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THE GEOLOGY OF THE DILJIN HILL, BLACK CAP, WATERHOUSE WEST AND CANOPY ROCK WEST AREAS, NORTHERN TERRITORY.

by

R. A. Ruker

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SUMMARY

The results of the geological survey of the area West, North and North-east of the Beswick Homestead are illustrated. The Katherine River Group rests unconformably on the Grace Creek Granite and is represented by interbedded sandstones and volcanics. It contains two probable breaks in deposition, one between the Edith River Volcanics and the Kombolgie Formation, the second between the Gundi Creek Greywacke and the West Branch Volcanics. The Katherine River Group is unconformably overlain by the Beswick Group which is represented by limestone, shale, chert and sandstone. This succession is analysed and related to part of the Bulman Group (B.H.P. Co. Ltd. - 1954). A new group lying unconformably on the Beswick Group has been recognised in the Canopy Rock mosaic area and named Flying Fox Group. It is represented by sandstone, shale and marl.

The original depositional structures of the Katherine River, Beswick and Flying Fox Groups have been partly modified by three phases of uplift and several periods of folding, faulting and subsidence. The Katherine River Group is formed in a North-east striking syncline and covered in the Beswick Homestead area by the south pitching and shallow Beswick Group basin. The Beswick Group and the Flying Fox Group in the north-eastern part of the investigated area are monoclinal. The Diljin Hill fault is the main disjunctive structure which crosses the area in a South-west direction.

INTRODUCTION

The area was mapped by the writer as part of the regional mapping programme of the Urapunga Party, Bureau of Mineral Resources under the leadership of P.R. Dunn. An initial reconnaissance of the area was held in company with B.P. Walpole and C.E. Prichard and the mapping programme decided and carried out under the supervision of B.P. Walpole, Supervising Geologist.

GENERAL

Reconnaissance trips have been previously done in the area by B.P. Walpole, A.A. Öpik in 1951 and 1952 and M.A. Randal in 1956. P.R. Dunn photointerpreted it in 1956 for the compilation of a Katherine-Darwin 1 inch : 10 miles geological map. No geological paper has yet been published on the area, but references to some of the formations recognized are found in geological reports on neighbouring areas (See Reference). In addition, as yet unpublished work done in preparation for a Bulletin on the Katherine-Darwin region was available to the writer.

Access from the south is by the Maranboy-Mainoru track and from the north through the Maranboy-Diljin Hill track. The first is a graded road in fairly good condition, the second an unformed dirt road which reaches the area at Diamond Creek 34 miles from Maranboy. Three crossings on the Waterhouse River, within the Diljin Hill East mosaic, are practicable during the "dry season".

Samples of rocks which occur in the area are held in the Darwin office of the Bureau of Mineral Resources and are numbered from 96401 to 96488 inclusive.

The stratigraphy in the area is summarized on Table 1. Three Groups of sediments are distinguished: Katherine River Group, Beswick Group and Flying Fox Group.

The Katherine River Group is characterized by an alternating succession of arenites and effusive volcanics. It crops out in a broad synclinal structure north-west of the Waterhouse River. The Beswick Group is characterized by fine grained terrigenous sediments and high lime content. It crops out in the Beswick Homestead area, forming a shallow basin open to the south, and in a gentle monocline along the upper reaches of Flying Fox Creek. The Flying Fox Group has been newly named to comprise a sequence of limestone, sandstone, and marl exposed in the south-eastern part of the Canopy Rock 1 mile area.

Age

The ages, as reported on Plate 1, are based on opinions of other workers in surrounding regions. The Grace Creek Granite is attributed to Lower Proterozoic (Walpole, 1955); the Katherine River Group is considered to be Upper Proterozoic (Rattigan and Clarke, 1955); and the Beswick Group has been dated as Upper Proterozoic by analogy with the Mt. Marumba Beds (Opik, 1952). The Mullaman Beds are Lower Cretaceous (Noakes, 1949). The Baker Sandstone is associated with the Mullaman Beds and ascribed tentatively to the Mesozoic.

Fossils

Beside the Collenia in the limestone of the Beswick Group, Beltanella fossils have been found in the sandstone at the base of the Flying Fox Group. The Baker Sandstone contains fern-like and root or coral fossils.

New Units

New formations have been identified and named. They are: BAKER SANDSTONE which underlies the Mullaman Beds; BONE CREEK FORMATION near the base of the Beswick Group; GUNDI CREEK GREYWACKE and DIAMOND CREEK MEMBER, both subdivisions of the Kombolgie Formation which lie stratigraphically below the West Branch Volcanics.

Correlations

Few difficulties have been encountered in stratigraphic correlation within the investigated area. The correlation between the Margaret Hill Conglomerate exposed in the Black Cap East and Diljin Hill East areas and the type section in the Gundi Creek area is tentative and is based only on lithologic analogies. The outcrops of the Beswick Group in the Beswick Homestead area are separated from those in the Flying Fox - Maiwok area by a capping of Mullaman Beds. However, the correlation, based on facies fossils (Collenia) and analogies of stratigraphic succession appears to be tenable.

The stratigraphic correlation between the studied area and the adjacent ones is tentative and illustrated on the following page.

Table I

STRATIGRAPHIC CORRELATIONS

Present Classification	Rattigan & Clarke (1955/56)	Öpik (1952/56)	B.H.P. Co. Ltd. (1954)
FLYING FOX GROUP			
Dolerite Sill.....	. . . . .	Sill No. 1 & No. 2. .	Dolerite Sill
Derim Creek Greywacke			Bunburra Sandstone
Mainoru Marls.....	. . . . .	Mainoru Shale)	
Mountain Valley Limestone.....	. . . . .	Emu Creek Beds) . . .	Showell Creek Shales
Canopy Rock Sandstone.....		)	
UNCONFORMITY.....	. . . . .	Wilton River Conglomerate - Wilton River Sandstone	
BESWICK GROUP	. . . . .	UNCONFORMITY	
Mount Rigg Formation			
Dook Creek Limestone	. . . . .	Mt. Marumba Beds	
Bone Creek Formation			
Margaret Hill Conglomerate			
UNCONFORMITY			
KATHERINE RIVER GROUP	UPPER PROTEROZOIC		
Kombolgie Formation	Fergusson Volcanics		
	MT. CALLANAN GROUP		
West Branch Volcanics	Buc D		
Local Unconformity in places			
Gundi Creek Greywacke Member.....?.....)			
Diamond Creek Member.....?.....)	Buc C		
Buk 4 & Buk 5)			
Buk 3. . . . .)			
Buk 2. . . . . Buc B			
Buk 1. . . . . Buc A			
Local unconformity in places	DISCONFORMITY (?)		
Edith River Volcanics	Edith River Volcanics		
UNCONFORMITY	UNCONFORMITY		
GRACE CREEK GRANITE			

STRATIGRAPHY

The formations that crop out in the investigated area are listed in Table 2 below in descending order, youngest to oldest. The use of the listed symbols is restricted to the present area and to those neighbouring to the east and should not be confused with those used previously in the Katherine-Darwin area.

Table 2

MULLAMAN BEDS

Klm - Undifferentiated sandstone, siltstone, porcellanite and conglomerate.

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

Mb - Baker Sandstone - White sugary sandstone

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

BESWICK GROUP

Mount Rigg Formation

Pui3 - White siltstone and flaggy sandstone.
Pui2 - Black or green basalt, locally amygdaloidal.
Pui1 - Pink, flaggy sandstone.

Dook Creek Limestone

Puo4 - Interbedded limestone, siltstone and sandstone.
Puo3 - White or grey brecciated chert.
Puo2 - Grey and purple limestone with Collenia.
Puo1 - Interbedded brown sandstone and siltstone.

Bone Creek Formation

Pum - White sandstone and boulder conglomerate.

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

Margaret Hill Conglomerate

Puh - Polymictic conglomerate and purple tuffaceous greywacke.

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

KATHERINE RIVER GROUP

Kombolgie Formation

West Branch Volcanics

Puw4 - Pink, medium grained sandstone.
Puw3 - Purple tuffaceous greywacke.
Puw2 - Black amygdaloidal basalt interbedded with sandstone and tuffaceous greywacke.
Puw1 - Interbedded conglomerate and quartz-greywacke.

LOCAL UNCONFORMITY IN PLACES

Gundi Creek Greywacke Member

Pug - Purple tuffaceous quartz-greywacke

Diamond Creek Member

Puq - Basalt and interbedded limestone, siltstone and conglomerate.

Kombolgie Formation

Puk5 - Pink granular sandstone
Puk4 - Brown fine sandstone interbedded with tuff and siltstone.
Puk3 - White fine-medium grained sandstone.
Puk2 - Tuff and basalt.
Puk1 - White, fine to medium grained sandstone. Locally breccia conglomerate at the base.

LOCAL UNCONFORMITY IN PLACES

Edith River Volcanics

Pue - Undifferentiated grits tuff, conglomerate and rhyolite.

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

GRACE CREEK GRANITE

Ppg - Porphyritic Granite.

GRACE CREEK GRANITE

The Grace Creek Granite is the oldest formation exposed in the area and forms the basement on which the Katherine River Group has been deposited. It crops out in the north-west corner of the Diljin Hill West area, within the Eva Creek catchment area.

In the investigated area, all the component minerals are well crystallized and consist of quartz, feldspars and biotite. The formation is intersected by two subparallel sets of veins of white quartz and by dykes of fine texture, possibly acid differentiations of the country rock. The dykes are up to 12 feet thick. Locally the rock has been kaolinized.

KATHERINE RIVER GROUP

Most of the investigated area is occupied by the Katherine River Group sediments. In the Beswick Homestead and Flying Fox Creek areas they are obscured by the Beswick Group.

The Group is characterized by the alternating succession of sandstone, greywacke and effusive volcanics with an interval of limestone and siltstone sediments. It lies unconformably on the Grace Creek Granite and under the Beswick Group sediments. The Katherine River Group is represented in the area by two formations. They are in ascending order: Edith River Volcanics and Kombolgie Formation including Diamond Creek, Gundi Creek Greywacke and West Branch Volcanic Members.

Edith River Volcanics

The formation is exposed along the central portion of Dook Creek and the upper reaches of Diamond Creek.

It is represented by dominantly red coloured sediments: greywacke, sandstone, grit, conglomerate, tuff and rhyolite. Owing to the small areas of exposure the relative position of these members has not been established. It is likely that the volcanics and pyroclastics are the lower members.

The base of the Edith River Volcanics is concealed, and therefore the thickness is unknown. Studies in areas neighbouring to the west have established a strong unconformity at the base of the formation (Rattigan and Clarke, 1955). The top of the formation is placed at the sharp change in lithology between the greywacke and the white sandstone of the Kombolgie Formation.

The correlation between the outcrop in the Dook Creek area and the outcrop in the Diamond Creek area is based on lithological analogies.

Kombolgie Formation

The Kombolgie Formation is exposed over most of the north-western part of the area.

It consists mainly of white sandstone lying on the Edith River Volcanics and conformably overlain by the Diamond Creek Member.

The type section for the investigated area is placed along the West Branch River north of the Maranboy - Diljin Hill track. The closely spaced faults which affect the formation in this area allow only a rough estimate of the thickness at 4000 feet. On the other side of the depositional basin, in the Dook Creek and Waterhouse Waterfall areas the thickness is 2100 feet. These thicknesses exclude the Gundi Creek Greywacke, Diamond Creek and West Branch Volcanic Members.

Excluding the three formally defined Members the Kombolgie Formation in this area has been subdivided into five units, different lithologically, but embraced in the same depositional cycle of white clean sandstones. Puk1 is the lowest and extends from the contact with the Edith River Volcanics to the base of the Puk2 (Birdie Creek) volcanics. In the Dook Creek area, it comprises a bottom bed of silicified breccia conglomerate, followed by quartz-greywacke and topped by white sandstone for a total thickness of 430'.

The breccia conglomerate has been observed on the northern bank of Dook Creek 2.6 miles above the Bone Creek confluence. Here it is up to 20' thick but it lenses out laterally within a short distance. The components are pink sandstone, purple quartz-greywacke and volcanics. The stratigraphical equivalent of the breccia conglomerate in the Diljin Hill area, south of Eva Creek, is a lenticular slump breccia of white silicified sandstone up to 50' thick.

The quartz-greywacke overlies the breccia conglomerate. It is purple, fine to medium grained and poorly bedded and about 60 feet thick.

The topmost beds of Puk1 are composed of clean white sandstone 320 feet thick. The sandstone is fine to medium-grained, locally with minor kaolin-like matrix, well sorted and well bedded, cross-bedded. Slump structures are interfingered with the normal sedimentary structures. Ripple marks occur on most bedding planes. The rock is of medium hardness and weathers to pink and light yellow colours. The fracture surfaces are slightly rough.

Puk2 is a southerly continuation of the Birdie Creek Volcanics of the Mt. Stow area (Walpole and White, 1955). It consists of basalt interbedded with very fine tuffs. It has a maximum thickness of 660 feet but lenses out towards the south-west. In the Dook Creek area the tuff is laminated and kaolinized and is more abundant than basalt. Quartz-chert and hematite-bearing veins intersect the member. Interbedded lenses of white sandstone slump breccia up to 30 feet thick occur in some places (see Figs. 5 and 5a).

Puk3 repeats the lithology, observed above, of the topmost beds of the Puk1 member. The maximum thickness is 1800'. In the type area a bed of boulder conglomerate, up to 30' thick (fig. 3) is present at the base, and slump folding and brecciation occur throughout the section. Intraformational conglomerate has been observed in the Dook Creek area Some of the upper beds of the member have a slightly tuffaceous matrix.

Puk4 and Puk5 designate variations of lithology in the upper part of the Puk3. North-east of Waterhouse Waterfall the Puk3 white sandstone is succeeded by Puk4, a lens 500 feet thick of soft, laminated, micaceous sandstone interbedded with grey siltstone (See Plate 8). This lens is overlain by Puk5, a hard granular sandstone 300 feet thick, which is a lateral variation of the topmost 100 feet of the Puk3. In the type area, the stratigraphic equivalents of Puk4 and Puk5 are respectively purple, soft, fine grained quartz-greywacke and pink, hard sandstone with slightly tuffaceous matrix.

The base of the Kombolgie Formation is placed at the change in lithology between the Puk1 and the rock types of the Edith River Volcanics. The top is placed at the change in lithology between the white Puk3 sandstone, or its lateral Puk4 - Puk5 facies, and the volcanics and limestone of the Diamond Creek

Member.

New information has been collected concerning the contact between the Kombolgie Formation and the Edith River Volcanics. The nature of this contact has been debated by Rattigan and Clarke (1955) and B.P. Walpole (1955) and is controversial. The present study shows that in some places the Puk and Pue are conformable and the boundary marked by a thin layer of pebble conglomerate, in others the Puk and Pue are unconformable, with breccia conglomerate on the base of the Puk succession. These features, apparently contrasting, are shown in the following list of observations made in different localities.

Dook Creek area -

1) On the northern bank of Dook Creek, 2.6 miles above the Bone Creek confluence, an angular unconformity is exposed. The average dips of the Edith River Volcanics and the Kombolgie Formation are respectively 30° and 20° and the difference in strike up to 45°. This unconformity is marked by lenticular breccia conglomerate. (see fig. 4).

2) In places the Edith River Volcanics have been folded and faulted and the dips range from 25° to 80°. These structures, possibly syngenetic, are overlain by the regular monocline of the Kombolgie Formation with an average dip of 30°.

South-west corner of the Diljin Hill mosaic area -

1) Edith River Volcanics monocline is overlain by a slightly less dipping Kombolgie Formation monocline and the sequence is apparently concordant. The transition is marked by clean quartz-pebble conglomerate 3 feet thick.

2) The three lower members of the Kombolgie Formation (Puk1, Puk2, Puk3), come laterally in contact with the Pue sediments, suggesting the progressive filling of a depositional trough.

3) A fracture in the Edith River Volcanics purple greywacke, several feet deep and 6 inches wide, has been filled by Kombolgie Formation white sandstone to form a "sandstone dyke" structure. (see Fig. 1).

4) A vein of Kombolgie Formation sandstone is present within the Edith River Volcanics greywacke in a slump folded structure. (see fig. 2).

Walpole (personal communication) considers that the co-existence of an unconformity and a conformity in different places but in the same stratigraphical position could be explained as the result of an unstable shelf environment. The stratigraphical record of the Edith River Volcanics and the Kombolgie Formation, with slump breccias and syngenetic folding testifies that discontinuous movements occurred during the deposition. In places these movements caused folds, faults and tilting in partly consolidated sediments and were followed by the deposition of younger rocks on an irregular surface. Conversely, in places where the movements have not affected the sediments the succession appears conformable. Hence the unconformity between the Edith River Volcanics and the Kombolgie Formation in the Dook Creek area has a local significance. A similar problem arises a few hundred feet higher in the sequence between members of Kombolgie Formation in the South-west corner of the Diljin Hill area, but here the unconformity between the Puk5 and Puk3 is well outlined in outcrop and on air photos and readily explained in terms of penecontemporaneous folding. It may be concluded that the Edith River Volcanics and the Kombolgie Formation are conformable in the

regional sense but separated in places by unconformity due to syngenetic folding of the Edith River Volcanics. This relationship has been designated on plates as - Local Unconformity in Places.

Diamond Creek Member

The Diamond Creek Member is exposed along the Waterhouse River, 3 miles North-east of the Waterhouse Waterfall, west and South-west of Diamond Creek, in a narrow belt north of the Maranboy-Diljin Hill track, and in the upper reaches of Maiwok Creek.

It is represented by volcanics and interbedded limestone, siltstone and conglomerate, in conformable sequence between the Kombolgie Formation below and the Gundi Creek Greywacke above.

The name is taken from a West Branch tributary which flows to south-east and joins the West Branch 13 miles above its confluence with the Waterhouse River.

The type section has been chosen on the Waterhouse River. It is directed southward from a point 3.7 miles above the Waterfall. The approximate geographical co-ordinates are Lat. 14° 10'S Long. 133° 10' E.

The Member is 700 feet thick in the type locality but thins laterally within a short distance to 100 feet. The average thickness south-west of the Diamond Creek mouth is 240 feet. The Member is absent in the upper reaches of Gundi Creek and the Gundi Creek Greywacke lies directly on Kombolgie Formation.

The Member begins with 500 feet of alternating limestone and siltstone. The limestone is pink, grey and purple, crystalline or microcrystalline and well bedded. The thickness of the beds is 6" to 12". In places they are laminated and thin layers of secondary calcite are present. The associated siltstone is laminated, mottled in purple, green, pink and grey and in places is calcareous. The upper 200 feet of the succession consists of black amygdaloidal basalt with thin beds of soft tuffaceous material. In a restricted area along the Waterhouse, polymictic conglomerate is interfingered with the limestone. It has been formed in an anomalous depositional environment connected with warping of the underlying Kombolgie Formation (See "Tectonics and Geological History"). In the Diljin Hill area on the eastern bank of the Waterhouse, thin horizons of grey chert interbedded with limestone have been found. In some places either limestone-siltstone or volcanics predominates or is the sole representative of the Member.

The bottom of the unit is placed at the change in lithology from one of the two members to the sandstone of the Kombolgie Formation. The top is placed at the change in lithology from one of the two members to the tuffaceous greywacke of the Gundi Creek Greywacke.

Gundi Creek Greywacke Member

The Gundi Creek Greywacke crops out north of Gundi Creek; in a strip north of the Maranboy-Diljin Hill track; in extensive areas between Waterhouse River and the West Branch; at Diljin Hill and in the upper reaches of Maiwok Creek. It is represented by purple, tuffaceous greywacke resting conformably on the Diamond Creek Member and overlain disconformably or with local possible unconformity by the West Branch Volcanics.

The name is taken from a tributary which enters the West Branch 5 miles above the West Branch Waterhouse confluence.

The type section is exposed on the northern bank of the Waterhouse River 3 miles above the Waterfall, approximately at Lat. 14° 10'S. and Long. 133° 10'E. The thickness of the formation in the type locality is 460 feet. It is fairly constant all over the investigated area.

The rock is purple tuffaceous greywacke, medium to coarse grained with minor pink feldspar and isolated sandstone and quartz pebbles. It is cross-bedded and has rough fracture surfaces and medium hardness. Fine pyroclastic materials are the matrix.

Some variations from this typical lithology have been observed east of Waterhouse River: the tuffaceous component of the rock is considerably smaller, 100 feet of flaggy sandstone is present at the base and the rock is generally yellow or brown in colour.

The photopattern of the Member is characterized by a network of closely spaced vertical joints.

The base of the Member is placed at the change in lithology between the tuffaceous greywacke and the volcanics or limestone and siltstone of the Diamond Creek Member. The top is between the tuffaceous greywacke and the lowermost conglomerate bed of the West Branch Volcanics.

West Branch Volcanics Member

The West Branch Volcanics crop out in the synclinal basin between the West Branch and Waterhouse River; in the Gundi and Dook Creek areas; and east of the Waterhouse to a point on Barmguerikba Creek 2 miles from its junction with Maiwok Creek.

The West Branch Volcanics are represented by interbedded basalt, tuff, conglomerate and tuffaceous greywacke, lying disconformably on the Gundi Creek Greywacke and topped unconformably by the Margaret Hill Conglomerate. The thickness of the formation is variable and estimated at a maximum of 5300 feet.

Four subdivisions of the West Branch Volcanics have been mapped:

Puw1 is exposed along the edges of the West Branch - Waterhouse basin and is the bottom subdivision. It consists of conglomerate interbedded with sandstone, quartz-greywacke or greywacke. The conglomerate is polymictic with predominance of sandstone elements, pebble-cobble size with sandstone matrix and strongly silicified. The sandstone is white, hard, fine to medium grained, in places well sorted and bedded. The quartz-greywacke is pink, tuffaceous and coarse, with rough breaking surfaces. The greywacke is purple, tuffaceous, and coarse-grained.

The thickness is variable ranging from approximately 200 feet to a maximum of 2300 feet in the area south of the Maranboy-Diljin Hill track. It is absent in the Dook Creek area.

Puw1 rests on Gundi Creek Greywacke and is interfingered and topped by the Puw2 basalt.

Puw2 is composed of basalt interbedded with tuff, greywacke and locally with agglomerate. The basalt is black or dark green,

amygdaloidal, with white quartz or green zeolitic fillings. Along the West Branch River, fragments of slaty, silicified glauconite are included. The tuffs are dark purple or dark brown, very fine grained and locally laminated. They occur in beds up to 5 feet thick. The greywacke is purple and coarse grained, and occurs in beds or lenses from 2 to 30 feet thick. This greywacke is very similar to that mentioned within Puk1. Southwest of Bone Creek, a lense of agglomerate has been observed, composed of angular sandstone fragments and tuffaceous material. The maximum thickness of the Puw2 is estimated at 2000 feet south of the Maranboy-Diljin Hill track. The Puw2 rests on, or is interfingered with the Puw1 conglomerate. In the Gundi Creek area it rests on Gundi Creek Greywacke and in the Dook Creek area on the Kombolgie Formation. The upper boundary is gradational and mapped in correspondence to the uppermost volcanic bed.

Puw3 is exposed in the central area of the West Branch - Waterhouse syncline. It is represented by dark brown and purple greywacke, fine to medium-grained, laminated or flaggy. Some beds of pink sandstone and numerous interbeddings of purple fine tuffs occur through the section. The top is obscured by Cretaceous capping. The thickness is estimated as more than 1000 feet.

Puw4 crops out in the Diljin Hill East area west of the Waterhouse River. It is represented by pink arkosic sandstone, medium grained and well-bedded and containing white and pink felspar. The relationship with the lower part of the formation, exposed west of an extensive Cretaceous capping, is not fully understood. It possibly represents a lateral lithofacies of the Puw3.

The base of the West Branch Volcanics is placed at the contact between the Puw1 conglomerate and the Gundi Creek Greywacke. In the Gundi Creek area the conglomerate lies on the Kombolgie Formation, suggesting an erosional phase with removal of the Gundi Creek Greywacke (the Diamond Creek Member has not been deposited in this locality). In the Bone Creek - Dook Creek areas the conglomerate is absent and the Puw2 basalt rests on Kombolgie Formation. North of the Maranboy-Diljin Hill track the transition between the Gundi Creek Greywacke and the Puw1 conglomerate is apparently continuous. In the first locality the features suggest a probable unconformity, in the second a disconformity at the base of the West Branch Volcanics. The top of the Member is not exposed in the investigated area.

BESWICK GROUP

The Beswick Group sediments are disposed in the shallow synclinal basin between Dook Creek and the Waterhouse Waterfall and in a gently dipping monocline on the Canopy Rock 1 mile area. The correlation of the two outcrops is based on analogies in lithology and in stratigraphical succession.

Only the lower part of the Beswick Group crops out in the investigated area. Fine terrigenous and chemical sediments, limestone, siltstone and chert are dominant. Conglomerate and sandstone occur at the base. Collenia limestone is characteristic for the Group and a major effusion of basic volcanics occurs.

The Group rests unconformably on the Katherine River Group and is overlain with a probable unconformity by the Flying Fox Group.

The Beswick Group has been mapped according to subdivisions suggested by previous reconnaissance work (Walpole

1955) but the nomenclature has been partly redefined. The lower portion of the Margaret Hill Conglomerate represented by polymictic conglomerate and tuffaceous greywacke has been separated from its upper portion represented by oligomictic conglomerate and clean white sandstone. It is proposed to restrict the term "Margaret Hill Conglomerate" to the older sediment and name the younger, Bone Creek Formation. There are four formations of the Beswick Group exposed within the investigated area. In ascending order these are: Margaret Hill Conglomerage, Bone Creek Formation, Dook Creek Limestone and Mount Rigg Formation.

Margaret Hill Conglomerate

The formation crops out in the Bone Creek watershed and in a narrow strip between the Gundi Creek area and the Waterhouse Waterfall. One isolated outcrop, attributed to the Margaret Hill Conglomerate by lithological analogies, is exposed 19 miles above the Waterhouse Waterfall.

The formation consists of polymictic conglomerate and purple tuffaceous greywacke; it rests unconformably on the West Branch Volcanics and is overlain by the Bone Creek Formation with a possible unconformity. The name is taken from the hill situated North of Bone Creek, one mile above its confluence with Dook Creek.

The type section crosses . Margaret Hill and starts from the point at Lat. 14° 13'S. and Long. 132° 59'E.

The thickness in the type locality is 960 feet. It is subject to lateral variations within a short distance. Maximum thickness of 1250 feet was observed in the area between Dook Creek and Bone Creek. The formation lenses out within 4 miles southeast of the type locality.

The basal member is a conglomerate bed 50 feet thick. It is polymictic with dominant sandstone elements and subordinate basic volcanics and metamorphic rocks. The texture is cobble to pebble size and the elements well rounded. The interstices are filled with a coarse, purple, quartz-greywacke.

Purple, tuffaceous quartz-greywacke 650 feet thick with lenses or isolated pebbles of quartz and sandstone overlies the basal member. The texture is coarse and poorly sorted. Cross bedding is common. This member in turn is overlain by dark, purple tuffs 100 feet thick. They are of very fine texture, laminated structure, and partly kaolinized.

The tuffaceous quartz-greywacke lithology, described above, is repeated in the topmost 360 feet of the formation.

The lithology of the Margaret Hill Conglomerate changes laterally: in the area between Dook Creek and the head of Bone Creek the formation is represented by boulder and cobble conglomerates alternated with pink quartz-greywacke, and purple tuffaceous greywacke. This dominantly conglomeratic facies, changes gradually towards the north to a dominantly quartz-greywacke facies in which the conglomerates are restricted to the lowermost 20 feet of succession.

The isolated outcrop on the Waterhouse River, 19 miles above the Waterfall, is represented by pink quartz-greywacke, coarse, cross-bedded or poorly bedded with quartz and sandstone pebbles. The matrix is tuffaceous.

The base f the formation is placed at the bottom of the lowermost conglomerate bed which in some places lies on Edith River Volcanics in others on West Branch Volcanics. The contact is sharp, irregular and unconformable. The top corresponds to the change in lithology between the tuffaceous quartz-greywacke and the overlying oligomictic conglomerate of the Bone Creek Formation.

Bone Creek Formation

The formation is exposed between Bone Creek and Gundi Creek: in a strip between Gundi Creek and the Waterhouse Waterfall; north of Dook Creek between a point 7 miles above it: mouth and Margaret Hill, and in the Canopy Rock 1 mile area.

The type section is 1 mile west of a point 2.6 miles above the mouth of Bone Creek. It crops out along a fault scarp trending 60° magnetic. The approximate geographical co-ordinates are Lat. 14° 12'S., Long. 132° 58'E.

The formation has been subdivided in a lower conglomeratic member and a higher sandstone member.

In the type locality the conglomeratic member is 40 feet thick. The top of the sandstone member is not present in this area but in the West Branch area it is about 170 feet thick. The dips in the type locality are not reliable and the outcrops in the West Branch area are intersected by faults. Hence the average of 210 feet for the Bone Creek Formation is an approximate figure.

The basal member is oligomictic conglomerate. The boulders and cobbles are dominantly white hard sandstone, subordinately rhyolite, green fine quartzite and amygdaloidal basalt. They are very well rounded, mostly spherical. The matrix is arenaceous and grey and coarse grained, poorly sorted and silicified. The member is not bedded.

The overlying sandstone member is a white medium grained rock. It is hard and silicified, well bedded and flaggy. The strata vary from 6 inches to 12 inches in thickness. Minor muscovite is contained. Weathered bedding planes are red stained.

The base of the formation is placed between the oligomictic conglomerates and the underlying rocks. The top of the formation corresponds to the change in lithology between the white sandstone and the overlying brown sandstone of the Dook Creek Formation.

A possible unconformity at the base of the Bone Creek Formation is evident where it overlies the West Branch Volcanics or older rocks. It is less evident where it overlies the Margaret Hill Conglomerate. In this case the boundary is sharply defined and uneven, but the bedding conformable. Two possible explanations are advanced. The first assumes an unconformity between the Bone Creek Formation and the Margaret Hill Conglomerate. The second considers the Margaret Hill Conglomerate as facies of the Bone Creek Formation which was developed locally at the beginning of the Beswick Group transgression. In this case the relationship would be a diastem.

Dook Creek Formation

The formation crops out between the lower reaches of Dook Creek and the Waterhouse Waterfall and along

Maiwok and Flying Fox Creeks.

It consists of limestone with Collenia fossils, sandstone and chert, lying in conformable sequence between the Bone Creek Formation below and the Mount Rigg Formation above.

The type section crosses a shallow saddle 2.6 miles west-north-west of the Waterhouse Waterfall. It includes the lower part of the formation up to the top of the chert member and is 580 feet thick. The lithology of the upper part has been deduced from isolated outcrops and eluvial materials. The total thickness of the Dook Creek Formation is therefore not known but estimated to exceed 900 feet.

The Dook Creek Formation comprises four members: Puo1, Puo2, Puo3 and Puo4.

Puo1 is a brown and grey sandstone very fine grained, laminated or thin-flagged, micaceous and shaley, interbedded with green shales (glauconitic?), soft, laminated and partly calcareous. Intermediate types of lithology are represented by shaley greywacke, siltstone and marl. Beds of pink and grey or red amorphous limestone are present. Some of them have brecciated structure. Oolitic limestone has been observed in rubble. The thickness of the member along the above mentioned section is 400 feet. The member is absent in the Flying Fox area.
Puo2 is represented by purple and grey microcrystalline limestone containing Collenia fossils (figs. 6a, 6b, 6c), interbedded with grey limestone which is laminated or locally brecciated. Veins of secondary calcite are present. Along the type section, this member is 100 feet thick and 400 feet in the Flying Fox area.
Puo3 is a white, ivory or grey, brecciated chert. The texture varies from fine grit to a coarse breccia. The coarse elements reveal a finely laminated structure of the original deposit. In the Flying Fox area the chert is interbedded with white medium grained sandstone. The thickness of the member varies between 80 feet in the type area and 400 feet along Flying Fox Creek.
Puo4 is composed of grey, pink and purple limestones interbedded with siltstone, shale and laminated sandstone. Fine, laminated, tuffaceous beds are present in places.

The bottom of the formation is placed at the sharp change in lithology between the brown sandstone (Puo1) and the white sandstone of the Bone Creek Formation. The top is placed between the limestone (Puo4) or its stratigraphical equivalents and the pink sandstone of the Mount Rigg Formation. Puo2 and Puo3 in the Flying Fox area may probably be related respectively to the Lower and to the Upper Mt. Marumba Beds as defined by the B.H.P. Co. Ltd. (1954) in the Bulman area.

Mount Rigg Formation

This formation crops out west and south-west of Beswick Homestead.

It conformably overlies the Dook Creek Formation and has been subdivided in three lithological units: pink sandstone, basalt, and white siltstone-sandstone. The thicknesses have not been computed because the boundaries between members are not well outlined and the top of the formation is not exposed within the investigated area.

Pui1 is the lowest member of the formation and is composed of coarse to medium grained pink sandstone. It is well bedded and locally flaggy. Slump folding and brecciation occur in the uppermost portion of this member.

Pui2 is black or green hard basalt, locally amygdaloidal with spherical weathering surfaces. It is interbedded with sandstone. Close to the base it includes contorted veins of sandstone and lenses of brecciated sandstone torn from the underlying beds.

Pui3 is represented by siltstone overlain by sandstone. The siltstone is grey and laminated and in places is chertified. A sample of analogous rock collected at Alligator Waterhole was found by Miss I. Crespin, Bureau of Mineral Resources, (Walpole 1955) to contain fine siliceous spicules and a number of indeterminate radiolaria(?) The sandstone is white, cherty, medium grained, well sorted, flaggy and ripple marked.

The bottom of the formation is placed at the contact between the pink sandstone (Pui1) and the limestone or its stratigraphical equivalents of the Dook Creek Formation. The top is not exposed.

FLYING FOX GROUP

This group of sediments crops out in the south-western part of the Canopy Rock 1 mile area where it unconformably overlies the Beswick Group. It has been subdivided into four formations. They are in ascending order: Canopy Rock Sandstone, Mountain Valley Limestone, Mainoru Marls, Derim Creek Greywacke. A Dolerite sill is intruded.

Canopy Rock Sandstone

The formation is exposed in a strip 2 miles wide which crosses Flying Fox Creek from 6 to 10.5 miles above the Maranboy-Mainoru track crossing.

It is represented by sandstone which rests with a probable unconformity on the Beswick Group and is topped conformably by the Mountain Valley Limestone.

The name is taken from an isolated outcrop occuring half a mile south of the Mountain Valley airstrip. The type section is exposed on the east bank of Flying Fox Creek and starts from a point 10.5 miles above the Maranboy-Mainoru track crossing. The formation is 750 feet thick.

The formation appears to be similar to the Wilton River Conglomerate as described by A.A. Opik (1950) and the Wilton River Sandstones as described by B.H.P. Co. Ltd. (1954). Three members are represented: sandstone - conglomerate with Beltanella type fossils, limestone and white sandstone.

The basal member crops out half a mile east of a tributary which joins Flying Fox Creek 9 miles above the Maranboy-Mainoru track crossing. It is a pink sandstone, coarse and poorly sorted, cross bedded with quartz pebbles and angular fragments of white chert, interbedded with pebble conglomerate and chert breccia. Hemispheric fossils up to 5" in diameter with a radial structure have been found and are supposed to be Beltanella or a similar form. The member rests on a strongly brecciated facies of the Beswick Group chert (Puo3) or on its stratigraphical equivalent, the grey limestone.

The second member, is a lateral change in lithology of the upper part of the basal member. It is grey limestone laminated and interbedded with chert, chert breccia or chert grit. The latter has limestone matrix. The combined thickness of sandstone-conglomerate and the limestone is 200 feet. The topmost member of the formation is the white sandstone. It is fine to medium grained, well sorted, hard, well bedded and the flat bedding planes are red, if weathered. This sandstone is similar to the sandstone of the Bone Creek Formation. The thickness is approximately 550 feet.

The bottom of the formation is placed between the sandstone-conglomerate and the underlying chert breccia. The top is between the white sandstone and the shale of the Mountain Valley Limestone.

Mountain Valley Limestone

This formation crops out between Mountain Valley Homestead and Flying Fox Creek and southwest towards Maiwok Creek.

The name is taken from Mountain Valley station situated 12 miles North of the Maranboy-Mainoru track in the Canopy Rock 1 mile area.

No suitable type section has been located and the lithology of the formation has been deduced from isolated outcrops. The thickness of the formation is approximately 400 feet.

The Mountain Valley Limestone is represented by interbedded shale, limestone and siltstone in conformable sequence between the Canopy Rock Sandstone below and the Mainoru Marls above. The shale and siltstone are mottled in grey, purple and green colours, laminated, glauconitic at the base and increasingly calcareous towards the top. The limestone is grey or purple, amorphous or microcrystalline, laminated or in beds from 1 inch to 5 inches thick. Some horizons contain specks of glauconite.

The bottom of the formation is placed at the change in lithology between the shale or limestone and the white sandstone of the Canopy Rock Sandstone. The contact with the overlying Mainoru Marls is gradational and placed for mapping purposes at the topmost limestone bed.

Mainoru Marls

The formation is exposed in a continuous and progressively widening strip from a point 5 miles west of Flying Fox Creek to the northeast corner of the Canopy Rock 1 mile area.

The type area is east of the track which connects Mountain Valley Homestead and the Maranboy-Mainoru track.

The Mainoru Marls rest conformably on the Mountain Valley Limestones and are overlain conformably by the Derim Creek Greywacke. They are represented by a 200 feet thick succession of laminated and flaggy marls in various colours. Following is the ascending order in the type area: purple, yellow, white and on top grey silty marls.

Corresponding rocks have been classified as Mainoru Shales (Opik 1952) and Showell Creek Shales (B.H.P. Co. Ltd. 1954).

The lower limit of the formation coincides with the top of the uppermost limestone bed of the Mountain Valley Limestone. The top is placed at the change in lithology between the marls and the overlying greywacke.

Derim Creek Greywacke

The formation is exposed east and west of the Mountain Valley turnoff. The name is taken from a Flying Fox tributary that flows southward from Mountain Valley Homestead. The formation is represented by grey shaley greywacke and fine grained and well bedded purple greywacke. The lower boundary of the formation is gradational and placed at the base of the lowermost greywacke bed. The top of the formation is not exposed within the investigated area.

A dolerite sill is intruded roughly parallel to the bedding of the Derim Creek Greywacke. It occupies different stratigraphical positions in different localities. In some places the sill separates the Mainoru Marls from the Derim Creek Greywacke, in others the succession between the Mainoru Marls and the Derim Creek Greywacke is continuous and the sill separates the lower part of the Derim Creek Greywacke from the upper. Contact phenomena have not been observed along the dolerite boundaries. The formation is represented by green dolerite from fine to coarse grained locally containing biotite phenocrysts. Traces of pyrite have been observed.

BAKER SANDSTONE

The formation crops out in three small separate areas. The first one, chosen as type locality, is 2.4 miles east-southeast of the Waterhouse Waterfall, at Lat. 14° 28½'S., Long. 133° 10¾'E. The second forms a bar across the Waterhouse River 21 miles above the Waterfall and the third is on Dook Creek 12 miles above its outfall.

The formation consists of clean sandstone resting unconformably on older rocks. It is overlain by the Mullaman Beds, with a possible unconformity.

The thickness of the formation in the type locality varies from 6 to 12 feet.

The Baker Sandstone is represented by white sugary sandstone, fine to coarse grained, poorly sorted and poorly rounded. The bedding is poor. The weathered surfaces are hard and silicified but fresh exposures are very friable. The distinctive feature of the Baker Sandstone is its fossil content. It consists of plant impressions (fern leaves?) and supposed roots. The latter abound in the upper part of the formation and are preferably oriented normal to the bedding. The Baker Sandstone can be related to the plant bearing formation in the lower part of the Mullaman Group interpreted by Noakes (1949) as freshwater-lacustrine sediment.

The bottom of the formation is placed at the unconformity between the white sugary sandstone and the underlying Kombolgie Formation. The top is marked by conglomerate of the Mullaman Beds.

On the Waterhouse River and on Dook Creek the formation shows the same lithological characteristics, except for the bedding which is well defined in strata 1 to 3 feet thick. The outcrops of the Baker Sandstone are associated with

those of the Mullaman Beds and when weathered they account for part of the eluvial sandy flats mapped as Cz/M.

MULLAMAN BEDS

This formation represents the topmost unit in the stratigraphical succession and is exposed over the investigated area as flat-lying beds of conglomerate, sandstone, marls and porcellanite. The conglomerate is present at the bottom of the formation and follows the irregular transgressional surface. In some places the conglomerate is replaced by iron rich sandstone. The sandstone is white, generally poorly sorted and with a kaolin-like white matrix. The marls are yellow, white or stained purple and brown by metallic oxides. They are sandy in places. In the Flying Fox area fossils have been found in the form of cylinders filled with sandstone. The porcellanite is a white, hard rock of pedological origin (Noakes, 1949) possibly silicified shale of fine texture and with concoidal fracture surfaces. The thickness of the formation varies between 50 and 200 feet.

TECTONICS AND GEOLOGICAL HISTORY

The flat-lying shelf deposits of the Katherine River Group which are present in extensive areas east of the Pine Creek Geosyncline are undulated in synclinal basins. One of those basins represents the dominant element of structure in the subject area. The axis is directed northeast and the structure complicated by faulting and folding. West and south-west of Beswick Homestead it has been obscured by the Beswick Group basin and in the northeast part of the investigated area by the Beswick Group and Flying Fox Group monocline.

The combined structural and sedimentary records have enabled recognition of the chronological order of the tectonic events and the superposition of sedimentary environments. The features are illustrated on Plate 2 and they will be reviewed in the following order:

1) Basement and the Edith River Volcanics.

2) The Kombolgie Formation

3) Beswick Group.

4) Flying Fox Group.

5) The latest movements.

1) Basement and the Edith River Volcanics.

Grace Creek Granite is the basement formation in the investigated area. It has been exposed to subaerial erosion and then transgressed by the sea. So the deposition of the Edith River Volcanics begins with a rapid accumulation of detrital and volcanic clastics and a flow of rhyolitic lava.

Two tectonic styles are evident in the Edith River Volcanics. First, in the Dook Creek area strong faulting has disturbed a dominantly southeast striking monocline which dips in average 40°. The faults are roughly parallel to the strike. Second, in the upper reaches of Diamond Creek the formation is arranged in a monocline striking to the southwest with average dips of 30° south-east. Minor faults have been observed.

Walpole (personal communication) considers that the strong tectonic activity in the Dook Creek area as compared with the mild displacements in the Diamond Creek area may be attributed to the instability of the marginal belt of the Katherine River Group sedimentary basin.

2) Kombolgie Formation

The tectonic activity which affected the Edith River Volcanics outlined a synclinal pattern between Diamond Creek and the Waterhouse River. Subsidence developed it further during the deposition of the Kombolgie Formation. The rate of sedimentation balanced the rate of subsidence and therefore shallow, shelf environment persisted throughout the deposition of the Kombolgie Formation. The axis of this syncline is directed to the northeast. In this direction it gradually flattens out, but it branches into two arms towards the south-west. One arm is directed west (Gundi Creek area) and the other, directed south, is partly obscured by the Beswick Group basin. These arms are separated from the central part of the syncline by a transverse anticline dipping 5° - 10°. The average dips along the northwest flanks of the syncline are 5° - 10°, along the south and southwest flanks 20° - 30°. These steeper dips are associated with folding and syngenetic brecciation of the Kombolgie Formation. It follows that during and after the deposition of the Kombolgie Formation, the diastrophic activity was more intense on the south and southwest flanks than on the north and northwest flanks. Taking into account analogous structural features mentioned for the underlying Edith River Volcanics it would appear that the south and southwest parts of the syncline (area between Dook Creek and the Waterhouse Waterfall) lie in a marginal mobile belt bordering to the south the relatively stable synclinal area between the Waterhouse River and Diamond Creek.

A typical example of gravitative displacement of the partly consolidated Kombolgie Formation occurs northeast of the Waterhouse Waterfall and is illustrated in Plate 8. A tight fold in syngenetically brecciated sandstone formed a rise in the sea bottom, with flanks dipping 60°. This rise isolated a neighbouring depressed area in a quiet depositional environment (siltstone and shale). The uppermost beds of the Kombolgie Formation have only partially levelled these irregularities.

A similar feature has been observed in the area north of the Maranboy-Diljin Hill track, where the lower portion of the Kombolgie Formation has been tightly folded and unconformably overlain by its uppermost beds.

The faults observed within the Kombolgie Formation are closely spaced, with a small throw and a general northeast strike. Two sets of joints are present, one striking northeast, the other east-northeast. They are particularly well developed where the formation overlies volcanic rocks (Puk3 on Puk2).

The tectonic activity decreased during the deposition of the Diamond Creek Member and the Gundi Creek Greywacke, allowing a general levelling of the submarine topography except in the Gundi Creek area, where portions of Kombolgie Formation remained uncovered. However the synclinal structure still persisted. This phase is characterized by a calm, possibly shallow sea environment, by fine terrigenous and chemical sediments and outpouring of basaltic lavas. A rapid deposition of unsorted detrital and volcanic clastics followed in a shallow sea, within wave action range, and is recorded by the Gundi Creek

Greywacke.

Two sets of faults have been observed in the Gundi Creek Greywacke. They affect the underlying formations as well but movement ceased before the West Branch Volcanics were laid down. The strikes are respectively northeast and east-southeast and the throw considerable. The Diamond Creek Fault, West Branch Fault and some faults in the Waterhouse Waterfall area belong to this category. The throw of the Diamond Creek and the canyon faults was greater to the west and less to the east. It is likely that this tilting movement results from a general uplift connected with the Grace Creek Granite. Moreover, since these faults do not affect the West Branch Volcanics, there was probably a phase of tectonic activity between the deposition of the Gundi Creek Greywacke and the West Branch Volcanics. It would imply a time break and explain the unconformity observed in the Gundi Creek area at the base of the West Branch Volcanics. But the information collected to date is not conclusive.

The cobble conglomerate at the base of the West Branch Volcanics starts a new phase of rapid deposition accompanied and succeeded by outpouring of submarine basaltic lava. The deposition of tuffaceous greywacke and arkosic sandstone which followed, silted almost completely the synclinal structure.

Dating and type of geological events which occurred between the close of the West Branch Volcanics and the transgression of the Beswick Group are imperfectly known. Diljin Hill Fault and minor northeast striking faults in the Diljin Hill area are attributed to this period. The Diljin Hill Fault is a regional line of weakness composed of closely spaced, subparallel faults exposed between Diljin Hill and Beswick Homestead. Its probable extension south of the Beswick Homestead is named Morey fault (Walpole 1955; Plate 1). These faults are subvertical with a throw of several hundred feet and the southwest strike in the Diljin Hill area swings to south-southwest in the Beswick area. The topographic expression of these faults has locally conditioned the form of the Beswick Group Basin.

3) Beswick Group.

The transgression of the continental sea in which the Beswick Group was deposited is marked by a period of rapid deposition of coarse clastics (Margaret Hill Conglomerate and part of Bone Creek Formation). This event was succeeded by a calm and relatively shallow sea environment and deposition of clean beach sandstone, fine terrigenous materials, chemical and biochemical deposits (part of the Bone Creek Formation and the Dook Creek Formation). A submarine effusion of basaltic lava followed and was topped by siltstone and cherty sandstone (Mount Rigg Formation). The possible sequence of events of the Beswick Group is not recorded within the investigated area.

The sediments of the Beswick Group are shaped in a broad and shallow basin which occurs west of the Beswick Homestead. The basin pitches to the south with dips generally under 10°. It is mainly a sedimentary feature and the irregularities of its margins reflect the undulations of the original depositional surface. In the Maiwok-Flying Fox Creek area the Beswick Group is disposed in a monocline dipping in average 10° towards east and southeast. On the Waterhouse River, 19 miles above the Waterfall, a syncline has been observed in the lowermost member of the Beswick Group. This is also a depositional feature.

The Beswick Group sediments have been affected by two groups of faults, both with several hundred feet displacement. The first, probably developed along old lines of weakness, strikes north-east. It comprises the Bone Creek, Gundi Creek and Morey Faults and minor interjacent faults. The second group of faults strikes north. It consists of the Waterhouse fault and several others in the Diljin Hill area. The Flying Fox Group rests unconformably on the Beswick Group, which suggests that Beswick Group was regionally displaced before the Flying Fox Group was deposited. No evidence has been found that the above mentioned faults belong to this period of diastrophic activity or to a later period.

4) The Flying Fox Group.

The lithological characteristics of the Flying Fox Group are similar to those of the Beswick Group, except that they contain no chert and more silt-grade sediments. It is therefore suggested that the source rocks and the depth zone of the depositional environment were the same, but the physico-chemical conditions and the rate of deposition were different.

The small outcrop of the Flying Fox Group within the investigated area is part of a wide monoclinal structure bordering the Bulman basin to the south-west. The dips are 10^{o} - 20^{o} to the south-east. The faults strike southeast, are few and of small throw.

5) The latest movements.

Diastrophic movements affected all the infra-cretaceous sediments and exposed them to subaerial erosion and peneplanation. The nature and dating of these movements are not properly documented in the area.

A depositional cycle preceding the Mullaman Beds has been recorded by the friable Baker Sandstone. The deposit is possibly freshwater lacustrine and has been referred to generically as Mesozoic. With the re-establishment of marine conditions (Noakes, 1949), the Mullaman Beds were formed and covered all the pre-existing geological features. An uplift brought the formation into the present continental condition. Probably related to this last movement is the faulting which has been observed in the Mullaman Beds along the Gundi Creek Fault and elsewhere in Mullaman Beds above old lines of weakness of the Kombolgie Formation.

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Fig. 1 Vein of Kombolgie Sandstone in Edith River Volcanics. South-western corner of Diljin Hill 1 mile area.

Fig. 2 Kombolgie Sandstone intermixed with Edith River Volcanics by penecontemporaneous slumping. Same locality as Fig. 1.

Fig. 3 Conglomerate at the base of Puk (3) Kombolgie Sandstone close to contact with Birdie Volcanics. Upper reaches of Diamond Creek, Diljin Hill 1 mile area.

Fig. 4 Bar[illegible] of Kombolgie breccia conglomerate overlying tuffs of Edith River Volcanics, Dook Creek, Katherine River 1 mile area.

Fig. 5 Slump breccia of Puk1 Kombolgie Sandstone intercalcated in Birdie Creek Volcanics. Diljin Hill 1 mile area.

Fig. 5a Slump breccia of Puk1 Kombolgie Sandstone intercalcated in Birdie Creek Volcanics. Diljin Hill 1 mile area.

Fig. 6a Collenia Forms in Dook Creek Formation, Flying Fox Creek, Canopy Rock 1 mile area.

Fig. 6b Close up of Fig. 6(a).

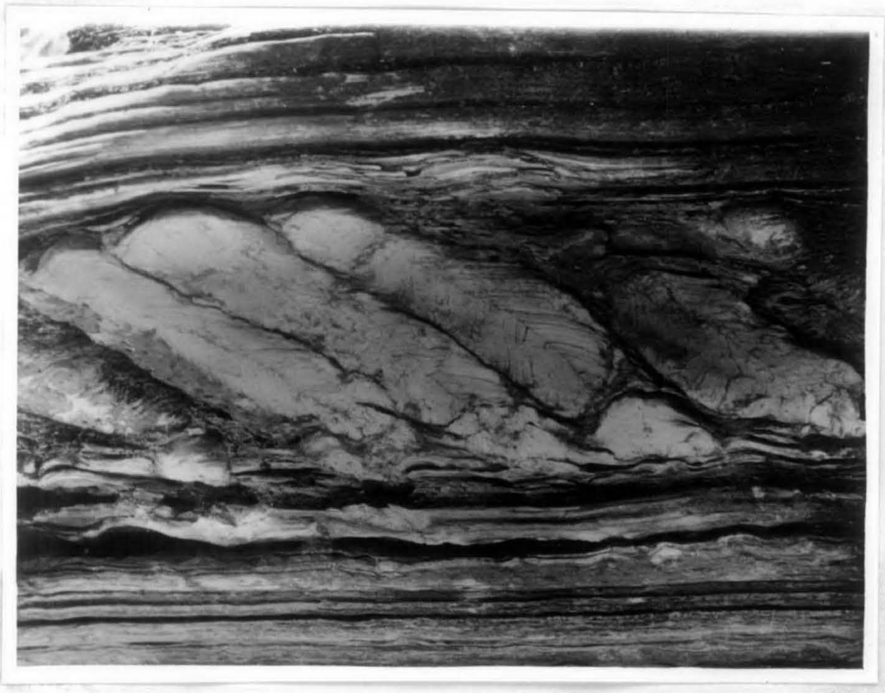
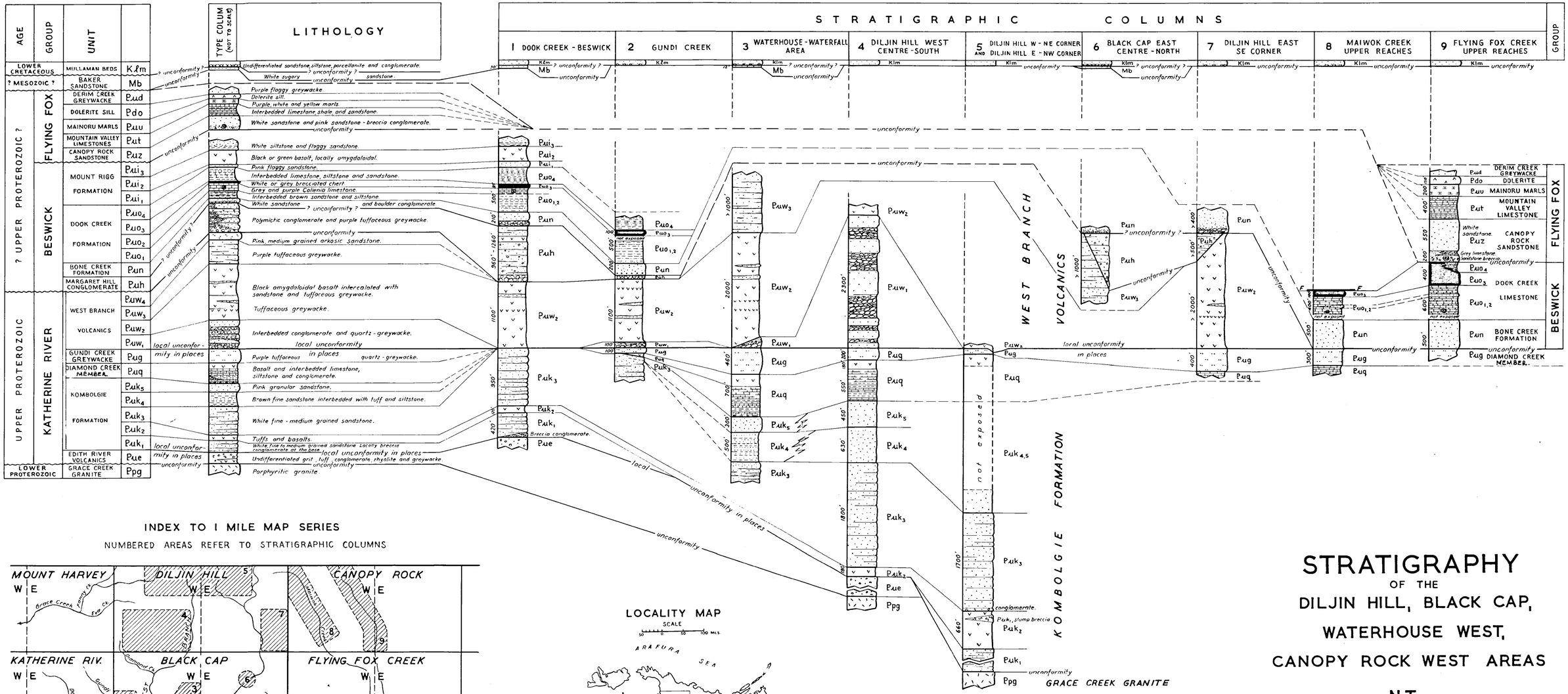


Fig. 6c Surface of Collenia band.

PLATE I

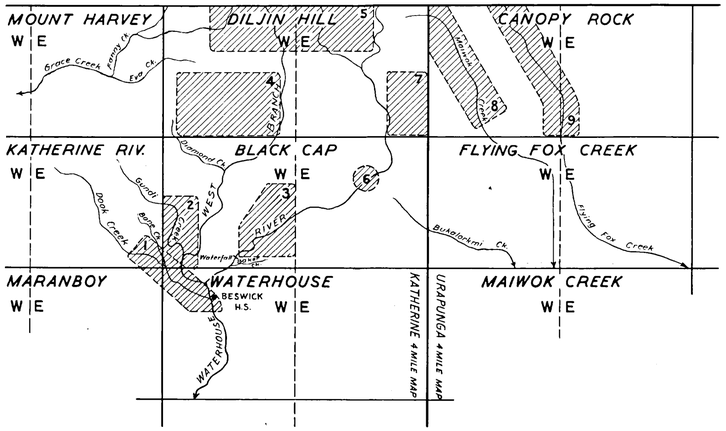


STRATIGRAPHY
OF THE
DILJIN HILL, BLACK CAP, WATERHOUSE WEST, CANOPY ROCK WEST AREAS
N.T.

SCALE
1000 0 1000 2000 3000 FT.

INDEX TO 1 MILE MAP SERIES

NUMBERED AREAS REFER TO STRATIGRAPHIC COLUMNS



LOCALITY MAP

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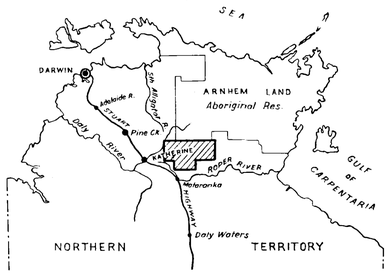

Bureau of Mineral Resources, Geology and Geophysics, Darwin, Jan. 1959. Drawn by E. Feeken.

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GEOLOGICAL HISTORY

PLATE 2

AGE	CLASSIFICATION			ENVIRONMENT	SEDIMENTATION	MACRO FOSSILS	TECTONICS	VULCANISM	MAX. THICKNESS
POST - LOWER CRETACEOUS				Subaerial	Erosion		UPLIFT. Faulting.	Not recorded.	
LOWER CRETACEOUS	Mullaman Beds			Epeiric Sea. Transgression.	Conglomerate, sandstone, porcellanite.	?	Slow subsidence.	Inactive.	200'
				? UNCONFORMITY ?					
?MESOZOIC?	Baker Creek Formation			Freshwater lacustrine?	Fossiliferous sandstone.	Roots ? Ferns.	Stable	Inactive.	30'
UNCONFORMITY				Subaerial.	Sedimentation not recorded. Erosion.		UPLIFT. Faulting.	Not recorded.	
? UPPER PROTEROZOIC ?	FLYING FOX GROUP	Dolerite Sill		CONTINENTAL SEA — Littoral and Neritic.		Nil.	Stable.	Intrusion Dating unknown.	150'
		Derim Creek Greywacke			Unsorted greywacke.			Inactive.	?
		Mainoru Marls			Marl. Slow sedimentation.				200'
		Mountain Valley Limestone			Limestone, shale, fine sandstone. Chemical precipitation.				400'
		Canopy Rock Sandstone			Sandstone breccia conglomerate. Rapid deposition.				750'
	UNCONFORMITY			Possible local erosion.			Displacement Beswick Group in Flying Fox area. Faulting. e.g. Bone Ck., Gundi Ck. faults	Not recorded.	
	BESWICK GROUP	Mt. Rigg Formation		Shallow water.	Sandstone, chert, siltstone and submarine flow of basalt.	Nil.	Stable, possibly minor subsidence. — Beswick Basin	Effusive phase.	> 500'
		Dook Ck. Formation		Neritic.	Limestone, shale, fine sandstone, chert. Slow sedimentation & precipitation.	Collenia	Stable	Possible minor eruptive activity.	> 600' (Beswick) > 1000' (Flying Fox)
		Bone Ck. Formation		Littoral.	Conglomerate and sandstone. Rapid deposition.	Nil		Inactive	500'
				? UNCONFORMITY ?					
		Margaret Hill Conglomerate		Littoral.	Conglomerate and tuff - greywacke. Rapid deposition. Transgression of continental sea	Nil		Minor eruptive activity.	1260'
UNCONFORMITY				Subaerial.	Not recorded in this area. Erosion.		UPLIFT. Jointing. Faulting. Diljin Hill Fault - Morey Fault ?	Not recorded.	
UPPER PROTEROZOIC	KATHERINE RIVER GROUP	West Branch Volcanics Member	P_{uw_4}	EPICONTINENTAL SEA — Littoral.	Arkosic sandstone. Silting of syncline.	Nil	Stable. — West Branch - Waterhouse Syncline	Inactive.	> 100'
			P_{uw_3}	Submarine.	Fine detrital clastics & tuffs.		Possible minor subsidence	Decreasing.	> 1000'
			P_{uw_2}		Flows of basalt; detrital clastics ; tuffs.			Major effusive phase.	2000'
			P_{uw_1}	Littoral	Conglomerate and coarse sandstone. Rapid deposition. Possible local transgression.			Inactive.	2300'
		LOCAL UNCONFORMITY IN PLACES		Local erosion (Gundi Ck)			Strong faulting and possible UPLIFT. Diamond Ck. & West Branch Faults.	Not recorded.	
		Gundi Ck. Greywacke Member.		SHELF — Littoral environment.	Detrital and volcanic clastics. Rapid deposition.	Nil.	Stable.	Inactive.	460'
		Diamond Creek Member.		Quiet environment. Neritic ?	Basalt and tuffs. Fine terrigenous and chemical sediments.			Effusive phase.	700'
		Kombolgie Formation	P_{uk_5}		Granular or coarse sandstone. Partial levelling of bottom topography.		Subsidence.	Inactive.	450'
			P_{uk_4}	Local depressions. Quiet environment.	Siltstone.			Possibly erruptive activity.	630'
			P_{uk_3}		Sandstone and intra - formational conglomerate.		Folding and faulting.	Inactive.	1800'
			P_{uk_2}		Tuff and basalt.		Slumping.	Minor effusive.	660'
			P_{uk_1}		Sandstone. Breccia - conglomerate. Rapid deposition.				> 500'
							Unstable shelf; intermittent vertical movements forming local depressions ; associated slump folding, brecciation, tilting and faulting of partly consolidated sediments.		
		LOCAL UNCONFORMITY IN PLACES			Local erosion. (Dook Creek)		Strong folding & faulting. (Dook Ck.) Relatively stable. (Diamond Ck.) West Branch - Waterhouse syncline poss. outlined.	Not recorded.	
		Edith River Volcanics		Possible shelf environment. Transgression.	Rhyolite and tuffs. Rapid deposition detrital and volcanic clastics.	Nil		Major effusive phase.	
UNCONFORMITY				Subaerial.	Erosion.		UPLIFT		
LOWER PROTEROZOIC	Grace Creek Granite			BASEMENT					

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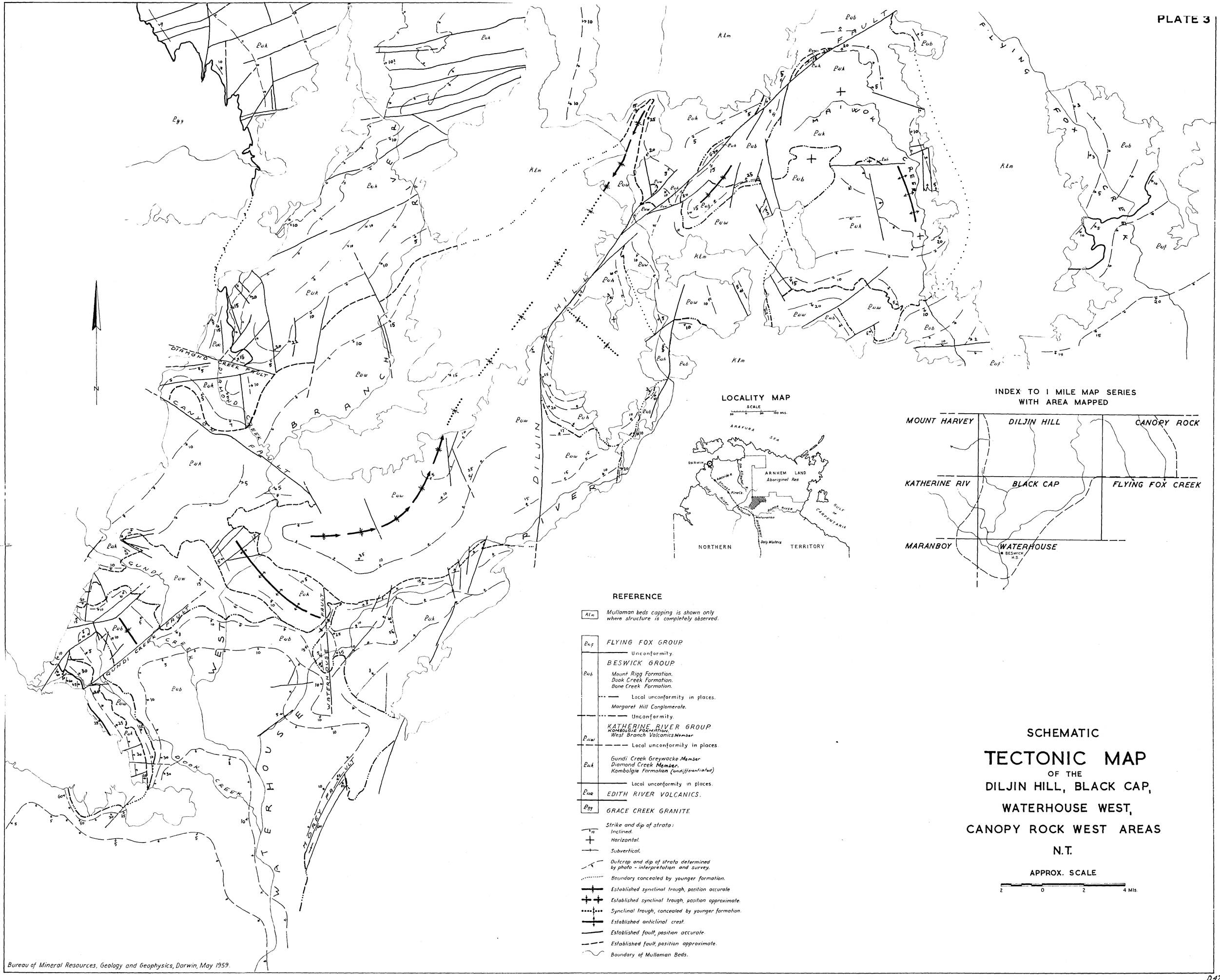
PLATE 3



LOCALITY MAP

INDEX TO 1 MILE MAP SERIES
WITH AREA MAPPED

REFERENCE

Klm — Mullaman beds capping is shown only where structure is completely observed.

Puf — FLYING FOX GROUP

Unconformity.

Pub — BESWICK GROUP
Mount Rigg Formation.
Dook Creek Formation.
Bone Creek Formation.

Local unconformity in places.

Margaret Hill Conglomerate.

Unconformity.

Puw — KATHERINE RIVER GROUP
KOMBOLGIE FORMATION —
West Branch Volcanics Member

Local unconformity in places.

Puk — Gundi Creek Greywacke Member
Diamond Creek Member.
Kombolgie Formation (undifferentiated)

Local unconformity in places.

Pue — EDITH RIVER VOLCANICS.

Pgg — GRACE CREEK GRANITE

Strike and dip of strata:
- Inclined.
- Horizontal.
- Subvertical.
- Outcrop and dip of strata determined by photo-interpretation and survey.
- Boundary concealed by younger formation.
- Established synclinal trough, position accurate.
- Established synclinal trough, position approximate.
- Synclinal trough, concealed by younger formation.
- Established anticlinal crest.
- Established fault, position accurate.
- Established fault, position approximate.
- Boundary of Mullaman Beds.

SCHEMATIC

TECTONIC MAP

OF THE

DILJIN HILL, BLACK CAP, WATERHOUSE WEST, CANOPY ROCK WEST AREAS

N.T.

APPROX. SCALE

2 0 2 4 Mls.

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DILJIN HILL

PLATE 4

REFERENCE

Geological Information to November 1958.

QUATERNARY

- Alluvium, soil cover.
- Cz/M — Sand or laterite cover on undifferentiated Mullaman Beds and Baker Creek Sandstone.

LOWER CRETACEOUS

- Klm — MULLAMAN BEDS. Undifferentiated friable quartz sandstone, conglomerate, siltstone, porcellanite.

? unconformity ?

- Mb — BAKER CREEK SANDSTONE. White sugary sandstone.

unconformity.

UPPER PROTEROZOIC

Beswick Group

- Pum — BONE CREEK FORMATION. White sandstone and boulder conglomerate.

(?)unconformity(?)

- Puh — MARGARET HILL CONGLOMERATE. Tuffaceous greywacke - conglomerate.

unconformity.

Katherine Riv. Group

- Puw_4 — WEST BRANCH VOLCANICS. MEMBER. Pink arkosic sandstone.
- Puw_3 — Purple tuffaceous greywacke.
- Puw_2 — Black amygdaloidal basalt with intercalated sandstone and tuffaceous greywacke.
- Puw_1 — Interbedded conglomerate and quartz greywacke.

local unconformity in places.

- Pug — GUNDI CREEK GREYWACKE. MEMBER. Purple tuffaceous quartz-greywacke and floggy sandstone.

Kombolgie Formation

- Pug_2 — DIAMOND CREEK MEMBER. Black amygdaloidal basalt.
- Pug_1 — Interbedded limestone, siltstone, chert

- Puk_5 — White fine floggy sandstone.
- Puk_4 — Purple fine greywacke.
- Puk_3 — White floggy sandstone.
- Puk_2 — BIRDIE CREEK VOLCANICS. MEMBER. Basalt interbedded with tuff.
- Puk_1 — White floggy sandstone.

local unconformity in places.

Edith River Volcanics

- Pue — Purple tuffaceous greywacke, conglomerate.

unconformity.

LOWER PROTEROZOIC

- Pgg — GRACE CREEK GRANITE. Porphyritic granite.

- Established geological boundary, position accurate.
- Established geological boundary, position approx.
- Inferred geological boundary.
- Strike and dip of strata.
- Horizontal strata.
- Outcrop and dip of strata determined by photo interpretation (dip < 15°).
- Established fault position accurate.
- Established fault position approximate.
- Fault concealed by younger sediments.
- Synclinal trough position accurate.
- Probable synclinal trough, concealed by younger sediments with pitch.
- Joint pattern from air-photos.
- Track position approximate.

SCALE

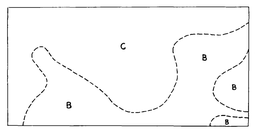
1 0 1 2 MLS.

LOCALITY MAP

SCALE

0 50 100 MLS.

GEOLOGICAL RELIABILITY DIAGRAM

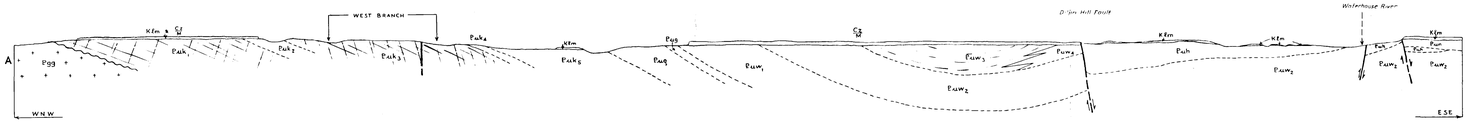


B Detailed reconnaissance - numerous traverses with photo-interpretation.

C Photo-interpretation.

SCHEMATIC GEOLOGICAL SECTIONS

SECTION A



SECTION B

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

BLACK CAP

PLATE 5

REFERENCE

QUATERNARY

- Alluvium, soil cover.
- Qz / M — Sand or laterite cover on undifferentiated Mullaman Beds and Baker Creek Sandstone.

LOWER CRETACEOUS

- Klm — MULLAMAN BEDS. Undifferentiated sandstone, siltstone, porcellanite and conglomerate.

?unconformity?

- Mb — BAKER CREEK SANDSTONE. White sugary sandstone.

unconformity

UPPER PROTEROZOIC Maiwok Group

- Pur — CHAMBERS RIVER FORMATION. Ripple marked friable quartz sandstone, flaggy micaceous quartz sandstone, siltstone.
- Pub — BUKALORKMI SANDSTONE. Ripple marked friable quartz sandstone.
- Pky — KYALLA FORMATION. Flaggy quartz sandstone, flaggy micaceous greywacke, siltstone, calcareous siltstone cone-in-cone limestone.
- Pur — MOROAK FORMATION. Ripple marked friable quartz sandstone.
- Pvr — VELKERRI FORMATION. Siltstone, calcareous siltstone.

Beswick Group

- Pud_4 — DOOK CREEK FORMATION. Limestone, siltstone and sandstone, interbedded.
- Pud_3 — White or grey brecciated chert.
- Pud_2 — Grey and purple Collenia limestone.
- Pud_1 — Interbedded brown sandstone and siltstone.
- Pun — BONE CREEK FORMATION. White sandstone and boulder conglomerate.

?unconformity?

- Puh — MARGARET HILL CONGLOMERATE. [illegible] conglomerate and purple [illegible] greywacke.

Katherine Riv. Group

KOMBOLGIE FORMATION.

- Puw_3 — WEST BRANCH VOLCANICS. MEMBER. Purple tuffaceous greywacke.
- Puw_2 — Black amygdaloidal basalt with intercalated sandstone and tuffaceous greywacke.
- Puw_1 — Interbedded conglomerate and quartz greywacke.

local unconformity in places

- Pug — GUNDI CREEK GREYWACKE MEMBER. Purple tuffaceous quartz greywacke.
- Pud_3 — DIAMOND CREEK MEMBER. Black amygdaloidal basalt.
- Pud_1 — Interbedded limestone, siltstone, conglomerate.
- Puk_5 — Pink granular sandstone and white fine flaggy sandstone.
- Puk_4 — Brown fine sandstone interbedded with tuff and siltstone.
- Puk_3 — White fine medium grained sandstone.
- Puk_2 — Tuffs, basalts.
- Puk_1 — White fine to medium grained sandstone. Breccia conglomerate at the base in places.

local unconformity in places

- Pue — EDITH RIVER VOLCANICS. Purple tuffaceous greywacke conglomerate.

IGNEOUS ROCKS

- Fine grained basic volcanic (?) rock.
- Fine to medium grained basic intrusive rock.
- Fine grained intermediate to basic intrusive rock.
- Medium grained basic intrusive rock.

Established geological boundary - position accurate.
Established geological boundary - position approximate.
Inferred geological boundary.
Strike and dip of strata
Horizontal strata.
Outcrop and dip of strata determined by photo interpretation (dip < 45°)
Established fault - position accurate.
Established fault - position approximate.
Established fault concealed by alluvium.
Joint pattern.
Synclinal axis - position approximate.
Anticlinal axis - position approximate.
Synclinal axis concealed by younger sediments.
Vehicle track.
Fence

SCALE
1 0 1 2 MLS.

LOCALITY MAP
SCALE
0 50 100 MLS.
ARAFURA SEA
DARWIN
ARNHEM LAND Aboriginal Res.
GULF OF CARPENTARIA
Katherine
Roper River
Mataranka
Daly Waters
NORTHERN TERRITORY

GEOLOGICAL RELIABILITY DIAGRAM
B — Detailed reconnaissance - numerous traverses with photo - interpretation.
C — Photo - interpretation.

SCHEMATIC GEOLOGICAL SECTIONS
SECTION A: Section ① WEST-WEST BRANCH; Section ② Canyon Fault; S — N
SECTION B: Section ④ WEST BRANCH; Section ③ Waterhouse River; NW — SE
SECTION C: Section ⑤ DOOK CREEK; Section ⑥ WEST-WEST BRANCH; Section ⑦ WEST BRANCH; SW — NE

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

WATERHOUSE

PLATE 6

REFERENCE

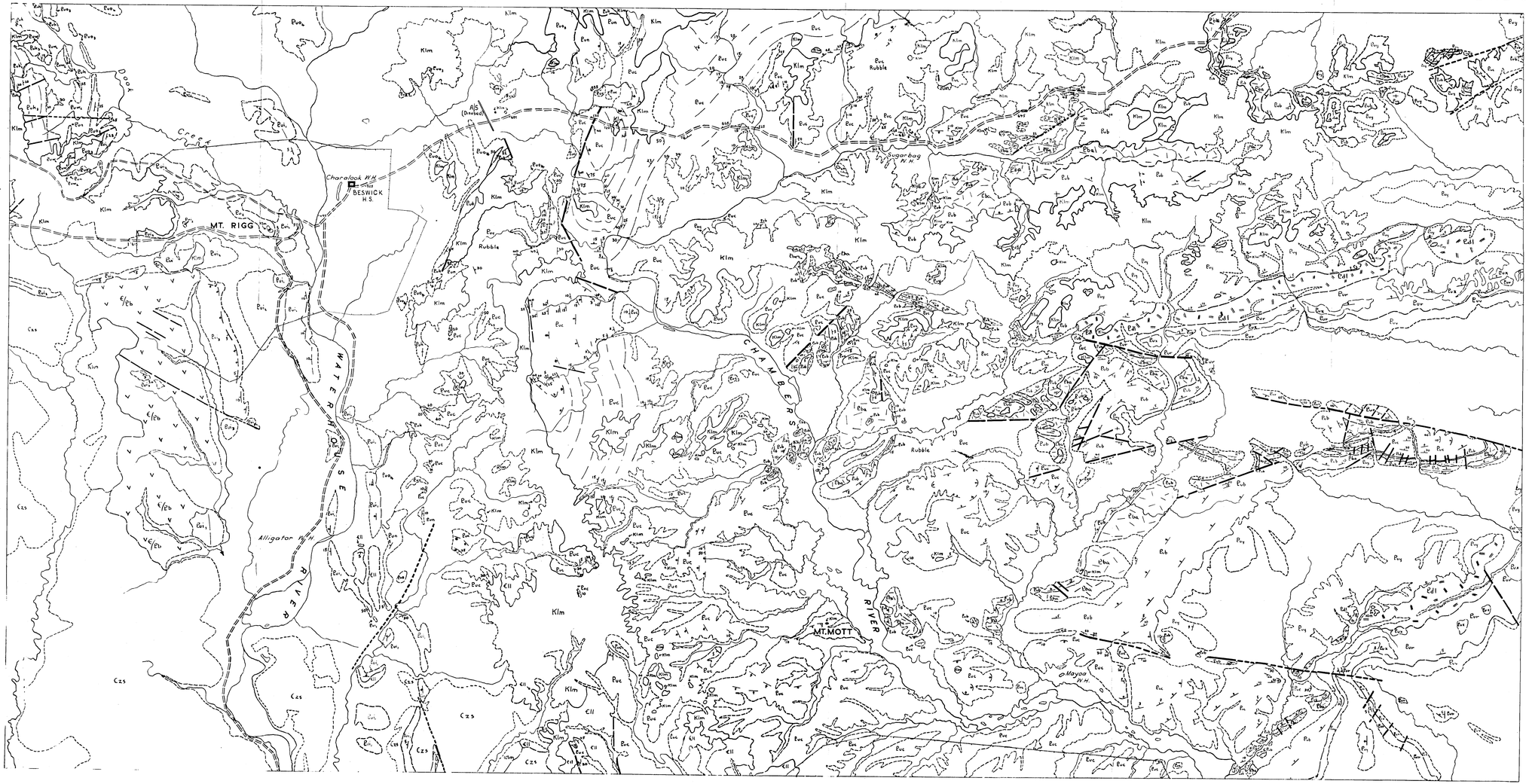
Geological Information to November, 1958

QUATERNARY		*Alluvium. Soil cover.*
QUATERNARY AND TERTIARY	Cz s	*Laterite, sand cover.*
LOWER CRETACEOUS	Klm	MULLAMAN BEDS *Undifferentiated friable quartz sandstone in places ferruginous. Lumpy mass porcellanite*
Unconformity		
LOWER CAMBRIAN	Cll	LIGHT CREEK VOLCANICS *Basic amygdaloidal subaerial, silicified sedimentary breccia*
Unconformity		
	Cuc	CHAMBERS RIVER FORMATION *Ripple marked friable quartz sandstone, sloggy micaceous quartz sandstone, siltstone*
	Cub	BUKALORKMI SANDSTONE *Ripple marked friable quartz sandstone.*
	Cuy	KYALLA FORMATION *Flaggy quartz sandstone, sloggy, micaceous greywacke, siltstone, calcareous siltstone, cone-in-cone limestone*
	Cur	MOROAK SANDSTONE *Ripple marked friable quartz sandstone*
	Cux	Mt. Karmain Member *Basaltic ironstone, ferruginous sandstone*
	Cuv	VELKERRI FORMATION *Siltstone, calcareous siltstone.*
Unconformity		
	Cu_{1_3}	MT. RIGG FORMATION *White siltstone, flaggy sandstone.*
	Cu_{1_2}	*Black or green basalt, locally amygdaloidal.*
UPPER PROTEROZOIC	Cu_{1_1}	*Pink flaggy quartz sandstone.*
	Cuo_4	DOOK CREEK FORMATION *Interbedded limestone, siltstone, sandstone*
	Cuo_3	*White or grey brecciated chert*
	Cun	BONE CREEK FORMATION *White sandstone, boulder conglomerate.*
?Unconformity(?)		
	Cuh	MARGARET HILL CONGLOMERATE *Polymictic conglomerate purple tuffaceous greywacke*
Unconformity		KOMBOLGIE FORMATION
	Cuw_2	WEST BRANCH VOLCANICS MEMBER *Black amygdaloidal basalt interbedded with sandstone and tuffaceous greywacke.*
Disconformity		
	Cuk	KOMBOLGIE FORMATION *Pink quartz sandstone.*
	Cuk_3	*White fine to medium grained quartz sandstone.*
	Cuk_2	*Tuff, basalt*
	Cuk_1	*White fine to medium grained quartz sandstone. Local breccia conglomerate at base.*
IGNEOUS ROCKS	Cb_{Cu}	*Fine grained basic volcanic(?) rock.*
	Cdl_{Cu}	*Fine to medium grained basic intrusive rock.*
	$C/_{Cb}$	*Undifferentiated basic volcanic rock*

- *Established geological boundary position accurate.*
- *Established geological boundary position approximate.*
- *Established alluvium boundary position approximate.*
- *Strike and dip of inclined strata.*
- *Horizontal strata.*
- *Trend lines determined by photo interpretation.*
- *Outcrop and dip of strata from air-survey determined by photo interpretation.*
- *Outcrop and dip of strata from air-survey determined by photo interpretation.*
- *Established fault - position accurate.*
- *Established fault - position approximate.*
- *Established fault - concealed by alluvium.*
- *Fault breccia*
- *Basic dyke*
- *Spot height, determined by theodolite survey*
- *Road*
- *Homestead*
- *Air strip*
- *Fence*

SCALE

½ 0 1 2 MILES



CANOPY ROCK

PLATE 7

FIELD SHEET ONLY – NOT FOR PUBLICATION

APPROXIMATE SCALE 1 MILE TO 1 INCH

ARNHEM LAND ABORIGINAL RESERVE

REFERENCE

Geological Information up to November 1960

QUATERNARY

Qal — Alluvium, soil cover.

QUATERNARY AND TERTIARY

Cz/M — Sand or laterite cover on undifferentiated Mullaman beds.

LOWER CRETACEOUS

Klm — MULLAMAN BEDS. Undifferentiated friable quartz sandstone in places ferruginous conglomerate, porcellanite. Fresh water and marine sediments.

Unconformity

But — MAORI CREEK BEDS. White friable quartz sandstone, ferruginous sandstone, flaggy quartz sandstone.

Pud — DERIM CREEK GREYWACKE. Purple flaggy and massive greywacke.

Puu — MAINORU MARLS. Purple white and yellow marls.

Put — MOUNTAIN VALLEY LIMESTONES. Interbedded limestone, shale, sandstone.

Puz — CANOPY ROCK SANDSTONE. White sandstone, pink sandstone, breccia conglomerate.

Unconformity

Puo — DOOK CREEK FORMATION. Undifferentiated limestone, siltstone, brown flaggy sandstone and chert interbedded with white sandstone.

Puo4 — Interbedded limestone, siltstone, sandstone.

Puo3 — White or grey brecciated chert.

Puo2 — Grey and purple Collenia limestone.

Pun — BONE CREEK FORMATION. White sandstone, boulder conglomerate.

Unconformity

KOMBOLGIE FORMATION

Puw2 — WEST BRANCH VOLCANICS MEMBER. Black amygdaloidal basalt interbedded with sandstone and tuffaceous greywacke.

Local Unconformity in places.

Pug — GUNDI CREEK GREYWACKE MEMBER. Purple tuffaceous quartz greywacke.

Puq — DIAMOND CREEK MEMBER. Basalt and interbedded limestone siltstone, conglomerate.

IGNEOUS ROCKS

Pdo — Fine to medium grained basic intrusive.

- Established geological boundary - position accurate.
- Established geological boundary - position approximate.
- Established alluvium boundary - position approximate.
- Indefinite geological boundary.
- Strike and dip of inclined strata.
- Outcrop of horizontal strata.
- Outcrop and dip of strata from 0° - 15° determined by photo interpretation.
- Trend lines determined by photo interpretation.
- Joint pattern determined by photo interpretation.
- Established fault - position accurate.
- Established fault - position approximate.
- Established fault - concealed by alluvium.
- Vehicle track.
- Homestead.
- Stock yard.
- A/S — Air strip.

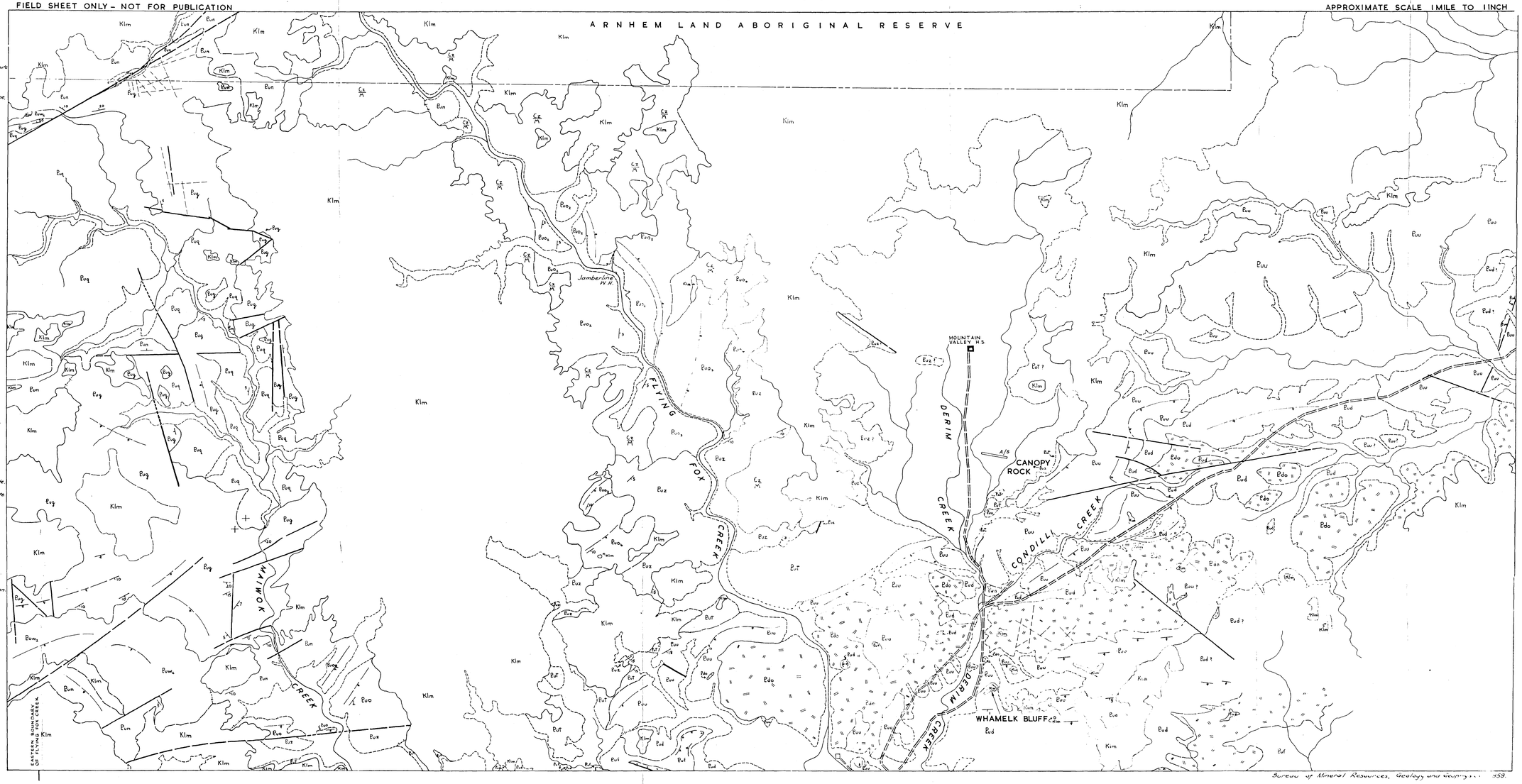
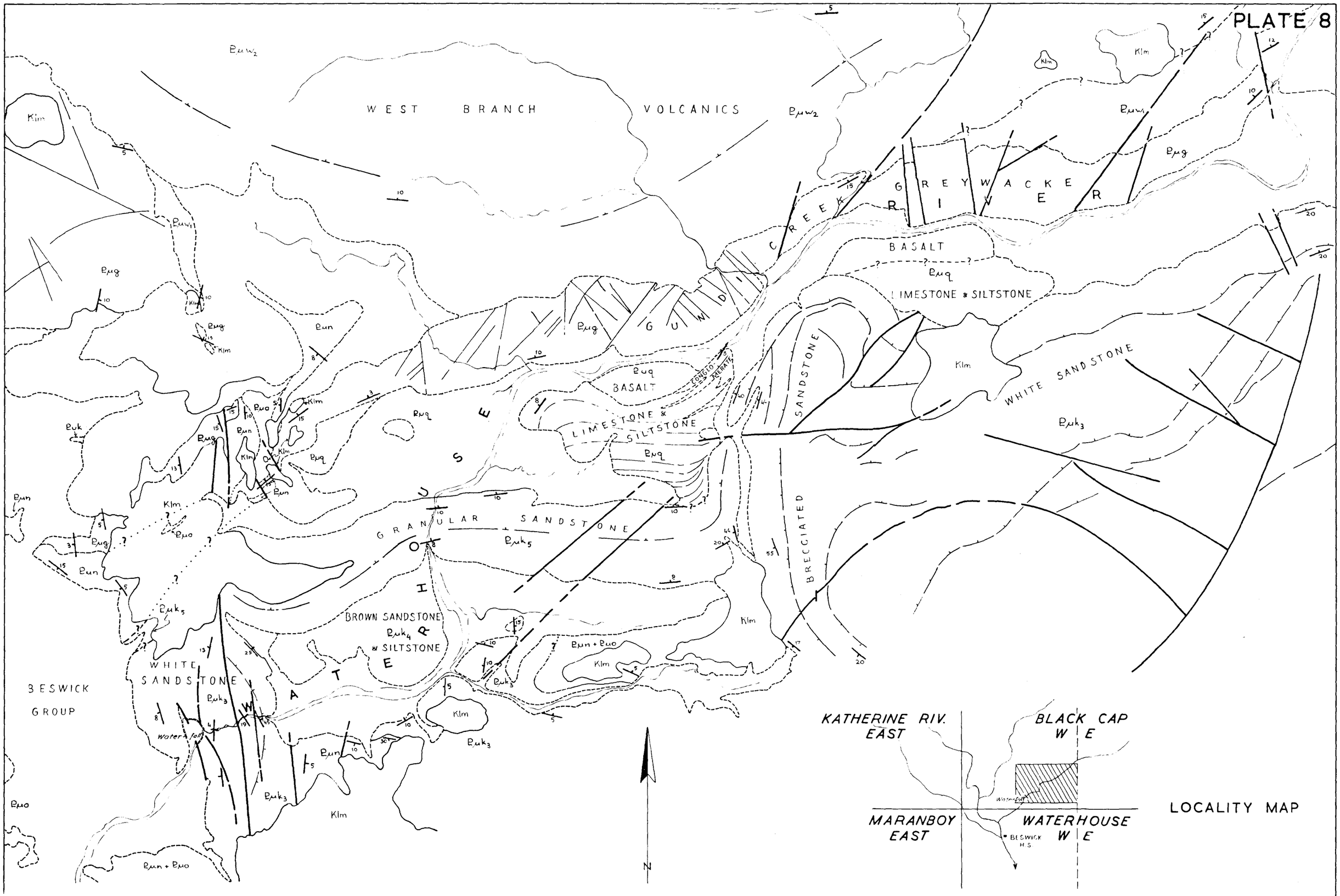


PLATE 8



LOCALITY MAP

REFERENCE

LOWER CRETACEOUS	Klm	Mullaman Beds. Sandstone, conglomerate and porcellanite.
unconformity		
?UPPER PROTEROZOIC?	Puo	Dook Creek Limestone. Limestone, sandstone and chert.
Beswick Group	Pun	Bone Creek Formation. Conglomerate and white sandstone.
unconformity		
UPPER PROTEROZOIC	Pμw2	Kombolgie Formation. Basalt.
Katherine Riv. Group	Pμw1	West Branch Volcanics. Conglomerate.
local unconformity in places.		
	Pμg	Gundi Creek Greywacke. Tuffaceous greywacke
	Pμq	Diamond Creek Member — Basalt
	Pμq	Limestone and siltstone.

UPPER PROTEROZOIC	Puk5	Granular sandstone.
Katherine Riv Group	Puk4	Kombolgie Formation
	Puk3	White sandstone.

- 10 — Strike and dip of strata.
- Trend line.
- Fault.
- Joints.
- Established boundary position accurate.
- Established boundary position approximate.
- Probable boundary.
- Inferred boundary, concealed.

GEOLOGICAL MAP

WATERHOUSE WATERFALL AREA (BLACK CAP 1 MILE AREA)

N.T.

APPROX. SCALE

0 0·5 1 1·5 2 MLS.

Bureau of Mineral Resources, Geology and Geophysics, Darwin, May 1959