DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1975/31

PROGRESS REPORT, ALLIGATOR RIVER PARTY, NORTHERN TERRITORY, 1972

(JIM JIM REGION)

by

R.S. Needham, P.G. Smart, & A.L. Watchman

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SUMMARY

This Record describes the results of fieldwork by the Alligator River Party during 1972 in the Jim Jim district of the Alligator Rivers uranium field.

The area mapped is occupied by a sequence of Lower Proterozoic sediments which dip generally east from a dome in the far west of the area. The sediments are intruded by dolerites and a granite, and are unconformably overlain by Carpentarian plateau sandstone.

The oldest unit within the sedimentary sequence is altered basalt and agglomerate of the Stag Creek Volcanics, exposed in a small inlier south of Mundogie Hill. It is overlain, probably conformably, by the Mount Partridge Formation sandstone, quartzite, siltstone, arkose, and conglomerate.

The Mount Partridge Formation is unconformably succeeded by a series of chert-banded carbonaceous and calcareous siltstone. West of the Mount Partridge Range this series is recognized as a continuation of the Koolpin Formation of the South Alligator River valley. East of the range the series is characterized by fewer chert beds, and discontinuous sedimentary quartzite horizons; it is continuous with a similar series of rocks traced farther north by us in 1971, and is the host rock to important uranium deposits (i.e. Koongarra, Ranger 1, and Jabiluka). We informally refer to this rock series as Koolpin Formation equivalent.

The Koolpin facies rocks are transitionally overlain by an homogeneous succession with minor arenaceous bands, the Fisher Creek Siltstone, which is metamorphosed to slate and phyllite in the east of the area.

The Lower Proterozoic sedimentary succession is intruded by two dolerites and a granite. The Zamu Complex, a group of differentiated dolerites, was intruded as sills before the sediments were folded and was subsequently folded, about 1800 m.y. ago, into steeply dipping bodies concordant with the enclosing sediments. The Jim Jim Granite was intruded after the sediments were folded; so too was the 'Oenpelli Dolerite', which probably postdates the granite. The granite forms a boss about 25 km in diameter in the centre of the area, and the Oenpelli Dolerite crops out as the edge of a large southerly and easterly dipping basin, or lopolith.

In the far north of the area, Mount Partridge Formation rocks were partly migmatized about 1800 m.y. ago to form part of the Nanambu Complex, an extensive migmatite complex exposed mostly in the Cahill and East Alligator 1:100 000 Sheet areas, to the north. Relations between the sediments and the Complex are not clear, but interbanded biotite schist and meta-arkose at Mount Basedow probably indicate a transition from slightly metamorphosed sediments into leucogneiss, which is a common rock type within the Complex.

The edge of the Carpentarian Kombolgie Formation plateau sandstone forms a scarp along the southern and western margins of the area mapped. It is mostly composed of coarse quartz sandstone, but massive basal conglomerate is commonly developed on or adjacent to rises in the pre-Kombolgie surface. The underlying rocks are generally best exposed in the footslope of the escarpment.

A small highly ferruginized exposure of undifferentiated Mesozoic rock caps a low hill near the Mundogie gold mine in the west of the area. Extensive Cainozoic sand and alluvium forms a veneer over the older rocks in the lower-lying areas.

The area is considered to have mineral potential, as the Koolpin facies rocks represent a continuation of a locally mineralized stratigraphic level between the uranium areas of South Alligator River valley and Alligator Rivers.

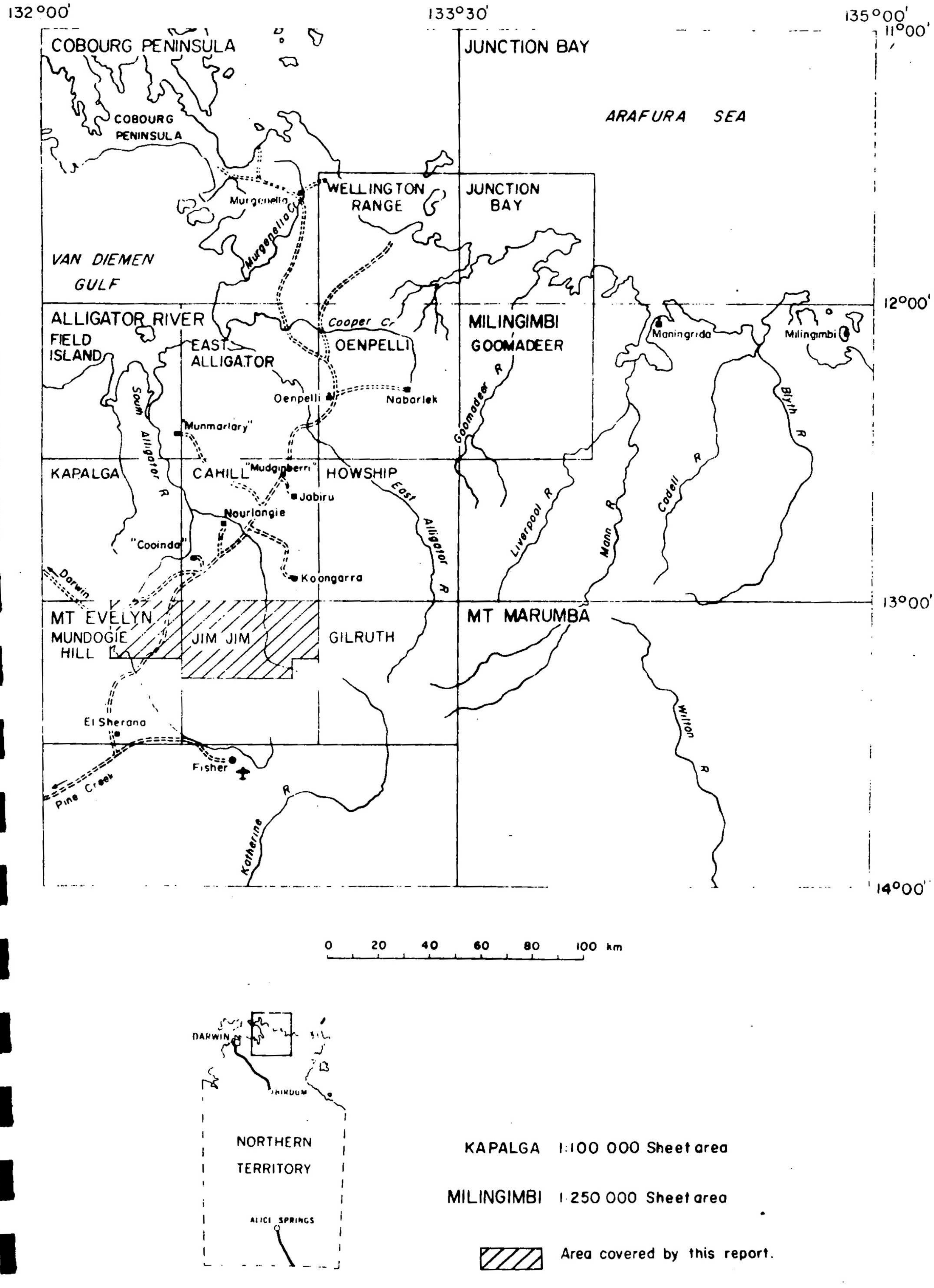

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Fig. 1 Location map.

NT/A/457

INTRODUCTION

During 1972 a Bureau of Mineral Resources (BMR) field party continued detailed mapping of the Alligator Rivers uranium field. This Record is a progress account that fieldwork, and includes 1:50 000 scale compilation sheets for the following 1:100 000-scale Sheet areas: Jim Jim NE, NW, and parts of SE and SW; and Mundogie NE.

The object of this work was to extend the detailed mapping done in 1971 (Cahill and East Alligator 1:100 000 Sheet areas), and to correlate the successions recognized in these areas with that of the Mount Evelyn 1:250 000 Sheet area.

Work during 1972 in the Oenpelli area is reported separately (Needham, Smart, & Watchman, 1975).

Traverses by Landrover and on foot were made over the survey area during June and July from a base camp situated on Jim Jim Creek, 1 km upstream from the Jim Jim crossing.

Field observations were plotted onto RC8 (1:16 000-scale) aerial photographs; detailed interpretation of these photographs was later transferred to overlays on 1:50 000-scale enlargements of RC9(1:83 000-scale) aerial photographs. This was then drafted onto 1:50 000 scale corrected bases drawn from the RASC topographic bases.

Location and access

The location of the survey area is shown in Figure 1. The area is 260 km east-southeast of Darwin and is reached by the Darwin-Oenpelli road or the Pine Creek road, both of which pass through the Mundogie NE Sheet area. Access to the Jim Jim NE and NW Sheet areas is not as good; rough tracks lead to Jim Jim Falls, and to an exploration camp near Graveside Gorge.

Previous investigations

Investigations before the 1960s are listed by Walpole et al. (1968). Since 1969 exploration companies have been active in the area, and have been prospecting principally for uranium. Reports of their activities are lodged with the Mines Branch, Darwin. In 1971, Needham & Smart (1972) mapped adjacent areas to the north as part of the current BMR detailed mapping program.

PHYSIOGRAPHY

The dominant physiographic unit of the survey area is the Arnhem Land Plateau (Fig. 2), the edge of which forms a sheer scarp up to 150 m high at Jim Jim Falls. The plateau is markedly dissected; in places, the main watercourses form gorges 100 m deep, and tributaries are commonly incised along joints and faults.

The Northern Plains are low-lying soil and sand-covered flats with occasional low strike ridges and hills of sandstone, quartzite, schist, and dolerite. Drainage of the Northern Plains is partly controlled by geology: Jim Jim Creek follows a fault line near Mount Basedow, and its west branch follows the margin of the Jim Jim Granite.

The Uplands are rugged hills and strike ridges of Mount Partridge Formation and Koolpin Formation, which rise sharply up to 100 m above the level of the Northern Plains. The Uplands, apart from Mount Basedow, are restricted to the western half of the survey area.

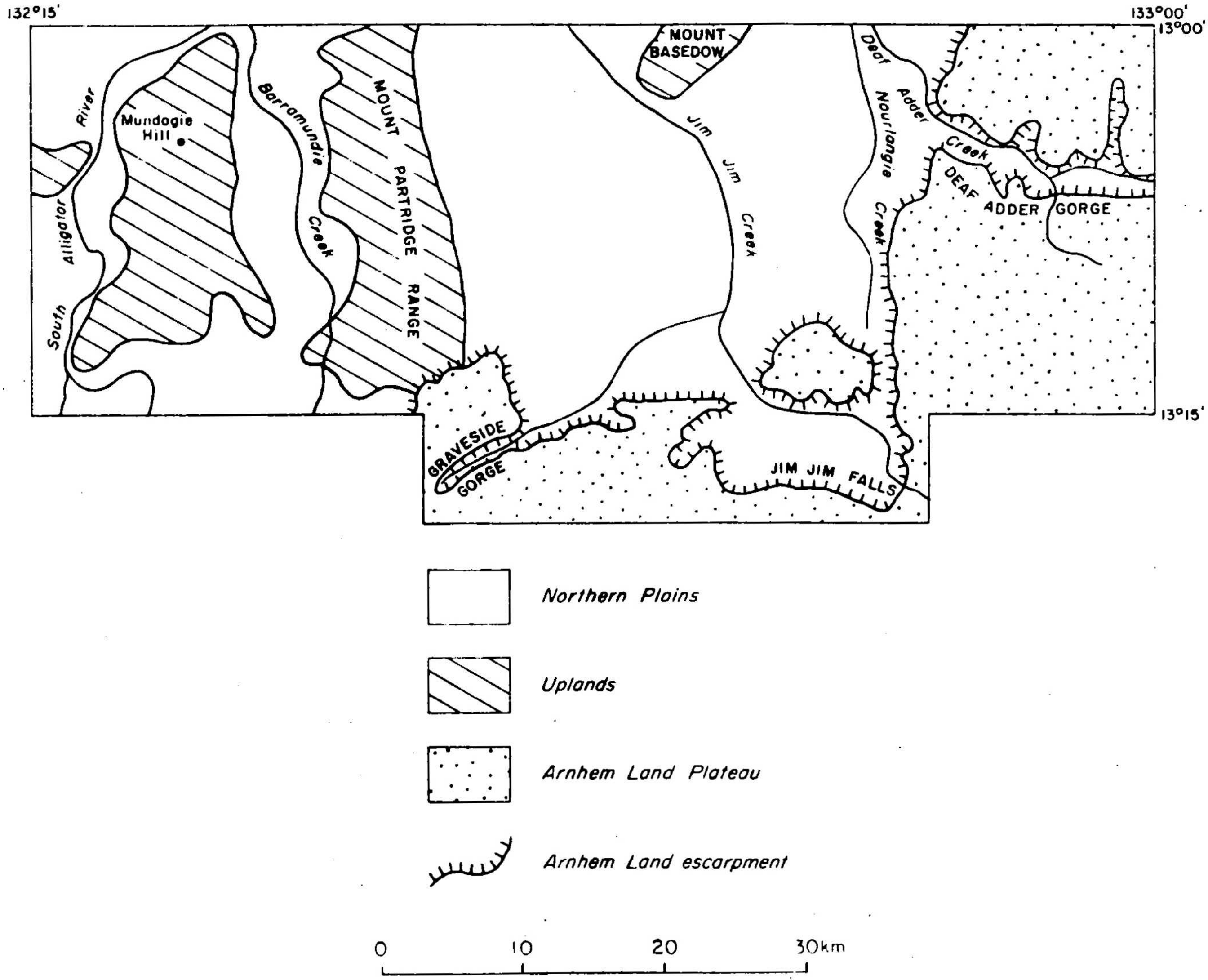

Fig. 2 Physiographic sketch map.

STRATIGRAPHY

The area mapped is occupied by Lower Proterozoic sedimentary units, metamorphosed to lower greenschist and upper greenschist facies, and intruded by an altered granite and two differentiated dolerites. Carpentarian plateau sandstone with interbeds of basic volcanics overlies the older rocks.

The oldest unit within the survey area is the Stag Creek Volcanics, altered basalt and agglomerate exposed in an inlier at Mundogie Hill. The unit is overlain by Mount Partridge Formation sandstone, siltstone, arkose, and conglomerate.

The Mount Partridge Formation is unconformably overlain by the Koolpin Formation chert-banded and carbonate-banded carbonaceous siltstone, which grades upwards into Fisher Creek Siltstone phyllite and slate.

Metadolerites of the Zamu Complex intrude the Fisher Creek Siltstone and have been folded concordant to the strike of the surrounding rocks. An extensive subhorizontal sheet of dolerite, the 'Oenpelli Dolerite', intrudes the Fisher Creek Siltstone round the margin of the Arnhem Land escarpment. The Jim Jim Granite appears to either assimilate the margins of the dolerite or was metasomatized by it.

The Carpentarian Kombolgie Formation unconformably overlies all the older units. The formation forms an extensive dissected plateau - the Arnhem Land Plateau - whose margin forms a sheer escarpment in the survey area. A small isolated capping of highly ferruginized coarse sandstone, probably Mesozoic, overlies Mount Partridge Formation near the Mundogie gold mine.

Cainozoic sand, soil, and alluvium form a veneer over the Northern Plains physiographic unit, and wedge-shaped talus accumulations adjacent to the Arnhem Land scarp.

The generalized geology of the area is shown in Figure 3.

Stag Creek Volcanics (Blsv)

Highly altered dark green basic volcanic rocks are exposed in a small inlier 14 km south-southwest of Mundogie Hill (Map Plate 2) as isolated large boulders (see Text - Plate i), and in creek beds. The surface of the inlier is in many places covered by extensive brown soil and sand, and talus deposits slope up to the overlying Mount Partridge Formation. The base of the Mount Partridge Formation is not exposed, but the presence of thick unmetamorphosed very coarse conglomerate beds at the base of the formation suggests that it probably disconformably overlies the volcanics. The volcanics are the oldest unit exposed in the survey area and are probably interbedded with the Lower Proterozoic sediments at the top of the Masson Formation (exposed 15 km farther southwest).

The volcanics appear to be altered basalts; small vesicles (up to 3 mm) contain euhedral epidote crystals and quartz. The fine-grained groundmass consists of epidote (probably altered from plagioclase), amphibole (tremolite?) with minor free quartz, and sphene. These rocks have probably undergone greenschist facies metamorphism.

LOWER PROTEROZOIC SEDIMENTS

The Lower Proterozoic sedimentary rocks grade from unmetamorphosed types in the west of the area to middle and upper greenschist facies metamorphics south of Mount Basedow. These rocks comprise the Mount Partridge Formation, Koolpin Formation, Koolpin Formation equivalents and Fisher Creek Siltstone.

Mount Partridge Formation (Blp)

The Mount Partridge Formation, a series of psammitic and pelitic rocks about 6000 m thick, forms the Mount Partridge Range, small strike ridges and hills west of Jim Jim Creek, and Mount Basedow (Map Plates 2 and 3).

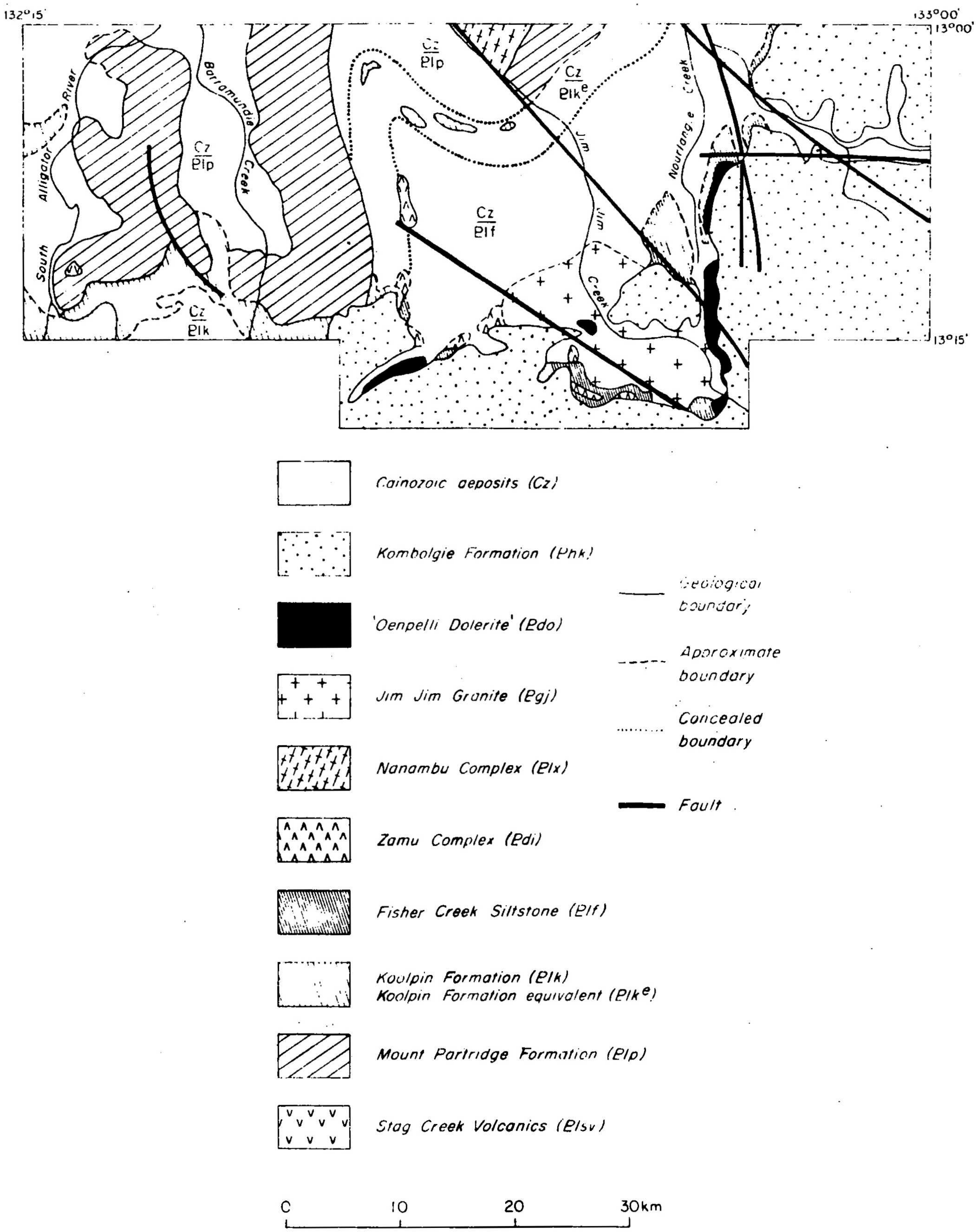

Fig. 3 Generalized geological map

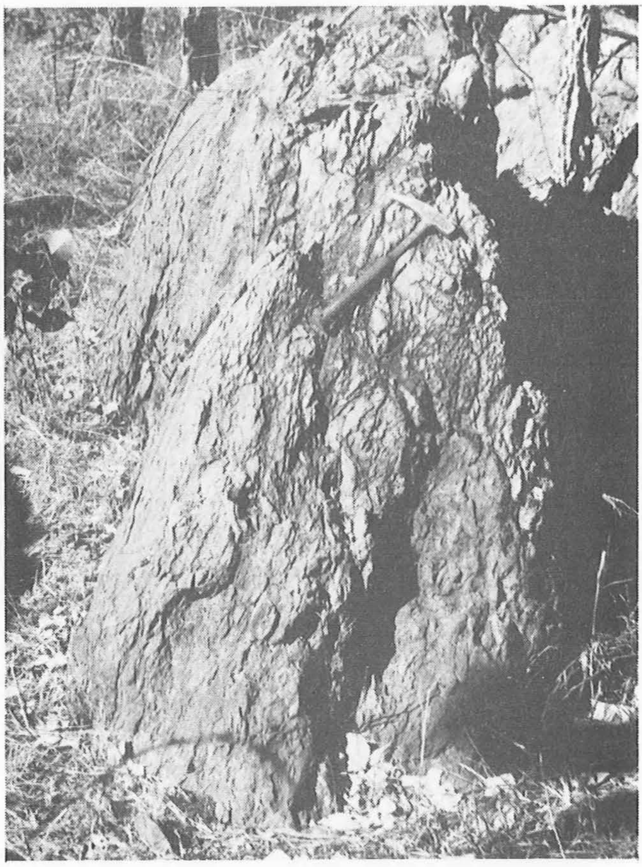

Plate i. Boulder of agglomeratic greenstone, Stag Creek Volcanics, in Mundogie Hill Inlier.

Five subunits are recognized:

(top)	Plp4	feldspathic sandstone, arkose, and quartzite
	Plp3	phyllite and minor feldspathic sandstone, quartzite, and schist
	Plp2	coarse conglomerate, feldspathic sandstone, arkose, and minor slate
	Plp1	Siltstone, and minor arkose, slate, phyllite, sandstone, and greywacke.
(bottom)	Plu	cross-bedded and ripple-marked sandstone with minor siltstone and slate; basal conglomerate (Mundogie Sandstone Member).

The Mundogie Sandstone Member was first described by Walpole (1962). It is a coarse clayey to feldspathic sandstone, medium-grained, massive to friable, and thickly bedded, with minor siltstone and pebble conglomerate bands. Some current-bedding and ripple-marking is present. Conglomerate layers typically consist of subrounded quartz and quartzite cemented in a clayey or feldspathic medium to coarse-grained quartz sandstone matrix.

The member grades vertically into Plp1, a poorly exposed sequence of micaceous and hematitic phyllite, micaceous siltstone, and pebbly arkose, with minor micaceous quartzite, pebbly hematite-quartz sandstone and coarse sandstone. Andalusite schist rubble covers the northern side of the hill at the Mundogie gold mine, and spotted (cordierite?) phyllite crops out 2 km to the north. These two rock types together with the hydrothermal gold-bearing and tin-bearing quartz veins of the region (Mundogie and Yemelba gold mines, and Spring Peak tin mine) may suggest the presence of a concealed acid intrusive body at depth.

The unit grades upwards into Plp2, a sequence of coarse conglomerate and feldspathic sandstone which forms the western flank of the Mount Partridge Range (Text-Plate ii(a)). The conglomerate consists of large milky quartz pebbles and boulders in a clayey or medium-grained sandstone matrix.

Above Plp2 is a sequence of phyllite, with minor arkose and quartzite (Plp3; Text - Plate ii(b)). In some places phyllite and schist are thought to result from dynamic metamorphism of siltstone in locally sheared zones.

The uppermost unit of the Mount Partridge Formation Blp4) is a sequence of fine to medium feldspathic sandstone, arkose, and quartzite (Text - Plate ii(c)). In some parts, the feldspars are several centimetres long, suggesting rapid deposition and a lack of sorting. At Mount Basedow this unit has a gneissic or schistose appearance, probably due to deformation and incipient migmatization at the margin of the Nanambu Complex (Text - Plate v).

Koolpin Formation (Blk)

The Koolpin Formation unconformably overlies the Mount Partridge Formation; it is poorly exposed, but where visible is composed of a pelite-carbonate-chert facies about 3000 m thick. The upper part is difficult to distinguish from the overlying Fisher Creek Siltstone: both are mainly pelitic and have surface exposures that are similarly ferruginous and weathered.

Outcrops are restricted to prominent strike ridges up to 70 m high southwest of the Mount Partridge Range (Map Plate 2). Typically the outcrop is weathered dark red-brown owing to surface concentration of hematite or goethite, or both.

Rock types are slate, phyllite, and schist, which are carbonaceous in places, with chert and carbonate bands and lenses (Text - Plate iii). The pelitic rocks consist essentially of quartz, sericite, and dust-like iron oxides, probably the product of weathered pyrite or magnetite. The carbonate rocks crop out poorly as yellow-brown vuggy brecciated rocks, and the chert bands are usually thin and interlayered with phyllite and schist. Columnar algal structures are apparent in silicified carbonate rock 12 km southeast of Mundogie Hill. Massive hematite-quartz breccia forms low rises in the same vicinity and may represent re-exhumed deep-weathering profiles over massive carbonate rock.

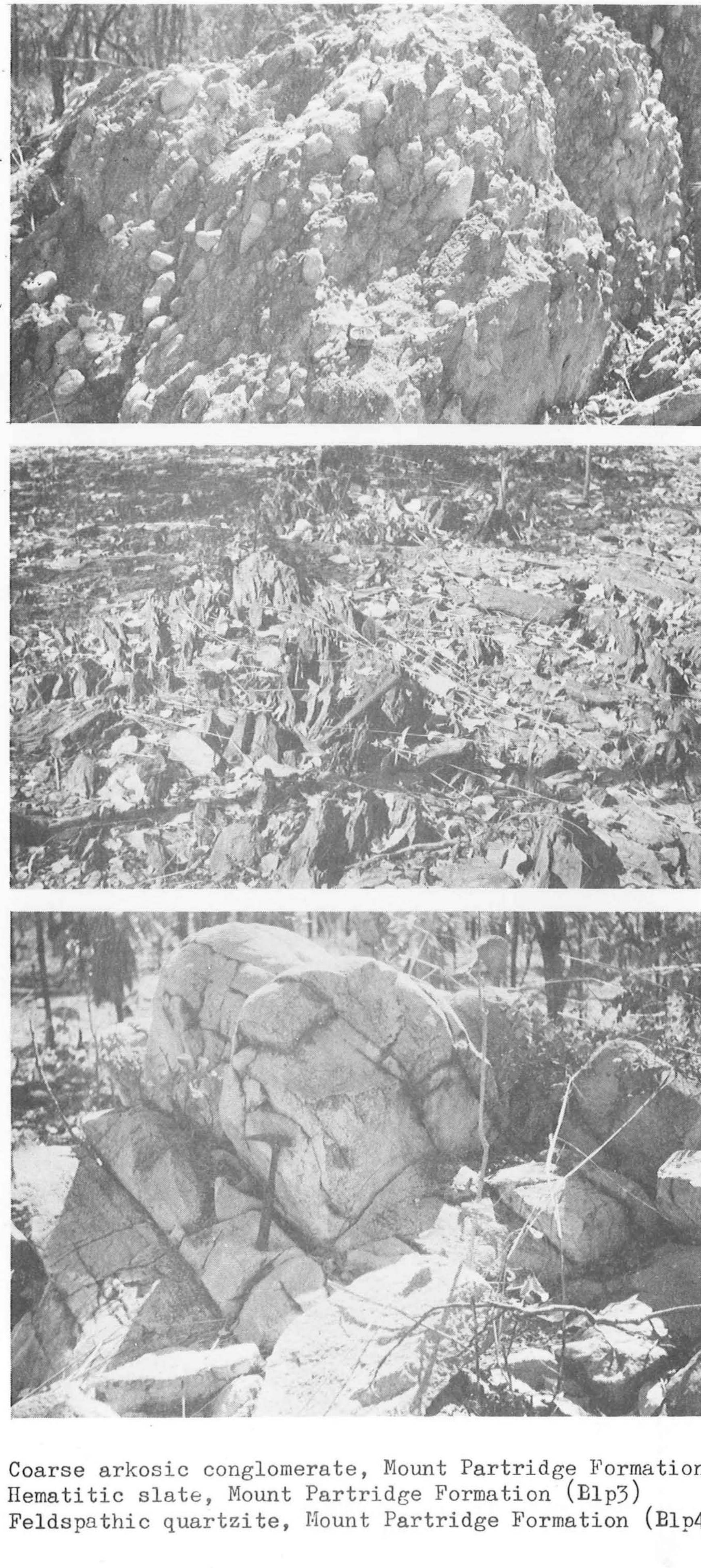

Plate ii. (a) Coarse arkosic conglomerate, Mount Partridge Formation (Blp2)
(b) Hematitic slate, Mount Partridge Formation (Blp3)
(c) Feldspathic quartzite, Mount Partridge Formation (Blp4)

Plate iii. (a) Chert-banded hematitic siltstone, Koolpin Formation southeast of Mundogie Hill Inlier
(b) Contorted slump-folded chert lenses and bands in hematitic carbonaceous siltstone, Koolpin Formation southwest of Mount Partridge Range

Koolpin Formation equivalent (B lk^{e})

A grey-white photopattern traced from Mount Cahill, in the Cahill Sheet area, south to Mount Basedow by Needham and Smart (1972) was thought to represent an arenaceous sequence within a series of rocks possibly correlating with the Koolpin Formation. This photopattern has now been traced (with difficulty) farther south to the eastern flank of the Mount Partridge Range, where it represents a sequence of poorly exposed quartzite and hematite schist with rare chert bands, which are stratigraphic equivalents to the quartzite exposed at Mount Cahill and near Koongarra.

These rocks, east of the Mount Partridge Range, lie in the same stratigraphic position as the Koolpin Formation southwest of the range, and form low discontinuous ridges of rubbly quartzite, with schist scree on the flanks. The ridges trend north, parallel to the Mount Partridge Range, for about 12 km from the Arnhem Land escarpment, then swing sharply east and then northeast to form low ridges on the southeast flank of Mount Basedow (Map Plate 3).

The sedimentary quartzite, and the rarity of chert bands in the pelitic rocks, serve to distinguish these rocks from the Koolpin Formation. The southern end of Mount Partridge Range is covered by Carpentarian sandstone, so that no relationship between Koolpin Formation and the series of rocks in the same stratigraphic position east of the range can be seen. The difference in lithological character between the two units suggests that they are not continuous under the capping of Carpentarian sandstone, but that the Mount Partridge Range formed a basement high during deposition of these units, and divided them into different sub-basins of deposition. The intersection of carbonaceous schist and massive carbonate rock in the Koongarra and Ranger 1 uranium deposits suggests that locally, at least, the environment of deposition of the host rocks was very similar to that of the Koolpin Formation.

The quartzite, schist, carbonaceous schist, and carbonate which extend northeast from Mount Partridge Range through the Jim Jim, Cahill, and

East Alligator Sheet areas is informally referred to as Koolpin Formation equivalent. A program of stratigraphic drilling in selected areas is planned; hopefully enough data will be acquired about this series to allow it to be formally named and defined.

Fisher Creek Siltstone (Elf)

The Fisher Creek Siltstone transitionally overlies the Koolpin Formation and Koolpin Formation equivalent. It consists of a thick sequence of siltstone with minor arenaceous bands, and is very poorly exposed except along the footslope of the Arnhem Land scarp where the rocks are generally deeply weathered (see Text - Plate iv). Slates are found in the south of the area (Map Plates 5 & 6), and, farther north near Deaf Adder Gorge, phyllites and quartz phyllites are common (Map Plate 4). Where the 'Oenpelli Dolerite' intrudes the siltstone, retrogressively metamorphosed hornfels is found. A thickness for the siltstone has not been established as its upper limit is not exposed, although Walpole (1962) proposed a thickness exceeding 5000 m in the South Alligator Valley.

NANAMBU COMPLEX (Elx)

Outcrop of the Nanambu Complex is poor, being restricted to incised creeks west of Mount Basedow to Jim Jim Creek (Map Plate 3). Leucogneiss, gneiss, schist, and quartzite have been mapped and are similar to those recognized for the remainder of the Jim Jim Mass of the Nanambu Complex, described by Needham & Smart (1972). The contact between the Nanambu Complex and the Mount Partridge Formation is not exposed. However gneiss and schist forming the main ridge of Mount Basedow, grade into sheared arkose and then meta-arkose down the east flank of the hill, and may represent a gradation from gneiss and schist of the Nanambu Complex into less metamorphosed sedimentary rocks of the Mount Partridge Formation*.

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* Results of age dating of the Nanambu Complex show that granites of Archaean age lie within migmatised and metamorphosed Archaean granite and Lower Proterozoic sediments, the whole comprising a mantled gneiss dome (R.W. Page, pers. comm.).

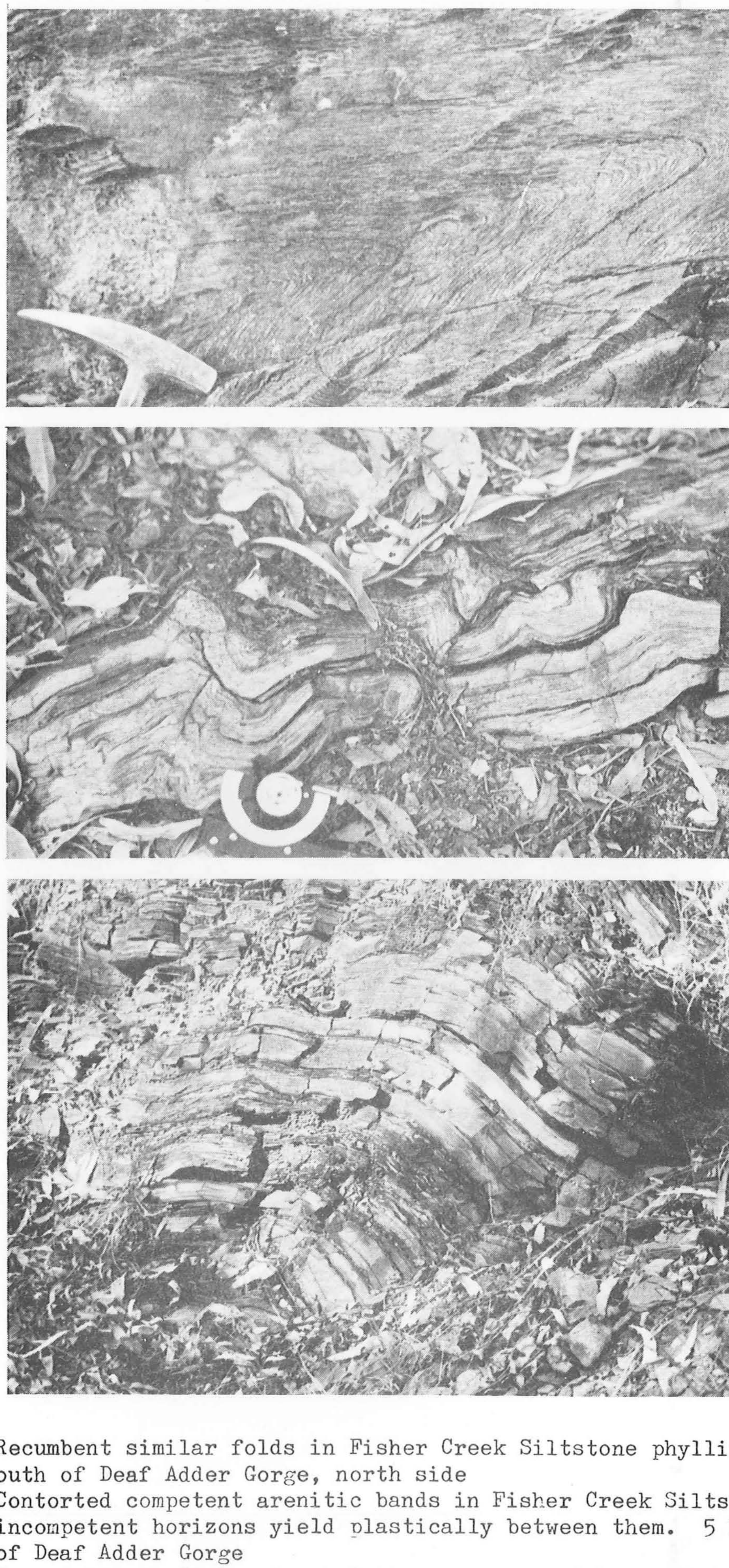

Plate iv. (a) Recumbent similar folds in Fisher Creek Siltstone phyllite, mouth of Deaf Adder Gorge, north side

(b) Contorted competent arenitic bands in Fisher Creek Siltstone - incompetent horizons yield plastically between them. 5 km south of Deaf Adder Gorge

(c) Open folds in Fisher Creek Siltstone slate, 4 km north of Deaf Adder Gorge

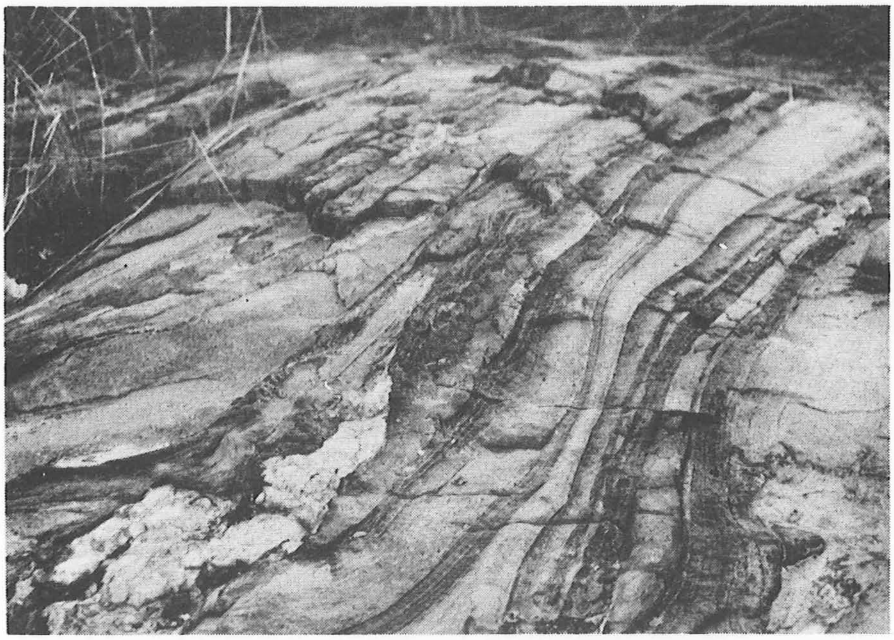

Plate v. Metamorphosed Mount Partridge Formation crops out as biotite schist and meta-arkose, Mount Basedow

INTRUSIVE ROCKS

Two groups of dolerite are recognized in the Jim Jim and Mundogie 1:100 000 Sheet areas. They are divided on the basis of their age: those intruded into Lower Proterozoic sediments before regional metamorphism and migmatization are called the Zamu Complex; those intruded after migmatization, the 'Oenpelli Dolerite'*.

Zamu Complex (Pdi)

Stewart (1959) first used this name to describe dolerite and gabbro sills and dykes in the Zamu Creek area. These intrusives are best exposed 8 km northeast of Graveside Gorge (Map Plate 6), where a fine-grained massive metadolerite forms a prominent ridge up to 70 m high. Elsewhere the Complex crops out as low hills of rounded in-situ boulders. Some of the metadolerites display chilled margins but internal layering is rarely apparent. Most Zamu Complex exposures are conformable with the regional trends of the Lower Proterozoic strata they intrude.

The intrusives are considered to be predominantly flat-lying sill-like bodies folded into their present steeply dipping positions condordant with the enclosing country rock. This broadly agrees with the findings of Bryan (1962), who noted that the basic intrusives in the Jim Jim Creek area are 'elongated and follow the Lower Proterozoic trends' and were probably intruded before the Lower Proterozoic folding. The petrography of these metadolerites is described by Bryan (op. cit.). Textural differences allow easy field distinction between the Zamu Complex and 'Oenpelli Dolerite' in the survey area. However, farther south and west in unmetamorphosed Lower Proterozoic terrain, where the Zamu Complex is less altered, the differences are less marked.

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* Name reserved but not yet approved by Territories Stratigraphic Nomenclature Subcommittee.

'Oenpelli Dolerite' (Pdo)

The 'Oenpelli Dolerite' is best exposed beneath the Arnhem Land scarp from near Deaf Adder Gorge to Jim Jim Falls (Map Plates 4 & 5), and in Graveside Gorge (Map Plate 6). From this area the dolerite is traced by discontinuous rubble outcrop and aeromagnetic pattern into the Oenpelli region (Needham et al., 1975). Elsewhere in the Jim Jim 1:100 000 Sheet area the dolerite is poorly exposed and can be traced only by its distinctive red-brown soil and characteristic vegetation. The structure of the intrusion is ill defined, because of lack of continuous outcrop; however, it clearly transects Lower Proterozoic trends. Geophysical interpretation suggests that the dolerite exposures in the Jim Jim area form the northern limb of a broad basinal structure, or lopolith (Horsfall & Wilkes, in prep.). The dolerite is not found in the Mundogie 1:100 000 Sheet area.

A differentiation sequence similar to that found in the Oenpelli area is recognized (Fig. 4), although not all differentiates are found in the same outcrop. This sequence indicates an alkali basalt parentage for the magma:

Olivine basalt -------- porphyritic olivine dolerite -------- ophitic dolerite -------- ophitic gabbro -------- granophyric dolerite -------- sodic syenite -------- sodic granophyre

South of Deaf Adder Gorge in phyllite adjacent to the dolerite is a poorly exposed retrogressively metamorphosed hornfels. Chlorite in the hornfels suggests either postintrusive alteration of the hornfels or intrusion of the dolerite into country rocks containing high water pressure.

Near Jim Jim Falls the 'Oenpelli Dolerite' is juxtaposed with the Jim Jim Granite. Several mafic granitoid rocks in this area inconclusively reveal the nature of the contact between these two rock types (see Jim Jim Granite).

The mineralogy of the 'Oenpelli Dolerite' is described in detail by Needham et al. (1975).

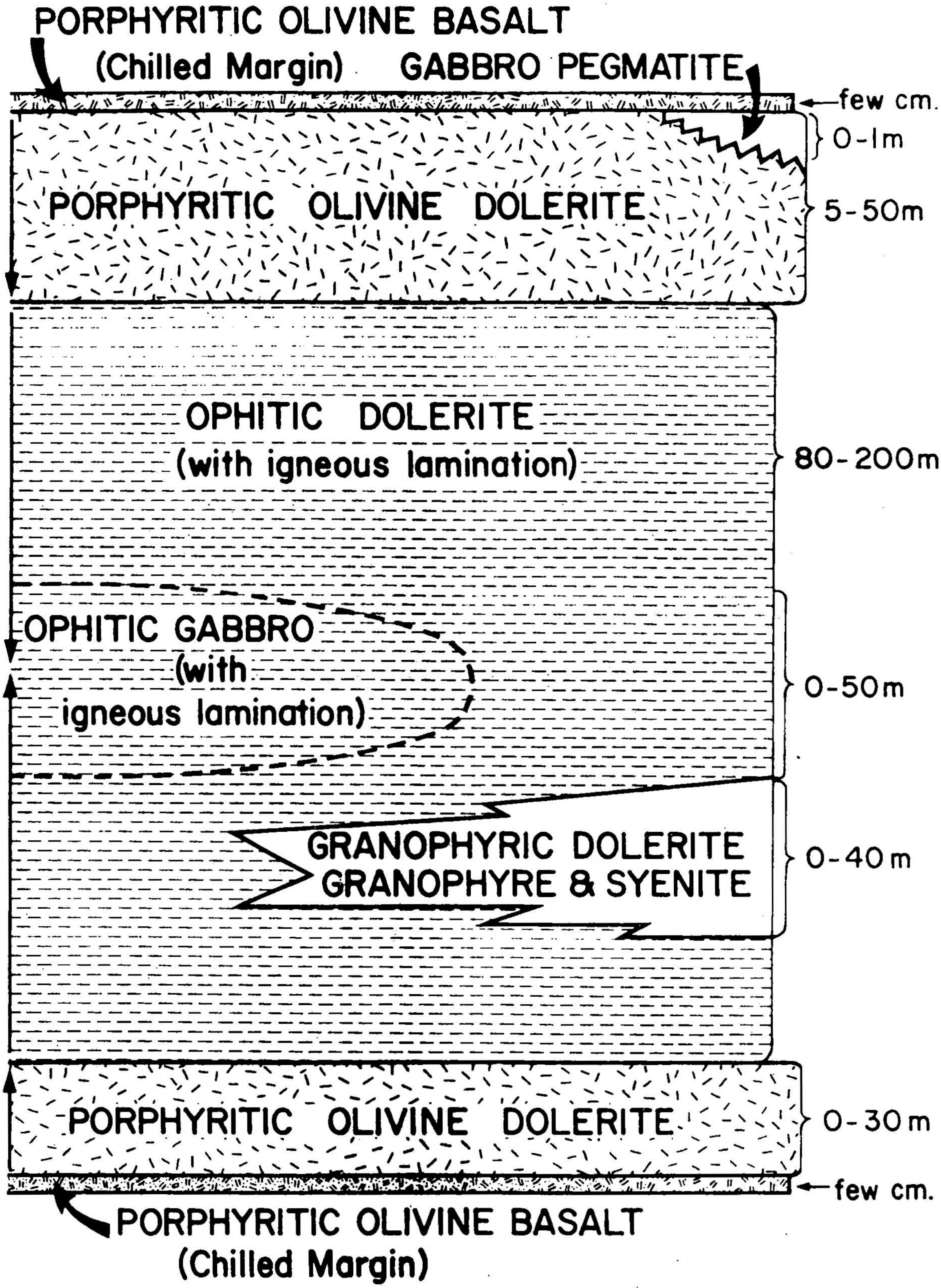


Fig. 4 Schematic diagram showing the internal structure of the 'Oenpelli Dolerite'. Arrows indicate direction of increase in grainsize of groundmass.

Jim Jim Granite (Egj)

The Jim Jim Granite is a homogeneous pink very coarse-grained biotite granite which crops out poorly over an area of about 250 km^2 at the centre of the Jim Jim 1:100 000 Sheet area. It forms exfoliated domes and platforms and deeply weathered cliff-like exposures immediately beneath the Arnhem Land escarpment (see Text - Plate vi).

A typical modal mineralogy of the granite is 45-50 percent orthoclase, 30-35 percent quartz, 10-15 percent plagioclase, 5 percent biotite, and rare opaques. The orthoclase is commonly sericitized and may form graphic intergrowths with quartz. A few perthite grains are also present. Quartz grains are mostly fractured, range from 0.01 cm to 1.0 cm in diameter, and commonly show strained extinction. Most of the plagioclase is saussuritized, and composition is generally indeterminate. Biotite, with inclusions of zircon and apatite, is altered to chlorite.

The margins of the granite, where exposed, appear fault-controlled, as silicified fault breccia reefs separate the granite from the country rocks. There is no evidence of contact metamorphism of the country rocks (slates and phyllites of the Fisher Creek Siltstone) by the granite, which also suggests faulting at the margins of the granite after intrusion; however, retrogressive metamorphism and weathering may have been responsible for obliterating any such effect.

Within the granite, especially near its margins, there are roughly radially disposed silicified fault breccias. Aplite veins partly altered to a quartz clay rock with some elongate quartz grains are common and range from a few centimetres up to a metre in width.

Near Jim Jim Falls the 'Oenpelli Dolerite' crops out within the granite. The contact between these two rock types is poorly exposed and the the relationship uncertain. A hornfels zone is not apparent in either the granite or the dolerite. However, a few mafic granitoid rocks similar to those recognized in the Nimbuwah Complex (Needham et al., 1975) are found in granite near the contact with the dolerite. Two possibilities are likely: either the granite partly assimilated marginal phases of the dolerite, or the dolerite metasomatized parts of the granite. The age relations between these two rock types is at present unresolved. Drilling and age dating studies are needed to find the nature of the contact.

The Jim Jim Granite is probably genetically related to other intrusive granites in the uranium province, e.g., the granite 7 km east of Nabarlek (Needham et al., 1975), as these granites are texturally, mineralogically, and radiometrically (high Th/U ratio) similar. The Jim Jim Granite is a post-tectonic or late-syntectonic magma which was intruded into metamorphosed rocks surrounding the Nanambu and Nimbuwah migmatite complexes from the deep zone of anatectic melting (Needham et al., 1975). The magma was probably formed in the root zone of the Nimbuwah Complex.

CARPENTARIAN SEDIMENTS

Kombolgie Formation (Bhk)

Only exposures of Kombolgie Formation lying below the Nungbalgarri Volcanic Member were visited in the survey area. This lower sandstone unit (Phk_1) is a homogeneous succession of medium to coarse sandstone with minor siltstone, and pebble and conglomerate beds.

The character of the sandstone ranges from well sorted to poorly sorted, with subrounded to subangular quartz grains (90%) and rounded to elongate grains of quartzite (5%). Sandstone near the base of the formation has a clay matrix, and accessory epidote, magnetite, and rare amphibole are present as small grains in sandstone overlying the Jim Jim Granite. Higher in the formation the sandstone is usually tightly packed and moderately to well sorted; the matrix, if developed, is composed of clays and very fine quartz grains.

Plate vi. Kombolgie Formation unconformably overlies Jim Jim Granite (note man for scale), south flank of sandstone outlier, 6 km northwest of Jim Jim Falls.

Siltstone within the formation is composed of very fine-grained quartz in a clay matrix. Stringers of hematite accentuate the direction of bedding; so too do lenses of higher clay content which contain small grains of minor epidote and amphibolite. There are a few grains of quartzite and magnetitic quartzite; magnetite is distributed throughout the matrix and marginal to the quartz grains. Rare bands of medium to coarse quartz sandstone are present within the siltstone.

Basal conglomerates are developed locally over and adjacent to highs in the pre-Kombolgie surface, especially at the southern end of the Mount Partridge Range (Text - Plate vii). Very coarse and angular breccio-conglomerates containing angular to subrounded cobbles and boulders of micaceous quartzite, sandstone, and vein quartz, with rare shards of phyllite, fill re-exhumed valleys in the unconformity surface.

Where the Kombolgie Formation overlies the Jim Jim Granite the sandstone contains a variety of detrital minerals derived from the granite. Weathered feldspar, some altered to clay, forms a matrix in the sandstone and gives the rock an arkosic appearance. The sandstone lacks lithic fragments.

The present shape of the Arnhem Land escarpment probably resulted from preferential erosion and removal of the sandstone over basement highs. This is suggested by the parallelism between the escarpment and the 'Oenpelli Dolerite', which forms a discontinuous basement high from Graveside Gorge to Deaf Adder Gorge.

UNDIFFERENTIATED MESOZOIC (K)

A small flat capping of highly ferruginized pebbly coarse sandstone overlies Mount Partridge Formation near the Mundogie gold mine (Map Plate 2). It contains shards and pebbles of siltstone, sandstone, and vein quartz derived from Mount Partridge Formation. The high degree of ferruginization suggests the rock is Mesozoic rather than Proterozoic in age; rocks of known Mesozoic age in surrounding areas are ferruginized, whereas the Proterozoic rocks are not. Laterite did not develop on the clean porous sandstones of the Kombolgie Formation.

CAINOZOIC UNITS

Cainozoic sediments form a veneer over the Northern Plains, talus slopes adjacent to the main escarpment and Uplands, and colluvial sand cover over the Arnhem Land Plateau.

The deposits have been divided into the following units:- Laterite, Late Tertiary sands, talus, and Quarternary sediments.

Laterite (Czl)

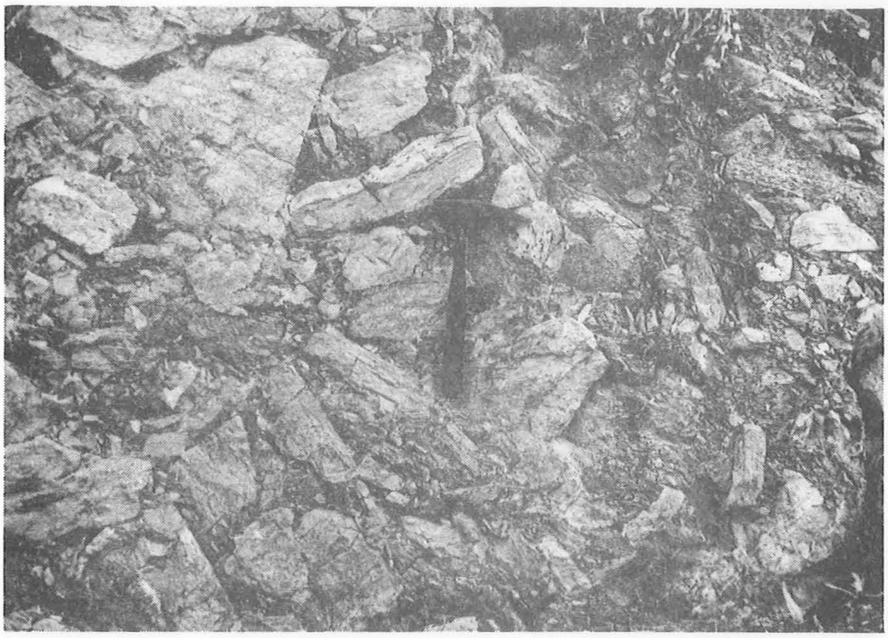
Generally the profiles seen in the survey area are either detrital or are truncated remnants of the standard laterite profile described by Whitehouse (1940).

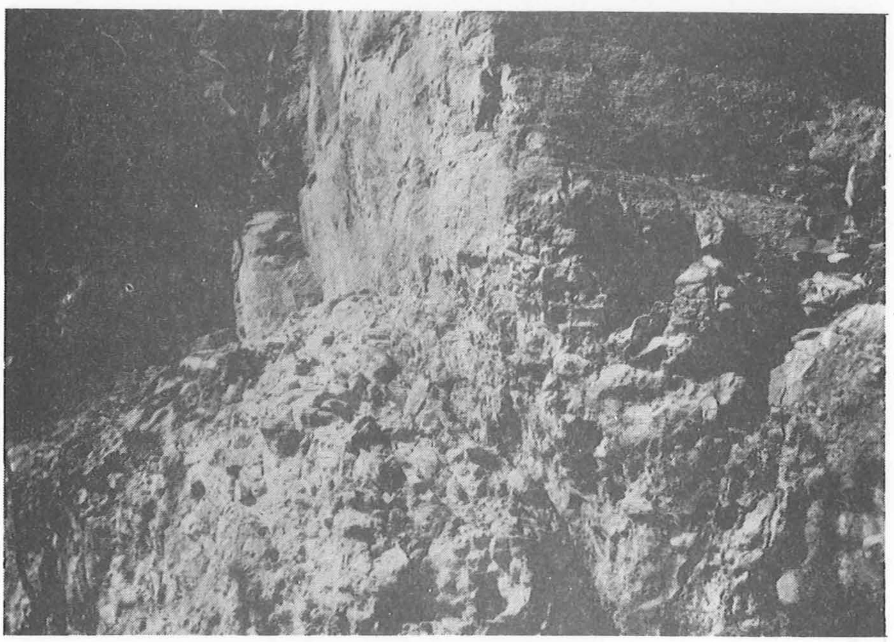
Of the laterite types described by Williams (in Story et al., 1969) for the Adelaide/Alligator Rivers area, the following types are recognized:

Detrital laterite is formed mainly from reworked material cemented in a ferruginous matrix. It generally forms blocks (up to 1 m in size), and pavements on low hills or breakaways over the Nanambu Complex and the South Alligator Group.

Pisolitic laterite is the upper part of the standard laterite profile, and predominantly consists of cemented ovoid ironstone pisoliths between 0.25 and 1.0 cm in diameter, often case-hardened or varnished. It forms blocks or pavements, and is occasionally exposed at the margins of flood plains. It can also be detrital in origin.

Mottled-zone laterite is the middle part of the standard laterite profile, and consists of deeply weathered bedrock grading up into a ferruginous zone of generally pisolitic laterite, and down into a pallid zone. It commonly overlies the Nanambu Complex in the bottom





(a) Coarse breccio-conglomerate fills steep valleys in pre-Kombolgie surface. Base of Kombolgie Formation, south end of Mount Partridge Range

Plate vii. (b) Coarse clayey basal conglomerate passes abruptly up into coarse quartz sandstone. Base of Kombolgie Formation, southwest of Mount Partridge Range

of amphitheatres at the heads of creeks, and is usually surrounded by a breakaway of pisolitic or detrital laterite.
Concretionary laterite is pedogenetic in origin and, unlike the laterites already described, is actively forming, rather than being in an erosional or stable environment. It forms either ferruginous mottles in poorly drained alluvial soils or ironstone nodules in situ in the soil profile.

Late Tertiary sands (Czs)

Coarse unconsolidated quartz sands form the remnants of the Koolpinyah Surface which is only preserved in the northern part of the survey area. Where the sands are almost completely removed, structures within the underlying weathered rocks become apparent on aerial photographs.

The late Tertiary sands are probably fan deposits (Story et al., 1969) derived from Mesozoic sand, silt, and claystone, Kombolgie Formation sandstone, and Lower Proterozoic rocks. Clean unconsolidated quartz sand, developed in situ on the Arnhem Land Plateau, has developed continuously since the Early Tertiary.

Talus and rubble (Czt)

Talus slopes are commonly developed adjacent to the Mount Partridge Range, and to the Arnhem Land Plateau, where the base of the Kombolgie Formation is exposed. Scree often conceals the contact between the Kombolgie Formation and the underlying strata, but in some places a bench is developed at the top of the talus slope. Here the unconformity is exposed below an overhang of sandstone formed by preferential erosion of the Lower Proterozoic rocks. The talus is composed mostly of large blocks (up to 20 m) of Kombolgie Formation sandstone, but pebbles or shards of the underlying rocks are commonly present.

Laterite, quartz, quartzite, and dolerite rubble is widely scattered over the Northern Plains and is best developed adjacent to strike ridges of Lower Proterozoic strata.

Dolerite is a common constituent of rubble. It is frequently found adjacent to outcrops of quartz and quartzite, on which 'grinding hollows' are often present. Aboriginals commonly used dolerite for making artifacts; they transported it to suitable 'workshops' where they ground or flaked it to make tools. Most of the dolerite rubble seen is assumed to have been transported by man; therefore only definite outcrops of basic intrusives have been shown on the maps.

Quarternary sediments

Deposition during the Quaternary is represented by a variety of alluvial types.

Alluvial silt, sand, and clay (Qa) is found in the courses and flood plains of active rivers. The large bodies of unconsolidated quartz sand (Qs) within the courses of major creeks and rivers, and the outwash deposits (Qs) over the adjacent flood plains, consist mostly of material derived from the Kombolgie Formation or Late Tertiary sands, and are mostly deposited during floods. The sediments of abandoned river courses (Qas) consist mostly of silt and mud. The abandoned river courses in the flood plain of the South Alligator River developed before the late Pleistocene to Recent coastal emergence, and are shallow depressions in the surface of the flood plain, into which the present drainage system is incised. Levees (linear ridges of silt and sand, Qal) are developed in places along the banks of the South Alligator River. Black humic soils and clays (Qf) are commonly developed in poorly drained depressions within the drainage systems; they often display anomalous radioactivity, caused by fixation of radioactive elements by the organic or carbonaceous content of the soil.

STRUCTURE

The geosynclinal structure of the Jim Jim and Mundogie 1:100 000 Sheet areas is difficult to recognize because of poor exposures, low grade regional

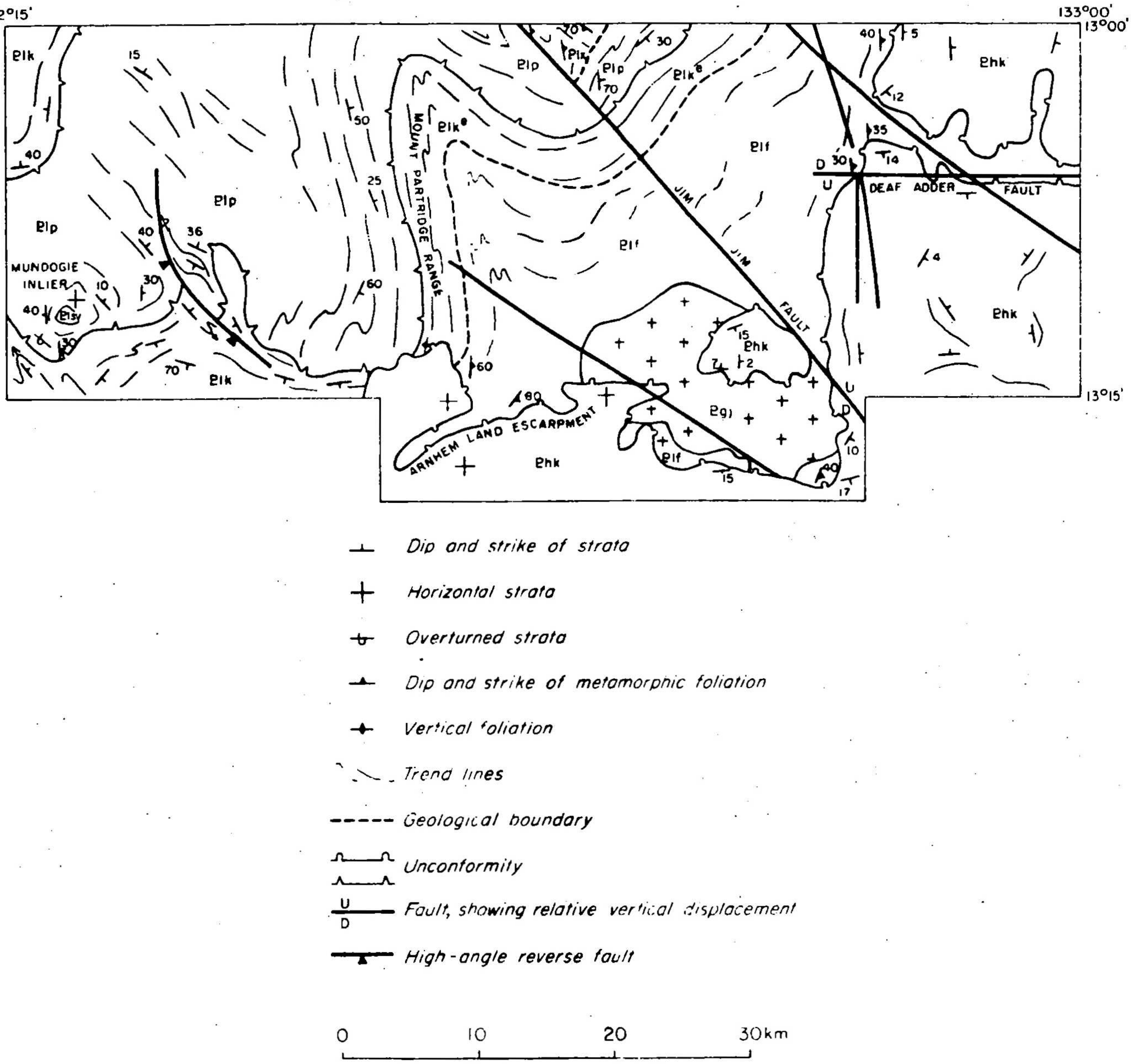


Fig. 5 Structural sketch map.

metamorphism, strong folding, and common faulting. Generalized structural elements are shown in Figure 5.

Walpole (1962) regarded this area as formed by sedimentation in 'a modified composite intracratonic basin'. We believe, however, that this area may have formed the edge of a major trough of Lower Proterozoic deposition which extended farther east, possibly even to the Goomadeer River (Needham et al., 1975). The Mount Partridge Formation is a wedge-shaped deposit, thinning westwards, and was laid down at the edge of this trough. A period of folding followed deposition of this formation, and the area near Mundogie Hill probably formed a basement high. Around this high, several basins formed and slight differences in sedimentary facies developed during subsequent deposition; for example, rocks east of Mount Partridge Range (Koolpin Formation equivalent) are less carbonaceous and cherty and more arenaceous than those southeast of Mundogie Hill (Koolpin Formation).

In the far southwest of the area, bedding is folded about northwest-trending axes. The inlier of Stag Creek Volcanics at Mundogie Hill lies at the centre of a broad dome, east of which easterly or southeasterly dips predominate. Bedding in the Mount Partridge Range is weakly folded along north-trending fold axes. At Mount Basedow, folded and sheared rocks may be transitional into the Nanambu Complex. Recumbent similar folds generally plunging east with north or northeasterly-dipping fold axes are common in Fisher Creek Siltstone north of Jim Jim Falls.

Faulting is common in the area, especially marginal to and within the Jim Jim Granite. The granite appears fault-emplaced as there is a lack of hornfels in the phyllitic country rocks. The Jim Jim Fault terminates the southwest extremity of Mount Basedow, truncates the Jim Jim Granite, and about 6 km north of Jim Jim Falls, displaces Kombolgie Formation sandstone. A silicified fault breccia reef about 5 km south of Deaf Adder Gorge may be the southeast extension of a fault which parallels Nourlangie Creek to the north.

A fault along the south side of Deaf Adder Gorge vertically displaces the Kombolgie Formation sandstone by about 150 m along the gorge. A reverse fault which may be a continuation of the South Alligator fault zone displaces the Mundogie Sandstone Member over Koolpin Formation southeast of Mundogie Hill. Shearing subparallel to bedding in the Mount Partridge Formation formed phyllite and mica schist within the siltstone sequence of Blp3, and siltstone interbeds of Blp2 and Blp4.

Other faults are usually silicified fault reefs trending north and northwest, but some are only reflected as photolineaments whose structural disconformities are difficult to interpret.

ECONOMIC GEOLOGY

Uranium

The area mapped is situated between the major uranium deposits of Ranger 1, Koongarra, Jabiluka, and Nabarlek, and the South Alligator valley uranium deposits. The Koolpin Formation equivalent is considered to be a favourable hostrock at the site of the major deposits (Needham et al., 1973b); this unit might, therefore, have mineral potential in the Jim Jim Sheet area. The Koolpin Formation is also worthy of investigation, especially where it is transected by faults.

In 1972, secondary uranium minerals were found by Pechiney (Australia) Exploration Pty Ltd in a quartz vein within rocks of the Fisher Creek Siltstone near the entrance of Graveside Gorge. Further work failed to prove extensions of the mineralization.

Other minerals

Minor gold has been worked in quartz veins at Mundogie Hill and Yemelba, but there are no records of production. The basal conglomerate of the Kombolgie Formation has traces of gold at Jabiluka; massive basal conglomerate developed in and around gullies in the rugged pre-Kombolgie surface in the Jim

Jim and Mundogie Sheet areas may warrant investigation for gold.

Several minor thorium anomalies are known near Mount Basedow.

Water supply

Waterholes and billabongs along the major rivers and creeks provide a plentiful supply of water. Several freshwater springs issue from the base of the Arnhem Land escarpment and the flanks of Mount Partridge Range.

GEOCHRONOLOGY

During 1971 and 1972 samples of the following units were collected and submitted for age dating by R.W. Page (BMR):

Mount Partridge Formation

Koolpin Formation equivalent ('mine series' at Koongarra, Ranger 1, and Jabiluka)

Fisher Creek Siltstone

Nanambu Complex

'Oenpelli Dolerite'

'Mudginberri Phonolite' (Cahill 1:100 000 Sheet area)

Jim Jim Granite

Samples of Jim Jim Granite and 'Oenpelli Dolerite' proved too altered and were unsuitable for dating; preliminary results suggest a minimum age of about 1800 million years for the Nanambu Complex, and regional metamorphism of the Mount Partridge Formation, Koolpin Formation, Koolpin Formation equivalent, and the Fisher Creek Siltstone.

ACKNOWLEDGEMENTS

We wish to thank Noranda Australia Ltd and Pechiney (Australia) Exploration Pty Ltd for their assistance and hospitality during the field season. We thank especially their field geologists who openly discussed many aspects of the regional geology of the area with us.

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39

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APPENDIX 1: Changes in stratigraphic nomenclature

Change approved: NANAMBU GRANITE to NANAMBU COMPLEX.

(extract from Needham et al., 1973a)

Reasons: The Nanambu Granite was described as a 'garnetiferous granite' by Condon & Walpole (1955), and as 'leucocratic garnetiferous granite and gneissic granite' by Walpole et al. (1968). This unit, in fact, consists of migmatite, leucogneiss, gneissic granite, augen gneiss, schist, basic amphibolite, and quartzite, the whole comprising a mantled migmatite dome; therefore we propose the name Nanambu Complex.

Type locality and Name: Walpole et al. (op. cit.) noted that the Nanambu Granite 'cropped out between the South Alligator and East Alligator Rivers'. The name was first published by Condon & Walpole (op. cit.) and was 'derived from Nanambu Creek, which flows into Woolwonga Swamp at about latitude 12°42'S, longitude 132°41'E'.

We do not wish to change the derivation of the name. The type locality we propose is from the headwaters of Nanambu Creek for a distance of 4 km south along the creek, terminating in the vicinity of Cubbarnby Spring.

Extent: The Nanambu Complex crops out in three areas or 'masses' which are situated between the South Alligator and East Alligator Rivers in the Alligator River 1:250 000 Sheet area.

Age: Lower Proterozoic, being formed by migmatization of Lower Proterozoic sediments, with the possible inclusion of Archaean material.

Another proposed addition to the nomenclature is the 'Mudginberri Phonolite'; the name has been reserved by the Territories Stratigraphic Nomenclature Subcommittee but we have not yet submitted details of the proposed change.

APPENDIX 2: List of abbreviations used in Map Plates 2-6

abnd	abandoned
alg	algal
Am	amphibolite
Ark	arkose
Au	gold
biot	biotitic
bndd	banded
brecd	brecciated
brn	brown
c	coarse
carb	carbonaceous
chl	chloritic
Cgl	conglomerate
Cl	clay
cl	clayey
crend	crenulated
Do	dolomite
f	fine
fed	ferruginized
Fest	Ironstone
fldg	folding
flg	flaggy
foldd	folded
fs	feldspathic
gar	garnetiferous
gn	green
Gns	gneiss
grnl	granular
Gvl	gravel
Gwke	greywacke

gy	grey
hem	hematitic
hqb	hematite-quartz breccia
HS	homestead
intbdd	interbedded
iso	isoclinal
jtd	jointed
latd	lateritised
m	medium
mass	massive
mi	micaceous
mnr	minor
musc	muscovitic
occ	occasionally
Pbl	pebble
pbl	pebbly
Phyl	phyllite
pk	pink
py	pyritic
qb	quartz breccia
Qt	quartzite
Qtz	quartz
qtz	quartzitic
qz	quartzitic
qzs	quartzose
Rub	rubble
Sch	schist
sd	sandy
shd	sheared
si	silicified
Sl	slate

Sltst	siltstone
Sst	sandstone
Struct	structures
To	tourmaline
v	very
Vn	vein
vnd	veined
wh	white
wthrd	weathered
Xen	xenolith
Yd	yard
xbdd	cross-bedded

Reference

CAINOZOIC	QUATERNARY		Qa	*Silt, clay, sand, alluvium*
			Qs	*Unconsolidated sand; outwash and colluvial deposits*
			Qf	*Black and brown humic soil and sand deposits*
			Qal	*Silt, clay; sand; levee deposits*
			Qas	*Silt, clay; abandoned channel deposits*
			Czt	*Sandstone, quartz and quartzite rubble, sand, talus deposits*
			Cza	*Sand, clay: partially stripped Czs*
			Czs	*Unconsolidated sand, clayey sand*
			Czl	*Laterite*
MESOZOIC	CRETACEOUS		K	*Sandstone, ferruginous sandstone, basal conglomerate*
PROTEROZOIC	CARPENTARIAN	Kombolgie Formation	Phk$_2$	*Quartz sandstone, minor conglomerate and siltstone cross-bedded, ripple marked*
		Kombolgie Formation – Nungbalgarri Volcanic Member	Phn	*Basalt, amygdaloidal in places, intercalated siltstone and tuffaceous sediments*
		Kombolgie Formation	Phk$_1$	*Quartz sandstone, conglomerate, minor siltstone; cross-bedded, ripple marked, screen denotes basal conglomerate*
	LOWER PROTEROZOIC	Jim Jim Granite	Pgjc	*Pink biotite granite with thin soil cover*
		Jim Jim Granite	Pgj	*Pink biotite granite, altered, anomalously radioactive*
		Oenpelli Dolerite	Pdo	*Porphyritic, ophitic and granophyric dolerite; syenite differentiates*
		Nanambu Complex	Plx$_c$	*Undivided Nanambu Complex with thin soil cover*
		Nanambu Complex	Plx	*Schist, gneiss, granitoid migmatite*
		Zamu Complex	Pdi	*Dolerite, meta-dolerite, amphibolite*
		South Alligator Group	Plc	*Undivided Lower Proterozoic sediments with thin soil cover*
		South Alligator Group – Fisher Creek Siltstone	Plf	*Siltstone, phyllite, minor quartzite*
		South Alligator Group – Koolpin Formation	Plk	*Siltstone, phyllite, quartzite, carbonate rock, chert bands*
		South Alligator Group – Koolpin Formation	Plw	*White photo-pattern denoting ? quartzite*
		Mount Partridge Formation	Plp	*Undifferentiated sandstone, phyllite arkose and conglomerate*
		Mount Partridge Formation	Plp$_4$	*Feldspathic quartzite, micaceous quartzite, quartzite, arkose Screen denotes conglomerate beds*
		Mount Partridge Formation	Plp$_3$	*Phyllite, minor schist and feldspathic sandstone Dotted screen denotes pelitic beds*
		Mount Partridge Formation	Plp$_2$	*Conglomerate, feldspathic sandstone, arkose, minor slate Screen denotes conglomerate beds*
		Mount Partridge Formation	Plp$_1$	*Siltstone, slate, phyllite, minor arkose, sandstone and greywacke, dotted screen denotes pelitic beds*
		Mount Partridge Formation – Mundogie Sandstone Member	Plu	*Sandstone, conglomerate, minor slate and siltstone ripple-marked Screen denotes basal conglomerate*
		Stag Creek Volcanics	Plsv	*Altered basalt and basalt-agglomerate*

PLATE 1

- Geological boundary
- Unconformity
- Anticline, position accurate
- Syncline, position accurate
- Fault, position accurate
- Fault showing relative vertical movement (D / U)
- High angle reverse fault
- Quartz breccia filled fault (qb)

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of drag fold
- Fault zone
- Shear zone

- Strike and dip of beds, measured (12)
- Strike and dip of beds, prevailing or unmeasured
- Strike and dip of beds, vertical dip
- Strike and dip of beds, horizontal dip
- Strike and dip of beds overturned (25)
- Strike and dip of beds, curving dip (60, 30)
- Trend lines
- Trend lines showing prevailing dip of beds
- Lineament
- Dip <15°
- Dip 15°-45°
- Joint pattern

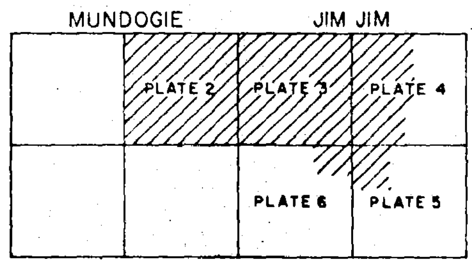
(Trend lines to Joint pattern: air-photo interpretation)

- Generalized strike and dip of undulating strata (40)
- Strike and dip of strata showing plunge of lineation (crenulation)
- Strike and dip of strata with horizontal crenulation
- Strike and dip of joint, measured (85)
- Vertical joint
- Strike and dip of metamorphic foliation, measured (38)
- Strike and dip of metamorphic foliation, vertical
- Strike and dip of cleavage, unmeasured
- Strike and dip of cleavage, measured (35)
- Vertical cleavage, dip of beds 80°, strike coincident (80)
- Strike and dip of platy flow in igneous rocks (30)
- Direction of movement of sediment-bearing currents (x denotes crossbedding, r denotes ripple marks)
- Direction of movement of sediment bearing currents sense unknown
- Dyke and vein, q denotes quartz, a denotes aplite
- Strike and dip of metamorphic foliation with plunge of lineation (crenulation)

- Prospect, little or no production
- Watercourse
- Waterhole (WH)
- Escarpment
- Track, ungraded
- Track graded and formed

KEY TO 1:50 000 COMPILATION SHEETS

AND 1:100 000 SHEET AREAS



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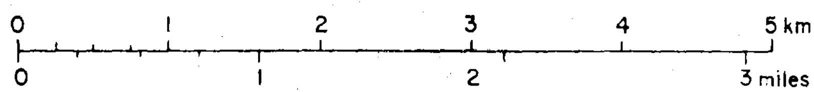


PARTS OF MUNDOGIE AND JIM JIM 1:100 000 SHEET AREAS NORTHERN TERRITORY

NT/A/4!

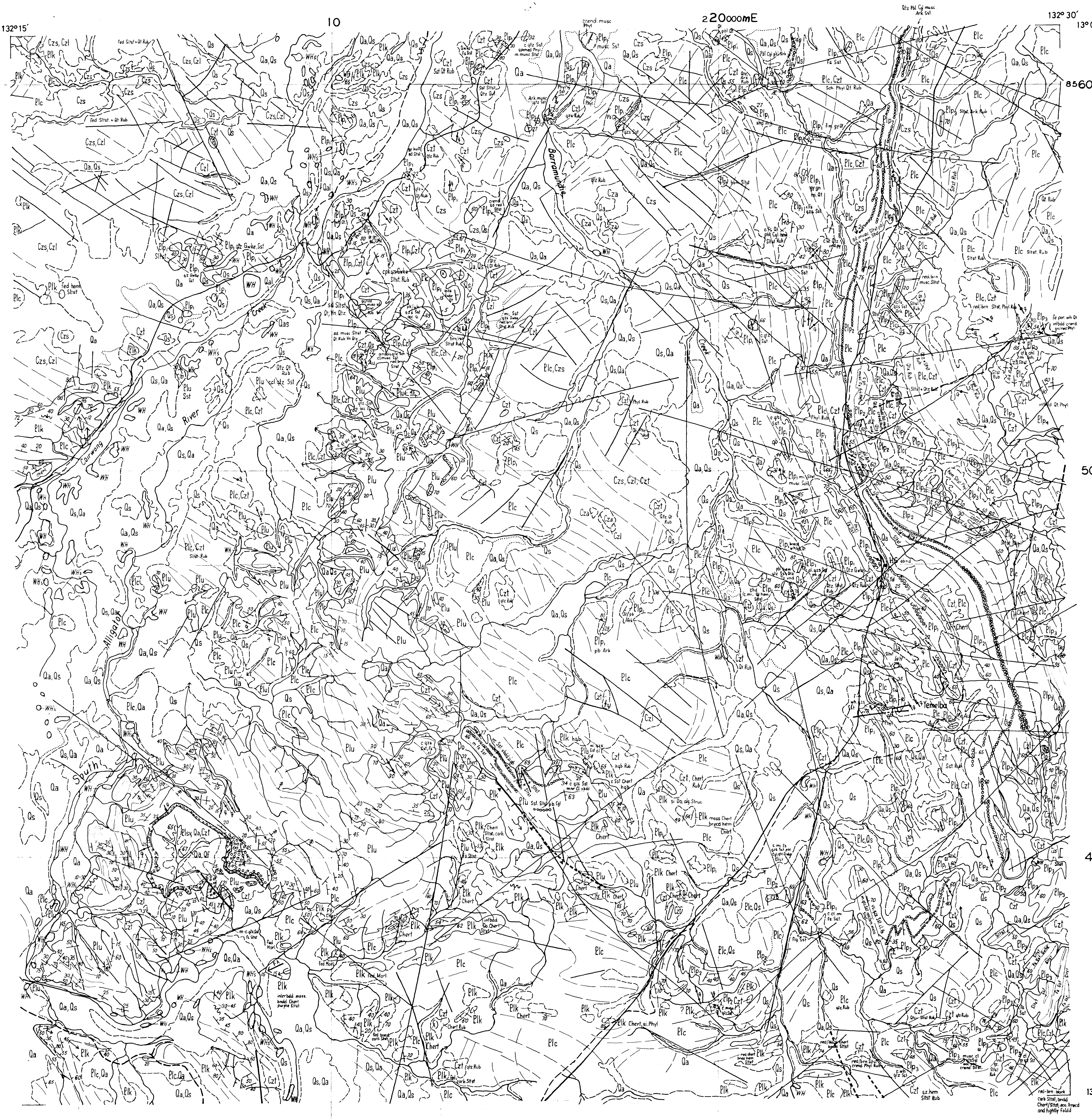
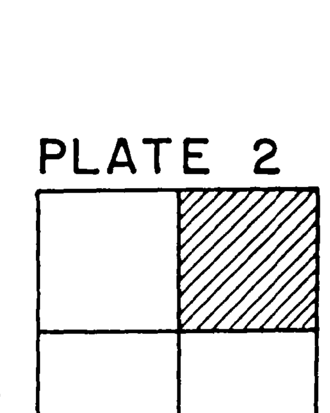


PLATE 2



MUNDOGIE NE

1:50000

GEOLOGY: R.S. Needham

COMPILED: P.H. Fuchs
25-3-74

Record 1975/31

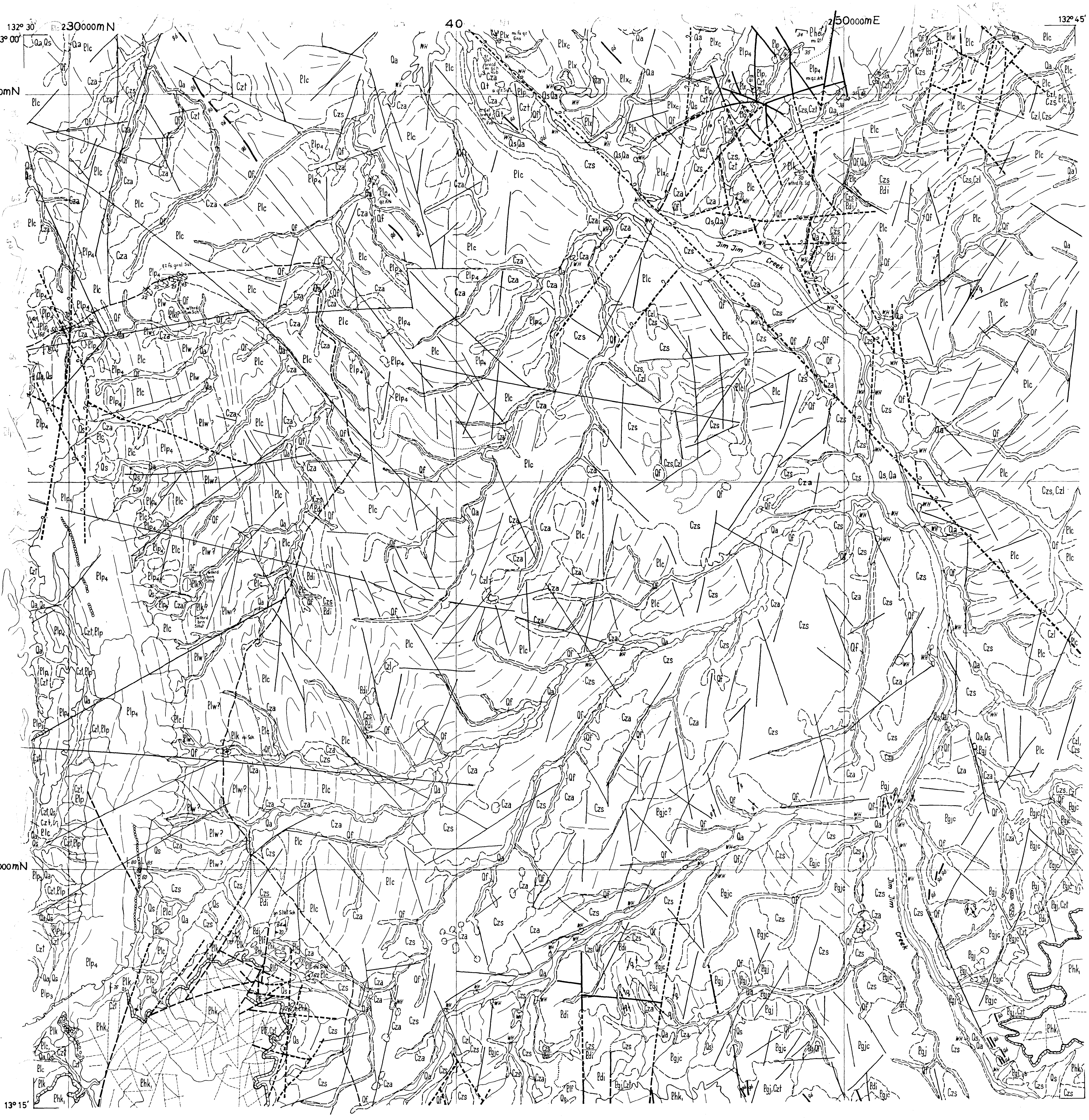


PLATE 3

JIM JIM N.W.

1:50 000

GEOLOGY: A.L. Watchman.

COMPILED: P.H. Fuchs.

July 1974

Record 1975/31

PLATE 4

JIM JIM N.E.

1:50 000

GEOLOGY: P.G.Smart.

COMPILED: P.R.Lachlan.

Record 1975/31

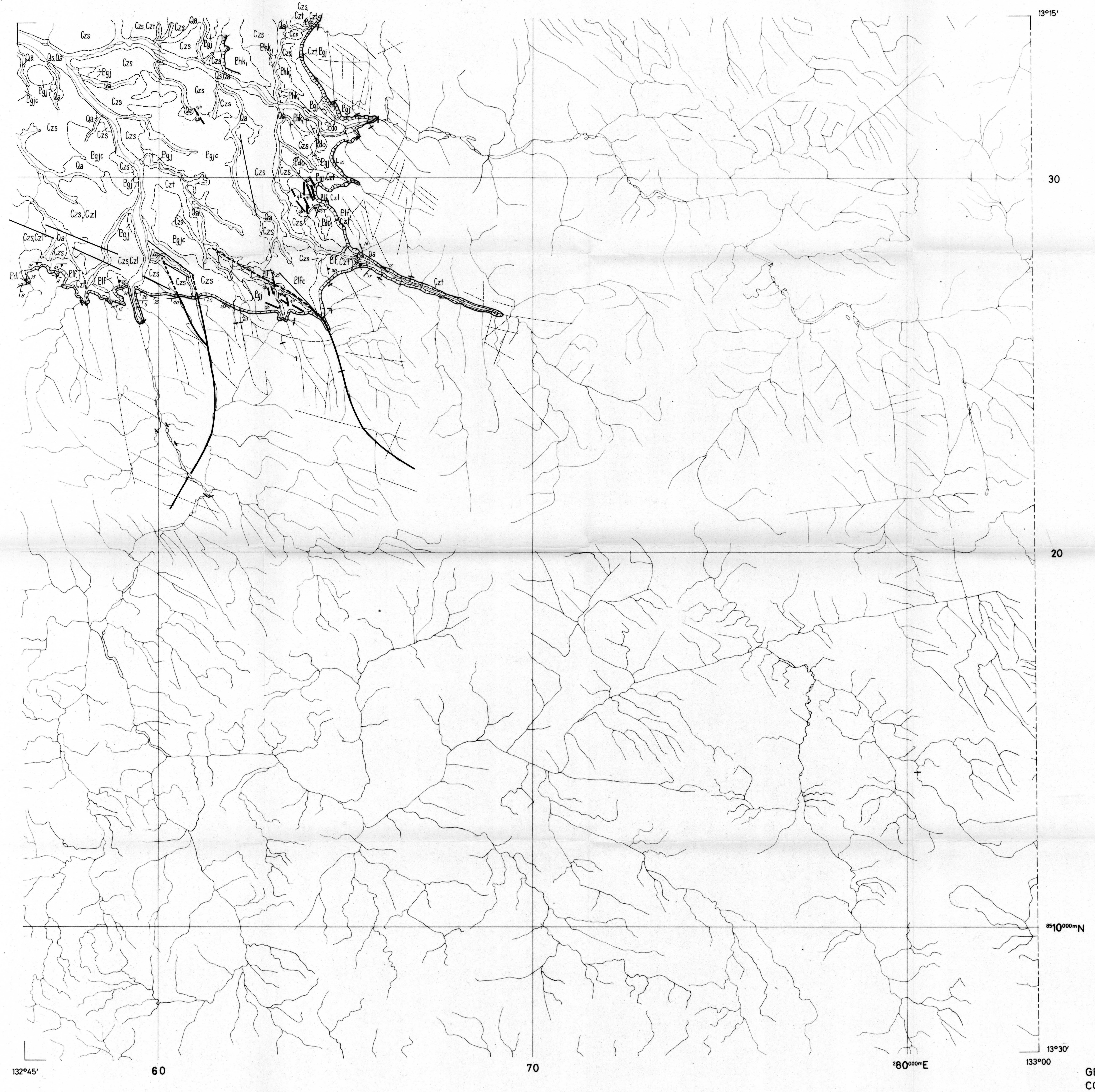


PLATE 5

JIM JIM S.E.

1: 50 000

GEOLOGY: R.S Needham

COMPILED: J Mifsud

Record 1975/31

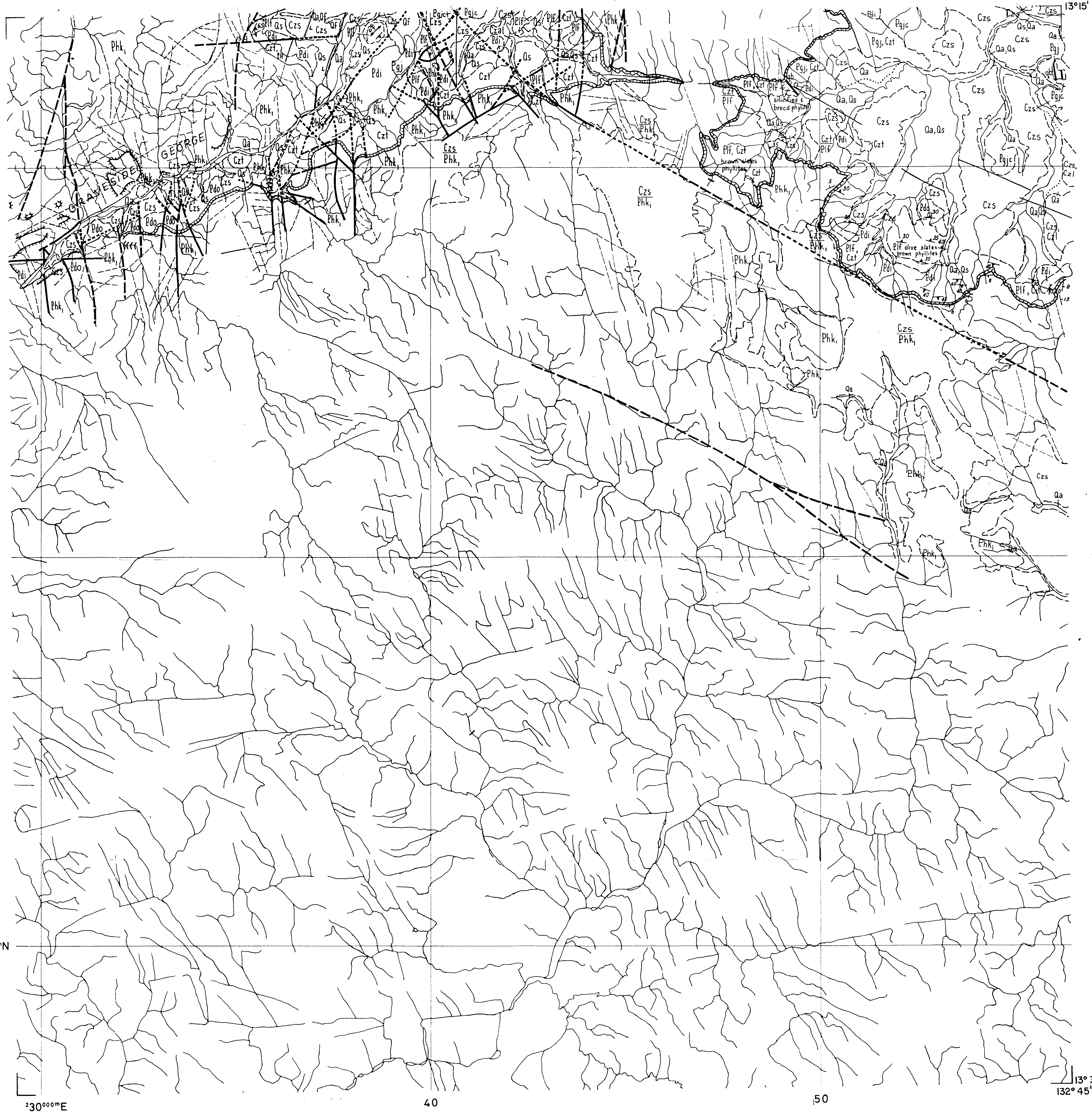


PLATE 6

JIM JIM SW
1:50 000

GEOLOGY R.S Needham
DRAFTSMAN J Mifsud
Record 1975/31