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The Geology of the Katherine, Mt Todd — Lewin Springs Sheets, Northern Territory.

by.

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THE GEOLOGY OF THE KATHERINE, MT. TODD AND LEWIN SPRINGS SHEETS, NORTHERN TERRITORY.

by

J. H. Rattigan & A. B. Clark

1955/54

CONTENTS.

ILLUSTRATIONS

Illustrations have not been supplied in the hardcopy of Record 1955/54.

1. Katherine One-Mile Geological Sheet.
2. Mt. Todd One-Mile Geological Sheet.
3. Lewin Springs One-Mile Geological Sheet.

SUMMARY

This report describes the regional geology of an area approximately 1350 square miles of country near Katherine, Northern Territory, which was mapped and radiometrically prospected during geological surveys of the Katherine-Darwin region in 1953.

Pre-Cambrian, Cambrian, and Mesozoic rocks outcrops in the area. Particular attention was paid to the stratigraphy, structure, and mineralized areas of the Pre-Cambrian. A marked unconformity between strongly folded, intruded, and metamorphosed rocks and a folded, unmetamorphosed sequence was taken as the division between the Lower Proterozoic and Upper Proterozoic.

The Lower Proterozoic rocks include strongly folded, intruded and quartz veined tuffaceous sediments of the Brocks Creek Group, and the transgressive Cullen Granite. Folded basic volcanic and pyroclastic rocks of the Dorothy Creek Volcanics, and the intrusive Maude Creek Diorite may be Lower Proterozoic in age.

The stratigraphy of the Upper Proterozoic was established in sections near Edith Falls. The rocks consist of alternating sequences of acid, intermediate, and basic volcanic and pyroclastic rocks with arenaceous rock units. It is proposed to supercede the name "Buldiva Quartzite" in this area by a new nomenclature.

The relationships of Cambrian basic volcanic rocks were established.

The structure and mineralization of the area is described and the results of regional radiometric investigations are given. The area mapped includes the uranium prospects discovered by private prospectors in granitic country near the Edith River. These are the Y.M.C.A. prospects east and south of Edith Siding, Yenberrie Prospect, the six prospects of Tennyson, and the Hore and O'Connor Prospect.

The regional geological work resulted in the discovery of the A.B.C. Uranium Prospect situated in Upper Proterozoic volcanic rocks 11 miles north east of Katherine. This discovery extended the possible uranium bearing country to the wide areas of Upper Proterozoic sediments and volcanic rocks of the Katherine-Darwin region.

INTRODUCTION

Description of the Area

The region comprises 1350 square miles mapped in the One-Mile Military Sheets of Mt. Todd, Katherine, and Lewin Springs, Northern Territory.

The town of Katherine (Long. 132°15'E, Lat. 14°28'S) lies in the southern portion of the area and the town of Pine Creek lies by the Stuart Highway twelve miles north of the northern boundary of the area. The population of Katherine at the 1947 census was 371, and of Pine Creek 201. The only other settlements of any permanence in the area are a fettler's camp at Fergusson Siding, the Mt. Todd Battery on the Edith River, and an agricultural research station 15 miles north-west of Katherine.

The Stuart Highway and the North Australia Railway pass through the area. Roads to Dorisvale and Wolfram Hill have been graded but most other vehicle tracks are rough. Access to

most parts of the area is restricted during the "wet" season.

The area has the northern Australian monsoonal climate with a "wet" season from November to March and a "dry" season from April to October. The average annual rainfall at Katherine is 35 inches.

The Katherine River flows throughout the year, but water supply in other areas is a problem in the later months of the "dry" season. Water may be obtained from waterholes along the major stream courses, billabongs, and springs during the early months of the dry season, but most of these supplies are not permanent.

The greater part of the area is covered with open forest vegetation with a thick grass cover over the low areas. Narrow strips of dense forest fringe the major rivers and from these paperbark, Leichhardt and other timbers have been cut for milling; cypress stands and several species of eucalypt have been cut and milled at a saw mill in Katherine.

Cattle raising is the most important industry of the area, but is not flourishing because of poor pastures and marketing facilities. Agricultural development is restricted to small scale vegetable, fruit, and peanut production along the Katherine River. Mining activity is limited to intermittent gouging operations of prospectors and treatment of tin ore from dumps by the Mt. Todd Battery. At present exploratory and testing work by prospectors and private companies for radioactive deposits is proceeding in the Katherine and Edith River areas.

Purpose of the Survey.

The immediate purpose of the survey was to map and report on the regional geology of an area surrounding localities in which radioactive minerals had been discovered. Regional radiometric prospecting and investigation of old mineral workings were carried out concurrently.

At the beginning of the survey the Edith River area was the southern known limit of the radioactive province of the northern portion of the Northern Territory. Mapping was initiated with a view to proceeding northwards, so as to join with regional mapping being conducted in northern areas surrounding the Rum Jungle Uranium Field.

Mapping Methods and Reliability

Mapping was done by traversing with Landrovers from a base camp situated near the Edith River Crossing. An average of four days per week were spent on traverse.

Aerial photographs of scale approximately 1:30,000 were used in the field during mapping. Base maps were compiled from tracings of mosaics prepared by the National Mapping Section, Department of Interior, in 1952. The topographic control of these sheets is not uniformly accurate owing to the use of alternate photographs in making mosaics.

Reliability of mapping is not uniform, because particular attention was paid to critical areas of Pre-Cambrian rocks for stratigraphical and structural information and to mineralized localities for radiometric testing. Less attention was paid to the Cambrian and younger sequences. The western section of the Lewin Springs Sheets was not mapped in any detail beyond the margins of granite outcrop, and the geology has been interpreted from aerial photographs.

Acknowledgments.

Thanks are due to local residents of the area who indicated the positions of old mineral workings and disused tracks.

TOPOGRAPHY

The relief of the area is variable but generally low, ranging from 450 feet to 1000 feet. The topographic divisions are closely related to the nature of the rock formations.

The eastern part of the area mapped is occupied by a plateau forming the south-western extension of the Arnhem Land Plateau. The plateau is bounded by steep sandstone escarpments and is strongly dissected at the margins, exposing Upper Proterozoic rocks. Flat-lying Mesozoic sandstones form the cap rock on the undissected portions of the plateau.

A belt of low but rugged hills, cut by an intricate drainage pattern, borders the plateau on the west and marks the sediments of the Brocks Creek Group.

The topography of the granite country is marked by low rugged hills and hill masses and wide areas of low country covered with soil and scattered tors.

West of the Stuart Highway are wide areas of flat and gently undulating country developed on Cambrian sediments and forming part of the physiographic unit named by Noakes (1949) the Daly River Basin.

Mesas, buttes, and tablelands of flat-lying Mesozoic sandstones occur as relics of the old peneplain formed before the present cycle of erosion.

The area mapped forms portion of the drainage basin of the Daly River and includes the upper reaches of the Fergusson River with its tributaries the Cullen and Edith Rivers, and of the Katherine River.

STRATIGRAPHY

The present stratigraphical nomenclature for rocks of the Katherine-Darwin region is based chiefly on reconnaissance mapping and has proved inadequate for more systematic regional mapping. For this report previous nomenclature has been revised or discarded, and new rock units recognised during mapping have been given tentative names.

In the Pre-Cambrian rocks the major unconformity recognised between strongly folded, intruded and metamorphosed sediments and younger sequences of broadly folded, unmetamorphosed sediments and volcanic rocks is regarded tentatively as the division between the Lower and Upper Proterozoic.

Lower Proterozoic

Brocks Creek Group:

The oldest rocks of the area are strongly folded tuffaceous sandstones and slates which were placed by Noakes (1949) in the Brocks Creek Group.

These rocks are exposed in two main belts

(1) an area mainly east of the Stuart Highway between the headwaters of Phillips Creek and the upper Fergusson River.

(2) an area east and north-east of Katherine, between Knuckeys Creek and Maude Creek.

The topographic expression of the Brocks Creek Group varies. Between Stow Creek and the headwaters of the Fergusson River

r cks form the dissected edge of the Arnhem Land Plateau. r cks, especially where they are hornfels, form rugged hills strike ridges with steep, sharp gullies and an intricate drainage pattern. Near Driffield Creek exposures over many are confined to creeks, and the ground surface is covered a mantle of residual and partly alluvial debris containing quartz boulders and tuffaceous sandstone and slate fragments. outcrops east of Katherine are covered with thick low scrub.

The sediments of the Brocks Creek Group are overlain unconformably by Upper Proterozoic sediments or volcanic rocks, Cambrian, or Mesozoic. Rocks of the group are intruded by granite and diorite and dykes of acid porphyry and dolerite.

In the area mapped for this report the rocks of the Brocks Creek Group consist of tuffaceous sandstones, slates, phyllites, and chloritic schists. The most common surface-weathering colours are red, brown, yellow, and light grey. The primary colours seen by exposure in deep cuttings are grey-green, blue-green, and purple.

The rocks form a very uniform sequence, and no prominent markers can be traced for any distance throughout the area. Attempts have been made in the past to distinguish locally the two main types of sediment: the tuffaceous arenites and the slates. Slates are interbedded with the thicker bedded arenites as well as predominating at intervals within the sequence. However because of the close nature of the folding, the absence of markers, the poor exposure over wide areas, and the absence of unconformities, lithological distinctions have not proved mappable on the scale of mapping attempted. It is doubtful whether any subdivision in this area can be of real value in regional mapping.

No high grade of regional metamorphism has been impressed on these rocks. The more intense metamorphic effects in the sediments can be related to local dynamic and contact metamorphism.

The sediments of the Brocks Creek Group have been strongly folded with the consequent development of fracture cleavage and close spaced jointing. Stress has resulted in shearing around the noses, along attenuated limbs, and in the axial zones of the tightest folds. Dynamic metamorphism in these deformed areas has produced metamorphic rocks with cataclastic structures including mylonites and augen gneisses.

Aureoles of dark, dense hornfels surround the intrusive Cullen Granite and Maude Creek Diorite. Granitization effects of the intrusives are limited to narrow selvedges adjacent to the contact. The hornfels are chiefly quartzose rocks. Cordierite is an important contact mineral in some hornfels in the inner zones of the aureole.

The wall rock of Brocks Creek Group sediments intruded by acid porphyry and dolerite dykes is indurated and hornfelsed.

The folded rocks have been injected by silica probably representing a late stage of the magmatic intrusion. The siliceous solutions have followed all structural weaknesses to give quartz veins and reefs. The veins and reefs are most common where stress in folding has given rise to shearing in the tightest folds.

The quartz veins have various dips and thicknesses and may be classified in the following types:

(1) a saddle type around the nose of plunging folds and plunging with the fold.

(2) linear and parallel to the bedding in the limbs of folds.

(3) linear, parallel to the axial planes.

(4) linear and irregular veining along fracture planes, surfaces and openings.

The quartz veins and reefs are mineral-bearing in part, and the bulk of gold and tin worked in the area was derived from them. Generally the more purely siliceous white quartz reefs are barren, and quartz-ironstone types have proved the richest of the mineral-bearing veins.

At several localities bedding-plane replacement of shaly members of the Brocks Creek Group by quartz-hematite veins adjacent to major fault zones are thought to result from injection or replacement of sediments of the Brocks Creek Group.

The thickness of the Brocks Creek Group cannot be readily estimated in the area mapped because of the complexity of folding. At least 15,000 feet of sediments are believed to be represented.

Cullen Granite:

Granitic rocks are exposed on both sides of the Stuart Highway north of the first railway crossing south of Edith Siding. The exposure of granite is bisected by an embayed outcrop of hornfelsed sediments in the Ferguson River Area.

These granitic rocks are the southernmost exposures of the Cullen Granite named by Noakes (1949), which extends in a northerly direction for about 60 miles.

The granitic rocks are intrusive into the Lower Proterozoic sediments of the Brocks Creek Group. They are intruded by acid porphyry and dolerite dykes covered in part by the flows of FergussonVolcanics, and overlapped by Upper Proterozoic, Cambrian, and Mesozoic sediments. The age of the granite is regarded as Lower Proterozoic.

The granite results from a transgressive magmatic intrusion. Intrusion at the level represented by the present erosion surface is proved to be younger than the folding by the truncation of the fold pattern of the Brocks Creek Group by the granite, and by the injection of granite along fracture cleavage planes to give a regular vein network in hornfels as observed along Yenberrie Creek.

The granite is surrounded by a contact-metamorphic aureole of Lower Proterozoic hornfels. The contacts of the granite with Lower Proterozoic sediments are generally clean and sharp with very little granitization or hybridization. Angular stoped blocks and fragments of hornfels may be seen in the granite near the contact at several localities.

Small cupolas of granite are observed at Yenberrie Wolfram Field and along Yenberrie Creek.

Three major phases of the Cullen Granite were recognised and distinguished during mapping. Most of the boundaries mapped were approximate, as good exposures along contacts were uncommon. The three phases were

(a) Edith Crossing Type

(b) Copperfield Creek Type

(c) Meenie Creek Type.

(a) Edith Crossing type

The dominant granitic type in the southern and eastern

x. sures of the Cullen Granite is a massive coarse-grained uartz-felspar-mica granite which is relatively uniform in xture, although the alkali felspars tend to be porphyritic. preferred orientation is shown by the component minerals.

The type is well exposed near the low level crossing of the Stuart Highway over the Edith River, and has been named the dith Crossing type. It is common in many parts of the Cullen tholith, and has been recognised near Coronation Hill and outh of Hayes Creek beyond the area mapped.

The Edith Crossing type is typically developed as large r unded tors distributed over grey soils scattered with a thin surface sand of coarse quartz and felspar. Sheet exposures are found along creek and river courses and the granite in places forms low rugged hills.

(b) Copperfield Creek type

A porphyritic coarse-grained granite or granodiorite exposed in the area between the Cullen River and Lewin Springs has been named after Copperfield Creek, a tributary of the Cullen.

This type has large, porphyritic, zoned and twinned felspars ranging up to 10 cm. in length, embedded in a coarse quartz-felspar-biotite-hornblende matrix.

The Copperfield Creek type is developed as residual large and small tors and in places forms low hills.

(c) Meenie Creek type.

A medium-grained pink quartz-felspar rock with very small amounts of accessory ferromagnesian minerals has been mapped throughout the area. This type has been named after Meenie Creek, a tributary of the FergussonRiver. It has been referred to by Fisher (1952) as "fine-grained granite" and in petrological reports by W. B. Dallwitz as "aplite" and "medium-grained adamellite".

In many areas the Meenie Creek type is quite distinct from the Edith Crossing type and Copperfield Creek type; but over wide areas it is associated with porphyritic medium-grained and coarse-grained rocks which are very variable in texture and composition and may represent hybrid varieties of the Meenie Creek type.

The Meenie Creek type is developed as low outcrops and small tors and has a characteristic cover of thick scrub. The porphyritic varieties commonly form low tor-strewn hills.

Relationships of the phases of Cullen Granite:

Exposed contacts of the three granitic types are rarely observed and their age relationships are not easily established.

Small exposures east of the Cullen River suggest that the Copperfield Creek type has been hybridised by assimilation of blocks of the Edith Crossing type.

Contacts of the Meenie Creek type with the Edith Crossing type may be observed west and West-north-west of the shaft sunk on the "A" prospect (Fisher, 1952) of the Edith River Uranium leases held by Messrs. Young, Mazlin, and Cousens. In this area the medium-grained Meenie Creek type is disposed as an irregular sheet over the coarse Edith Crossing type and caps the highest hills. The apparent topographic relationship is that the coarser type intrudes the finer type, but narrow parallel-walled dykes and veins of the Meenie

Creek type have been observed cutting into the coarse granite from the normally sharp contact. Supporting petrological evidence from specimens at the contact suggest that the Meenie Creek type definitely intrudes the Edith Crossing type. The Meenie Creek type appears to form a sheet-like intrusion over the roof of the coarse granite in this area.

Intrusion of the Edith Crossing type and Copperfield Creek type by dykes of the Meenie Creek type has been observed at other localities near contacts. In some places confusion with aplitic veins may exist.

The tentative age relationships based on the limited information available is that the Edith Crossing type is the oldest and the Meenie Creek type the youngest of the intrusive phases of the granite.

Greisens:

Associated with the granite are a number of dyke-like structures which have been grouped under the term greisen. These greisens consist of granular, almost purely quartzose rocks with minor quantities of micaceous minerals and tourmaline. Wolfram, tin and molybdenite are localised in the greisen bodies which usually trend at about 160°.

Certain quartz-mica rocks of sheared zones have also been termed greisen. These are commonly sheared and are considered to have formed through alteration of sheared granite.

Dorothy Creek Volcanics:

Near the Maude Creek gold workings and in the Carpentaria Valley is a sequence of folded basic lavas, pyroclastic rocks, and tuffaceous sediments, which have been intruded by hypabyssal rocks and by coarse plutonic basic rocks which are referred to the Maude Creek Diorite.

These rocks appear to be more strongly folded, more altered and petrologically distinct from the volcanic rocks of the Edith River Group. They are apparently part of an older sequence which is tentatively placed in the Lower Proterozoic and termed the Dorothy Creek Volcanics.

They overlie the Brocks Creek Group, but the relationship with the Edith River Volcanics has not been established. A correlation probably exists with similar petrological types found in the South Alligator area near the hill known as Big Sunday.

Maude Creek Diorite:

A coarse-grained plutonic rock consisting of felspar and hornblende has intruded sediments of the Brocks Creek Group and the Dorothy Creek Volcanics near Maude Creek and in the Carpentaria Valley. This rock has been named the Maude Creek Diorite. The diorite is overlain by the Mt. Callenan Group and is regarded as possibly Lower Proterozoic in age.

Similar plutonic rocks are found in the South Alligator Region near Coronation Hill.

Upper Proterozoic

The Upper Proterozoic sequence was established in sections along the upper reaches of the Edith River, where a continuous section is exposed across the western flank of a broad basin.

Previously the only Upper Proterozoic rock unit recognised in the area was the "Buldiva Quartzite" (Noakes, 1949), the sandstones of the area being correlated with those at Buldiva.

This term was used for what have proved to be three sandstone units alternating with basic lavas and pyroclastics; and since the relationships of these units with the Buldiva Quartzite in the type area are not sufficiently clear, local names have been given to the rock units.

Volcanic rocks of the Katherine Edith River area were placed in the Lower Cambrian by Noakes (1949), who referred them to two units, the Edith River Volcanics and the Maude Creek Volcanics, named from two areas in which volcanic rocks had been observed.

In the areas mapped as Lower Cambrian Volcanics by Noakes are Cambrian volcanic rocks, several sequences of Upper Proterozoic volcanic rocks, intrusive hypabyssal and plutonic igneous rocks, and some Lower Proterozoic volcanics. The terms Edith River Volcanics and Maude Creek Volcanics have therefore been revised and redefined as a result of the mapping programme of 1953.

Edith River Volcanics:

A marked unconformity is observed between the strongly folded sediments of the Brocks Creek Group and the broadly folded Upper Proterozoic rocks which include sandstone, conglomerate, volcanic and pyroclastic rocks, and tuffaceous sediments. These rocks, forming the base of the Upper Proterozoic sequence and here named the Edith River Volcanics correspond in part to the Edith River Volcanics of Noakes (1949). They are distributed along the flanks of the Edith Falls Basin and surround a core of Brocks Creek Group sediments in the 17-mile Creek Anticline.

The Edith River Volcanics are a complex assemblage of volcanic rocks, pyroclastic rocks, sediments, and tuffaceous sediments, which have marked lateral and vertical variation.

Near Phillips Creek, 900 feet of sandstone, conglomerate, slate, and tuffaceous sediments form a north-trending strike ridge which truncates the fold pattern of the Brocks Creek Group. These sediments are regarded as forming the base of the Edith River Volcanics in the Phillips Creek area and have been distinguished as the Phillips Creek Sandstone Member.

The lithology of the Phillips Creek Sandstone Member is variable. The most typical rock type is a dense even medium-grained purple sandstone with dark crescentic markings. Red and purple shales are interbedded. Conglomerates, which are very lenticular and variable in thickness, are important in the section. They comprise pebbles and boulders of sediments of the Brocks Creek Group and reef quartz embedded in a heterogeneous unsorted sandy matrix.

Near the unconformable contact with the Brocks Creek Group the sediments are folded into small anticlines and synclines which may be due to initial deposition modified by later folding. The slates are commonly fracture cleaved.

The typical lithology of the Phillips Creek Sandstone Member is not developed at the base of the Edith River Volcanics in areas north-east of Katherine. However, the base of the Edith River Volcanics in these areas is commonly a heterogeneous conglomerate with a pyroclastic or volcanic matrix, which probably corresponds with the Phillips Creek Member.

Above the Phillips Creek Sandstone Member near Edith Falls and unconformably above the Brocks Creek Group in other areas, are acid, intermediate, and basic flows, pyroclastic rocks, and tuffaceous sandstones, slates, and conglomerates. A section measured west of Edith Falls is summarised below.

t. llanan roup	Conglomerate and Conglomeratic Sandstone
	Minor Unconformity
	Thin and well bedded, red and purple greywacke with derived volcanic constituents and slates. 20 feet.
	Dark intermediate and basic lavas, with contorted flow structures; dense black basalt; and pyroclastic rocks. 1,300 feet.
Edith River Volcanics.	Brown porphyritic acid or intermediate lava, possibly dacite, with well developed flow structure and jointing. 1,200 feet.
	Conglomerate, with boulders of Brocks Creek Group sediments, volcanic rocks, and reef quartz, in an unsorted heterogeneous matrix. 20 feet.
	Dense blue-black basalt. 50 feet.
	Conglomerate with boulders of Brocks Creek Group sediments, volcanic rocks, and reef quartz, in a fracture-cleaved unsorted heterogeneous matrix. Approximately 400 feet.
	Major Unconformity
Brocks Creek Group	Strongly folded quartz-veined tuffaceous sandstones and slates.

At other localities tuffs and tuffaceous sediments form an important part of the Edith River Volcanics: they include tuffaceous sandstone, shales, conglomerate, agglomerate, tuffs, and ashstones, red, green and grey-green in colour, and fracture-cleaved and jointed.

Another section from the Phillips Creek area is shown in cross-section in Fig. 1.

Flow structure is very well developed in some of the brown acid porphyritic flows which are tentatively called dacite. The more basic dark flows, which are probably andesitic in character, are characterised by a less regular flow structure. Strongly contorted flow structure in these rocks at many localities results from deformation of a viscous cooled lava, which suggests that the composition of the dark flows was andesitic rather than basaltic.

At some localities the dark intermediate flows have been replaced by hematite. Narrow quartz and quartz-haematite veining and some brecciated quartz-haematite veins are observed in these rocks.

The intrusion of dolerite dykes has bleached and indurated the rocks of the Edith River Volcanics where they form the wall rock.

The rocks of the Edith River Volcanics are folded into minor anticlines and synclines on the flanks of the major structures.

Mt. Callanan Group:

A conglomeratic sandstone is transgressive over the Brocks Creek Group and Edith River Volcanics north of Edith Falls and at other localities. Basal conglomerates of this unit contain boulders of tuffaceous sediments of the Brocks Creek Group and volcanic rocks of the Edith River Group: these range in size up to 30 inches in length.

From this evidence an unconformity is believed to exist between the Edith River Volcanics and the overlying sequence of alternating sandstones and volcanic rocks, although angular discordance is never very marked. The sequence above the Edith River Volcanics has been named the Mt. Callanan Group in the South Alligator River area. The rocks mapped by Noakes (1949) in the Katherine area as Buldiva Quartzite correspond with the Mt. Callanan Group.

The Mt. Callanan Group, capped with a thin discontinuous cover of Mesozoic sediments, forms the dissected plateau north and north-east of Katherine. The basal conglomeratic sandstone forms a cap rock for the steep escarpments which bound the plateau. Volcanic rocks developed on the plateau form low soil-filled strike valleys with bounding escarpments of sandstone.

The Mt. Callanan Group is well exposed east of Edith Falls which is the type locality for the sequence in the area mapped. At the type locality, the rock units distinguished have been assigned letter symbols until their continuity and extent into surrounding areas is determined and formal naming proved applicable.

The sequence established east of Edith Falls is summarised below.

1. Puc A.

This unit consists chiefly of massive, light grey or white, unsorted, conglomeratic and silty, medium-grained to coarse-grained sandstone succeeded by well bedded even medium-grained sandstones and red silty sandstones and sandy siltstones. Its thickness is approximately 3,000 feet.

Basal conglomerates developed in some areas are lenticular and variable in thickness, ranging up to 80 feet two miles north of Edith Falls. The phenoclasts comprise pebbles and boulders of tuffaceous sediments from the Brocks Creek Group, reef quartz, and volcanic rocks from the Edith River Volcanics, ranging up to 30 inches in length. Where the conglomerates are deposited over the Edith River Volcanics the matrix is heterogeneous and is composed of a considerable proportion of derived tuffaceous and volcanic material. Where developed over the Brocks Creek Group the conglomerate matrix is an unsorted sandstone.

The massive conglomeratic sandstones are strongly jointed and coarsely current-bedded. The most common phenoclasts are well rounded white quartz pebbles. The well-bedded sandstones at the top of the unit are characterised by ripple marking and regular current bedding. Bedding and current bedding are often outlined by brown or grey colour-banding.

. Puc B.

This unit consists of volcanic and pyroclastic rocks including amygdaloidal basalt, dense blue basalt, dolerite, acid lavas, tuffs and agglomerate, approximately 740 feet thick.

These rocks form low strike valleys outlining the major folds on the plateau surface. Exposures are generally poor, being low outcrops projecting from residual volcanic soils and ferruginous pisolitic laterite gravel.

The amygdaloidal fillings in basalt comprise chalcedony, zeolite and carbonate and are often copper bearing. Secondary uranium minerals coat the vesicles at the A.B.C. Prospect which is in this unit.

3. Puc C.

This unit, about 650 feet thick, consists chiefly of well bedded current-bedded ripple-marked light grey sandstone with thin-bedded red, brown, and purple silty sandstones and sandy siltstones.

4. Puc D.

This is a second unit of volcanic rocks (370 feet thick) including basic and intermediate lavas and pyroclastic rocks which occupy a low valley in the plateau surface and are masked by residual soil and pisolitic laterite. The continuity of the unit around the Edith Falls Basin has not been proven.

Cupriferous amygdaloidal fillings have been observed in basalts.

5. Puc E.

The youngest unit recognised in the Upper Proterozoic sequence is a third sandstone exposed in the axial area of Edith Falls Basin and capped by Mesozoic sediments. Only a partial thickness of 1,000 feet was measured.

The sandstone and volcanic units of the Mt. Callanan Group are generally distinct and continuous over the area mapped. The normal sequence is irregular in the most structurally complicated area near the ABC Prospect north of Katherine. In this area volcanic rocks apparently similar in type to those of the Edith River Volcanics are found interfingering with the sandstones of the unit Puc A. Near the Carpentaria Valley thin intercalations of lava occur at intervals in the Puc A sequence: apparently vulcanism of type characteristic of the Edith River Volcanics persisted later in this area than elsewhere.

Ferguson Volcanics.

Acid lavas and associated hypabyssal rocks of the Ferguson River area were described by Carter (1952) and named the Ferguson Toscanite. These rocks are now called the Ferguson Volcanics.

The acid flows, dykes, and sills overlie or intrude sediments of the Lower Proterozoic Brocks Creek Group and the Cullen Granite and are overlain by Cambrian sediments. The Ferguson Volcanics are therefore considered to be Upper Proterozoic in age.

Pink and brown acid lavas with small phenocrysts of pink felspar, hornblende, and rarely quartz are exposed over about nine square miles of hilly country west of the junction of the

Cullen and Fergusson Rivers. The lavas range from trachyte to dacite in composition. They are strongly fractured by well developed systems of closely spaced joints. Flow structures where present dip at low angles. A detailed analysis of flow and fracture structures was not attempted, but there appears to have been little disturbance of the flows from their original attitude by later folding.

Acid lavas of varying macroscopic appearance and composition, associated in many places with hypabyssal intrusives, are distributed as outlying patches over 200 square miles of the Mt. Todd and Lewin Springs Sheets, west of the Yenberrie Uranium Prospect. The lavas also extend into the unmapped areas of the Table Top Sheet and occur as inliers within the area of Cambrian overlap along the Dorisvale Track. The hypabyssal intrusives include sills and dykes of varying macroscopic appearance, texture, and composition. Carter (1952) reports a sill of maximum width 1,100 feet exposed south-east of Mt. Giles and apparently the source of lavas in this area.

The relationships of the hypabyssal rocks are not always clear as they commonly outcrop as piles of boulders which have a linear distribution in the case of dykes. Contact relationships have been observed where dykes of acid porphyries cut the Cullen Granite. Fine-grained chilled phases adjacent to the dyke walls grade into the coarse central phases of the dyke.

In texture the hypabyssal rocks are porphyritic fine-grained to coarse-grained rocks corresponding to adamellite and granodiorite. The phenocrysts are large euhedral grey or pink felspar crystals, with subordinate hornblende and quartz. The felspar phenocrysts range up to 3 cm in length in the coarser grained rocks.

The dykes range in thickness from inches, as in narrow veinlets near the Yenberrie and Tennysons Uranium Prospects, to 30 feet.

Porphyry Dykes;

Sediments of the Brocks Creek Group between Bull Creek and Phillips Creek are cut by porphyry dykes which range up to 2½ miles in length and up to 30 feet in thickness.

The dykes consist of porphyritic fine-grained acid or intermediate rocks which differ from the dyke rocks of the Fergusson Volcanics of the Fergusson River area in that they are generally slightly altered and strained. They are for this reason distinguished from the Fergusson Volcanics.

The phenocrysts consist of fresh pink or reddish alkali felspar, greenish altered alkali felspar, and dark amphiboles. The matrix is commonly brown or pink, and fine-grained.

The dykes trend northerly or north-north-westerly. In some cases they appear to have been feeders for porphyritic acid lavas overlying the Brocks Creek Group in this area.

The age of these dykes is tentatively placed as Upper Proterozoic.

Cambrian.

The Cambrian rocks of the area consist of sub-horizontal or broadly folded basic volcanic rocks and a sequence of sediments which overlie the Brocks Creek Group, Cullen Granite, and Upper Proterozoic rocks unconformably.

Noakes (1949) distinguished two units as Lower Cambrian Volcanics, the Edith River Volcanics and Maude Creek Volcanics. The rocks mapped as these units consist largely of Pre-Cambrian volcanic rocks and as these names are no longer suitable for the Cambrian a new nomenclature is proposed.

Leight Creek Volcanics:

The most northerly exposures of Cambrian volcanics observed in the area lie west of the Stuart Highway about five miles south from the Edith River Crossing. Here thin amygdaloidal basalt flows are interbedded with the conglomeratic brown sandstones which overlie the Brocks Creek Group with marked unconformity.

The sequence of well-bedded brown sandstone and conglomerate, with interbedded basalt and dolerite, is exposed in a belt trending south-east through Helling Siding to Leight Creek, and north-east of Katherine to Maude Creek.

The basalt and dolerite form patches of high-level poorly drained cracked black soils scattered with slabs of brown Cambrian sandstone and with few exposures of basalt. The interbedded sandstones are generally expressed as low rises or as scattered slabs.

The relationship of these Cambrian volcanics to the older rocks of the Edith River Volcanics is best seen on the banks of Leight Creek or its tributaries. In this area thin horizontal conglomerates or sandstones interbedded with basalt overlie folded andesitic lavas unconformably. The basal Cambrian sequence of basalt and sandstone has been named from this locality the Leight Creek Volcanics.

The basal member of the Leight Creek Volcanics is generally a thin bed of conglomerate containing fragments of granite, reef quartz, tuffaceous sandstone of the Brocks Creek Group, or volcanic rock from the Edith River Volcanics, depending on the nature of the underlying rocks.

This distinctive conglomerate is followed by amygdaloidal basalts and melaphyres and brown ophitic dolerite interbedded with brown even-grained sandstones. The sandstone beds range from inches to tens of feet in thickness and are indurated at the upper surface by the overlying basalt flows.

The Cambrian volcanics differ from the underlying Upper Proterozoic sequences by being invariably basic in composition and in this respect can be correlated with the Antrim Plateau Volcanics of the Ord-Victoria River Region.

The volcanics appear to be thicker where they are exposed along the old track to Maude Creek and Maranboy, north-east from Katherine.

Basal Cambrian Sandstones:

The base of the Cambrian sequence near the junction of the Edith and Fergusson Rivers consists of about 40 feet of coarse brown arkose, conglomeratic sandstone, and brown sandstone members which are similar to the sandstone members of the Leight Creek Basalt.

These rocks are probable time equivalents of the Leight Creek Volcanics but differ in having no volcanic components. They will not be named until their extent is known; but it is possible that they form a unit distinct from the overlying algal and brachiopod limestones of the Daly River Group.

Daly River Group:

The name Daly River Group (Noakes, 1949) has been retained for an undifferentiated sequence of massive algal limestones, well-bedded limestone, calcareous sandstone, calcareous siltstone, and sandstone, which overlie the Leight Creek Volcanics.

The Daly River Group covers wide areas of country south-east, south-west and north-west of Katherine. The rocks of the group have given rise to characteristic residual red soils forming timbered plains country with some sink-holes.

The type of outcrop varies according to the lithology. The massive fluted and pinnacled algal limestones near Katherine crop out as low, rugged, karst-weathered hills and rises. Caverns and sink-holes are characteristic of the limestone country. Well-bedded calcareous and arenaceous sediments are exposed as low rises and as lines of scattered slabs which may occur over wide areas.

The programme of mapping in the area was chiefly concerned with the Pre-Cambrian rocks and their economic importance and the rocks of the Daly River Group were crossed only along widely spaced traverses. With more detailed mapping the Daly River Group may be subdivided into units of lower rank, although the gentle folding and discontinuous exposure of the rocks will make mapping difficult.

Massive Girvanella limestones occur low in the sequence and are apparently succeeded by well bedded limestones containing glauconite and carrying a brachiopod and trilobite fauna. These rocks are succeeded by interbedded brown even-grained sandstones, flaggy limestones, red calcareous siltstones, and calcareous sandstones, which are exposed along an old timber track which runs westward from the Stuart Highway near the 15-mile Agricultural Research Station.

The thickness of the Daly River Group in this area is difficult to estimate because of the sub-horizontal or gently folded attitude of the rocks and their discontinuous exposure.

Dolerite Dykes:

Systems of dolerite dykes cut the sediments of the Brocks Creek Group, the Cullen Granite, the Edith River Group, and probably the Mt. Callanan Group.

In the Edith River area the dolerite dykes are developed in the sheared zones of the granite trending at 160°-180°. Dolerite dykes may be observed near the uranium prospects of Yenberrie, Tennyson's and YMC Syndicate. North-east of Katherine the trend of the dolerite dykes is east-north-east. The dolerite is not everywhere well exposed and the dykes are commonly expressed by two parallel indurated and sometimes brecciated walls between which is a depression where the dolerite has weathered. The dolerite has not been seen cutting the Mt. Callanan Group, but dykes cutting the Edith River Volcanics trend into narrow linear gorges in the sandstones of the Mt. Callanan Group and these may represent dykes in which the dolerite has weathered deeply. The dykes range up to 2 miles in length and 15 feet in thickness.

The age of the dykes is tentatively placed as Cambrian: they cut at least part of the Upper Proterozoic sequence and the Cambrian igneous rocks, like the dykes, are invariably basic in type.

Mesozoic

Mullaman Group:

Mesozoic rocks named by Noakes (1949) the Mullaman Group are exposed in many parts of the area as thin, essentially horizontal cappings over older rocks.

The level undissected tableland over the plateau formed of Upper Proterozoic rocks in the eastern portion of the Mt. Todd Sheet is formed of laterite-covered sediments of the Mullaman Group. Outliers of the group are disposed over Pre-Cambrian rocks in the dissected portions of the plateau.

Near Foulsches Headland and Beasleys Pillar horizontal sediments of the Mullaman Group form tablelands with steep escarpments, promontories, long reintrant valleys, and outlying mesas and buttes.

Sandstones with a dense siliceous hard-cap exposed in isolated masses and as thin cover over the Cambrian limestones on the Katherine Sheet were once regarded as Cambrian; these rocks are however unconformable on the Cambrian and are now regarded as belonging to the Mullaman Group.

The rocks of the Mullaman Group have been observed unconformably on all older rock units and the lithology of the basal beds varies according to the nature of the underlying rocks.

Above sandstones of the Mt. Callanan Group the basal members of the Mullaman Group are frequently conglomeratic. The pebbles are chiefly of white quartz and are probably pebbles derived from older conglomeratic sandstones.

Where developed over granite, the basal members are generally arkose, white claystone or clayey sandstone consisting of granitic debris with a clay matrix derived from the decomposition of felspars.

Distinct lithological and colour variation mark the members of the Group exposed in escarpments. Generally the group consists of white, buff, and brown current-bedded ripple-marked, sorted and unsorted sandstone, white siltstone, claystone and sandy siltstone.

The maximum observed thickness of the Mullaman Group in this area was approximately 100 feet.

No collections of fossils were made from the Mullaman Group in this area and the age of the rocks is uncertain. Noakes placed them as Lower Cretaceous in age rather than the Upper Jurassic age used. Determinations made by previous workers; Brunnschweiler (1953) on plant fossils collected from other parts of the Northern Territory suggest that part of the Mullaman Group may be Upper Jurassic.

Post-Mesozoic Sediments.

Tertiary Laterite:

Laterite remains as cap rocks on the undissected tablelands formed by the Mullaman Group. Profiles showing an upper cap of sand-covered pisolitic ironstone of the ferruginous zone and siliceous material of the mottled and pallid zones were examined east of Helling Hill where the laterite is developed on Mesozoic and Cambrian strata.

Sand-covered pisolitic ironstone gravels are disposed over wide areas of plains country underlain by Cambrian sediments west of the Sturt Highway north of Katherine.

Superficial Deposits.

Brown-stained grey chert covers low rises underlain by Cambrian rocks between Leight Creek and the Dorisvale track. This chert is believed to be a secondary replacement of limestones and calcareous siltstones, and may be related to laterization processes.

Consolidated stream conglomerates and gravels are found fringing many creeks between Mt. Todd Battery and Horseshoe Creek, and near Yenberrie Creek.

Over wide areas in the Driffield Creek area the Brocks Creek Group is covered by a mantle of residual and alluvial debris through which project quartz reefs and blows.

Patches of siliceous sinter probably marking old springs were observed west of Emerald Creek tin workings.

Residual and alluvial soils cover wide areas of the Katherine area; these are described by Christian and Stewart (1952).

STRUCTURAL GEOLOGY

Folding.

Brocks Creek Group:

The sediments of the Brocks Creek Group were folded before the transgressive intrusion of Cullen Granite. The type of folding ranges from open folding with moderately steep flank dips to tight isoclinal folding with steeply dipping and overturned limbs. The development of fracture cleavage and shearing accompanied the fold movements.

In the area mapped the fold structures were not mapped in detail except for a few folds in the area between Bull Creek and Phillips Creek. The mapping of the complete fold pattern was not possible in the time available because of the absence of prominent marker beds, concealment over wide areas, and hornfels near the granite contact. In strongly cleaved rocks bedding can only be determined at distinct lithological boundaries.

The Upper Proterozoic Rocks:

The Upper Proterozoic rocks were folded into broad basins and domes before the deposition of the Cambrian rocks of this area. The flank dips of these structures range up to 45°. The two major structures of this type have been named the Edith Falls Basin and the Seventeen-Mile Creek Anticline. Tight minor folding accompanied by strong fracturing occurs at the southern nose of the Edith Falls Basin.

Cambrian Rocks:

The Cambrian sediments of the Daly River Basin (Noakes, 1949) are gently folded into small closed and open structures with flank dips ranging up to 12°.

Mesozoic Rocks:

The Mesozoic rocks have suffered very little deformation and are essentially sub-horizontal. These rocks are disposed in broad gentle structures with dips ranging up to 2°.

Faulting and Shearing.

The Brocks Creek Group:

The deformation of the Brocks Creek Group has been mainly by folding. Many small shears and faults of small displacement cut the Lower Proterozoic sediments they were probably associated with the folding movements.

Fault zones have been mapped in sediments of the group at several localities, but wide zones are not numerous. The fault zones consist of brecciated rocks which have been replaced and veined by silica to give dense greenish-grey rocks, or by haematite and quartz to give "quartz-haematite-breccias" and "banded ironstone". Rejuvenation of movement can be proved in a fault zone north of the Carpentaria Mine. In this area Upper Proterozoic conglomerates, which have been faulted, contain boulders of brecciated and veined Lower Proterozoic sediments derived from an adjacent older fault breccia of the same zone.

The Cullen Granite:

Faults in the granite are commonly expressed by linear quartz reefs and the displacement can rarely be estimated. Faults generally conform to the two regional directions bearing approximately 160° and 070°.

The granite has been sheared along zones of varying width, generally trending at about 160°. Wide belts of shearing are particularly common between the Edith River and the Cullen River. These belts contained many individual sheared zones separated by unsheared granite.

The sheared zones are characterised by alteration and replacement of the granite which has produced a variety of rocks, including "greisenous", siliceous, and haematitic types. Quartz veins and reefs cut the altered granite of the sheared zones and generally conform to the trend of shearing. These veins are cut and displaced by cross-fractures which were infilled by quartz to give transverse quartz veins. The altered granite and quartz veins have been brecciated and infilled with haematite to give haematite-quartz breccias. Detailed descriptions of individual sheared zones are available in the reports of Gardner and Jones on the radioactive prospects of the Edith River area.

The Upper Proterozoic Sequence:

Systems of fractures are developed in the Upper Proterozoic rocks. They are best expressed in competent sandstone where differential erosion has taken place along the fractures, which commonly determine stream courses and gullies.

Many of the fractures may be referred to as joints because although brecciation is present, no great displacement has occurred. Other fractures are faults which generally have small displacement ranging up to 150 feet. A few faults of larger displacement trend north-easterly or south-easterly. These are commonly denoted by a zone of crushing, brecciation and silicification; steep dips are developed in and adjacent to the fault zones. Specular haematite is developed in some fault zones. Dolerite dykes conform to the trend of jointing and faulting.

The major trends of fracturing in the areas north-east of Katherine are north-east and north, with other subsidiary trends transverse to these directions.

GEOLOGICAL HISTORY

The earliest geological event known in the area was the deposition during Lower Proterozoic time of the thick sequence of geosynclinal sediments which form the Brocks Creek Group.

During subsequent Lower Proterozoic orogeny, these rocks were closely folded, and intruded by granitic magma forming the transgressive Cullen batholith. Injection of the folded rocks with siliceous solutions carrying gold and tin, and greisenization of the granite, followed in the late stages of magmatic intrusion.

The age of initial formation of sheared zones in the granitic mass is not known but may have closely followed the solidification of granite. These sheared zones thereafter had a complex history marked by greisen-like alteration of granite, siliceous injection, haematite replacement, brecciation and cross fracturing and intrusion by dolerite and acid porphyry dykes.

A sequence of basic volcanics, pyroclastics, and tuffaceous sediments (the Dorothy Creek Volcanics) was deposited after an erosion interval which followed the Lower Proterozoic orogeny. These rocks were subsequently folded and intruded by diorite.

Uplift and a considerable period of erosion ensued before the deposition of Upper Proterozoic sediments. The Upper Proterozoic opened with widespread outbursts of vulcanism which gave rise to intermediate, acid, and basic lavas with interbedded sediments and tuffaceous sediments. Periods of relative quiescence marked by deposition of thick sandstones were interrupted by further outbursts of vulcanism.

Broad folding and fracturing of the Upper Proterozoic was followed by an erosion interval. Subsequently the Cambrian seas transgressed the area and algal limestones, sandstones, limestones, and siltstones were deposited. The early part of the Cambrian Period was characterised by vulcanism over a wide area of Northern Australia. Cambrian sedimentation ceased with minor structural deformation and uplift and the area thereafter has been characterised by relative stability.

A Mesozoic transgression began probably in the Upper Jurassic and the whole area was submerged by an epeiric sea in which were deposited the sediments of the Mullaman Group. These rocks show little disturbance. Emergence followed and peneplanation of the thin cover of Mesozoic rocks began on a land surface which offered little scope for erosion. During the Tertiary Period the mature land surface was lateritized.

The present cycle of erosion was probably initiated after differential uplift during Mid-Tertiary (Miocene?). Erosion during the present cycle has stripped much of the old lateritized land surface and caused dissection of the Pre-Cambrian and Cambrian rocks from which the Mesozoic cover has been removed.

ECONOMIC GEOLOGY

History of Mining Activity

The earliest known mineral discovery in the area were made by a prospector, A. Giles, who panned gold colours in the bed of the Cullen River in 1871 and later in the Maude Creek area. J. V. Parkes, Inspector of Mines for the South Australian Government reported upon the favourable mineral prospects of the Katherine-Maude Creek Track in 1892.

Records of mining activity in the area through the years is recorded in the annual reports of the Administration. The geologists of B.M.R., operating between 1935 and 1940, visited many of the mineral fields in the area and did detailed geological investigation of some of them. The results of their investigations are recorded in the Reports of B.M.R.

A brief history of the major mineral fields is outlined below.

Woolgni Gold Field:

This field is located on the southern bank of the Fergusson river approximately 1½ miles west of Fergusson Siding.

Jensen (1919) reported that the auriferous reefs were of the saddle type in an overfolded anticline of sediments now known as the Brocks Creek Group.

A little copper and gold had been worked in the area before 1896. Gold production was first reported in the Chief Mining Wardens report of 1898, which stated that 20 oz of gold was recovered from the crushing of 82 tons of ore.

Several shafts were sunk and the population reputedly reached 1,000. By 1908 the field was abandoned.

Since that time activity in the area has been restricted to occasional gougings by prospectors.

Mt. Todd Gold-Field:

The Mt. Todd field lies about 8 miles north-east of Edith Siding, and approximately 1½ miles west of Mt. Todd, and may be reached by a graded road leaving the eastern side of Stuart Highway near the Edith River Crossing and passing through the new Mt. Todd Battery. An alternative route is by the new graded road to Wolfram Hill, which leaves the Stuart Highway on the eastern side, approximately 2 miles north of the Edith Crossing.

Gold and tin have been worked from reefs in the area.

The discovery and first workings of the field are obscure. The Administrator's Reports of 1908 and 1909 referred to the area as the Mt. Todd Tinfield.

The first reported working of the field was by Jones Bros. for Gold in 1908. In 1910 the Foote Mining Company was formed from local capital to work the Jones Bros. Claim but lack of funds stopped development. Until 1911 the ores were crushed, roasted, and cyanided by a plant situated 48 chains N of Mt. Todd. Small holdings at this time were the Clean Sweep Mine, Buttles, Tollis', and Chinese.

After 1919 the field was abandoned except for the occasional gougings of prospectors.

Attempts to revive the field have been made at intervals by mining companies and syndicates. In 1937 the Mt. Todd Gold Mining Co. NL drilled the areas near the Jones Claim and proved diminishing values at depth with a 467' hole.

The YMC Syndicate removed the old Mt. Todd Battery to a site on the Edith River but have confined their activity to treating tin from dumps at old workings on the Mt. Todd and Horseshoe Creek fields.

The rocks of the field consists of closely folded light-grey yellow or red slates and tuffaceous sandstone of the Brocks Creek Group. The folding is difficult to map because.

of the absence of prominent markers, local faulting and shearing, and concealed areas on the south eastern portion of the field. The general strike is northerly.

The auriferous reefs appear to be parallel to fold axes and flank bedding of pitching anticlines. Of the two types of reef exposed on the field the quartz-ironstone reefs are more auriferous than the quartz reefs. Old workings include 5 shafts on Jones Bros. Reef and one shaft on Tollin Reef with surface pits and costeans. The ore at shallow depths consists of quartz and oxides of iron, but in the primary zone consists of quartz and sulphides, including arsenopyrite. The sulphide and arsenical ores are difficult to treat.

Horseshoe Creek Tin field:

The site of the old battery for this field lies about six miles north of the new Mt. Todd Battery and may be reached by a graded road from the Stuart Highway. This field adjoins the Mt. Todd Gold Field and the two fields were jointly referred to in early records of production.

Shafts and old alluvial workings extend from one mile north of the Horseshoe Creek Battery Site southwards to Stow Creek.

The early history of the field is obscure but apparently the first workings were by Chinese for alluvial tin and gold. The field was worked actively between 1906 and 1910 when high-grade ores were recovered, several crushings averaging 30% metallic tin. After 1910 the activity on the field fell as the grade of ore decreased. Since 1921 very little work has been done.

In 1953 one prospector was working a "leader" for tin with the help of native labour and the YMC Syndicate trucked material from ore dumps at the old Bayling and Morris workings for recovery of tin at the Mt. Todd Battery. These dumps were reported to carry up to 1% tin. The Mt. Todd Battery, which is treating all the locally produced tin ore, is situated on Edith River, five miles ENE of Edith Siding. The working of the battery suffers from inadequate water supply during the dry season when the normal supply from waterholes in the Edith River is exhausted: at times water has been trucked from the Fergusson Siding to keep the battery in operation.

The field consists of folded red, grey, and yellow tuffaceous sandstones and slates. Cassiterite occurs in ore-shoots up to 30 inches in width, in veins and reefs following narrow zones of fissuring and shearing, which trend approximately parallel to the bedding. The length of the ore-shoots can only be estimated by the dimensions of the old workings; and these indicate that payable ore was extracted over lengths of 20 feet to 200 feet. Most exposed shoots were mined to water level by Chinese tributers. Unworked portions of the veins carry up to 1% tin.

Alluvial deposits have been worked near small creeks adjacent to the hills but rich alluvials were apparently limited in extent.

The future prospects of the field appear to be limited to gouging operations in small "leaders" and treatment of low-grade ores when the price of tin is high.

Driffield Gold Field:

This field lies approximately 4½ miles north of the Horseshoe Creek Battery site and access is by the Wolfram Hill road.

The first activity was by Chinese who worked alluvial gold in 1890. The peak of production was achieved during 1903, by which time a five-head battery was in operation. Grade of ore decreased markedly after 1903 and the field was abandoned in 1911. During the years of active operation approximately 15,000 tons of ore were treated for a recovery of about 5,500 ozs. of gold.

The bulk of the gold was won from ore-shoots in quartz reefs and from smaller "leaders" filling fractures adjacent to the larger reefs. The country rocks are folded tuffaceous sandstones and slates of the Brocks Creek Group. The ore-shoots appear from old workings to have had little continuity either in length or depth.

The present activity on the field is limited to the occasional operations of prospectors sampling quartz reefs. Prospecting alluvial deposits is hampered by poor water supplies during the Dry Season.

Emerald Hill Tin Field:

This field is situated 3 miles north-north-west of the Driffield area. Access is by a road which turns north from the Wolfram Hill road three miles north-east of Horseshoe Creek.

The records of the field are obscure, but 29 tons of tin concentrate were produced from 1909 to 1912.

Tin was mined from small shoots in quartz-ironstone reefs to depths of 70 feet. The reefs are parallel with the bedding and the occurrences are analagous to the Horseshoe Creek Field.

A small quantity of tin has been recovered in recent years by prospectors who occasionally work the field.

Yenberrie Wolfram Field:

This field is situated about four miles east of the Stuart Highway and may be reached by the Wolfram Hill Road, which leaves the Stuart Highway two miles north of the Edith River Crossing. The field was discovered by H. Morris in 1911 and was gazetted to prevent Chinese labour entering the field. The field was worked until 1919, when the field was abandoned by Mr. J. Hore.

Attempts were made by the Yenberrie Wolfram Co.NL to develop the field while tungsten ore was at a high price during the Korean War after 1950, but this company abandoned the area in 1953.

The field is located in a small cupola of granite which has intruded sediments of the Brocks Creek Group. The granite is cut by a coarsely granular quartzose dyke rock, which was called by Gray and Winters (1916) quartz-aplite, but for which the term greisen is preferred because of the association of interstitial greenish and yellowish micaceous minerals with the quartz. These micas also occur in partings and fissures. These greisens are fractured longitudinally and transversely.

Wolfram and molybdenite occur disseminated throughout the greisens. Coarse wolfram crystals are present where mica is strongly developed along cleavages and fissures. The main lodes are said to have been white quartz veins filling longitudinal strike fissures in the greisen dykes. The lodes average 9" to 12" in width, widening in places to three feet. Workings extend over 500 feet in Hores Lode. Payable wolfram apparently carried over this distance. Enrichments of wolfram were maintained for short lengths only but persisted to the water table.

The ore mined above the water table consisted mainly of wolfram with quartz gangue, but towards the water level copper carbonates, molybdenite, and copper sulphides including bornite and arsenopyrite were present.

Wolfram generally is more abundant than molybdenite; but in one lode on the field molybdenite is dominant.

The deposits were worked to an average depth of 35 feet, but none were mined below the water table. Future prospects of the field are dependent on the market price for wolfram. The lodes from which good values were obtained have not been worked to great depth. Consideration might be given to sampling of the greisen dykes to test the values of the disseminated wolfram with the possibility of working large-scale low-grade deposits when tungsten prices are high.

Maude Creek Gold Field:

This field is situated on Maude Creek approximately 15 miles east of Katherine on the old Maranboy Road. Little is known of the history of the field before 1890, when small parcels of gold were won. J. V. Parkes, Inspector of Mines, reported on the field in 1891 and during his visit a battery was operating, but by 1892 the field was abandoned. A brief revival occurred on the field during the years 1932 to 1934 when small crushings were treated with a small "Hi-speed" battery.

Gold occurs in reefs which cut the Dorothy Creek Volcanics and the intrusive Maude Creek Diorite. The auriferous reefs are of a quartz-ironstone type at the surface and are probably sulphidic at depth. Copper is associated with the gold in some of the lodes. Difficulty was experienced in the treatment of the ores, but the cause of the difficulty is not recorded.

Carpentaria Mine:

This field is located approximately three miles north of Maude Creek Crossing of the old Katherine-Maranboy track. The history of the field is obscure, but activity began before 1905, when 10 tons of 40% copper ore were sold. In 1905 a syndicate began development with shaft sinking, and some activity carried through until 1919, when the field was abandoned.

Shallow shafts, cesteans, holes, and adits, now mainly inaccessible, extend along the Carpentaria Valley for about a mile in a northerly direction near Dorothy Creek. The country rocks are basic volcanics and pyroclastics which have been intruded by diorite. Copper is located in sheared and veined volcanics: the secondary ores azurite and malachite are conspicuous at the surface. The nature of the primary ore is not known.

RADIOACTIVE MINERALS.

Private Prospecting.

Interest in prospecting for radioactive minerals in the Northern Territory was stimulated by the discovery of uranium minerals by J. White, a prospector, at Rum Jungle during 1949. Subsequently several prospectors began searching for radioactive minerals with Geiger counters.

The first discovery of radioactive minerals in the area mapped for this report was made on the site of an old gouging for copper near the Fergusson River in 1950 by Messrs. J. Johnson and A. Hawker. This find was investigated and reported upon by Messrs. Matheson and Ward of the Bureau of

Mineral Resources. Subsequently finance was made available to a syndicate comprising Messrs. Johnson, Hawker, and Tennyson of Katherine for developing the prospect.

A shallow shaft was sunk to a depth of 20' at the site of the discovery and this revealed that the deposit is of no prospective economic importance. E. K. Carter (1952) mapped the geology of the area of 100 square miles surrounding the prospect.

The uraniferous minerals of the Fergusson Deposite are torbernite and autunite, occurring in association with copper and cobalt minerals in a narrow vein in a sheared zone of the Cullen Granite near its margin with hornfelsic sediments of the Brocks Creek Group. The minerals recorded from the shaft at the prospect included malachite, covellite, erythrite, torbernite, and autunite from the oxidised zone and chalcopyrite, pyrite, uraninite, cobaltite, tennantite, native bismuth, lollingite and enargite from the primary zone (Stillwell 1951a and 1951b).

The second discovery of radioactive minerals in the area was made near the Edith River by Messrs.Mazlin and Young, acting for a syndicate comprising Messrs. Young, Mazlin, Cousin and Atkinson, which operates the Mt. Todd Battery. These deposits were reported on by Fisher (1952). Uranium occurs as meta-autunite associated with apatite and hematite in quartz-hematite reefs, which are found over a distance of three miles along zones of shearing and alteration in the Cullen Granite. The main reefs are cut by transverse quartz veins and reefs and are in part brecciated. The grade of ore sampled at the surface was too low to expect significant commercial production but two shafts have been sunk by the syndicate at deposits A and F (Fisher, op.cit) to test the grade and nature of mineralization in the primary zone.

Messrs. Young and Mazlin were also responsible for the discovery of torbernite north of Yenberrie Creek late in 1952. The torbernite occurs in a narrow gossanous quartz-limonite vein in a sheared, altered, and silicified zone of the Cullen Granite.

The Yenberrie Prospect was reported on by D. E. Gardner (1953c). Two shallow shafts were sunk on the prospect but the uraniferous minerals appeared to cut out at shallow depth. The nature of primary mineralization is not known and although good values were obtained from surface samples the deposit does not appear to have commercial prospects because of the limited quantity of ore.

Mr. S. B. Tennyson of Katherine with the aid of a Geiger counter located a number of radioactive anomalous areas in the Cullen Granite south of the Florina track between October 1952 and April 1953. The six most significant prospects were termed Tennyson's Prospects 1-6 and reported on by Gardner (1953 a,b) and Jones (1953 b).

The deposits are located in zones of shearing and alteration of the Cullen Granite. The altered granite has been injected by quartz and replaced by hematite in the sheared zones which trend N.N.W. Longitudinal quartz reefs have been cut and often displaced by cross fractures infilled with quartz. to give transverse veining. The reefs are brecciated in part.

The radioactive material, which is probably autunite or meta-autunite, is invariably associated with hematite; but the converse relationship does not hold: hematite replacement is common to many sheared zones in the area and generally has no anomalous radioactivity associated with it.

A characteristic of the radioactive anomalies on the Tennyson's Prospects is their localisation near the intersection of the main quartz hematite reefs by secondary cross-fracturing. This feature is not universal; some lenticular deposits bear no relationship to cross-fracturing.

These deposits at the Tennyson's Prospects are too small and low in grade at the surface to be of economic importance

Messrs. J. Hore and J. O'Connor late in 1952 discovered an anomalous area similar in type to the Tennyson Prospects; This prospect is north of the Edith River.

Regional Radiometric Investigations 1953:

The regional geological party based at Edith River carried out radiometric investigations with portable geiger counters of the ratemeter type. (Austronic PRM.200) During this work all old workings on the mineral fields and all localities where mineralization was discovered were tested with a geiger counter. Particular attention was paid to copper-bearing areas, but no significant anomalies were located.

Several local radiometric anomalies were observed in sheared zones of the Cullen Granite. A local count of 4 times background was recorded on sheared granite near the boundary with hornfelsic sediments, about 500 yards south of the turnoff to the Yenberrie Prospect on the Wolfram Hill Road. Detailed prospecting activities were begun in this area by the detailed geological party under the supervision of D. E. Gardner. Small occurrences of torbernite were found in sheared zones which form part of a wide belt of shearing trending N.N.W. near the contact of granite with the Brocks Creek Group in the Yenberrie Creek area (Gardner, 1953 f). These occurrences are of no importance economically.

Late in the 1953 season the attention of the regional party was transferred from the granite and area of Lower Proterozoic sediments around the granite to the sequences of Upper Proterozoic volcanic and pyroclastics.

The stratigraphical position of these volcanic sequences had previously been established during mapping by the party. The volcanics generally have a higher background count and are veined with quartz-hematite at some localities. Messrs. Mazlin and Young in late 1952 blasted a small hole in slightly anomalous area of volcanic rocks of the Edith River Volcanics at Edith Falls, and revealed copper stainings.

While the regional party was mapping and radiometrically testing the volcanic rocks near Knuckeys Creek, north-east of Katherine, secondary uraniferous minerals were discovered by A. B. Clark on September 2nd, 1953, at a locality subsequently named the A.B.C. Prospect. The regional party did a preliminary investigation of this deposit and resumed regional testing when the detailed investigation of the deposit was undertaken by the detailed party (Jones, 1954).

At the A.B.C. prospect autunite and phosphouranylite are associated with replaced rocks which are veined by quartz and hematite. The veins are often brecciated.

Basalts exposed at the surface and by costeaning at the deposit have amygdular coatings of secondary uranium minerals. Fracture planes and surfaces in the basalts and in the veins are coated with uranium minerals.

The volcanic rocks with which the uranium is associated are part of the unit PUCB of the Upper Proterozoic Mt. Callanan Group and are underlain and overlain by massive sandstone and conglomeratic sandstone.

Development up to the end of 1953 consists of shallow costeans done by hand labour, and five deep bulldozed trenches. Drilling of the prospect is about to be undertaken.

Flights were made with the airborne scintillometer party of the geophysical section during September over areas considered worthy of prospecting in the Maude Creek area, and the one anomaly recorded was investigated by Gardner (1953 g).

Conclusions from Regional Radiometric Investigation:

1. The three types of Cullen Granite have a radiometric count ranging from 70-100 counts per minute (Austronic PRM.200 ratemeter). This is higher than the normal background for the area which was taken as the 50 counts per minute recorded on barren quartz reefs.

2. Radiometric anomalies are localised in sheared zones of the granite and surface counts are 4 to 10 times background. Detailed investigations of the anomalous areas showed probable secondary uranium minerals in association with hematite in small deposits with low values at the surface. Detailed radiometric testing of all sheared zones in granite, especially those showing hematite replacement, would probably reveal many small anomalies similar to those discovered, upon which detailed work has been done. However this type of occurrence does not appear likely to result in important economic deposits.

3. In this area no uranium minerals have been discovered in the sediments of the Brocks Creek Group either in the metamorphic zone marginal to the granite or distant from the contact. Fault zones, generally silicified, in these sediments show a count in some localities of 120-130 per minute, which is twice normal background, but no mineralization was found in the zones.

Where slates of the group have been sheared and converted to chloritic schists and phyllitic rocks, copper mineralization was discovered at several localities. Such mineralized areas would appear to be the best for radiometric testing, although no anomalies were observed.

4. The Upper Proterozoic volcanic sequences are regarded as favourable prospecting country for uranium. No uranium has been found in the Edith River Volcanics, but in areas of siliceous and specular hematite veining small local radioactive anomalies occur.

The ABC Prospect is located in Upper Proterozoic volcanic rocks and prospecting near major faults cutting volcanics and in areas of these rocks where veins occur would be warranted.

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