composition and age of the magnetic basement are unknown, but some Precambrian rocks probably occur above it.

**Cambrian**

The Cambrian rocks cropping out in the Alroy Sheet area are part of a widespread Cambrian sequence which covers most of the Barkly Tableland in both Queensland and the Northern Territory. The stratigraphic units and their regional and palaeogeographic significance have been discussed by Opik (in Opik & others, 1957); the units in the Brunette Downs and Alroy areas have been mapped at 1:250,000 scale by Randal & Nichols (1963), and those in the Ranken and Avon Downs Sheet areas by Randal & Brown (1962 a, b).

Opik (op.cit.) used the term *Wonarah Beds* to describe outcrops of Middle Cambrian rocks along the Barkly Highway west of Soudan. They crop out between the Barkly Highway and the South Barkly Stock Route, and extend on to the adjoining Ranken, Avon Downs, and Frew River Sheet areas. The Beds consist of fossiliferous siltstone, chert, silicified shale, and silicified oolitic limestone; Condon (1961) reports leached dololutite and chert replacing dolomite. Milligan (1963) records subsurface calcareous sandstone and siltstone, limestone, calcarenite, coquinite, fossiliferous crystalline limestone, and crystalline dolomite. Frewena No. 1 penetrated limestone and dolomite to 1024 feet (E. A. Webb, pers. comm.). The fossil determinations have not been completed and it is not yet known if the subsurface rocks are all Middle Cambrian and whether they form a continuous sequence with the surface exposures; no apparent disconformities have been reported in the bore logs.

The Wonarah Beds form low hills covered by loose pebbles of fossiliferous chert, silicified shale, and limestone; the rocks are deeply lateritized and show the marked leaching effects seen in carbonate rocks elsewhere in the Georgina Basin (Condon, 1961).
They may be contiguous with other Middle Cambrian units on the Barkly Tablelands and its environs: the Sandover Beds (Smith, 1966) to the south, the Burton Beds to the north-east (Randall & Brown, 1962a), and the Gum Ridge Formation to the west (Ivanac, 1954).

The thickness of the Wonarah Beds is at least several hundred feet: trilobite and brachipod fragments from the interval 325 to 337 feet in the water bore at Wonarah (T.D. 366 feet) are considered to represent the fauna in the nearby surface exposures of the Wonarah Beds (A. A. Opik, BMR, pers. comm.). If the sequence penetrated by Frewena No. 1 is referable to the Wonarah Beds, the thickness may exceed 1000 feet. Although the depth to magnetic basement in the west reached 3000 feet below sea level (about 3700 feet below surface level) this section probably contains non-magnetic Precambrian rocks, and may include non-outcropping Lower Cambrian sediments.

Dolomitic limestone, limestone, and chert pebbles along Desert Creek, the Playford River, and west of Ulginulu waterhole are unlike the known rock types of the Wonarah Beds, and are shown as 'undifferentiated Cambrian'.

**Cainozoic**

Noakes & Traves (1954) used the name *Brunette Limestone* to describe a white nodular limestone which crops out on Brunette Downs, Alroy Downs, and Rockhampton Downs Stations. In the Alroy Sheet area, the Brunette Limestone extends from Kennedy Creek in the north-east to the South Barkly Stock Route, thence westwards and northwards to the western margin of Lake Sylvester. It occurs as scattered blocks and boulders in the black soil, particularly in minor topographic depressions. However, although the unit rings the major centres of internal drainage on the Barkly Tableland it does not occur within them.

The Brunette Limestone is a white to brown fine-grained to coarsely crystalline limestone and dolomite. The rock is siliceous, containing chert and opaline nodules and smears; it is frequently nodular or skeletal in appearance. Nichols (1963) has described specimens.

The thickness of the Brunette Limestone is not known but on the adjoining Brunette Downs Sheet area it is 60 feet (Randal, 1966a).

The Brunette Limestone is similar to the Austral Downs Limestone (Noakes, 1951; Noakes & Traves, 1954) in lithology and stratigraphical position: both were unconformably laid down on older carbonate rocks while the older rocks were being lateritized or shortly afterwards, probably during the Tertiary. Leaching of lime and silica from the Cambrian rocks has apparently provided the source for the younger siliceous limestones. The limestone was previously regarded as a lacustrine deposit; however, fossils found in the Brunette Downs Sheet area to the north (Randal & Nichols, 1962) indicate a possible marine transgression in northern Australia during the Miocene (Lloyd, 1966). Probably the siliceous carbonates were laid down under mainly lacustrine conditions, but owing to a brief marine incursion lagoonal or estuarine conditions were locally produced.
Outcrops of travertine are widespread between Dalmore Downs homestead, Alroy Downs homestead, and Frewena Roadhouse. The travertine is in part opaline and siliceous like the Brunette Limestone; but it contains more detrital quartz and is not so cohesive. Despite this, it forms low scrubby and stony rises in contrast to the usual grassy flat plains associated with the Brunette Limestone. The thickness of the travertine is not known, but exceeds 15 feet. Both Stewart (1954a) and Noakes & Traves (1954) consider this travertine as aeolian loess—windblown material from the Tertiary Lake Limestone (i.e. the Brunette Limestone) which was deposited to the north.

Unconsolidated Cainozoic deposits are widespread; they consist of black and grey clayey soils, alluvium, sand and sandy soils, river gravels, and residual (?) gravelly rises of chert and ironstone pebbles.

The grassy downs country is underlain by black and grey pedocalcic soils, moderately to weakly leached and with carbonate and gypsum horizons. Stewart (1954b) considers that the areas now occupied by these soils were swamplands during the Tertiary lateritic cycle, with the watertable at or above their surfaces. The soils overlie the carbonate rocks of the Cambrian sequence and the Tertiary Brunette Limestone; they are of mixed origin, partly residual on the carbonate material and partly derived from material deposited in the Tertiary swamp.

Chert gravel is widespread and may be residual from chert bands and nodules in the underlying carbonate rocks. Rises of pisolitic ironstone gravel are presumably remnants of lateritized rocks, but are in places deposits of detrital laterite derived from the reworking of lateritized material. Deposits of detrital laterite are known along the Barkly Highway, where they are 3 to 4 feet thick. They are mostly covered by sand, but are exposed in small quarries from which material has been removed for road metal. The deposits are well sorted, but to the west they become coarser and contain much chert rubble, and thin out rapidly.

Sand and sandy soils occur in the south and west. The term ‘sandy soils’ is mainly a textural description; quartz sand is often subordinate, but gives the soil a sandy texture which is distinct from the clayey nature of the black or grey pedocalcic soils. The soils shown on the map as sand or sandy soils are termed by Stewart (1954b) red desert alluvial soils, calcareous desert soils, lateritic red sand, and lateritic red earths.

Stream alluvium consists of transported gravels and reworked clayey and sandy soils. The fine-textured alluvium in the swamps of the internal drainage centres is likewise derived from clayey black soils.

STRUCTURE

The structure of the area is difficult to evaluate because of the poor outcrops and the lack of exposed contacts. Very few outcrops have well defined dip and strike directions; some dip directions have been interpreted from the air photographs,
but most cannot be verified on the ground. Nowhere have the various units on the Barkly Tableland been seen in contact or in definite superposition, and the variations in lithology as reported by drillers cannot be used because of the vagueness of their descriptions and because of lateral variations.

The regional structure can only be interpreted in relation to the adjoining areas. The Upper Proterozoic rocks in the north of the Brunette Downs Sheet area and on the Mount Drummond and Ranken Sheet areas dip to the south and south-west, and in some parts form the basement for the Cambrian sequence. In the Tennant Creek and Helen Springs Sheet areas, the Middle Cambrian sediments dip eastward off the Precambrian Ashburton Sandstone and Warramunga Group. It appears that the Cambrian rocks have been deposited in depressions in the Precambrian land surface.

In Bureau of Mineral Resources Report 41A (BMR, 1960) the area occupied by the Alroy Sheet area was included in the 'Barkly Basin', which is shown as the link between the Georgina Basin and the Daly River Basin. A structural demarcation between the latter two is possible, but has not been proved. At present the Cambrian rocks of the Barkly Tableland are regarded as part of the Georgina Basin.

**GEOLOGICAL HISTORY**

During Proterozoic time extensive sedimentation occurred all round the area, with the deposition of the Hatches Creek and Warramunga Groups, the Ashburton Sandstone, and the rocks of the Limmen Geosyncline (Dunn, Smith, & Roberts, in prep.). Presumably some of this sedimentation extended into the Alroy area, but the rocks are now completely covered and their nature is unknown. After the Proterozoic rocks were folded, the area was covered by an early Middle Cambrian sea, and sediments deposited on an irregular basement surface. Probable Lower Cambrian volcanics are known to the west of the Alroy area (Ivanac, 1954) below the base of the Middle Cambrian rocks, but they have not been encountered in the Sheet area either in outcrop or in the subsurface.

For the interval between the Middle Cambrian and the Tertiary lateritization, the record is almost blank. Gentle folding and warping during the late Mesozoic or Tertiary produced a series of freshwater lakes. Probably in the late Tertiary lateritization proceeded on the higher ground and silica and lime, leached from the older rocks, were deposited in the lakes along with other alluvial material. A brief marine transgression occurred to the north during the Miocene and may have extended into this area, but its extent is unknown. The pre-laterite landform is still reflected in the present-day surface, though it has been somewhat modified by the deposition of detrital laterite and the aeolian loess. Slight rejuvenation of the streams has produced the present cycle of erosion.
ECONOMIC GEOLOGY

Petroleum
The petroleum prospects cannot be assessed until the surface mapping is supplemented by adequate subsurface investigations.

Fossiliferous marine Cambrian rocks are known in the area and may provide source rocks for petroleum. The carbonate rocks could form reservoirs for oil or gas; the large quantity of subartesian water produced from them is proof of their porosity, but also of their transmissibility, which may have permitted the escape of any accumulations. No indications of oil have been reported from the numerous bores in the area, but few bores have penetrated more than half of the probable Cambrian section. Fine-grained and compact carbonates are known in outcrop and have been reported in drillers’ logs; these may act as cap rocks for potential reservoir rocks. However, the structure and lithological sequence of the potential source, reservoir, and cap rocks are not well known.

Water
There is not enough surface water for the cattle in the area: the rainfall is adequate for the abundant growth of good-quality grasses, but none of the watercourses are perennial, and few of the waterholes are permanent because of the low rainfall, the shallow valley profiles, and the high evaporation (more than 60 inches per year). Consequently the cattle industry is dependent on groundwater. Nonetheless, Buchanan Dam on Alroy Downs Station is an excellent example of surface water conservation. It is the largest dam on the Barkly Tableland: the water is backed up for 1½ miles and in places is 200 yards wide; the depth in places exceeds 10 feet.

Seventy-eight water bores have been located, of which only five have been abandoned for technical reasons: one for poor supply, two for poor quality, and two because of mechanical trouble. Five more, which include some of the old Army bores, are shut down because they are not required at present. There are no records of bores being completely dry, or completely failing for other than mechanical reasons. There are no bores in the desert south of the Barkly Highway, except for Grg 17, which was completed as a water-bore.

The groundwater is obtained from an aquifer system ranging in depth from 100 to 450 feet, corresponding to a range in elevation of 400 to 625 feet above sea level. Many bore logs record two or more aquifers, but their inter-relationships are not clearly understood. Unlike the majority of bores elsewhere in the Barkly Tableland, where the depths to good supplies are controlled largely by the incidence of fractures and cavities, most of the groundwater so far exploited in the Alroy Sheet area appears to come from porous rocks overlain by less porous strata. This suggests that the subsurface rocks are more varied than in the monotonous carbonate sequence to the east and north-east. (The corehole drilling programme and Frewena No. 1 have shown the presence of carbonates
and porosity due to cavities in this area.) Despite this apparent lithological control most of the groundwater in the Aroy Sheet area is unconfined: in only a few bores—near Lake De Burgh and around Dalmore Downs—does the standing water level lie at a higher level than the first aquifer. However, the first aquifers rarely provide sufficient water, and deeper aquifers are sought; the standing water levels for these deeper aquifers are usually the same as for the shallower aquifers—that is, the deeper water is confined.

The piezometric surface—obtained by contouring the standing water levels—ranges from 530 to 670 feet above sea level (Fig. 2). It declines in a general north-westerly and northerly direction, reaching its lowest elevations near Lake De Burgh and in the north-east. Its highest elevation is along the eastern margin of the Sheet area south of the Playford River. The general direction of groundwater flow as evidenced by the piezometric surface, i.e. from the south and the east, is reflected by the directions of increasing salinity of the groundwater.

![Fig. 2. Piezometric surface and groundwater chemistry, Aroy Sheet area](image)

The quality of the groundwater is extremely variable. It is generally suitable for stock, but the water from many of the bores is unfit for human consumption because of the high salinity (more than 2500 ppm of total dissolved solids), high sulphate content (more than 250 ppm), or high fluoride content (more than 1.5 ppm). Analyses for 60 bore waters from this Sheet are available and are presented
in detail in a report on the occurrence of groundwater in the Barkly Tableland (Randal, in prep.). The salinity (in terms of total dissolved solids) ranges from 440 ppm in the south to 5000 ppm near Lake Sylvester and 6800 ppm north of the Playford River: most of the bore waters contain more than 1500 ppm. The fluoride content ranges from 0.2 ppm in the south to 5.6 ppm in the north-west; most bore waters contain more than 2 ppm. The sulphate content also increases from south to north; the highest concentration—more than 3000 ppm—occurs in the north-east.

In the south bicarbonate is the dominant anion but to the north it is gradually replaced by the chloride ion, and in places by the sulphate ion. There is close coincidence between the chemical types and the general direction of groundwater flow (Fig. 2).

The hydraulics and geochemistry of the groundwater in this area have been examined by Randal (op. cit.) in relation to the entire groundwater province of the Barkly Tableland.

Construction Materials

Flaggy carbonate rocks and altered sandstones have been used for minor building purposes—pathways around homesteads, mounts for bore-equipment, foundations for cattle troughs, and overflow dams.

Thin deposits of gravel are scattered over wide areas. In the downs country, the gravels are mainly chert with minor occurrences of silicified ironstone. In the timbered areas only the detrital laterite gravels on the Barkly Highway are more than 3 feet thick. Some of these gravels were used during the construction of the Barkly Highway and are occasionally still used for its maintenance. These deposits should be tested before use for their grading and plasticity characteristics, as chert and silty sand are frequently admixed.

Good quartz sand does not occur; the ferruginous and often silty sand of the "desert" and timbered areas is of doubtful value for building purposes: however, mixed with a very high proportion of Portland cement it has been used for paved floors. Most of the streams contain gravel and reworked black soil rather than sand.

The heavy clayey soils of the downs country make excellent earth tanks for the storage of bore water. These soils become plastic and impervious when wet and if maintained in moist and vegetated conditions make a virtually waterproof container ("turkey nests"). They are, however, considerably weakened by admixed sand, and in the sandy areas the use of iron tanks is the only permanent solution against leaking turkey nests.
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