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1961/103

THE SAUNDERS CREEK RADIOACTIVE PROSPECT, HALLS CREEK DISTRICT, WESTERN AUSTRALIA

by

R.A. Ruker

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SUMMARY

The radiometric anomalies recorded by Bureau of Mineral Resources airborne scintillometer surveys and by ground investigations at the Saunders Creek Radioactive Prospect (Halls Creek W.A.) are associated with the Saunders Creek Formation. This formation has been newly defined to include a succession of coarse to medium clastics which were formed in a phase of shallow water conditions during the cycle of the Halls Creek Geosyncline. The conglomerate at the base of the formation - and in particular the heavy mineral matrix which contains thorogummite - is the source of radioactivity. The conglomerate crops out for 3 miles along the western limb of a closed anticline in the area, where structure is complicated by strike faulting and isoclinal folds. Readings for radioactivity are from 3 to 10 times background. Two bore sites have been located for the testing of the formation below the zone of oxidation.

INTRODUCTION

The geological investigation of the Saunders Creek Radioactive Prospect was carried out by R.A. Ruker and R.R. Connolly on behalf of the Bureau of Mineral Resources and the West Australian Government in the period 28th May to 27th August, 1959. The working programme was planned and supervised by B.P. Walpole, Supervising Geologist, Bureau of Mineral Resources.

Location and Access

The prospect is situated in the East Kimberley District of Western Australia, north-east of the old Halls Creek township, between the Great Northern Highway and the Albert Edward Ranges. The road to the prospect turns off the Great Northern Highway 14 miles north of new Halls Creek. It is a dirt road 17 miles long which ends at the Ding Dong Downs windwill. At the fifteenth mile, side tracks lead to the Bulman Waterhole on Saunders Creek, to the two proposed boresites, and to the airstrip. The airstrip is situated 0.5 mile west-north-west of the Bulman Waterhole and has a graded surface, 50 feet wide and 540 feet long, suitable only for emergency landings. Access to the prospect area from the south is possible by a bush track which connects Sophie Downs and Ding Dong Downs, and is negotiable by four wheel-drive vehicles.

The Prospect is covered by TR 1703H, of 256 square miles, held by United Uranium N.L. This area is quadrangular and its south-west corner is 4.5 miles from the old Halls Creek township along a bearing N67°E magnetic. The present survey has covered 110 square miles of this area.

Water Supply

The Bulman Waterhole on Saunders Creek contains approximately 80,000 gallons of non-potable water in the middle of the dry season. This waterhole is difficult of access. A permanent supply of potable water is available at Ding Dong Downs, where a windmill is kept in working order and the water stored in one 4,000 gallon tank. A graded road leads from this water supply to the proposed boresites.

Previous Investigations and Scope of Present Survey

In 1954 prospectors, Gordon and Coussins, discovered a radioactive anomaly at the Bulman Waterhole on Saunders Creek. Investigation by United Uranium N.L. showed that the radioactivity is due to heavy mineral in the matrix of a conglomerate horizon. This horizon was mapped in the area south of Bulman Waterhole (P. Grenning 1955), and AP 1603H was granted to United Uranium N.L. by the W.A. Government in April 1958. Three additional anomalies were located by the Bureau of Mineral Resources airborne scintillometer survey in 1954 and were confirmed in 1958 by a Bureau of Mineral Resources VH-MIN Group. B.P. Walpole and C.E. Prichard (1958), after field inspection and photo-interpretation of the area south of Saunders Creek, pointed out that all the anomalies are controlled by an overturned anticlinal structure and that the low surface radioactivity may be due to leaching. Therefore further investigation was recommended to establish the extension and characteristics of the radioactive horizon and to locate sites for its underground testing. This work was done by the writer and R.R. Connolly, and the results are presented in this report.

Reliability

The geological map presented with this report has been compiled from numerous reconnaissance traverses. In areas difficult of access the information has been interpolated with the aid of photo-interpretation (Plate 1). On the other hand, the area where the radioactive conglomerate crops out has been studied in some detail - most of the lithological boundaries have been "walked", and four sections measured by tape and Abney level.

REGIONAL SETTING

The sediments within the Saunders Creek Radioactive Prospect are part of the Lower Proterozoic sequence designated by Traves (1955) "Halls Creek Metamorphics". This sequence has been deposited in what is now a linear geosynclinal basin which is 20 miles wide, and extends from Turkey Creek in the north to Rockhole Station in the south. It is adjacent in the west to the metamorphic and intrusive rocks of the Lamboo Complex, and to the east it is overlain by the Upper Proterozoic of the Albert Edward Ranges. The sequence is composed of interbedded and interfingered greywacke, quartz-greywacke, calcareous and carbonaceous siltstone, laminated dolomite, feldspathic sandstone, conglomerate, and basic volcanics. All these rocks are affected by a low- to medium-grade regional metamorphism.

The dominant structural trend is north-north-east roughly parallel to the geosynclinal axis; dips are subvertical or steeply inclined to the east. Steep, closed anticlines and synclines are developed in the geosynclinal belt, and are complicated by tight isoclinal folds and disrupted by faults trending north and north-east.

THE PROSPECT AREA

Stratigraphy

The Lower Proterozoic sequence in the prospect area is illustrated in Plate 1. The difficulty in subdividing and classifying an assemblage of consanguineous rocks deposited in a geosynclinal environment has been overcome by grouping the rocks characterized by a dominant lithological type.

TABLE 1

UPPER PROTEROZOIC

Pu - UNDIFFERENTIATED - Basal breccia-conglomerate overlain by sediments and volcanics.

U N C O N F O R M I T Y

LOWER PROTEROZOIC

Agicondian Series

Pgs - LAMBOO COMPLEX?
SOPHIE DOWNS GRANITE - Fine- to medium-grained granite with xenoliths of schist and slate.

\- BASIC INTRUSIVES - Uralitized dolerite with minor acid differentiates.

Plo - OLYMPIO CREEK GREYWACKE - Thin-bedded, medium-grained greywacke grading up into coarse greywacke.

CASTLE CREEK BEDS

Plc3 - Calcareous siltstone, carbonaceous siltstone, rhythmically bedded black slate and quartz greywacke.

Plc2 - Laminated dolomite interbedded with siltstone, amphibolite, and calc-silicate rocks; sheared rhyolite.

Plc1 - Thin-bedded ferruginous chert, laminated siltstone, and minor quartz-greywacke; actinolite schist.

Plm - MARIN CREEK BEDS. Green laminated calcareous greywacke, dark grey and red slate, and calcareous siltstone.

Pls - SAUNDERS CREEK FORMATION. Cross-bedded quartz-sandstone, locally with basal radioactive pebble-conglomerate, feldspathic sandstone, massive quartz-greywacke, and bedded greywacke.

Pl - UNDIFFERENTIATED. Green schistose greywacke, phyllite, rhyolite, slate, basic amygdaloidal volcanics.

The rocks treated as "carbonate assemblage" by B.P. Walpole and C.E. Prichard (1958) correspond to the Castle Creek beds, and those treated as "greywacke assemblage" correspond to the Plm, Pls and Pl.

In the following chapters the rock units will be reviewed in ascending order, from oldest to youngest.

ROCK UNITS

P1 - UNDIFFERENTIATED

This rock unit crops out in the cores of the two anticlinal structures south and south-east of Saunders Creek and represents the lowest element of the sedimentary succession within the Saunders Creek Radioactive Prospect. It consists of interbedded greywacke, phyllite, slate, albitized rhyolite, and amygdaloidal basalt.

The greywacke is green, fine-grained, schistose or laminated, epidote-rich and calcareous; it contains lenses of epidotized and silicified amygdaloidal basalt.

The phyllite is carbonaceous in places with nodular schistosity planes due to quartz and possibly garnet crystals.

The rhyolite is a grey, porphyritic rock with a high quartz content, and with planes of schistosity defined by muscovite, biotite, and chlorite.

The unit is strongly folded and faulted, and therefore the thickness can not be estimated.

The base of this unit has not been observed, and the top has been mapped at the base of the Saundors Creek Formation.

Pls - Saunders Creek Formation

This formation crops out on the limbs of the two anticlinal structures south of Saunders Creek. The type section is 1.5 miles south-west of Bulman Waterhole at the Proposed Borehole BMR No. 1 (See Plate 1). The approximate geographic co-ordinates are Lat. 18°05' S; Long. 127°58' E.

The formation consists of interbedded conglomerate, sandstone, greywacke, quartz-greywacke and arkose and is characterized by the dominance of medium-grained and coarse clastics. Four members have been distinguished in the type locality:

a) Sandstone with interbedded radioactive conglomerate is the lowest member. The sandstone is medium- to coarse-grained and cross-bedded. It contains feldspar and glauconite and bands carrying heavy-minerals. The conglomerate, restricted to the base of the member, is in bands up to 12 inches thick. The number of bands varies from two to eight and they have a maximum aggregate thickness of 7 feet in the type area. The rock is a quartz-pebble conglomerate with a medium-grained sandstone matrix containing a high proportion of heavy minerals. For further details see Economic Geology.

b) Feldspathic Sandstone overlies the sandstone-conglomerate member. It is a white, medium-grained rock, well bedded and silicified. Its maximum thickness is about 150 feet.

c) and d) Greywacke and quartz-greywacke are the topmost members of the Saunders Creek Formation. Both are dark-coloured and very fine-grained rocks. The greywacke is laminated and contains a high proportion of biotite, chlorite, and sericite. The quartz-greywacke is a massive rock in which quartz is dominant over sericite and chlorite. The two rock types are interbedded and the boundaries are in many places gradational.

The upper part of the Saunders Creek Formation, namely the greywacke and quartz-greywacke, has been intruded by dolerite sills. These sills are up to 500 feet thick, and are concordant with the host rock but petrographic examination shows that they are not metamorphosed. (See Appendix).

The thickness of the Saunders Creek Formation is difficult to compute because of the complicated structure. However, it can be estimated. In the type area the aggregate thickness of the three lowest members is 600 feet, and the thickness of the greywacke and quartz-greywacke members , including the dolerite sills, reaches 1500 feet, so the total thickness of the formation amounts to 2100 feet. 5 miles south-west of the type locality the three lowest members are 100 feet thick, and this value seems to be constant for most of the undisturbed outcrops on the Saunders Creek Anticline. On the eastern, linear, anticline the formation is represented by a sandstone bed up to 50 feet thick and by greywacke 200 feet thick. Therefore the formation rapidly decreases in thickness towards the east and to a certain extent towards the south. This fact will be given further consideration in the chapter on Economic Geology.

Associated with changes in thickness are lateral changes in lithology. The basal conglomerate bed and the overlying cross-bedded sandstone are present between the northern nose of the Saunders Creek Anticline and a point on its western limb 3.5 miles south of Saunders Creek. Both members gradually thin out towards the south and are replaced by feldspathic sandstone and greywacke.

The bottom of the Formation is placed between the lowest conglomerate or sandstone horizon and the greywacke or phyllite of the underlying Undifferentiated Complex. The top of the formation is ill-defined and is tentatively placed between the top of the greywacke member and the calcareous greywacke of the Marin Creek Beds. West of the Saunders Creek Anticline this boundary is marked by a dolerite sill.

Plm - Marin Creek Beds

The area between the outcrops of the Saunders Creek Formation and the siltstone-carbonate rock assemblage to the west is occupied by interbedded calcareous greywacke, siltstone, and volcanics. This assemblage, named Marin Creek Beds, is lithologically a transition between the underlying formations to the east and the overlying formations to the west.

The lower half of the Marin Creek Beds resembles the topmost members of the Saunders Creek Formation. It consists of dark green greywacke which is fine-grained and laminated, and has slaty cleavage and schistosity. Minor siltstone horizons have been observed. This member is intruded by uralitized dolerite sills from 50 to 300 feet thick.

In the north the upper part of the Marin Creek Beds is represented by siltstone. The rock is grey or dark red, laminated, and calcareous. Numerous quartz veins and nodules are present.

The bottom of the unit is marked by a dolerite sill between the greywacke and the Saunders Creek Formation. In the north of the mapped area the top is placed between the calcareous siltstone and the thin-bedded chert of the Castle Creek Beds. In the remaining areas the top of the formation has been mapped between the calcareous greywacke and the laminated dolomite-siltstone of the Castle Creek Beds.

Plc - Castle Creek Beds

The Castle Creek Beds are a carbonatic assemblage characterized by dolomite and calcareous siltstone. The assemblage crops out in the north-west of the mapped area, along the road connecting Sophie Downs with Ding Dong Downs, and in the north-east occupies a triangular, synclinal area on Saunders Creek.

The assemblage has been subdivided into three units. The uppermost **Plc3, occurs only in the north-east.**

Plc1 - is thin-bedded ferruginous chert interbedded with grey, laminated siltstone and minor thin beds of brown quartz-greywacke. A local horizon of actinolite schist is present east of Bulman Waterhole. This unit, being more resistant to weathering, is the sole reliable structural and stratigraphic marker within the investigated area.

Plc2 - is laminated, crystalline, grey dolomite interbedded and interfingered with grey and brown laminated siltstone. Amphibolite, calc-silicate rocks and sheared rhyolite are present in the north-western part of the area in the vicinity of the Sophie Downs Granite outcrop.

Plc3 - is grey, laminated, calcareous siltstone interbedded with black, carbonaceous siltstone and rhythmically-bedded, black slate and quartz-greywacke. The calcareous siltstone is dominant in the lower part of the unit, whereas the slate and quartz-greywacke abound in the upper part.

The boundaries of the Plc units are gradational, and the limits on the map are therefore approximate. Lateral variations in lithology and the complicated structure prevent estimation of the thickness of this assemblage.

A green fine-grained uralitized dolerite sill has been intruded along the contact between Plc2 and Plc3.

In the western part of the map area the base of the Castle Creek Beds has been placed between the ferruginous chert and the green greywacke of the Marin Creek Beds; in the north-west it has been placed between the ferruginous chert and the dolerite intrusion overlying the Saunders Creek Formation. The top of the assemblage is gradational, and has been placed approximately between the calcareous siltstone and the lowermost bed of the Olympic Creek Greywacke.

Plo - Olympio Creek Greywacke.

The Olympio Creek Greywacke crops out in the south-eastern part of the investigated area.

The formation consists of thin-bedded, dark grey greywacke. The rock is medium-grained and interbedded with calcareous siltstone in the lower part of the formation, and is coarse-grained in the upper part. At its base the formation grades into the calcareous siltstone of the Castle Creek Beds. The top of the formation does not occur in the investigated area, and the thickness is therefore unknown.

Pgs- Sophie Downs Granite

This unit crops out in an ovate area 8.5 miles long and 5 miles wide west of Marin Creek. The eastern half of this area falls within the mapped area.

It is a fine- to medium-grained granite containing biotite and muscovite. It contains xenoliths of green amphibolite schist, brown laminated slate, and dark green basic volcanics. The xenoliths measure up to 30 feet, and they are contact metamorphosed, but they still show original textures. The sandstone and slates of the Halls Creek Metamorphics which are in contact with the granite do not show any effects of contact metamorphism.

The Sophie Downs Granite has been ascribed to the Lamboo Complex.

Pu - Upper Proterozoic

The Upper Proterozoic rocks which form the Albert Edward Ranges are present in the south-east of the mapped area. They are marine rocks which overly the Lower Proterozoic with marked unconformity, and consist of a breccia-conglomerate at the base, followed by sandstone, shale, limestone, and volcanics.

STRUCTURE

The area under consideration presents a complicated structure due to the superposition of the tectonic stresses upon the original sedimentary features. The dynamism of the sedimentary environment caused local slumping of the sediments and consequent thickening of the stratigraphic succession. Moreover the vertical movements of the sea bottom gave rise to a wide range of textures and chemical compositions in the deposited materials and formed them into irregular and discontinuous sedimentary bodies. East-west compression then tilted and folded the rocks to give them their present north-north-east trends and steep dips. Field evidence, in the form of two sets of intersecting fault-joint patterns and quartz veins, suggests that there were at least two episodes in this tilting process. Whether the low-grade metamorphism of the rocks occurred during the first or a later stage could not be established. The Olympio Creek Greywacke tops the succession and is formed in an undisturbed north-north-east directed monocline.

On the basis of this interpretation of the field evidence two structural areas can be defined:

The first one is in the west and comprises the strongly tilted, folded, and faulted Lower Proterozoic rocks adjacent to the Lamboo Complex. The second area is in the east, and is occupied by the monocline of the Olympic Creek Greywacke. This area, although reconnoitred, falls beyond the scope of the present investigation, and the following chapter will, therefore, deal only with the structural conditions of the first area, where the Saunders Creek Radioactive Prospect occurs.

STRUCTURE OF THE SAUNDERS CREEK RADIOACTIVE PROSPECT

The area containing the Prospect is characterized by a series of anticlines alternating with tight, linear synclines directed north-north-east. Three major anticlinal structures are present in the mapped area and the strongest radioactive anomalies are located on the limb of one of them. This anticline has been named the Saunders Creek Anticline. The anticline extends for 8 miles, from Saunders Creek towards the south-south-west; its maximum width is 2.5 miles. Morphologically it is outlined by the ridge formed by the Saunders Creek Formation, which is more resistant to weathering than the neighbouring rocks. It is a closed structure with the western limb dipping about 65° to the west and the overturned eastern limb dipping about 80° towards the west (see Pl. 1, Section B-B'). This anticline is complicated by tight isoclinal folding which is particularly evident within the Saunders Creek Formation. (see Pl. 1, Section C-C'). Some beds are repeated up to eight times across the strike. Most of the fold-crests have been disrupted by thrust faults with a throw ranging up to several hundred feet. The fold-axes are nearly horizontal in the middle section of the anticlinal zone, and their pitch gradually increases to between 40° and 60° in the areas of closure.

In studying the geological map for structure it should, therefore, be borne in mind that the Saunders Creek Formation excluding the basic intrusions, is up to 1500 feet thick, and the apparent width of the Formation, as recorded on the map, is partly attributable to structural repetitions.

The metamorphic processes and the associated stresses have produced a wide variety of microstructures in the Halls Creek Metamorphics. Boudinage is present in the sandstone of the Saunders Creek Formation (see Fig. 4 to 7), and concertina folds, symmetrical folds, and fracture cleavage are common in siltstones and greywackes.

To the east of the Saunders Creek Anticline the Saunders Creek Formation has been shaped in a linear brachy-anticline. This structure is 9 miles long, averages 1 mile in width, and is closed at both ends. The average dip of the limbs is 50°. It is separated from the Saunders Creek Anticline by a narrow syncline open to the north-east. The isoclinal folds, so widespread on the Saunders Creek Anticline, are here absent, and only minor boudinage structures and folding have been observed. On the eastern limb of this anticline the Saunders Creek Formation is absent, due either to lack of deposition or to overlapping of younger sediments after the anticline was partly formed. If the second explanation is accepted, this anticline was formed in the period between the deposition of the Saunders Creek Formation and the deposition of the topmost member of the Castle Creek Beds (Plc3).

The third of the major anticlines occurs north-west of the Bulman Waterhole, on the edge of the mapped area. It is outlined by the ferruginous chert of the Castle Creek Beds. The structure is a regular brachy-anticline whose limbs dip about 75° and whose axial plane trends north-north-west.

The north-western part of the mapped area is occupied by rocks folded into minor anticlines and synclines.

There are three main sets of faults in the area as a whole. The first set strikes north-west and has thrown up the north-easterly blocks up to several hundred feet in some places. These faults are present over the whole of the mapped area. The second set of faults, roughly orthogonal to the first, strikes north-east, and is present in the west and south. The direction and amount of throw are variable. Both sets of faults intersect and displace each other, and they are, therefore, considered to be contemporaneous. It is possible that in the west they originated through movements associated with the emplacement of the Sophie Downs Granite.

The third set of faults strikes north and affects the northern closure of the Saunders Creek Anticline. These faults have a large horizontal component of throw, and are tension release faults of the closure area. To the same type belong the radial faults which developed on the southern nose of the Saunders Creek Anticline. A long fault, east of the Bulman Waterhole, crosses the area from north to south. This fault has thrown down the eastern block for several hundred feet, and has ruptured the eastern limb of the Saunders Creek Anticline.

In a few places it is possible to determine the succession of faults relative to each other, but no evidence has been found for their absolute dating.

ECONOMIC GEOLOGY

The purpose of the geological study was the assessment of the nature and extent of the radioactive conglomerate horizon and the location of drilling sites for underground testing of the Saunders Creek Radioactive Prospect. The investigation brought to light the major influence which sedimentological and structural factors had in the genesis and the present nature and distribution of the mineralisation. These factors are here briefly recapitulated in conjunction with economic considerations.

The Saunders Creek Formation was deposited in a geosynclinal environment during a period of shallow-water conditions. These conditions developed in a restricted depositional area; hence the sedimentary body is irregular and characterized by lateral variations in lithofacies and thickness. This applies in particular to the basal radioactive member which is represented by cross-bedded sandstone containing beds of radioactive conglomerate. The conglomerate beds extend south-south-west from Bulman Waterhole along the western limb of the Saunders Creek Anticline for about 3.5 miles. They then lens out, and the member is replaced by coarse sandstone.

The basal member reaches its maximum thickness of 62 feet 1 mile south-south-west of Bulman Waterhole. Included in the 62 feet is an aggregate thickness of 7 feet of radioactive conglomerate horizons.

On the Bulman Waterhole the readings for radioactivity of conglomerate horizons are from 7 to 10 times background. This anomaly is marked 43A on the map entitled "Radioactive Anomalies (detected by airborne scintillometer) in the Wyndham-Halls Creek Region; Southern Part (Sheet 2) by the Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics". Two anomalies, E 14 and E 15 were recorded in the same locality by an Auster Airborne Scintillometer Survey in August-November 1959. Three miles to the south-south-west the readings were only 3 times background. Still farther south the conglomerate member, and with it the anomalous radioactivity, are absent. One isolated reading up to twice background was registered on a fresh exposure of coarse sandstone in locality 44 on the above-mentioned map. This locality corresponds to F16 of the Auster Airborne Scintillometer Survey in August-November 1959. The anomaly 43B located by the airborne survey on the eastern anticlinal structure has not been found on the ground.

Field observation and mineralogical studies have shown that the heavy mineral content in the matrix of the conglomerate is the source of radioactivity. The radioactive mineral has been identified as Thorogummite by W.M.B. Roberts and the evidence suggests that the mineralisation at Saunders Creek is of detrital origin.

PROPOSED DRILLING PROGRAMME

Several factors influenced the selection of the drill-sites. The necessity of intercepting the radioactive horizons where they were expected to be thickest was the foremost consideration. Tape and Abney level surveys pointed to an area one to two miles south-south-west of Bulman Waterhole. The depth of the oxidized zone was assumed to be 300' below the surface, and it was, therefore, necessary to drill below this depth. It was also necessary to avoid disturbed areas where faulting and isoclinal folding could complicate the picture. Both these conditions appear to be satisfied in the selection of the drill-site marked B.M.R. 1. Two bores have been proposed for underground testing of the radioactive conglomerate. Bore B.M.R. 1 has first priority, and B.M.R. 2 is proposed to test the extension of the conglomerate to the south in the event of a favourable result from B.M.R. 1. Tape and Abney level surveys were conducted to establish the probable succession of rock types underground. The results are shown on Plates 2 and 3, and are here summarized to the nearest 10 feet.

B.M.R. 1.

Position: 1 mile south-south-west of Bulman Waterhole on the western limb of the Saunders Creek Anticline.

Azimuth: 104° magnetic

Depression: 60°

Length: 750 feet (approx.)

Distance from water supply: 5 miles.

Sited to drill at 50 degrees to bedding, intersecting the radioactive conglomerate at a vertical depth of 520 feet below surface, and 550 feet below collar of hole.

Rock types likely to be encountered are as follows:

0' - 90' Sandstone

90' - 280' Laminated greywacke

280' - 480' Feldspathic sandstone

480' - 600' Cross-bedded sandstone and greywacke

600' - 690' Sandstone with interbedded conglomerate

690' onwards, Footwall: phyllite and volcanics.

B.M.R. 2.

Position: 2.5 miles south-south-west of Bulman Waterhole on the western limb of the Saunders Creek Anticline.

Azimuth: 126°30'

Depression: 60°

Length: 750 feet

Distance from water supply: 6.5 miles

Sited to drill at 53 degrees to bedding, intersecting the radioactive conglomerate at a vertical depth of 560 feet below surface, and 670 feet below collar of hole.

Rock types likely to be encountered are as follows:

0' - 460' Laminated greywacke

460' - 550' Feldspathic sandstone

550' - 640' Cross-bedded sandstone

640' - 700' Sandstone with interbedded conglomerate

700' onwards, Footwall: phyllite and volcanics.

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Fig. 1. Saunders Creek Radioactive Prospect. White scree in foreground is on eastern limb of Saunders Creek Anticline. Radioactive anomaly is in gorge centre left. Aerial view from N.W.

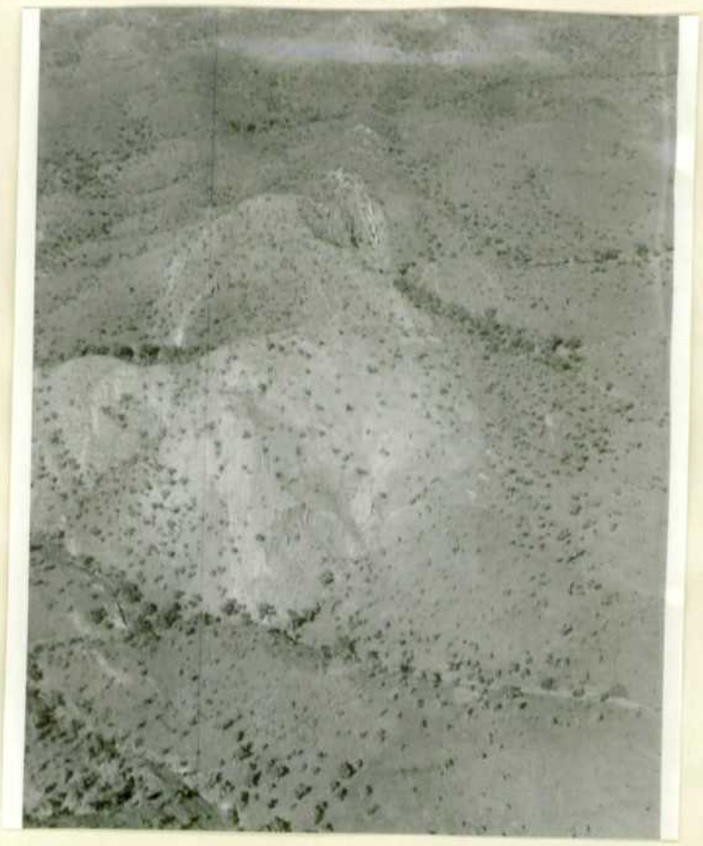


Fig. 2. Saunders Creek Anticline. Western limb is in upper centre and northern closure area in centre left. Aerial view from N.

Fig. 3. Outcrop of radioactive formation, Southern Anomaly, looking south. The outcrop forms the prominent spur in the centre of photograph.

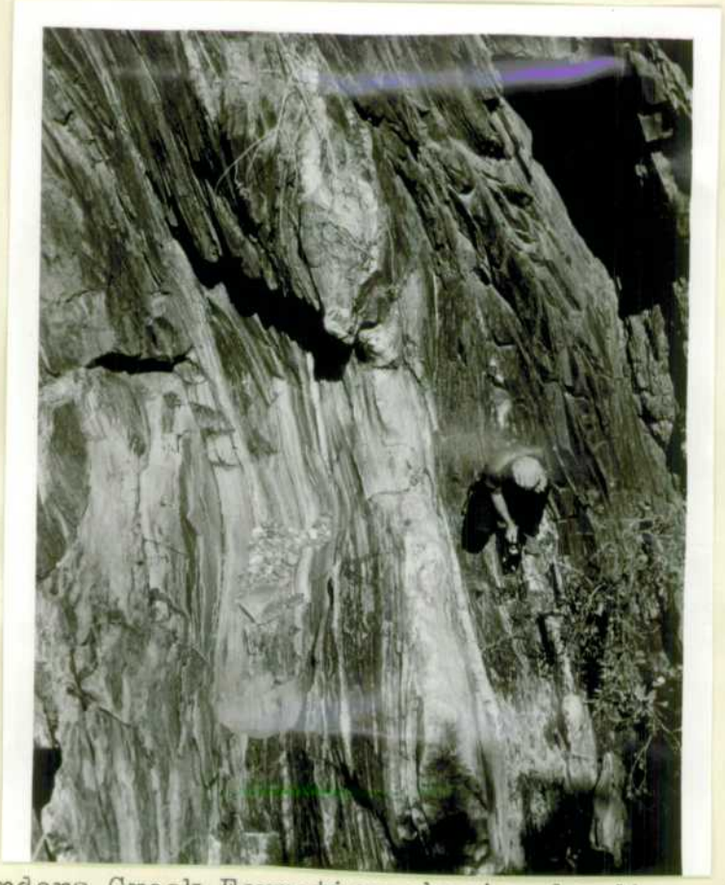


Fig. 4. Saunders Creek Formation showing boudinaged sandstone interbedded with greywacke. 3 miles S.W. of Saunders Creek on the western limb of anticline.

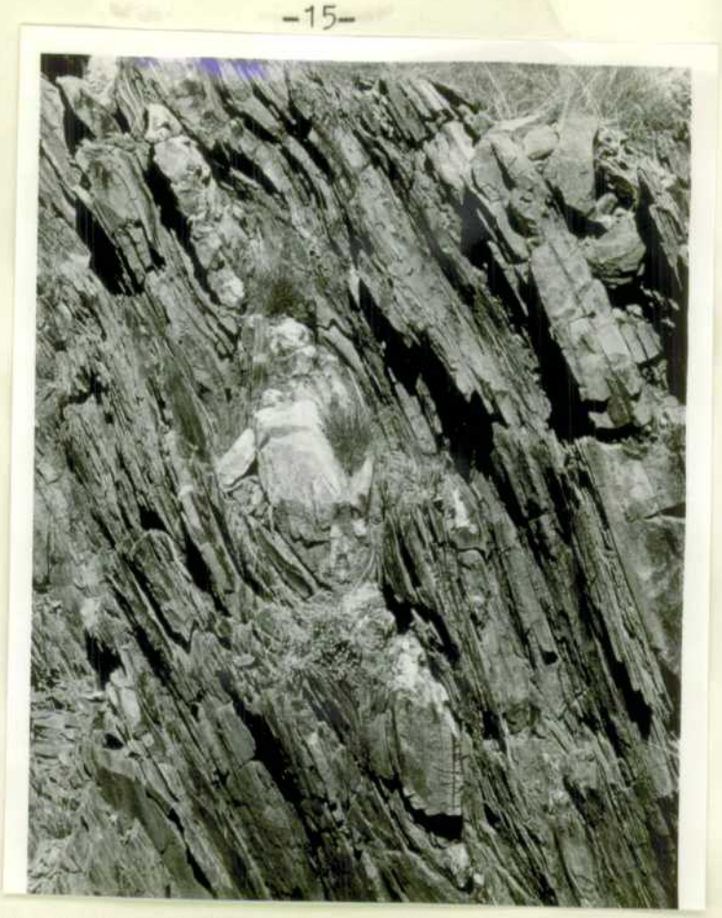


Fig. 5. Saunders Creek Formation showing boudinaged sandstone interbedded with greywacke. 3 miles S.W. of Saunders Creek on the western limb of anticline.

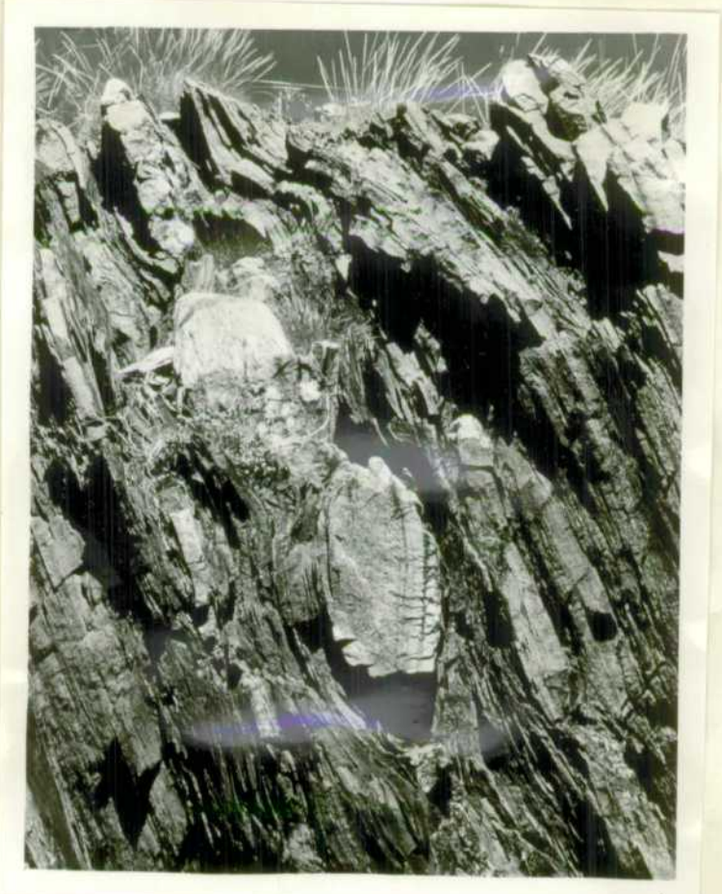


Fig. 6. Saunders Creek Formation showing boudinaged sandstone interbedded with greywacke. 3 miles S.W. of Saunders Creek on the western limb of anticline.

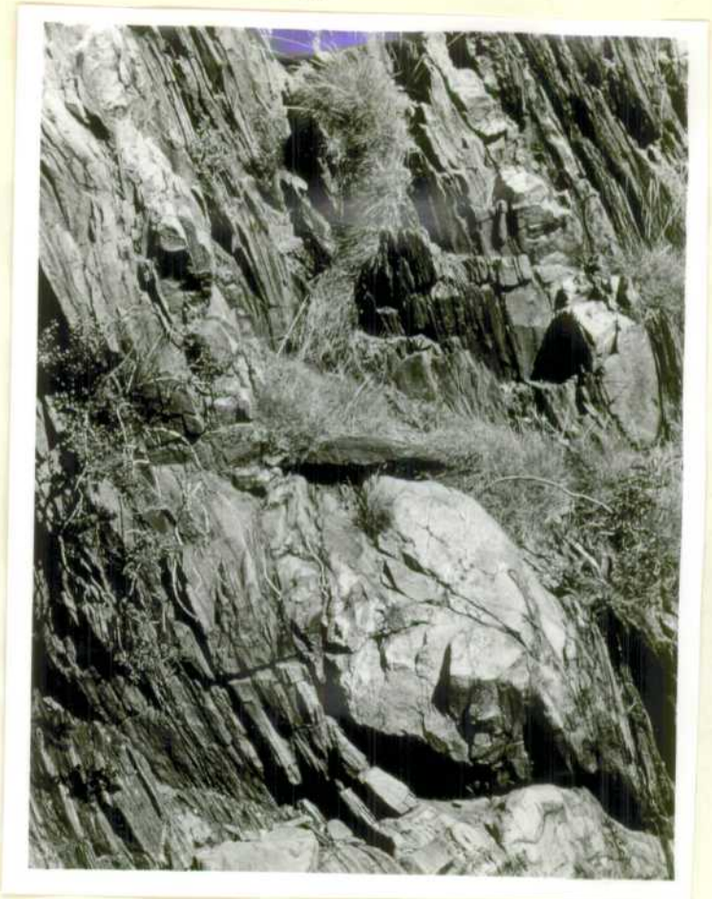


Fig. 7. Saunders Creek Formation showing boudinaged sandstone interbedded with greywacke. 3 miles S.W. of Saunders Creek on the western limb of anticline.

Fig. 8. Poorly defined conglomerate bands grading into quartz greywacke, Southern Anomaly. Note also increased heavy mineral content of rock as compared to Fig. 9.

Fig. 9. Well defined conglomerate band in quartz greywacke. Northern Anomaly.

Fig. 10. Strongly cleaved greywacke in shear zone. 2 miles south of Bulman Rockhole.

Fig. 11. Closed anticline in the N.W. of area mapped. Northern closure in left foreground. Albert Edward Range in far background. Aerial view from North.

Fig. 12. Upper Proterozoic sediments (right) unconformably overlying the Halls Creek Metamorphics (lower left). Turner Station out of view to the right. Aerial view from south.

APPENDIX I

PETROGRAPHIC NOTES

by W.B. Dallwitz

INTRODUCTION

R.A. Ruker has submitted selected specimens from the Saunders Creek area for petrographic examination. The rocks have been described under the following headings:

1. Sheared albitized rhyolites and albite rhyolites.
2. Metamorphosed sediments.
3. Altered basic igneous rocks.

PETROGRAPHY

1. Sheared albitized rhyolites and albite rhyolites

Specimen 195001. Slide 4987.

Rock unit: Undifferentiated Lower Proterozoic.

Locality: 2 Miles south of Bulman Rockhole-Gordon Downs 4 mile Sheet.

This is a hard, grey, fine-grained rock with some directional structure. It contains what appear to be porphyritic crystals of feldspar measuring about 1 mm. across.

In thin section the rock is found to consist of porphyritic crystals of albite, partly albitized microcline, and microcline embedded in a fine-grained groundmass of quartz, sericite, probable albite, biotite, and chlorite. Some parts of the groundmass are more sericitized than others. Accessory minerals are calcite, black iron-ore, epidote, hydrated iron oxide, and zircon. Original porphyritic quartz and biotite have been recrystallized on a fine scale, and the quartz especially has been drawn out into elongated bodies. A few fragments of more coarsely crystalline rock, possibly cognate xenoliths, were noted.

The original porphyritic feldspar in this rock appears to have been largely or wholly microcline. It is now seen in various stages of replacement by albite.

The rock is a sheared albitized rhyolite.

Specimen 195003. Slide 4989.

Rock Unit: Undifferentiated Lower Proterozoic

Locality: 2 miles south of Bulman Rockhole-Gordon Downs 4 mile Sheet.

This rock is light grey on the freshly broken surface and is somewhat more strongly cleaved than is specimen 195001. Some phenocrysts or clots measuring up to 5 mm. x 1 mm. lie along the cleavage.

Under the microscope the rock is seen to be generally similar to specimen 195001. However, it is less strongly sericitized, the biotite is only very slightly chloritized, and porphyritic quartz is even less plentiful than in 195001. The only microcline present occurs as relics in albite. The elongated lenses noted in hand-specimen are seen to consist of quartz and epidote. A few quartz-epidote veins also lie at an angle of about 45° to the cleavage.

The rock is a sheared albitized rhyolite.

Specimen 195007. Slide 4993.

Rock Unit: Within dolerite sill

Locality: Southern closure of Saunders Creek Anticline-Gordon Downs 4 mile Sheet.

This is a somewhat sheared light grey porphyry containing phenocrysts of quartz and pink feldspar, and thin streaks of ferromagnesian material.

In thin section the rock is found to consist essentially of porphyritic quartz and albite (Ab_{97} An_3) in a groundmass of quartz, albite, and biotite. Accessory minerals are sericite, epidote, leucoxene, (?)allanite, chlorite, black iron-ore, and zircon. The albite microlites are 0.08-0.16 mm. long, and the quartz in the groundmass has probably been finely recrystallized.

The albite microlites have a pronounced parallel alignment, but it is not possible to gauge whether this is due mainly to flow or to shearing. However, the biotite in the groundmass is considerably drawn out by shearing, so it is likely that the parallelism of the feldspar microlites is at least partly due to shearing also.

Clots consisting of biotite and epidote are fairly prominent; the origin of these is problematical; maybe they represent an original biotite-epidote association (which is common enough in acid igneous rocks) or they may result from the transformation of amphibole or pyroxene.

The quartz phenocrysts are strongly strained, and many of them have partly recrystallized as a fine mosaic.

A few of the albite phenocrysts are antiperthitic. It is possible that the albite has replaced potash feldspar, as in specimens 195001 and 195003, but one can not be certain that this is so. Most of the albite crystals contain inclusions of chlorite, and a few contain epidote as well.

The rock is a sheared albite rhyolite.

Specimen 195015. Slide 5001.

Rock Unit: Castle Creek Beds (Plc_2)

Locality: 4 miles north of Sophie Downs-Gordon Downs 4 mile Sheet.

A greyish buff, strongly schistose, fine-grained rock in which rare traces of porphyritic crystals can be distinguished with difficulty.

In thin section the rock is found to consist of a strongly sheared fine-grained groundmass in which are embedded strained and granulated porphyritic quartz crystals, scattered crystals of albite, and very rare drawn-out books of biotite. The groundmass is made up of finely granular quartz, alkali-feldspar, and strongly-aligned flakes of sericite.

Nearly all of the quartz phenocrysts have been recrystallized and drawn out into lenticular streaks; some of the albite crystals have been granulated.

Accessory minerals, apart from biotite, are calcite (as thin veins along the cleavage), iron oxide (after pyrite), leucoxene, black iron-ore, and rare (?)allanite.

The rock is a schistose albite rhyolite.

2. Metamorphosed Sediments

Specimen 195002. Slide 4988.

Rock Unit: Undifferentiated Lower Proterozoic

Locality: 2 miles south of Bulman Rockhole-Gordon Downs 4 mile Sheet.

An apparently fine-grained, grey, strongly schistose micaceous rock containing whitish lenticular streaks and thin bands measuring up to 2 mm. in width.

In thin section the rock is seen to consist of irregular, lenticular bands, some rich in sericite, and others rich in fine-grained quartz.

Magnetite is unusually abundant; it makes up an estimated 5-10% of the rock. A few grains are about 0.15 mm. across, but most average 0.025 mm.

The origin of this rock is problematical. It may be a sheared fine conglomerate or argillaceous pebble-bed, now virtually converted to a phyllonite.

The rock is a magnetite-rich quartz-sericite schist.

Specimen 195004. Slide 4990.

Rock Unit: Undifferentiated Lower Proterozoic

Locality: Saunders Creek Radioactive Prospect-Eastern anticlinal structure - 3 miles S.E. of Bulman Rockhole-Gordon Downs 4 mile Sheet.

A distinctly banded, medium-grained schistose rock consisting of irregular lenticular bands alternately rich in biotite and quartz; the bands lack continuity, and the widest is about 2.5 mm. across.

In thin section the rock is found to consist of biotite (65%), quartz (30%), muscovite and orthoclase or cordierite (5%), and rare fine-grained epidote, black iron ore, and (?)apatite. The average size of the biotite books is 0.5 mm., and of the quartz grains, 0.1 mm. The biotite has random orientation, and this, combined with a consideration of the appearance of the handspecimen, suggests that the rock was once a schist, but that it has been reconstituted by thermal metamorphism or hydrothermal activity.

The identity of the orthoclase is uncertain, some of this mineral occurs as grains with an area 5 to 20 times that of some of the biotite flakes, several of which are enclosed in the (?)orthoclase. It is possible that the mineral is cordierite, though its refractive index is probably too low.

The rock is a banded quartz-biotite "schist"; the cleavage appears to be a relict structure from a pre-existing state when the rock was entirely schistose. The rock breaks in the direction of banding, even though the mica flakes within the bands have a random orientation.

Specimen 195011. Slide 4997.

Rock Unit: Saunders Creek Formation

Locality: Saunders Creek Radioactive Prospect, 4 miles S. of Bulman Rockhole-Gordon Downs 4 mile Sheet.

This is a distinctly banded dark grey and greyish-black fine-grained, schistose rock. The widest of the dark grey bands measures about 1.5 cm. across, and is itself made up of a number of less distinct layers. The widest of the greyish black bands in the specimen measures 6-7 mm., but it seems likely that the total width of this band is not seen in the specimen.

In the slide it is found that the rock is a banded biotite-quartz-sericite schist, containing accessory magnetite octahedra. Epidote is a rare accessory.

Specimen 195017. Slide 5003.

Rock Unit: Saunders Creek Formation

Locality: Southern closure area of Saunders Creek Anticline, Gordon Downs 4 mile Sheet.

A fine-grained, dark chocolate-brown, schistose rock consisting of biotite, sericite, quartz and abundant minute (0.007 to 0.03 mm.) limonite pseudomorphs after pyrite. The rock is strongly iron-stained. The grainsize of the sericite is about that normally found in a phyllite, but the quartz occurs in very well aligned lenticles measuring about 0.1 mm. x 0.02 mm.

The rock is a ferruginous biotite-quartz-sericite schist derived from a pyritic siltstone.

Specimen 195006. Slide 4992.

Rock Unit: Undifferentiated Lower Proterozoic

Locality: 2 miles south of Bulman Rockhole-Gordon Downs 4 mile Sheet.

A hard, dark greenish grey, fine-grained schist with a rather poor cleavage. In thin section the rock is seen to be a magnetite-epidote-muscovite-albite-quartz-chlorite-schist. The muscovite, albite, and chlorite are quite well aligned. Octahedra and grains of magnetite are prominent, though not abundant, and may be seen glistening in the handspecimen. The rock has probably been derived from a calcareous chloritic shale or a calcareous greywacke-siltstone.

Specimen 195009. Slide 4995.

Rock Unit: Saunders Creek Formation

Locality: Saunders Creek Anticline, 4 miles south of Bulman Rockhole-Gordon Downs 4 mile Sheet.

This is a hard, pale pinkish grey, medium- to fine-grained rock which has the appearance of a sheared quartzite. It contains numerous light brown flecks measuring about 1 mm. across; on inspection with a lens these turn out to be weak concentrations of small grains of dark minerals. Grains of pinkish feldspar, recognizable by their cleavage, are scattered through the rock.

In thin section the rock is seen to consist mainly of quartz and clouded feldspar. The largest quartz grains measure about 1 mm.; most of the quartz occurs as finer grains (down to about 0.05 mm.) which appear to have been derived from larger grains through shearing and recrystallization. All of the quartz grains, except some of the smaller ones, are strongly strained. Nearly all the grains are of irregular shape, and interlock firmly.

Feldspar - orthoclase and subordinate microcline - makes up somewhat less than 20 percent of the rock. The size of the grains averages about 0.5 mm., and the largest is 0.75 mm. long. The dark clots noted in the handspecimen are places where a little magnetite, biotite, chlorite, or limonite (some of it pseudomorphous after pyrite), or combinations of two or more of these minerals are concentrated.

The rock is a sheared feldspathic quartzite (according to Pettijohn and Williams, Turner and Gilbert, the lower limit of feldspar content for arkose should be 25%).

Specimen 195010. Slide 4996.

Rock Unit: Saunders Creek Formation

Locality: Southern closure area of Saunders Creek Anticline-Gordon Downs 4 mile Sheet.

A medium- to fine-grained, grey, roughly cleaved, sedimentary rock containing bands rich in dark minerals.

In thin section the rock is seen to consist mainly of quartz, (about 40%), feldspars (orthoclase, microcline, and albite), calcite, probable fragments of phyllite, and octahedra of magnetite (5%). Rare accessories are chlorite, biotite, glauconite, muscovite, and zircon.

The glauconite is greenish brown and distinctly pleochroic, and some of it has a radiating structure. This mineral, as seen in thin section, appears to be identical with that described as allanite by Whittle in a private report (1958) to United Uranium, N.L., on radioactive material from Saunders Creek. However, it could not be satisfactorily separated from the crushed rock by gravity methods (superpanner and bromoform), and it was, therefore, necessary to resort to hand-picking under a microscope; this separation was done by W.M.B. Roberts. Some of the glauconite occurs as rounded to angular bodies, and some has partly replaced feldspar. Its maximum double refraction appears to be about 0.022. Most of the glauconite bodies are composite - i.e., they consist of aggregates of grains. The mineral is rather soft, and may be easily broken with a needle. Its identity was established by W.M.B. Roberts from an X-Ray powder photograph.

Quartz has mostly been recrystallized as a mosaic of fine grains, but its original grain size was probably about the same as that of the feldspar (0.3 - 9.5 mm.), which appears not to have been affected by the shearing.

The fact that the magnetite occurs as octahedra suggests that it is of metamorphic or metasomatic origin; if of metamorphic origin, it may simply represent recrystallized detrital magnetite, or it may have been derived from limonite or hematite.

The rock is a slightly sheared calcareous, feldspathic greywacke containing magnetite-rich bands.

Specimen 195012. Slide 4998.

Rock Unit: Saunders Creek Formation

Locality: 4 miles south of Bulman Rockhole on western limb of Saunders Creek Anticline - Gordon Downs 4 mile Sheet.

In the handspecimen this rock is closely similar to specimen 195009. Dark spots are more pronounced and feldspar is somewhat more plentiful. The accessory minerals are sericite, biotite, octahedra of magnetite, and chlorite. Most of the quartz has recrystallized as a mosaic of grains whose diameter measures about 0.1 mm. The feldspar grains have been only slightly affected by the shearing, and their average size is 0.3 mm.; probably the original quartz grains were of similar size.

As the feldspar percentage appears to be very close to 25, this rock may be called a sheared arkosic quartzite.

Specimen 195008. Slide 4994.

Rock Unit: Saunders Creek Formation

Locality: 2.5 miles S.E. of Bulman Rockhole on eastern wing of Saunders Creek Anticline - Gordon Downs 4 mile Sheet.

This is fairly well cleaved rock consisting of predominantly white, angular, fine-grained fragments in a grey matrix. The ratio of fragments to matrix is about 1:1. Several fragments are dark grey, and one appears to be of gossanous material containing (?)chrysocolla. The length of the largest fragment is over 3 cm; most fragments are elongated, probably through the influence of shearing.

Under the microscope nearly all the fragments appear to be sericitized acid volcanic rock; most of them are non-porphyritic, but those that contain porphyritic crystals are albite rhyolite. A few fragments are trachytic, and one or two of siltstone were also noted.

The matrix consists of fine-grained quartz, biotite, sericite, and chlorite; it contains accessory iron oxide and zircon.

The rock is a sheared breccia-conglomerate.

Specimen 195018. Slide 5004.

Rock Unit: Saunders Creek Formation

Locality: Southern closure area of Saunders Creek Anticline - Gordon Downs 4 mile Sheet.

A grey, hard, irregularly iron-stained fairly fine-grained rock with a fragmental appearance. The specimen is finely porous, and contains glistening octahedra of magnetite.

Examination of the thin section does little to clarify the identity of this rock. Most of it consists of quartz in irregular grains whose sizes range from 0.25 mm. to 0.015 mm. The larger quartz grains show strain shadows. Some of the quartz is clear, and some contains dark dust-like inclusions. The outlines of some of the "dust" - charged areas resemble flattened and distorted rhombs. Magnetite octahedra are irregularly distributed through the slide, and are commonly crowded together, especially within those areas containing dusty inclusions. An especially puzzling feature of the rock is the presence of thin sheaf-like wisps and radiating "needles" of hydrated iron oxide about 0.08 mm. long.

This rock appears to have been formed by the action of metasomatic and probably metamorphic processes upon some pre-existing material whose identity can only be guessed at. A search for clues in the field would probably give useful leads; with the evidence available I can only suggest, tentatively and most diffidently, that the rock may originally have been a siliceous sideritic ironstone, and that it could, on this assumption, be now called a silicified de-carbonated ironstone.

3. Altered Basic Igneous Rocks.

Specimen 195014. Slide 5000.

Rock Unit: Castle Creek Beds (Plc_1)

Locality: Saunders Creek, 1.5 miles east of Bulman Rockhole.

This is a hard, grey fine-grained, very slightly schistose rock consisting essentially of closely intergrown very pale green actinolite and subordinate clinozoisite. Minor constituents are calcite and leucoxene; quartz is rare. Average grainsize is 0.2 mm. or somewhat less. The rock is a clinozoisite-actinolite schist, derived from a basalt, basaltic tuff or, less probably, a dolomitic shale.

Specimen 195013. Slide 4999.

Rock Unit: Dolerite sill.

Locality: 2.5 miles south of Bulman Rockhole on western limb of Saunders Creek Anticline - Gordon Downs 4 mile Sheet.

A massive medium-grained, greenish grey, somewhat porous igneous rock consisting essentially of actinolite, oligoclase, and secondary quartz. Accessory minerals are leucoxene pseudomorphing ilmenite, possible primary quartz, epidote, chlorite, and calcite.

The rock is a uralitized dolerite.

Specimen 195016. Slide 5002.

Rock Unit: Dolerite sill

Locality: Southern closure area of Saunders Creek Anticline - Gordon Downs 4 mile Sheet.

This rock is closely similar to specimen 195013. It differs only in not being porous, and in containing considerably more epidote, less quartz, no calcite, and a trace of apatite.

It is a uralitized dolerite.

Specimen 195005. Slide 4991.

Rock Unit: Undifferentiated Lower Proterozoic

Locality: 2 miles south of Bulman Rockhole - Gordon Downs 4 mile Sheet.

A massive, medium- to fine-grained, greenish grey rock containing sub-parallel quartz veins up to 1 mm. wide. Slightly raised areas of oval, round, or somewhat irregular but smooth outline appear to be amygdales; the sizes of these areas range from about 1 cm. down to 1 mm.

In thin section the rock is seen to consist essentially of granular epidote and quartz. Very pale actinolite is a minor constituent, and chlorite is an accessory confined to amygdales and quartz veins. Some parts consist entirely of epidote, actinolite needles, and quartz.

There are some small, irregular pockets consisting of actinolite, subordinate quartz, and accessory epidote. The quartz veins contain a little epidote and actinolite, quite irregularly distributed, and rarely a little chlorite or biotite; nearly all of the actinolite needles lie at right angles to the direction of the vein.

Most of the amygdales consist of quartz, epidote, and a little chlorite; others consist of chlorite and quartz, either of which may be dominant. One is made up of quartz and only a minute amount of chlorite, and another contains actinolite needles as well as quartz, epidote, and a little chlorite and iron-ore.

This rock is most likely an epidotized and silicified amygdaloidal basalt, although it is possible that it is an altered amygdaloidal dolerite, as such rocks are known to occur. No trace of basaltic or doleritic texture remains.

CONCLUSIONS

The rocks described in this report have undergone low- to medium-grade regional metamorphism. Most belong to the greenschist facies, but specimen 195004, which has been thermally as well as regionally metamorphosed, may belong to the amphibolite facies. Evidence of shearing is quite strong in most of the specimens, less so in others, and non-existent in a few (altered dolerites and basalt).

Straight-out dynamic metamorphism appears to have been the main factor responsible for the observed changes in the sheared rhyolites.

The uralitized dolerites may have been intruded after the regional metamorphism, or they may have escaped shearing because of their competency.

PLATE 1

REGIONAL GEOLOGY
SAUNDERS CREEK RADIOACTIVE PROSPECT
WESTERN AUSTRALIA

Geology by R.A. Ruker and R. Connolly

Scale

2 Miles
2000 0 2000 4000 6000 8000 Feet

Reference

UPPER PROTEROZOIC — Pz — Undifferentiated - basal - breccia - conglomerate overlain by sediments and volcanics

UNCONFORMITY

LOWER PROTEROZOIC
AGICONDIAN SYSTEM

Sophie Downs Granite — Pgs+ — Fine to medium grained granite with xenoliths of schists and slate.

Halls Creek Metamorphics

Olympic Creek Greywacke — Plo — Thin bedded medium grained greywacke grading up into coarse greywacke

Castle Creek Beds
- Plc4 — Calcareous siltstone, ferruginous chert carbonaceous siltstone rhythmic-bedded black slate and quartz greywacke.
- Plc3 — basic volcanics grading into laminated dolomitic siltstone amphibolite and calc-silicate rocks in western part of map area.
- Plc2 — thin bedded ferruginous chert laminated siltstone and minor quartz greywacke.

Marin Creek Beds — Plm — Green laminated greywacke quartz greywacke basic volcanics dark grey and red slate

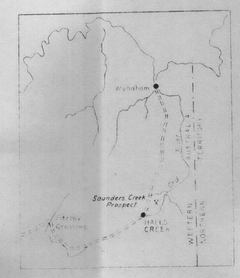
Saunders Creek Formation — Pls — Basic sills. Laminated greywacke. Massive greywacke. Fetzpathic sandstone. Undifferentiated greywacke and basic volcanics. Cross bedded sandstone with basal radioactive conglomerate

Undifferentiated — Pl — Green schistose greywacke phyllite mica-schist slate basic and amygdaloidal volcanics

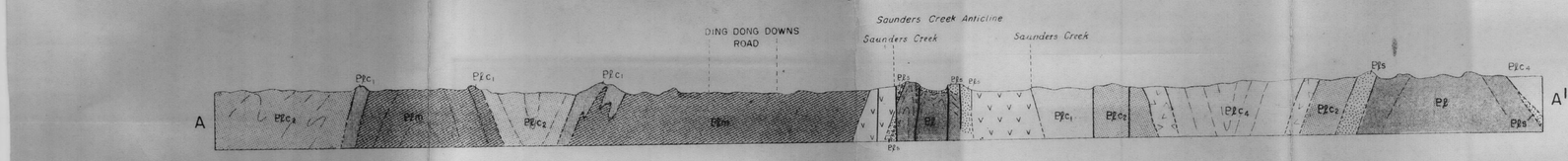
- Established geological boundary position accurate
- Geological boundary determined by photo-interpretation
- Inferred geological boundary
- Strike and dip of strata
- Strike and dip of strata determined by photo interpretation, dip over 45°
- Interpolated bedding trends
- Plunge of structure from air-photo interpretation.
- Established fault position accurate
- Established fault position approximate
- Inferred fault
- Synclinal axis position approximate
- Anticlinal axis
- Joint pattern from air photo interpretation
- Track position approximate
- Proposed borehole
- (D) 44 Airborne (DC3) radiometric anomaly
- (A) Airborne Auster radiometric anomaly
- 5122 Photo centre points

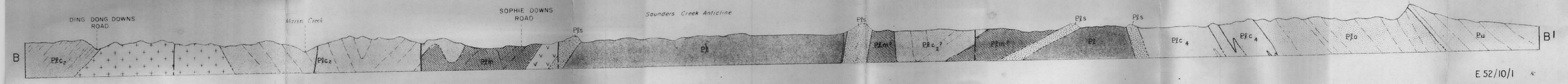
Halls Creek 1 mile area | Antrim 1 mile area — AREA MAPPED

GORDON DOWNS
4 MILE SHEET

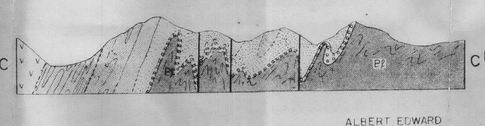


DIAGRAMMATIC CROSS SECTIONS A A', B B'





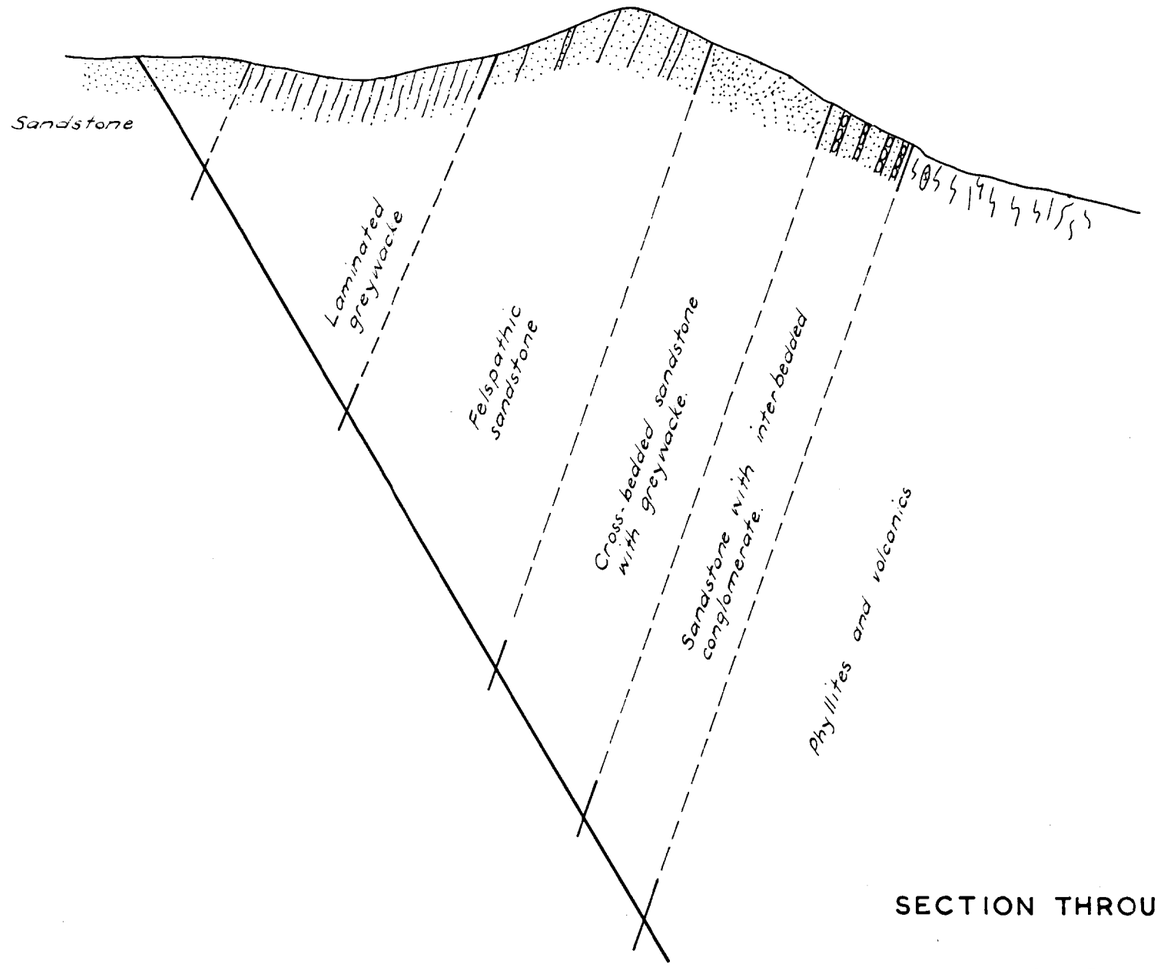
SECTION C C' (by Abney & Tape survey)



E 52/10/1

To Accompany Record 1961/39

Bureau of Mineral Resources, Geology and Geophysics, Oct 1960



Bearing : 105° magnetic
Angle of Depression : 60°
Length 750 feet (approx)

SECTION THROUGH PROPOSED BOREHOLE B.M.R. 1

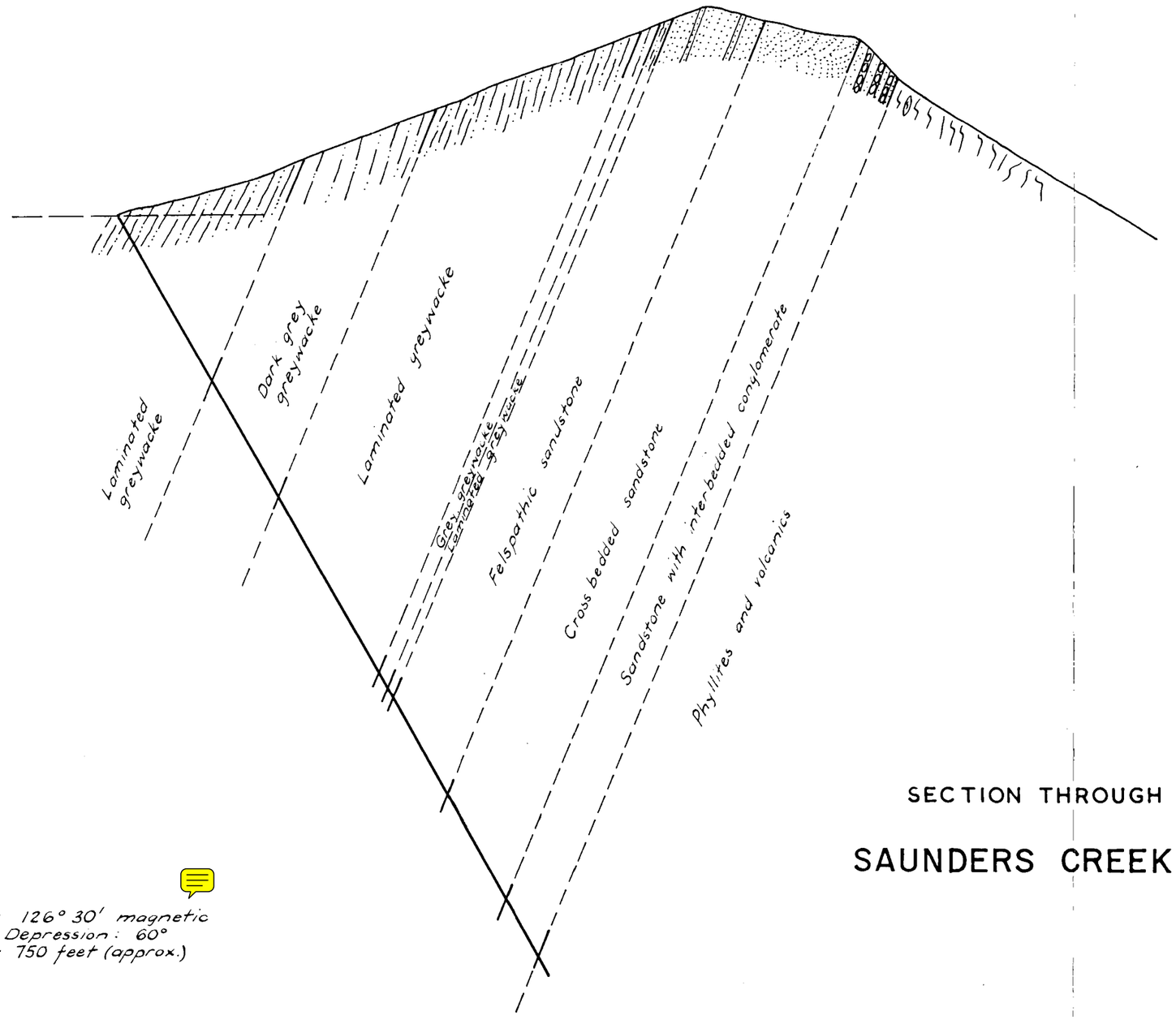
SAUNDERS CREEK RADIOACTIVE PROSPECT

SCALE

100 0 100 200 300 FEET

Bureau of Mineral Resources, Geology and Geophysics, Darwin, Sept. 1959

E 52/10/8



Bearing : 126° 30' magnetic
Angle of Depression : 60°
Length : 750 feet (approx.)

SECTION THROUGH PROPOSED BOREHOLE B.M.R. 2

SAUNDERS CREEK RADIOACTIVE PROSPECT

SCALE

100 0 100 200 300 FEET

Bureau of Mineral Resources, Geology and Geophysics, Darwin, Sept. 1959

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