BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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GEOLOGY OF THE ILLOGWA CREEK
1:250 000 SHEET AREA, CENTRAL
AUSTRALIA - PRELIMINARY DATA, 1979-80 SURVEYS

by

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SUMMARY

The area described is part of the crystalline Arunta Block situated in and around the Harts Range northeast of Alice Springs. The Arunta Block rocks are overlain in the southwest of the Sheet area by Late Proterozoic to Palaeozoic sedimentary rocks of the Amadeus Basin. Thin Cainozoic sediments conceal much of the outcrop in the eastern two-thirds of the Sheet area.

The oldest rocks, presumed to be Early Proterozoic, are the meta-acid and basic rocks of the Strangways Metamorphic Complex. In the northwest they are structurally overlain by a mixed volcanic-sedimentary sequence of the Harts Range Group which comprises the quartzofeldspathic Entia and Bruna Gneisses and the conformably overlying pelitic Irindina and Brady Gneisses. The Irindina Gneiss includes an amphibolite member (Riddock Amphibolite Member) and a calcareous member (Stanovos Gneiss Member). The Brady Gneiss also includes a calcareous unit in its upper part. The Harts Range is intruded by granodiorite and basic rocks, which are metamorphosed to varying degrees.

In the southwest of the Sheet area the Illogwa Schist Zone separates the Harts Range Group from a well-layered sequence of quartzofeldspathic gneiss, amphibolite, and metasediments (Albarta Metamorphics). The southern sequence is intruded by the Atneequa Granitic Complex and the Arema Granodiorite.

The northwestern part of the region is well known for its mica deposits which occur in pegmatites within the Harts Range Group. Ruby occurs in a prospect located in the Riddock Amphibolite Member of the Irindina Gneiss.

The overlying Late Proterozoic units of sandstone, shale and carbonate are part of the intracratonic, structural Amadeus Basin. Except for the Bitter Springs formation these units are not described in detail.

Cainozoic and some Mesozoic sediments are widespread in the eastern part of the sheet area and include a Tertiary Basin up to 250 m thick, known only in the subsurface. The Tertiary sequence is capped in places by a thin veneer of chalcadonic limestone.

INTRODUCTION

Location

The Illogwa Creek 1:250 000 Sheet area is northeast of Alice Springs, bounded by latitudes 23°00'S and 24°00'S, and longitudes 135°00'E and 136°30'E. The Quartz 1:100 000 Sheet area occupies the northwest corner and the Limbla 1:100 000 Sheet area the southwest corner of the 1:250 000 Sheet area.

Access

Access to the Sheet area is good, but access within parts of the Sheet area is difficult. Alice Springs is 120 km to the west from the southern part of the Sheet area along a road via Ross River Chalet and Ringwood homestead, but it is about 200 km by formed gravel road along the Plenty River Highway from the northern part. A rough track gives access to the Harts Range area from Alice Springs via Arltunga or the Garden and Claraville homesteads. Because of the rugged nature of the country much of the Harts Range area cannot be penetrated by vehicle. Access to parts of the Simpson Desert area is difficult, because of high sand dunes and some extensive areas covered with thick spinifex and low scrub. A licenced landing strip suitable for light aircraft is maintained at Indiana homestead and an authorised landing area suitable for light aircraft is available at Atula homestead.

Population and industry

A police station is manned at Harts Range just outside the Sheet area to the northwest. A small group of aborigines living at the Police Station wander as far as the Harts Ranges. Cattle stations are run from small family settlements established at Indiana, Atula, Limbla, and Numery homesteads.

Ruby and pink corundum of cabochon-grade are being mined by Mistral Mining Ltd north of Spriggs Creek Bore. Small-scale mining or fossicking has continued intermittently in the Harts Range area for many years. In the past, mica from the Harts Range area has provided the bulk of the revenue from mining in the Alice Springs area. Mica mining began in about 1890 and was particularly active between 1943 and 1956. Fossicking for semi-precious gemstones and specimen material is a popular activity.

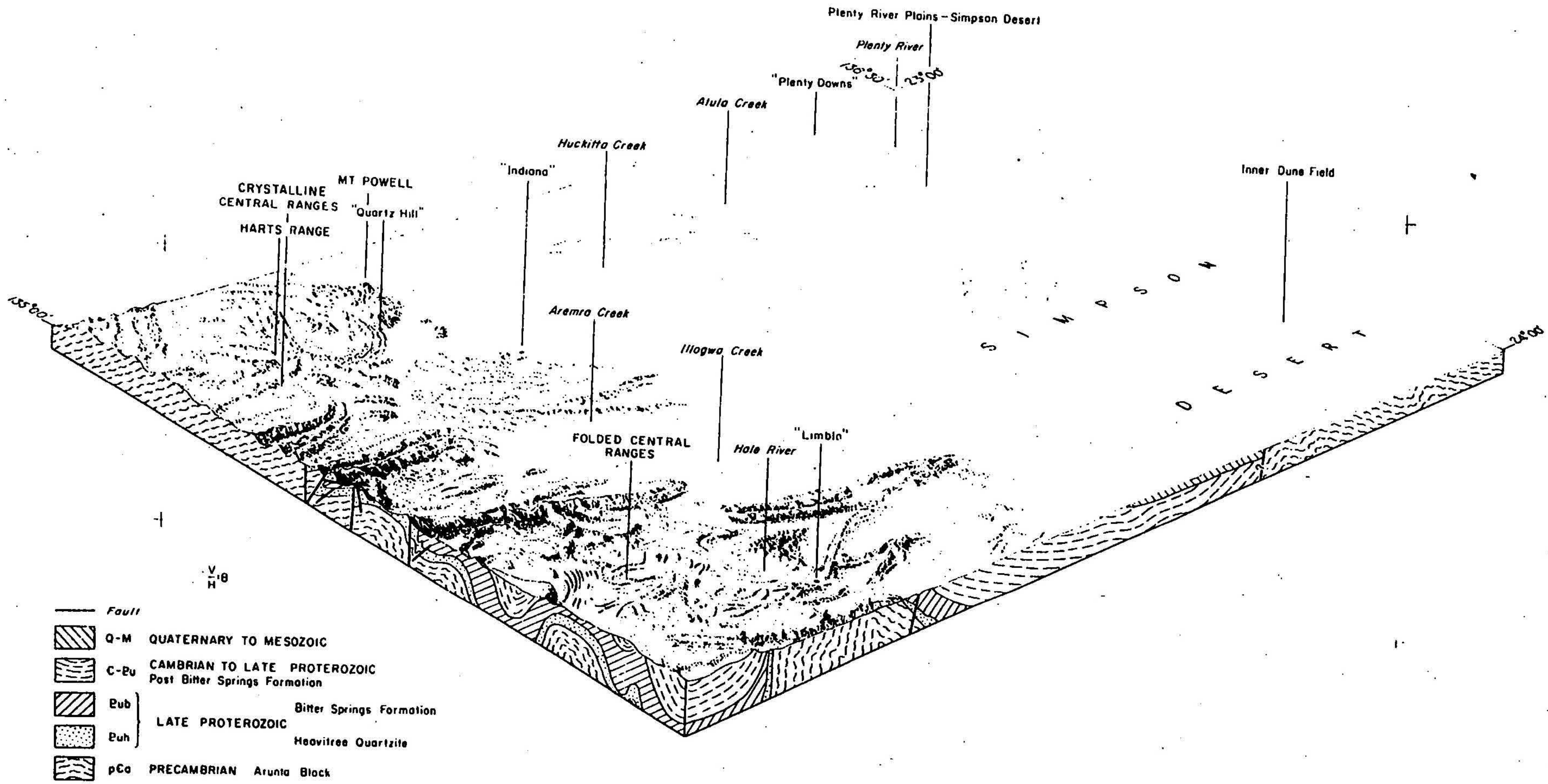

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Fig. 1 Physiography and its relationship to geology

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Climate

The area has a semi-arid climate. Summer temperatures commonly exceed 38°C, and some frosts occur during winter months. The area lies in the 210 to 230 mm rainfall belt; most rain falls during sporadic storms. Climate, soil, vegetation, and land use are described by Perry & others (1962)

Topography and drainage

Mabbutt (in Perry & others, 1962) subdivided the region into gross physical units and described in detail a series of land systems. The topography and drainage and their relationship to the geology is shown in Figure 1: The Crystalline Central Ranges of the Harts Range are steep-sided and rise to over 300 m above the valleys, which are 400 to 600 m above sea level. The Folded Central Ranges composed of high quartzite ridges and intervening narrow valleys occupy the southwest sector of the area. To the east the ridges are not as prominent and to the southeast are separated by sand plains. The Plenty River plains cover much of the region surrounding the Simpson Desert and comprise broad flat sand plains with a few low flat-topped hills. The Inner Dune Field has north-northwesterly aligned longitudinal dunes separated by broad sand plains scattered with very low mesas and hills.

Previous investigations

A summary of previous investigations in the general area is given in Wells (1969), and in Shaw & others (1979). Brown (1899, 1890) visited the Lindsay Mica Mine in the headwaters of Illogwa Creek and commented on its economic potential. Hodge-Smith (1932) subdivided the rocks in the northwest of the Sheet area into six units, and postulated at least one unconformity. Jensen (1943a, 1943b, 1944a, 1944b, 1944c, 1947) began more systematic investigations of mica deposits and the surrounding geology in the Harts Range area. The first comprehensive survey including a detailed investigation of the mica deposits of the Harts Range area was made by Joklik (1955a, 1955b). Other investigations of the mica fields included those of Armstrong (1954), Tomich (1952), and Daly & Dyson (1956).

In 1964, Wells & others (1967) mapped the Amadeus Basin sequence in the Sheet area. During the same year Forman, Milligan & McCarthy (1967) made a study of basement-cover relations. The first Explanatory Notes for the Illogwa Creek* 1:250 000 Sheet area was compiled by Shaw & Milligan (1969).

Geophysical investigations covering the area include total magnetic intensity surveys of the southern half of the Sheet area in 1962 (Quilty & Milson, 1964) and of the northern half in 1963-64 (Wells, Milson & Tipper, 1966), and gravity surveys in 1961 (Langron, 1962) and in 1962 (Barlow, 1965, 1966).

Company activity between 1964 and 1979 was concerned principally with base metal exploration in the Amadeus Basin sequence (Youles, 1964; Australian Geophysics Pty Ltd, 1967; McIntyre Mines Aust. Pty Ltd, 1968; Plumridge & MacDonald, 1970; and Sullivan, 1970). The Arunta Block received less attention (Tham, 1971). Several companies have also been active in the search for either uranium and rare earths in the Harts Range (Capricornia Mineral Development - Morrison & Matheson, 1968; - Corbett, 1970; Geopeko - Faulkner, 1971; Australus Mining Co. Pty Ltd, 1970, 1970b - no author; Acadia Mines - Miller, 1971; and Clarke, 1978a). Cainozoic sediments along Illogwa Creek were explored for uranium (Agip Nucleare Australia Pty Ltd, 1977 & 1979). Reports for Kewanee Australia by Cogar & Felderhof (1973), and Barraclough (1973) were concerned with scheelite mineralisation in the Entire Valley. Traces of nickel and chromium accompanying small siliceous ironstone bodies east of the Harts Range were briefly investigated by Barraclough (1978) and Howland (1971). The recently discovered ruby prospect in the Harts Range was briefly described by McColl & Warren (1979) and by Kratz (1981).

Present investigation

Fieldwork in 1979 was a co-operative effort between geologists of the Metalliferous and Sedimentary Sections, BMR (RDS, BRS, LAO, JMM), and a geologist (MJF) from the Northern Territory Geological Survey. The research entailed 35 man-weeks of Land Rover traverses supported by 35 hours of helicopter drops and helicopter reconnaissance in areas of poor access. Field studies were preceded by photo-interpretation of colour aerial photography at a scale of about 1:25 000 in **QUARTZ and LIMBLA. Field checks were carried out in 1980.

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* Throughout this report 1:250 000 Sheet areas will be referred to by name only using lower case lettering. eg. Illogwa Creek Sheet area.

** Names of 1:100 000 Sheet areas are indicated by upper case lettering eg. LIMBLA.

Photo-interpretation was combined with field data on photo-overlays and then transferred to National Mapping line-conversions at 1:26 316 in the case of LIMBLA, 1:25 510 in the case of QUARTZ and 1:80 000 in the eastern two-thirds of the Sheet area. Some of this transfer was done by D. Walton (Draftsman) in the field. Completion of data transfer and further generalisation and compilation was done by J. Stirzaker. In each case drainage was used for scale control. A reference set of about 2500 data sheets summarising field points (FPS) visited in a format suitable for storage and retrieval on the BMR Hewlitt Packard Computer, was compiled during the survey, together with some points from previous surveys. Compilation sheets for QUARTZ and LIMBLA can be purchased through the Copy Service, Government Printer, Canberra.

Boundaries between lithological units are shown as normal approximate geological boundaries (dashed-lines) on the 1:25 000 compilation sheets. However, stratigraphic boundaries separating formations, members, and other less formal units are shown by a special thick-boundary line which becomes a broken dot-dash line when extrapolated under Cainozoic cover. The special stratigraphic boundaries are interpreted and approximate, and have an inferred and concealed status when extrapolated under Cainozoic cover. Enlarged, bolder lettering is used to designate the stratigraphic units. Rock types in unlabelled outcrops within Late Proterozoic stratigraphic units are specified in the formation reference. This means that the outcropping parts of Late Proterozoic stratigraphic units are unlabelled as they are enclosed within stratigraphic boundaries referenced by widely spaced stratigraphic symbols.

Rock nomenclature and petrographic descriptions

Igneous rock nomenclature follows Streckeisen (1976) and the naming of sedimentary rocks conforms to Gary & others (1973). Metamorphic rocks are given field terms and the usage adopted is explained in the final section of this report. The final section also includes a list of rock symbols used and the definition of some structural terms and more specific definitions of some igneous rocks. Mineral contents of rocks given in parenthesis in petrographic descriptions throughout the text are visually estimated modes only. In general, minor rock types are not described in detail.

Stratigraphic nomenclature

The system of stratigraphic nomenclature used for units in the Arunta Block from 1970 to 1980 is explained in Shaw & others (1979). In brief, units defined in this period are of two types:

1. Named informal units, e.g. Bungitina metamorphics. These units have clearly defined boundaries, but relationships with other units are uncertain, and their component rock types and order of internal superposition may not be known completely. Informality is indicated by the lower case first letter of the rock name. 'Metamorphics' is used for a mixture of rock types.
2. Named formal formations, e.g. Heavitree Quartzite, Bruna Gneiss. These have clearly defined boundaries, distinctive compositions, known relationships to other units, and their order of internal superposition is known, or is not applicable, as in the case of (meta) igneous rocks. Formality is indicated by the upper case first letter of the rock name.

Since 1980 informal units indicated by the lower case letter of the rock name are no longer used. Units of equivalent status are regarded as FORMAL UNITS, but it is recognised that these are only PARTLY DEFINED i.e. have the status of Beds in the old Australian stratigraphic guide e.g. Albarta metamorphics (informal) in the pre-1981 system of nomenclature becomes Albarta Metamorphics (partly defined but formal) in the new system.

OUTLINE OF GEOLOGY

The stratigraphy is summarised in Tables 1 & 2. A brief description of the Cainozoic sediments and weathering episodes is outlined in Table 5. Cainozoic sediments cover most of the eastern two thirds of the Sheet area. A generalised distribution of rock units is shown in Figures 2A & 2B and a Rock Relationship Diagram for the Harts Range Group is given in Figure 2C. For more information on the distribution of Amadeus Basin sedimentary units the reader is referred to the Illogwa Creek 1:250 000 First Edition Geological Map (SF 53-15) and to Preiss & others (1978) for more recent revisions. Detailed revisions to rock units are shown in the reduced compilation sheets (Plates).

Metamorphic Rock Units

Rocks of the Arunta Block are divided into three broad lithological groups, previously described by Shaw & others (1979) and by Shaw & Stewart (1975). Division 1 is presumed to be the oldest lithological group and is characterised by interlayered basic and acid granulites. Division 2 commonly overlies Division 1 with discordant, commonly faulted, contacts. What is believed to be the basal unit of Division 2 is dominantly quartzofeldspathic gneiss, but the main part of Division 2 is characterised by abundant pelitic rocks. Division 3, presumed to be the youngest Division, is characterised by quartz-rich metasediments.

Most of the metamorphic units in the Sheet area belong to the Harts Range Group or are correlated with it. These rocks are assigned to Division 2. The Harts Range Group has been shown to overlie the Strangways Metamorphic Complex in the adjacent Alice Springs Sheet area (Shaw & others, 1979; Shaw & Wells, in press). The contact between the Harts Range Group and the Strangways Metamorphic Complex is discordant and is probably an unconformity, disrupted by sliding and thrusting (Shaw & others, 1979). Rocks of the Strangways Metamorphic Complex are assigned to Division 1. Division 3 rocks are known from only one locality in the Sheet area.

DIVISION 1

Within the Sheet area the Strangways Metamorphic Complex consists of amphibolite, quartzofeldspathic gneiss, and biotite gneiss. These rock types are assigned to the Bungitina metamorphics, extrapolated from the adjacent

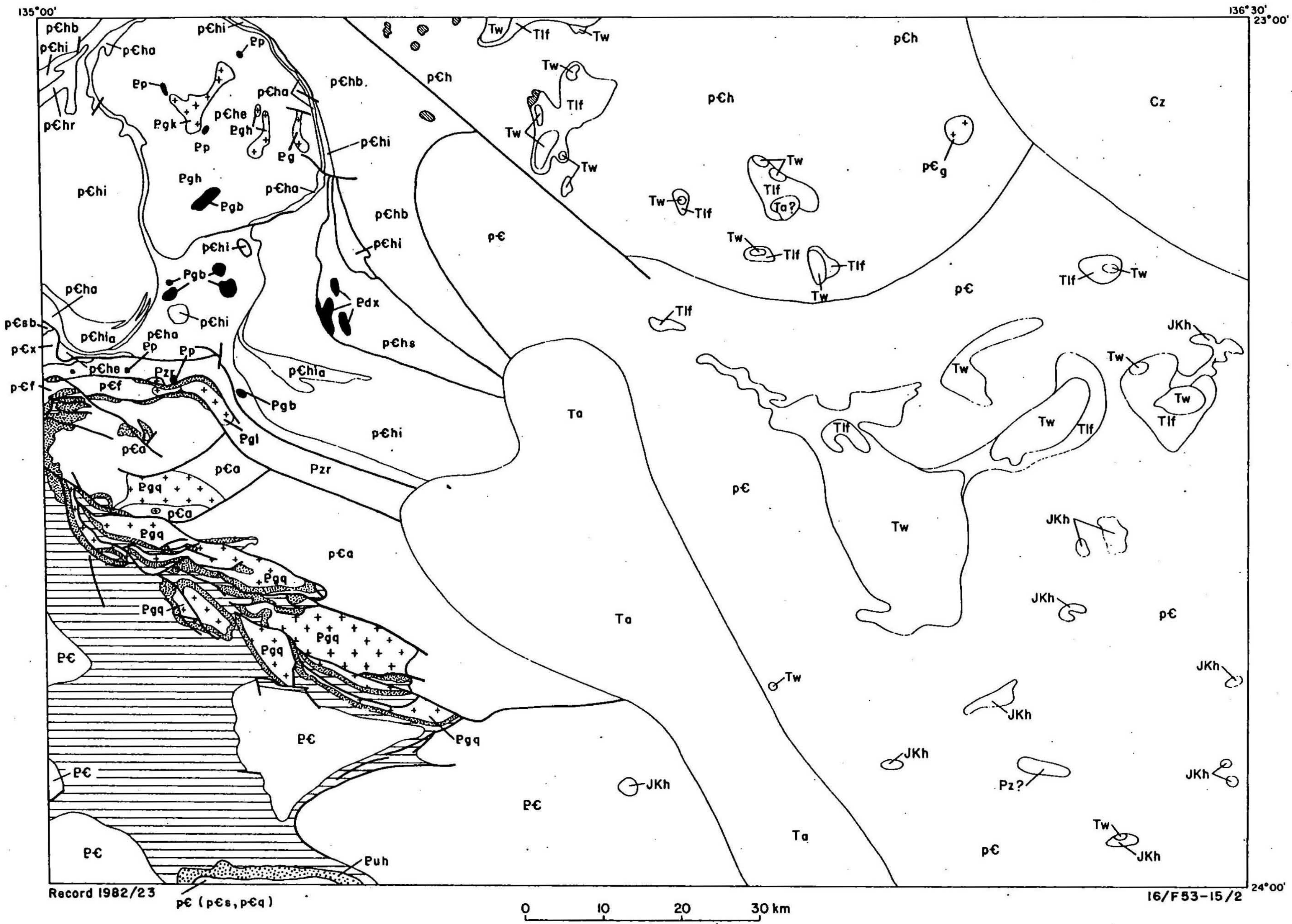

Fig. 2A Geological map of the Illogwa Creek 1:250 000 Sheet area

CAINOZOIC	Cz	Fanglomerate
		Chalcedonic cappings on basic and ultra-basic bodies
TERTIARY	Ta	Sandstone, claystone (sub-surface)
	Tw	Chalcedony, limestone, siltstone
	Tlf	Laterite profile
MESOZOIC	Jkh	Hooray Sandstone: Kaolinitic quartz sandstone
PALAEOZOIC?	Pz	Orthoquartzite
CAMBRIAN & LATE PROTEROZOIC	Є₱	Arumbera Sandstone, Julie & Pertatataka Formations, Pioneer Sandstone, Aralka and Areyonga Formations: Sandstone, shale, siltstone, carbonate, rare diamictite
LATE PROTEROZOIC		Bitter Springs Formation: Carbonate, siltstone, sandstone
		Heavitree Quartzite: Sandstone, conglomerate

Arunta Block

PALAEOZOIC	Pzr	Illogwa Schist Zone: Retrograde green schist facies schist
PROTEROZOIC	₱p, ₱gb	Metahornblendite metamorphosed and partly metamorphosed gabbro and norite
	₱gx	Metamorphosed basic igneous rock

PROTEROZOIC	₱g, pЄg	Granite, augen granitic gneiss
	₱gl	Aremra Granodiorite: Granodiorite, tonalite diorite
	₱gq	Atnequa Granite Complex: Granodiorite, granite, diorite, granite gneiss
	₱gk	Inkamulla Granodiorite, Granodiorite gneiss, granodiorite
	₱gh	Huckitta Granodiorite: Granite gneiss, foliated granodiorite
	pЄ (pЄq, pЄs)	Unnamed metamorphics: Muscovite - biotite schist and gneiss, metasandstone
Harts Range Group	pЄh	Undivided Harts Range Group: Biotite gneiss, calc-silicate rock
	pЄhb	Brady Gneiss: Garnet-muscovite - biotite gneiss, biotite gneiss, calc-silicate rock
	pЄhi	Irindina Gneiss: Schistose garnet-biotite-quartz-plagioclase gneiss biotite gneiss, quartzofeldspathic gneiss; layered and massive amphibolite
	pЄhi$_a$	Well-layered and massive amphibolite
	pЄhs	Stanovos Gneiss Member: Marble, quartzite, garnet-biotite gneiss megacrystalline feldspar gneiss grading into quartzofeldspathic and biotite gneiss

PROTEROZOIC	pЄhr	Riddock Amphibolite Member: Well-layered and massive amphibolite, garnet-biotite gneiss
Harts Range Group	pЄha	Bruna Gneiss: Mega-crystalline-feldspar gneiss grading into quartzofeldspathic gneiss and biotite gneiss
	pЄhe	Entia Gneiss: Quartzofeldspathic gneiss, layered amphibolite, biotite gneiss
	pЄf	Quartzofeldspathic gneiss, biotite gneiss
	pЄa	Albarta Metamorphics: Quartzofeldspathic gneiss biotite and muscovite schist. Massive and layered amphibolite
Strangways Metamorphic Complex	pЄx	Quartzofeldspathic gneiss, amphibolite
	pЄsb	Bungitina metamorphics; Amphibolite, biotite gneiss, quartzo-feldspathic gneiss

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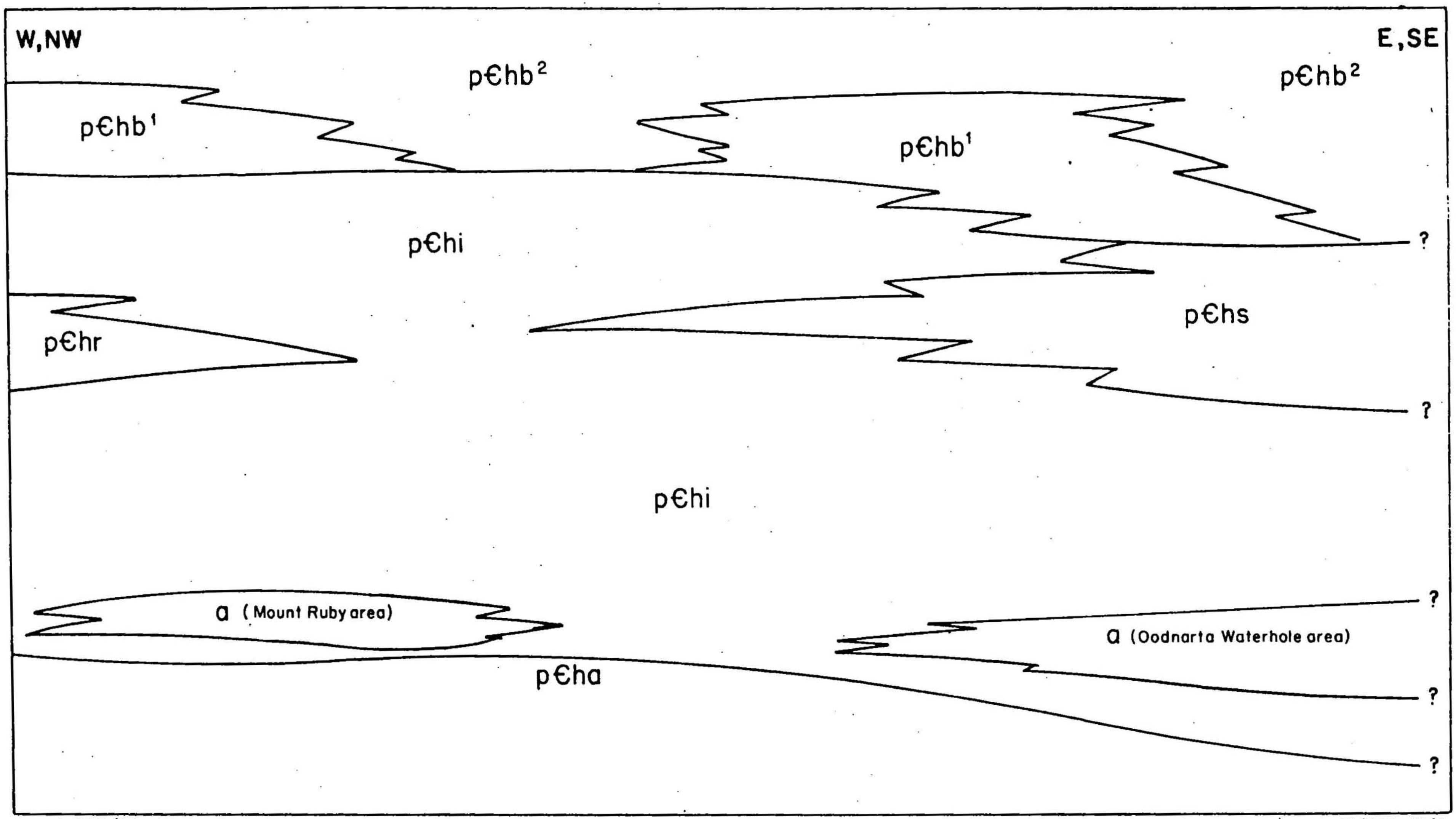
Fig. 2B Reference to Figure 2A

Illogwa Creek Sheet

Fig. 2C DIAGRAMMATIC RELATIONSHIP OF HARTS RANGE GROUP



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LEGEND

p€hb¹, p€hb² ...... Brady Gneiss
p€hi ...... Irindina Gneiss
p€hr ...... Riddock Amphibolite Member
p€hs ...... Stanovos Gneiss Member
a ...... Major amphibolite body
p€ha ...... Bruna Gneiss

TABLE 1: SUMMARY OF METAMORPHIC AND IGNEOUS ROCK UNITS

ROCK UNIT	MAIN ROCK TYPES	DISTRIBUTION	REMARKS
Pzr (Illogwa Schist Zone)	Muscovite-biotite quartzo-feldspathic schist, vein quartz lenticles, epidosite	Central-western part	Retrogressively metamorphosed igneous and metamorphic rocks
Harts Range pegmatites (not symbolised)	Pegmatite	Northwestern part	Both conformable with and cross-cut rocks of Harts Range Group. Age uncertain, may be Palaeozoic
Unnamed dolerite (including dykes-d1) Ꝑd	Dolerite	Central-western part	East-west striking dykes intrude the Albarta Metamorphics. Normally shown by dyke symbol (d1). Includes some unmetamorphosed gabbro
Unassigned ultra-basic rocks Ꝑp	Metahornblendite	Northwestern Part	Small cross-cutting bodies and lenticular sills; most are metamorphosed
Unclassified basic rocks Ꝑgb	Metamorphosed and partly metamorphosed norite and gabbro	Northwestern part	Small cross-cutting bodies and sills up to 200 m thick. Several bodies show relict igneous textures.

Unclassified meta-basic rocks Pdx	Metamorphosed basic igneous rocks	NW part near Mount Stanovos	Similar to Pgb, but spacially confined to Stanovos Gneiss Member; lacking relict igneous textures.
Unnamed granite, Pg	Porphyritic and fine even-grained granite	NW part	Intrudes Entia Gneiss
Unnamed granite and granitic gneiss pЄg	Granitic gneiss, porphyroblastic gneiss	NE part	Intrude Harts Range Group
Aremra Granodiorite Pgl	Granodiorite, tonalite, diorite	Central-western part	Intrudes unnamed unit pCf
Atneequa Granite Complex Pgk	Granodiorite, granite, diorite, granitic gneiss, amphibolite, syenite	Central-western part	Intrudes Albarta Metamorphics; unconformably overlain by Heavitree Quartzite
Inkamulla Granodiorite Pgh	Granodiorite gneiss, granodiorite	NW	Locally intrudes Entia Gneiss, elsewhere contacts are conformable.

Huckitta Granodiorite Pgh	Granitic gneiss, foliated granodiorite, amphibolite	NW	Intrudes Entia Gneiss, but generally has conformable contacts with it. Encloses numerous lenses of amphibolite
Unnamed Unit pЄq	Quartzite, schist, slate	SW	Sharp increase in metamorphic grade at pЄs contact.
Unnamed Unit pЄs	Gneiss, migmatite, mafic schist	SW	See above
Unnamed metamorphics pЄ	Muscovite-bearing biotite schist and schistose gneiss-biotite schistose gneiss stone, quartzite	SE	May be a facies equivalent of rocks mapped as undivided Harts Range Group pЄh
Undivided Harts Range Group pЄh	Biotite gneiss, calc-silicate rock, muscovite-bearing biotite, gneiss, metasediment; minor quartzofeldspathic gneiss, quartzite, sillimanite-bearing, gneiss, migmatitic gneiss, muscovite gneiss and amphibolite.	Central-north	A facies equivalent of the Irindina Gneiss and at least part of the Brady Gneiss
Brady Gneiss pЄhb	Schistose garnet-bearing muscovite-biotite gneiss overlain by muscovite-biotite gneiss, biotite gneiss and calc-silicate rock	NW	Conformably overlies Irindina Gneiss

Irindina Gneiss p€hi	Garnet-biotite-quartz-plagioclase gneiss, biotite gneiss, quartzo-feldspathic gneiss, layered and massive amphibolite, calc-silicate rock, marble.	NW	Conformably overlies Bruna Gneiss, contact is gradational
Stanovos Gneiss Member p€hs	Marble, quartzite, garnet-biotite gneiss overlain by unit characterised by porphyroblastic feldspar quartzofeldspathic gneiss grading into biotite gneiss and quartzofeldspathic gneiss followed by a unit of quartzite, marble and calc-silicate rock	NW	Conformable unit in Irindia Gneiss
Riddock Amphi-bolite Member p€hr	Amphibolite showing a well-developed compositional layering, some massive amphibolite, sub-ordinate intercalated garnet-biotite-plagioclase-quartz gneiss	NW	Conformable unit in Irindia Gneiss
Bruna Gneiss p€ha	Porphyroblastic-feldspar gneiss grading into quartzofeldspathic gneiss and biotite gneiss	NW part	Conformably overlies Entia Gneiss

Entia Gneiss pЄhe	Acid muscovite-biotite gneiss overlain by tonalitic quartzofeldspathic gneiss, hornblende-bearing quartzofeldspathic gneiss, layered amphibolite and biotite gneiss. Minor to rare kyanite-bearing schist lenses, calc-silicate rock and marble	NW part	Forms core of Entia Domal Structure. Conformably overlain by Irindina Gneiss.
Unnamed Unit pЄf	Quartzofeldspathic gneiss, subordinate biotite gneiss	Central-western part	Unconformably overlain by Heavitree Quartzite, faulted contact with Albarta Metamorphics
Albarta Metamorphics pЄa	Quartzofeldspathic gneiss, biotite and muscovite-biotite schist, massive and compositionally layered amphibolite	Central-western part	Includes minor calc-silicate rock
Bungitina metamorphics pЄsb	Amphibolite, biotite gneiss, quartzofeldspathic gneiss, muscovite-biotite schist	Central-western part	
Unnamed Unit, pЄx	Quartzofeldspathic gneiss, lenticular bodies of amphibolite, minor biotite gneiss	Central-western part	Probably a facies equivalent of the Ongeva granulite present in the Alice Spring Sheet area

TABLE 2: SUMMARY OF STRATIGRAPHY, AMADEUS BASIN SEQUENCE

ROCK UNIT	ROCK TYPES	DISTRIBUTION	REMARKS
Pz?	Orthoquartzite	SE part	Flat-lying unit is unlike any formation known in Amadeus Basin sequence.
Arumbera Sandstone Pu€a	White, grey and purple-brown sandstone unit overlain by siltstone, followed by purple-brown to pale brown sandstone	Southern-central part	Conformable on Julie Formation; about 400 m thick.
Julie Formation Puj	Pale brown to red-brown sandstone overlain by oolitic dolomite	Southern-central	Lies conformably between Pertatataka Formation below and Arumbera Sandstone above. Thickness estimated to be 200 m.
Pertatataka Formation Pup	Laminated siltstone and shale, sandstone.	SW part	Conformably overlies Pioneer Sandstone up to 1400 m thick.
Waldo Pedlar Member Pul	Thin-bedded to laminated sandstone	SW part	Conformable member of Pertatataka Formatio 60 m thick.
Pioneer Sandstone Pux	Sandstone, feldspathic sandstone, minor granule conglomerate	SW part	Disconformably and locally unconformably overlies Bitter Springs Formation. Conformably overlies the Olympic Formation. Preiss & others (1978) suggest that it may interfinger with the Olympic Formation.

Olympic Formation Ꝑuf	Diamictite, overlain by green shale with scattered boulders	One locality SW part (2 km W dead Horse Waterhole)	Disconformably overlies Aralka Formation with very local angular discordance at base. Thickness very variable - roughly 100 m.
Aralka Formation Ꝑuk	Laminated grey-green to red-brown siltstone and shale with beds of limestone, some oolitic or stromatolitic	SW part	Conformably overlies Areyonga Formation.
Limbla Member Ꝑum	Fine-grained cross-laminated sandstone, some with festoon cross-bedding	SW part	Conformable member at top of Aralka Formation; disconformably overlain by Olympic Formation in Alice Springs Sheet area; possibly 150 m thick.
Ringwood Member Ꝑur	Calcarenite; limestone, dolomite some oolitic and stromatolitic	SW part	Conformable member within lower part of Aralka Formation; thickness possibly 150 m
Areyonga Formation Ꝑua	Siltstone with some erratics, feldspathic sandstone, conglomerate, diamictite, dark grey cap dolomite	SW part overlain by Aralka Formation.	Inferred to disconformably overlie Bitter Springs Formation. Conformably overlain by Aralka formation. About 600 m thick in Limbla Syncline
Bitter Springs Formation Ꝑub	Dolomite, limestone, siltstone, sandstone	SW part	Everywhere subdivided into two members.

Loves Creek Member Ꝑue	Thick basal stromatolitic limestone and dolomite, overlain by thinner unit of dolomite and limestone contained in pink siltstone marked with notable cream-coloured 'reduction' spheres. Also spilite beds.	SW part	Conformable on Gillen Member. Inferred to be disconformably overlain by Areyonga formation. Overlain disconformably by Pioneer Sandstone.
$Ꝑue_{dl}$	Dolerite	SE part; one very small plug	Intrudes Ꝑue.
Gillen Member Ꝑug	Subunits: Ꝑug1-Interbedded grey limestone and siltstone Ꝑug2-Sandstone and interbedded siltstone overlain by limestone and siltstone. Ꝑug3-Interbedded carbonate and siltstone. Ꝑug4-Limestone overlain by limestone, dolomite and sandstone, then by thick sandstone. Ꝑug5-Interbedded carbonate and siltstone.	SW part	Conformable on Heavitree Quartzite. Conformably overlain by Loves Creek Member. Locally overlain disconformably by Pioneer Sandstone.
Heavitree Quartzite Ꝑuh	Sandstone, conglomerate, quartzite	SW part	Nonconformable on rocks of the Arunta Block. Conformable below Gillen Member. Thickness 300 to 400 m in Coulthards Gap area; 188 m east-southeast of Waldo Pedlar Bore in SE LIMBLA

Alice Springs Sheet area. The Strangways Metamorphic Complex here is considered to be in faulted contact with the Harts Range Group. Unnamed unit p€x, composed of quartzofeldspathic gneiss, subordinate amphibolite and various schists, may also belong to Division 1, but its relationships are uncertain. Both units contain rocks which may have been retrogressed from granulite facies.

DIVISION 2

The Albarta Metamorphics and unit p€f have lithological features transitional between those of Division 1 and 2, but are tentatively assigned to Division 2 because they have a compositional layering indicating deposition in sedimentary or sedimentary-volcanic sequences. These are feature typical of Division 2. The Albarta Metamorphics crop out in the northwest LIMBLA, south of the Illogwa Schist Zone. They are intruded by Atneequa Granitic Complex and are unconformably overlain by the Heavitree Quartzite. The Metamorphics are composed mainly of quartzofeldspathic gneiss of granitic appearance interlayered with schist and lessers amount of calc-silicate rock, hornblende gneiss, amphibolite, and rare, thinly-laminated magnetite-quartz rock. Although some of the quartzofeldspathic gneiss in the Albarta Metamorphics contains garnet and hornblende, indicating amphibolite grade metamorphic conditions, much of the sequence is retrogressed to muscovite and chlorite-bearing assemblages. The Albarta Metamorphics are lithologically similar to the Cavenagh metamorphics in the Arltunga region, Alice Springs Sheet area, and like the Cavenagh metamorphics are assigned to the lower part of Division 2.

Unit p€f occurs in the southwest LIMBLA and occupies a thrust faulted block north of the Albarta Metamorphics. It consists mainly of quartzofeldspathic gneiss. The unit is lithologically similar to the western part of the Albarta Metamorphics and may be stratigraphically equivalent to it. Because unit p€f occupies the core of the Ruby Gap Nappe in the adjacent Alice Springs Sheet area and has, therefore, undergone significant tectonic displacement, it is mapped separately from the Albarta Metamorphics.

The Harts Range Group occurs in the northeast of the Illogwa Creek Sheet area, mainly in western QUARTZ. The group is made up of two lower quartzofeldspathic units, the Entia Gneiss and the Bruna Gneiss, overlain by two upper pelitic units, the Irindina and Brady Gneisses. A large number of scattered outcrops in the central north of the Sheet area are also included in the Harts Range Group but are not sufficiently distinctive to be assigned to individual formations.

The Entia Gneiss crops out in central QUARTZ around a large central dome in Entire Valley centred on the Inkamulla and Huckitta Granodiorites. A narrow belt of probable Entia Gneiss also re-occurs along the northern margin of the Illogwa Schist Zone some 20 km farther south. The Entia Gneiss is the lowest unit in the Harts Range Group and is conformably overlain by the Bruna Gneiss. The Entia Gneiss consists mainly of a well-layered sequence of quartzofeldspathic gneiss. The lower part of the Entia Gneiss contains one or more lenses of kyanite-bearing biotite-schist; at very isolated localities these schists also contain cordierite, gedrite, and pink corundum. Near the middle part of the Entia Gneiss a thin discontinuous interval of calc-silicate rocks is exposed 2 km west of Valley Bore. The upper part of the Entia Gneiss consists of hornblende-bearing quartzofeldspathic gneiss, numerous lenticular layers of para-amphibolite which locally grade into calc-silicate rocks, and some small lenticular-plug-like bodies of basic to ultrabasic ortho-amphibolite.

The Bruna Gneiss surrounds the Entia Gneiss in central QUARTZ. It forms a transitional unit between the Entia Gneiss and the overlying Irindina Gneiss and has conformable contacts with both. It consists of quartzofeldspathic gneiss containing conspicuous K-feldspar megacrysts and a biotite-rich gneiss also containing K-feldspar megacrysts. The Bruna Gneiss forms a good marker unit.

The Irindina Gneiss surrounds the Bruna Gneiss and is conformably overlain by the Brady Gneiss. The unit consists mainly of schistose biotite-rich gneiss and subordinate quartzofeldspathic gneiss, both of which are commonly garnet-bearing. The biotite-rich gneiss locally contains minor sillimanite. The Irindina Gneiss also contains lenticular amphibolite bodies as well as small amounts of calc-silicate rock, marble, quartzite, and porphyroblastic feldspar-gneiss. In the northwest of the Sheet area the Irindina Gneiss is calcareous in its lower part and contains an amphibolite unit in its upper part known as the Riddock Amphibolite Member. At the Hillrise Ruby Mine the Member includes an unusual layer consisting mainly of plagioclase, some hornblende (5-10%), and commonly biotite (10-15%). It is 20 to 40 m thick and can be traced for some 20 km to the west and north. This unit is thought to be a metamorphosed calcareous sediment. Rare anorthite-rich pods and phlogopite-hornblende amphibolite in the layer contain traces of ruby-corundum. A number of other large, layered amphibolite bodies occur elsewhere within the Irindina Gneiss. They are lithologically equivalent to the Riddock Amphibolite Member and are shown on the compilation sheets by the same stratigraphic symbol. However, they appear to occur at a number of different stratigraphic levels.

Southwest of the Last Chance Mica Mines garnet-biotite gneiss of the Irindina Gneiss is interlayered with quartz-bearing amphibolite and quartzite and is overlain by the Stanovos Gneiss Member which lacks garnet in the gneiss and contains amphibolite. It is characterised by quartzofeldspathic gneiss, including varieties containing K-feldspar megacrysts, are interlayered with biotite gneiss and enclose discordant basic lenses assigned to a separate unit (Pdx). In the upper part of the Stanovos Gneiss Member several beds of quartzite are intercalated with calc-silicate rock, marble, and schistose biotite-gneiss.

The Brady Gneiss forms the main arcuate ridge of the Harts Range in central QUARTZ. It conformably overlies the Irindina Gneiss. The unit is interpreted to be in faulted contact with undivided rocks of the Harts Range Group to the east, although the contact is obscured by Cainozoic cover. The Gneiss is composed mainly of garnetiferous muscovite-biotite schistose gneiss. Biotite gneiss and calc-silicate gneiss are also common rock types particularly in the upper part of the unit.

Rocks mapped as undivided Harts Range Group (p€h) crop out as isolated exposures in central northern Illogwa Creek Sheet area east of the Harts Range. Their relationship to the units in the well-exposed part of the Harts Range is uncertain. They appear to interfinger with the Irindina Gneiss to the north, mainly in the Huckitta Sheet area. They are regarded as a facies equivalent of the Irindina Gneiss and at least part of the Brady Gneiss. These undivided rocks consist of schistose muscovite-biotite gneiss and biotite gneiss in addition to a more conspicuous epidote-scapolite-clinopyroxene calc-silicate rock. The characteristic rock type of the Brady Gneiss, garnet-bearing muscovite-biotite schistose gneiss, occurs only in small amounts in unit p€h. Biotite gneiss is also much less abundant and commonly is more migmatitic in the undivided unit (p€h) than in the Brady Gneiss. Unit p€h also lacks garnet-biotite gneiss and sillimanite-bearing gneiss that characterise the Irindina Gneiss.

Farther to the southeast in the eastern part of the Sheet area unnamed metamorphic rocks (p€) form scattered low hills and ridges of muscovite-bearing biotite schist and quartzose metasandstone. The metamorphic grade of these rocks is similar to or less than the rocks mapped as undivided Harts Range Group (p€h). However, stratigraphy relationships are uncertain. They may also be a facies equivalent of the Harts Range Group i.e. upper Irindina Gneiss - Brady

Gneiss interval. Isolated low hills of metamorphosed arkose and granule conglomerate to the southwest, 55 km east of Illogwa Bore, may form part of the same sequence. Unit p€s forms small scattered hills in an inlier of Arunta Block rocks in southwestern LIMBLA. The unit is unconformably overlain by unit pCq in the far northeastern corner of the inlier. Unit p€s was not examined during the present survey. Leitch & others (1979) describe these rocks as 'gneiss, migmatite, and mafic schist'.

DIVISION 3

Division 3 rocks are known from only one small locality "just outside" in the Illogwa Creek Sheet area. They occur 13 km south-southeast of Limbla homestead where they are mapped as unit p€q. This unit probably unconformably overlies unit p€s. The unconformity is inferred from the marked difference in metamorphic grade between p€q and the nearby unit pCs. Unit p€q consists of cleaved quartzite, schist, and slate (Leitch & others, 1970).

Igneous Rocks

Basic Rocks

A number of gabbroic, noritic, and ultramafic bodies (Pgb, Pb), showing various degrees of metamorphic recrystallisation, may have been emplaced at the height of the regional metamorphic event or slightly afterwards. The most conspicuous body of this type is the metanorite at Mount Emma. The discordant amphibolites (Pdx) enclosed within the Stanovos Gneiss Member of the Irindina Gneiss probably also belong to this category.

Granites

The Atneequa Granitic Complex occurs in central LIMBLA. It has intruded the Albarta Metamorphics and is unconformably overlain by the Heavitree Quartzite. It is mainly granite and granodiorite in composition, but includes some tonalite, and more mafic rock, possibly diorite, has also been photo-interpreted. The Complex is lithologically like the Atnarpa Igneous Complex in the Alice Springs Sheet area. The Atnarpa Igneous Complex has a Rb-Sr age of about 1700 m.y. (Cooper & others, 1971; Armstrong & Stewart, 1975; Black & others, in press) and the Atneequa Granitic Complex is likely to have a similar age.

The Aremra Granodiorite occurs in northwestern LIMBLA where it intrudes unit p€f and is unconformably overlain by Heavitree Quartzite. It consists mainly of granodiorite, tonalite, and small amounts of diorite. The unit is very similar to the Atneequa Granitic Complex.

The Inkamulla and Huckitta Granodiorites occupy two separate domes within the larger Entia Domal Structure. Both are gneissic and conformable with the contact and compositional layering in the Entia Gneiss country rock. These features suggest that the granites may have been emplaced before the main regional metamorphism. A small granite, Ꝑg, occurs 2 km east of Huckitta Bore within the Harts Range. It intrudes the Entia Gneiss and is intruded by dolerite dykes and gabbro. The granite is made up of porphyritic and fine-grained granite and is foliated.

Unassigned Granite and Granite Gneiss, p€$_{g}$, form small isolated hills about 70 km east of the Harts Range. They are inferred to intrude undivided Harts Range Group (p€h) and consist of granitic gneiss, porphyroblastic gneiss, and other foliated granitic rocks.

Conspicuous east-trending dolerite dykes (Ꝑd) intrude the Albarta Metamorphics in northwest LIMBLA, and small dolerite dykes intrude the Harts Range Group near Indiana homestead.

Late-stage Schist Zones

The Illogwa Schist Zone occupies a broad belt, some 5 km wide, separating unit p€f and the Albarta Metamorphics in the south from the Harts Range Group in the north. The zone contains schists formed by metamorphic retrogression of amphibolite facies rocks to greenschist facies assemblages. It is bounded to the north and south by faults. In the adjacent Alice Springs Sheet area, similar zones have Rb-Sr ages of 300-400 m.y. (Armstrong & Stewart, 1975). Minor schist zones occur on either side of the Illogwa Schist Zone.

Late Proterozoic to Cambrian Sediments

The Amadeus Basin is an intracratonic structural sedimentary basin containing Late Proterozoic and younger sandstone, shale, and carbonate deposited in a predominantly shallow marine environment. The stratigraphy of the basin is described by Wells & others (1970) and a more detailed description of the northeastern Amadeus Basin including the Sheet area is given by Wells & others (1967). More recent revisions to the stratigraphy are given by Preiss & others (1978).

Heavitree Quartzite is the oldest unit in the Amadeus Basin and unconformably overlies crystalline basement of the Arunta Block in southwestern LIMBLA. It consists of sandstone and conglomerate, and is much coarser grained and more conglomeratic than it is to the west in the Alice Springs Sheet area, possibly due to thickening of the Fenn Gap Conglomerate Member (see Clarke in Stewart & others, 1980a).

The Bitter Springs Formation crops out in southern LIMBLA. It conformably overlies the Heavitree Quartzite with a gradational contact. In most places it is overlain disconformably by the Areyonga Formation. Locally, it is disconformably overlain by the Pioneer Formation. The Bitter Springs Formation consists of carbonate, siltstone, and sandstone.

The Gillen Member, the lower member of the Bitter Springs Formation, is made up of five units as follows, beginning at the base -

1) A thick unit of limestone containing laminae of siltstone.
2) Quartzitic to arkosic sandstone interbedded with red and green laminated siltstones.
3) Thick stromatolites carbonate beds alternating with recessive beds of siltstone and shale. Lenses of gypsum occur in this unit.
4) A thick yellow limestone overlain by interbedded limestone, dolomite, and sandstone, and a very thick sandstone with conglomerate, calcareous sandstone and ferruginous sandstone.
5) Prominent beds of dark grey dolomite interbedded with recessive beds of laminated siltstone.

The Loves Creek Member, the upper member of the Bitter Springs Formation, consists of a thick stromatolitic dolomite overlain by a thick unit of pink calcareous siltstone containing beds and lenses of stromatolitic dolomite, succeeded by a dark red ferruginous siltstone containing lenses of spilite a few metres thick.

The Areyonga Formation occurs in southern LIMBLA where it disconformably overlies the Bitter Springs Formation. It consists mainly of grey-green, poorly sorted feldspathic sandstone, siltstone and claystone, together with small amounts of diamictite and conglomerate.

The Aralka Formation occurs in southern LIMBLA where it conformably overlies the Areyonga Formation. It consists of a thick sequence of siltstone and shale.

Ringwood Member consists of carbonate rocks within the lower part of the formation. The Limbla Member occurs at the top of the Aralka Formation. It is composed of carbonate interbedded with minor conglomerate and sandstone overlain by finely cross-laminated sandstone.

The Pioneer Sandstone occurs in southwestern LIMBLA along the eastern margin of the Mulga Syncline where it disconformably overlies the Bitter Springs Formation. It is absent in the section east of Bronco Bore, but a small body of Pioneer Sandstone disconformably rests on Olympic Formation west of Deadhorse waterhole. The Pioneer Sandstone is composed of cross-bedded, medium to coarse-grained sandstone which is feldspathic in places.

The Pertatataka Formation occurs in the southwestern corner of LIMBLA. It conformably overlies the Aralka Formation and consists of unexposed siltstone and small amounts of sandstone. A small outcrop of Waldo Pedlar Member, a unit of thinly bedded to laminated sandstone, occurs within the formation.

The Julie Formation conformably overlies the Pertataka Formation and crops out east of the Limbla Syncline. It consists of mainly oolitic dolomite interbedded with white and red-brown sandstone, small amounts of siltstone, and rare crytocrystalline dolomite and limestone.

The Arumbera Sandstone conformably overlies the Julie Formation in the central-southern Illogwa Creek Sheet area. The sandstone consists of upper and lower sandstone units separated by a siltstone interval. No fossils are known from the Sheet area, but in the adjacent Alice Springs Sheet area it contains Early Cambrian trace fossils in its middle part (Daily, 1972) and Late Proterozoic metazoans in its lower part (Glaessner & Walter, 1975).

A shallow-dipping orthoquartzite (Pz) of unknown affinity crops out about 20 km east of Junction Bore in the southeastern part of the Sheet area.

Cainozoic to Mesozoic Sediments

The Cretaceous-Jurassic Hooray Sandstone (a correlate of the de Souza Sandstone of Wells & others (1970)) overlies the unnamed schist unit (pЄ) in the southeastern part of the Sheet area. The sandstone is coarse to fine-grained, poorly sorted, and ferruginised. It crops out sporadically over a wide area in the southeast of the Sheet area. Rocks in much of the eastern two-thirds of the Sheet area have undergone deep weathering in the mid-Tertiary.

A number of highly ferruginous and silicified cappings in the northern central part of the Sheet area are thought to have formed on small, non-outcropping ultrabasic and basic bodies, the presence of which can only be inferred from the weathered remnants. Some of these show local surface enrichment of chrome and nickel.

A Tertiary sedimentary basin known only in the subsurface, extends to the southeast from just west of Gidgee Bore along the margin of the main ranges of metamorphic rocks. The sequence is similar to that in the Ti Tree and Waite Basins (Alcoota and Napperby Sheet areas).

The oldest sediments (Ta), known only from drill core, are green pyritic mudstone. The homogeneity of the mudstones indicates quiet water deposition coupled with low-input of terrigenous detritus from the nearby Harts and MacDonnell Ranges. The mudstones pass abruptly into overlying poorly sorted clastics, which were probably deposited rapidly in a series of piedmont fans. These sediments are strongly weathered and contain abundant iron oxide pisoliths.

This sequence is capped by a thin veneer of chalcedonic limestone (Tw), which has a more extensive distribution to the east where it caps highly weathered metamorphic rocks.

DESCRIPTIVE NOTES ON METAMORPHOSED ROCK UNITS

Division 1 - Strangways Metamorphic Complex

The Strangways Metamorphic Complex is the most distinct major group in Division 1 of the Arunta Block. The only know representative of the Complex in the Illogwa Creek Sheet area is the Bungitina metamorphics; the unnamed unit pCx may also be part of the Strangways metamorphics Complex because it crops out along strike from, and may be a retrogressed equivalent of, the Ongeva granulite (part of the Strangways Metamorphic Complex) which crops out to the west in the Alice Springs Sheet area.

Bungitina metamorphics (informal)

Map Symbol: p€sb

Nomenclature: From Bungitina Well (abandoned) (GR RIDDOCH - 900374) on the upper reaches of Maude Creek, 9 km south of Mount Brassey, in the northeastern part of RIDDOCH. For more details refer to Shaw & others (1979) and Stewart & others (1980a).

Distribution: Southwestern QUARTZ, north of the Illogwa Schist Zone at the western margin of the Sheet area.

Reference area: Florence Creek between GR 5851-847427 and -836381 in RIDDOCH.

Thickness: Unknown.

Topographic expression and airphoto characteristics: Subdued low hills with pale photo colours.

General lithology: Amphibolite (a), biotite gneiss (b), quartzofeldspathic gneiss (f), and muscovite-biotite schist (s).

Relationships: The Bungitina metamorphics are inferred by Shaw & others (1979) to unconformably underlie the Harts Range Group (see section on Harts Range Group for further discussion).

Correlation: The Bungitina metamorphics were originally correlated with the Entia Gneiss (Shaw & others, 1979, p. 102). However, further investigation has shown that these two units differ considerably in the amount and type of mafic rock present in each. The bulk of the mafic rock in the Entia Gneiss is considered to be para-amphibolite because it is well-layered, and grades into calc-silicate rock. Much of the mafic rock in the Bungitina metamorphics is massive and forms ovoid bodies which locally show cross-cutting relationships. The units are, therefore, no longer considered correlatives.

Age: Middle Proterozoic or older. The unit is presumed to have been regionally metamorphosed at about 1800 m.y. like other units of the Strangways Metamorphic Complex (Shaw & others, 1979).

Unnamed Unit, p€x

Map Symbol: p€x

Nomenclature: The unit is unnamed because its relationship to other units is uncertain.

Distribution: Crops out 3-5 km southwest of Mount Ruby in southwestern QUARTZ between the Illogwa Schist Zone (Pzr) in the south and the Harts Range Group (p€he? and p€ha) in the north. The unit has been extrapolated from the Alice Springs Sheet area.

Reference area: In the Star and Pig Hole Creek areas in RIDDOCH.

Topographic expression and airphoto characteristics: Forms low-lying hills. Weathered and partly covered by thin soil. Mixed yellow-brown (felsic) and greenish-grey (amphibolite) photo-tones.

General lithology: Quartzofeldspathic gneiss (f) containing commonly lenticular bodies of amphibolite (a) and narrow layers of biotite gneiss (b), granitic gneiss (gg) and very minor megacrystalline feldspar gneiss (p). Much of the quartzofeldspathic gneiss is partly retrogressed to muscovite-bearing schist (s, sf). The amphibolite is locally converted to greenschist facies rocks (sc). The unit is progressively deformed and metamorphicaaly retrogressed southwards.

Details of lithology:-

Quartzofeldspathic gneiss (f) consists of biotite, plagioclase, quartz, and K-feldspar. It is generally fine to medium-grained and has a granoblastic texture.

Biotite gneiss (b) in uncommon. The term is used for quartzofeldspathic gneiss where the mafic mineral content exceeds 10 percent.

Quartzofeldspathic schist (sf) (e.g. FPS 1293, 1294, 1925) is used for the most deformed and retrogressed varieties of quartzofeldspathic gneiss which have a strong schistosity.

Muscovite-bearing schistose gneiss (s) consists of muscovite, plagioclase, quartz and K-feldspar. Some varieties contain biotite. It has been derived from quartzofeldspathic gneiss by partial retrogression in which epidote and muscovite have formed by alteration of a more calcic-plagioclase.

Amphibolite (a) (e.g. FPS 3363-65) is slightly retrogressed and contains minor minerals typical of greenschist facies: tremolite, actinolite, epidote, white mica, chlorite, and biotite.

Tremolite schist (sc), derived from amphibolite by complete retrogression and severe deformation, is present at FP 1293.

Granitic gneiss (gg) (e.g. FPS 1295) forms tors and rounded boulders in a 40 m wide unit in a sequence of quartzofeldspathic gneiss. It differs from the quartzofeldspathic gneiss in being a medium- to coarse-grained, relatively massive rock lacking internal compositional layering and having a granitic texture.

Structure and metamorphism: The rocks become progressively schistose, more strongly lineated and more completely retrogressed to greenschist facies assemblages southwards towards the Illogwa Schist Zone. Narrow retrograde schist zones occur within unit p€x.

Relationships: The rocks are the eastwards continuation of a unit mapped as p€x in eastern part of the Alice Springs Sheet area. Unit p€x is probably a facies equivalent of the Ongeva granulite in the central part of the Alice Springs Sheet area (Shaw & others, 1979). At the northwestern border of the sheet area Unit p€x is overlain by an extension of the Bungitina metamorphics. However, relationships are not well established and more work is required.

Units Transitional between Divisions 1 and 2

Unnamed Unit, pЄf

Map Symbol: pЄf

Nomenclature: Unnamed because it is fault bounded and its relationship to other units is uncertain. First used in the 1:250 000 Preliminary 2nd Edition Map of the Alice Springs Sheet area where it is unconformably overlain by the Heavitree Quartzite. Described by Shaw & others (1979, p. 149) as subunit 6 of unit pCx.

Distribution: Occupies the western part of a thrust slice outlined by lenses of Heavitree Quartzite (Єuh) south of the Illogwa Schist Zone between Ruby Gap (Alice Springs Sheet area) and Illogwa Creek in southwestern QUARTZ. It is the eastern extension of a unit mapped in the core of the Ruby Gap Nappe in the Alice Springs Sheet area.

Topographic expression and airphoto characteristics: Forms low-lying hills over a wide area between ridges of Heavitree Quartzite. Yellow-brown photo-colour and even photo-tones.

Thickness: Unknown.

General lithology: Mainly quartzofeldspathic gneiss (f) and subordinate biotite gneiss (b), locally intercalated with two-mica schist (s). Much of the quartzofeldspathic gneiss has been deformed to produce quartzofeldspathic schist (sf) and schistose biotite gneiss (sb). Minor rock types include amphibolite (a) and amphibolite retrogressed to actinolite schist (sc).

Detailed lithology:

Quartzofeldspathic gneiss (f) compositional layering several metres thick. It contains muscovite and very fine-grained biotite in addition to quartz and feldspar. (e.g. FPS 1496, 1499).

Quartzofeldspathic schist (sf) (e.g. FP 1496) is a strongly schistose to phyllite-like rock composed of quartz, feldspar, very fine-grained biotite and sericite. It is thought to have formed from the quartzofeldspathic gneiss due to deformation and retrograde metamorphism. Schistosity increases towards the Illogwa Schist Zone.

Biotite gneiss (b) (e.g. FP 1499) is a less common rock type in unit p€f. It is medium-grained rock type consisting of biotite, quartz, plagioclase and K-feldspar. It forms outcrops with a more subdued relief than the quartzofeldspathic gneiss.

Muscovite-biotite gneiss and schist (s) is an uncommon rock type concentrated towards the Illogwa Schist Zone (e.g. FP 1154).

Schistose biotite gneiss (sb) is a minor rock type containing quartz, feldspar and both coarse and fine-grained biotite (e.g. FP 1156). A second schistosity is evident and is due to the preferred orientation of fine flakes of biotite considered to be a later mineral formed during metamorphism which accompanied the Alice Springs Orogeny (Shaw & others, 1979).

Metamorphism and Structure: Occupies an easterly trending thrust-slice. During the Alice Springs Orogeny (Shaw & others, 1979) the unit was partly retrogressed to greenschist facies minerals.

Relationships: Unconformably overlain by Heavitree Quartzite (Puh). The contact with the Albarta Metamorphics is faulted.

Correlation: Unit p€f may be equivalent to the westernmost part of the Albarta Metamorphics which contains abundant quartzofeldspathic gneiss.

<u>Mineralisation</u>: The Hale River gold-copper prospect occurs in the eastern part of the unit. Its location has not been field checked. The mineralisation is structurally localised in quartz-veins formed during the late-stages of the Alice Springs Orogeny (Shaw & others, 1979).

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Albarta Metamorphics (new name, partly defined)

Map symbol: p℮a

Nomenclature: Named after Albarta Creek, about 36 km north-northwest of Limbla homestead.

Distribution: Crops out north of Albarta Creek in northwestern LIMBLA and southwestern QUARTZ between the range formed of Heavitree Quartzite at Ruby Gap (Alice Springs Sheet area) and Aremra Creek to the east. A second outcrop-area extends from Bullhole Dam east to near Junction Bore. The metamorphics are also photointerpreted as roof pendants in a basement klippe of granite which occurs in the upper reaches of Five Mile Creek.

Reference section: East-west tributary of Illogwa Creek that parallels Albarta Creek, 3-4 km to the north (i.e. from GR 5950-100040 to 4950-981180).

Thickness: Unknown as structure uncertain; probably in excess of 5000 m.

Topographic expression and airphoto characteristics: Forms blocky low-lying hills; gives rise to contrasting yellow and grey-brown bands on colour aerial photographs. Schistosity commonly apparent.

General lithology: A sequence consisting mainly of quartzofeldspathic gneiss (f); locally containing pegmatitic portions, interlayered with biotite and muscovite-biotite schist (sb, s), and massive and compositionally layered amphibolite (a, pa). The sequence also contains small amounts of calc-silicate rock (cs) hornblende gneiss (h), laminated hematite quartzite (qf), granitic gneiss (gg), porphyroblastic-feldspar gneiss (p), and biotite gneiss (b). Marble (ma) is an uncommon rock type associated with calc-silicate rocks in the sequence in the southeast and far north.

Details of lithology:

Quartzofeldspathic gneiss (f) (e.g. 1468, 1334A) is the dominant rock type. It forms massive layers up to ten metres thick and is mainly medium-grained in places is very coarse textured. The mineral content of the rocks ranges widely from those where K-feldspar is considerably in excess of plagioclase (20:1), to types where plagioclase is slightly in excess of K-feldspar (3:2). The K-feldspar is commonly microcline. The quartz content ranges from 10 percent to 35 percent. Minor minerals are generally muscovite and biotite, and accessory minerals are zircon, ilmenite, and sphene. Biotite, where present, is commonly altered to chlorite. Traces of hornblende and garnet are present locally (e.g. FPS 1334, 1341). It is partly migmatitic (FPS 1334, 1341) and here may contain disseminated tourmaline or tourmaline-quartz pods (e.g. FP 1447).

Pematite (peg): The more potassic quartzofeldspathic gneiss grades into pegmatite (e.g. at FP 1470): the composition remains similar.

Biotite schist (sb) consists of up to 25 percent biotite in addition to quartz and feldspar which is mainly plagioclase. Muscovite-biotite schist (s) is similar in composition, but contains a small amount of muscovite. These schists include fine, medium, and coarse-grained types. In specimen 1187, quartz grains (45%) with sutured grain boundaries, or quartz-mica beards, together with elongate aggregates of sericite (40%) derived from plagioclase are separated by biotite (13%) and muscovite (2%) folia. About (2%) of the biotite is altered to chlorite, and accessory magnetite is altered to hematite. The schists rarely contain garnet as is the case at FP 1140. Schists are mainly in the northern outcrop-area between the upper reaches of Albarta Creek in the west and Aremra Creek in the northeast. Schists containing muscovite are common towards Aremra Bore whereas in the west the schists more commonly lack muscovite.

Hornblende gneiss (h) commonly occurs as thin layers intercalated with quartzofeldspathic gneiss or calc-silicate rock. Typically it is composed of quartz, feldspar, hornblende, and locally garnet (e.g. FP 1140). In places hornblende is altered to actinolite (e.g. FP 1147). Specimen 1139A, a finely layered, schistose fine-grained rock representative of the hornblende gneiss, is visually estimated to consist of microcline (56%), quartz (20%), blue-green hornblende (13%), clinozoisite (5%), biotite (5%), zircon (1%), a trace of apatite, and accessory sphene and tourmaline.

Layered amphibolite (pa) occurs in the west of the outcrop-area. Specimen 79091478 is typical of the layered amphibolite. It has a granuloblastic texture and has an average composition of hornblende (65%), saussuritised plagioclase (33%), quartz (2%), and rare opaque grains. The layering is compositional and due to a changing ratio of hornblende to plagioclase.

Massive amphibolite (a) forms lenses up to 250 m wide by 5 km long, and occurs mainly in the western part of the Albarta Metamorphics. An example is specimen 7909 1209 which is a medium-grained schistose rock, visually estimated to consist of blue-green hornblende (65%), saussuritised plagioclase (30%), quartz (3%), magnetite (2%), and a trace of hematite.

Marble (ma) is uncommon but widely distributed. A typical example is the impure marble at FP 1481 which is visually estimated to consist of calcite (75%), epidote (15%), K-feldspar (2%), actinolite (7%), plagioclase (0.5%) and a trace of sphene. Thin calcite-rich layers commonly alternate with epidote-rich layers (e.g. FP 1207, 1147). Only rarely does the marble consist entirely of calcite (e.g. FP 1372).

Hematite quartzite (qf) is a granular rock in which thin magnetite or hematite layers alternate with quartz-rich layers (e.g. FPS 1143, 1481). Apatite is a common accessory. The banded rock is commonly intercalated with schist.

Porphyroblastic-feldspar gneiss (p) is a variety of quartzofeldspathic gneiss in which scattered feldspar augen make up about 3 percent of the rock (e.g. FP 1384).

Granitic gneiss (gg) is generally coarse-grained, foliated, and contains up to 12 percent biotite (e.g. FPS 2500, 2505, 2506). Such gneiss occurs southwest of Atneequa Bore at FP 1373, south of Illogwa Bore at FPS 2500 and 2505-6, and in the northeast of the outcrop-area of FPS 1330-31, 1649, and 1652. A muscovite-bearing granitic gneiss which locally contains tourmaline, occurs in the east of the outcrop-area at FP 1447.

Biotite gneiss (b) (e.g. FP 2510) is uncommon in this unit. It contains 10-13 percent biotite in addition to plagioclase, quartz, and K-feldspar. It grades into quartzofeldspathic gneiss (e.g. at FPS 1326-7).

Structure: The sequence has been isoclinally folded about north-trending axes. The unit is cut by a system of closely spaced northwest-trending faults.

Metamorphism: Prograde metamorphism attained amphibolite facies conditions. The presence of hornblende and garnet in quartzofeldspathic gneiss indicates that conditions were possibly as high as upper amphibolite grade. A zone of retrograde metamorphism to greenschist facies occurs along a major northeast-trending fault (7-20 km north-northeast of Coulthards Gap waterhole) and may be genetically related to it.

Relationships: Intruded by Atneequa Granitic Complex and some east-west dolerite dykes. The Metamorphics are unconformably overlain by Heavitree Quartzite. The northern contact is faulted, and the eastern contact is obscured by Cainozoic cover.

Correlation: Correlated on lithological grounds with the Cavenagh metamorphics in the Alice Springs Sheet area. Rock types common to both include compositionally layered quartzofeldspathic gneiss (f), calc-silicate rocks (cs), para-amphibolite (pa), and quartz-hematite rock (qf). The Albarta Metamorphics lack quartzite and andalusite schist which are minor rock types in the Cavenagh metamorphics.

Age: No age determinations have been carried out on the Albarta Metamorphics.

Remarks: The quartzofeldspathic gneiss in the Albarta Metamorphics may have originated from either quartzofeldspathic sediments or acid volcanics because they are part of a compositionally layered sequence. The schists probably represent pelitic metasediments. An original marine environment for the sequence is suggested by the marble and calc-silicate rocks intercalated with these rocks.

The origin of the massive amphibolites (a) is uncertain. The layered amphibolite (pa) may be either metamorphosed semi-calcareous sediments or metamorphosed basic tuffs. The hematite-magnetite bodies are likely to be chemical metasediments as they are closely associated with pelitic schist and calc-silicate rock.

Division 2 - Harts Range Group

The Group overlies the Strangways Metamorphic Complex with a disjunctive boundary, which is probably a deformed unconformity, in the northeastern part of the Alice Springs Sheet area (Shaw & others, 1979). At the disjunctive boundary there is an abrupt change from structurally complex units containing numerous discordant basic meta-igneous rocks to a well-layered sequence made up of laterally continuous rock units lacking discordant mafic meta-igneous rocks. The name, Harts Range Group, divided into Entia Gneiss, Bruna Gneiss, Irindina Gneiss and Brady Gneiss was introduced by Joklik (1955a). Scattered outcrops on the plains east of the Harts Range are mapped as undivided Harts Range Group. These rocks are considered to be facies equivalent of the Brady Gneiss and/or part of the Irindina Gneiss because they interfinger with the Irindina Gneiss in the north and include calc-silicate rocks that are lithologically very similar to those in the Brady Gneiss.

Entia Gneiss (formal)

Map Symbol: p€he.

Nomenclature: Named after the Entia drainage basin, Joklik's term for the saucer-like upper catchment of Entire Creek (then known as Entia Creek).

Distribution: Envelopes the Huckitta and Inkamulla Granodiorites in the catchment area of Entire Creek in northwestern QUARTZ. Possibly reappears to the south along the northern margin of the Illogwa Schist Zone between Hale River and Aremra Creek.

Reference area: Joklik (1955a) nominated only a broad reference area surrounding Inkamulla Bore. The reference locality is taken to be 1.5 km north-northwest of Inkamulla Bore (GR5751-447184), where Joklik collected specimen R4559, which was described in detail and has been chemically analysed.

Thickness: Difficult to estimate because of folding: more than 2000 m.

Topography expression and airphoto characteristics: Very rough, hilly country, interspersed with alluvial valleys, forming a pound almost surrounded by a circle of hills made up of the overlying units. Has a pale-yellow brown, well-layered expression on the coloured aerial photographs.

General lithology: The typical rock type is a quartzofeldspathic gneiss of granitic appearance. A lower unit and an upper unit are recognised, but are not separated on the map.

The lower unit consists of acid biotite-muscovite gneiss (f) of granite composition, containing thin intercalations of muscovite-biotite schist (s) which locally contains kyanite (y), and also layered quartz-amphibolite (pa), small amounts of homogeneous amphibolite (a), hornblende-bearing quartzofeldspathic gneiss (h) and rare calc-silicate rock (cs), and ankerite-rich marble (ma).

The upper unit is characterised by hornblende-bearing quartzofeldspathic gneiss of tonalite composition (h), and compositionally layered amphibolite (pa), as well as quartzofeldspathic gneiss (f), and biotite gneiss (b). It includes a wide variety of minor, less abundant rock types such as porphyroblastic quartzofeldspathic gneiss (p), epidote calc-silicate rock (cs), and rare sillimanite gneiss (z) garnet-muscovite gneiss (sv), and marble (ma). Hornblende-bearing gneiss in the upper part of the Entia Gneiss are of tonalitic composition.

Detailed lithology:

Quartzofeldspathic gneiss (f) has a granitic texture and ranges in composition from granite to tonalite. The estimated mode given by Joklik (1955) R4559 (FP 3032, 1.5 km NNW of Inkamulla Bore, GR5751-477184) is quartz (37.7%), microcline (37.5%), andesine (22.7%), biotite (1.3%), muscovite (0.4%) and a trace of apatite. Fabric is granoblastic; all minerals are completed recrystallised. Specimens R4559 and 78916633, from 1.6 km north-northeast and 11 km northeast of Inkamulla Bore respectively were chemically analysed (see APPENDIX C). Specimen 78916633 has the composition of tonalite and consists of plagioclase (60%), quartz (31%), biotite (8%), K-feldspar (0.5%), traces of blue-green hornblende, muscovite and biotite and accessory apatite and monzonite. Where muscovite is more conspicuous the K-feldspar content is commonly higher. For example, specimen 1232A from north-northwest of Huckitta Well (fm) has 10 percent K-feldspar and 1.5 percent muscovite.

Biotite gneiss (b) is used for granodiorite to tonalitic types of gneiss with the same mineralogy of quartzofeldspathic gneiss (f), but lacking muscovite and containing in excess of 10 percent biotite. It is an important rock type in the upper unit.

Hornblende-bearing quartzofeldspathic gneiss (h) is a well-layered gneiss containing up to 20 percent hornblende. It locally contains epidote-rich layers and is commonly intercalated with layered amphibolite (pa). A typical specimen (78916631A, FP1895) contains microcline (70%), hornblende (17%), clinopyroxene (5%), quartz (4%), plagioclase (4%) and a trace of sphene; some (e.g. specimen 7891 6631B) contains scapolite. Specimen 78916631A collected 10 km northeast of Inkammula Bore was chemically analysed and is listed in Appendix C (4).

Layered amphibolite (pa) is commonly quartz-rich; a typical sample contains quartz (45%), hornblende (30%), clinopyroxene (15%), plagioclase (10%), traces of epidote and rare garnet: examples include R4570 and R4571 at FPS 3056-6 near Lone Pine Mine, which contain layers rich in hornblende and quartz. Specimen R4571 also contains a small amount of scapolite.

Generally the amphibolite is interlayered with granitic quartzofeldspathic gneiss but is also interlayered with calc-silicate rock, and rarely with impure ankerite-rich marble (west of Inkamulla Bore). Compositional layering ranges from less than a millimetre to several metres in thickness. Quartz content ranges by as much as 20 percent between layers.

Calc-silicate rock and calcareous gneiss (cs) are rare rock types intercalated with amphibolite (pa); Specimen 6629 (FP 1894), a typical example of calcareous gneiss is composed of microcline (65%), quartz (20%), green hornblende (12%), clinopyroxene (2%), plagioclase (1%) and a trace of sphene. Another type just south-southwest of Lone Pine Mine is made up of quartz-feldspar-scapolite layers and green hornblende-epidote layers (FPS 3043, R4569).

Amphibolite (a) is a massive rock consisting of hornblende and plagioclase and is substantially confined to the upper unit.

Biotite-muscovite schist (s) A seris of schist lenses appear to form two thin discontinuous horizons around the Huckitta Granodiorite, but strike-continuity is not sufficient to be certain that the schist lenses represent the same horizon. Where kyanite is present it is shown on the map by the symbol (y). Specimen R4557 (FP 3029, about 6 km Km abandoned Huckitta Well) contains quartz (35%), muscovite (20%), sericite (25%), kyanite (10%), and biotite (10%).

Structure: The Entia Gneiss forms domal structures around the Huckitta and Inkamulla Granodiorites. Some internal, reclined folding is evident on the scale of the map. Reappearance in the south is due to upturning along the northern margin of Illogwa Schist Zone.

Metamorphism: Conditions range from upper amphibolite facies to granulite facies. Orthopyroxene and clinopyroxene coexist in basic rocks at several widely separated localities. Dobos (1978) used the mineral assemblage cordierite-spinel-gedrite-kyanite at FP 1846 to estimate the P-T conditions of the Entia Gneiss.

Relationships: The Entia Gneiss is conformably overlain by the Bruna Gneiss with a transitional contact and is intruded by the Huckitta and Inkamulla Granodiorites.

Correlation: The upper unit is similar to the upper part of the Bungitina metamorphics which occur in the Alice Springs Sheet area and are assigned to Division 1. However, the Entia Gneiss is assigned to the lower part of Division 2, together with the Irindina Gneiss, as they form part of the conformable sequence of the Harts Range Group and have a number of common rock types. The Entia Gneiss is not considered part of the Strangways Metamorphic Complex because it is well-layered and lacks the very high content of mafic rocks typical of the Strangways Metamorphic Complex (Shaw & others, 1979).

Age: Probably Early Proterozoic. The regional metamorphism affecting the unit was probably the Strangways Metamorphic Event dated by Rb-Sr methods at about 1800 m.y. (Black, 1975; Shaw & others, 1979).

Bruna Gneiss (formal)

Map Symbol: p€ha.

Nomenclature: Name derived from Mount Bruna in the northwest of the Sheet area. Name published by Joklik (1955a).

Distribution: Forms a circle of hills around the drainage basin of Entire Creek in northwestern QUARTZ. Also forms low flat-topped hills and small rocky exposures over a wide area between Harding Springs Bore and Aremra Bore in the region largely drained by Aremra Creek.

Reference sections: Joklik (1955a), who defined the unit, did not nominate a type area, but the upper reaches of Entire Creek provide a good reference section. Joklik's reference specimen, R4596, a quartzofeldspathic gneiss containing conspicuous megacrysts of microperthitic microcline, was collected 1.5 km south of the junction of Florence and Maude Creeks in the Alice Springs Sheet area.

Thickness: Roughly 500 m in upper reaches of Entire Creek. Thins to the northeast and east.

Topographic expression and airphoto characteristics: Forms low foothills bordering more resistant Irindina Gneiss. Generally forms scattered flaggy outcrops. Pale yellow-brown on aerial photographs. Characterised by a close rectangular joint pattern.

General lithology: Porphyroblastic feldspar gneiss (p) grades into and is intercalated with quartzofeldspathic gneiss (f) and biotite gneiss (b). Two subunits are commonly recognisable:

(1) A lower unit of quartzofeldpathic gneiss (i.e. f, p or p, f). In contrast to the upper unit it contains only rare K-feldspar megacrysts concentrated in thin layers and in places missing, particularly near the top. Some amphibolite is present locally near the base.

(2) An upper unit containing abundant K-feldspar megacrysts set in biotite-rich quartz-feldspar matrix (i.e. p, b). Garnet and hornblende are also commonly present as small megacrysts.

Detailed lithology:

Porphyroblastic feldspar gneiss (p). Joklik (1955) recognised three types of porphyroblastic feldspar gneiss:

(1) In the first and most abundant type, megacrysts of microperthitic microcline poikiloblastically enclose numerous inclusions of plagioclase and mafic minerals. The gneiss is biotite-rich in the lower part of the Bruna Gneiss and feldspar-rich in the upper part. Minor hornblende and garnet are present in the lower part. Sample R4596A (Alice Springs Sheet area) has been chemically analysed (Joklik, 1955, p.67) (Appendix C(2)). Many megacrysts (e.g. FP 1115) have plagioclase rims, others have a concentration of biotite at their margins (e.g. FP 1104).

In deformed variants, recrystallisation of megacrysts preceded their deformation to form augen. With further deformation the augen become elongate due to strain and form small lenses of granular feldspar.

(2) In the second subordinate type, commonly intercalated with the first type, large megacrysts of bluish-grey orthoclase enclose grains of altered feldspar, quartz, and hornblende. The megacrysts are weakly perthitic and poorly twinned. The matrix is composed mostly of oligoclase-andesine. Garnet is also present locally.

(3) An example of the third type of gneiss, in which megacrysts are practically absent, is exposed at FP 3037 5 km southeast of Spriggs Camp Bore. It is composed of quartz (33%), microline (32%), and oligoclase (37%) (e.g. R4563), in addition to biotite (5%), hornblende (2%), sphene (0.5%), magnetite (0.3%), and apatite (0.2%). It is the least common type, and is restricted to narrow layers (e.g. FP 3037).

Biotite gneiss (b) is used for phases of gneiss that grade into biotite-rich porphyroblastic feldspar gneiss described above.

Quartzofeldspathic gneiss (f) (e.g. FP 1301) is migmatitic. It is an uncommon rock type.

Amphibolite is present in negligible amounts (e.g. FP 1310) except in the transitional contact with the Irindina Gneiss northeast of Aremra Bore. It is medium to fine-grained, schistose and contains minor biotite. Hornblende has been altered completely to tremolite-actinolite, and plagioclase is bent and partly recrystallised. Rare relict garnet is present.

Structure: The Bruna Gneiss is folded around the Entia Domal Structure. Small thrusts occur as the base of the unit in places. Elsewhere the unit shows little internal deformation.

In Aremra Creek (FP 1301) deformed gneiss is refolded by shallow plunging folds in which a space-cleavage is developed at wide, irregularly spaces intervals in the tightly folded, axial-plane regions.

Metamorphism: Hornblende and garnet coexisting with microcline and oligoclase and quartz, in rock with such a quartzofeldspathic composition suggests conditions of the upper amphibolite facies.

Relationships: Sharp, conformable contact with underlying Entia Gneiss. Contact with overlying Irindina Gneiss is conformable and transitional. In a few places the lower boundary is a decollement (e.g. FP 1288).

In the transitional contact east of Aremra Bore the Bruna Gneiss is very like the Irindina Gneiss in that it contains abundant garnet, is strongly foliated and is intercalated with abundant amphibolite. This part of the transitional sequence is assigned to the Bruna Gneiss only because it contains abundant K-feldspar megacrysts.

Correlation and age: The Bruna Gneiss has no obvious correlates, and has not been the subject of age determination studies.

Remarks: Three hypotheses have been suggested for the original nature of the Bruna Gneiss. In the first hypothesis the Bruna Gneiss is considered to be a deformed and metamorphosed acid volcanic or ignimbrite (Shaw & others, 1979). Such an origin would explain its widespread distribution, its consistent composition over a wide area and its broad-scale compositional layering. Joklik (1955a) favours a second hypothesis which is that the Bruna Gneiss is a metamorphosed arkosic sedimentary rock. He considered that such an origin was in keeping with its mineralogical composition and texture. The least favoured hypothesis is that it is a rapakivi granite. Joklik (1955a) suggested the latter idea as it is in keeping with the composition and appearance of the Bruna Gneiss. However, the feldspar megacrysts are typical products of crystal growth during metamorphism.

The K-feldspar megacrysts in the Bruna Gneiss are thought to have formed during metamorphism for the following reasons:

(1) K-feldspar megacrysts are most common in the Arunta Block in rocks of upper amphibolite metamorphic grade. They are not found at lower grades and are uncommon at higher grades.

(2) The K-feldspar megacrysts have formed in a variety of rock types including rocks very like the Irindina Gneiss at the transitional contact between the two units.

(3) The presence of the K-feldspar megacrysts appears to be unrelated to the degree of deformation because massive gneiss of uniform composition contains as many megacrysts as undeformed portions.

(4) The megacrysts are generally rounded, suggesting some reaction with the matrix (blastesis?)

(5) There is textural evidence that the megacrysts were formed before the final stages of metamorphism were complete. In at least one locality (FP 1301) an irregular mobilizate phase of coarse to fine-grainsize probably formed at the peak of the regional metamorphism, cross-cuts the main foliation and post-dates K-feldspar megacrysts aligned in the foliation.

Irindina Gneiss (formal)

Map Symbol: p€hi

Nomenclature: This unit was first described by Joklik (1955a) who named it after Irindina Creek in the southwest corner of the adjoining Huckitta Sheet area and the northwest corner of Illogwa Creek Sheet area. Within the Sheet area it includes the Riddock Amphibolite Member, and the Stanovos Gneiss Member, in addition to undifferentiated Irindina Gneiss (Fig. 2C). The members are described below under separate headings.

Distribution: Crops out as a discontinuous ring around a composite dome (the Entia Domal Structure) at the northern end of the Huckitta Anticline (Fig. 14). The unit continues west (area about 470 km^2) to the western edge of the Sheet area and also continues south and southeast to Atnarpa Creek (area about 550 km^2).

Reference section: Joklik (1955a, p 38) defined the valley of Irindina Creek as a type area; outcrop in the valley is poor but upper and lower contacts are well-exposed. Joklik's type specimen (R4577) was collected 3 km west-northwest of the Last Chance Mica Mine (abandoned). Good outcrop of sub-horizontally dipping gneiss is also exposed between Lizzie Dam and the western crossing of Yambla Creek on the track to Harding Springs Bore.

Thickness: No estimate is possible because of structural complexity. The unit thins markedly around the northern part of the Entia Domal Structure where only the upper part of the unit is present. The unit is thickest in the Mount Stanovos region.

Topographic expression and airphoto characteristics: Where dips are steeper than 20° the unit forms strike ridges and valleys with rugged topography and up to 100 m of relief. With low dips, resistant layers (centre of western outcrop) form plateaux with deeply incised creeks. Gently dipping homogenous rock in the south-central part of western outcrop-area forms gently rolling hills separated by broad, shallow, alluvium-floored valleys. Overall, the generally well-defined compositional layering parallel to schistosity results in flaggy exposures.

Airphoto colours are pale brown, with green colours developed on garnetiferous horizons and red colour on the more siliceous horizons. Darker colours, commonly green-grey, are present wherever amphibolite occurs. Well-defined banding is evident on the airphotos.

General lithology: The dominant rock type of the Irindina Gneiss is schistose garnet-bearing gneiss (v). Other rock types which make up undifferentiated Irindina Gneiss are -

Sillimanite - garnet-bearing gneiss (z)
Quartzofeldspathic gneiss (f)
Marble (ma)
Calc-silicate rock (cs)
Layered amphibolite (pa)
Amphibolite (a)
Garnetiferous amphibolite (av)
Garnetiferous quartzofeldspathic gneiss (vf)
Porphyroblastic quartzofeldspathic gneiss (p)
Biotite - muscovite schist (s)
Magnetite - bearing quartzite (qf)
Anthophyllite-rich rock (ae) and
Hornblende gneiss (h)

Individual compositional layers range in thickness from less than 0.5 cm up to many metres.

Detailed lithology:

Garnet-biotite gneiss (v) is typified by reference specimen (R4577), collected 3 km west northwest of the Last Chance Mica Mine and described by Joklik (1955a). It consists of quartz (31%), biotite (30%), andesine (29%), almandine (9%) and traces of microcline, magnetite, apatite, zircon and sillimanite. The garnet is commonly poikiloblastic and up to 15 mm in diameter. It is a schistose gneiss, locally more even-grained and granular, with a decreasing biotite content. It is the most common rock type in the Irindina Gneiss. Garnet-biotite gneiss grades into biotite gneiss, garnetiferous quartzofeldspathic gneiss, garnet-biotite-sillimanite gneiss, and hornblende gneiss. A rough visual estimate of the mineral composition in specimen

79090911C is biotite (30%), quartz (30%), andesine (30%), microantiperthite (trace). It also contains idiomorphic garnet (8%) as even-sized grains about 10 mm in diameter. In specimen 79090917, biotite (20%) has a random orientation and the rock is not schistose. It also contains garnet (12%) as xenomorphic grains up to 6 mm and plagioclase (45%) which occurs as two populations: a dominant population of finer grains (up to 0.5 mm) and a subordinate population of coarser grains (3 to 6 mm). Specimen 7909929B comprises biotite (25%), in elongate, curvilinear aggregates up to 20 mm by 0.1 mm; garnet, (5%) as rotated fine xenomorphic grains; oligoclase to andesine (50%) as rounded grains in 2-3 grain aggregates up to 3 mm in diameter; quartz (15%) as fine xenomorphic grains and opaques (5%) as fine irregular, elongate grains, always associated with and commonly surrounded by biotite. Specimen 79090911D is a porphyroblastic garnet-biotite gneiss. In thin section a single large K-feldspar grain (in excess of 25 mm diameter and containing zones of string microperthite) is rimmed by a 5 mm halo of myrmekitic, fine-grained quartz and oligoclase. The remainder of the rock is visually estimated to be composed of biotite (30%), xenoblastic garnet (20%), plagioclase (oligoclase? 20%), quartz (15%), blue-green hornblende (2%), opaque grains (2%) and traces of apatite and sphene. This rock is interlayered, on a one to two metre scale, with hornblende gneiss.

Specimen 79090620 also considered to be part of the unit was estimated to consist of quartz (30%), K-feldspar (orthoclase?) (20%), plagioclase (15%), biotite (20%), green hornblende (5%), garnet (5%), clinopyroxene (2%) and traces of muscovite, zircon, opaque grains and an unidentified mineral (scapolite?).

Sillimanite-garnet-biotite gneiss (z) is widespread in the Irindina Gneiss, but in only a few localities is it predominant. This gneiss is commonly a well-layered schistose rock composed of the following range of minerals; sillimanite (0% to 25%), garnet (0% to 15%), biotite (5% to 40%), feldspar (10% to 40%), and quartz (10% to 40%). In specimen 79090637 from 2 km north-northwest of Mount Ruby sillimanite occurs in ragged knots up to 25 mm in diameter in layered gneiss; other mineral components were estimated to be: biotite (35%), sillimanite (25%), plagioclase (20%), garnet (15%) and muscovite (5%).

Quartzofeldspathic gneiss (f) is widely distributed in the Irindina Gneiss commonly as extensive layers of even thickness. It is a leucocratic rock visually estimated to be composed of quartz (15 to 35%), K-feldspar (15 to 40%), plagioclase (15 to 45%), biotite (0 to 10%), muscovite (0 to 5%) and traces of garnet and hornblende.

Marble (ma) is a granoblastic, medium to coarse-grained, white rock. It occurs sparsely throughout the unit as thin, lenticular beds, but immediately east and south of Last Chance Mica Mine beds are up to several tens of metres thick. The marble consists of interlocking calcite grains which comprise up to 95 per cènt of the rock. Accessory minerals include quartz, clinopyroxene (diopside?), garnet, biotite (or phlogopite), quartz, scapolite, and, rarely, muscovite. Specimen 79090965B consists of fine to coarse-grained polygonal calcite grains (75%), small lenticular aggregates of medium-grained quartz (15%) and rounded to idioblastic, medium to coarse-grained clinopyroxene (10%). At this locality the marble contains clinopyroxene-rich layers up to 50 cm thick. The marble is interlayered with quartzite and garnet-quartz rock. Specimen 79090680 is visually estimated to consist of very coarse-grained, embayed and very irregular-shaped calcite (95%), medium-grained phlogopite (3%), muscovite (1%) and quartz (1%). The laminae in the micas are strongly curved.

Calc-silicate rock (cs) occurs widely throughout the Irindina Gneiss mostly as thin lenses and layers. It is composed of quartz, garnet, clinopyroxene (diopside), epidote, calcite, plagioclase, scapolite, hornblende, tremolite and accessory minerals: sphene, biotite, apatite, zircon, magnetite and other opaque grains. Layeriayered,
on a one to two metre scale, with hornblende gneiss.

Specimen 79090620 also considered to be part of the unit was estimated to consist of quartz (30%), K-feldspar (orthoclase?) (20%), plagioclase (15%), biotite (20%), green hornblende (5%), garnet (5%), clinopyroxene (2%) and traces of muscovite, zircon, opaque grains and an unidentified mineral (scapolite?).

Sillimanite-garnet-biotite gneiss (z) is widespread in the Irindina Gneiss, but in only a few localities is it predominant. This gneiss is commonly a well-layered schistose rock composed of the following range of minerals; sillimanite (0% to 25%), garnet (0% to 15%), biotite (5% to 40%), feldspar (10% to 40%), and quartz (10% to 40%). In specimen 79090637 from 2 km north-northwest of Mount Ruby sillimanite occurs in ragged knots up to 25 mm in diameter in layered gneiss; other mineral components were estimated to be: biotite (35%), sillimanite (25%), plagioclase (20%), garnet (15%) and muscovite (5%).

Quartzofeldspathic gneiss (f) is widely distributed in the Irindina Gneiss commonly as extensive layers of even thickness. It is a leucocratic rock

Layered amphibolite (pa) and amphibolite (a) are differentiated by well-defined, internal compositional layering in (pa). Mineralogical compositions do not differ greatly between these two rock types and in places the differentiation is arbitrary. The amphibolites are composed of hornblende and plagioclase with lesser amounts of clinopyroxene, quartz, garnet, epidote, biotite, magnetite and other opaque grains. The ratio plagioclase: hornblende ranges from 2:1 to 1:4.

Samples 79090965A from a concordant layer within gneiss near Last Chance Mica Mine is visually estimated to consist of hornblende (55%), andesine (40%) and with accessory opaques and sphene. It is well-foliated with subparallel alignment of the medium-grained hornblende. Sample 79090732, from an equidimensional plug nearby, is visually estimated to be composed of andesine-labradorite (60%), brown hornblende (20%) and clinopyroxene (20%) and is a fine to medium-grained, slightly foliated rock.

A large lens near Mount Ruby comprises up to 2000 m of amphibolite (a), layered amphibolite (pa), gneiss (v, b, f) and calc-silicate rock (cs). The amphibolite has a broad range in grain size from fine to very-coarse. Changes in grain size locally outline the layering.

A second large lens of layered amphibolite occurs near Rockhole Dam. An example of this amphibolite (79090943) contains plagioclase, pyroxene, hornblende and quartz.

Garnetiferous amphibolite (av) is a rare variant of amphibolite. At FP 0976 very tightly and complexly folded amphibolite contains both layers and pods of coarse-grained hornblende (50% to 60%), garnet (20% to 30%), and plagioclase (10% to 25%). The garnet may have formed from some of the plagioclase.

At FP 0959, 2.5 km east of Lizzie Dam, the amphibolite contains fresh pyrite. Emission spectroscopic determination of a broad range of elements on two samples from this site measured the following elements; V (200, 300 ppm), Cr (200, 300 ppm), Y (80, 60 ppm) and Cu (300, 400 ppm) (Appendix A.). These values may be slightly high for a para-amphibolite, but are within the normal ranges of composition for orthoamphibolite.

Garnetiferous quartzofeldspathic gneiss (vf) is a less common rock type. Known occurrences are in the area from Last Chance Mica Mine south-southwest for 10 km and in an area of a few kilometres diameter around Log Cabin Dam. It is an even-textured, leucocratic rock composed of garnet (5% to 15%), quartz (15% to 40%) and both K-feldspar and plagioclase, (aggregating 20% to

55%). Biotite is (by definition) less than 10 per cent. Accessory and trace minerals include hornblende and apatite. Specimen 79090979, from near Rockhole Bore, is visually estimated to consist of garnet (40%), plagioclase (40%), and quartz (18%) and trace pyrite. It is a fine to medium-grained, very even-textured pink rock, in which the 0.8 mm to 1.5 mm garnet grains form a continuous network with the plagioclase and quartz as isolated grains or aggregates within it. An emission spectroscopic analysis of this rock (Appendix A) gave the following results: Mn (0.1%), and La (600 ppm), with other elements (metals) being very low in concentration. The low Mn content indicates the pink colour is not due to manganese garnet. No cause is known for the high La.

Porphyroblastic quartzofeldspathic gneiss (p) is composed of biotite (0% to 15%), K-feldspar (30% to 60%), and quartz (15% to 60%). Large (4 x 2 cm) crystals of K-feldspar characterise the rock type and exceptionally reach up to 6 x 4 cm in size. Progressive and sequential flattening of the porphyroblastic feldspar has occurred at FP 0823, immediately east of the Hillrise Ruby-Corundum locality. The extreme flattening and recrystallisation of some megacrysts has produced elongate lenses of feldspar up to 15 cm x 5 mm.

On the northeast flank of the Huckitta Anticline biotite-rich porphyroblastic gneiss has discordant, and presumably intrusive, relationships with a hornblende gneiss (FP 2010).

Biotite-muscovite schist (s) is uncommon in the Irindina Gneiss. It occurs as thin layers throughout the unit mainly in the area from the Lindsay Mica Mine north to Yambla Creek. It is a fine to coarse-grained schistose rock, composed essentially of muscovite (10% to 60%), and biotite (10% to 50%) with lenses up to 3 x 10 mm, of quartz and feldspar which typically are fine-grained. Chlorite or phlogopite may be accessory minerals. At FP 721, adjacent to the Last Chance Mica Mine, the quartz and feldspar account for up to 40 percent of the rock. At FP 912, near Acacia Bore, texture is so fine-grained it resembles phyllitic schist.

Magnetite-bearing quartzite (qf) occurs at FP 970, 2 km west of Last Chance Mine. It occurs in two one-metre-wide bands within biotite gneiss and garnet-biotite gneiss. Sample 79090970B consists of a fine-grained mosaic, roughly estimated to be composed of quartz (30%), opaque (magnetite, 30%), garnet (20%), plagioclase (15%), and apatite (5%). Concentration of minerals into fine layers give the rock a laminated appearance. Rare boxwork-filled voids believed to be weathered out sulphide grains. An emission spectroscopic analysis of two samples of this rock (Appendix A) indicated normal concentrations of most metals but one gave La (100 ppm) which may be slightly high for this type of rock.

Anthophyllite-bearing rock (ae) (FP 981) 3 km east of Rockhole Bore forms small (<1m) pods and lenses in an area of about 50 m^2 within quartzo-feldspathic gneiss. The anthophyllite typically consists of cores up to 4 cm diameter surrounded by a rim of radiating fibres up to 2 cm long. XRD determination (Appendix E) identified anthophyllite with traces of clorite and muscovite.

Hornblende gneiss (h) is a rare rock type. It appears to be graded into layered amphibolite.

Structure: The Irindina Gneiss is a compositionally well-layered rock unit. In the area around the Entia Domal Structure at the northern end of the Huckitta Anticline, it dips away from the core of the dome at between 20° and 45°. Near Mount Ruby it dips northward at up to 35°. North of Mount Ruby is an extensive area where dips are very shallow. In the southeast of its outcrop-area the gneiss dips northeastward at over 65°.

Throughout the outcrop-area most of the folding is broad, open-style, but in places the folding is complex. At two sites, one 4 km east of the Lindsay Mica Mine and one 3 km west of Log Cabin Dam, some reclined isoclinal mesoscopic folds are refolded by mesoscopic isoclinal folds with subhorizontal axial planes and shallow westerly plunges.

There may be a fault or thrust contact between the Irindina Gneiss and the Bruna Gneiss in the northwest sector of the Entia Domal Structure. At the contact strong foliation is developed in a gradational zone up to 10 m thick. It is coincident with an angular discordance, of less than 10° between the two formations.

Metamorphism: The widespread occurrence of garnet, plagioclase and amphibole in the gneisses is indicative of the amphibolite facies of metamorphism. In the area around Rockhole Bore and in the southeast corner of the QUARTZ some gneiss contains orthopyroxene indicating granulite facies metamorphism. At FP 0979 (3 km east southeast of Rockhole Bore) lenses of orthopyroxene up to 20 cm x 10 cm in hornblende gneiss have a rim up to 2 cm wide of hornblende indicating retrograde metamorphism under hydrous conditions.

Relationships: The Irindina Gneiss has a gradational basal contact with the Bruna Gneiss (Fig. 2C). In Entia Creek biotite, hornblende and garnet are more abundant in porphyroblastic quartzofeldspathic gneiss which is the dominant rock type in the underlying Bruna Gneiss. The contact is taken to be the base of strongly-foliated, biotite-rich gneiss. A weak angular discordance at this locality may be coincident with a thrust fault. A similar gradational contact is present west of Mount Ruby (FP 0620) and also 3 km southeast of Oodnanta Waterhole (FP 0664). A sharp contact between porphyroblastic biotite-quartz-feldspar of the Bruna Gneiss and garnet-biotite-quartz-feldspar of the Irindina Gneiss is exposed 2 km east of Atnarta Dam (FP 0967).

Two members form the upper part of the Irindina Gneiss:

(1) in the southeast the Stanovos Gneiss Member occurs as an easterly-thickening body and
(2) in the northwest the Riddock Amphibolite Member accounts for a large proportion of the outcrop-area of the Irindina Gneiss.

The upper contact between the Irindina Gneiss and the Brady Gneiss is gradational. Across the boundary, the biotite content decreases and the muscovite content increases over approximately 100 m.

On the north and northeast flank of the Huckitta Anticline a mafic, fine-grained, hornblende-rich layer marks the top of the Irindina Gneiss. Eight kilometres northeast of Mount Stanovos an abrupt facies change marks the gradation from typical Irindina Gneiss in the north into typical Brady Gneiss in the south along strike. In the same area the Irindina Gneiss grades into the Stavovos Gneiss Member also along strike.

Relationships between the Irindina Gneiss and the undifferentiated Harts Range Group (pCh) to the east in BRAHMA are not known; lack of outcrop has hampered the elucidation of the relationships.

Correlation and age: The Irindina Gneiss is considered by Shaw & others (1979) to be in Division 2 of the Arunta Block. There are no obvious correlates in the Arunta Block.

The main metamorphism affecting the Irindina Gneiss is thought to be the 1800 m.y. episode (Black, 1975; Shaw & others, 1979).

Riddock Amphibolite Member of the Irindina Gneiss (formal)

Map Symbol: pЄhr

Nomenclature: Named after Mount Riddock in the northeast of the Alice Springs Sheet area. The original spelling, and the current spelling of the Mount Riddock homestead, is now adhered to. Thus the spelling for the Member differs from the current spelling of the Mountain and RIDDOCH 1:100 000 Sheet area first published by Joklik (1955a).

Distribution: The primary occurrence is in the northwest corner of the Sheet area where it is continuous with outcrops in the type area. Joklik (1955a) recognised two other occurrences; a 14 x 5 km lens at Mount Ruby and a second, which extends 15 km southeast from near Oodnarta Waterhole. These may not be at the same stratigraphic level as the primary occurrence and are not included within the Member.

Reference area: Type specimen (R4619) was collected by Joklik 2.5 km northeast of Mount Riddoch, and this locality is taken to be the type area. (in RIDDOCH).

Thickness: About 2000 m at the western boundary of QUARTZ.

Topographic expression and airphoto characteristics: Forms areas of high relief with well-defined strike ridges. On airphotos it is dark brown to green-brown with prominent, lighter-coloured bands.

General lithology: The Riddock Amphibolite Member is characterised by a thick (greater than 2000 m) sequence of amphibolite (a) alternating with layered amphibolite (pa) and typical Irindina Gneiss rock types. A thin unit of plagioclase-rich amphibolite intercalated with biotite gneiss near the base of the Member.

Detailed lithology:

Amphibolite (a) a typified by Joklik's (1955a p.49, see Appendix C) type specimen which has the following modal composition (measure wt. percent); hornblende (58.2%), andesine (35.8%), diopsidic augite (2.1%), quartz (1%), sphene (1%), magnetite (1%), apatite (0.3%) and a trace of scapolite. The amphibolite ranges in composition between approximately 40% and 90% hornblende, with plagioclase comprising the greater part of the remainder. Accessory minerals include clinopyroxene, quartz, garnet, biotite, sphene, scapolite and apatite. Specimen 0624, from near the Hillrise (Spriggs Creek) Ruby-Corundum Deposit is visually estimated to be composed of green-brown hornblende (65%), andesine (28%), sphene (4%), opaque (?magnetite, 2%), clinopyroxene (1%) and trace of apatite. Grainsize ranges from fine to coarse. Some very coarse-grained migmatitic segregations occur as irregular, elongate lenses.

Layered-amphibolite (pa) is compositionally very similar to amphibolite (a) but contains fine, even layering on a millimetre to metre scale due to differences in the concentration of quartz, feldspar, garnet, biotite and, rarely, scapolite. Layered amphibolite (pa) grades into amphibolite (a) and in such cases the distinction between these rock types is subjective.

Plagioclase ranges in composition from oligocene to labradorite, and rarely to bytownite, and accounts for 15% - 60% of the rock; hornblende accounts for 15% - 60%, quartz up to 15%, biotite up to 10%, garnet up to 10%, clinopyroxene up to 10%, K-feldspar up to 5% and sphene and apatite both up to 4%. Minerals occurring in trace amounts are muscovite, phlogopite, scapolite, epidote and opaque grains. In any single specimen, however, feldspar and amphibole dominant which justifies the name amphibolite. For example, specimen 0828A (from south of Spriggs Camp Bore) is visually estimated to be composed of andesine (55%), green hornblende (30%), biotite (7%), quartz (2%), K-feldspar (2%), clinozoisite (2%), a trace of chlorite and accessory apatite and sphene. Specimen 0812C, from near the Hillrise Ruby-Corundum Deposit, is visually estimated to be composed of hornblende (55%), plagioclase (?bytownite 38%), muscovite (5%), clinopyroxene (1%) and opaque grains. Both rocks are medium-grained with weak foliation and idioblastic to sub-xenoblastic texture.

Plagioclase-rich amphibolite (bp) forms a characteristic layer up to 50 m thick, 100 m above the base of the Riddock Amphibolite Member. It is intercalated with biotite gneiss (b) and extends from Entia Creek to the western boundary of the Sheet area (QUARTZ). The plagioclase-rich amphibolite is a medium-grained, even-textured pale coloured rock. Specimen 0812A is visually estimated to be composed of bytownite (70%), blue-green hornblende (28%), biotite (1%) and a trace opaque grains. The ruby-corundum at the Spriggs Creek Deposit is confined to this unit. At the Ruby-Corundum Deposit the layer contains separate lenses of anorthite and of phlogopite-chlorite-green hornblende rock up to several metres thick and up to 20 m long, and these are parallel to the regional layering. Both of these rock types contain the ruby-corundum. Specimen 79090812F is composed of over 95% anorthite and small amounts of spinel and accessory minerals; corundum megacrysts, up to 20 mm long, are rare, but locally constitutes up to 2% of the rock. The corundum generally has a tabular form with hexagonal outline and ranges from deep ruby red to colourless in separate crystals over distances of only a few centimetres. Blue grains of corundum are exceptionally rare.

Specimen 79090812E, also from the deposit, is visually estimated to be composed of anorthite (55%), phlogopite (10%), light green hornblende (30%) and an alteration product (5%) within and around the anorthite. Corundum megacrysts up to 50 mm are randomly oriented in the matrix. The corundum in this rock is surrounded by a halo, up to 0.5 mm wide, of mica: Kratz (1981) confirmed this as margarite. One of the corundum crystals is surrounded by a halo of altered anorthite which, in turn, is surrounded by a halo of phlogopite; both halos have a thickness of approximately 1 mm.

The anorthite-rich lenses rarely have cross-cutting veins and commonly have peripheral veins of hornblende up to about 3 cm wide which may be a reaction rim. These rims separate the anorthite-rich rock from both the leucocratic-amphibolite and form the hornblende-phlogopite rocks. Massive green ?chlorite rock also occurs with the amphibolite. Fuchsite and yellow calcite both occur in trace quantities.

The mineralogy of the corundum-bearing rock is detailed in McColl & Warren (1979) and elsewhere in this Record (p. 211).

<u>Structure</u>: The Riddock Amphibolite Member extends from the western boundary of the Sheet area for approximately 12 km in a north-dipping limb of a regional anticline. Adjacent to its eastern edge it is complexly kink folded with fold wave-lengths up to 300 m. In places, small scale folding is common. South of the anticline, the dip is subhorizontal and the Riddock Amphibolite Member occurs as several hill cappings.

<u>Metamorphism</u>: The common assemblage of hornblende-plagioclase-sillimanite-garnet is indicative of amphibolite facies metamorphism.

<u>Relationships</u>: The Riddock Amphibolite Member occurs in the middle of the Irindina Gneiss (Shaw & others, 1979) in the Alice Springs Sheet area and at roughly the same stratigraphic level in the Illogwa Creek Sheet area (Fig. 2C). Severe thinning of the Irindina Gneiss on the northwest flank of the Entia Domal Structure in QUARTZ brings the Member to within 320 m of the base of the formation, and in this area the Riddock Amphibolite Member pinches out from a thickness of 1500 m to zero over a distance of about 5 km.

Stanovos Gneiss Member of the Irindina Gneiss

Map symbol: p€hs.

Nomenclature: Named after Mount Stanovos (Lat. 23°19'27"S, Long. 135°21'25"E) QUARTZ. To be published in forthcoming Explanatory Notes on the Illogwa Creek Sheet area.

Distribution: It occupies an area of between 150 and 200 km^2 in an arcuate area extending from Last Chance Mica Mine southeast of Indiana homestead and beyond to where it is covered by Recent deposits.

Reference area: From 4 km northwest to 3.5 km north-northeast of Mount Stanovos.

Thickness: Not possible to determine accurately because fold and fault repetition is likely and a complete section of outcrop is not exposed. To the east it may be up to a thousand metres thick.

Topographic expression and airphoto characteristics: Forms low hills at its eastern end with broad alluvial valleys between them. In the west it forms rugged hills; dominant drainage style is dendritic, but locally trellis drainage is present. Calc-silicate rocks have a white to blue-white airphoto colour; quartzite is red; biotite gneiss is dark grey; all well-banded on the scale of the photos.

General lithology: The Member consists of three suites of rock types - rock-suite 1 being recognised in the west; rock-suite 2 in central region and rock-suite 3 in the east.

(1) Quartzite (qt), marble (ma), calc-silicate-rock (cs), biotite gneiss (b) and rare quartzofeldspathic gneiss (f), and hornblende gneiss (h);

(2) Porphyroblastic-feldspar gneiss (p) grading into biotite gneiss (b) and quartzofeldspathic gneiss; some well-layered amphibolite (pa) and rare metadolerite (dl);

(3) Marble (ma), quartzite (qt), calc-silicate rocks (cs), garnet-biotite gneiss (v), thinly layered quartzite (qt), layered amphibolite (pa), amphibolite (a), quartzofeldspathic gneiss (f). A discontinuous porphyroblastic-feldspar gneiss (p) is locally intercalated with biotite gneiss (b) occurs near the top of the Member in the far east.

Distinguising features: Unlike the bulk of the Irindina Gneiss the Member contains abundant calcareous rocks and a distinctive porphyroblastic-feldspar gneiss. It also lacks garnet. It differs from the Bruna Gneiss in that its porphyroblastic feldspar gneiss is notably more biotite-rich (i.e. up to 25%) and also differs in being intercalated with calc-silicate rock and quartzite. The lack of muscovite in the gneiss of the Stanovos Gneiss Member distinguishes it from the Brady Gneiss which includes muscovite-bearing pelitic gneiss. The Brady Gneiss also lacks porphyroblastic-feldspar gneiss.

Detailed lithology:

Quartzite (qt) includes layers containing accessory muscovite and feldspar. Elongate voids (1 x 5 mm) are believed to be derived from the weathering-out of feldspar grains. Quartzite grades into schistose gneiss composed of lenticular aggregates of quartz separated by muscovite schist laminae. Other quartzites contain amphibole and/or clinopyroxene - for example, specimen 8009 0985A is composed of quartz (95%) and small quantities of green hornblende, clinopyroxene and plagioclase. Specimen 80090979 is visually estimated to consist of fine-grained quartz (55%), plagioclase (25%), and hornblende (20%).

Marble (ma) in rock-suite 1 is well-bedded and consists of calcite plus muscovite and diopside. Marble in rock-suite 3 is a thickly layered coarse-grained rock consisting predominantly of calcite and accessory muscovite, biotite, clinopyroxene, and quartz. In places the marble includes thin lenses of garnet-clinopyroxene-quartz-feldspar calc-silicate rock.

Calc-silicate rock (cs) is widespread as a subordinate rock type throughout eastern and western part of the Member. It grades into other types of calcareous rocks. Its mineral content ranges widely. For example, at FP 0895 it is made up of various combinations of plagioclase, K-feldspar, quartz, clinopyroxene, amphibole and small quantities of sphene, apatite, opaque grains, clinozoisite and calcite.

Porphyroblastic-feldspar gneiss (p) is the rock type that characterises and dominates the central suite of rocks (i.e. 2). It consists of K-feldspar augen (up to 3.5 cm long) in a medium to coarse-grained gneissic matrix composed of quartz, K-feldspar, plagioclase, and biotite in roughly equal proportions.

Biotite gneiss (b) is very similar to the porphyroblastic-feldspar gneiss (p) except that it lacks augen. It is intercalated with and grades into the porphyroblastic-feldspar gneiss. In places it (e.g. FP 996) contains thin quartzofeldspathic migmatitic veins.

Quartzofeldspathic gneiss (f) is also a subordinate component of the unit characterised by porphyroblastic-feldspar gneiss (p) into which it grades. It is locally migmatitic (e.g. FP 986). Typically, the gneiss (in suite 2) consists dominantly of K-feldspar, subordinate quartz and accessory biotite, muscovite and opaque grains. Quartzofeldspathic gneiss in the eastern rock suite (i.e. 3) is a medium to coarse-grained rock forming compositionally distinct layers from less than one metre to over 30 m thick.

Layered amphibolite (pa) occurs throughout the Member as thin layers rich in hornblende and for plagioclase. It is commonly interlayered with and grades into quartzite, calc-silicate rock or schistose biotite gneiss. A typical specimen, of gneiss gradational into layered amphibolite 7909081A from 6 km east of Rockhole Bore, is an xenoblastic, fine- to medium-grained well-layered rock consisting of roughly equal proportions of quartz and oligoclase, lesser amounts of biotite and hornblende, and accessory clinopyroxene and opaque grains. Other examples which grade into quartzite (e.g. FP 979) contain up to 55 percent quartz.

Minor to rare rock types include amphibolite (a) (e.g. FPS 2055), garnet-biotite-plagioclase gneiss (v), (e.g. FPS 647, 2052, 2055) metadolerite (dl), hornblende gneiss (h) (e.g. FP 1564), granitic gneiss (gg) (e.g. FP 1812), and granite (g) (FP 894).

Relationships: The unit is a Member in the upper part of the Irindina Gneiss and has gradational contacts with the undivided portions of the Irindina Gneiss. The Member contains negligible quantities of garnet-biotite-quartz plagioclase gneiss (v) which is the dominant rock type in the Irindina Gneiss. North of Indianna homestead the Member is overlain directly by the Brady Gneiss whereas in the northeast of the outcrop-area the Member is overlain by undivided garnet-biotite gneiss (v) of the Irindina Gneiss. The Stanovos Gneiss Member was intruded by numerous basic igneous rocks (principally unit Pdx) before the main regional metamorphism. The Member is also cut by numerous post-metamorphic pegmatities.

Correlation and age: The main metamorphism affecting the unit may be the 1800 m.y. episode recorded elsewhere (Black, 1975; Shaw & others, 1979). The original age of deposition is unknown.

Brady Gneiss (formal)

Map symbol: pЄhb. The unit is divided into two sub-units, notated pЄhb^{1} and pЄhb^{2}.

Nomenclature: Named by Joklik (1955) after Mount Brady in the northwest of the Illogwa Creek Sheet area.

Distribution: pЄhb^{1} is the lower sub-unit of the Brady Gneiss; it is discontinuous and flanks the northwestern and northeastern parts of the Entia Domal Structure in the Alice Springs, Alcoota, Huckitta, and Illogwa Creek Sheet areas. Sub-unit pЄhb^{2} is more widespread than pЄhb^{1} and extends as a band from the northwest, through north and northeast, to east about the Entia Domal Structure in the Alice Springs, Alcoota, Huckitta, and Illogwa Creek Sheet areas. pЄhb^{2} also forms scattered low rises and hills on the plain east of the Entia Domal Structure.

Reference area: The reference area for sub-unit pЄhb^{1} is 1.5 km north-northwest of the Central Mica Mine (abd) northwest of Mount Brady in RIDDOCH surrounding GR 5851-973548. A well-exposed section of sub-unit pЄhb^{1} showing relatively well-defined lower and upper contacts occurs near Mount Powell in QUARTZ from GR 5951-364420 to GR 5951-389426.

The reference area of the lower part of sub-unit pЄhb^{2} is well-exposed at Old Indiana homestead (GR 5951-392443) in QUARTZ. Ready access is also provided to the lower part of sub-unit pЄhb^{2} by the track from the Plenty River Highway to Valley Bore in the Harts Range in the Huckitta Sheet area. The upper part of sub-unit pЄhb^{2} is not exposed.

Thickness: No thickness estimate of the Brady Gneiss has been made because the top of sub-unit pЄhb^{2} is not known and folding in each sub-unit has caused a repetition of strata.

Topographic expression and airphoto characteristics: Sub-unit pЄhb^{1} forms moderate to high hills and ridges. Photo-pattern is dominated by discordant and concordant pegmatite and granite dykes which form a network through the brown-coloured gneisses. Where pegmatite and granite are not abundant the well-layered nature of the unit is apparent.

Sub-unit pЄhb^2 forms moderate to low hills adjacent to the main ranges, but crops out poorly away from the ranges. Photo-colour is usually brown; some calc-silicate bodies are dark greenish-brown.

General lithology: Sub-unit pЄhb^1 is characterised by schistose garnet-bearing muscovite-biotite gneiss. At many localities it is the dominant rock type. Pegmatite and granite intrude much of this sub-unit and in places such as the Mount Mary area in QUARTZ form the dominant rock types in a section across the sub-unit.

Sub-unit pЄhb^2 is characterised by calc-silicate rocks. These are the most distinctive and in most places the major outcropping component of the sub-unit.

Detailed lithology:

1) Sub-unit pЄhb^1 consists largely of brown or grey schistose fine to medium, rarely coarse-grained gneiss typically containing muscovite and biotite (s). Garnet is commonly present as conspicuous red sub-idiomorphic grains up to 10 mm and rarely 15 mm across (sv). Locally the gneiss contains feldspar porphyroblasts up to 15 mm long. Sillimanite was not recognised in hand specimen but does occur as an accessory in some areas (such as FP 1674). Joklik (1955 p. 74) estimated the average mineral composition of the mica gneiss of the Brady Gneiss to be approximately 46% quartz, 29% plagioclase, 13% biotite, 7% muscovite, 2% almandine, with accessory sillimanite and magnetite and traces of apatite and zircon. Potash feldspar is uncommon in this rock type but Joklik (1955 p. 75) records eight percent microcline in a specimen (R4632) from about 3 km south-east of the abandoned Harts Range Mica Depot in RIDDOCH (GR 5851-947539). A similar gneiss (R4631) from nearby (GR 5851-973548) has been chemically analysed (Joklik, 1955, p. 75 Table IX: See APPENDIX C/1). Samples 79091674, 79091717B, and 79091722C collected during the recent survey are similar to Joklik's estimated average mineral composition for mica gneiss of the Brady Gneiss.

Subordinate rock types are biotite gneiss (b), calc-silicate rock (cs) (e.g. FPS 1537, 1722A, 2042), and amphibolite (a); cordierite-bearing gneiss (i) was recorded from two localities. In the Huckitta Sheet area quartz-rich gneiss consists of quartz (80%), cordierite and possibly andalusite (together 12%), biotite (7%), ?chlorite (1%), and accessory muscovite, sphene, apatite, epidote,
biotite (7%), ?chlorite (1%), and accessory muscovite, sphene, apatite, epidote,

clinozoisite, and opaque grains (79091714). Nearby in the adjacent Alcoota Sheet area another quartz-rich gneiss consists of quartz (60%), cordierite (12%) biotite (12%), muscovite (10%), plagioclase (5%), fibrous sillimanite (1%), and accessory apatite, zircon, and opaque grains (79091722D). The calc-silicate rocks form pale brown and grey layers consisting of various amounts of quartz, clinopyroxene, plagioclase, amphibole, garnet, scapolite, and accessory amounts of calcite, sphene, biotite, and clinozoisite. Amphibolite is fine to medium-grained and forms thin layers or lenses less than about a metre thick. Metamorphosed feldspathic-quartz sandstone is rare and at FP 2095 contains 10 to 15 cm long calc-silicate pods. Marble is also rare and forms layers a few metres thick containing scattered pyroxene grains.

The layer parallel pegmatite and granite veins are commonly strongly foliated.

2) The most conspicuous exposed rock type of sub-unit p€hb^2 is calc-silicate rock (cs). It is fine or fine to medium-grained and generally has a saccharoidal texture. Calc-silicate bands range from about 5 cm thick upwards. Some bands are compositionally layered; individual layers are generally less than 5 cm thick. Most calc-silicate rock is brown, brownish-grey, or grey and invariably contains a preponderance of light-coloured minerals such as quartz, scapolite, and feldspar. The dark greenish-black calc-silicate rocks are not as abundant and contain a preponderance of dark-coloured minerals such as clinopyroxene, hornblende, epidote, and clinozoisite. Calc-silicate rock at FP 2035 contains accessory pyrite. Table 3 presents the modal compositions of calc-silicate rocks sampled from sub-unit p€hb^2.

Calc-silicate rocks are interlayered with various micaceous gneisses (sv, s, b, v), amphibolite, and rare marble and metaquartzite. Muscovite-biotite gneiss is abundant; it is generally schistose and commonly contains garnet. Biotite gneiss is also common and in places contains garnet and locally feldspar porphyroblasts up to 12 mm long. Granodioritic rock crops out at FP 1681A and contains lenses of fine-grained biotite gneiss several metres long by about 1/3 m wide. The enveloping rock consists of feldspar megacrysts up to 15 mm long in a medium-grained matrix composed of andesine, perthite, quartz, biotite, and accessory muscovite and opaque grains. At FP 1807 the gneiss is dotted with pinkish feldspar grains up to 6 mm long. Sillimanite is rare; at FP 1797A muscovite-biotite gneiss contains about 2 percent sillimanite.

TABLE 3: Modal estimates: calc-silicate rock from subunit p€hb2, Brady Gneiss

Sample	Quartz	Pyroxene	Scapolite	Plagioclase	Hornblende-Actinolite	Epidote-Clinozoisite	Sphene	Other
79091524	30	cpx:40	30	-	-	-	A	-
79091525	60	-	5	15	5	13	A	opaque grains 2, calcite
79091527	5	cpx:75	-	A	20	-	A	-
79091546A	P	P	P	-	5	A	A	calcite
79091574	A	35	-	20	20	20	A	calcite 5, opaque grains
79091575	8	60	-	25	5	-	2	calcite
79091582	45	5	-	30	16	-	2	garnet 2, calcite, opaque grains, apatite
79091587	-	cpx:79	20	-	-	-	1	calcite
79091697	45	cpx: 8	-	+microcline:35	12	A	A	opaque grains
79091732	50	cpx:25	A	10	5	5	A	apatite, calcite, zircon
79091770A	35	cpx:30	30	-	2	3	A	apatite
79091770B	30	cpx:35	25	A	-	A	A	calcite, apatite, chlorite, zircon

Table 3 (con'd)

Sample	Quartz	Pyroxene	Scapolite	Plagioclase	Hornblende-Actinolite	Epidote-Clinozoisite	Sphene	Other
79091779A	20	cpx:20	-	-	A	55	-	pinkish-orange garnet, calcite, opaque grains
79091779B	60	-	-	A	A	40	A	chlorite, opaque grains
79091789	50	cpx:15	A	20	15	A	-	zircon
79091808	25	cpx:30	A	labradorite:25	5	10	A	calcite, biotite, zircon, tourmaline

Quantities are in percentages.

P = present but not evenly distributed throughout rock

A = accessory

- = absent

Amphibolite does not appear to form a large part of sub-unit pChb^2. Samples 79091546B, 1581, and 1773 consist of brownish-green, green, and light green hornblende, sericitized plagioclase, and minor sphene, apatite, chlorite, quartz, biotite, and opaque grains. A thin mafic layer in the Alcoota Sheet area consists mainly of chlorite, with some quartz and opaque grains, and accessory biotite and apatite and contains voids (79091726B).

Marble is a rare outcropping constituent of the sub-unit. At FP 1703B, grey marble forms a layer about one metre thick composed of medium to coarse calcite, with some tremolite, scapolite, quartz, and accessory clinopyroxene and sphene.

Metaquartzite is also rare in outcrop and generally forms layers less than 2 m thick.

Structure: Lithological layering in the Brady Gneiss strongly resembles bedding; however, no sedimentary structures are preserved. Lithological layering ranges from several millimetres to tens of metres thick. Metamorphic foliation nearly always parallels lithological layering and is defined by oriented mica and other mineral aggregates.

Boudinaging of amphibolite, calc-silicate rock, and granite is suggested by the presence of amphibolite lenses and calc-silicate nodule (e.g. FP 2089) within schistose gneiss, and pinch and swell structure within layer-parallel granite veins.

The layer-parallel foliation of the Brady Gneiss dips generally between 40° and 60° away from the Entia Domal Structure. Intrafolial as well as mesoscopic tight folds occur locally. At FP 1699 granite veins appear to have intruded during deformation as they are folded but not to the same degree as the host gneiss. Here micas appear to have recrystallised in fold noses parallel to the axial-plane.

At FPS 1808 and 1809 the calc-silicate rock displays both compositional layering, about 2 cm thick, as well as a discordant foliation defined by the alignment of elongate grains and clinopyroxene-hornblende-clinozoisite aggregates. The mineral elongation lineation is caused by the intersection of the compositional layering and foliation, and is roughly paralleled by a fracture cleavage. In the same area an isoclinal mesoscopic fold in calc-silicate rock and schistose gneiss plunges at a moderate angle to the north. The plunge is roughly paralleled by the lineation; schistosity parallels the axial-plane.

Metamorphism: The assemblages found in the calc-silicate layers indicate regional metamorphism up to lower to middle amphibolite facies. The association of muscovite and sillimanite and more specifically cordierite and sillimanite and muscovite confirms this (79091722D); the occurrence of isolated migmatitic rocks indicates high amphibolite facies conditions under hydrous conditions.

Relationships: p€hb^{1} is underlain by the Irindina Gneiss and locally by the Stanovos Member (Fig. 2C). This lower contact is generally gradational and is marked by the incoming of amphibolite and calc-silicate rocks and the steady decrease in abundance of muscovite-bearing gneisses towards the Irindina Gneiss and the Stanovos Member. About 8 km north-northwest of Indiana homestead rock types typical of the Irindina Gneiss grade laterally into rock types typical of the Brady Gneiss. Sub-unit p€hb^{1} is overlain and in places grades along strike into sub-unit p€hb^{2}. This contact is not sharp, but is marked by the abrupt increase in calc-silicate rock content towards sub-unit p€hb^{2}. The upper-most boundary of sub-unit p€hb^{2} is not exposed and in the Illogwa Creek Sheet area is based on a northwest-trending magnetic lineament (BMR, 1967) separating a magnetically quiet area (Brady Gneiss) from a more disturbed magnetic area to the east.

Both sub-units are intruded by pegmatite and granite masses and dykes. Small noritic plugs intrude sub-unit p€hb^{2} about 5 km north of Indianna homestead.

Geochemistry: The chemically analysed specimen R4631 (APPENDIX E/1) is a coarse-grained, intensely foliated gneiss (Joklik, 1955a, p. 75). In this sample oligoclase is poorly twinned and green pleonaste is associated with garnet. Joklik (1955a, p. 75) regarded the analysed specimen to be a metamorphosed psammo-pelitic sediment, which has been metasomatically altered by the injection of pegmatitic fluids.

Correlation and age: Sub-unit p€hb^{1} shows some lithological similarity to the Hillsoak Bore metamorphics (Stewart, 1971b) which crop out in the Alice Springs Sheet area. Sub-unit p€hb^{2} shows some lithological similarity to the Cadney metamorphics. However, the Cadney metamorphics have been metamorphosed to a higher grade and are probably older than the sub-unit. Sub-unit p€hb^{2} is also similar lithologically to the unit to the east, the undifferentiated Harts Range Group p€h.

No isotopic age determinations have been carried out on the Brady Gneiss.

<u>Origin</u>: The Brady Gneiss may be a metamorphosed psammo-pelitic sediment containing thin calcareous interbeds (sub-unit pЄhb^{1}) which grades laterally and vertically into calcareous sediments (sub-unit pЄhb^{2}).

Undivided metamorphics of the Harts Range Group

Map Symbol: p€h

Distribution: Scattered outcrops north of Huckitta Creek in the northeast of the Illogwa Creek Sheet area.

Topographic expression: Low hills and strike ridges separated by Cainozoic cover. Some bedrock is concealed by thin superficial cover; bedrock trends are visible on airphotos.

Lithology: Undivided metamorphics p€h consist of interlayered gneiss and calc-silicate rock. Metaquartzite layers occur throughout the outcrop-area, but are not common. Weathered quartz-rich metasediments occur southeast of Mount Turner. Amphibolite, ultramafic rock, and marble are rare.

South, southwest, and west of Mount Turner the gneisses are commonly partly migmatitic with small concordant and discordant blebs and veins composed of quartz and feldspar disrupting the penetrative schistosity. The most abundant and widespread gneisses are biotite gneiss, muscovite-biotite gneiss, and quartzofeldspathic gneiss; locally abundant are granitic gneiss, garnet-biotite gneiss, garnet-muscovite-biotite gneiss, and sillimanite gneiss. The calc-silicate rocks are commonly flaggy with a saccharoidal texture and range widely in composition (Table 4). At FP 2165A, B, D, E plug-like and semi-concordant mafic bodies appear to intrude fine-grained strongly lineated quartzofeldspathic gneiss. The mafic bodies are spotted and consist of hornblende, pyroxene, plagioclase, quartz, garnet, and opaque grains. The spots comprise vermiform quartz and hornblende, in places cored by plagioclase, or plagioclase and hornblende separating clinopyroxene and garnet grains.

Southeast of Mount Turner the unit consists of strongly weathered brown micaceous quartz-rich metasediment, biotite-muscovite gneiss, muscovite gneiss, biotite schist, and thin metaquartzite layers as well as isolated outcrops of light grey or brown calc-silicate rock.

Meta-ultramafic rock, composed almost completely of actinolite or hornblende (79090018b, c, d, e), occurs at Hammer Hill and FP 1029.

Structure: Lithological layering in the undivided metamorphics strongly resembles bedding; however no sedimentary structures are preserved. Layering is generally paralleled by a penetrative schistosity which commonly trends northwest.

TABLE 4: Modal estimates: calc-silicate rock from unit p€h, Harts Range Group.

Sample	Quartz	Pyroxene	Scapolite	Plagioclase	Hornblende-Actinolite	Epidote-Clinozoisite	Sphene	Other
78091500 (1032)*	20	cpx:9	-	+microline:50	20	A	1	calcite, apatite, opaque grains
78091505 (1045)	20	-	-	+microcline:37	28	15	A	calcite
78091506 (1046)	25	20	-	+microcline:40	15	A	A	calcite
78091507 (1047)	65	35	-	A	marginal alteration of pyroxene	A	A	calcite, apatite, opaque grains tourmaline
78091508 (1049)	30	A	-	+microcline:37	30	1	1	biotite, calcite, opaque grains, tourmaline
79090079C	40	cpx:10	5	10	10	20	1	calcite, tourmaline
79090081A	40	cpx:18	-	+microcline:20	17	A	A	opaque grains, calcite, zircon
79090081B	30	cpx:30	-	25	10	4	1	calcite
79090086	60	cpx: 7	-	+microcline:22	11	-	A	biotite, garnet

Table 4 (con'd)

Sample	Quartz	Pyroxene	Scapolite	Plagioclase	Hornblende-Actinolite	Epidote-Clinozoisite	Sphene	Other
79090088	30	cpx:12	-	35	18	-	1	apatite 2, calcite 1, biotite 1
79090089A	25	cpx:39	35	-	-	-	1	tourmaline, opaque grains
79090089B	67	cpx:18	13	-	2	-	A	opaque grains

*bracketted numbers are field localities

Small-scale isoclinal to open folding occurs at several places throughout the outcrop-area. Flow folding occurs in migmatitic gneiss (e.g. FP 2186).

Large-scale folds occur about FPS 1864 and 2195. A smaller structure may also be present at FP 0089. At these three localities the folds are overturned and have a northeast-dipping axial-plane.

At FP 2195 folded layers of calc-silicate rock are brecciated and recemented by coarse clinopyroxene-rich material.

Metamorphism: Grade ranges from low greenschist (actinolite in ultramafic rocks) to high amphibolite under hydrous conditions (migmatitic rocks). The textures noted in the mafic rocks from FP 2165 suggest hydration of an earlier metamorphic assemblage.

Relationships: The relationship between the undivided metamorphics and nearby units is masked by Cainozoic cover. A northwest-trending magnetic lineament (BMR 1967) may separate the unit from the Brady Gneiss. To the north (Huckitta Sheet area) outcrops contain more rock types typical of the Irindina Gneiss.

The unit is cut by pegmatite, granite, and quartz veins. Muscovite and tourmaline are common constituents of the veins. At FP 2220 a quartz vein contains abundant tourmaline up to 20 cm long; at FP 0083 quartz veins include gahnite.

Correlation and age: This unit is lithologically similar to the Brady Gneiss to the east. However, it has a gradational contact to the north (Huckitta Sheet area) with rocks typical of the Irindina Gneiss which is known to underlie the Brady Gneiss in the Harts Range.

No isotopic age work has been attempted on this unit.

Origin: The micaceous gneisses, calc-silicate rocks and other less abundant rock types generally suggest an origin from interbedded silty clays and calcareous sediments. The origin of the intrusive-looking mafic plugs at FP 2165 is uncertain; they may be derived from calcareous sediments or a mafic igneous rock.

Unnamed units p€s and p€q

Map Symbols: p€s, p€q

Nomenclature: Unnamed. Units not examined during present survey. Descriptions based on Leitch & others (1970).

Distribution: Crops out in small Arunta Inlier adjoining the southern margin of LIMBLA. The units are contiguous.

Topographic expression and airphoto characteristics: p€s - subdued relief and sub-dendritic drainage pattern. Medium grey on black and white airphotos. p€q forms a single sharp ridge which is pale grey to white on black and white airphotos.

General lithology: Cleaved quartzite, schist and slate assigned to p€q; unconformably overlie gneiss, migmatite and mafic schist assigned to p€s.

Structure: Both units dip steeply and are characteristics by northerly strikes.

Relationships: An unconformity between units p€q and p€s is suggested by the discordance in metamorphic grade between these two units that occur alongside each other; p€q structurally overlying p€s.

Correlation: p€q is correlated with the Laughlen metamorphics and the Chewings Range Quartzite in the Alice Springs Sheet area and is assigned to Division 1 (Shaw & others, 1979). Unit p€s is of uncertain affinity and is tentatively assigned to Division 2.

Age: No age determinations have been carried out on either unit.

Unnamed metamorphics, Simpson Desert area

Map Symbol: p€

Nomenclature: These rocks may be related to undivided Harts Range Group (p€h). They are left unassigned because contacts with surrounding units are not exposed.

Distribution: Scattered outcrops at the margin of the Simpson Desert south of Huckitta Creek and east of Illogwa Creek.

Reference area: These rocks were examined by helicopter and are not readily accessible. Outcrops southeast of Christmas Dam can be reached by four-wheel drive vehicle.

Topographic expression and airphoto characteristics: Scattered, low, rounded hills. Fine trend-lines are visible in places and help to distinguish these metamorphics from the generally flat-lying Cainozoic and Mesozoic cover rocks.

General lithology: Consists mainly of muscovite-bearing biotite schist (s) and some schistose gneiss. Varieties lacking muscovite are present, but uncommon (sb,b). Interlayered with more massive and quartzose metasandstone (j) in which bedding is preserved. Quartzite is very rare (e.g. FPS 0043 and 1121). In places biotite gneiss is interlayered with the schists in the central-western part of the outcrop area (e.g. FPS 1127-8). Tourmaline-bearing quartz veins cut the schist sequence. Meta-granule conglomerate (cm) is a rare rock type.

Detailed lithology:

Muscovite-biotite schistose gneiss or schist(s) is typically composed of muscovite, biotite, K-feldspar, plagioclase, and quartz (e.g. 79091128A). It is the most extensive rock type in the Simpson Desert area. In places muscovite is absent (e.g. FP 1125) in which case the term biotite schist (sb) applies. The schists are commonly highly weathered (see j below).

Quartzite (qt) crops out at FP 0048 south of Atula homestead. It is a grey, fine-grained metaquartzite, containing muscovite in part, and small amounts of opaque grains and accessory tourmaline and zircon. Quartzite is also interbedded with schist at FP 0043.

Metasediment (j) a medium-bedded, fine-grained metasandstone, which weathers to pale purple-brown; some cross-bedded. The metasandstone crops out mainly southeast of Christmas Dam. Many of these outcrops are strongly weathered and consist of fractured quartz and limonite-stained clay, opaque grains, and accessory tourmaline and zircon (0040A, B; 0043A, B; 0044; 0049B, 0050). Fracturing of quartz may have occurred during weathering of the rock in the Mesozoic.

A typical metasediment (1125A) is visually estimated to consist of quartz (71.5%), biotite (24%), muscovite (3.0%), epidote (0.5%), and iron oxide grains (1.0%); in other examples muscovite is absent. In a sample from FP 1127B muscovite is absent but it does contain what is believed to be highly altered feldspar. Quartz grains retain some of their original angularity; about sixty five percent of specimen 0053 consists of deformed elongate grains of recrystallised quartz.

Biotite gneiss (b) is a minor rock type composed commonly of biotite, quartz, a trace of plagioclase and a small amount of muscovite. It has very thin composition layering and is schistose.

Meta-granule conglomerate (cm) grades from granule conglomerate into coarse-grained metasandstone. It is very highly weathered (e.g. FPS 1121, 0053) well-bedded, strongly deformed, and possibly cross-bedded. The conglomerate is interbedded with narrow bands of quartzite and psammopelite. Highly weathered coarse-grained varieties contain rounded ferruginous pisolites with cellular structure. The conglomerate is made up of highly deformed quartz grains. Quartz veins cut the rock. Meta-conglomerate at FP 0049 consists of a fine to medium-grained recrystallised matrix of quartz, muscovite, and opaque grains containing ellipsoid-shaped metaquartzite cobbles.

Metamorphic rock (mt) is used for outcrops which have not been field checked where photo-interpretation is uncertain.

Structure: The schists appear to strike south-southeast and have steep dips both to the east and west.

Metamorphism: Lower amphibolite to upper greenschist facies grade. Muscovite is ubiquitious and sillimanite was observed at one locality in the far north (e.g. FP 1008). The schists are locally interlayered with gneiss in the northern and central parts of the outcrop-area. No migmatites were noted so conditions probably correspond to those of the upper greenschist faces up to the middle amphibolite facies. In the southwest the grade is difficult to assess because the rocks are deeply weathered.

Relationships: The unnamed metamorphics are lithologically similar to the rocks mapped as undivided Harts Range Group (p€h) to the north, but lack calc-silicate rocks typical of that unit and appear to be of an overall lower metamorphic grade than p€h. They merge northwards into, and may overlie, rocks of the undivided Harts Range Group. However, they could be a more distal facies equivalent of rocks of undivided Harts Range Group located farther away from the centre of metamorphism.

Correlation: They are typical of the pelitic rock types generally assigned to Division 2 elsewhere in the Arunta Block. They are lithologically similar to the Lander Rock beds (Stewart & others, 1980b).

Age: Uncertain; probably of similar age to the Harts Range Group which is considered to have a metamorphic age of about 1800 m.y.

Remarks: Originally a sequence of mainly pelitic rocks.

DESCRIPTIVE NOTES ON INTRUSIVE UNITS

Granites

Huckitta Granodiorite (formal)

Map Symbol: Pgh

Nomenclature: Named by Joklik (1955a p.42) after Huckitta Bore (abandoned) in QUARTZ.

Distribution: Forms dome-shaped hills and oval ridges in northwestern QUARTZ in the region extending from Huckitta Bore 7 km to the northeast and 5 km to the west.

Type areas: (1) At GR5951-298431, 4.8 km north of Huckitta Bore (abandoned) at the FP 3040. This is a foliated variety of granodiorite (specimen R4566).

(2) At GR5951-284404, 1.6 km northwest of Huckitta Bore (abandoned) at FP 3521. This is a massive variety of granodiorite (specimen 71090521).

(3) A more leucocratic foliated granodiorite occurs one kilometre north of FP 3521 (specimen 79090520).

Topographic expression and airphoto characteristics: Line of small smoothly rounded hills and scarps against a flat alluvial plain. Pale yellow phototone.

General lithology: A pale grey granitic gneiss or foliated granodiorite containing hornblende clots and discontinuous layers and xenoliths of hornblende-rich gneiss and very rarely, megacrysts of garnet. The colour index ranges from about 10 to 20. Leucosome layers within the most gneissic portions account for 1 to 5 percent of the rock. The contact of the granitic gneiss (gg) with quartzofeldspathic gneiss (f) of the Entia Gneiss is difficult to establish in places because the foliation in both rocks is concordant. The granitic gneiss is distinguished by its relatively uniform composition and by the presence of xenoliths (FPS 1220, 1221, 1222, 1223, 3519). The less abundant leucocratic foliated granodiorite (FP 3520) locally includes folded aplite veins indicating a metamorphic history. Small outcrops of massive granodiorite (FP 3521) near Huckitta Well appear to be near the core of the intrusion.

Detailed lithology:

Granitic gneiss (gg) has the mineralogy of tonalite. A modall estimate of specimen R4566 (FP 3040) is slightly altered oligoclase (An20) (67.8%), microcline (4.1%), epidote (1.2%), hornblende (0.9%), apatite (0.4%), and sphene (0.1%) (Joklik, 1955 P.42). Most of the minerals are partly polygonised and recrystallised. Specimen 79091223 (FP 1223) is of similar composition but has a granoblastic texture and contains elongate xenoliths of hornblende gneiss.

Granodiorite (gd) represented by the type specimen 71090521 (FP 3521) of massive granodiorite-tonalite is visually estimated to be composed of plagioclase (50%), quartz (25%), K-feldspar (10%) biotite (10%), epidote (4%), hornblende (1%) and traces of opaque grains, zircon and apatite. The biotite is only weakly aligned although the granodiorite appears foliated. The texture is allotriomorphic granular. Leucocratic granodiorite at FP 3520 is in contact with melanocratic granodiorite (FP 3521) believed to be the older rock because xenoliths of melanocratic granodiorite are included in the leucocratic granodiorite. Specimen 71090520 of the leucocratic variety consists of microcline (63%), quartz (30%), biotite (4%), plagioclase (2%), muscovite (1%), traces of epidote and chlorite, and accessory zircon and apatite. It is moderately foliated alaskitic granitoid with an allotriomorphic granular texture.

Structure: Joklik (1955a p.42) considered the foliation to be primary. However, the foliation is concordant with that of the marginal rocks, ranges from weak to strong in intensity, and is folded. The granitoid occupies the core of a dome may be a younger post-metamorphic intrusion and hence responsible for the doming of the foliation.

Relationships: Intrudes the Entia Gneiss, but has conformable contacts with it. It encloses numerous lenses of amphibolite, several lenses of quartzofeldspathic gneiss, and rare pods of kyanite-bearing biotite schist.

Correlation and age: Results of Rb-Sr age determinations are still being assessed (L.P. Black, 1980, BMR personal communication-FP 3579, specimen 72095237 (AS3006), also 71090519A, B). The massive granodiorite at FP 3521 gives a K-Ar biotite age of 370 m.y. (Webb & Lowder, 1972), which is considered to be the approximate age of the reheating during the Alice Springs Orogeny (cf. Armstrong & Stewart, 1975).

Remarks: The hornblende content and the presence of xenoliths of hornblende-rich gneiss suggests the granite is of an I-type in the sense of Chappell and White (1974).

Inkamulla Granodiorite (formal)

Map Symbol: Pgk.

Nomenclature: Named by Joklik (1955a, p.41) after Inkamulla Bore in QUARTZ.

Distribution: Occupies a flat-lying region encircling the Inkamulla Bore in northwestern QUARTZ, and also extends 8 km to the northeast.

Type areas: (1) Massive granodiorite (gd) at FP 3031 (R4559) in the core region of the intrusion, 1.2 km south-southeast of Inkamulla Bore.

(2) An example of the more common granodioritic gneiss (gg) at the margins of the body, which shows a transgressive contact with the Entia Gneiss is exposed 1.6 km north-northeast of Inkamulla Bore.

Topographic expression and airphoto characteristics: Forms rounded mounds and steep scarp-faces at the margin of a flat-lying plain covered by alluvium (Qa) and Cainozoic gravels (Czc). Prominent small isolated hills and steep slopes. Pale yellow colour on air photos.

General lithology: At its core region near Inkamulla Bore the unit is composed of massive hornblende-granodiorite (gd), but becomes progressively more foliated, coarser-grained, and biotite-rich towards its margins (gg) where it is difficult to distinguish from the quartzofeldspathic gneiss (f) of the Entia Gneiss.

Detailed lithology:

Granodiorite gneiss (gg) is the most abundant rock type and is coarser grained than the massive variety. The gneiss (e.g. FP 3511, south of Inkamulla Bore, TS=71090511) is visually estimated to be composed of plagioclase (38%), microcline (20%), quartz (30%), chlorite (4%), epidote (4%), hornblende (2%), sphene (less than 1%), opaque grains (less than 1%), and traces of biotite, calcite, zircon and apatite. The gneiss has an allotriomorphic granular texture. Biotite has been largely replaced by chlorite. Epidote is closely associated with the chlorite. Most hornblende is unaltered and is pleochroic from pale yellow to bluish green. The plagioclase is clouded and partly altered to sericite and epidote (description of 3511 after Webb & Lowder, 1972).

<u>Granodiorite</u> (gd) is well illustrated by sample (R4559) from 1.2 km south-southeast of Inkamulla Bore which is a massive rock consisting of quartz (17.8%), oligoclase (48.3%), hornblende (16.7%), microcline (14.7%) epidote (1.4%), apatite (0.5%), biotite (0.1%) and sphene (0.5%) (Joklik, 1955a). It has been chemically analysed (Joklik, 1955a, p.41; and Appendix (C(8)).

<u>Structure</u>: Occupies a dome elongate in a northeast direction. The foliation at the margin of the granodiorite is conformable with that of the country rock.

<u>Relationships</u>: Intrudes the Entia Gneiss, but generally has conformable contacts with it. Transgressive contact exposed 1.6 km northeast of Inkamulla Bore (Joklik, 1955a). As is the case with the Huckitta Granodiorite pegmatites are rare in the granodiorite; those that are present are generally unaltered and unstrained (Joklik, 1955a, p.47).

<u>Correlation and age</u>: Similar in composition, texture and structural setting to the Huckitta Granodiorite. Specimens from FPS 3501, 3502, 3510 and 3511 (specimens 71090501, 502, 510 and 511) were collected for K-Ar age determination. Specimen 71090511 gave a K-Ar hornblende age of 386 m.y. (Webb & Lowder, 1972).

Atneequa Granitic Complex (new name, partly defined)

Map Symbol: Pgq

Nomenclature: Named after Atneequa Creek. Name to be published in notes to accompany second edition 1:250 000 map of Illogwa Creek.

Distribution: In northwestern LIMBLA mainly south of Albarta Creek in a zone of high-angle faulting in which fault slices are composed of Heavitree Quartzite and Atneequa Granitic Complex. A few small roof pendants of granite have been photo-interpreted about 20 km northwest of Albarta Dam.

Type areas:
(1) At GR 5950-906207, LIMBLA. Hills of massive granodiorite and minor granite (e.g. FP 1184D and A); some greenschist retrogression.
(2) At GR 5950-943132, LIMBLA. Creek exposure of muscovite-biotite granite. Further granite exposure in continuation of creek to south (e.g. specimen 70090088, FP 3313).
(3) At GR 5950-970120, LIMBLA. Granitic gneiss exposures in sides of gully. Also in continuation of gully to south (FPS 1212 to 1216).

Topography expression and airphoto characteristics: Low-lying rubbly hills. Pale-yellow colour on airphotos.

General lithology: An igneous complex consisting mainly of granodiorite (gd) in the south and west, and granite (g) in the north and east. Granodiorite is more abundant. Both show various degrees of retrogression to greenschist facies metamorphic assemblages.

Small exposures of diorite (dr) were photo-interpreted. Granitic gneiss (gg) containing xenoliths and in many places K-feldspar megacrysts, occurs in the same region north of Albarta Creek and also 25 km northwest of Albarta Dam. The granitic gneiss is interpreted to be an early phase of the Complex. Numerous amphibolite bodies included in the granite unit. A small elongate body of hornblende syenite 5 km northeast of the Albarta Prospect (sy) may also belong to the Complex. Aplitic veins cut the granitoids in places (e.g. 7 km NW Albarta Dam).

Detailed lithology:

Granodiorite (gd) has a colour index of 10-20. The granodiorite is typically greenish grey or grey, medium-grained, mostly massive rock but in places is foliated. A typical example (e.g. FP 1184A) is composed of partly saussurtised plagioclase (63%), quartz (20%), K-feldspar (12.5%), chlorite (3%) opaque grains (1.0%) biotite (0.3%), epidote and accessory apatite. Locally (e.g. FP 1178) it contains green hornblende.

Granite (g) occurs as three varieties:

(1) A porphyritic variety (e.g. FP 3313) containing biotite and muscovite. The granite at FP 1401 is slightly foliated and at FP 1201 is gneissic, but both otherwise resemble the granite at FP 3313. K-feldspar megacrysts range from 1 to 4 cm across. Xenoliths are present at FPS 3313 and 1210.

(2) Leucogranite containing about one percent biotite (e.g. FP 1181), or lacking biotite and containing only muscovite (e.g. FP 1184A). The K-feldspar at FP 1184A poikiloblastically encloses plagioclase.

(3) Homogeneous even-grained, fine to medium-grained (5 mm size), pink granite in the klippe 1-10 km north east of Oolera Spring (FPS 1504, 1505), locally cut by pegmatite veins (e.g. FPS 795, 796).

Granite gneiss (gg) ranges texturally from granitic gneiss to gneissic granite and its composition from granite to granodiorite. Locally contains K-feldspar megacrysts and xenoliths (e.g. FPS 1210, 1347). Megacrysts at FP 1347 are aligned parallel to the foliation. In places the gneiss included well-formed 'eyes' of quartz granules (e.g. FP 1214). Commonly cut by aplitic or granitic mobilisate phase (e.g. FPS 1346-7). Contains rafts of muscovite-biotite schist and quartzofeldspathic gneiss (e.g. FP 1215). Some schists have formed due to deformation and retrograde metamorphism in narrow zones (e.g. FP 1213). At GR LIMBLA-970120, and to south, and to south, about one-third of outcrop-area contains K-feldspar megacrysts. This rock is intimately mixed on the scale of individual exposures with fine to medium-grained biotite-bearing foliated granite. The granitic gneiss (FP 1216) is both deformed and extensively saussuritised indicating that the schistosity may have been imposed during greenschist retrogression. At FP 1213 the granitoid has been deformed to produce fine-grained rock (less than 2.0 mm diameter) in what is probably a retrograde schist zone.

Amphibolite (a) represents relics of country rock. Specimen 1183 from 5 km southwest of Albarta Dam is a granoblastic rock and is visually estimated to consist of green hornblende (60%) saussuritised plagioclase (29%), quartz (10%) and opaque grains (1%). Specimen 3311 from 5 km northeast of Coutlands Gap Waterhole is a more retrogressed example composed of actinolite, plagioclase, calcite, sphene, garnet (colourless), and chlorite.

Syenite (sy) forms a small body at the northwestern margin of the Complex FPS 1211, 1345). It is visually estimated to consist of hornblende (34%), K-feldspar (28%), plagioclase (16%), actinolite (9%), clinopyroxene (6%), quartz (2%), epidote (2%), and accessory sphene and sulphide.

Structure and metamorphism: Most of the schistosity and retrograde metamorphic effects are believed to be related to the Alice Springs Orogeny, as are the high-angle reverse faults. The granitoids are probably syntectonic intrusions emplaced during the main amphibolite facies metamorphism which affected the country rocks in the Proterozoic.

Relationships: Intrudes the Albarta Metamorphics and unconformably overlain by the Heavitree Quartzite.

Correlation and age: Because the Atneequa Granitic Complex is lithologically similar to the Atnarpa Igneous Complex (Stewart & others, 1980a; Shaw & others, 1979) and because they are intruded into lithologically similar units they are considered to be likely correlatives. It differs from the Atnarpa Igneous Complex in being composed mainly of granodiorite and in containing little diorite and tonalite. The Atnarpa Igneous Complex has a Rb-Sr total rock age of about 1700 m.y. (Armstrong & Stewart, 1975; Stewart in Shaw & others, 1979) and the Atneequa Igneous Complex is likely to be of similar age, based on the above correlation.

Aremra Granodiorite (formal)

Map Symbol: Ꝑgl.

Nomenclature: Named after Aremra Creek. Name to be published in forthcoming notes to accompany second edition 1:250 000 map of Illogwa Creek.

Distribution: Can be traced from Aremra Bore (also locally called Leaky Bore) westwards alongside the Illogwa Schist Zone to about 3 km beyond Illogwa Creek in southwestern QUARTZ. It mainly occurs immediately south of the Illogwa Schist Zone, but also occupies the southern part of the Schist Zone where it is intersected by Illogwa Creek.

Reference area: Southwestern QUARTZ where the batholith is intersected by Illogwa Creek between GR 5951-161095 and GR 5951-150115.

Topographic expression and airphoto characteristics: Low smoothly rounded hills, partly reduced to a peneplain in places and covered by soil and gravel (Czc). Medium greenish-grey colour on colour aerial photographs. Closely spaced trend-lines reflect the presence of a strong schistosity.

General lithology: Mainly granodiorite (gd) and tonalite (to) together with small amounts of diorite (dr). The distribution of rock types shown on the map is mainly based on field estimates of composition. Much of the unit has undergone retrogression to greenschist rocks (r).

Detailed lithology:

Tonalite (to) and diorite (dr) (e.g. FPS 1151, 1153, 1350, 1351) are transitional to granodiorite in composition and contain biotite and hornblende. They are moderately foliated to gneissic and medium to coarse-grained. Estimated compositions grade from tonalite to quartz diorite (or monzodiorite). Specimen 1153B is composed of plagioclase (34%), hornblende (25%), biotite (15%), K-feldspar (12%), epidote (6%), quartz (5%), apatite (1%), and traces of carbonate and opaque grains. Hornblende is present in some thin epidote-bearing layers (e.g. 1351). Mafic xenoliths occur at FP 1153; a rare hornblendite xenolith at FP 1350. The rocks are metamorphically retrogressed and deformed.

Granodiorite (gd) (e.g. FPS 1316, 1317, 1206, 1653). The rock (FP 1317) is gneissic and is visually estimated to consist of plagioclase (50%), quartz (19%), K-feldspar (17.5%), hornblende (7%), biotite (3%), epidote (3%), carbonate (0.5%), and accessory opaque grains.

Structure and metamorphism: Markedly gneissic in places. The most widespread foliation is thought to be due to the superimposition of a foliation formed during the Alice Springs Orogeny, but more work is required to substantiate its distribution.

Relationships: Intrudes unnamed unit p€f and similar quartzofeldspathic schists in the Illogwa Schist Zone.

Correlation and age: The Aremra Granodiorite is similar lithologically to the Atnarpa Igneous Complex (Stewart & others, 1980a; Shaw & others, 1979). It is also similar to the Atneequa Granitic Complex. The presumed age is, therefore, the Rb-Sr age of the Atnarpa Igneous Complex, of about 1700 m.y. (Armstrong & Stewart, 1975; Black & others, in preparation).

Remarks: Like the Atnarpa Igneous Complex and the Aremra Granodiorite it is most probably and I-type granite as classified by Chapell & White (1974).

Unassigned granitoid rocks southeast of Mount Turner

Map symbols: p€g. Subscripts gg, p, f, gd, apl

Nomenclature: Unassigned because relationship with other rock units not exposed.

Distribution: Several small outcrops are known 15 km and 20 km southeast of Mount Turner in the northeast of the Illogwa Creek Sheet area.

Reference locality: Granitic gneiss 15 km southeast of Mount Turner (FPS 0036, 0523).

Topographic expression and airphoto characteristics: Rounded tor-like exposures with dome exfoliations surfaces.

Lithology: The rocks are granitic to granodioritic in composition; all are foliated. Granitic gneiss from the reference locality (FP 0036) consists of K-feldspar augen up to 15 by 8 mm size in a matrix of microperthitic microcline, quartz, plagioclase, biotite, minor green amphibole, and accessory opaque grains, sphene, apatite, and zircon. Fine to medium-grained biotite-bearing quartzofeldspathic gneiss also crops out near reference locality (FP 2213B) and consists of perthitic K-feldspar, plagioclase, biotite, opaque grains, and a trace of ?zircon, and ?monazite. At FP 2212, medium-grained biotite-bearing granitic gneiss containing sparse small feldspar crystals up to 6 mm long and coarser porphyroblastic gneiss crop out.

At FP 2209 the rock is porphyroblastic with white feldspars up to 35 mm long; the finer-grained matrix consists of plagioclase, quartz, green hornblende (about 15%), sphene, and accessory epidote.

All the rock types from this unassigned granitoid unit are foliated; some feldspar grains show deformed twin lamellae and at FP 2213A the rock contains elongate aggregates of polygonal quartz grains.

Relationships: The small granitoid bodies are presumed to intrude the undivided metamorphics of the Harts Range Group (p€h). No contacts are exposed although rare dark schlieren in granitoid occur at locality FP 2209. The contact between the finer and coarser granitoid types is exposed at two localities. However, the relationships are not clear; at one locality (FP 2212) the contact is concordant while at the other (FP 2213) the finer-grained gneiss forms layers and lenses within the coarser gneiss and locally the contact between the two rock types is discordant.

Unnamed Granite in the Huckitta Bore area, Pg

Map Symbol: Pg.

Nomenclature: This granite is unassigned because it is texturally unlike other granite bodies in the area.

Distribution: Occurs as a small pluton centred 7 km north-northwest of Coggans Bore in northeastern QUARTZ. Also forms a small sill 4 km north-northwest of Coggans Bore.

Reference locality: Two kilometres east of Huckitta Bore at FP 1092.

Topographic expression and airphoto characteristics: Exposed in a valley because more prone to weathering than surrounding ridges of quartzofeldspathic gneiss and amphibolite. Uniform, medium-brown photocolour.

General lithology: Porphyritic, fine-grained, includes large rafts of quartzofeldspathic gneiss and layered amphibolite. Small mafic xenoliths at FP 1092, and xenolith of biotite gneiss at FP 1094. Specimen 1094A contains numerous xenocrysts and small xenoliths. It consists of K-feldspar (52%), quartz (30%), plagioclase (15%), green hornblende (1%), biotite showing slight alteration to chlorite (2%), and traces of garnet and opaque grains. The quartz is recrystallised to a mosaic of smaller polygonal grains.

Structure: The two granites are elongate in a northerly direction and roughly concordant with the country rock. The northern granite has a moderately developed foliation, which is irregularly folded at FP 1092.

Relationships: Interfingers with, and appears to intrude, biotite-rich gneiss at FP 1092. Intruded by dolerite dykes and very small bodies of gabbro.

Correlation and age: May be synchronous with the nearby Huckitta Granodiorite. No age determinations have been carried out on the unit.

Basic Igneous Rocks

Metamorphosed basic igneous intrusive rocks, Ꝑdx, in the Mount Stanovos area.

Map Symbol: Ꝑdx.

Distribution: Fine-grained, metamorphosed, basic intrusive bodies crop out at Mount Stanovos and for 5 km to the south and southwest.

Reference area: The mafic body that forms Mount Stanovos in central-eastern QUARTZ. Type specimen is 79090989.

Topographic expression and airphoto characteristics: Prominent, smoothly-rounded hills and ridges. Dark grey-brown homogeneous colour on airphotos. Also as a large number of small to very small dark spots scattered throughout the airphotos.

General lithology: Relatively fine-grained, metamorphosed basic igneous rocks. They typically are granuloblastic to granular textured, but in rare cases they retain relict igneous textures. Many of these bodies have a contact zone of hybrid rock (mixed felsic and mafic rock); at one locality a reaction rim occurs at the margin of a mafic body and the country rock.

Detailed lithology:

Fine-grained amphibolite (a) (e.g. FP 693) has a granuloblastic texture with an average grainsize of 0.15 mm, visually estimated to be composed of plagioclase (40%), brown hornblende (27%), clinopyroxene (20%) and opaque grains (3.0%). It includes scattered ragged megacrysts of plagioclase up to 1 cm across. The type specimen (79090989) is similar in texture and composition, but contains 30% biotite. Plagioclase megacrysts are zoned; the centre and outer zones are clear, the middle parts contain small inclusions of clinopyroxene and hornblende. Pegmatitic rock composed largely of coarse-grained feldspar with minor quartz and up to 2 cm thick occur around the small plugs of this rock. Sample 79090573 is a blastophitic-textured rock consisting of indented plagioclase laths with ragged margins partly replaced by granular plagioclase grains (together 30%) surrounded by brown hornblende (69%) surrounding and replacing grains of clinopyroxene (1%) and trace opaque grains.

Hybrid rocks (a) are even-textured fine-grained granoblastic textured rocks forming halos up to 20 cm wide separating intruded metadolerite from enclosing hornblende gneiss and biotite gneiss. Sample 80092054A consists of plagioclase, subordinate sub-parallel oriented biotite and clinopyroxene, small quantities of brown and green hornblende, and a trade of opaque grains.

Hornblende gneiss (h) is a medium-grained, granoblastic rock with the approximate composition of diorite. Specimen 80092054 is composed of plagioclase, subordinate hornblende (some altered to actinolite), small quantities of quartz and K-feldspar, and accessory opaque grains, sphene, apatite, and biotite. Garnet is present as very isolated aggregates up to 30 mm diameter. Many of the plagioclase grains are irregular in shape, embayed and mantled by sub-grains.

At FP 2054 the margin between hornblende-gneiss and biotite gneiss country rock in one place is a 20 to 30 mm wide hornblende-rich rim, which is thought to be a reaction rim.

Structure: The basic rocks form small laccolith or sill-like bodies. Insufficient data are available to identify the structure, but it is possible that the basic bodies are intruded into the core of a north-northeasterly-trending anticline. The small rod-like bodies of metabasic rock have shallow southward to horizontal plunges.

Metamorphism: The rocks generally contain abundant brown hornblende, and some (e.g. FP 989) contain abundant clinopyroxene. Plagioclase sectioned is mostly labradorite. Metamorphic conditions in the upper amphibolite facies are indicated; this is in keeping with the granular texture of the rocks.

Relationships: The rocks appear to have intruded the Stanovos Gneiss Member before the main regional metamorphism.

Correlation and age: This group of metabasic intrustions is similar to that mapped as Ꝑgb. Judging from their degree of metamorphism, they predate the main regional folding and metamorphism which is presumed to have culminated in the Strangway Metamorphic Event at about 1800 m.y. (Shaw & others, 1979).

Metamorphosed and partly metamorphosed basic igneous rocks, Pgb

Map Symbol: Pgb.

Distribution: Basic rocks, principally metanorite and metagabbro, form widely scattered small bodies throughout QUARTZ.

Topographic expression and airphoto characteristics: Resistant oval or circular-shaped features with a dark tone on aerial photographs. Metagabbros commonly form blocky exposures whereas metanorite generally weathers to rounded tors.

Lithology:

Metanorite occurs at five main localities:

1. Six km south-southwest of Harding Springs Bore Specimen R4547 is visually estimated to consist of (FP 3023) andesine (60%), hypersthene (15%), diopside (10%), biotite (10%), magnetite (3%) and traces of hornblende, epidote, orthoclase, and quartz. All minerals have been recrystallised. The rock is fine-grained and massive.

2. At Mount Emma a metanorite sill is medium-grained and massive in its core and fine-grained and foliated at its margins. Joklik (1955a, p. 56) described specimen R4579, collected from the main mass of the sill (FP 3054), as blastophitic-textured and composed of hypersthene (59.2%), labradorite (31.8%), hornblende (2.7%), diopside (2.7%), biotite (2.9%), magnetite (0.4%), and apatite (0.3%). Most minerals are finely recrystallised at the grain margins. The sill is considerably deformed and recrystallised at its margins (e.g. R4793).

3. A metamorphosed and deformed leuconorite forms the flat-top of a hill 6 km southwest of Mount Emma (FP 245C, 248-C, 250A-B, 251A). Specimen 7909248C is estimated to consist of plagioclase, partly altered to scapolite (63%) and hypersthene (18%) partly altered to clinopyroxene (12%), phlogopite (5), hornblende (1%) and ilmenite (1%). Garnet occurs within this mass at FP 248B.

4. A small metabasic intrusion near Coggan's Bore (FP 261A) is granular and is visually estimated to consist of plagioclase (65%), clinopyroxene (16%), hypersthene (12%), green hornblende (5%), opaque grains (2%), and accessory apatite and garnet. Some parts of this body (FP 261B, 265) lack hypersthene.

5. South of Indiana homestead (FP 3326A) norite contains igneous orthopyroxene relics in a rock consisting of metamorphic plagioclase, clinopyroxene, brown hornblende, biotite and opaque grains.

Metagabbro occurs at Black Mountain, 3 km northwest of Aremra waterhole, 8 km north-northeast of Coggan's Bore, and 4 km south-southwest of Indiana homestead.

The metagabbro at Black Mountain (FPS 221, 222) is extensively altered to clinopyroxene-scapolite amphibolite. In places it grades into metamorphosed gabbro, and rarely anorthosite (FP 222B) and olivine gabbro (FP 221E).

The metagabbro near Aremra waterhole contains large primarily igneous clinopyroxene crystals surrounded by metamorphic granular plagioclase and orthopyroxene.

The gabbro 8 km north-northeast of Coggan's Bore (FP 10840) consists of elongate, primary igneous zoned plagioclase grains and primary pyroxene crystals and metamorphic green hornblende and red-brown biotite.

Structure and metamorphism: Original igneous textures are preserved in the core of the norite at Mount Emma, and gabbros at Black Mountain and near Aremra waterhole, but most norites and gabbros are recrystallised and altered - some to granular hornblende and hypersthene-bearing rocks indicating metamorphism to granulite facies, but most are metamorphosed to amphibolite facies. The smaller bodies and the margins of some of the larger bodies, such as that of Mount Emma, are foliated.

Relationships: The larger basic bodies (e.g. at Black Mountain, Mount Emma and 6 km southwest of Mount Emma) form sills, up to 200 m thick, intrusive into the Harts Range Group.

Age: The basic bodies were intruded before or during the regional metamorphism, presumed to be the Strangways Metamorphic Event with a probable Rb-Sr age of about 1800 m.y. (Black, 1975; Shaw & others, 1979).

Metamorphosed and partly metamorphosed ultrabasic igneous rocks

Map symbol: Pp

Distribution: Small plug-like bodies of ultrabasic rock (Pp) occur in the Entia Gneiss near Inkamulla Bore and in parts of the Illogwa Schist Zone.

Topographic expression and airphoto characteristics: The rocks crop out as dark lenticular shaped bodies which are closely jointed and weathered to a blocky rubble.

Lithology

Meta-hornblendite forms sills up to 100 m thick in the Entia Gneiss just south, west and northwest of Inkamulla Bore. The sills are weakly foliated, granular and commonly have plagioclase-rich margins and also hornblende-rich cores. Specimen 79090205A from the core of one sill is visually estimated to be composed of hornblende (77%), clinopyroxene (15%), plagioclase (5%), scapolite (3%) and a trace of sphene. Quartz (up to about 5%, e.g. 200A) and garnet (e.g. specimen 201A) are locally present.

Hornblende amphibolite occurs as small plug-like bodies southwest of Huckitta Well (FP 209) and southwest of Spriggs Camp Bore (FP 214). Specimen 79090214C is estimated to consist of hornblende (75%), plagioclase (24%) and opaque grains (1%). Some parts of the amphibolite also contain clinopyroxene, orthopyroxene and K-feldspar as megacrysts up to 1 cm across (e.g. FP 214D). Amygdale-like structures suggesting an origin from basalt were observed at FP 209 in a massive clinopyroxene-rich amphibolite containing a trace of chalcopyrite.

Meta-ultramafic rock in the Illogwa Creek Schist Zone forms plug-like bodies consisting mainly of granular tremolite-actinolite. For example, specimen 79091353 consists of tremolite-actinolite (84%) which poikiloblastically encloses clinopyroxene (15%) and also contains epidote (1%) and a trace of opaque grains. Specimen 79091352 also contains quartz, chlorite, plagioclase and carbonate.

Structure and metamorphism: Generally massive rocks lacking a foliation. Those in the Entia Gneiss were emplaced before the regional metamorphism. Some in the Illogwa Schist Zone have granoblastic textures indicating that they were intruded or recrystallised in the late stages of the Alice Springs Orogeny after the main period of schistosity formation.

Relationship: Most of the metahornblendites are small cylindrical bodies that crosscut the foliation in the country rock; concordant ones in the Inkamulla Bore area may be sills.

Correlation and age: Similar metahonblendites occur in the Giles Creek Syncline in the Alice Springs Sheet area, where they are closely related to and are possibly similar in age to the 1700 m.y. old Atnarpa Igneous Complex (Shaw & others, 1979).

Mafic dykes and plugs

Map symbol: Basic hyperbyssal igneous rocks are given the symbol Ed; dolerite dykes dl.

Distribution: At a few scattered outcrops throughout the crystalline basement, e.g.

1) 20 km northeast of Atniempa waterhole (FPS 1215, 1465, 1472);
2) immediately north of Indiana homestead at FPS 1805 and 2082;
3) north-northwest of Indiana homestead at FP 2231;
4) intruding granite 1 km north of Oolera Spring (FPS 1504-5);
5) in Illogwa Creek at the northern margin of the Illogwa Schist Zone (FP 1349);
6) two km southwest of Black Diamond Mica Mine (FP 929);
7) several small bodies of olivine norite (n) 5 km north of Indiana homestead (FP 1591).

Thickness: Commonly less than 10 m, but one body is over 100 m wide 20 km northeast of Atniempa waterhole. Dyke near Indiana homestead is about 1 m wide. A complex of dolerite, gabbro, and ultrabasic bodies located 5.5 km southeast of Aremra Bore (FPS 934, 935), show slight metamorphic retrogression to biotite and actinolite.

Topographic expression and airphoto characteristics: More resistant than adjacent rocks. They form prominent dark-toned linear features on airphotos. Dyke near Indiana homestead is too small to be seen an airphoto and has been eroded at the same rate as the country rocks.

General lithology: dolerite, commonly altered; micronorite; also several small bodies of olivine norite.

Detailed lithology: (FPS 1215, 1465, 2231) The dolerite (1215) is subophitic textured and composed of plagioclase which is partly saussuritised, and uralitised pyroxene (?augite). Alteration products include actinolite, tremolite, sericite, and epidote. The rocks contain some ilmenite (2%), and traces of quartz. Specimen 1349 contains unaltered ragged plagioclase laths, but the original ferromagnesian minerals are completely altered to actinolite and some biotite. Micronorite forms the thin dyke near Indiana homestead and consists of hornblende, plagioclase, orthopyroxene, biotite, opaque grains, and accessory calcite and muscovite (80092082). The rock has a recrystallised granular texture. The olivine norite consists of orthopyroxene, clinopyroxene, olivine, poikilitic plagioclase, and minor hornblende, actinolite, tremolite, biotite, calcite, opaque grains, and talc (79091591).

Structure and metamorphism: Steeply dipping to vertical. Those 20 km northeast of Atniempa waterhole strike east-west, perpendicular to the strike of the country rock. The dyke northeast of Oolera Spring also trends west. Alteration may be greenschist retrogression produced during the Alice Springs Orogeny.

Relationships: East-west striking dykes intrude the Albarta Metamorphics.

Correlation and age: Proterozoic. They may be same age as the Stuart Dyke Swarm dated by Black & others (1980) at about 900 m.y. However, the Stuart Dyke Swarm trends north-south.

Other Igneous Rocks

Harts Range pegmatites and associated granite
(after Joklik, 1955a)

Map symbol: peg. The pegmatite dykes in the Harts Range area are shown on the map by the unlabelled dyke symbol because they are so numerous. Only larger bodies are labelled 'peg'.

Distribution: Pegmatite dykes and associated granite bodies are widely distributed throughout the eastern part of the Arunta Block. In the Harts Ranges they are extremely abundant and intrude all the components of the Harts Range Group, but are less common in the amphibolites and metamorphosed calcareous sediments. The granite bodies are a minor component and are most abundant in the Mount Mary area.

Thickness: The dykes are up to 20 m thick. Granite plugs are up to several hundred metres long.

Topographic expression and airphoto characteristics: Resistant ridges with a cream coloured tone on airphotos. Scree derived from the pegmatites commonly gives an erroneous idea of their thickness. Granite plugs are commonly smooth and rounded in outcrop.

General lithology: The pegmatite and associated granite consist mainly of quartz, feldspar and mica (mainly muscovite, but also biotite).

Detailed lithology: Joklik recorded three types of pegmatites.

(1) Concordant lenses, which are abundant in the Brady Gneiss and present in the Irindina Gneiss; he considered these to have formed by anatexis of their country rock. The concordant pegmatites include granite lenses which have been deformed along with the country rock and show a poor foliation. They form pinch and swell structures. Other types of pegmatite veins are folded.

(2) Cross-cutting calc-alkaline pegmatites. These are typically well-zoned with quartz segregations away from the edges of the pegmatite. They contain plagioclase, quartz, subordinate K-feldspar, and abundant mica, and are the common cross-cutting type in the Irindina and Brady Gneisses.

(3) The cross-cutting potash pegmatites. These are also compositionally zoned, generally consist of K-feldspar and quartz, and are commonly poor in mica. They are typical of the pegmatites in the Entia and Bruna Gneisses.

Relationships: Cut all units of the Harts Range Group, but are uncommon in rocks mapped as undivided Harts Range Group (p€h) in central-northern part of the Sheet area.

Age: Joklik considered that the pegmatites were emplaced towards the end of the diastrophism with the granodiorites and the granites when the Harts Range Group rocks were metamorphosed, migmatised, feldspathic, and granitised. Many of the pegmatites have transitional contacts with the country rocks and appear to be the product of ultra-metamorphism and local anatexis. However, the fact that retrograde metamorphism of the country rocks surrounds the periphery of the dykes and that the dykes generally show cross-cutting relationships suggests they are probably much younger than the main regional metamorphism. Riley (1968) obtained a Devonian Rb-Sr age from the Rex pegmatite in RIDDOCH. Its initial strontium isotope abundance determined on apatite and plagioclase suggest that it is a product of anatexis originated by reworking of basement material.

Remarks: Described in considerable detail by Joklik (1955a).

NOTE ON LATE-STAGE SCHIST ZONES

A broad schist zone referred to as the Illogwa Schist Zone separates the Harts Range Group in the north from the Albarta Metamorphics in the south. Smaller narrower schist zones occur on either side in unnamed units p€x and p€f, and in the Albarta Metamorphics. The zones are characterised by retrograde greenschist facies metamorphic assemblages.

Illogwa Schist Zone

Map Symbol: Pzr.

Nomenclature: A superimposed structural-metamorphic feature rather than a stratigraphic unit. It separates the Harts Range Group in the north from the Albarta metamorphics in the south. Previously referred to as the Illogwa Shear Zone (Milligan in Shaw & Milligan, 1969); named after Illogwa Creek.

Distribution: A belt, some 5 km wide, extends from Ruby Gap (Alice Springs Sheet area) east to Aremra Creek and may extend farther east under Cainozoic cover.

Reference areas: In Illogwa Creek and also southwest of Ruby Dam.

Topographic expression and airphoto characteristics: Forms belts of subdued, relatively slight relief. Marked schistosity apparent as closely spaced trend-lines on aerial photographs.

General lithology: Schist of various types containing both biotite and muscovite. Quartzofeldspathic schist (sf) is dominant; also biotite schist (sb), biotite-muscovite schist (s) and chloritic schist (sc). Lenses of relict amphibolite (a) quartzofeldspathic gneiss (f) granitic gneiss (gg) and tonalite (to) are minor components of the zone. Also contains quartz lenticles and epidosite.

Structure and metamorphism: Northern margin marked by abrupt termination schistosity, but no major compositional change. Strike discordance at the eastern end of norther margin near Aremra Creek suggests the northern boundary may be a fault. A major low-angle reverse fault at the southern margin separates the schist zone from slivers of Heavitree Quartzite. The Illogwa Schist Zone is characterised by greenschist retrograde metamorphism.

Relationships: Contains relics of granodioritic gneiss (gg) and tonalite (to) assigned to the Aremra Granodiorite (Pgl) and small bodies of meta-pyroxenite (Pp); these meta-pyroxenites appear to have largely escaped deformation but have undergone greenschist facies retrograde metamorphism.

Age: The Schist Zone may have developed during the Alice Springs Orogeny as similar greenschist retrogression in the Arltunga Nappe Complex give an early Carboniferous Rb-Sr age (Armstrong & Stewart, 1975).

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DESCRIPTIVE NOTES ON UNMETAMORPHOSED STRATIGRAPHIC UNITS

Late Proterozoic to Cambrian Sediments

Heavitree Quartzite (formal)

Map Symbol: Puh

Nomenclature: The Heavitree Quartzite was named and defined by Joklik (1955a). Clark (in Wells & others 1976, p.26; and in Stewart & others, 1980) divided the Heavitree Quartzite into four Members, but the division is not recognisable in the Illogwa Creek Sheet area. The conglomeratic units are like the Fenn Gap Conglomerate Member (Stewart & others, 1980a), and most, if not all, of the Heavitree Quartzite in the Sheet area is thought to belong to this member.

Distribution: In QUARTZ it occurs in a series of high-angle thrust slices between Atniempa waterhole in the west and south of Illogwa Bore in the east, and at Ruby Gap to the northwest. In LIMBLA on the margin of the basement inlier near Spring Gap in the southwest of the Sheet area.

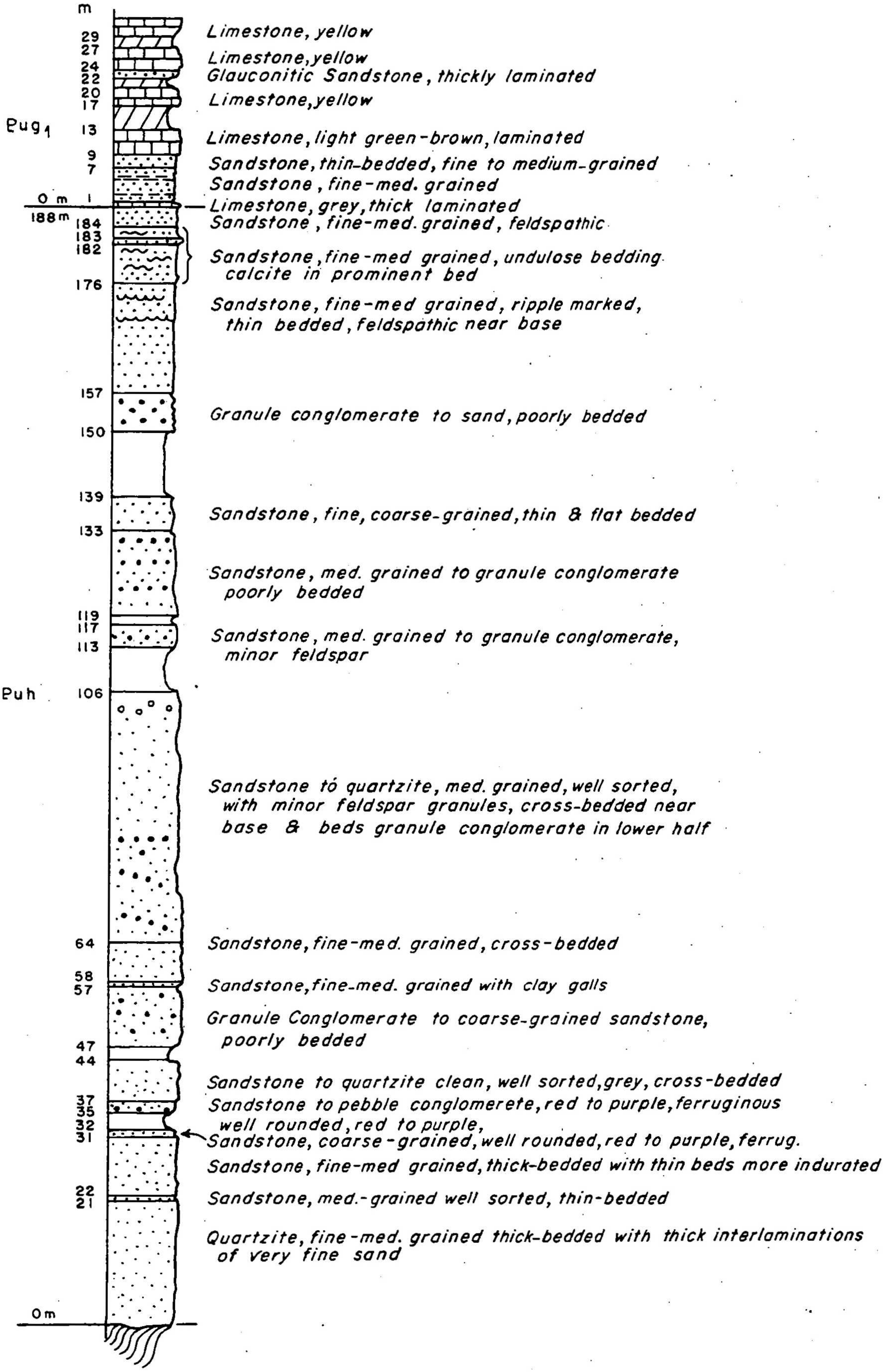
Type Section: Heavitree Gap in the Alice Springs Sheet area is generally taken to be the type locality (Wells & others, 1979), although Joklik (1955a) did not nominate a type section. The main measured reference section (Fig. 3A & 3B) in the Illogwa Creek Sheet area is 4 km east-southeast of Waldo Pedlar Bore (F1, F2 on compilation sheets at GR 5950 - 161469 to 163471 and 162472 to 162473). Another reference section is 3.5 km northwest of Oolera Spring (Fig. 4). Two additional reference section are north of Coultards Gap (Figs. 5 & 6).

Thickness: 188 m in measured reference section east-northeast of Waldo Pedlar Bore. 300-400m in Coulthards Gap area.

Topographic expression and airphoto characteristics: Forms major ridges and some escarpments. The most resistant unit in the area. Pale photo-colour.

General lithology: White to purple sandstone, intercalated with pebble and granule conglomerate, is more common in upper part. Units of pink, fine to very fine-grained quartzite, 40-8- m thick, are interbedded with intervals of conglomerate and pebbly sandstone in the lower part.

Fig.3A Measured Reference Section, Heavitree Quartzite (Puh), 4km east-southeast Waldo Pedlar Bore. (Pug is Gillen Member of Bitter Springs Formation).



Record 1982/23

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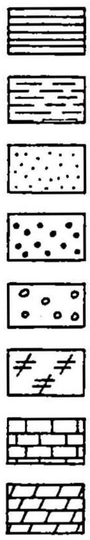
Fig.3 B Reference to Columnar Sections (Figs. 3-7)



Shale

Siltstone

Sandstone

Coarse sandstone-fine conglomerate

Conglomerate

Chert

Limestone

Dolomite

GRAIN SIZE

Fine	*0·12-0·25 mm*
Medium	*0·25-1·0 mm*
Coarse	*1·0-2·0 mm*
Very coarse	*2·0-4·0 mm*
Granule conglomerate	*4·0-16·0 mm*
Pebble conglomerate	*>16 mm*

BEDDING

Very thick	*> 1.m*
Thick	*30-100 cm*
Medium	*10-30 cm*
Thin	*1 -10 cm*
Thick laminae	*5-10 mm*
Thin laminae	*<5 mm*

Gaps in columnar section are concealed areas

Fig.4 Schematic section, Heavitree Quartzite, 6 km NW Oolera Spring

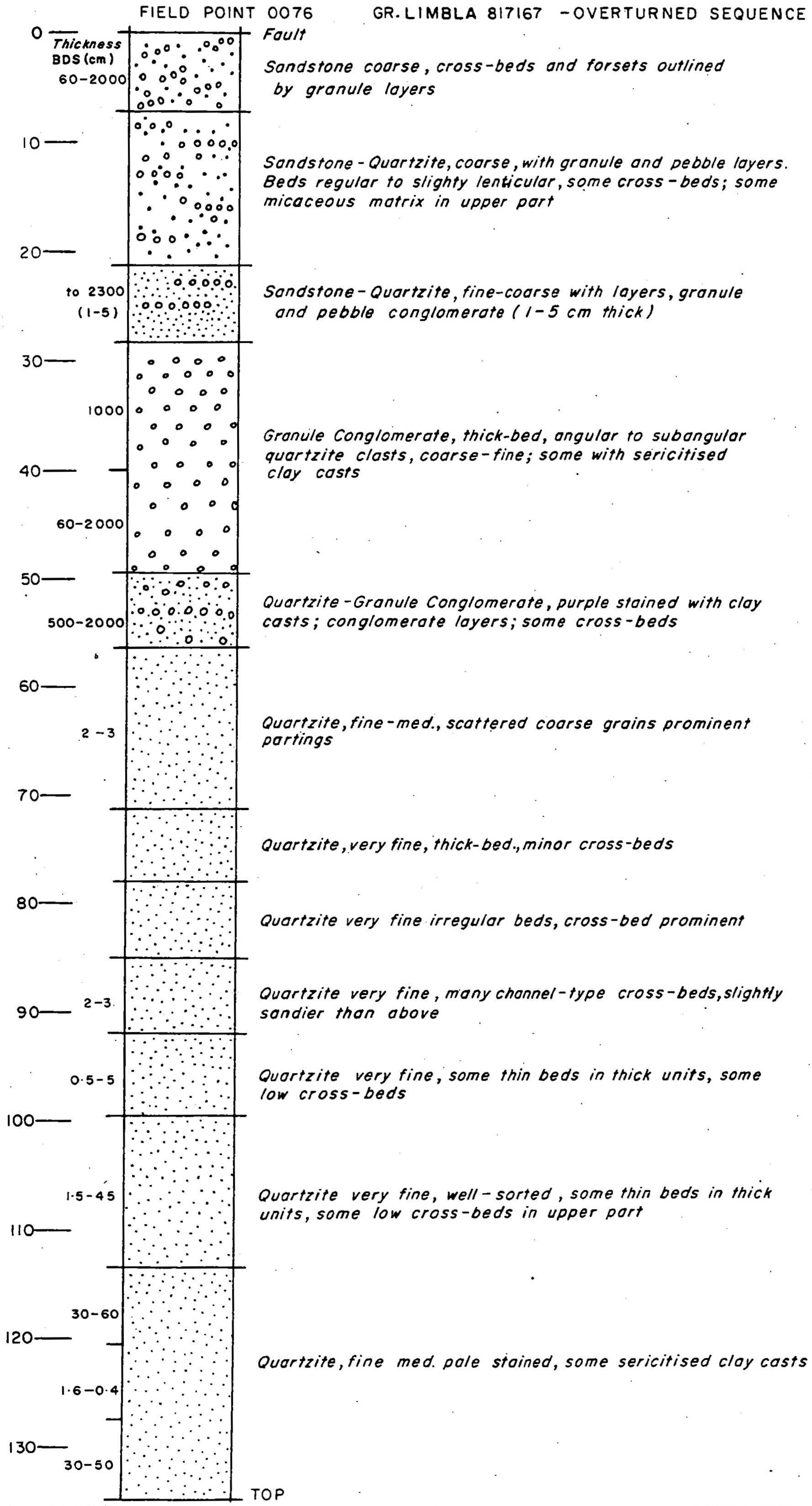


Fig. 5 Schematic section, Heavitree Quartzite,
5·5 km NNW Coulthards Gap Waterhole. GR. LIMBLA 038933

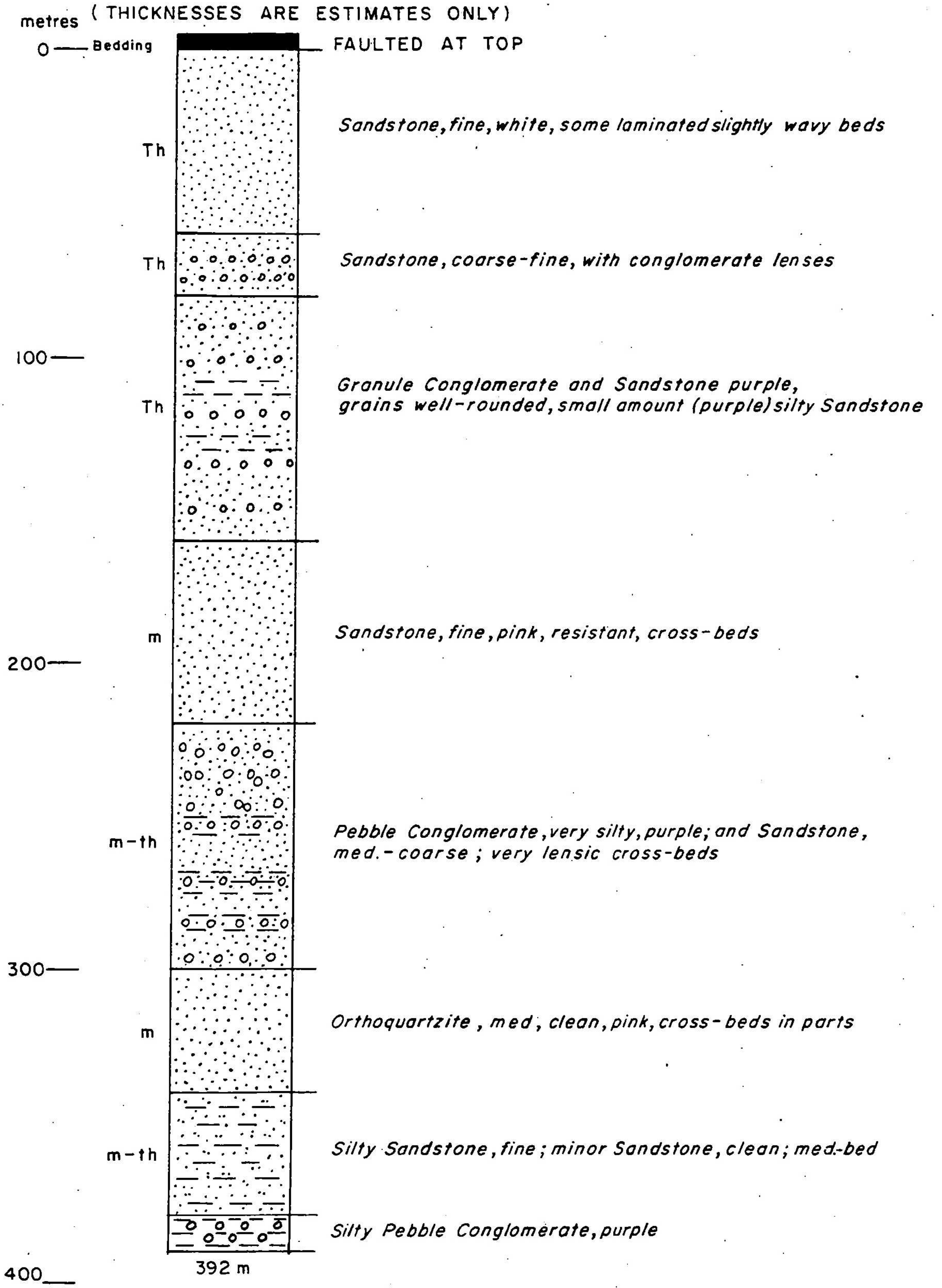
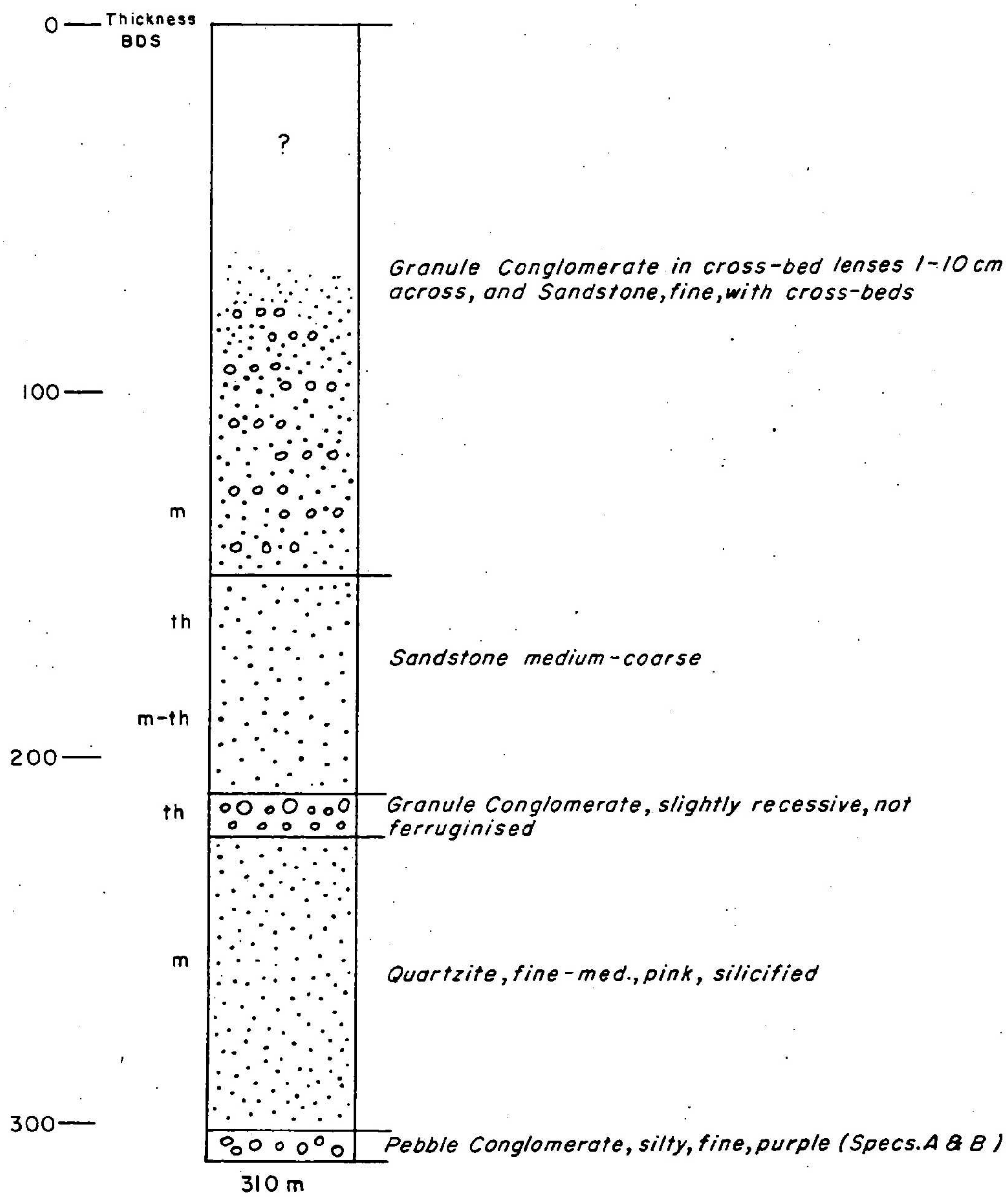


Fig. 6 Schematic section, Heavitree Quartzite, 3 km NE of Coulthards Gap waterhole

PT 1425, GR. LIMBLA 084904

(THICKNESSES ARE ESTIMATES ONLY)



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In the reference section in the southwest, fine to medium-grained quartz sandstone is interbedded with minor granule conglomerate and lessen amounts of feldspar quartz sandstone. Much of the sandstone is cross-bedded. Some ripple-marked beds occur in the upper part.

Detailed lithology: Presented graphically in Figures 3-6.

Structure: In the Illogwa Schist Zone Heavitree Quartzite is preserved as remnants along two major thrust faults. Heavitree Quartzite also occupies a complex of high-angle reverse faults (Oolera Fault Zone, Fig. 14). These faults repeat the sequence of crystalline basement-Heavitree Quartzite - Bitter Springs Formation several times. Farther south shallowly dipping, overturned Heavitree Quartzite envelopes two granitoid bodies to form the folded hinge region in two small nappes preserved as klippen.

Metamorphism: In the Illogwa Schist Zone several thrust slices of Heavitree Quartzite have undergone prograde greenschist facies metamorphism. Farther south in the zone of high-angle reverse faults the same rocks are essentially unmetamorphosed.

Relationships: Unconformably overlies cyrstalline basement and is conformably overlain by Bitter Springs Formation.

Age: Late Proterozoic. Younger than Stuart Dyke Swarm which have a Rb-Sr age of 897 m.y. (Black & others, 1980) and older than the 700-800 m.y. glacial units.

Bitter Springs Formation (formal)

Map Symbol: Ꝑue, Ꝑug (divided into two Members)

Nomenclature: First named Bitter Springs Limestone by Joklik (1955) after Bitter Springs Gorge in Alice Springs Sheet area. The name was revised to Bitter Springs Formation by Wells & others (1967). Subdivided into a lower Gillen Member and an upper Loves Creek Member (Wells & others, 1967). These members are each described in detail in following sections.

Distribution: Crops out over a wide area in the southwestern corner of LIMBLA.

Type Area: At Bitter Springs Gorge northeast of Ross River Chalet in the Alice Springs Sheet area. A reference section has been measured in the lower part (Gillen Member) 1.5 km northeast of Waldo Pedlar Bore in southwestern LIMBLA from GR 122494 to GR 146501.

Topographic expression and airphoto characteristics: Low arcuate ridges and shallow valleys. Photo-colours are pale brown and pink in the lower parts with medium to dark reds in the upper parts.

General lithology: An interbedded sequence of siltstone, limestone, dolomite, sandstone and granule conglomerate. A more detailed description is given below for the two Members.

Structure: The formation is intensely folded and faulted. Fold style ranges from broad arching to isoclinal and is commonly disharmonic between adjacent beds. Complex superimposed folding is recognizable on aerial photographs. In the northern part of the outcrop-area single units are exposed over large areas. It is thought that unrecognized subhorizontal thrust planes may separate these units. Faulting is common and in places their planes are curved. South and southwest of Limbla homestead several close-spaced faults radiate to the northwest and west and become 'lost' in a complex of folds.

In the Oolera Fault Zone (Fig. 14) only the Gillen Member, and probably only the lower part, is preserved along with the Heavitree Quartzite and basement rocks. During the Alice Springs Orogeny a décollment formed at or near the top of the Gillen Member; rocks below the décollment were grossly affected by thrust faulting; rocks above the décollment were only slightly affected and are not now found within the Oolera Fault Zone.

Metamorphism: The formation may have undergone prograde metamorphism to zeolite facies. Pumpellyite has been recognised in spilite within the Loves Creek Member in Section Rd R7 in the Rodinga Sheet area (TS 14455-6). The possible presence of zeolite minerals in spilite in LIMBLA requires checking. Within thrust slices as far as northwestern LIMBLA the argillaceous sediments in the formation have been converted into slate and phyllite.

Relationships: The Heavitree Quartzite, at its reference section 5 km east-southeast of Waldo Pedlar Bore, grades up into Bitter Springs Formation. In the Heavitree Quartzite, silt interbeds increase in proportion approaching the top and similar siltstones occur near the base within the Bitter Springs Formation. The contact is taken to be the base of the lowest carbonate bed within the Bitter Springs Formation. The formation is unconformably overlain by the Areyonga Formation near Gypsum Creek. Here, the contact is marked by a siliceous, limonitic rock up to 2 metres thick extending several hundred metres along strike. The uppermost part of Loves Creek Member is missing here. It is thought that the limonitic rock may be a palaesoil. Near Pulya Pulya Creek in the main Mulga Syncline Pioneer Sandstone rests on the Gillen Member: the Loves Creek Member, and Areyonga and Aralka Formations are missing.

Correlation and age: The Bitter Springs Formation and Heavitree Quartzite are younger that the Stuart Dyke Swarm which occurs in the Alice Springs area and has a 897 ± 9 m.y. Rb-Sr age (Black & others, 1980). The formation is older than the Areyonga Formation which is thought to correlate with the older of two late Proterozoic glacial units deposited in the Adelaide Geosyncline and Kimberley Basin in the interval 800-700 m.y. (Priess & others, 1978). Walter (1972) correlated the Bitter Springs Formation with the Upper Riphean of the USSR, dated at 950 ± 50 m.y. to 680 ± 20 m.y.

Gillen Member of the Bitter Springs Formation (formal)

Map Symbol: Pug

Nomenclature: First named by Wells & others (1967), based on work of Banks (1964, unpublished), after Mount Gillen, west of Alice Springs.

Distribution: In a single block of about 1000 km^2 in southwest LIMBLA and also in numerous fault slices in the Oolera Fault Zone (Fig. 14).

Type area: South of Mount Gillen in the Alice Springs Sheet area. The reference section in LIMBLA is 1.5 km northeast of Waldo Pedlar Bore (Fig. 7A-D).

Topographic expression and airphoto characteristics: Low strike ridges, hills and shallow valleys. Photo-colours are light brown to grey or green-brown in the case of carbonates and red-brown in the case of detrital sediments. Carbonate beds up to several metres thick within siltstone in parts of the Member form very conspicuous, lined units on the air photographs.

General lithology: Complex interbedded relationships between limestone, dolomite, siltstone, shale, sandstone and granule conglomerate. Bedding ranges from very thin to very thick. It has been sub-divided into five lithological units (informal).

Detailed lithology: Subdivided in to five informal units as described and presented graphically in Figures 7a-d.

BASE

Pug^1 Poorly-bedded, medium to thick-bedded limestone with subordinate dolomite in the lower part, overlain by thinly-bedded limestone with thin interlaminations of silt (Fig. 7D). The proportion of dolomite increases upwards but is not the dominant rock type in any part of the unit. Irregular masses of poorly-bedded chert up to 0.5 m long occur near the top.

The base of this unit is not clearly defined in the reference section. Dip variation along the contact suggests it is faulted against the Heavitree Quartzite.

Fig. 7A Measured Reference Section,
Bitter Springs Formation (Gillen Member)

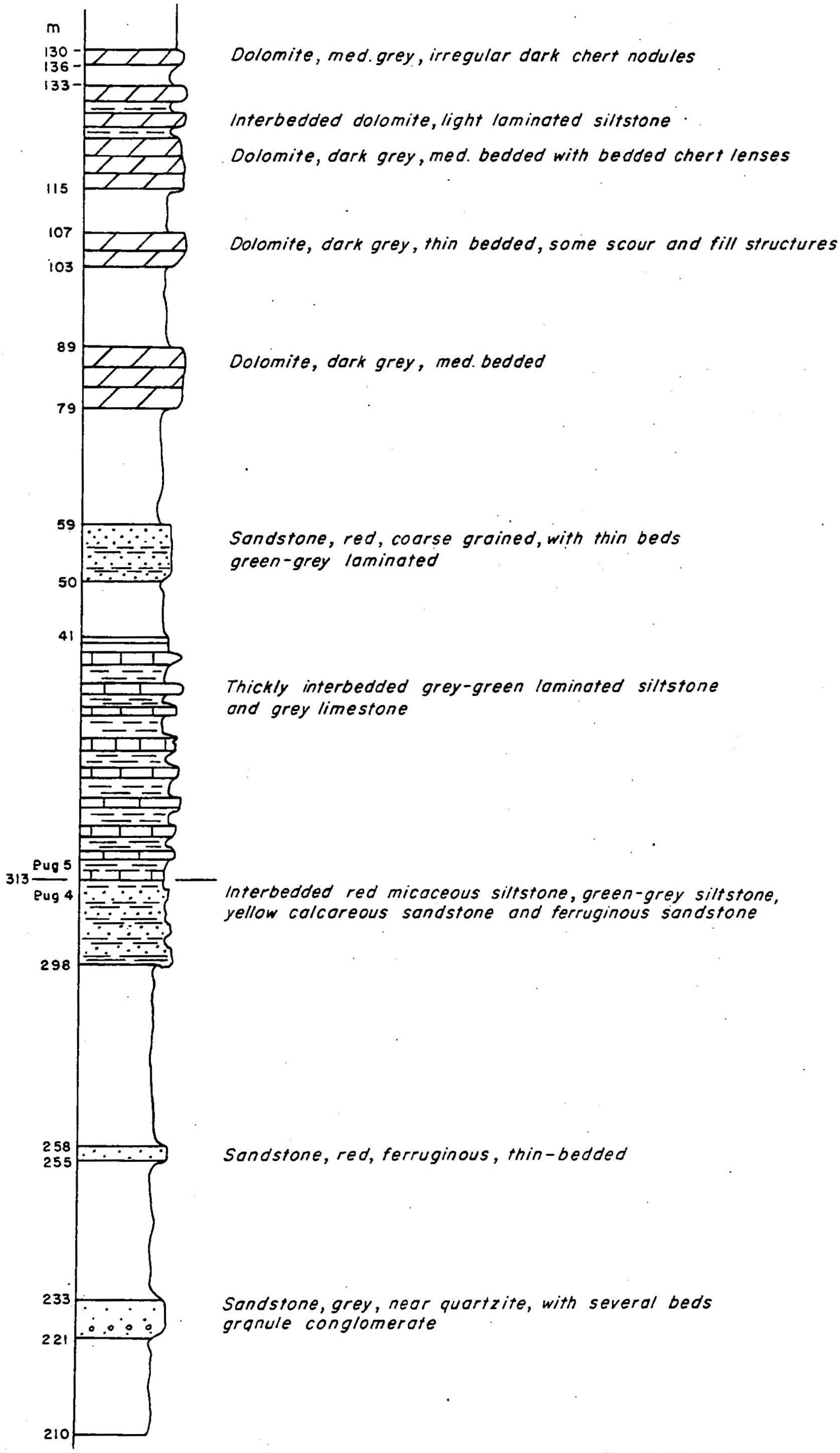


Fig. 7B Measured Reference Section, Bitter Springs Formation (Gillen Member)

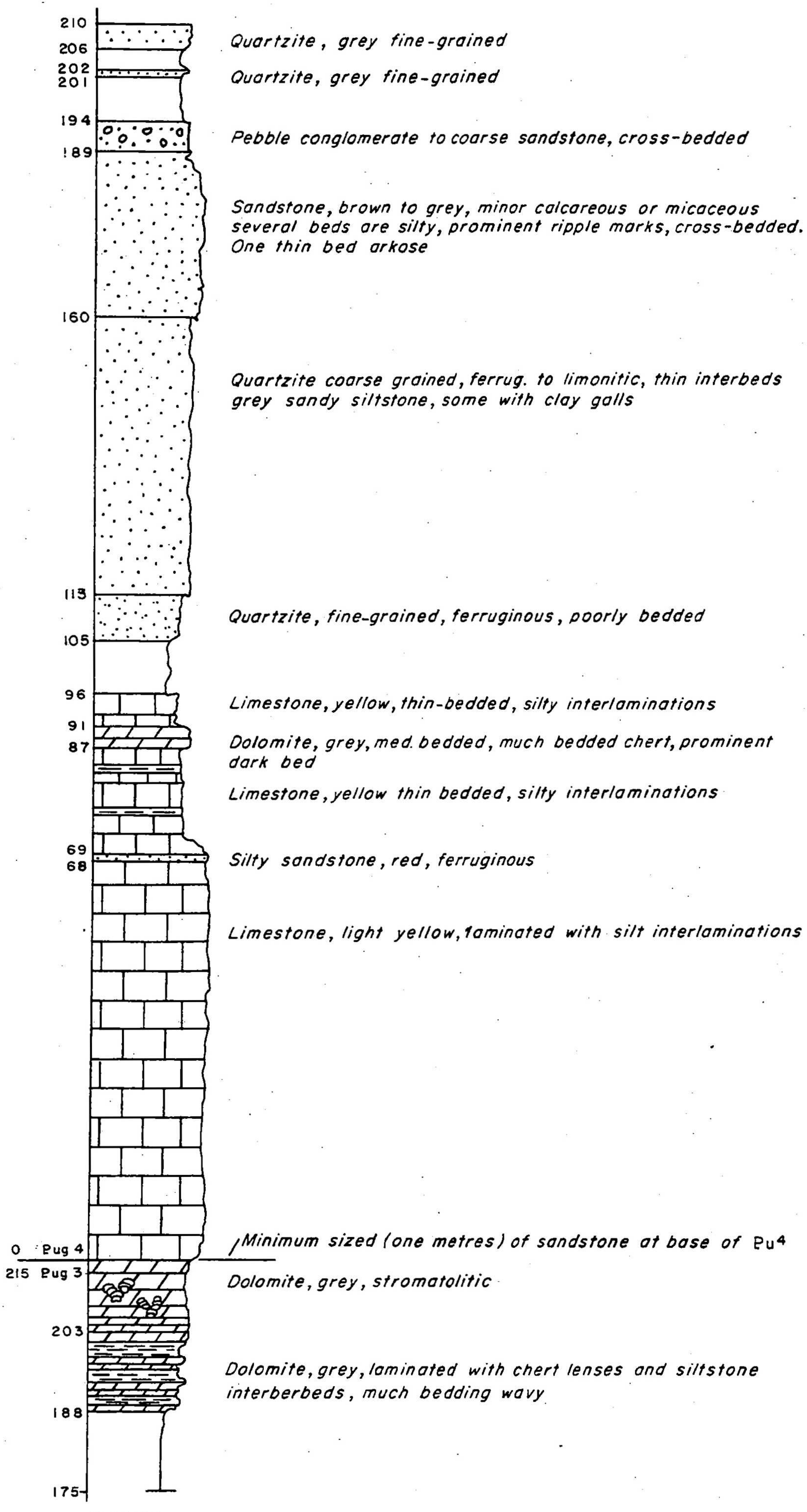


Fig. 7 C Measured Reference Section,
Bitter Springs Formation (Gillin Member)

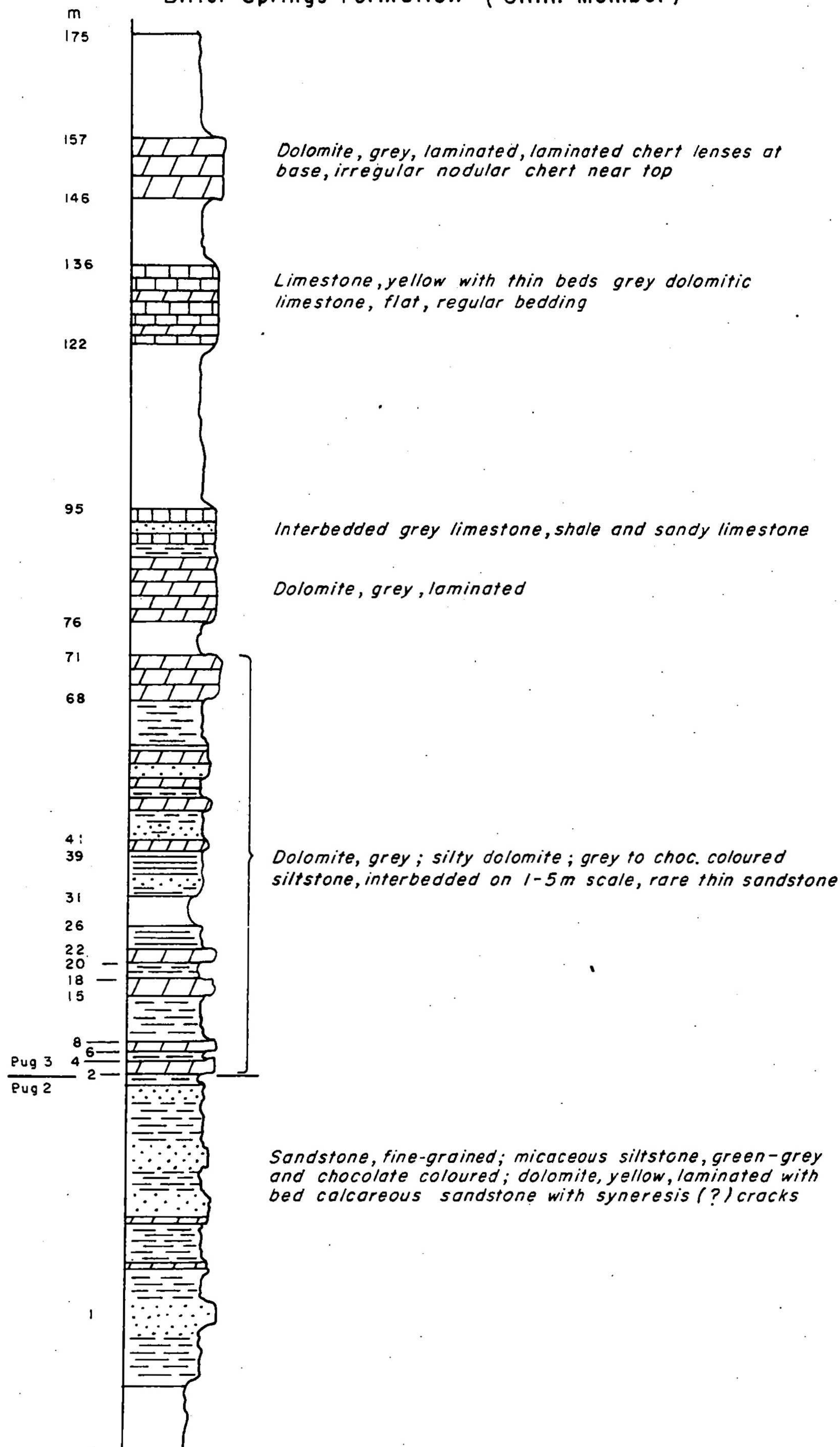
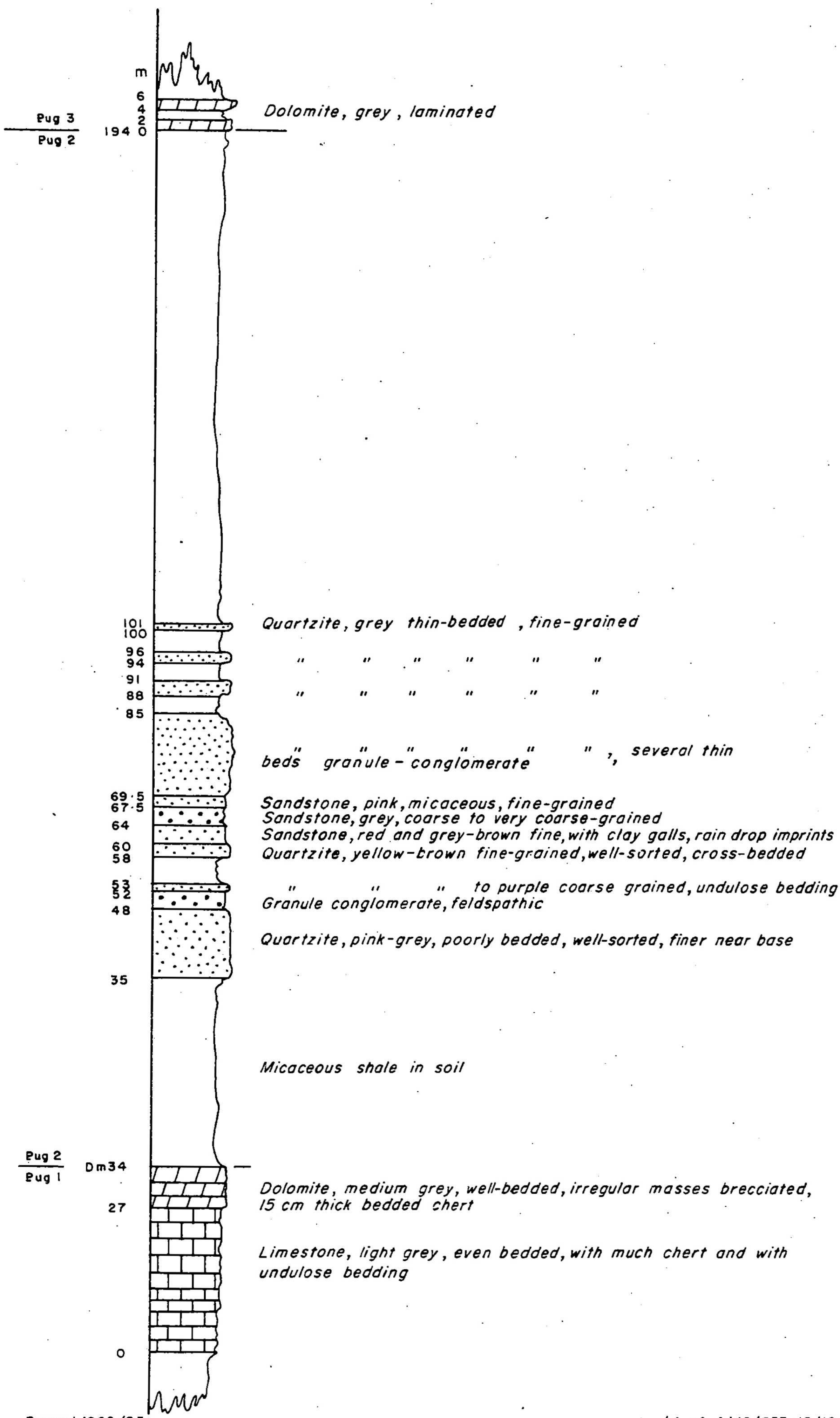


Fig. 7D Measured Reference Section, Bitter Springs Formation (Gillin Member)



The top of Pug[1] is defined as the top of the uppermost carbonate beds. At the reference section the overlying rocks are not exposed, but micaceous shale float occurs in the soil stratigraphically below poorly bedded quartzitic sandstone.

Pug[2] Consists of quartzitic sandstone and granule conglomerate interbedded with red or purple to green laminated siltstone and micaceous shale (Fig. 7D). The more indurated quartzitic sandstones form prominent ridge cappings. In the upper part of the unit they are ferruginous and have dark red photo-colour. The beds range from less than one to fifteen metres thick. Clay galls and fossil raindrop imprints occur in a sandstone bed 64 m to 67.5 m above the base (Fig. 7D). A granule conglomerate near the base contains poorly rounded phenoclasts of gneiss (?) and feldspar (FP 0703).

In the measured section some 80 percent of the 194 m thickness is recessive and soil covered. The recessive zone is thought to correspond to green to red to purple laminated siltstone and micaceous shale.

In the northern part of the outcrop-area the upper part consists of thin to medium beds of yellow, laminated limestone intercalated with green and red or purple laminated siltstone. Three kilometres northwest of the reference section the upper part of the unit is capped with a laterite crust.

In a fault block near Atniempa waterhole on the Hale River, a 500 m thick sequence of poorly bedded, cross-bedded feldspathic sandstone to granule conglomerate is considered to belong to Unit 2.

The top of Unit 2 is defined as the top of the uppermost fine-grained micaceous sandstone. In the reference section this underlies 2 m of grey to purple coloured siltstone which underlies 2 m of grey dolomite.

Pug^{3} is the lower of the two 'tramline' units. These are characterised by alternation of beds composed of resistant, and hence prominently outcropping carbonates and more readily weathered, and hence recessive siltstone (Fig. 7B, C). Bed thicknesses range from 2 m to over 15 m. Airphotos show these resistant beds as lines along the unit.

Stromatolites are common in the carbonates, particularly towards the top of the unit. Laminations in these are commonly wavy and develop into low domes. Locally branching columns occur and are up to 20 cm in diameter and 30 cm tall. Intercolumnar sediments commonly consist of a poorly bedded carbonate matrix with coarse-grained, well-rounded disseminated quartz sand. Rarely the sand occurs as a close-packed framework.

Gypsum at GR LIMBLA 170847 (FP 750) is thought to be a bedded deposit. However, because of very poor exposure the nature of the gypsum is not readily identifiable and drilling would be required to confirm its occurrence. Other gypsum occurrences at Oolera Spring and west of Limbla homestead are thought to be surficial deposits.

Chert in this section is commonly black, moderately well-bedded and lenticular. In the measured section it grades from this type to irregular nodular chert over several metres of section.

In the reference section Pug^{3} is composed of 215 m of grey limestone or dolomite in beds ranging from one to 19 metres in thickness occurring in grey to chocolate or purple siltstone.

Pug^{4} The base of this unit is a sandstone bed, less than on metre thick, which overlies the uppermost dolomite of Pug^{3}. The sandstone is overlain by 68 m of yellow laminated limestone with interlaminations of silt, small amounts of thin-bedded pale grey dolomite and limestone and, near the top, some oolitic beds; 37 m of yellow thin to medium-bedded limestone, grey dolomite and silty sandstone with silt interlaminations; 193 m of ripple marked and cross-bedded sandstone to ortho-quartzite with pebble conglomerate and arkose, calcareous sandstone and ferruginous sandstone (Fig. 7A, 7B). Approximately 70 m of the 193 m thick sandstone sequence visible along strike is not exposed at the reference section. It is thought to consists of siltstone as in the uppermost 15 m of section. Some of the limestone is oolitic. The top of the unit is defined as the base of the lowest carbonate bed in Pug⁵.

Pug[5] This is the uppermost unit in the Gillen Member. It is composed of dolomite and limestone intercalated with siltstone (Fig. 7A). At the reference section its top is not exposed. Elsewhere, the boundary between the Gillen Member and the overlying Loves Creek Member is exposed and from examining these sites it is thought that very little is missing at the top of the reference section. Like Pug[3], unit Pug[5] has a 'tramline' appearance on air photographs, but differs from the lower sub-unit in that colour contrast is stronger between the beds. The sub-unit is more dolomitic than Pub[3] and it was not observed to contain stromatolites. Cherts in this sub-unit are black to dark grey, but commonly have a rust-coloured weathered surface.

At the base 41 m of thickly interbedded laminated micaceous silstone and shale, and yellow and pink laminated limestone is overlain by 9 m of soil covered (?) siltstone, 9 m of coarse-grained sandstone, 20 m of soil covered (?) silstone, and 60 m of very thickly interbedded dark grey dolomite and laminated micaceous siltstone. Stromatolites were not observed within this unit.

TOP

Structure and metamorphism: Discussed in the description of the Bitter Springs Formation.

Relationships: The Member conformably overlies the Heavitree Quartzite and is generally conformably overlain by the Loves Creek Member. In one region the Member is overlain by the Pioneer Sandstone with an angular unconformity or a disconformity.

Correlation and age: Discussed under Bitter Springs Formation.

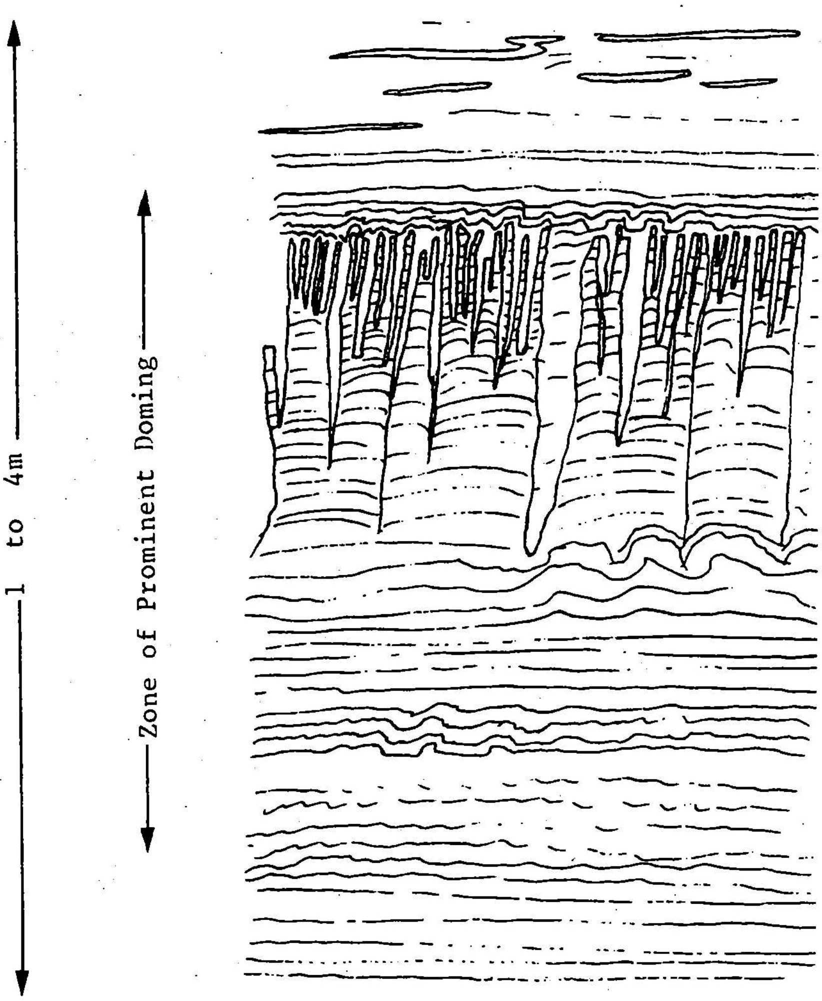


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Fig.8 Schematic Illustration of some of Loves Creek Member Stromatolites. Only one cycle shown.

Loves Creek Member of the Bitter Springs Formation (formal)

Map Symbol: Pue

Nomenclature: Named by Wells & others (1967) after Loves Creek.

Distribution: Crops out (1) east of Waldo Pedlar Bore (2) west of Limbla homestead as two well-defined northwest-trending belts (3) west of Dead Horse waterhole in a structurally complex area and (4) east of Ringwood homestead (which is in the Alice Springs Sheet area).

Type area: Ellery Creek is the type locality, but the reference section used by Wells & other (1967) to define the Member was compiled from several localities. The reference section in LIMBLA for the lower, thick, stromatolitic dolomite (Ꝑue^1) part is west of Limbla homestead. The upper part (Ꝑue^2), consisting of pink siltstone with stromatolitic dolomite beds, was recorded on this Sheet area only on the western boundary in the Mulga Syncline where it is below a regional disconformity. This upper unit may be more extensive but it is easily weathered and hence does not crop out. The upper and lower units (Ꝑue^1, Ꝑue^2) are not differentiated on the compilation sheets.

Topographic expression and airphoto characteristics: The lower unit forms a prominent strike ridge but the upper unit typically forms a valley with discontinuous, low ridges within it. On the colour airphotos Ꝑue^1 occurs as a medium to brown massive-looking outcrop commonly speckled with moderate vegetation cover (Acacia spp. & Eremophila spp. shrubs) but the upper Ꝑue^2. occupies an evenly textured region with thin dark bands in a dark pink to pale red background.

General lithology: The basal part of the Member is a thick, prominently outcropping limestones or dolomite containing abundant stromatolites (Fig. 8) and, particularly above the main stromatolite bistromes, ubiquitious lenses of well-bedded chert.

Characteristic morphology of the stromatolites is shown in the attached Figure 8. Only one cycle is shown but up to five cycles were observed in outcrop. Each cycle is though to represent a sequence shallowing upwards. Overlying this dolomite is a thick unit of calcareous, pink, poorly bedded siltstone. Conspicuous round to oval patches of sharply defined, white to very light pink siltstone occur in the darker matrix. They may be caused by a redox reaction. At FP 2252 (LIMBLA, FR241666), pink breccia consists of clasts of pink siltstone and grey dolomite up to 60 cm in diameter, in a pink siltstone matrix which contains small aggregates of sericite. Spilitic lava occurs at several localities within the Loves Creek Member as dark, finely mottled, pale green, poorly bedded volcanic rock. It commonly occurs with a dark red, ferruginous, poorly bedded, calcareous siltstone which forms prominent dark red to black distinctive ridges. The spilite is only a few metres thick and occurs at various stratigraphic levels throughout the area. At FP 2250 (LIMBLA, GR 241619) a small outcrop of carbonate breccia along strike from a spilite bed contains trace amounts of malachite. At FP 0875 (LIMBLA, GR 036647) a very poor outcrop of dolerite occurs within Loves Creek Member rocks. This may be just a small basic plug but is could be a conduit through which the parent magma forming the spilites could have passed.

Structure and metamorphism: The Loves Creek Member has not been involved in complex folding and overthrust-faulting like the Gillen Member, except near Limbla homestead where it has several strike-slip faults within it. Metamorphism is discussed in the section on the Bitter Springs Formation.

Relationships: The Member conformably overlies the Gillen Member and is disconformably overlain by the Areyonga Formation and locally disconformably overlain by the Pioneer Sandstone.

Areyonga Formation (formal)
(Compiled from field descriptions by A.T. Wells)

Map Symbol: Pua.

Nomenclature: Originally defined by Prichard & Quinlan (1962) and named after Areyonga Settlement. Redefined by Preiss & others (1978) because a disconformity was recognised between the upper sandstone unit (Pioneer Sandstone) and the lower unit (Areyonga Formation). In the type section the redefined Areyonga Formation consists of diamictite, sandstone, dolomitic arkose, conglomerate and dolomite; with dolomitic silty shale at the top.

Distribution: In the Limbla Syncline and as a northwest striking belt immediately east and north of Waldo Pedlar Bore in the southwest corner of the Sheet area.

Type section: Ellery Creek; Hermannsburg Sheet area. Best exposed section in Illogwa Creek Sheet area is about 5 km northeast of Bronco Bore in LIMBLA.

Thickness: About 600 m in the Limbla Syncline (Fig. 14), northeast of Bronco Bore (estimate from aerial photos).

Topographic expression and airphoto characteristics: Forms an undulating region of poor relief. Lower siltstone units are commonly yellowish on the coloured airphotos. Upper more pebbly sandstone-siltstone units, containing diamictite, are red-brown on the coloured airphotos.

General lithology: Siltstone with some erratics and poorly sorted, feldspathic sandstone with micaceous and pyritic conglomerate lenses. Small amounts of diamictite. Dark grey cap dolomite reported and described by Preiss & others (1978). The erratics suggest that the siltstone and diamictite are of glacial origin.

Detailed lithology: Best exposed section northeast of Bronco Bore.

TOP

? Dark grey cap dolomite (thickness uncertain)

85 m Micaceous, grey-green siltstone (st) with a few boulders up to 0.5 m across and subordinate interbeds of fine-grained, dark grey to grey brown, thick-bedded sandstone (ss), which grades locally into coarse-grained, slightly pebbly sandstone.
(FPS 2530, 2531)

235 m Dark grey to green-grey, medium to coarse-grained sandstone (ss), commonly containing weathered feldspar fragments, and in some places containing scattered pebbles, in other places clay galls, and in very rare localities pseudomorphs after pyrite. Non-bedded diamictite (tl) with boulders of gneiss and quartzite up to 2 m across grades into siltstone with conglomerate lenses. Less common boulder types include granite, chert, dolomite, and silty sandstone. Striated cobbles at FPS 2550 and 2549. Minor grey, fine-grained sandstone (ss), commonly either cross-laminated or platy.
(FPS 2520, 2533, 2534)

280 m Red-brown and grey-brown (less commonly yellow) pebbly siltstone (st) and subordinate fine-grained conglomeratic silty sandstone (ss) intercalated with a number of thin, grey boulder beds (tl?). Discontinuous lenses of white, medium to coarse-grained feldspathic sandstone (ss) at base (FPS 2527, 2528B, 2529, 2537, 2538).

BASE

Structure and metamorphism: In Limbla Syncline and as a shallow (20°?) southwest-dipping sequence near Waldo Pedlar Bore. Not metamorphosed.

Relationships: Disconformably overlies Bitter Spring Formation (Pub) and conformably overlain by Aralka Formation (Puk).

Age: The lower of the two glacial units, which are widely represented in the Late Proterozoic of Australia. Thought to be between 800-700 m.y. (cf. Preiss & others, 1978, p.50).

<u>Correlations</u>: Correlated with Naburula Formation in the northern Ngalia Basin and the Stuartian tillite in the Adelaide Geosyncline (Preiss & others, 1978). Possibly equivalent to diamictite in Boord Formation and Inindia Beds of the southern Amadeus Basin (Wells, in press).

<u>Remarks</u>: North of Waldo Pedlar Bore the Areyonga Formation is separated from the underlying Loves Creek Member by a ferruginous cherty horizon of less than 1 m to 3 m thick. It is brecciated in parts and re-cemented with silica and ironstone. It may be a palaeosoil.

Brief notes on the Aralka Formation (including Ringwood Member) , Olympic Formation, Pioneer Sandstone, and Pertatataka Formation (including Waldo Pedlar Member) (formal units)

Only a minimal amount of work was carried out on these units during the present survey.

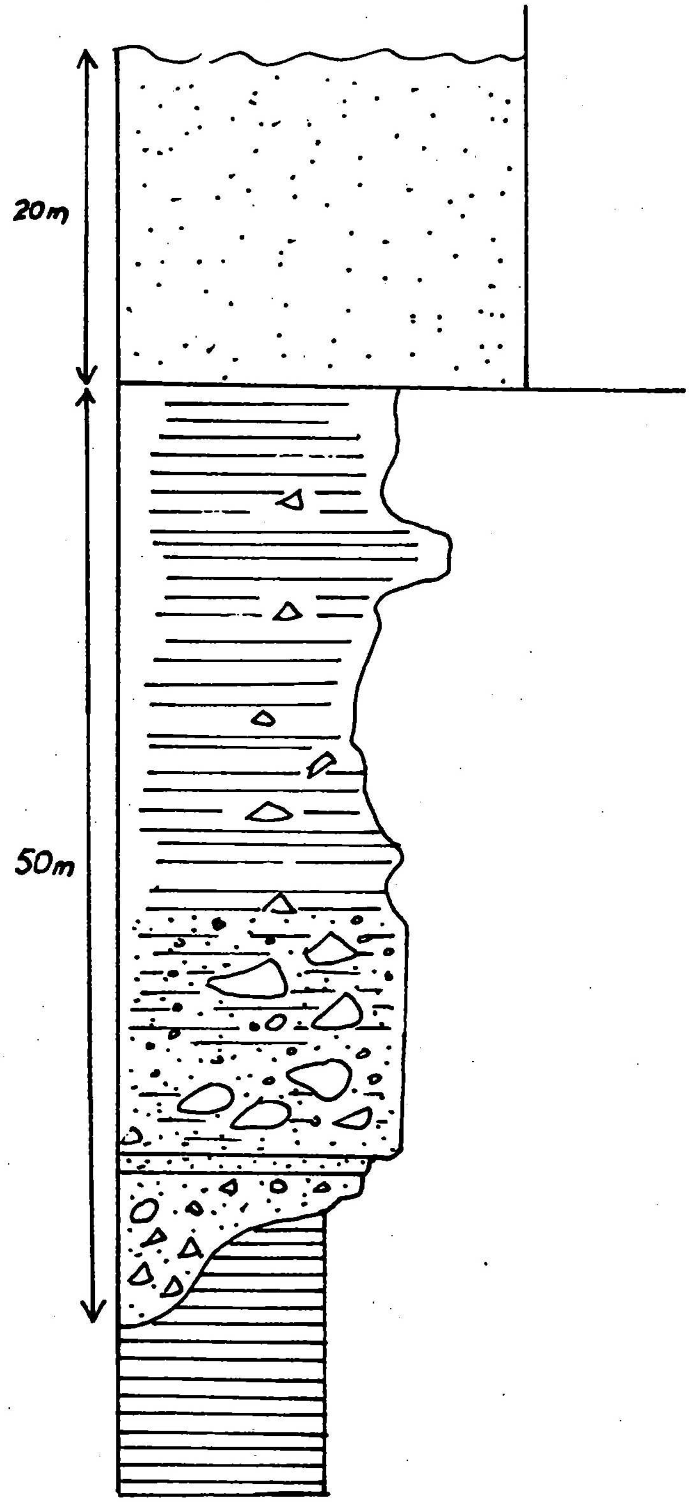
The Aralka Formation (Ꞓuk) consists of siltstone and shale with interbedded oolitic or stromatolitic carbonates and laminated, fine-grained sandstone. It conformably overlies the upper, aphanitic, pink dolomite of the Areyonga Formation. At the type section, 6.4 km south east of Ringwood homestead in the Alice Springs Sheet area, the formation is approximately 1020 m thick. In the central part of the formation, the Ringwood Member (Ꞓur) consists of oolitic and pellet limestone interbedded with siltstone and thin bands of conglomerate. The Ringwood Member is 166 m thick at the type section. Limestone and dolomite beds occur at a number of stratigraphic levels throughout the formation; 3 km west-south-west of Dead Horse waterhole carbonates form a unit about 50 m thick near the top of the Aralka Formation.

The Limbla Member (Ꞓum) occurs at the top of the Aralka Formation. At the type locality it is a 144 m thick, cross-laminated, calcareous sandstone. Three kilometers west-southwest of Dead Horse waterhole, the lower part of the Aralka Formation is composed of thin-bedded, yellow, current-bedded sandstone containing 2-3 percent feldspar. The upper part here is red, thin-bedded, festoon cross-bedded, quartz sandstone. Several beds have intricate slump structures and the upper part is pebbly.

The Olympic Formation (Ꞓuf) consists of diamicite. Some of the boulders are faceted, some striated. The Olympic Formation lies on the Limbla Member with apparent conformity at most sites known, but at the only exposure in the Illogwa Creek Sheet area, 3 km west-southwest of Dead Horse waterhole, it rests with a marked disconformity on red weathering, laminated siltstone and shale of the Aralka Formation (Fig. 9). A disconformity is indicated by an infilled scour channel up to 20 m across and 5 m deep cut into the Aralka siltstone. A bed of diamictite about half a metre thick at the base of the formation is overlain by 1 m of clayey silty sandstone, then by about 50 m of diamictite. The diamictite contains boulders up to 1 m diameter near the base and fines upwards, grading into the overlying green, laminated siltstone with scattered cobbles, pebbles and sand-sized grains. The siltstone is approximately 50 m thick. It is overlain by the Pioneer Sandstone.

The Pioneer Sandstone (Pux) consists of medium to coarse-grained sandstone which is feldspathic in places. At GR 726043 it overlies the Gillen Member of the Bitter Springs Formation along the eastern margin of the Mulga Syncline. It is unknown in the section east of Bronco Bore, but small outliers of Pioneer Sandstone rest disconformably on the Loves Creek Member of the Bitter Springs Formation several kilometres northwest of Bronco Bore. Preiss & others (1978) correlate the Pioneer Sandstone with the Olympic Formation. However, at one locality 3 km of Dead Horse Waterhole the Pioneer Sandstone rest on the Olympic Formation (Fig. 9).

The Pertatataka Formation: Recorded by Wells & others (1967) as mainly siltstone and some sandstone. Exposures in LIMBLA are rare. A small outcrop of the Waldo Pedlar Member (Pul) in the southwest corner of LIMBLA consists of thin bedded to laminated fine sandstone. A few discontinuous ridges 12 km northeast of Moonlight Bore have been photo-interpreted as sandstone; they occur in a similar stratigraphic position of the Waldo Pedlar Member of the Pertatataka Formation.



Pioneer Sandstone, medium-grained to coarse-grained feldspathic to arkosic quartz sandstone, slightly coarser near base.

Olympic Formation, diamictite, angular phenoclasts up to 1.5 m diameter through to sand in green shale or siltstone matrix. Proportion of boulders and sand to matrix decreases upwards from base. Bedding ill-defined near base. Fifty centimetre thick sandstone bed near base. Erosional base with scour channel, infilled with diamictite, 20 m across 5 m deep.

Aralka Formation, shale, pink to purple - weathering grey to purple-grey, thinly-laminated, micaceous shale with several thin beds at laminated fine-grained quartz sandstone.

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Fig. 9 Sketch section of Aralka Formation - Pioneer Sandstone interval. 3 km WSW Dead Horse Waterhole

Julie Formation

Map Symbols: Ꝑuj$_{ss}$, Ꝑuj$_{dm}$.

Nomenclature: Originally named Julie Member of Pertatataka Formation by Wells & others (1967) after Julie Dam in the Alice Springs Sheet area. Status upgraded to Formation by Preiss & others (1978).

Distribution: Crops out in the core of a gentle anticline 25 km east-northeast of Moonlight Bore in south-central LIMBLA. Southern limb extends to 10 km east-southeast of Moonlight Bore.

Type Section: At Ross River Chalet in Alice Springs Sheet area.

Thickness: In this Sheet area 200 m estimated from aerial photos; 128 m in type section.

Topographic expression and airphoto characteristics: Low, discontinuous ridges; pale grey on black and white airphotos.

General lithology: A unit characterised by oolitic dolomite (Ꝑuj$_{dm}$) is underlain by a pale brown to red-brown sandstone unit (Ꝑuj$_{ss}$). Both units contain interbedded siltstone and are capped by thin, white sandstone.

Detailed lithology:

Oolitic dolomite (dm) is pale grey or greenish-grey on fresh surfaces but typically has a yellow, pink or pale-brown surface coating. The dolomite is made up of pellets and some oolites, commonly 3 mm across, some of which have sand grains at their centres. It is generally medium to thick bedded. Minor related rock types are massive cryptocrystalline dolomite, and dolomitic sandstone.

Sandstone (ss). Two types of sandstone are present: one (a) underlying the oolitic dolomite and the other (b) a thin unit overlying the dolomite and the lower sandstone. The underlying sandstone (a) is red-brown, pale brown, grey-brown or grey, fine to medium-grained, rarely coarse-grained, and in places displays abundant ripple marks, cross-bedding. Some contains clay galls. The sandstone is kaolinitic and in places micaceous. Locally it has a dolomitic cement.

Sandstone (b) at the top of both Puj_{dm} and Puj_{ss} is white or yellow-white, micaceous, medium to coarse-grained, cross-bedded and slumped in places. It is less commonly fine-grained, thin-bedded, and lacking in cross-beds.

Siltstone is red-brown, purple, olivine-green to pale green, rarely blue-green laminated, and typically micaceous.

Limestone is rare. It is purple-brown to brown, cryptocrystalline, and contains chert in places.

Structure: The formation is folded into an anticline plunging slightly north of east. Limbs dip up to 10°, but are commonly less than 5°.

Relationships: Underlies the Arumbera Sandstone with a gradational contact. The lower sandstone unit, Puj_{ss}, contains rock very similar to sandstone in the Arumbera Sandstone. The formation conformably overlies the Pertatataka Formation.

Age: Inferred to be Late Proterozoic. Occurs stratigraphically above the younger of two glacial units in the Alice Sprins Sheet area (Preiss & others, 1978; Wells & others, 1967). Directly underlain by Pertatataka Formation, which may be about 700-600 m.y. (see discussion in Preiss & others, 1978). Overlain by Arumbera Sandstone, which is considered to straddle the Cambrian-Precambrian boundary (Daily, 1972).

Arumbera Sandstone

Map Symbol: Pєa.

Nomenclature: Originally named Arumbera Greywacke by Prichard & Quinlan (1962); redefined as Arumbera Sandstone by Wells & others (1967). 'Arumbera' means 'red' in the Aranda language.

Distribution: On the flanks of a gently dipping anticline 12 km northwest and 16 km east of Moonlight Bore in central-southern LIMBLA. Also in a gently southeast-dipping sequence 10 km southeast of Perseverance Bore.

Type section: In Ellery Creek in the Hermannsburg Sheet area.

Thickness: Estimated from airphotos to be 400 m. Three hundred and thirty five metres at Ross River Chalet and 820 m in the Phillipson Pound both in the Alice Springs Sheet area.

Topographic expression and airphoto characteristics: A series of mesas and low hills with steep scarps on the up-dip side. Forms two ridges northeast of Moonlight Bore. The unit generally has a dark photo-pattern.

General lithology: Northeast of Moonlight Bore the Formation can be divided into three units which correspond with Pєa1, 2 and 3 shown on the 2nd Edition 1:250 000 map of Alice Springs. The three units are:

(1) Lower ridge-forming sandstone about 60 m thick. It is a white to yellow, fine to medium-grained sandstone interbedded with subordinate red and white siltstone; overlain by 60 m of pale grey and purple-brown, medium to coarse-grained sandstone containing some clay galls.

(2) A largely concealed siltstone unit is estimated to be about 100 m thick. Green and some red siltstone intercalated with fine-grained, pale grey sandstone at the top of the unit.

(3) Ridge forming sandstone which is purple-brown to pale brown, medium to coarse-grained and kaolinitic. It contains clay galls and is notably slumped and cross-bedded in places. It is estimated to be about 180 m thick.

A similar sequence southeast of Perseverence Bore appears to be slightly finer grained and is not so obviously slumped in its upper part. It includes a very thin brown limestone bed and is unconformably overlain by about 7 m of fine pebble conglomerate which is assigned to the Hooray Sandstone.

Detailed lithology:

Sandstone occurs as two varieties:

(1) The sandstone in the lower ridge. It is a pale grey white, to yellow, fine to medium-grained sandstone, which is locally micaceous and calcareous and shows few cross-beds and slumps.

(2) The sandstone in the upper ridge. It is a medium to coarse-grained sandstone which is typically purple-brown, kaolinitic, contains clay galls and is notably slumped and cross-bedded in places.

Siltstone occurs as red-brown to white varieties in the lower ridge, but is commonly green in the middle recessive interval. Locally micaceous.

Structure: The units outlines an east-trending anticline. Dips on the northern limb of the anticline steepen towards a fault which separates the unit from Arunta Block (i.e. basement) to the north. On the southern limb of the anticline the dips are consistently shallow to the southeast.

Relationships: Conformably overlies the Julie Formation with a transitional contact. The sandstone subunit in the lower part of the Julie Formation is very like the Arumbera Sandstone. The Arumbera Sandstone appears to be disconformably overlain by the Lower Jurassic to Upper Cretaceous Hooray Sandstone.

Daily (1972) suggested that a disconformity may occur at the base of the middle siltstone unit, PЄa_2, in the Alice Springs Sheet area, but this has yet to be confirmed by detailed studies.

Age: Considered to straddle the Cambrian-Precambrian boundary (Daily, 1972). Impressions of the trace fossil Rangea arborea have been identified in the unit in the Alice Spring Sheet area by Glaessner (1969) and Taylor (1959; in Wells & others, 1967). The basal sandstone in the Rodinga Sheet area contains impressions of soft-bodied metazoans (Ediacara fauna) considered to be late Precambrian whereas the upper parts contain a variety of trace fossils assigned to the Early Cambrian (Glaessner, 1969; Glaessner & Walter, 1975).

Orthoquartzite of unknown affinity (Pz?), 70 km east-southeast of Junction Bore

A shallowly dipping siliceous, medium-grained orthoquartzite crops out at FP 1122. The orthoquartzite is medium-bedded and has fine cross-laminations and contains rare pyrite? casts. It is interbedded with minor fine-grained laminated orthoquartzite and rare medium-brown siltstone. Slight metamorphism is suggested by both very thin quartz veins lining some joints in the sandstone and traces of sericite in the siltstone. The unit is unlike any in either the Arunta Block or the Amadeus Basin sequence. It is lithologically most like the Ordovician Stairway Sandstone of the Amadeus Basin and on this basis it is assumed to be Palaeozoic, although a Proterozoic age cannot be discounted.

Mesozoic sediments

Hooray Sandstone (formal)

Map symbol: JKh

Nomenclature: Named after Hooray Creek, 19 km northeast of Tambo township, Tambo Sheet area, Queensland. Name published first by Hill & Denmead, (1960, p. 311); Exon, (1966); usage extended by Senior & others (1978, plate 1).

Distribution: In southeastern part of Sheet area.

Type Section: Hooray Creek; see Exon & others (1972, Fig. 15, p. 54).

Thickness: Northwest margin of the Eromanga Basin up to 40 m and an estimated 50 to 100 m in the subsurface, southeast part of the Illogwa Creek Sheet area. In the axial part of the Eromanga Basin the apparent thickness is 200 to 300 m.

Topographic expression and airphoto characteristics: Forms clusters of small steep-sided hills with up to 30 m relief. Indentified on aerial photographs by dark-tones, due to intense ferruginisation of the upper 1 to 5 m of the outcrops.

General lithology: Quartzose sandstone with pebble conglomerate and minor siltstone.

Detailed lithology: Medium to coarse, moderately indurated quartzose arenite with a kaolinitic matrix. Thin to medium-bedded, commonly conglomeratic, with high-angle cross-stratification. The upper part of most outcrops is altered to dense black and brown ironstone, formed by precipitation of iron-oxides within former porous and permeable zones. Less commonly the sandstone is silicified, and contains irregular lens-like bodies of hard grey silcrete. In places, such as FP 0052, this silcrete includes sinous tabular cavities which appear to have resulted from selective groundwater solution.

Structure: Flat-lying. Prevailing regional dip probably in the order of 1 to 2° southeast.

Relationships: Part of the Jurassic to Cretaceous Eromanga Basin sequence. In the Illogwa Creek Sheet area this formation thins and wedges-out northwestwards. Near its truncated margin it thins and infills irregularities on unconformably underlying Arunta Block metamorphics and steeply dipping metasediments. In places such as FPS 0053 and 0060, the angular unconformity is clearly exposed.

Age: Late Jurassic to Early Cretaceous determined by palynomorphs (Evans & Burger in Exon and others, 1972) identified elsewhere in the Eromanga Basin. Traces of plant debris occur, notably at FP 0058.

Tertiary Sediments

Unnamed Tertiary sediments

Map Symbol: Ta. No outcrops: known subsurface (Fig. 10).

Nomenclature: Unnamed. Symbol first used is Alcoota Sheet area by Shaw & Warren (1975).

Distribution: Known only in subsurface core north from Illogwa Bore (BMR 1, 2 & 3 Figs. 11-13) to near New Block Diamond Bore.

Thickness: Up to 250 m in drill holes.

General lithology: Soft red and green siltstone, claystone, and friable lithic sandstone, with lesser quartzose sandstone and conglomerate. Carbonaceous matter, gypsum and lateritic ironstone are present locally with calcareous lenses and pedomorpholiths at shallow depths. The sequence grades up into aeolian and alluvial Quaternary sediments.

Detailed lithology: Based on results from 18 holes drilled by Agip Nucleare (1979), core drilling in three holes by BMR (Figs. 11-13), and one by the Northern Territory Geological Survey (NTGS Gidyea No. 1) this sequence is divided into five units (Fig. 10).

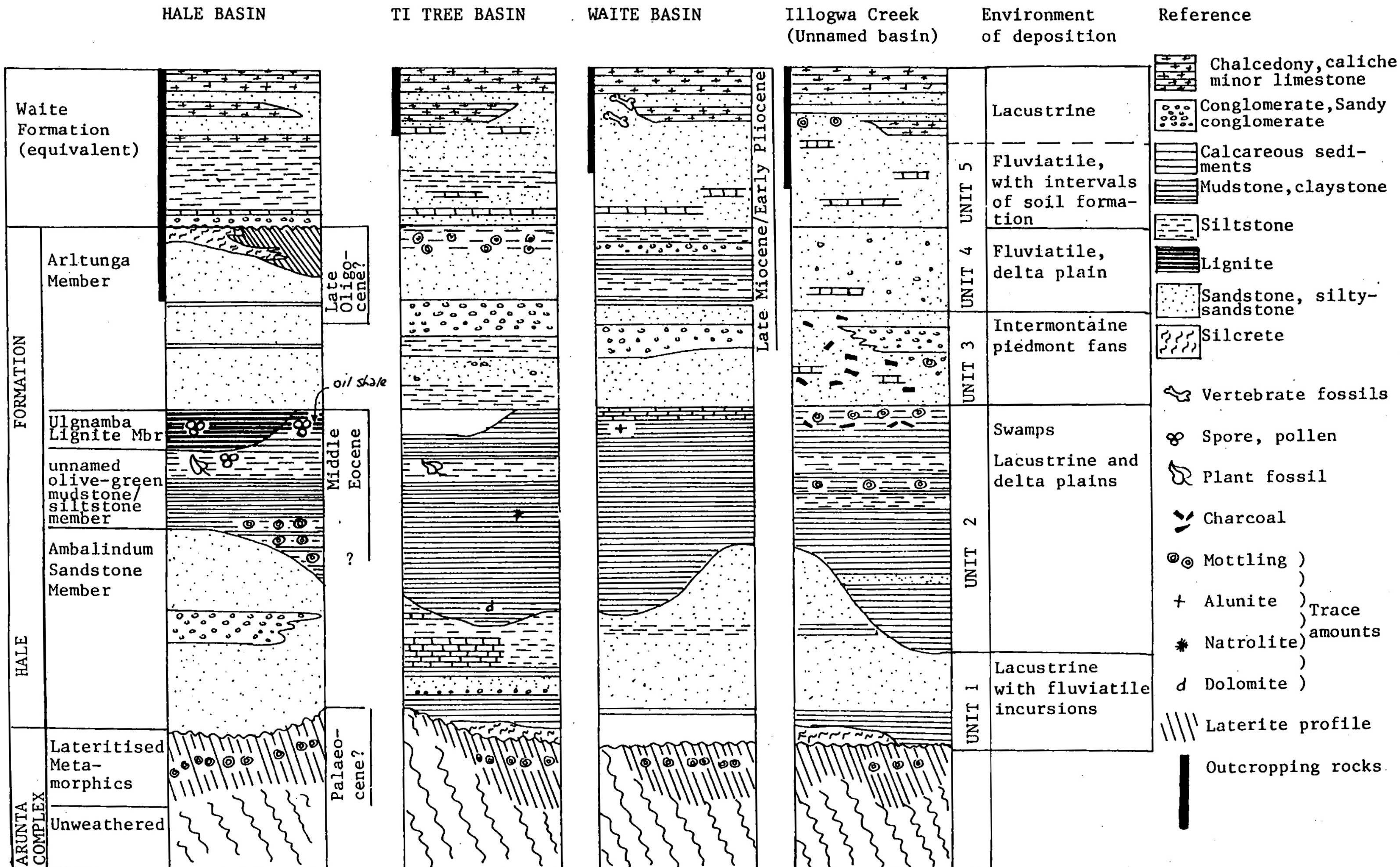

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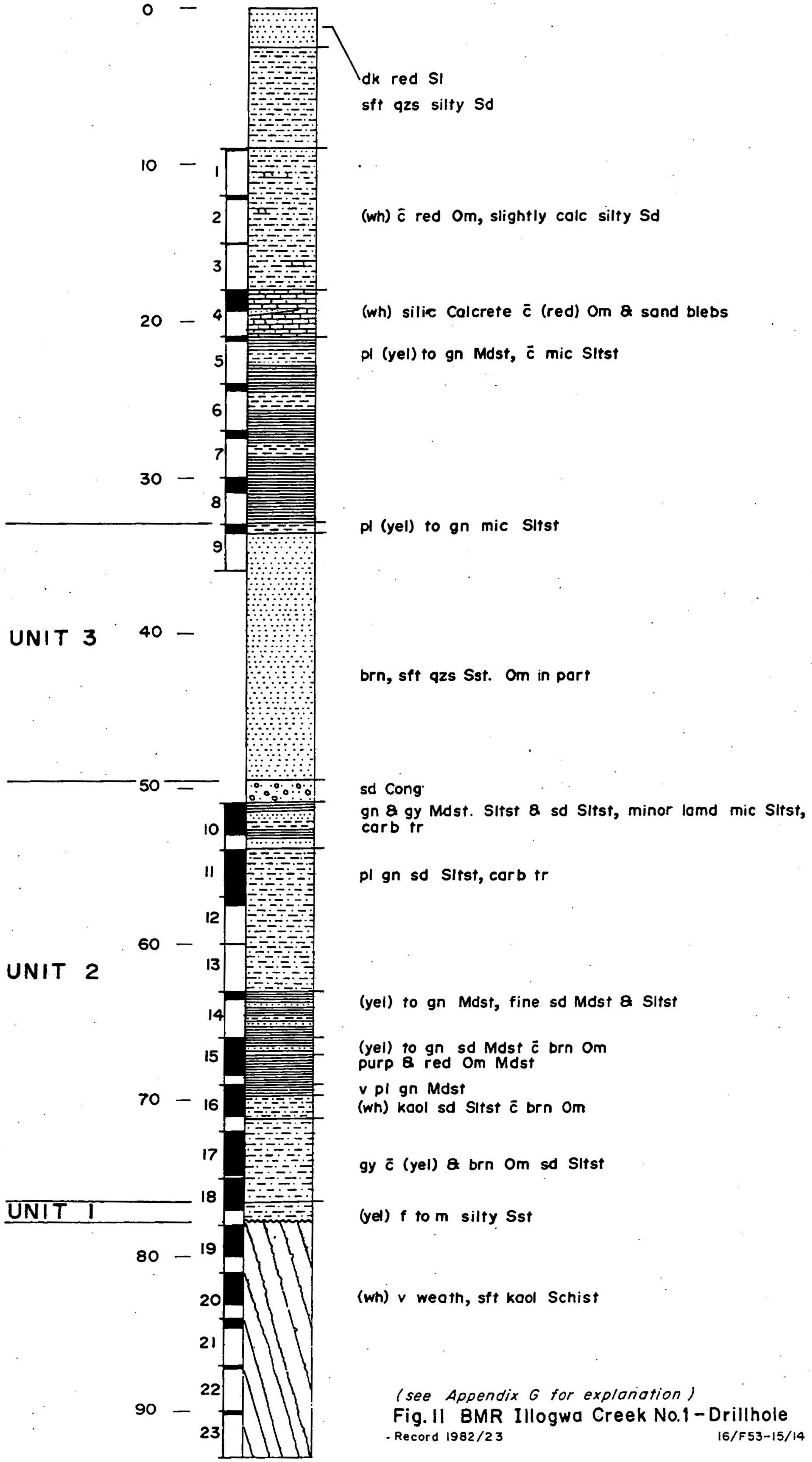
Fig. 10 Diagrammatic correlation of Tertiary rock units in the Alice Springs region. These composite sections represent the rock sequences of the axial zones of the four basins.



(see Appendix G for explanation)

Fig. 11 BMR Illogwa Creek No.1 - Drillhole

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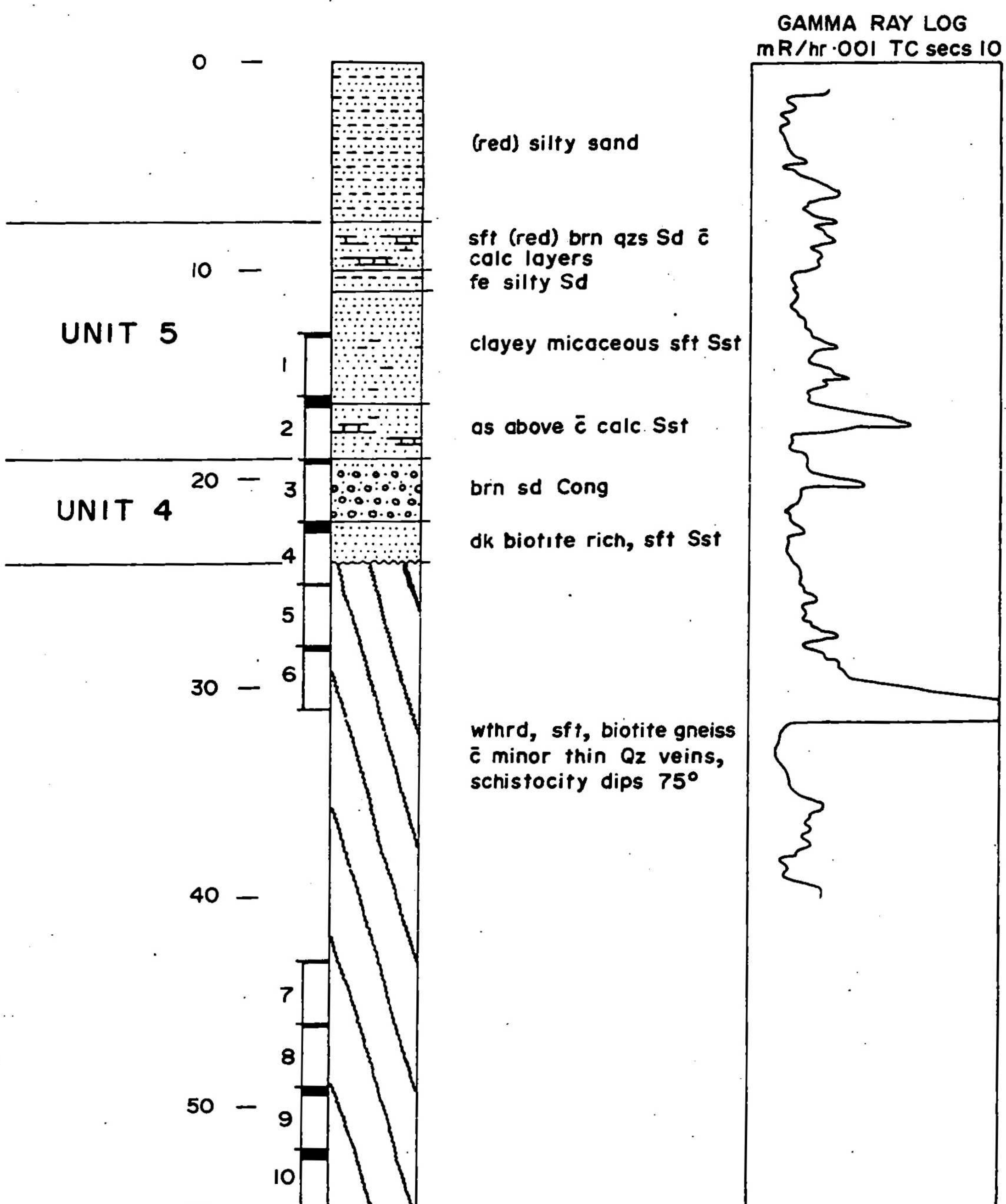

(see Appendix G for explanation)

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Fig. 12 BMR Illogwa Creek No.2-Drillhole

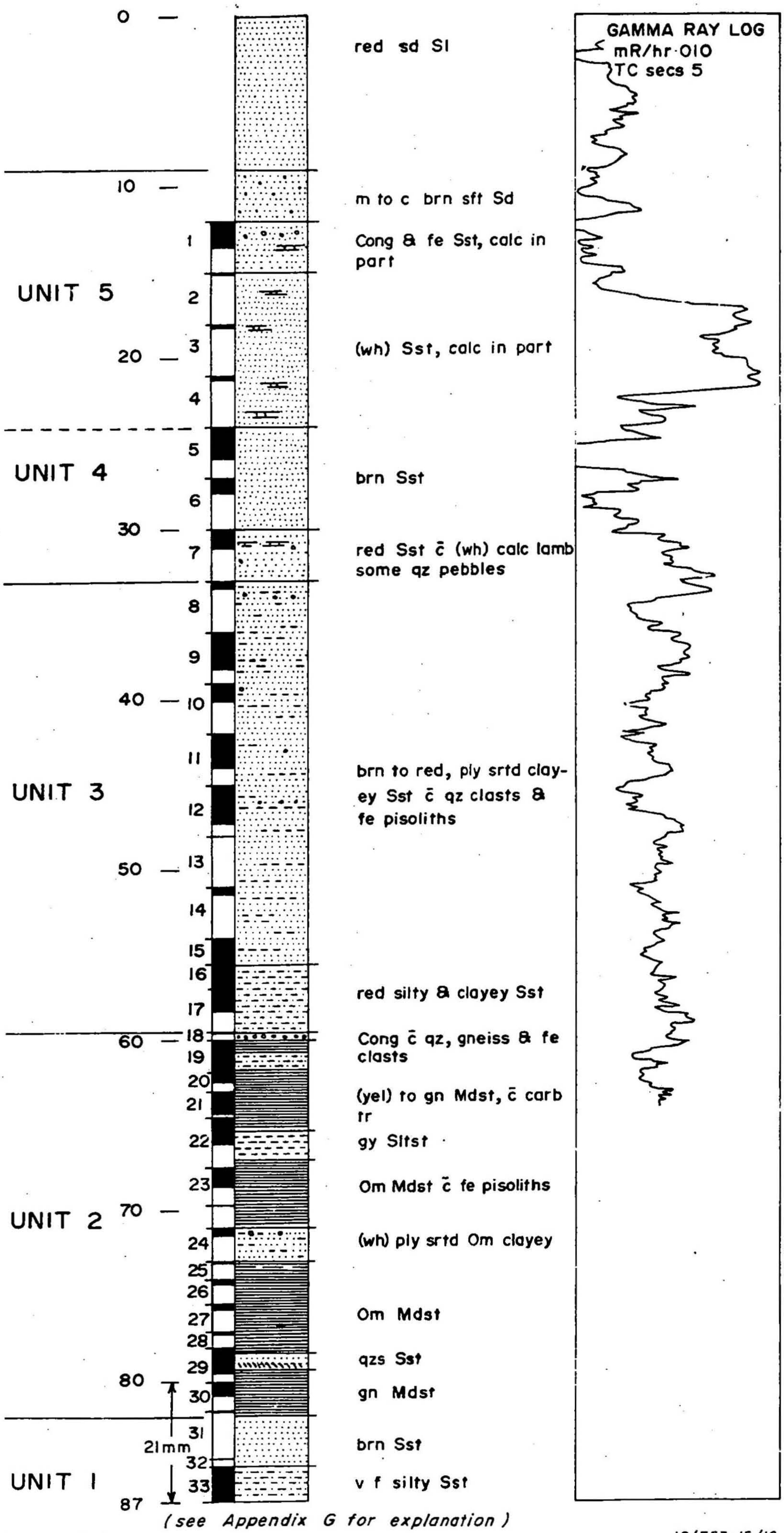

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Fig. 13 BMR Illogwa Creek No. 3 - Drillhole

Unit 1. The basal unit consists of lateritised red-brown and yellowish claystone interbedded with reddish quartzose sandstone, some silcrete, and white or greenish claystone. This sequence is up to 20 m thick.

Unit 2. This unit is composed mostly of olive and green claystone with interbeds of quartzose sandstone and minor red-brown siltstone. Gypsum and carbonaceous fragments occur locally. Unit 2 is up to 144 m thick and grades through a mottled zone into Unit 3.

Unit 3. Oxidised red-brown silty and clayey sandstone, with some layers of quartzose sandstone are diagnostic of this unit. Fragments of lateritic ironstone and rare charcoal-like carbonaceous matter also occur. This unit ranges in thickness from less than 20 m (DH's IR6 and IR9), to more than 100 m (DH's IR11 and 12). A prominent coarse quartzose sand, 10-15 m thick, is widespread and generally occurs at depths of 50 to 60 m below the surface.

Unit 4. This unit is widely distributed and consists of up to 21 m of medium, brownish, coarse or very coarse quartz-lithic sandstone. The sandstone is generally clean, in places it contains brown clay.

Unit 5. The upper unit consists of red-brown silty sandstone with thin, dirty, calcareous layers and nodules of probable pedogenic origin. Plant fragments were noted at a depth of 18 m in BMR Illogwa Creek 3. This unit ranges in thickness from 4 to 15 m and grades up into the Waite Formation or into dark red-brown Quaternary sediments.

Structure: Flat-lying sediments occupy a southeast-trending depression the axis of which approximates the present-day position of Aremra Creek. Thick Cainozoic sediments (>100 m) in the vicinity of Gidgea Bore (1979 drilling by Northern Territory Department of Mines and Energy) and Indianna New Black Diamond water bore may represent separate basement depressions or lobes of a much more extensive Cainozoic sequence which remains largely concealed below the northwest part of the Simpson Desert.

Relationships: Unconformable on schist and gneiss of the Arunta Block (BMR Illogwa Creek 1 & 2) and, in the southeast probably unconformable on Mesozoic rocks of the Eromanga Basin sequence. The sequence is overlain (probably conformably) by the Waite Formation (Fig. 10) or by unconsolidated Quaternary sediments.

Follows from p. 109

Laterite

Map Symbol: Tlf

Distribution: In eastern part of Sheet area

Lithology and origin: Decomposed, soft, kaolinitic Arunta Block metamorphics were intersected below unnamed Cainozoic sediments in BMR drillholes Illogwa Creek 1 and 2. These deeply weathered rocks extend eastwards where they crop out in the form of a laterite profile. The main area of preserved laterite is along the interfluve between Huckitta and Atula Creeks. Scattered occurrences are found throughout the Sheet area except for the steeper hilly country in the west.

The laterite is up to 30 m thick, composed of a lowermost kaolinised zone, an intermediate mottled zone, and a ferruginous upper zone.

Correlation and age: An identical profile (Tla) is described by Senior (1972) in the Alcoota Sheet area. The laterite previously formed a continuous lowland across Illogwa Creek and Alcoota Sheet areas. Palaeomagnetic dating of laterite from the Eromanga Basin indicates that it formed approximately 30 m.y. ago. if laterite chronology is similar to that in the Eromanga Basin (Idnurm & Senior, 1978). At the margins of the Cainozoic basins the laterite is overlain unconformably by Waite Formation, sediments which are Late Miocene in age as indicated by vertebrate fossils (Woodburne, 1967).

Waite Formation equivalents

Map Symbol: Tw.

Nomenclature: Waite Formation is named after Waite Creek, Alcoota station, Alcoota Sheet area. Symbol Tw is applied to correlated in the Illogwa Creek Sheet area. The name Waite Formation was published by Woodburne (1967), and Shaw & Warren (1975).

Distribution: In the eastern part of the Sheet area.

Type Section: Small mesa on the north side of Waite Creek located 6 km southwest of Alcoota station, and 15 km northeast of Mud Tank in the southern part of the Alcoota Sheet area.

Thickness: Up to 35 m in the Illogwa Creek Sheet area; the full thickness is nowhere exposed. Evidence from drill holes demonstrates that this formation grades down into unnamed, poorly sorted clastics and mudstones in excess of 200 m thick (see Ta - Unnamed Cainozoic sediments).

Topographic expression and airphoto characteristics: Forms extensive plateaus, mesas, and rounded pinnacle-like hills. Pale tones on aerial photographs are due to the presence of bedded white, cream or buff coloured chalcedony, which is prevalent in the upper part of this formation. Upstanding landforms have flat summits and prominant bounding escarpments formed by beds of resistant chalcedony.

General lithology: Mainly red and green silty sandstone with irregular calcareous nodules, travertine pelletoidal limestone, and massive chalcedony.

Detailed lithology: Interbedded, reddish or greenish silty sandstone, sandstone, siltstone, and minor sandy conglomerate. Derived pisoliths and laterite fragments occur near the base, particularly where this formation onlaps lateritised rocks of the Arunta Block. Massive, white, cream and grey chalcedony and minor limestone form steep-sided cappings up to 6 m thick to flat-topped landforms. In places this cap-rock diverges to form a multiplicity of chalcedonic layers. These layers are sandwiched between soft greenish-grey or reddish-brown siltstone and calcareous silty-sandstone.

The origin of the very abundant chalcedony in this sequence is not known. In places the chalcedony merges laterally or grades down into moderately hard grey or white limestone. The limestone contains veins and blebs of chalcedony. It is not certain whether the silica was chemically precipitated at the time of deposition or was the product of post-diagenetic silicification of former carbonates.

Structure: Nearly flat-lying unit. Summit levels slope gently southwards in the Illogwa Creek Sheet area and possibly reflects gentle downwarping in the Late Cainozoic towards the Lake Eyre Basin.

Relationships: Part of an extensive lacustrine and partly fluviatile sequence of probable Late Miocene and Early Pliocene age (Woodburne, 1967). Onlaps lateritised Arunta Block rocks at the periphery of the main basin of deposition, notably to the north and east of Hugh Dam. Elsewhere, this formation grades downwards into older Cainozoic sediments (Unit 1-4, Fig. 10).

Correlation and age: Unconformably overlies laterite which is correlated with laterite in the Eromanga Basin dated palaeomagnetically at 30 m.y. (Idnurm & Senior, 1978). Locally contains indeterminate plant debris. At the type section contains Late Miocene or Early Pliocene fossil vertebrates (Woodburne, 1967).

Siliceous cappings on basic and ultrabasic bodies

Map symbol: Shown by cross-hatching; no symbol.

Distribution: In the northeast of the Sheet area, north of Indiana homestead and east of the Harts Range. Best known exposures are at the Hammer Hill Prospect.

Thickness: 5 to 40 m or more.

General lithology: Pale chocolate-brown siliceous rock intersected by a vein network of white chalcedony. Rare veins of a dark green micaceous mineral (fuchsite?) and grey-black pyrolusite. A few open veins line with botryoidal silica and some vein-fill of an apple-green crypto-crystalline (tridymite at FP 1037) siliceous mineral. In places the main body of siliceous rock contains boxworks, and the otherwise smooth rock surfaces are in part etched into 'honeycomb' weathering patterns. The bulk of the rock consists of masses of radiating aggregates of chalcedony. NTGS drillcore contains secondary minerals formed by alteration of ultramafic rock such as montmorillonite, antigorite, and chlorite (see Appendix F).

Topographic expression and airphoto characteristics: Form a group of prominent, rounded hills, jutting out of otherwise level sandplain. The dark colour of the rock gives dark tones on the aerial photographs similar to those of lateritised rock.

Structure: The Hammer Hill body is elongate and strikes northwards. Internal structure has been obliterated by intense alteration.

Relationships: At Hammer Hill the siliceous rocks are flanked on the eastern side by weathered mica-schist, but are probably an alteration product of serpentinised rock intersected in the Northern Territory Geological Survey 1978 Drillhole. The siliceous rock lacks characteristics of a weathering profile, and it is not known if it formed due to weathering or by hydrothermal alterations.

Remarks: These rocks are discussed and described further in the section on ECONOMIC GEOLOGY.

TABLE 5: SUMMARY OF MESOZOIC AND CAINOZOIC STRATIGRAPHY

Age	Rock Unit	Lithology	Thickness	Tectonic Events	Environment, fossils and age
RECENT	Qa	Fine and coarse clay-quartz sand, silt and minor gravel, lacking a marked soil profile. Subdivided in part into: Qa_1 claypans; Qa_2 alluvium in and along creeks; Qa_3 floodout plains		Possible uplift in the area of the Harts Ranges or rejuvenation due to subsidence within the Lake Eyre Basin	Channels date from latest pluvial period - either Holocene or latest Pleistocene
	Qr	Red earth; sand, silt, clay, gravel; more fine sand and silt than in Qa		NW part	Underlies alluvium around ranges
RECENT and PLEISTOCENE	Qs	Aeolian quartz sand (Qs); subdivided into Qs_1 sand plains with dunes; Qs_2 sand plains lacking dunes		Region tectonically stable	Humid oxidising conditions followed by aridity and aeolian activity. Development of broad sandplains with minor dunefields. Cementation of porous surface sediments and colluvium forming calcareous crusts.
	Qc	Colluvium, eluvium, scree			
	Cz	Slightly weathered rock related to Czc			Flat to slightly undulating peneplain surface, commonly partly dissected by ?Holocene erosion
	Czc	Fanglomerate; dissected alluvium and colluvium	20 m	Movement on some faults suspected	Period of extensive erosion and development of outwash plains during or immediately preceding sand dune formation.

	T	Poorly developed weathering profile. Also used for calcrete on dissected peneplain on Puh (3 km W. Coulthards Gap W.H.)			Flat peneplain surface; commonly elevated with respect to Cz. Age uncertain, possibly Miocene
ate iocene nd Early liocene	Waite Formation equivalents, Tw	Greenish-grey siltstone, chalcedony and limestone	20 m	Region tectonically stable	Argillaceous sediments and chemical precipitates in very quiet, lacustrine environment
	Fe	Localised ferricrete development		As for Tlf	Ferruginous lenses in Proterozoic sediments accentuated during Tlf development
	Tl	Highly siliceous and ferruginous cap rock		May be partly of hydrothermal origin or may be related to Tlf	Age uncertain
ligocene nd ocene	Ta (in subsurface)	Red-brown and yellowish clay stones interbedded with reddish sandstone (20 m); overlain by green claystone and interbeds of sandstone (144 m); followed by red-brown silty and clayey sandstone (20-100 m); then coarse clean quartz - lithic sandstone (20 m); capped by red-brown silty sandstone (4-12 m)	Up to 250 m	Possible tectonic activity corresponding to intermontaine fans; alternatively may be climatic change causing increased erosion through a reduction in vegetation cover	Mainly lacustrine in early stages; intermontaine piedmont fans in middle part; becoming fluviatile in upper part

Late Oligocene and Early Miocene	Tlf	Laterite profile with well-developed ferruginous, mottled and leached zones; in places grading down into unweathered rocks. Best developed on coarsely crystalline rocks. Ferricrete present.	± 20 m	Region tectonically stable, widespread peneplanation	Deep weathering under humid conditions. Seasonal precipitation and fluctuating water-table, forming a trizonal laterite profile. Plaeomagnetic evidence suggests a Late Oligocene or Early Miocene age (Senior, 1980).
	Tla	Undifferentiated deeply weathered rock		As above	As above
MESOZOIC Upper Jurrassic to Lower Cretaceous	Hooray Sandstone, JKh	Medium to coarse quartz sandstone with kaolinitic cement. Upper part altered to ironstone	1-40 m	Downwarping of the axis of the Eromanga Basin	Fluviatile. Age determined by palynomorphs from elsewhere in the Eromanga Basin (Evans & Burger in Exon & others, 1972)

Quaternary Sediments

Quaternary sediments are summarised in Table 5. Mild tectonic activity or a major plurial episode, possibly in the Late Pliocene, is postulated to explain the extensive erosion resulting in the formation of outwash plains (Czc), deposition of some alluvium (Qa), and the formation of red earth soils (Qr). This period of extensive erosion and deposition possibly occurred under humid conditions immediately preceding sand dune formation (Qs) under conditions of aridity. Red earth soil (Qr) formation and alluvium (Qa) deposition continued. Movement of colluvium (Qc) dates from the same period and is active on present-day hill slopes. Renewed erosion, formation of drainage channels, and deposition of alluvium (Qa) occurred in the Holocene or latest Pleistocene during the latest pluvial period.

STRUCTURE AND REGIONAL METAMORPHISM

Folding

Basement Rocks (Fig. 14)

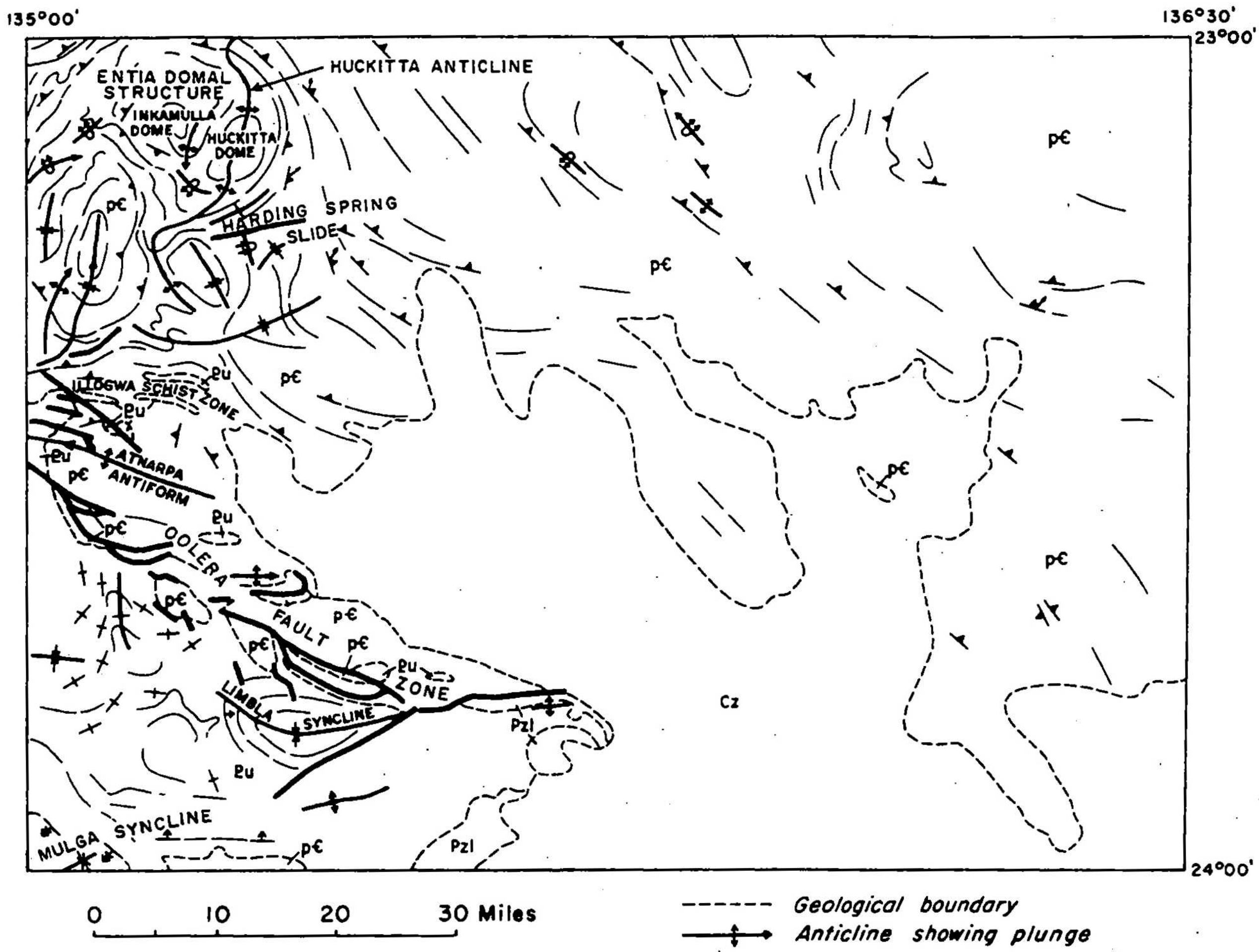
Only two phases of folding have been recognised in the Harts Range Group. The main phase of small-scale folding has axial-plane trends between 160° and 200°. Fold axes are paralleled by a strong northerly plunging lineation. Many of these small folds are overturned to reclined. The folds distort the megascopic compositional layering and the gneissic foliation; an axial-plane schistosity is not developed. This generation of folds is correlated with the second phase of folding recognised in the Alice Springs Sheet area (Shaw & others, 1979). The second phase of folding is more easily recognised on a regional scale. The map pattern of the Riddock Amphibolite Member north of Sprigg's Camp Bore suggests refolding, which may be related to this phase.

The principal structure in the northwestern Harts Range area is the complex-double dome, Entia Domal Structure, (including the Huckitta and Inkamulla Domes); around which units the Harts Range Group sequence are draped with shallow dips. Granite and granitic gneiss occur in the core of the smaller, secondary domes centred near Inkamulla Bore and Huckitta Well (abd). The Entia Domal Structure (Fig. 14) is considered to be a bulbous segment of Harts Range Group overlying postulated uplifted Strangways Metamorphic Complex basement. The negative Bouguer anomaly in this area suggests that the extent of subsurface granite may be much larger at depth than is indicated at the surface.

A north-trending anticline, the Huckitta Anticline, extends southwards from the Entia Domal Structure. It is a very broad arch centred over almost flat-lying Bruna Gneiss.

Cover Rocks

The folding of cover rocks of the Amadeus Basin sequence is mainly related to faulting including thrust-faulting. Minor folds in the Bitter Springs Formation are commonly upright, and overturned to the north reflecting southerly thrust movements. The easterly trending Limbla Syncline (Fig. 14) is interpreted to be a folded thrust nappe because a structural discordance is



CAINOZOIC	Cz	Sand, alluvium, travertine
EARLY PALAEOZOIC	Pzl	Pertaoorrta Group
PROTEROZOIC	Ꝑu	Heavitree Quartzite, Bitter Springs Formation, Areyonga Formation, Pertatataka Formation
PRECAMBRIAN	pЄ	Arunta Complex

- *Geological boundary*
- *Anticline showing plunge*
- *Syncline showing plunge*
- *Overturned anticline showing plunge*
- *Overturned syncline*
- *Fold axis, closure unknown*
- *Fault*
- *Vertical strata*
- *Dip < 15°* } *air-photo interpretation*
- *Dip 15°–45°* } *air-photo interpretation*
- *Trend lines* } *air-photo interpretation*
- *Prevailing dip of foliation*
- *Foliation with plunge of lineation*

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Fig. 14 Structural Sketch

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evident at the base of the Loves Creek Member throughout the structure (see compilation sheets). The southern limb of the Limbla Syncline parallels a complex zone of thrusting in the Gillen Member to the south. The complex folding in the Bitter Springs Formation has been enhanced by the presence of evaporites, notably gypsum, in the Gillen Member of the Bitter Springs Formation.

Faulting

Basement Features

A low-angle (20°), south-dipping 'fault', the Hardings Springs Slide (Fig. 14), separates the Entia Gneiss from the Bruna Gneiss over a distance of 20 km between Hardings Springs Bore and Last Chance Mine (abandoned). The fault is a tectonic slide (see NOMENCLATURE AND TERMINOLOGY) rather than a brittle fracture and has formed due to high strain under metamorphic conditions. The gneisses are more intensely lineated near to the fault plane, but otherwise there is little other evidence for fault movement. Numerous small decollments occur parallel to the boundaries between units within the Harts Range Group. They are particularly common at the boundary between the Bruna Gneiss and Irindina Gneiss (e.g. northeast of Aremra Bore).

Younger Features

The Alice Springs Orogeny (Forman & others, 1967) of late Devonian to Carboniferous age included a period of mainly brittle and some ductile deformation when regional overthrusting resulted in a complex zone of faults at the margin of the Amadeus Basin, termed the Oolera Fault Zone. In this zone, between Atniempa waterhole in the west and Junction Bore in the east, the sequence: crystalline basement - Heavitree Quartzite and Bitter Springs Formation - is repeated several times. Several shallow-dipping overturned sequences suggest that the major faults are high-angle reverse-faults and that the two regions of granitoid surrounded by Heavitree Quartzite in the southern part of the same zone are the 'noses' of small nappes preserved as klippen. Milligan (in Shaw & Milligan, 1969), however, believed these faults were a special type of high-angle normal fault, arcuate in plan, and presumed to be also arcuate in section. The faults are nearly vertical at depth, but change progressively to a shallow dip near the surface. Although normal faults, the sense of movement on them is upthrust or piecemeal and not tensional. Milligan compared these unusual normal faults to those of Laramide-style tectonics described by Prucha & others (1975).

Both overthrust-fault and upthrust-normal fault interpretations for this zone of faulting may be accommodated if this was a zone of strike-slip faulting with an overthrust component. However, there is no direct evidence for strike-slip movements such as the offset of marker horizons.

A second major zone of overthrust-faulting with shallow dips coincides with the Illogwa Schist Zone to the north near Aremra Bore. This zone is considered to be the eastern extension of the root zone of the Ruby Gap Nappe, structurally the lowest thrust-nappe in the Arltunga Nappe Complex (Forman, 1971; Shaw & others, 1971). A major overthrust-fault at the southern margin of the Schist Zone appears to override slices of Heavitree Quartzite. The northern margin of the zone is marked by an abrupt cessation of the schistosity, but no major lithological change. Strike discordance at the eastern end of the northern boundary near Anemra bore suggests it may be a fault.

The faults in the cover sequence between Limbla homestead and Junction bore may be thrust-faults developed in response to gravity sliding during uplift of the basement to the west and north. The principle fault appears to begin within the Bitter Springs Formation at a level where gypsum has been observed, and the evaporites are thought to have facilitated the thrust movements.

Regional Metamorphism

The metamorphic map of Forman & Shaw (1973) shows the general distribution of metamorphic facies. The present study has not substantially change this distribution.

The Harts Range Group (p€h), mapped east of the Harts Range, have been metamorphosed to the amphibolite facies. Conditions in the schists and gneisses (p€) to the southeast probably ranged from upper greenschist to lower amphibolite facies; biotite and muscovite are widespread, but original grain-shapes are commonly preserved indicating a low metamorphic grade.

Shaw & others, (1979) have argued that the metamorphism affecting the Harts Range Group is the Strangways Metamorphic Event which has a Rb-Sr age of 1800 m.y. The regional metamorphism south of the Illogwa Schist Zone may be younger. The stratigraphic position of the Albarta Metamorphics in the southwest is uncertain but they appear to have been initally metamorphosed to the upper amphibolite facies. The Atneequa Granitic Complex may be a series of syntectonic intrusions introduced during this metamorphic event. Lithological correlation of the Atneequa Granite Complex with the dated Atnarpa Igneous Complex suggest that both may have been emplaced during the same tectonic event at about 1700 m.y. (Armstrong & Stewart, 1975; Black & others, in preparation).

Widespread retrograde metamorphism has affected the region and is most evident in the retrograde schist zones of which the Illogwa Schist Zone is the most spectacular example. A common mineral assemblage is albite-epidote-sericite-chlorite. This retrograde metamorphism is considered to have formed during the Alice Springs Orogeny (Shaw & others, 1979).

During the Orogeny minor to marked saussuriterisation of plagioclase, alteration of biotite to chlorite, and polygonisation of quartz commonly occurred in the rocks adjacent to major faults particularly in the Oolera Fault Zone. The situation is similar to that recognised by Stewart (1971b, and in Shaw & others, 1971) in the Artunga Nappe Complex to the west.

Present evidence suggests that the Harts Range pegmatites may also have been emplaced during the Alice Springs Orogeny (Forman & others, 1967; Riley, 1968) although further age determination work is needed to clarify this age correlation. These pegmatites are generally surrounded by a zone of retrogression and possible metasomatism up to 100 m wide in which muscovite is common.

ECONOMIC GEOLOGY

In the past the Harts Range region has produced significant amounts of mica and small amounts of other minerals. More recently (1978) a small mining company began mining cabochon grade rubies and pink corundum. The Illogwa Creek region contains a moderate number of small copper, copper-lead-zinc and uranium prospects as well as numerous gemstone localities, and rare scheelite and molybdenite prospects. Small nickeliferous, siliceous lateritic bodies occur in the central-north of the Sheet area. Known mineral prospects and occurrences are briefly described by commodity in alphabetical order and are also listed in Table 6. Information on mica is also tabulated in Table 6, and the interested reader is referred to Joklik (1955a) for more details. Notes are given on the more important prospects in a following section. NTGS Mineral File descriptions refer to those compiled by Kingdom (Undated Report).

Aluminious minerals (including ruby-corundum)

Corundum has been reported in trace amounts from a number of localities throughout the region. Pink and white corundum occurs as an accessory constituent of kyanite and cordierite-bearing biotite schist (sb) in the Entia Gneiss at GR QUARTZ - 299 526 (FPS 1846, 1898, 3357). Red and pink corundum (ruby) occurs in a quartz-free hornblende-bearing plagioclase rock (bp) within the Riddock Amphibolite Member of the Irindina Gneiss at the Hillrise Ruby Mine (GR QUARTZ 542463). Flack (1970b) reported large "porphyroblasts of corundum near Atnarpa Dam".

Kyanite occurs in biotite schists in the Entia Gneiss 6.7 km west of Inkamulla Bore 2.5 km northwest, 4.5 km west and 5 km north-northwest of Huckitta Well (abandoned).

Beryllium

Beryl has been recorded at the Atrichs, Delma, Leprichaun, Valiant Sister, Eastern Chief and Mount Ruby mica mines, and at an unnamed mica prospects 5 km WNW of Rockhole Dam and 2 km west of Lindsay Mica Mine. Beryl localities in the Harts Range were examined by Jones (1957), but the berylium potential is not very great.

TABLE 6: LIST OF MINERAL OCCURRENCES IN ILLOGWA CREEK 1:250 000 SHEET AREA

ame (& umber TGS iles)	Grid Reference Q=Quartz, L=Limbla 1:100 000 SHEETS IC=1:250 000 SHEET	Commodity, minerals	Lode rock	Country rock(s)	Remarks	References
ale iver	Q007101	Au, Cu	ENE-striking quartz veins	Quartzofeldspathic schist	Production nil: Traces of copper carbonate, rare chalcopyrite, rare Au in assay	Ruxton 1963 Shaw & Milligan, 1969 Warren & others, 1974
unction	IC3570E 0402N	Cu	Quartz-goethite rock forms low circular rise 75 m across, cut in places by minute veins of malachite	Calc-silicate rock, quartzofeldspathic gneiss	3 samples averaged 4250 ppm Cu, 30 ppm Pb, 12 ppm Ni. Traces of gold (0.05-2.0 ppm) in analysis by Agip Nucleare	Agip Nucleare Aust. Pty Ltd., 1979
llogwa reek (M53)	Q1645	Cu	Quartz reef	Schist, gneiss, granite	Malachite with hematite	NTGS Mineral File F53/15-M53.
	L241619	Cu	Fine disseminated bornite chalcopyrite, chalcocite and a trace of malachite	In intercalated spilite and dolomite, Loves Creek Member	Chip sampling - 5 m at 1900 ppm	
	Q275348	Cu	Ferruginous, coarse-grained quartzite bed	Quartzofeldspathic gneiss, Entia Gneiss	100 ppm Cu	FP 1261.

M82,M85) M52)	L328552 L332560	Cu	Trace of Crysocolla	Limbla Member	Trace mineralisation only	McIntyre Mines Pty Ltd; Faulkner, 1971; NTGS Mineral File F53-15/M82
M10)	Q229526	corundum, Cordierite (Iolite)	Kyanite-cordierite-gedrite-biotite schist	Quartzofeldspathic gneiss	Fossikers locality, rare pink corundum (see also Ruby)	Dobos, 1978
M6) M14,M15, M16)	Q278477) Q102458) Q117446) Q252385) Q177422)	Kyanite	Lenses of biotite schist	Quartzofeldspathic gneiss	Some blue in colour	Joklik, 1955a; Jensen, 1943a
	Q047342	Pb, Zn	Calc-silicate rock	Garnet-bearing quartzofeldspathic rock, garnet-biotite gneiss	Host rock contains galena and smithsonite	
	L316678 L301615	Zn	Finely disseminated sphalerite	Calcarenite and siltstone, in Ringwood Member		Australian Geophysical, 1967;
trichs M67)	Q112395	Mi, Be	Pegmatite (muscovite)	Sillimanite-garnet-biotite gneiss	Accessory beryl; production unknown	Australus Mining, 1970.
ennets others	unlocated	Mi	Pegmatite (muscovite)		Small, near Last Chance Mine	Daly & Dyson, 1956
lack iamond M28)	Q476059	Mi, Ap	Pegmatite containing muscovite garnet, apatite	Quartzofeldspathic gneiss with traces of biotite and garnet biotite gneiss, thin layers of amphibolite	Production small, near Last Chance Mine, 420 lbs 1948-52, trench 20 m long, 3 m wide, 2 m deep	Joklik, 1955a, p. 15; FP 0925

Crespins	unlocated	Mi	Pegmatite (muscovite)	Quartz-feldspar-muscovite schistose gneiss, biotite gneiss	Production unknown	Joklik, 1955a, p.15;
Crown (M31)	unlocated	Mi		Gneiss	3 km WNW Last Chance Mine	Hodge-Smith, 1932; FP 0892
Delma (M23)	Q406387	Mi, Be	Pegmatite (muscovite)	Exposure rare at mine; nearby garnet bearing muscovite-biotite schistose gneiss, biotite gneiss, calc-silicate rock	Production 10, 923 lbs 1948-51, 5 tons 1954-59; accessory minerals - beryl, apatite, tourmaline	Joklik, 1955a, p. 196; Daly & dyson, 1956, p.10; Armstrong, 1954; Jones, 1957; Rochow, 1962.
Dempsey's (M60)	Unlocated	Mi	Pegmatite (muscovite)	Gneiss	Approx. 1.5 km east of Hugh Dam	NTGS Mineral Files
Desperate (M21)	Q381404	Mi, Cu	Pegmatite (muscovite) with large irregular quartz core	Garnet-bearing muscovite-biotite schistose gneiss	Production 3964 lbs 1949-51; traces of chalcopyrite and pyrite in quartz-rich pegmatite	Joklik, 1955a, p.194 & p.119 Daly & Dyson, 1956, p.10
Eastern Belle (M38) (Carrana Group)	Q110305	Mi, Cu	Pegmatite (muscovite)	Biotite gneiss, sillimanite biotite gneiss, garnet-biotite gneiss	Production 1300 lbs, 1957 (ref. Royalty returns)	Joklik, 1955a, p.205 & PL25; Jensen, 1944a & b, F P 0953
Eastern Chief (M1)	Q027549	Mi, Be	Pegmatite (muscovite)	Garnet and sillimanite-bearing muscovite-biotite gneiss	Production 20 tons (est.) 1924-43; 4788 lbs 1944-51; accessory beryl	Sullivan, 1942; Jensen 1944 a & b; p.205 p.125; Daly & Dyson, 1956, p.13; Jones, 1957.
Flying Fox (M52)	Q374412	Mi	Pegmatite (muscovite)	Garnet-bearing muscovite-biotite schistose gneiss	Production 600 lbs, 1957	NTGS Mineral Files; Rochow, 1962

Indiana (M26)	unlocated	Mi	Pegmatite (muscovite)		Production 1000 lbs, 1953; 7 km SE Mount Mary	NTGS Mineral File, Joklik, 1955a
Last Hope (24)	Q369338	Mi, U, Nb, Ta, Ce	Pegmatite (muscovite)	Garnet-biotite gneiss, layered amphibolite	Production 3000 lbs, 1944-50; accessory betafite, monazite	Joklik, 1955a, p. 175 Daly & Dyson 1956, p.8.
Last Chance (Moronis, Mammoth)	Q335291	Mi, Be	Pegmatite (muscovite) beryl	Garnet-biotite gneiss, rarely containing sillimanite	Production 22.2 tonnes 1946-53; accessory biotite, apatite, garnet, diopside. Blanket Reef, Flat dyke, and Big Reef (M34, M35) occur NE and SW of main mine	Joklik, 1955a, p. 191 & PL. 17 & 18; Daly & Dyson, 1956, p.9; FP 0720
Leprechaun (M78	Q032232	Mi, Be	Quartz-rich pegmatite (muscovite, beryl)	Garnet-biotite gneiss	Accessory chryso-beryl, sphene	NTGS Mineral Files
Lindsay	Q071202	Mi	Well-zoned pegmatite with quartz-rich core (muscovite)	Garnet-biotite gneiss	Accessory tourmaline	
Lindsay West group of mines (M33, M44, M51)	Q049198 Q051197	Mi	Pegmatite	Schistose biotite gneiss, garnet-biotite gneiss, sillimanite gneiss, quartzofeldspathic gneiss	Trace beryl, rutile and tourmaline at Q549198; beryl at Q551197. accessory hydroxyapatite	FP 0638-0640; Daly & Dyson, 1956; NTGS mineral File

Little Sister (M40)	Q118309	Mi	Pegmatite	Garnet-biotite gneiss	Abundant garnets	
Lone Pine (Cone Hill M25)	Q313373	Mi, U, Nb, Ta, Ce	Pegmatite	Coarse-grained amphibolite	3 m trench. Accessory samarskite, bismuthinite	Joklik, 1955a, p. 175; Daly & Dyson, 1956, p.78; FP 0733
Lower Mine (Carrara Group)	Q118312	Mi	Pegmatite	Garnet-biotite gneiss	Accessory garnet, aegirine	NTGS Mineral File; Flack, 1970.
Mirror Finish (M17)	Q379430	Mi	Pegmatite	Garnet-bearing schistose muscovite-biotite gneiss	Open-cut over a vertical range of about 30 m (100 ft)	Joklik, 1955a, p.219; Daly & Dyson, 1956, p.9; Jensen, 1944b; Armstrong, 1954
Moon-light (M20)	Q368424	Mi	Pegmatite	Garnet-bearing schistose muscovite-biotite gneiss	Production 1175 lbs, 1950	NTGS Mineral File.
Mount Powell (M21, M32, M50)	Q383395	Mi	Pegmatite	Garnet-bearing muscovite-biotite gneiss	Production unknown, M32 is 2km SE Mt Powell	NTGS Mineral File
Orfaa (M61)	Unlocated	Mi	Pegmatite	Unknown	Abundant ruby mica Production 20 065 lbs 1954-59, 5.5 km NE Table Top Bore	NTGS Mineral File; Rochow, 1962
Ragonesi (M37)	Q293272	Mi	Pegmatite	Garnet-biotite gneiss	Operating in 1944	Daly & Dyson, 1956, p.9
	Q290241	Mi	Pegmatite	Garnet-biotite gneiss	South of Ragonesi Mine, Production unknown	

Rockhole Bore	Q308184 Q311185	Mi	Pegmatite	Garnet-biotite gneiss	Production unknown	
Solo	Q365360	Mi	Pegmatite	Garnet-biotite gneiss, hornblende gneiss	Minor	Daly & Dyson, p.9
Spriggs Camp (M2)	Q021438	Mi	Pegmatite	Biotite gneiss, garnet-biotite gneiss	Production unknown	Mathews, 1905
Valiant Sister (Carrara Group) (M39)	Q119310	Mi, Be	Pegmatite	Garnet-biotite gneiss	Production 3700 lbs, 1957; accessory beryl, enstatite, spodumene	Daly & Dyson, 1956, p.10 FP 0952
	Q010359	Mi	Pegmatite	Garnet-biotite gneiss	Production unknown	
	Q075319	Mi	Pegmatite	Garnet-biotite gneiss	Production unknown	FP 0659
	Q283143	Mi, Be	Pegmatite	In alluvium surrounded by garnet-biotite gneiss, biotite gneiss	Production unknown pit 3 m across, 2 m deep, accessory beryl, tourmaline	FP 0674
	Q358138	Mi	Pegmatite	Garnet-biotite gneiss, biotite gneiss	Production unknown	
	Q324513	Mo	Conformable pegmatite	Garnet-bearing muscovite-biotite schistose gneiss	Slight trace of molybdenite only; also occurs in trace amounts at DNEIPER GR197564 in a quartz vein cutting amphibolite	Warren & others, 1974

Hammer Hill (M80)	Q451551	Ni, Cr	Siliceous rock formed by alteration of serpentinised rock, which is possibly a quartz-plagioclase-amphibole rock	Unknown, some pale-brownish carbonate in drill core	Siliceous body contains patches of pale green, translucent nickeliferous silcrete composite rock chip samples (7) at 10 m intervals across body averaged 2317 ppm Ni, 483 ppm Cr and 43 ppm Co. One sample contained 1.01% Ni. DDH by NTGS	Howland, 1971; Barraclough 1978; Flack, 1970
Hillrise (M81)	Q042463 Q044458 Q044466 Q043461	Ruby corundum	Hornblende-bearing plagioclase-rich rock, mantled by and containing lenses of hornblende and phlogopite-rich gneiss	Schist rich in phlogopite and plagioclase intercalated with sillimanite-bearing garnet-biotite-quartz-plagioclase rock	Series of costeans and bulldozer pits. Blue, pink and clear corundum forms tabular, hexagonal crystals up to 5 cm diamenter. Some corundum is ruby of cabochon grade.	Clarke, 1978b; McColl & Warren, 1979; Katz, 1981
	Q166506	Tourmaline	Quartz vein	Quartzofeldspathic gneiss		
Tourmaline Gorge (M94)	L039971	U	Flakes of 'meta-torbernite' in microfractures in narrow deformed zone	Granite containing tourmaline (5-3%) and traces of garnet and altered beryl	Production nil	Craven, 1978; FP 1439

Walter Smiths (M66)	Q160520 Q154505	U, Nb, Ce	Patch of calcsilicate rock containing samarskite and allanite cut by E-W pegmatite with magnesite, actinolite, actinolite, fluorospar, calcite and microcline at margins	Quartzofeldspathic gneiss, calc-silicate rock muscovite-biotite schist	Bulldozer cut 0.5 m deep, at GR159509 allanite and sepiolite possibly present	Australus Mining, 1970
Albarta (M94)	L074959	U	Brecciated quartz filled tensional fault flanked to W by fractured muscovite-chlorite quartzofeldspathic schist containing up to 5% pyrite	Quartzofeldspathic gneiss and chlorite muscovite schist	Prospect. Grab rock chips samples of schist assayed 80-140 ppm U. U concentrated in structural features of high porosity	Frazer, 1977 Craven, 1978; FPS1416, 1202
	Q216118	W, Cu	Biotite schist	In Illogwa Schist Zone		AMDL Report AC 40921/80 and AC 23581/80, specimen 1820 Appendix A(1).
Valley Bore	Q150502 Q147497 Q145496	W	Scheelite in calc-silicate rock, cut by quartz veins	Quartzofeldspathic gneiss, muscovite-biotite schist, calc-silicate rock	Production nil, bulldozer cuts up to 1.5 m deep and 10-30 m long	Faulks, 1967 Australus Mining, 1970 Barraclough, 1973 Cogan & Felderhof, 1973

Copper-lead-zinc

Prominent magnetic anomalies in the Albarta Metamorphics south of the Illogwa Schist Zone indicate iron-rich, fine-grained sediments containing 3-5 percent magnetite (Tham, 1971). Analyses of the sediments for Pb, Zn, Cu, Ni, Co and Cr were disappointing. Two rock chip samples (FP 1332, 1338B) collected by R.D.S. during the present survey contained 260 and 60 ppm Cu, and 35 and 120 ppm Zn respectively. (Analysis by AAS, AMDL Code C1; see Appendix A1). Both samples contained above average Ba (600, 400 ppm) and P (800, 4000 ppm).

Copper (310 ppm), lead (60 ppm) and zinc (220 ppm) were detected in a laterised schistose gneiss at FP 1129 at the western edge of the Simpson Desert (Appendix A1).

Australian Geophysics Pty Ltd (1967) and Kratos Uranium N.L. (Sullivan, 1970) have explored for base metals in Late Proterozoic sediments in the Ringwood area. Minor copper mineralisation was noted in the spilite within the Loves Creek Member and minor zinc mineralisation detected at two localities at the base of the Ringwood Member. A rock chip sample containing 210 ppm Cu and 200 ppm Zn was collected from a ferruginous siltstone in a white sandstone unit of the Gillen Member of the Bitter Springs Formation (FP 1395 R.D.S. - present survey).

Copper

Traces of copper mineralisation were detected in the Harts Range Group in three different environments during the present survey.

1. Two small well-layered quartz-garnet-magnetite gneiss lenses (1.5 m x 10 m) in the Stanovos Gneiss Member 4 km west-southwest of Last Chance Mica Mine contain a trace of pyrite; 150 ppm Cu was detected in one grab sample (79090 970B). A small amphibolite lens in quartzite nearby (FP 0969) contains Cu (80 ppm), P (1000 ppm), and Y (100 pm) (both analyses by semi-quantitative emission spectrometry AMDL 3754/80).

2. Copper (400 ppm) was detected (analyses as above) in calc-silicate gneiss in a schist sequence of undivided Harts Range Group in the central-north of the Illogwa Creek Sheet area, southwest of No. 1 Atula Station Bore (FP 522).

3. Copper occurs locally in amphibolite in the Irindina Gneiss. For example, 300-400 ppm Cu were detected in a layered amphibolite lense containing sulphides at the 'jump-up' east of Lizzie Dam (FP 0959). Cu (600 ppm) was detected in a cross-cutting quartz-tourmaline vein containing a trace of weathered sulphide in layered amphibolite (pa) of the Riddock Amphibolite Member 3 km east of Oodnarta waterhole (FP 0672) (both analyses as above).

Traces of copper (100 ppm Cu, see Appendix A1) were detected in a coarse-grained ferruginous quartzite at FP 1261 in the Entia Gneiss southwest of Huckitta Well (abandoned).

Traces of copper occur in and alongside the Illogwa Schist Zone at FPS 1315, 1820 (see Appendix A1) and at the Hale River Au-Cu Prospect.

Copper (300 ppm) and bismuth (75 ppm) were detected in one of three samples from a ferruginous patch in a schistose quartz vein protruding through sand plain east of the Plenty River, east of No. 2 Atula Station Bore (FP 524, Appendix A2).

Gemstones and specimen material

The region has supplied numerous specimens held in museums and private collections and some material is sold as part of the tourist trade in Alice Springs.

Chrome Spinel has been reported from gabbro at Black Cone (GR QUARTZ 0191505), 2.2 km slightly north of east from Valley Bore (NTGS Mineral File F53/15-M5). Similar mafic bodies reported to contain chrome spinel are located 1.5 and 4 km south-southwest of Mount Mary.

Epidote is common in crystal form where the Harts Range pegmatites have intruded basic rocks in the Entia Gneiss (e.g. Northeast of Harding Springs Bore) and also in the Irindina Gneiss (e.g. GR QUARTZ 570386).

Kyanite and cordierite have been excavated by prospectors 9 km north-northeast of Inkamulla Well. The cordierite is grey to blue-grey and is locally referred to as iolite. Kyanite cystals up to 15 cm long occur in a coarser-grained biotite schist. Corundum and gedrite are also present. Gem quality kyanite crystals from other localities have been described by Males (1974).

Ruby (see description of corundum and note on Hillrise Ruby Mine).

Spodumene (Li Al $(SiO_3)_2$) has been noted at the Valiant Sister Mica Mine (Daly & Dyson, 1956).

Tourmaline crystals (common, black) occur in a quartz vein east of Valley Bore at GR QUARTZ 166506 (FP 1238).

Gold

In the Alice Springs Sheet area many small gold-bearing lodes at Arltunga and Winnecke in the Arltunga Nappe Complex lie both in and close to zones subject to severe deformation and hydrothermal activity during the Alice Springs Orogeny. The geology of these lodes was summarised by Warren (1980). The Oolera Fault Zone (Fig. 14) and the Illogwa Schist Zone represent an extension of the deformed zones into the Illogwa Creek Sheet area. In this region the Albarta Metamorphics, which resemble the Cavenagh metamorphics at Arltunga, are intruded by an extensive igneous granitoid complex similar to the Atnarpa Igneous Complex at Arltunga, a geological situation similar to that of the historic Arltunga Gold Field, 50 km to the west. The only known deposit in the area is the Hale River Prospect.

Gypsum

Several small gypsum deposits occur in the Gillen Member of Bitter Springs Formation.

Petroleum potential

A brief preliminary discussion of source rock potential is given in Felton and West (1982).

Phosphate

Forman & others (1967) describe a single specimen of magnetite-apatite metaquartzite containing 15 percent apatite from the upper reaches of Illogwa Creek. The extent of the apatite-bearing rock is unknown.

Up to 1%P, 200 ppm Cu and 60 ppm Y were detected in ironstone in the Loves Creek Member at GR LIMBLA 053630 (FDS 873, 876).

Mica

Mica deposits occur in large cross-cutting pegmatites. Zoned, coarse-grained pegmatites, particularly those containing oligoclase, have been the most productive. Productive mica mines are most abundant in the Irindina and Brady Gneisses. The mica deposits of the Harts Range area were described by Joklik (1955a & b). Earlier, more general descriptions were given by Hodge-Smith (1932) and Jensen (1947). Muscovite was mined between 1888 and 1961 and a total of 1660 t produced (Gourlay, 1965). The Commonwealth Mica Pool ceased operation when the mica mines could no longer compete with overseas mines. Other reports on the mica mines include those of Sullivan (1942a, b), Dunn (1947), Tomich (1952), and Rochow (1962).

Molybdenum

Molybdenite occurs as coarse flakes in a unit in the Entia Gneiss in the Inkamulla Dome at the eastern end of the Harts Range (L.A. Johannsen, personal communication in Warren & others, 1974). A trace of molybdenite occurs in a quartz vein cutting amphibolite at GR DNEIPER 197564 FP 1903 and in a conformable pegmatitic phase in the Brady Gneiss at GR QUARTZ 324513 (FP 3506).

Nickel and chrome

A small nickeliferous siliceous lateritic body (Hammer Hill) was examined and drilled by the Northern Territory Geological Society (Barraclough, 1978). Several other similar bodies were located southeast of Hammer Hill. Analyses of these show similar low Ni and Cr values (Appendix B).

A sample from a fault breccia cutting the Limbla Member adjacent to Waldo Pedlar Bore (FP 1836) contained 150 ppm Ni, 100 ppm Co and 0.8% P. A bedded siliceous limonite horizon between the Loves Creek Member and the Areyonga Formation 3 km north of Waldo Pedlar Bore (FP 0857) contains 150 ppm Ni and 1500 ppm P (Appendix A2).

One sample collected from meta-basic intrusive (Pdx) immediately northwest of Mount Stanovos (FP 0572) was analysed and contained 400 ppm Cr, 100 ppm Co, 600 ppm Cu.

Two samples collected from a pyritic amphibolite (FP 0595) were analysed: Ni (100, 50 ppm), Cr (200, 300 ppm), Cu (300, 400 ppm) and V (200, 300 ppm). The amphibolite is in Irindina Gneiss.

Rare earth minerals (Daly & Dyson, 1956)

Betafite was recorded from the Last Hope Mine.

Samarskite was recorded from the Lone Pine Mica Mine.

Rare earth minerals, reported by Matheson (1968) and Corbett (1970) from the Mount Mary area, could not be located. A garnet-plagioclase rock from 4.5 km south-southwest of Mount Stanovos (FP 0979), contains traces of pyrite, and 600 ppm La (Appendix A2).

Tungsten

A thin unit of calc-silicate rock 2 km west of Valley Bore was prospected for scheelite and rare earth minerals. Alluvial scheelite with traces of molybdenite and a bismuth mineral were reported from the centre of Inkamulla Dome and at a locality about 5 km east of there (L.A. Johannsen, personal communication in Warren & others, 1974).

2000 ppm W was detected by semi-quantitative emission spectrometry (AMDL Report AC 2538/80) in a biotite schist containing 0.8% Cu (AMDL Code C1 Report AC 4092/80) at FP 1820 (GR QUARTZ 215118) in the Illogwa Schist Zone.

Calc-silicate rocks in the Albarta Metamorphics and the undivided Harts Range Group (p€h) may be prospective for scheelite especially near granite bodies as a similar rock-association is related to scheelite deposits in the Bonya-Jervois area in the Huckitta Sheet area.

Uranium

Uranium in the Harts Range region commonly occurs in the minerals betafite or samarskite. Betafite containing 0.01 to 0.02% U_3O_8 has been reported from the Last Hope Mine and samarskite is recorded at the Lone Pine Mine. An unidentified mineral in pegmatite at Sprigg's Camp Uranium Prospect (Clarke, 1978a) contains 6.2% U_3O_8 and 1100 ppm ThO_2.

A scintillometer traverse across the Entia Gneiss between FPS 386 (Huckitta Well), 398 and 411-413 during the present survey did not show any anomalous readings (Appendix D).

Agip Nucleare Pty Ltd (1979) explored for uranium in Tertiary sediments near Junction Bore. Afmeco Pty Ltd also explored Tertiary sediments in the lower reaches of Illogwa Creek and along the Plenty River (French, 1980).

Slightly higher scintillometer count rates (60 to 160 c/s) recorded throughout the Albarta Metamorphics are ascribed to the high potassium contents of the rocks; uranium concentrations appear to be closely associated with zones of fracture and faulting, and in schist zones of high permeability (Appendix D). One high count rate is due to thorium in pegmatite (Specimen 2506, Appendix D).

Notes on Prospects
(excluding Mica Mines)

Albarta Prospect; U; GR LIMBLA 074959

References: Frazer (1977); Craven (1978).

Surface workings: A series of east-west costeans and several percussion drill holes are evident.

Country rocks: Predominantly of quartzofeldspathic gneiss and chlorite-muscovite schist.

Lode: A brecciated quartz-filled tensional fault, 1-5 m wide, containing discontinuous zones of chlorite alteration. Flanked to west by fractured uranium-bearing zone in quartzofeldspathic schists containing muscovite and chlorite as retrograde minerals. Schists and fault-rock both contain up to 5 percent pyrite. Chip samples of schist, giving scintillometer readings of 80-160 c/s, assayed between 80 and 140 ppm U (XRF analysis, samples 1411, 1412, 1414, AMDL Code B1/1 Report AC 4490/80); see Appendix D)

Production: Nil

Remarks: Uranium is concentrated in structural features of higher porosity and permeability.

Hale River Prospect: Au, Cu; GR QUARTZ 007101

References: Ruxton (1963); Shaw & Milligan (1969); Warren & others (1974).

Surface Workings: Minor gouging.

Country Rocks: Quartzofeldspathic schist.

Lode: East-northeast striking quartz veins.

Ore and gangue: Traces of copper carbonates occur at the margins of several quartz veins, and rare chalcopyrite occurs in the unoxidised part of the veins.

Production: Nil.

Hammer Hill Prospect: Ni, Cr; GR QUARTZ 451551

References: Howland (1971), Barraclough (1978).

Surface workings: A shallow excavation about 1 m deep at southern end of outcrop. Angled diamond drill hole by Northern Territory, Department of Mines & Energy, through body just north of excavation.

Country rocks: unknown.

Lode: Secondary chalcedonic body exposed at surface. A few fragments of greenish quartz-plagioclase-amphibole chlorite rock (79090018), in excavation. Drill core (NTGS) includes fragments of serpentinised rock (antigorite) and some montmorillonite, ?talc, chlorite and pale-brownish carbonate (Appendix F). The siliceous body at the surface is probably the alteration product of these rock types.

Ore and gangue: Rare patches of pale green, translucent, silcrete containing a trace of nickel. Composite rock chip samples collected at 10 m intervals across the body at FP 0018 (7 samples) averaged 2317 ppm Ni, 483 ppm Cr and 43 ppm Co (Appendix B; AMDL Code C4, Report AC 4466/80). One sample (7909-0018A) contained 1.01% Ni.

Production: Nil.

Remarks: The siliceous bodies may have formed either by weathering or by deposition from hydrothermal solutions. A number of similar bodies occur to the east and southeast (Appendix B).

Hillrise Ruby Mine: Cm; GR QUARTZ 042458, 044466, 043461.

References: Clarke (1978); McColl & Warren (1979); Katz (1981).

Surface Workings: A series of costeans and bulldozer pits follow the ruby-bearing unit.

Country rocks: Biotite and/or hornblende and/or garnet-bearing plagioclase-rich gneiss intercalated with garnet-biotite-quartz-plagioclase rock some of which is sillimanite-bearing (FP 999), and biotite gneiss. This unit, including lode rocks, portrayed as symbol bp. Locally gneiss contains thin (5-10 mm) continuous layers of hornblende-rich amphibolite and metahornblendite.

Lode: Plagioclase-rich rocks rimmed by or containing boudins of meta-ultramafic rocks. Visual estimates of specimen 79090818F (FP 818), a plagioclase gneiss, are anorthite (61% ca), bluish-green hornblende (20%), phlogophite (4%), pink corundum (3%) and traces of spinel, carbonate, Mg-chlorite, ?gedrite and ?scapolite.

The lode horizons are commonly grossly lenticular, are patchily distributed possibly as a result of boudinage, and have sharp, concordant contacts with the country rock. Hornblende-rich zones up to 20 mm thick occur at the periphery of some of the lenses.

Ore and gangue: blue, pink and clear corundum occurs as a rare constituent of both the hornblende-phlogophite (chlorite)-rich rock and the plagioclase-rich rock, particularly in the plagioclase-rich rock near the contact with the hornblende-phlogophite rock. Corundum includes ruby of cabochon grade.

Mineralogy of ruby: As well-formed, tabular, hexagonal crystals up to 5 cm diameter and 1 cm thick, or a roughly ovoid mass up to 12 cm long. Little fully transparent ruby has been found, most are translucent. Larger crystals are commonly finely fissured, and some contain inclusions of mica and zircon crystals near their margins (McColl & Warren, 1979).

Chemical analysis of a representative sample of cleaned ruby crystal gave the following minor components (AMDL 1979 in McColl & Warren, 1979).

Fe	1.93%
Si	0.33%
Cr	0.31%
Ti	less than 0.02%

Remarks: McColl & Warren (1979) interpreted the lode to be a metamorphosed "terra rossa" soil profile formed on a limestone contaminated with pyroclastics and interlaminated with lavas and tuffs. The relationship between the hornblende-rich rim around the plagioclase-rich gneiss may be formed by reaction between the primary lode rock and the country rock during metamorphism. An alternative interpretation suggesting the lode unit is a layered anorthosite complex has been published by Katz (1981).

Junction Bore Copper Occurrence: Cu; GR 3570 0402 Illogwa Creek Sheet area.

Reference: Agip Nucleare Australia Pty Ltd (Appendix 8 1979). FP 0019 this survey.

Country Rocks: Calc-silicate rock, quartzofeldspathic gneiss.

Lode: Quartz goethite rock which forms a low circular rise approximately 75 m in diameter and rises 3 m above surrounding gently undulating ground. Blocky ferruginous rocks consist of black goethitic ironstone containing vuggy cavities lined with crystalline iron minerals. In places these rocks are complexly cut with minute veins of malachite. These analyses by AMDEL (semi-quantitative emission spectroscopy AMDL Report 2643/80) averaged 4250 ppm Cu, 30 ppm Pb, 12 ppm Ni. Agip Nucleare (1979) recorded similar values from nine samples together with traces of Au (.05 - 2.0 ppm), Co (90-400 ppm), Mn (110-360 ppm) and Mo (3-8 ppm).

Mount Eagle-Beak Molybdenite Occurrence: Mo; GR DNEIPER 197 564.

References: N.T. Geological Survey-Mineral Files.

Surface Workings: Prospecting Pit.

Country rock: Amphibolite.

Lode: Quartz vein.

Ore and gangue: Trace of molybdenite seen in one hand specimen only. (R.D.S., 1968).

Production: Nil.

<u>Tourmaline Gorge Prospect</u>: U; GR LIMBLA 039 971

References: Craven (1978); FP 1439

Surface Workings: Access track.

Country rock: A coarse-grained pegmatitic granite which consists of quartz, tourmaline (5-30%) (spec. 1439A Appendix E), orthoclase, and subordinate albite and muscovite. Traces of beryl and garnet are present, but most of the beryl is altered to yellow hydro-muscovite.

Lode: Small flakes of 'metatorbernite' are present in microfractures in a narrow lenticular deformed zone in the granite. A grab sample from this deformed zone not including metatorbernite (79091439B) contained only 6 ppm U (Appendix E).

Production: Nil.

<u>Valley Bore Scheelite Prospect</u>; W; GRS QUARTZ - 150502 (FP406), 147497 (FP407), main prospect, GR 145496 (FP1240).

References: Faulks (1967), Australus Mining NL. (1970), Barraclough (1973), Cogan & Felderhof (1973).

Surface workings: A series of east-west bulldozer blade cuts, 1-1.5 m deep and 10 to 30 long.

Country rocks: Quartzofeldspathic gneiss, muscovite-biotite schist and minor calc-silicate rock intruded by pegmatite.

Lode: Quartz vein with epidote cutting epidote-garnet-calcite calc-silicate rock (specimen 1240), 3-27 m (19-90 ft) wide. A visual estimate of the context of the lode is plagioclase (53%), clinopyroxene (35%), epidote (5%), quartz (5%), and sphene (2%). Scheelite float also reported "1.6 km (0.5 ml) south of rare earth locality" (Australus Mining NL, 1970).

Ore and gangue: Scheelite (greyish-blue to colourless, strongly fractured, psuedo-hexagonal crystals) described by Faulks (1967).

Production: Nil; considered uneconomic.

<u>Walter Smith's Radioactive Show</u>: U, Nb, Ce; GRS QUARTZ 160520, 159509, -154504.

References: Australus Mining (1970); N.T. Geological Survey Mineral Files.

Surface workings: Bulldozer blade cut 0.5 m deep, 10 m long at GR 159509 (FP 402).

Country rocks: Quartzofeldspathic gneiss, calc-silicate rock and muscovite-biotite schist.

Lode: Calc-silicate rock cut by east-west pegmatites with magnesite, actinolite, fluorspar, calcite and microcline at margins (Australus Mining 1970a).

Ore and gangue: Possible allanite (at FP 401) is contained in a garnet-epidote-feldspar-quartz calc-silicate rock. (Appendix E). Australus Mining (1970) has report possible samarskite.

Production: Nil.

NOMENCLATURE AND TERMINOLOGY OF METAMORPHIC ROCKS, SOME IGNEOUS ROCKS AND SOME STRUCTURAL TERMS

(With Notes on Rock-Type Symbols)

Igneous rock nomenclature used in this Record is that of Streckeisen (1976) and sedimentary rock terminology that of Gary & others (1973), unless specified otherwise. Following is a brief glossary of rock names and textural definitions used in the text.

Amphibolite (a): consists essentially of hornblende (30 to 80%) and plagioclase; also used for rock containing mainly actinolite if some relict hornblende is also present.

(ae)-Mg-rich rocks: consist almost entirely of either anthophyllite, cummingtonite, gedrite or enstatite.

apl: aplite

av: garnet-bearing amphibolite.

Biotite gneiss (b): field term for gneiss containing quartz, feldspar, and 10 percent or more of biotite. Many of these gneisses are of granodiorite composition, but some, particularly the more biotite-rich varieties, are considered to be pelitic metasediments. Rocks photo-interpreted as biotite gneiss commonly have a brown photo-colour, as distinct from the pale brownish-yellow photo-colour diagnostic of quartzofeldspathic gneiss.

bp: symbol for plagioclase-rich gneiss containing hornblende and/or biotite or phlogopite. Locally contains rare corundum.

Biotite schist (sb): schist, with 20 percent or more biotite and little or no muscovite.

Calc-silicate rock (cs): consists of calcium-bearing silicate minerals such as diopside, calcic plagioclase, epidote and grossularite. Calc-silicate rocks formed by metamorphism of impure marble or calcareous sediments (Gary & others, 1973).

Coarse-grained: refers to grain sizes in the range 5-30 mm.

Cordierite gneiss and sillimanite-cordierite gneiss (i): for granular rocks containing cordierite, or cordierite and sillimanite.

cm: metaconglomerate.

Deformed rock (d): a very general field term for highly strained or brecciated rocks.

dl: dolerite, metadolerite.

dr: diorite.

Epidote rock or Epidosite (e): rocks rich in epidote.

Fine-grained: refers to a grain size less than 1 mm.

f: quartzofeldspathic gneiss (see Quartzofeldspathic gneiss).

fe: ironstone.

fm: muscovite-bearing quartzofeldspathic gneiss. A subdivision of quartzofeldspathic gneiss (f).

Granite (g): rocks of either granite or adamellite composition, having a mafic content of about 10 percent, and a hypidiomorphic texture. Some metamorphically retrogressed equivalents are included in the same category.

gb: gabbro and partly metamorphosed gabbro or norite.

gd: granodiorite, includes partly retrogressively metamorphosed granodiorite.

Granitic gneiss (gg): macroscopically (i.e. map scale) heterogeneous gneiss of broadly granitic mineralogy. The rock is commonly texturally or compositionally layered on a small-scale (outcrop to hand-specimen). Differs from quartzofeldspathic gneiss in forming large roughly equant to irregular bodies more than 1 km across rather than lenticular bodies within a compositionally layered sequence.

Granofels: metamorphic rocks that have a massive granular texture, but do not necessarily belong to the granulite facies (Goldsmith, 1959). In the Sheet area the use of 'granofels' is generally restricted to rocks of lower metamorphic grade than granulite.

Granulite (fn, mn, if, in): field term for hypersthene-bearing metamorphic rocks (White in Behy & others, 1971). In the Sheet area, the rocks are invariably granular, and include rare foliated and lineated varieties.

Granoblastic: is a texture consisting of a mosaic of anhedral grains (Collerson, 1974), which do not necessarily have smooth, straight grain boundaries.

Granuloblastic: is a texture characterised by grains having smooth boundaries and polygonal shapes. It is a special case of a granoblastic texture (Spry, 1969 p. 159; Binns, 1964).

Garnet-biotite gneiss (v): biotite gneiss containing garnet, in biotite in excess of 10 percent.

Gneiss: medium- to coarse-grained, irregularly layered (banded) and foliated rock in which the schistosity is commonly poorly defined because of the preponderance of quartz and feldspar over micaceous minerals (compare Joplin, 1968).

Hornblende gneiss (h): gneiss containing hornblende, and of acid to intermediate composition.

hp: symbol for clinopyroxene and hornblende-bearing plagioclase-rich gneiss, commonly with a moderate to abundant plagioclase content. Lacks corundum. May contain garnet. Used on RIDDOCH. Compare bp.

i: Cordierite-anthophyllite-kyanite gneiss. Very rare.

j: quartz-rich metasediment, mainly metasandstone.

ma: marble.

Medium-grained: refers to grain sizes between 1 and 5 mm.

Megacryst: A non-genetic term for any crystal or grain in an igneous or metamorphic rock, that is significantly larger than the surrounding groundmass or matrix. It may be a phenocryst, a porphyroblast or a porphyroclast.

Migmatite (mi): composite rock composed of igneous or igneous-looking and metamorphic materials, which are generally distinguishable megascopically (Dietrick, 1960 p. 50; Gary & others, 1973).

Mylonite (m): is used in the sense of Lapworth (1885) for a fine-grained layered rock, but without the genetic connotation that mylonites are a product of brittle deformation (Bell & Etheridge, 1973).

Mafic granulite (mn): nongenetic field term for hypersthene-bearing metamorphic rocks in which the colour index exceeds 50.

mt: unclassified metamorphic rock, identification normally based on photo-interpretation.

n: norite, micronorite.

"Porphyroblastic"-feldspar gneiss (p): quartzofeldspathic gneiss, biotite gneiss, or biotite schist containing megacrysts of feldspar. The megacrysts are generally but not always porphyroblasts.

pa: layered amphibolite or mafic calc-silicate rock: compositionally layered amphibolites or calc-silicate rocks having a relatively high colour index (e.g. 20 or more), and for uncommon amphibolites which are unusually layered, quartz-rich or have some other unusual feature.

peg: pegmatite. Most pegmatite dykes are unlabelled in the Harts Range area because they are so numerous.

Quartzofeldspathic gneiss (f): is a field term used for granular gneisses having a colour index of about 10 or less that form layers or lenticular bodies. They have a distinctive brownish-yellow in colour aerial photographs. These rocks are similar to leptite, a Fennoscandian term for meta-acid volcanics (Sederholm 1935). They are typically granitic, adamellitic, or granodioritic in composition. The gneiss commonly forms part of a layered sequence and shows internal compositional layering.

q: vein quartz

qf: magnetite-quartzite, quartz-magnetite rock or hematite-quartz rock.

qt: quartzite; is used for metamorphic quartzites rather than diagnetic quartzite.

Retrogressed rock (r): field term for a wide variety of rocks which have been remetamorphosed to a lower metamorphic grade, generally greenschist facies.

Schist: (s, sb, sc, sf, sm, sv): a cleaved or schistose rock in which the individual grains are visible to the naked eye. The symbol s is used for schist containing both muscovite and biotite; the symbol sb is used for biotite-rich varieties, particularly those that lack muscovite; the symbol sc, is used for the retrogressed equivalents of amphibolite which commonly contain actinolite, tremolite, or chlorite; the symbol, sf is used for highly schistose quartzofeldspathic rocks; the symbol sm, is used for muscovite or sericite schist; the symbol sv is used for garnet-bearing muscovite-biotite schist.

sp: spilite.

sv: garnet-muscovite-biotite schist and schistose gneiss.

Tectonic slide: A term proposed by Fleuty (1964) for a fault formed in close connection with folding that is accompanied by thinning and/or disappearance of the folded beds. Slides as used in this Record refer to ductile zones of high strain typically formed under moderate to high-grade metamorphism conditions rather than faults formed under low temperature brittle conditions.

to: tonalite; includes partly retrogressively metamorphosed tonalite.

un: meta-ultrabasic rock; includes meta-hornblendite and hornblende-rich amphibolite.

v: garnet-bearing gneiss or schistose gneiss.

vf: garnet-bearing quartzofeldspathic gneiss.

vm: garnet-muscovite gneiss (i.e. lacks biotite).

w: Staurolite schist: a rare rock type associated with muscovite-biotite schist (s).

y: kyanite-bearing phlogopite or biotite schist or gneiss.

z: sillimanite-bearing gneiss and garnet-sillimanite gneiss.

REFERENCES

AGIP NUCLEARE AUSTRALIA, PTY LTD, 1977 - Annual Report, Exploration Licence 1056, Illogwa Creek, July, 1977. Open File Report, Northern Territory Geological Survey, CR 77/82 (unpublished).

AGIP NUCLEARE AUSTRALIA PTY LTD., 1979 - Final report for exploration licence 1056, Northern Territory. Open File Report, Northern Territory Geological Survey, Alice Springs Office File CR 79/63.

ARMSTRONG, G., 1954 - Harts Range and Plenty River Mica Fields. Report - Northern Territory Geological Survey Office, File MBR/54/5 (unpublished).

ARMSTRONG, R.L., & STEWART, A.J., 1975 - Rubidium-strontium dates and extraneous argon in the Arltunga Nappe Complex, Northern Territory. Journal of the Geological Society of Australia, 22(1), 103-116.

AUSTRALIAN GEOPHYSICAL PTY LTD., 1967 - Results of prospecting operations in the Ringwood area. Open File Report by Kenneth McMahon & partners. Northern Territory Geological Survey CR 67/4 (Alice Springs ref. no. 67/8 (unpublished).

AUSTRALUS MINING CO PTY LTD, 1970 - Final Report on Prospecting Authority Number 2277, Mount Eaglebeak, Harts Range, N.T. Open File Report Northern Territory Geological Survey CR 70/16 (Alice Springs ref. no. 78/19) (unpublished).

BANKS J.E., 1964 - Mineral reconnaissance in the Amadeus Basin, Northern Territory, Australia. Report for Magellan Petroleum Cooporation (unpublished).

BARLOW, B.C., 1965 - Georgina Basin reconnaissance gravity survey, Northern Territory and Queensland, 1959. Bureau of Mineral Resources, Australia, Record 1965/96 (unpublished).

BARLOW, B.C., 1966 - Georgina Basin reconnaissance gravity survey using helicopters, Northern Territory and Queensland, 1960-61. Bureau of Mineral Resources, Australia, Record 1966/147 (unpublished).

BARRACLOUGH, D., 1973 - Final report on Exploration Licence 562, Entire Valley. Open File Report for Kewanee Australia Pty Ltd. Northern Territory Geological Survey, C73/176 (Alice Springs, ref. no. 78/59) (unpublished).

BARRACLOUGH, D., 1978 - Hammer Hill nickeliferous laterite prospect. Northern Territory Geological Survey Record G.S. 78/9, Alice Springs Office File MBR/78/9 (unpublished).

BEHY, H.J., DEN TEX, E., DE WAARD, D., MEHNERT, K.R., SCHARBERT, H.G., SOBOLEV, V., WATZNAUER, A., WINKLER, H.G.F., WYNNE-EDWARDS, H.R., ZOUBER, V., & ZWART, H.J., 1971 - Granulites. Results of a discussion. Neus Jahrbuch fur Mineralogie, Monatshefte.

BELL, T.H., & ETHERIDGE, M.A., 1973 - Microstructure of mylonites and their descriptive terminology. Lithos, 6, 337-48.

BINNS, R.A., 1964 - Zones of progressive regional metamorphism in the Willyama complex, Broken Hill District, N.S.W. Journal of the Geological Society of Australia, 11, 283-330.

BLACK, L.P., 1975 - Present status of geochronological research in the Arunta Block in PROTEROZOIC GEOLOGY. 1st Australian Geological Convention, Adelaide, South Australia, May, 1975. Geological Society of Australia, Abstracts.

BLACK, L.P., SHAW, R.D., & OFFE, L.A., 1980 - The age of the Stuart Dyke Swarm and its bearing on the initiation of sedimentation in the Amadeus Basin. Journal of the Geological society of Australia, 27, 151-155.

BLACK, L.P., SHAW, R.D., & STEWART A.J., in press-Rb-Sr geochronology of Proterozoic events in the Arunta Block. BMR Journal of Australian Geology & Geophysics (March, 1983).

BMR, 1967 - Total magnetic intensity and radioactivity, Illogwa Creek 1:250 000 Sheet area, N.T., F53/B1/7.

BROWN, H.Y.L., 1889 - Government geologists's report on a journey from Adelaide to the Hale River. South Australian Parliamentary Paper 24.

BROWN, H.Y.L., 1890 - Report of geological examination of country in the neighbourhood of Alice Springs. South Australian Parliamentary Paper 189.

BROWN, H.Y.L, 1897 - Report on Arltunga Goldfield and Harts Mica Field. South Australian Parliamentary Paper, 127.

BROWN, R., 1981 - X-ray diffraction work, Northern Territory Geological Survey Australian Mineral Development Laboratory, Report GS 5981/81 (unpublished).

BUREK, P.J., WALTER, M.R., & WELLS, A.T., 1979 - Magneto-stratigraphic tests of correlations between latest Proterozoic sequences in the Ngalia, Georgina and Amadeus Basin, central Australia. BMR Journal of Australian Geology & Geophysics 4(1), 47-55.

CHAPPELL, B.W., & WHITE, A.J.R., 1974 - Two contrasting granite types. Pacific Geology, 8, 173-4.

CLARKE, D.B., 1978a - Spriggs Camp Uranium occurrence. Northern Territory Geological Survey Internal Report, Alice Springs File MBR/78/1 (unpublished).

CLARKE, D.B., 1978b - Note on Spriggs Camp Bore ruby-corundum occurrence. Northern Territory Geological Survey, Data Files, Alice Springs (unpublished).

COATES, R.P., & PREISS, W.V., 1980 - Stratigraphic and geochronological reinterpretation of Late Proterozoic glaciogenic sequences in the Kimberley region, western Australia. Precambrian Research, 13, 181-208.

COGAR, P.E, & FELDERHOF, J.B., 1973 - Report on AP 3193, Entire Valley. Kewanee Australia Pty Ltd, Open File Report - Northern Territory Geological Survey Office, File CR/73/20 (unpublished).

COLLERSON, K.D., 1974 - Descriptive microstructural terminology for high-grade metamorphic tectonites. Geological Magazine 111, (4), 313-318.

COOPER, J.A., WELLS, A.T., & NICHOLAS, T., 1971 - Dating and galuconite from the Ngalia Basin, NOrthern Territory, Australia.

CORBETT, S., 1970 - Final report on P.A. 2277, Mount Eaglebeak, Harts Range. Australian Mining Co. Pty Ltd Open File Report. Northern Territory Geological Survey, Alice Springs Office Files CR/70/5 (unpublished).

CRAVEN, B.L., 1978 - Annual Report - Hale River exploration licence 1324. Esso Australia Ltd, Coal and Minerals Department, Report to November 11, 1978. Northern Territory Geological Survey Open File Report CR 79/29A.

DAILY, B., 1972 - The base of the Cambrian and the first Cambrian faunas. University of Adelaide, Centre for Precambrian Research, Special paper, 1, 13-37.

DALY, J., 1951 - Report on radiometric investigations at the Queen Mine, Harts Range, N.T. Bureau of Mineral Resources, Australia, Record 1951/27 (unpublished).

DALY, J., & DYSON, D.F., 1956 - Geophysical investigations for radioactivity in the Harts Range area, Northern Territory. Bureau of Mineral Resources, Australia, Report 32.

DIETRICH, R.V., 1960 - Nomenclature of migmatitic and associated rocks. Geotimes, Jan.-Feb. 4(5), 1960.

DOBOS, S.K., 1978 - Phase relations, element distributions and geochemistry of metamorphic rocks from the eastern Arunta Block, N.T. Ph.D. thesis, Macquarie University (unpublished).

DUNN, J.A., 1947 - Possibilities of developing the Harts Range mica belt. Bureau of Mineral Resources, Australia, Record 1947/89 (unpublished).

EXON, N.F., 1966 - Revised Jurassic to Lower Cretaceous stratigraphy in the southwest Eromanga Basin, Queensland. Queensland Government Mining Journal, 67(771), 232-8.

EXON, N.F. GALLOWAY, M.C., CASEY, D.J., & KIRKEGAARD, A.G., 1972 - Geology of the Tambo-Augathella area, Queensland. Bureau of Mineral Resources, Australia, Report 143.

FAULKNER, J.W., 1971 - Inspection of AP 2444, 2449, 2697 & 2698 Harts Range area. Geopeko Ltd Open File Report. Northern Territory Geological Survey, Alice Springs Office File CR/71/15 (unpublished).

FAULKS, I.G., 1967 - Monthly Report. Resident Geologists Office, BMR, Alice Springs, April 1967.

FELTON, E.A., 1981 - Well completion reports for BMR Illegwa Creek Nos. 3,4,5,6 and BMR Rodinga No. 4, Amadeus Basin NT. Bureau of Mineral Resources, Australia, Reocrd 1982 (unpublished).

FLACK, D.S. 1970 - Final report on A.P. 1991, Mount Powell, Harts Range. Report for Australus Mining Co. Pty. Ltd., for Placer Prospecting (Aust.) Pty. Ltd. Open File Report, Northern Territory Geological Survey CR 70/8 (Alice Springs ref. no. CR70/5) (unpublished).

FLEUTY, M.J., 1964 - Tectonic slides. Geological Magazine 1, (5), 452-456.

FORMAN, D.J., 1971 - The Arltunga Nappe Complex, MacDonell Ranges, Northern Territory, Australia. Journal of the Geological Society of Australia 18(2), 173-82.

FORMAN, D.J., MILLIGAN, E.N., & McCARTHY, W.R., 1967 - The structure of the northeastern margin of the Amadeus Basin, Northern Territory. Bureau of Mineral Resources, Australia, Report 104.

FORMAN, D.J., & SHAW, R.D., 1973 - Deformation of crust and mantle in central Australia. Bureau of Mineral Resources, Australia, Report 103.

FRENCH, D.J., 1980 - Drilling in the Illogwa Creek area - 1980. Unpublished report of Afmeco Pty Ltd on exploration conducted in EL 1056. Open File Report, Northern Territory Geological Survey, Alice Springs, N.T.

FRAZER, N., 1977 - Annual Report - Hale River Exploration Licence 1324. Minerals Department, Esso Australia Ltd. Open File Report, Northern Territory Geological Survey, Alice Springs, N.T.

GARY, M., McAFEE, Jr., R., & WOLF, C.L. (Eds), 1973 - GLOSSARY OF GEOLOGY. American Geological Institute, Washington, D.C.

GLAESSNER, M.F., 1969 - Trace fossils from the Precambrian and basal Cambrian. Lethaia, 2, 369-393.

GLAESSNER, M.F., PREISS, W.V., & WALTER, M.R., 1969 - Precambrian columnar stromatolites in Australia: morphological and stratigraphic analysis. Science 164, 056-1058.

GLAESSNER, M.F., & WALTER, M.R., 1975 - New Precambrian fossils from the Arumbera Sandstone, Northern Territory, Australia. Alcheringa, 1, 1, 59-69.

GOLDSMITH, R., 1959 - Granofels, a new metamorphic name. Journal of Geology, 67(1), 109-110.

GOURLAY, A.J., 1965 - Mica: in McLEOD, I.R. (Editor), AUSTRALIAN MINERAL INDUSTRY: THE MINERAL DEPOSITS. Bureau of Mineral Resources, Australia - Bulletin 72, 423-33.

HILL, DOROTHY, & DENMEAD, A.K., (Eds), 1960 - The geology of Queensland. Journal of the Geological Society of Australia, 7, 311.

HODGE-SMITH, T., 1932 - Geological and mineralogical observations in central Australia. Record Australian Museum 18, 415-42.

HOWLAND, D.B., 1971 - Report on Northern Territory field trip 14/10-14/11/78. EL378. Arcardia Minerals Ltd Open File Report. Northern Territory Geological Survey, Alice Springs Office File CR/78/7 (unpublished).

IDNURM, M., & SENIOR, B.R., 1978 - Palaeomagnetic ages of weathered profiles in the Eromanga Basin, Queensland. Palaeogeorgraphy, Palaeoclimatology and Palaeoecology, 24, 263-277.

JENSEN, H.I., 1936 - Water supply in the Harts Range area. Northern Geological Survey, Brief Internal Report, Alice Springs Office File MBR/39/3 (unpublished).

JENSEN, H.I., 1943a - Notes on field work in the Harts Range and Plenty River areas. Resident Geologist's Office, Alice Springs, Northern Territory, File F6-40 (unpublished).

JENSEN, H.I., 1943b - Report on mica deposits at Harts Range. Resident Geologist's Office, Alice Springs, Northern Territory, File F6-41 (unpublished).

JENSEN, H.I., 1944a - Mica Mines, Mount Powell-Hardings Springs locality, 1943/44. Northern Territory Geological Survey, Internal Report, Alice Springs Office Files MBR/44/8 (unpublished).

JENSEN, H.I., 1944b - General report on the geology and mineral resources of the Harts Range and Plenty River areas. Northern Territory Geological Survey, Alice Springs Office File MRB/44/4-5 (unpublished).

JENSEN, H.I., 1944c - The geology of Central Australia. Proceedings of the Royal Society of Queensland, 56, 85-94.

JENSEN, H.I., 1947 - The origin, distribution and mode of occurrence of mica in central Australia. Proceedings of the Royal Society of Queensland 57(4), 37-52.

JOKLIK, G.F., 1955a - The geology and mica fields of the Harts Range, central Australia. Bureau of Mineral Resources, Australia, Bulletin 26.

JOKLIK, G.F., 1955b - The mica-bearing pegmatites of the Harts Range, central Australia. Economic Geology 50(6), 625-49.

JONES, N.O., 1957 - Report on the examination of beryl prospects, Harts Range, Northern Territory. Bureau of Mineral Resources, Australia, Record 1957/28 (unpublished).

JOPLIN, G.A., 1968 - A PETROLOGY OF AUSTRALIAN METAMORPHIC ROCKS. Agnus & Robertson, Sydeny.

KATZ, M.B. 1981 - Note on the layered anorthosite complex of the Harts Range ruby deposit in the Arunta Block, central Australia. Journal of the Geologcal Society of Australia, 28, 247-248.

KINGDON, E.K., undated - NTGS Mineral Files - Compilation of references to minerals in the Alice Springs Office of the Northern Territory Geological Survey. Department of Mines and Energy, Northern Territory Government.

LANGRON, W.J., 1962 - Amadeus Basin reconnaissance gravity survey using helicopters, Northern Territory, 1961. Bureau of Mineral Resources, Australia, Record 1962/24 (unpublished).

LAPWORTH, C., 1885 - The highland controversy in British geology, Nature 32, 558-559.

LEITCH, E.C., FISHER, D., & MASON, D.R., 1970 - A suggested orogenic break within the metamorphic rocks of the Arunta complex, Central Australia. Search, 1(4), p.159.

MABBUTTT, J.A., 1967 - Denudation chronology in central Australia. In LANDFORM STUDIES FROM AUSTRALIA AND NEW GUINEA, (Ed.) JENNINGS, J.N., & MABBUTT, J.A. Canberra ANU Press, 144-181.

McCOLL, D.H., & WARREN, R.G., 1979 - The first discovery of ruby in Australia. Australian Mineralogist, 26, 121-125.

McINTYRE MINES (AUSTRALIA)PTY LTD., 1968 - Report on the Numery Prospect, Authority to Prospect, 1923. Open File Report prepared by R.A. Dodge & Associates, Northern Territory Geological Survey File CR/68/62. (Alice Springs Ref. No. CR78/73) (unpublished).

MALES, P.A., 1974 - Gem quality kyanite crystals from the Harts Range. The Australian Gemmologist, Northern Territory Geological Survey, Alice Springs, File MR/80/7.

MARJORIBANKS, R.W., & BLACK, L.P., 1974 - Geology and geochronology of the Arunta Complex, north of Ormiston Gorge, central Australia. Journal of the Geological Society of Australia, 21(3), 291-299.

MATHESON, D.J., 1968 - Mount Mary rare earths deposits, Harts Range. Capricornia Mineral Deposits Co Pty Ltd, Open File Report, Northern Territory GeologicaL Survey Files, Alice Springs CR/68/7.

MATTHEWS, W.H., 1905b - Report on the Arltunga and Winnecke's gold fields, and Harts Range mica fields. South Australian Parliamentary Paper, 75.

MILLER, P.G., 1971 - Assessment of exploration AP 2568, Harts Range area. Acadia Mines Ltd Open File Report by William Johnson and Associates Pty Ltd, Northern Territory Geological Survey File CR71/14. (Alice Springs ref. no. CR78/8) (unpublished).

MORRISON, M.E., & MATHESON, D.J., 1968 - Mount Mary rare earths deposits, Harts Range. Capricornia Mineral Development Co. Pty Ltd, Open File Report, Northern Territory Geological Survey, Alice Spring Office File CR/68/7 (unpublished).

PERRY, R.A., & OTHERS, 1962 - Lands of the Alice Springs area, Northern Territory, 1956-57. Commonwealth Scientific and Industrial Research Organisation, Melbourne Land Research Series 6.

PLUMRIDGE, C.L., & MACDONALD, R.D., 1970 - AP 2459, Hale River, Final Report, North Broken Hill Ltd. Open File Report, Northern Territory Geological Survey, CR7/58 (Alice Springs ref. no. 78/78) (unpublished).

PRICHARD, C.E., & QUINLAN, T., 1962 - The geology of the southern half of the Hermannsburg 1:250 000 Sheet area. Bureau of Mineral Resources, Australia, Report 61.

PREISS, W.V., 1972 - Proterozoic stromatolites - succession, correlations and problems. In JONES, J.B., & McCOWRAN, B., (Eds.) - University of Adelaide, Centre for Precambrian REsearch, Special Paper 1, 53-62.

PREISS, W.V., WALTER, M.R., COATS, R.P., & WELLS, A.T., 1978 - Lithological correlations of Adelaidean glaciogenic rocks in parts of the Amadeus, Ngalia, and Georgina Basins. BMR Journal of Australian Geology & Geophysics, 3, 43-53.

PRUCHA, J.J., GRAHAM, J.A., & NICKELSON, R.P., 1965 - Basement controlled deformation in Wyoming Province of the Rock Mountains Foreland. Bulletin American Association of Petroleum Geologists 49(7), 966-992.

QUILTY, J.H., & MILSON, J.S., 1964 - Simpson Desert aeromagnetic survey, 1962. Bureau of Mineral Resources, Australia, Record, 1964/115 (unpublished).

RENNIE, E.H., 1889 - On some so-called South Australian rubies. Transaction of Royal Society of South Australia, 11, 17-18.

RICKARD, M.J., 1975 - The structures of the Harts Range, Northern Territory. In PROTEROZOIC GEOLOGY Abstracts of First Australian Geological Convention, Adelaide, South Australia, May 1975. Geological Society of Australia.

RILEY, G.H., 1968 - Revision of granite ages in the Northern Territory, Australia. Special Paper Geological Society of America, Abstract 115, 184.

ROCHOW, K., 1962 - An investigation of the Harts Range and Plenty River mica mines. Bureau of Mineral Resources, Australia, Record 1962/34.

RUXTON, B.P., 1963 - Report of the Resident Geologist Office for the Northern Territory Administration. Northern Territory Geological Survey Alice Springs Files (unpublished).

SEDERHOLM, J.J., 1935 - SELECTED WORKS: GRANITES AND MIGMATITES. Wiley, New York.

SENIOR, B.R., 1972 - Cainozoic laterite and sediments in the Alcoota Sheet area, Northern Territory. Bureau of Mineral Resources, Australia Record 1972/47 (unpublished).

SENIOR, B.R., 1980 - Cainozoic studies in the Alice Springs region in Geological Branch Annual summary of Activities. Bureau of Mineral Resources, Australia, Record 1980/61 (unpublished).

SENIOR, B.R., MOND, A., & HARRISON, D.O., 1978 - Geology of the Eromanga Basin. Bureau of Mineral Resources, Australia, Bulletin 167.

SHAW, R.D., & MILLIGAN, E.N., 1969 - Illogwa Creek, Northern Territory - 1:250 000 Geological Series. Bureau of Mineral Resources, Australia, Explanatory Notes SF/53-15.

SHAW, R.D., STEWART, A.J., YAR KHAN, M., & FUNK, J.L., 1971 - Progress reports on detailed studies in the Arltunga Nappe Complex, Northern Territory, 1971. Bureau of Mineral Resources, Australia, Record 1971/66 (unpublished).

SHAW, R.D., & STEWART, A.J., 1975 - Towards a stratigraphy of the Arunta Block. In Proterozoic Geology. 1st Australian Geological Convention, Adelaide, South Australia, May 1975. Geological Society of Australia, ABstracts.

SHAW, R.D., & WARREN, R., 1975 - Alcoota, N.T. 1:250 000 Geological Series. Bureau of Mineral Resources, Australia, Explanatory Notes SF/53-10.

SHAW, R.D., LANGWORTHY, A.P., OFFE, L.A., STEWART, A.J., ALLEN, A.R., & SENIOR, B.R., 1979 - Geological Report on 1:100 000 scale mapping of the southeastern Arunta Block, alice Springs 1:250 000 Sheet area, Northern Territory. Bureau of Mineral Resources, Australia, Record 1979/49; BMR Microform MF133.

SHAW, R.D., & WELLS, A.T., in press - Alice Springs, Northern Territory - 1:250 000 Geological Series - 2nd Edition. Bureau of Mineral Resources, Australia, Explanatory Notes SF/53-15.

SPRY, A., 1969 - METAMORPHIC TEXTURES. Pergamon Press, Oxford.

STEIGER, R.H., & JAGER, E., 1977 - Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmo-chronology. Earth and Planetary Science Letters, 36, 359-62.

STEVENS, R.D., 1954 - Petrographic examination of rock specimen from the copper prospect on Ringwood station. Northern Territory Geological Survey Files, Alice Springs BMR/54/1.

STEWART, A.J., 1971a - Potassium-argon dates from the Arltunga Nappe Complex, Northern Territory. Journal of the Geological Society of Australia, 17, 205-211.

STEWART, A.J., 1971b - Structural evolution of the White Range Nappe, central Australia. Ph.D. thesis, Yale University. University Microfilms Incorporated, Ann Arbor, Michigan.

STEWART, A.J., & WARREN, R.G., 1977 - The mineral potential of the Arunta Block, central Australia. BMR Journal of Australian Geology and Geophysics, 2, 1977, 21-34.

STEWART, A.J., SHAW, R.D., OFFE, L.A., LANGWORTHY, A.P., WARREN, R.G., ALLEN, A.R., & CLARK, D.B., 1980a - Stratigraphic definitions of named units in the Arunta Block, Northern Territory. Bureau of Mineral Resources, Australia, Report 216; BMR Microform MF104.

STEWART, A.J., OFFE, L.A., GLIKSON, A.Y., WARREN, R.G., & BLACK, L.P., 1980b - Geology of the northwestern part of the Arunta Block, Northern Territory. Bureau of Mineral Resources, Australia, Record 1980/63; BMR Microform MF152 (unpublished).

STRECKEISEN, A., 1976 - To each plutonic rock its proper name. Earth-Science Reviews 12, 1-33.

SULLIVAN, C.J., 1942a - Brief notes on the Harts Range Mica Mines which may be capable of being re-opened. Bureau of Mineral Resources, Australia, Record 1942/39 (unpublished).

SULLIVAN, C.J., 1942b - Report on the Water Survey of the Harts Range Mica Field. Bureau of Mineral Resources, Australia, Record 1942/38 (unpublished).

SULLIVAN, D.A., 1970 - AP 2652 Ringwood copper/lead/zinc prospect. Kratos Uranium N.L. Open File Report, Northern Territory Geological Survey, Alice Springs Office File CR/78/69.

THAM, G.H.P., 1971 - Illogwa Creek Authority to Prospect No. 2712 and Atneequa Spring Authority to Prospect No. 3258, Northern Territory. CRA Exploration Proprietary Limited. Open File Report, Northern Territory Geological Survey File CR71/127 (Alice Springs Ref. No. 71/4) (unpublished).

TOMICH, S.A., 1952 - Brief report on an investigation of mines in the Harts Range and Plenty River Mica Fields, Northern Territory. Bureau of Mineral Resources, Australia, Record 1952/8.

WALTER, M.R., 1972 - Stromatolites and the biostratigraphy of the Australian Precambrian and Cambrian. Palaeontology, Special Paper 11.

WARREN, R.G., STEWART, A.J., & SHAW, R.D., 1974 - Summary of information on mineral deposits of the Arunta Complex, Alice Springs area, N.T. Bureau of Mineral Resources, Australia, Record 1974/117 (unpublished).

WARREN, R.G., 1980 - Summary descriptions of mineral deposits by commodities in the Alice Springs 1:250 000 Sheet area, Northern Territory. Bureau of Mineral Resources, Australia, Record 1980/44 (unpublished).

WEBB, A.W., & LOWDER, G.G., 1972 - K-Ar dating of rocks from the Arunta Complex. Australian Mineral Development Laboratory MP 2236/72 (unpublished).

WELLS, R., MILSOM, J.S., & TIPPER, D.B., 1966 - Georgina Basin aeromagnetic survey, Queensland and Northern Territory 1963-1964. Bureau of Mineral Resources, Australia, Record 1966/142 (unpublished).

WELLS, A.T., 1969 - Alice Springs, Northern Territory - 1:250 000 Geological series. Bureau of Mineral Resources, Australia, Explanatory Notes SF/53-14.

WELLS, A.T., 1(76 - Geology of the Late Proterozoic-Palaeozoic Amadeus Basin. 25th International Geological Congress, Sydney Australia, Excursion Guide No. 48A. Progress Press Pty Ltd, Canberra.

WELLS, A.T., in press - Late Proterozoic diamictites of the Amadeus and Ngalia Basins, central Australia. In HAMBREY, M.J., & HARLAND, W.B., PRE-PLEISTOCENE TILLITES: a record of Earth's Glacial History. Project 38 of the International Geological Correlation Programme. Cambridge University Press.

WELLS, A.T., RANFORD, L.C., STEWART, A.J., COOK, P.J., & SHAW, R.D., 1967 - Geology of the northeastern part of the Amadeus Basin. 1. Bureau of Mineral Resources, Australia, Report, 113.

WELLS, A.T., FORMAN, D.J., RANFORD, L.C., & COOK, P.J., 1970 - Geology of the Amadeus Basin, central Australia. Bureau of Mineral Resources, Australia, Bulletin 100.

WOODBURNE, M.O., 1967 - The Alcoota Fauna, Northern Territory. Bureau of Mineral Resources, Australia, Bulletin 87.

WOOLLEY, D.R., 1963 - Geology and groundwater resources of Plenty River Downs, N.T. Report to Resident Geologist, Alice Springs (unpublished).

YOULES, I.P., 1964 - Copper prospect - Illogwa Creek. Northern Territory Geological Survey, Internal Report, Alice Springs Files MBR/64/3 (unpublished).

Appendix A (1): Selected analyses - rock chip samples

Specimen Number	AAS* Analysis ppm			Semi-Quantitative Emission Spectoscopy AMDL Rept. AC2538/80 ppm							
	Cu	Pb	Zn	Co	Mn	Ni	V	Ag	P	Ba	W
Detection Limit	(2)	(5)	(2)	(5)	(10)	(5)	(10)	(0.1)	(100)	(200)	(50)
1082A	250	25	220	80	600	80	200	2.0	400	200	X
1129A	310	60	220	60	100	40	200	0.1	80	X	X
1203	80	5	20	200	2500	15	60	0.3	200	200	X
1261A	100	-5	8	80	150	20	60	0.4	X	X	X
1315A	740	1550	3700	200	4000	300	200	2.0	4000	X	X
1332	60	-5	120	80	2500	50	150	0.2	X	X	X
1338B	260	15	35	20	2500	40	30	0.1	X	X	X
1395	210	20	200	100	300	100	60	1.0	800	600	X
1820A	20	15	20	80	500	100	170	X	2000	3000	150
1820B	8000	5	140	100	500	150	150	2.0	800	1000	20000
2512	1000	10	10	50	150	20	40	0.8	400	X	X

- = less than
X = not detected
* AMDL Report AC4092/80; CODE C1; Perchloric acid digestion; Accuracy = 5%

APPENDIX A(2)

SELECTED ANALYSES - ROCK CHIP SAMPLES.

Specimen No. SEMI-QUANTITATIVE EMISSION SPECTROSCOPY. AMDEL REPORT AC3754/80

PPM

Specimen No.	V	Mn	Ni	Cr	Co	La	Y	Cu	Pb	Zn	P
Detection Limit	10	10	5	20	5	50	10	5	1	20	100
522A	100	300	25	80	15	100	40	400	20	60	100
524D	100	100	10	30	5	X	10	300	25	X	100
524E	150	100	25	30	30	X	20	10	50	X	200
524F	80	100	20	20	X	X	10	15	40	X	100
525B	100	150	10	100	X	X	10	80	20	X	200
672	500	500	80	400	100	X	30	600	5	X	100
680A	100	>1%	50	X	40	X	20	80	25	150	200
748	50	300	30	X	25	X	30	100	10	20	1000
773	40	400	40	X	10	X	30	15	10	40	5000
836A	100	8000	150	20	100	X	20	100	15	250	8000
840	25	200	X	20	X	50	20	8	8	X	100
854	25	1500	80	20	30	X	20	80	15	40	6000
857A	150	400	150	40	80	X	X	50	30	150	1500
873	25	250	80	X	30	X	40	40	10	60	>1%
876	25	200	40	20	15	X	60	100	25	60	500
959A	300	1000	50	200	50	X	80	300	10	X	100
959B	200	800	100	300	80	X	60	400	15	X	1000
969	40	800	30	40	10	50	10	30	20	40	100
970A	50	3000	40	40	15	X	20	80	10	20	X
970B	80	3000	40	40	15	100	100	150	10	40	500
978	25	300	30	X	5	X	X	30	3	X	1500
979B	250	1000	15	30	X	600	80	15	15	X	800

Also Mo contents: 524D(30ppm) 774(10ppm), 836A(10) Nb: 970B(20ppm)

Ag: 959A(0.6ppm), 959B(0.6). As: 748(100ppm), 876(50ppm)

Bi: 524E(25ppm)

X: below detection limit.

Appendix B. Analysis of siliceous laterite (Atomic absorption analysis using hydrofluoric acid digestion, Code C4, AMDL Report AC 4466/80).

Sample	No. of specimens per transect	Av. Ni	Av. Cr	Av. Co
7909-0018	7	2317	483	43
-0024	10	1350	146	47.5
-0025	7	1326	311	30
-0030	9	397	310	20
-0031	7	756	263	36
-0032	4	1075	410	17.5
-0307	6	1752	653	153

Locations:

-0018	Hammer Hill Prospect
-0024	10km north of Brahma Bore
-0025	As above (alongside 1037)
-0030	Southeast of Hammer Hill Prospect
-0031	West of Hugh Dam
-0032	East of Hugh Dam, 17 km northeast of Brahma Bore
-0307	15 km northeast of Brahma Bore.

APPENDIX C. WHOLE ROCK GEOCHEMICAL ANALYSES.

1) Brady Gneiss
2) Bruna Gneiss
3) Upper Entia Gneiss
4) Upper Entia Gneiss
5) Lower Entia Gneiss
6) Upper Entia Gneiss (trace elements)
7) Inkamulla Granodiorite
8) Riddock Amphibolite Member

See following pages for results.

1) SAMPLE NO. R 4631 - BRADY GNEISS

LOCATION: 1.6 km north-northwest of Central Mine, RIDDOCH

SILICATE ANALYSIS		NORM	
OXIDE	PERCENT		
SiO_2	77.56	q	52.38
TiO_2	0.37	or	13.34
Al_2O_3	10.64	ab	11.53
Fe_2O_3	0.23	an	10.01
FeO	3.09	c	2.24
MnO	*		
MgO	1.41	hy	8.38
CaO	2.02	mt	0.23
Na_2O	1.34	il	0.71
K_2O	2.26	ap	0.36
P_2O_5	0.22		
H_2O^+	0.74		
H_2O^-	0.17		
TOTAL	100.05		

Analysis by Avery & Anderson Joklik (1955a, p. 75)

* not analysed.

2) SAMPLE NO. R4596A. BRUNA GNEISS CONTAINING K-FELDSPAR MEGACRYSTS

LOCATION: 2.4 km north of Florence Creek Camp. RIDDOCH

SILICATE ANALYSIS

OXIDE	PERCENT	CIPW NORM		RATIOS	
SiO_2	63.80	Diopside En_x	0.00	Mg-No	45.60
TiO_2	0.78	Hypersthene	10.91	Plagioclase An_x	46.60
Al_2O_3	16.00	Olivine Fo_4	0.00	Denisty	2.78
Fe_2O_3	1.06			Solidification Index	13.78
Feo	4.32	Quartz	18.96	Thornton-Tuttle D.I.	68.16
MnO	*	Corundum	0.93	Peralkaline Index	0.57
MgO	2.03	Zircon	0.00	K_2o/Na_2O	2.34
CaO	3.64	Orthoclase	30.54	Total Fe as Feo	5.27
Na_2O	2.19	Albite	18.66		
K_2O	5.13	Anorthite	16.28		
P_2O_5	0.29	Nepheline	0.00		
H_2O^+	0.37	Leucite	0.00		
H_2O^-	0.35	Magnetite	1.55		
		Chromite	0.00		
		Ilmenite	1.49		
TOTAL	99.96	Rutile	0.00		
		Apatite	0.69		
		Calcite	0.00		

Analysis by Avery & Anderson   Joklik (1955a, p. 67)

* MnO not analysed.

3) SAMPLE NO. 78916633 TONALITIC BIOTITE QUARTZOFELDSPATHIC GNEISS FROM UPPER ENTIA GNEISS

LOCATION: 11.1 km northeast of Inkamulla Bore, field point 1900B, GR QUARTZ 294801

SILICATE ANALYSIS		CIPW NORM		RATIOS		TRACE ELEMENTS	
OXIDE	PERCENT					Element	ppm
SiO_2	70.99	Diopside	0.00	Mg-No.	49.78	V	25
TiO_2	0.21	Hypersthene	3.31	Plagioclase An_x	32.96	Cr	15
Al_2O_3	15.97	Olivine	0.00	Density	2.71	Li	6
Fe_2O_3	0.59			Solidification Index	8.71	Cu	15
FeO	1.26	Quartz	31.86	Thornton-Tuttle D.I.	75.88	Zn	25
MnO	0.03	Corundum	0.85	Peralkaline Index	0.53	Ni	20
MgO	0.70	Orthoclase	6.49	K_2O/Na_2O	0.25	Ba	380
CaO	3.83	Albite	37.53	Total Fe as FeO	1.79	Ce	110
Na_2O	4.40	Magnetite	0.86			Pb	13
K_2O	1.09	Ilmenite	0.40			Nb	*4
P_2O_5	0.04	Apatite	0.10			Rb	42
H_2O^+	0.11					Sr	400
CO_2	0.07					U	*4
SO_3	0.20					Y	*4
						Zr	100
TOTOAL	99.85						

4) SAMPLE NO. 78916631A BIOTITE-HORNBLENDE GRANITIC GNEISS FROM UPPER PART OF ENTIA GNEISS

LOCATION: 10.3 km northeast of Inkamulla Bore, field point 1895, GR QUARTZ 227493

SILICATE ANALYSIS		CIPW NORM		RATIOS		TRACE ELEMENTS	
OXIDE	PERCENTAGE					Element	ppm
SIO_2	66.64	Diopside	7.40	Mg-No.	68.80	V	45
TiO_2	0.35	Hypersthene	5.08	Plagiclase An_x	41.67	Cr	25
Al_2O_3	13.48	Olivine	0.00	Density	2.72	Li	6
Fe_2O_3	0.81			Solidification Index	17.42	Cu	70
FeO	1.95	Quartz	20.24	Thornton-Tuttlle D.I.	76.31	Zn	25
MnO	0.08						
MgO	2.42	Orthoclase	43.53	K_2O/Na_2O	4.97	Ba	1250
CaO	3.81	Albite	12.55	Total Fe as FeO	2.68	Ce	120
Na_2O	1.46	Anorthite	8.96			Pb	28
K_2O	7.25	Magnetite	1.19			Nb	*4
P_2O_5	0.12	Ilmenite	0.68			Tb	140
H_2O^+	0.41	Apatite	0.29			Sr	100
H_2O^-	0.16	Calcite	0.09			Th	8
CO_2	0.04					U	*4
SO_3	0.17					Y	12
TOTAL	99.66						

* = less than

Analyses by AMDEL AL3590/79 - oxides by Code H3; V, Cr, Li, Cu, Zn, by Code C4(i.e. Atomic absorption, hydrofluoric acid digestion); Ba, Ce, Pb, Nb, Rb, Sr, Th, U, Y, Zr by Code B1, (i.e. x-ray fluorescene, accuracy ± 5%).

5) SAMPLE NO. R4559 GRANITIC GNEISS FROM LOWER PART OF THE ENTIA GNEISS

LOCATION: 1.6 km north-northeast of Inkamulla Bore

FIELD POINT 3093, GR QUARTZ 191459

SILICATE ANALYSES OXIDE PERCENTAGE		CIPW NORM		RATIOS	
SiO_2	75.67	Diopside En_x	0.00		
TiO_2	0.08	Hypersthene En_x	0.45	Plagioclase An_x	25.22
Al_2O_3	14.45	Olivine Fo	0.00	Density	2.65
Fe_2O_3	0.37			Solidification Index	2.27
FeO	0.00**	Quartz	37.72	Thornton-Tuttle D.I.	88.84
MnO	*	Corundum	1.74	Peralkaline Index	0.67
MgO	0.18	Orthoclase	26.24	K_2O/Na_2O	1.51
CaO	1.77	Albite	24.88	Total Fe as FeO	0.33
Na_2O	2.94	Anorthite	8.39		
K_2O	4.44	Hematite	0.37		
P_2O_5	0.06	Magnetite	0.00		
H_2O^+	0.12	Ilmenite	0.00		
H_2O^-	0.02	Rutile	0.08		
		Apatite	0.14		
	100.11				

Analysis by Avery & Anderson (Joklik, 1955a, p. 63).

* MnO not analysed

** FeO not recorded.

6) SAMPLE NO. 78916632: QUARTZOFELDSPATHIC GNEISS, UPPER PART OF ENTIA GNEISS

LOCATION: 10.6 km northeast of Inkamulla Bore, field point 1900A GR QUARTZ 294480

TRACE ELEMENTS	
Ba	1450
Ce	95
Pb	14
Nb	* 4
Rb	40
Sr	630
Th	8
U	* 4
Y	8
Zr	70

* = less than

Analyses as for 78916631.

7) SAMPLE NO. R4559 INKAMULLA GRANODIORITE

LOCATION: 0.8 km south-southeast of Inkamulla Bore, field point 3031; GR QUARTZ 189441

SILICATE ANALYSIS

SiO_2	63.38	Diopside En_x	0.00	Mg-No	50.60
TiO_2	0.54	Hypersthene	7.25	Plagioclase An_x	46.74
Al_2O_3	18.50	Olivine Fo_x	0.00	Density	2.74
Fe_2O_3	0.83			Solidification Index	13.07
FeO	2.70	Quartz	16.27	Thornton-Tuttle D.I.	64.90
MnO	*	Corundum	0.20	Peralkality Index	0.50
MgO	1.55	Zircon	0.00	K_2O/Na_2O	1.03
CaO	5.34	Orthoclase	20.35	Total Fe as Feo	3.45
Na_2O	3.34	Albite	28.28		
K_2O	3.44	Anorthite	24.82		
P_2O_5	0.26	Nepheline	0.00		
H_2O^+	0.24	Leucite	0.00		
H_2O^-	0.08	Magnetite	1.20		
		Chromite	0.00		
		Ilmenite	1.03		
		Rutile	0.00		
		Apatite	0.62		
		Calcite	0.00		

Total 100.2

Analysis by Avery & Anderson Joklik (1955a, p. 41).

* MnO not analysed

8) SAMPLE NO. R4619 - RIDDOCK AMPHIBOLITE MEMBER OF THE IRINDINA GNEISS

LOCATION: 2.4 km northeast of Mount Riddock, RIDDOCH.

SILICATE ANALYSIS

OXIDE	PERCENT	NORM	
SiO_2	50.32	or	1.73
TiO_2	2.08	ab	25.15
Al_2O_3	14.95	an	26.69
Fe_2O_3	1.34	di	20.65
FeO	9.48	hy	13.54
MnO	*		
MgO	7.58	ol	5.98
CaO	10.66	mt	1.91
Na_2O	3.00	il	3.95
K_2O	0.34	ap	0.38
P_2O_5	0.23		
H_2O^+	0.14		
H_2O^1	0.10		
Cl	0.09		
	100.30		

Analysis by Avery & Anderson, Joklik (1955a, p.49).
* not analysed.

Appendix D. Analysis of radioactive rocks (AMDL Code B1/1-2, Report AC 4490/80, XRF analyses)

Speciman Number	U	Th	Pb	Y	Rb	Count Rate C/S	Rock Type Symbol	Unit
79090378	4-*	20	7	20	95	80	f	pChe
1303	8	75	20	75	60	80	peg	pChe
1345B	60	4	50	12	880	60	peg	pCa
1372A	4-*	28	9	38	160	85	sb	pCa
1372B	4-*	50	16	16	110	120	gg	pCa
1384	6	32	16	80	330	130+	p	pCa
1385	4	40	42	16	330	100	f	pCa
1411A	140	36	22	40	520	100	sb?	pCa
1412A	110	24	26	30	560	80	sb?	pCa
1414	80	26	19	26	360	160	gg	pCa
1418A	95	44	17	65	500	150	sb?	pCa
1439B	6	10	22	14	310	85	g	Pgq
1440A	10	4	5	4	110	-	bc	Pgq
1441	95	20	38	16	380	-	bc	Puh
1459A	16	32	22	14	270	130	gg,r	pCa
1482	6	12	55	8	290	80	sb	pCa
2501A	8	46	28	16	290	60	f	pCa
2504	4	44	9	20	260	80	qf	pCa
2506	6	140	32	14	280	100+	f,peg	pCa

* x - = less than x

E. X-RAY DIFFRACTION RESULTS - (GENERAL)

79091056A - PYROXENE GROUP (poss. Aegirine-augite) in layered amphibolite west of Mount Powell

1056B - CALCITE (as above)

1070 - AMPHIBOLE GROUP in layered amphibolile (Entia Gneiss) west of Mount Powell.

1085A - QUARTZ, MICA, K-FELDSPAR present in altered margin of metagabbro west of Mount Powell.

1110A - STILBITE $(No_2, Ca) Al_2Si_6O_{16} \cdot 6H_2O$ - pale brown a circular crystals in layered amphibolite (Entia Gneiss) 10 km west of Huckitta Well (abandoned)

1217A - QUARTZ, CHLORITE, POSS, BIOTITE PRESENT; deformed zone, Albarta Prospect

1219B - AMPHIBOLE - POSS. TREMOLITE, meta-ultramatic rock 7 km NNW Huckitta Well

1237A - AMPHIBOLE POSS. Hornblende; meta-ultrabasic rock 3 Km east of Valley Bore

1237B - AMPHIBOLE GROUP poss. Paragsite, as above

1239A - CHLORITE in schist 3 Km west of Valley Bore

1240B - EPIDOTE-GROUP Poss. Epidote, in quartz vein at Valley Bore Scheelite Prospect

1244 - CHRYSOBERYL, Yellow-green mineral of Leprechaun Mica Mine

1245B - HYDROXY APATITE in pegmatite, mica mines 1 Km west of Lindsay Mine

1418A - CALLED 1418B MICA GROUP- POSS. SERICITE AND tr. CHLORITE, black schist 15 Km west of Albarta Dam, restrograde schist zone.

1439A - TOURMALINE in granite 5 Km northeast of Atniepa wh, LIMBLA, Tourmalive Gorge Prospect

1459C - HEMATITE in retrograde schist zone northern extension of Albarta Prospect

0403 - GARNET in C2c 2 Km northwest of Valley Bore

79090410A - LIGHT MINERAL - EPIDOTE GROUP in calc-silicate rock, 2 Km northwest of Valley Bore

79090401B - DARK MINERAL - EPIDOTE GROUP POSS. CLINOZOISITE, as above

0401C - ?SEPIOLITE, NO EVIDENCE OF SCHEELITE IN EITHER SURFACE COATING OR WHOLE ROCK SAMPLES, local as above

1343 - AMPHIBOLE GROUP POSS. TREMOLITE in altered amphibolite 23 Km northwest of Albarta Bore

1314A - DARK GREEN MINERAL AMPHIBOLE GROUP poss. Hornblende in meta-ultramafic rock; north of Aremra Bore

- LIGHT GREEN MINERAL AMPHIBOLE GROUP poss. Hornblende, as above

1315B - AMPHIBOLE GROUP POSS. PARGASITE, Copper occurrence 2.5 Km northwest Aremra Bore

1354 - LIGHT GREEN FLAKY MINERAL - CHLORITE in meta-ultramafic rock 12 Km southeast of Mount Ruby

1150 - MICA POSS. MUSCOVITE in tonalite in Illogwa Creek 12 km southeast of Mount Ruby

1148 - AMPHIBOLE, POSS. MICA (BIOTITE) AND POSS. TRACE CHLORITE in schist in retrograde zone 13 km southeast of Mount Ruby

997B - CALCITE, yellow mineral, Hillrise Ruby Mine

1888D - (a) COATING MATERIAL - CALCITE in ruby-bearing rock at Hillrise Mine

(b) WHOLE ROCK - AMPHIBOLE AND MICA as above

Identifications by Julie Fitzsimmons (BMR)

APPENDIX F. XRD LABORATORY REPORT HAMMER HILL PROSPECT NTGS DRILL HOLE.

1. 0-26 m Quartz felspar, clays
   Clays - kaolinite, montmorillonite, illite.
2. 20.17 m Montmorillonite.
3. 30-40 m Montmorillonite, talc or pyrophyllite.
4. 65-85 m Green area - serpentine (antigorite) major, chlorite minor, dolomite minor, amphibole minor.
   Dark zone - chlorite major, serpentine minor.

JULIE FITZSIMMONS (BMR)

12/2/82

APPENDIX G(6) ABBREVIATIONS USED ON LITHOLOGICAL LOGS AND MEASURED SECTIONS

Above	abv	Matrix	mtx
Abundant	abd	Medium	m
Altered	alted	Mica (ceous)	Mic, mic
And	&	Moderate	mod
Angular	ang	Montmorillonite	M
Black (ish)	blk, (blk)	Mudstone	Mdst
Blue (ish)	bl, (bl)	Opaline silica	O
Brown (ish)	brn, (brn)	Olive	olv
Calcareous	calc	Mottled	Om
Carbonaceous	carb	Orange	orng
Coarse	c	Pale	pl
Chemically	chem	Pink (ish)	pk, (pkP)
Chlorite	C	Poor	p
Clinopitilolite	CL	Purple	purp
Dark	dk	Pyrite	Pyr
Fair	fr	Quartz	Qz
Feldspar	Fld	Quartzose	qzs
Fe minerals	Fe	Randomly inter-stratified clays	R
Ferruginous	fe	Rounded	rndd
Fine	f	Sand (y)	Sd, sd
Friable	fri	Sandstone	Sst
Glauconite	Glau	Secondary	sec
Goethite	G	Silcrete	Sil
Grained	grnd	Siltstone	Sltst
Grey (ish)	gy, (gy)	Siliceous	silic
Green (ish)	gn, (gn)	Soft	Sft
Gypsum	Gyp	Soil	Sl
Hard	hd	Sorted	srtd
Illite	I	Staining (ed)	Stng stnd
Interbedded	intbdd	Subangular	subang
Intercalated	intcld	Subrounded	subrndd
Kaolinite	K	Very	v
Kaolinitic	Koal	Weathered	wthrd
Laminated	lamd	Well	w
Light	lt	White (ish)	wh, (wh)
Limestone	Lst	With	c
		Yellow (ish)	yel, (yel).

APPENDIX G(a) SYMBOLS USED ON LITHOLOGICAL LOGS AND MEASURED SECTIONS

BEDDING STRUCTURES

- bioturbation
- concretions
  - f ferruginous
  - c calcareous
- slickensides
- mudclast (rounded)
- mudclast (angular)
- parallel lamination
- cross stratification (solitary)
- cross stratification (group)
- undulose
- scour & fill
- slumped
- mottled
- remnant bedding trace
- joints or cracks
- unconformity

BED THICKNESS

very thick	>120 cms	
thick	60-120	
medium	5- 60	
thin	1- 5	
laminate	<1	

LITHOLOGICAL SYMBOLS

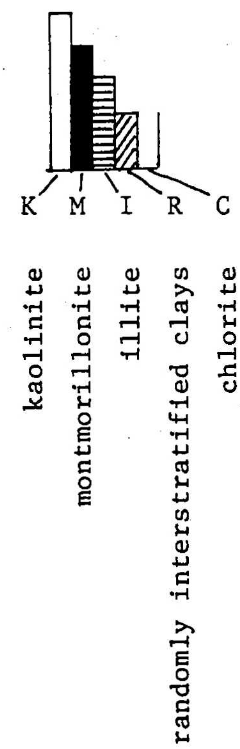
- sandstone
- pebbly sandstone
- conglomerate
- sandy limestone with clasts
- silcrete
- siltstone
- mudstone
- ferruginous layers
- limestone or calcareous sandstone
- lignite

FOSSILS

- plant fossil
- fossil wood
- spore or pollen

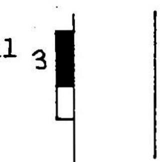
CLAY MINERALOGY

dominant	>50%
subdominant	20-50%
accessory	5-20%
trace	<5%

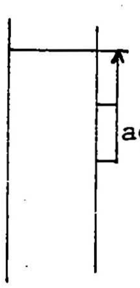


DRILLING DATA

cored interval & recovery



GROUNDWATER



PLATES

Reduced Compilation Sheets of QUARTZ and LIMBLA 1:100 000 Sheet areas, and the eastern two-thirds of Illogwa Creek 1:250 000 Sheet area.

ILLOGWA CREEK F53/15

Scale 1:46000

N.B. p€h not differentiated from p€

Geology 1979 by R.D. Shaw, B.R. Senior, L.A. Offe BMR
M.J. Freeman NTGS

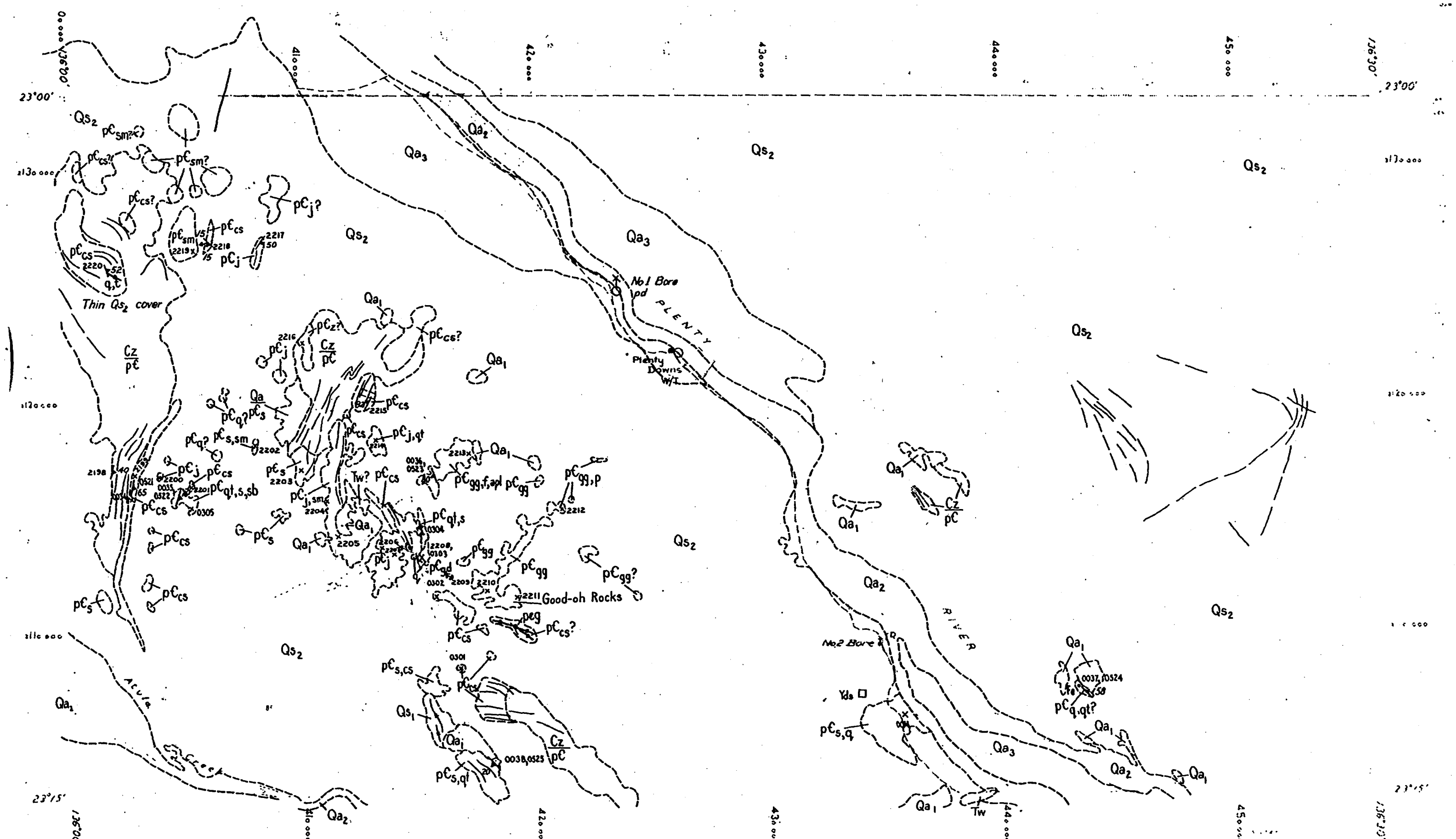
Compiled 1979 by R.D. Shaw, B.R. Senior, L.A. Offe,
D.G. Walton BMR,
M.J. Freeman NTGS

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Northern Territory Geological Survey. Issued under the joint authority of the Minister for National Development, and the Minister for Mines and Energy, Northern Territory. Base map compiled by the Division of National Mapping from orthophoto maps at 1:100 000 scale.

1 0 2 4 6 8 10 Kilometres

Scale 1:81 833

ILLOGWA CREEK
SF 53-15



☐ ILLOGWA CREEK F53/15
SHEET 5/382
SCALE 1:46 000 NMP 56/039

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I 0 2 4 6 8 10 Kilometres

Scale 1:81 833

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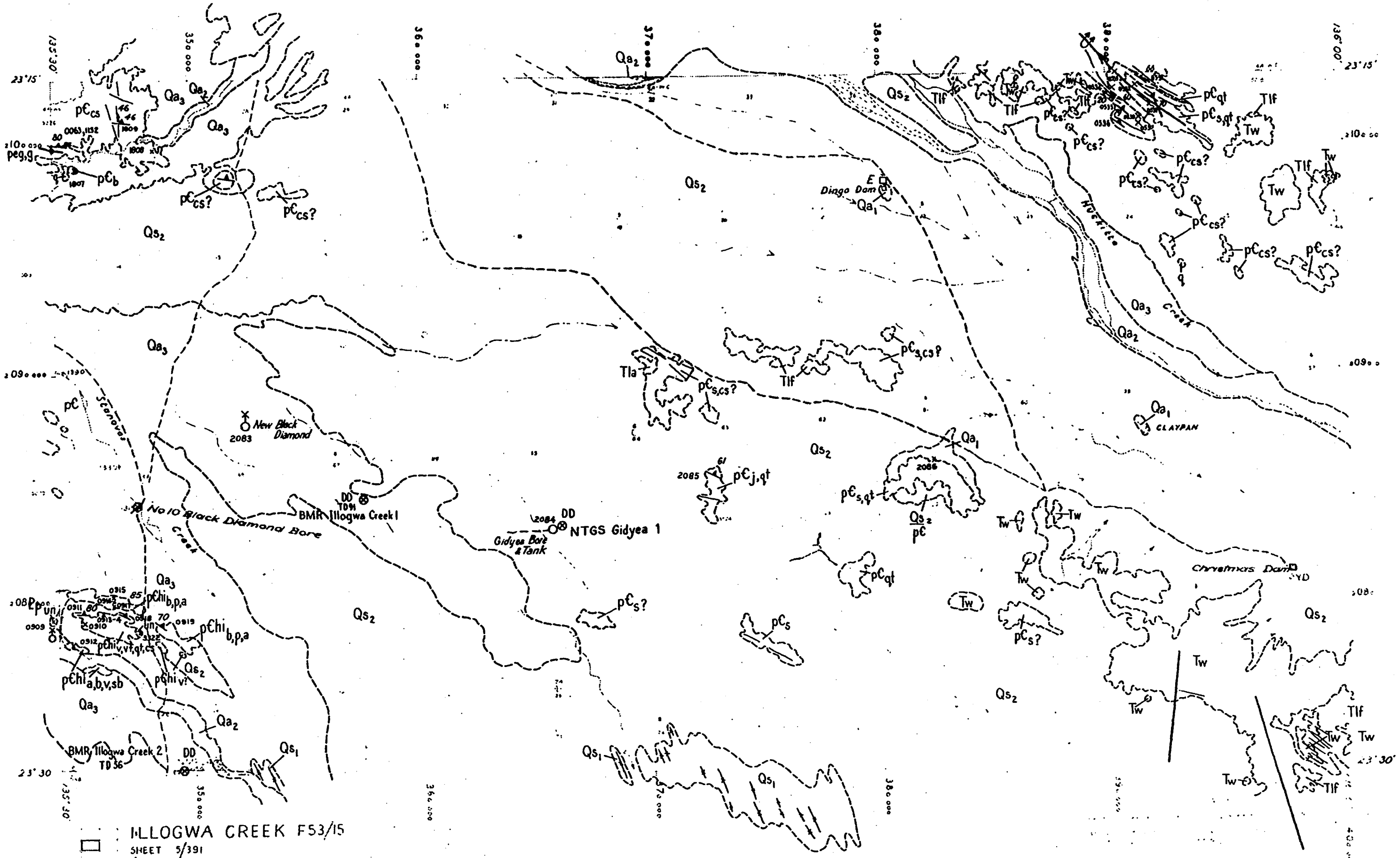
ILLOGWA CREEK
SF 53-15



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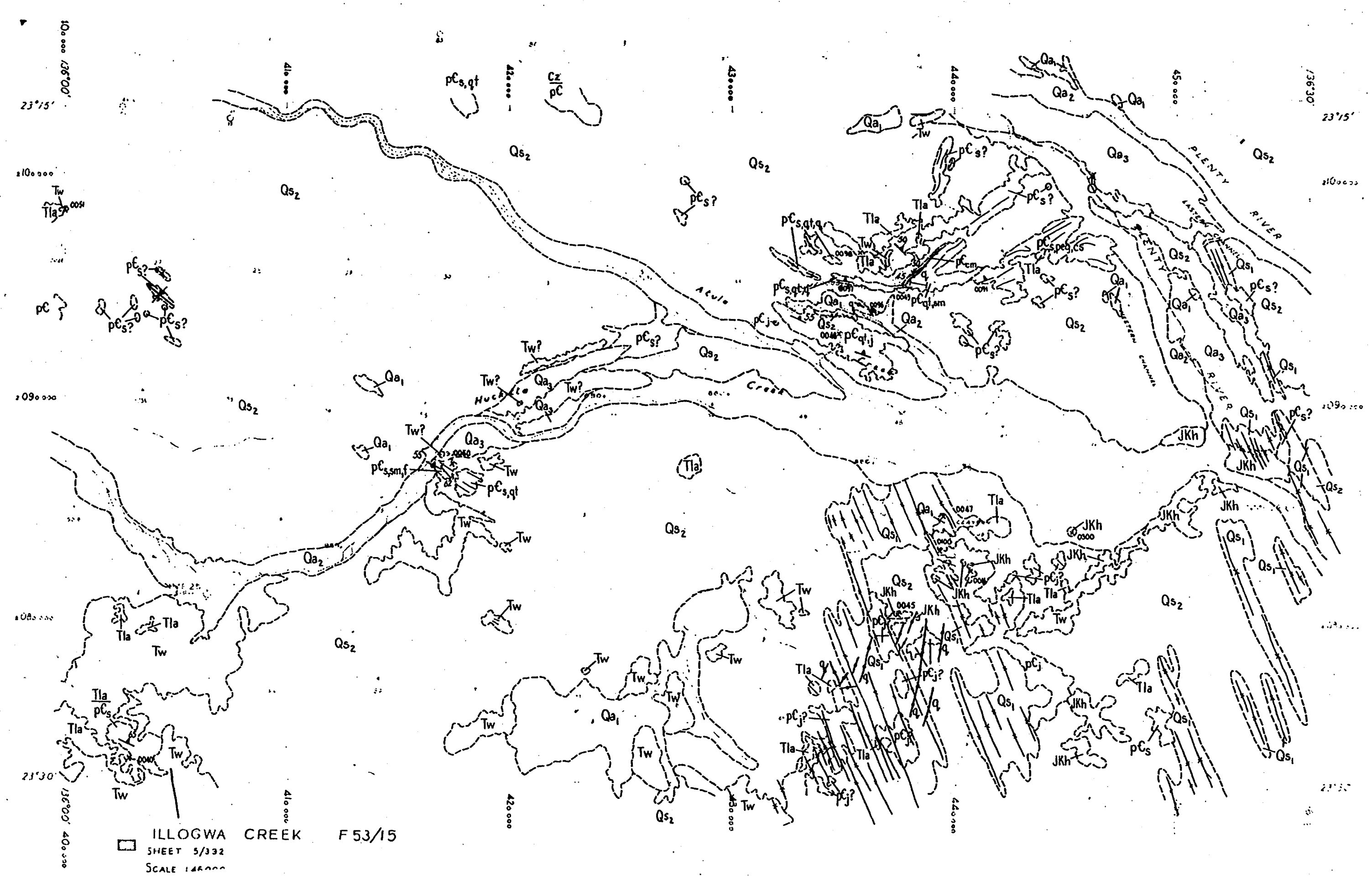
ILLOGWA CREEK
SF 53-15



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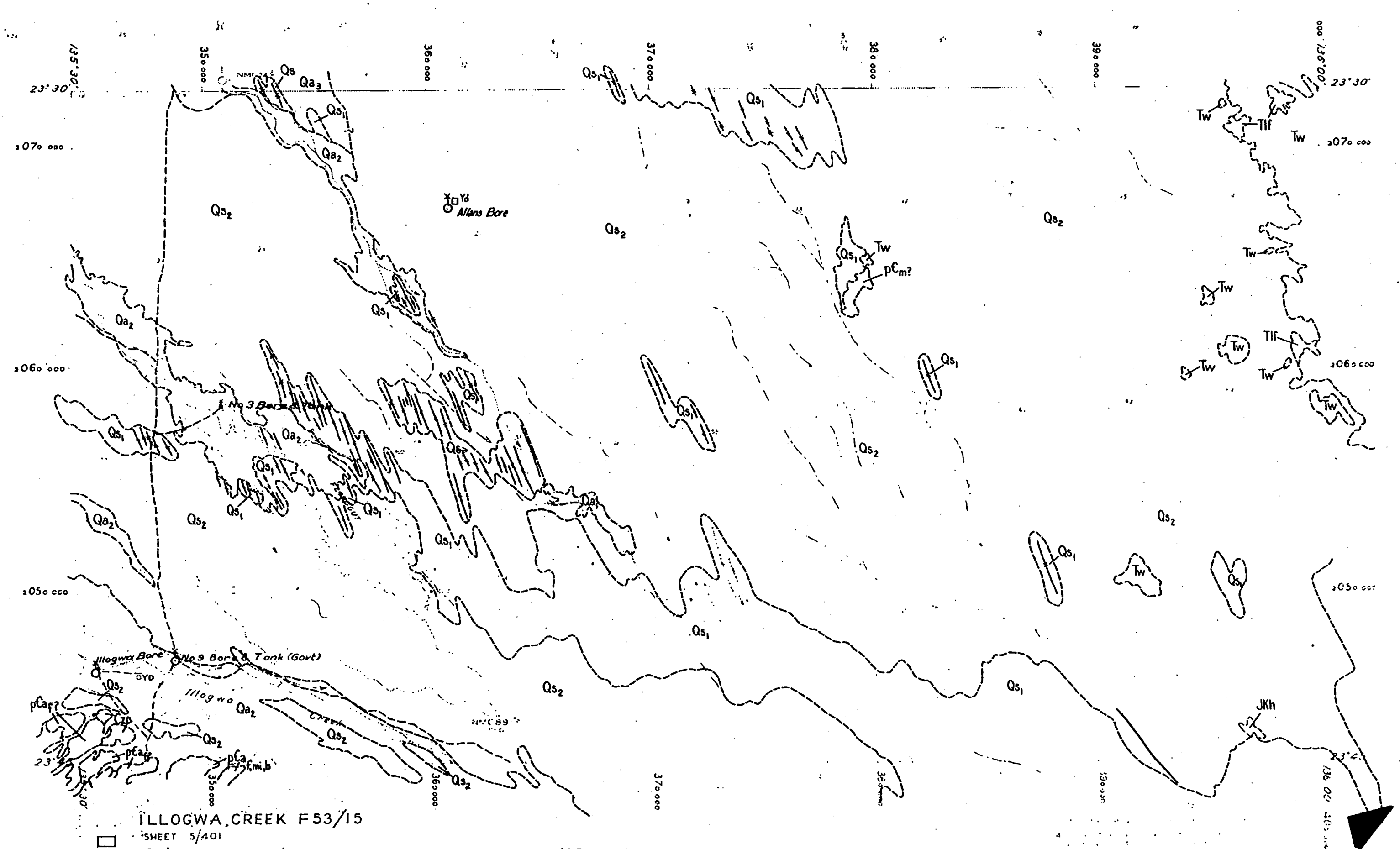
ILLOGWA CREEK
SF 53-15

Record 1982/23



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1 0 2 4 6 8 10 Kilometres

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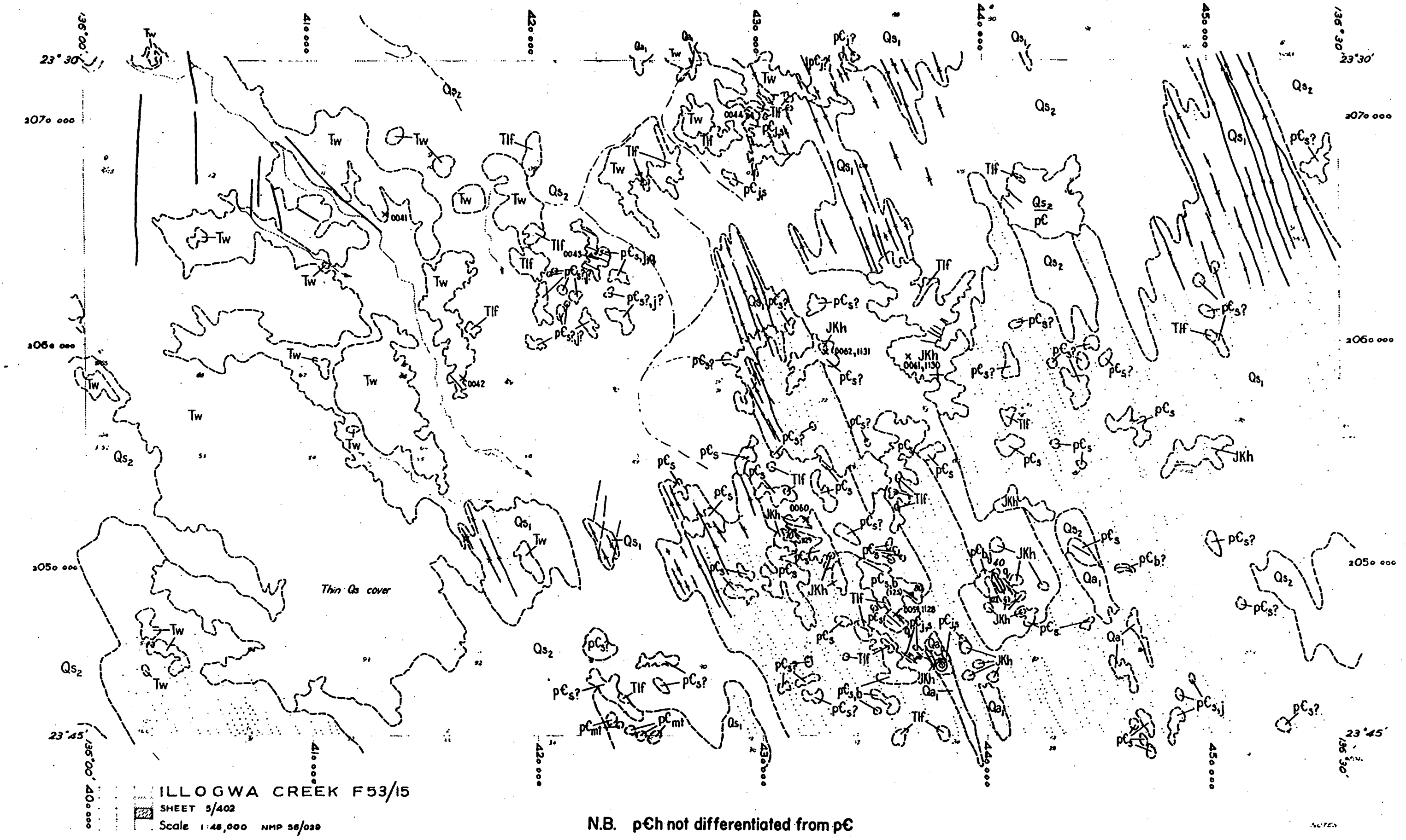
ILLOGWA CREEK
SF 53-15

Record 1982/23



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1 0 2 4 6 8 10 Kilometres

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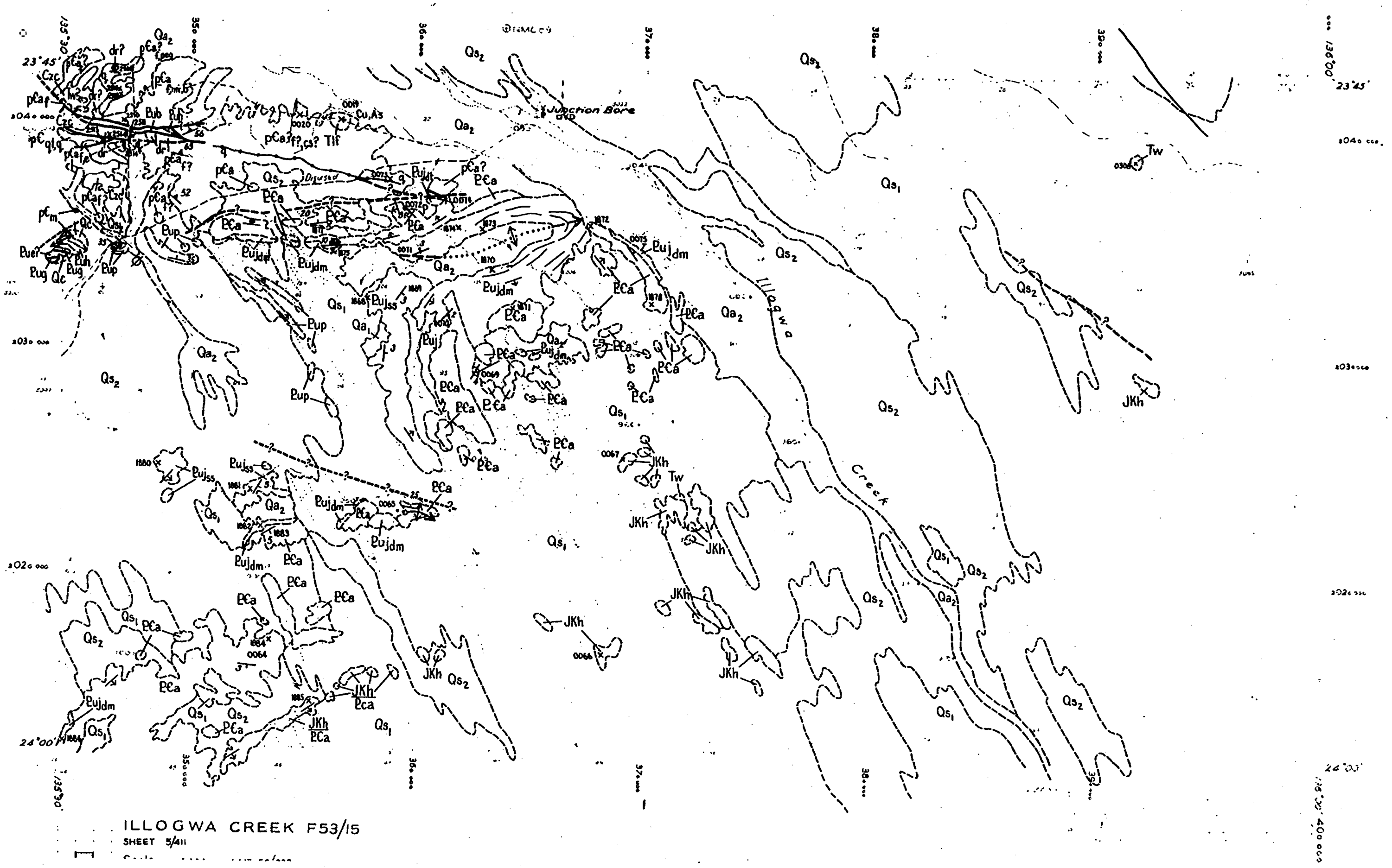
ILLOGWA CREEK
SF 53-15

Record 1982/23



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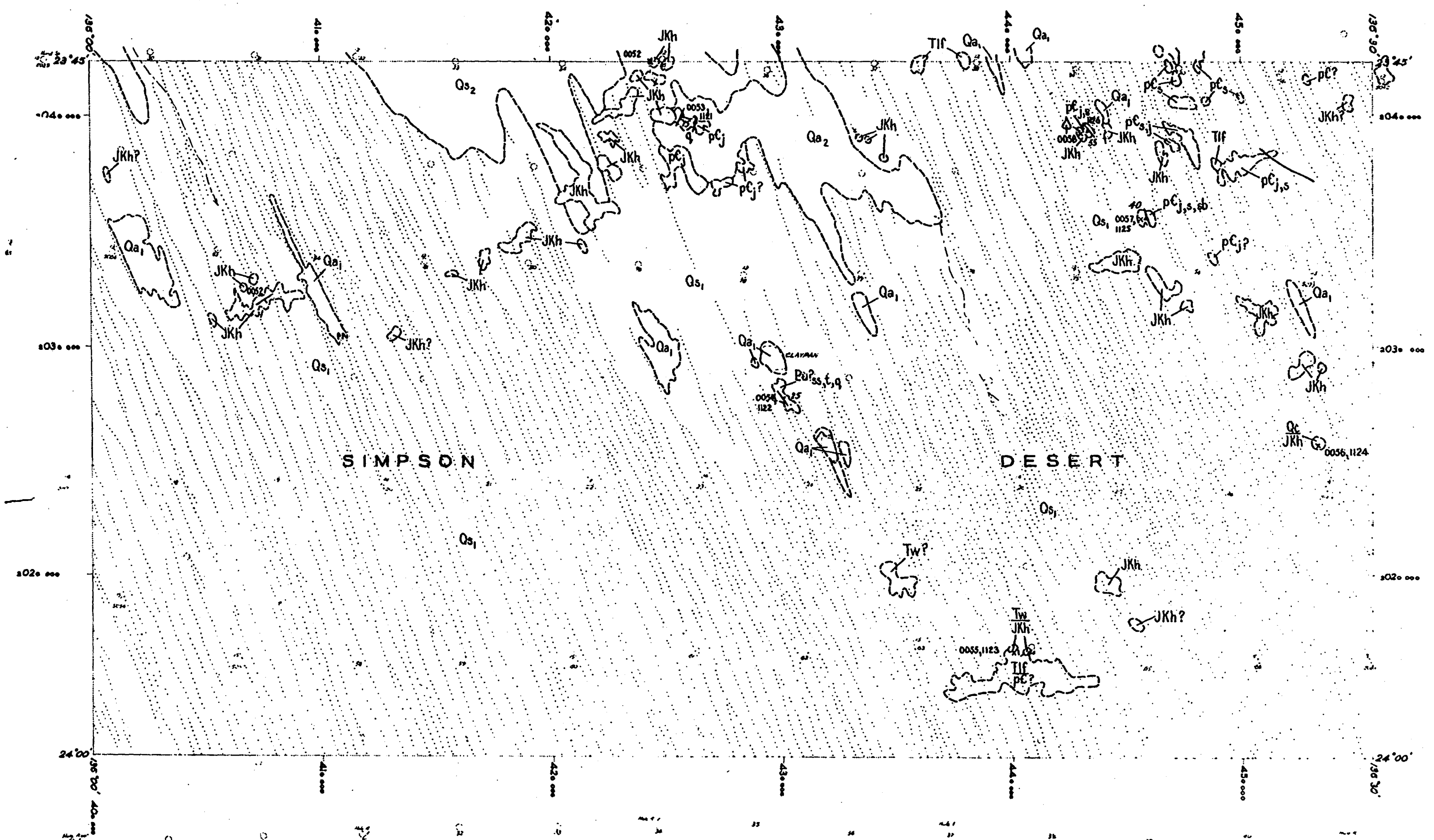
1 0 2 4 6 8 10 Kilometres

Scale 1:81 833

ILLOGWA CREEK
SF 53-15



ILLOGWA CREEK F53/15
SHEET 5/412

N.B.. pЄh not differentiated from pЄ

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1 0 2 4 6 8 10 Kilometres

Scale 1:81 833

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ILLOGWA CREEK
SF 53-15

REFERENCE TO ACCOMPANY COMPILATION SHEETS FOR THE QUARTZ 1:100 000 MAP AREA

CAINOZOIC	QUATERNARY		Qa	*Alluvium; sand, silt, clay, gravel*
			Qc	*Colluvium, eluvium, scree; cobbles, sand, silt, clay*
			Qs_2	*Aeolian quartz sand*
			Qr	*Red earth; sand, silt, clay, gravel; proportion of fine sand and silt greater than in Qa*
			Cz	*Slightly weathered rock related to Czc*
			Czc	*Fanglomerate; dissected alluvium and colluvium*
	TERTIARY		Tl	*Highly siliceous and ferruginous cap-rock*
PALAEOZOIC			Pzr	*Muscovite-biotite quartzofeldspathic schist (sf), vein quartz lenticles (q); minor to rare sb,s,sc,cs,a,f,b,pa,r*
PROTEROZOIC	LATE PROTEROZOIC	Bitter Springs Formation, Gillen Member	Ꝑug	*Siltstone (t), limestone (ls), dolomite (dm)*
		Heavitree Quartzite	Ꝑuh	*Quartzite (qt), sandstone (ss), conglomerate (c)*
			Ꝑd	*Dolerite, including dl dykes, norite (n); minor b,gb,sc*
			Ꝑp	*Metahornblendite (un); minor mn*
			Ꝑgb	*Metamorphosed and partly metamorphosed gabbro (gb) and norite (n); minor a,dl,mn,un*
			Ꝑdx	*Metamorphosed basic igneous rocks (a); rare h*
			Ꝑg	*Porphyritic and fine-grained granite (g); minor f,a*
		Aremra Granodiorite	Ꝑgl	*Granodiorite (gd), tonalite (to), diorite (dr); minor r,a*
		Atneequa Granitic Complex	Ꝑgq	*Granite (g)*
		Inkamulla Granodiorite	Ꝑgk	*Granodiorite gneiss (gg)*
		Huckitta Granodiorite	Ꝑgh	*Granitic gneiss (gg), foliated granodiorite (gd), amphibolite (a)*
	EARLY PROTEROZOIC ? — Division 2 — HARTS RANGE GROUP	Brady Gneiss	p€h	*Undivided; calc-silicate rock (cs), biotite gneiss (b); minor j,qt,av,a,h,mi*
			p€hb¹	*Calc-silicate rock (cs), garnet-muscovite-biotite gneiss (sv), biotite gneiss (b); minor s,g,qt,ma,v*
			p€hb²	*Garnet-muscovite-biotite gneiss (sv), biotite gneiss (b), calc-silicate rock (cs); minor s,a,sb,vf,g,peg*
		Irindina Gneiss	p€hi	*Schistose garnet-biotite-quartz-plagioclase gneiss (v), biotite gneiss (b), quartzofeldspathic gneiss (f), layered and massive amphibolite (pa,a), calc-silicate rock (cs), marble (ma); minor to rare z,vf,h,s,p,qt,sv,sb,sc,av,qf,mn,gb,peg*
		Stanovos Gneiss Member	p€hs	*Unit of marble (ma), quartzite (qt), garnet-biotite gneiss (v), overlain by unit characterised by megacrystic feldspar gneiss (p) grading into quartzofeldspathic gneiss (f) and biotite gneiss (b), followed by a unit of quartzite (qt), marble (ma) and calc-silicate rock (cs); minor pa,dl,a,h,g,gg*
		Riddock Amphibolite Member	p€hr	*Well-layered amphibolite (pa), some massive amphibolite (a), subordinate intercalated garnet-biotite-plagioclase-quartz gneiss (v); minor to rare bp,vf,ma,cs,sb,sv*
		Bruna Gneiss	p€ha	*Megacrystic-feldspar gneiss (p) grading into quartzofeldspathic gneiss (f) and biotite gneiss (b); minor to rare pa,a,v,mn,gg,h,mi*
		Entia Gneiss	p€he	*Acid muscovite-biotite gneiss unit (fm) overlain by unit of tonalitic quartzofeldspathic gneiss (f), hornblende-bearing quartzofeldspathic gneiss (h), layered amphibolite (pa) and biotite gneiss (b); minor to rare cs,ma,p,z,v,sv,sb,s,a,sc,sf,mn,g,mi,y,dl,un*
			p€f	*Quartzofeldspathic gneiss (f), subordinate biotite gneiss (b); minor to rare sf,sb,sc,s,qt,a,r*
		Albarta metamorphics	p€a	*Quartzofeldspathic gneiss (f), biotite and muscovite-biotite schist (b,sb), massive and layered amphibolite (a,pa); minor to rare sf,gg,cs,fm,peg,b,qt,h,sm,v,dl,qf,mi,p,z,w*
	Division 1 — STRANGWAYS METAMORPHIC COMPLEX		p€x	*Quartzofeldspathic gneiss (f), lenticular bodies of amphibolite (a); minor to rare s,b,gg,sf,sc,sb,p*
		Bungitina metamorphics	p€sb	*Amphibolite (a), biotite gneiss (b), quartzofeldspathic gneiss (f), muscovite-biotite schist (s)*

a *Amphibolite*
av *Garnet-bearing amphibolite*
b *Biotite gneiss CI>10*
bp *Plagioclase-rich gneiss, in places containing biotite (or phlogopite) hornblende and rarely corundum*
c *Conglomerate*
cs *Calc-silicate rock*
dl *Dolerite*
dm *Dolomite*
dr *Diorite*
f *Quartzofeldspathic gneiss*
fm *Muscovite-bearing quartzofeldspathic gneiss*
g *Granite, adamellite, includes retrogressively metamorphosed equivalents*
gb *Metamorphosed and partly metamorphosed gabbro and norite*
gd *Granodiorite, includes retrogressively metamorphosed granodiorite*
gg *Granitic gneiss, granodiorite gneiss*
h *Hornblende gneiss*
i *Cordierite anthophyllite-kyanite gneiss*
j *Metasediment, mainly quartz-rich metasandstone*
ls *Limestone, includes oolitic limestone*
ma *Marble*
mi *Migmatite*
mn *Mafic granulite CI>50*
mt *Unclassified metamorphic rock*
n *Norite*
p *Porphyroblastic-feldspar gneiss*
pa *Mafic calc-silicate rock, para-amphibolite, quartz-amphibolite*
peg *Pegmatite*
q *Vein quartz*
qf *Quartz-magnetite rock, hematite-quartz rock*
qt *Quartzite*
r *Metamorphically retrogressed rock, generally greenschist facies*
s *Muscovite-biotite schist or gneiss*
sb *Biotite schist*
sc *Chlorite schist, tremolite-actinolite schist*
sf *Quartzofeldspathic schist*
sm *Muscovite schist, sericite schist*
ss *Sandstone*
sv *Garnet-muscovite-biotite schist or gneiss*
t *Siltstone, shale, slate*
to *Tonalite, includes retrogressively metamorphosed tonalite*
un *Meta-ultramafic rock*
v *Garnet-bearing biotite gneiss*
vf *Garnet-bearing quartzofeldspathic gneiss*
w *Staurolite schist*
y *Kyanite biotite (or phlogopite) gneiss or schist*
z *Sillimanite-bearing gneiss, sillimanite-garnet gneiss*

p€ha *Stratigraphic unit symbol eg Bruna Gneiss*
a *Rock type symbol eg amphibolite*
Lithological boundary
Stratigraphic boundary
Extrapolated stratigraphic boundary
Facies boundary
Fault showing relative horizontal displacement
70 *Inclined sheared zone, facing not known*
Anticline
Overturned syncline
Antiform
Synform
Overturned antiform

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

27 *Drag-fold*
35 *Minor anticline*
25 *Minor antiform*
Minor synform
20 35 *Minor fold with dip of axial plane*
Minor fold showing 'S' vergences
Minor fold showing 'Z' vergences
Minor fold showing 'M' vergences
Locality of superposed folds

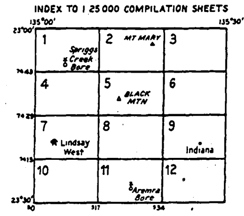
Arrowhead indicates direction of plunge of fold axis, value indicates angle of plunge

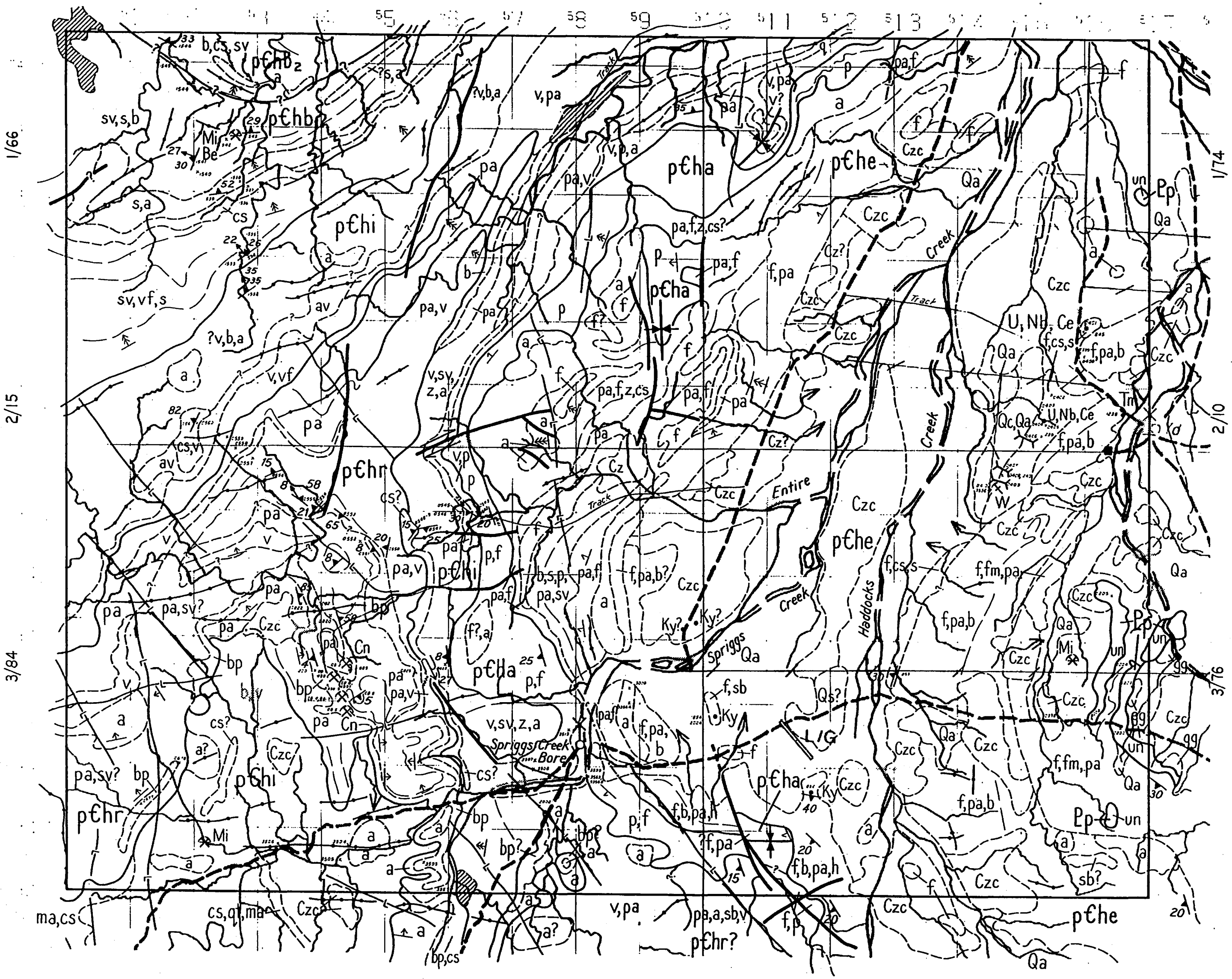
Undifferentiated lineation
Mineral elongation
Bedding-cleavage intersection
Crenulation
50 *Strike and dip of strata*
Horizontal strata
Strike and dip of strata, dip not estimated
Strike and dip of strata, dip 5°-15°
Strike and dip of strata, dip 15°-45°
Strike and dip of strata, dip >45°
Trend-line
Lineament
Joint pattern
(*airphoto interpretation*)
35 *Strike and dip of foliation*
Vertical foliation
Horizontal foliation

70 *Late stage schistosity associated with retrograde metamorphism*
75 *Strike and dip of joint*
Sample locality for isotopic age determination
dl *Dyke; dl-dolerite, q-quartz, unlabelled dykes are pegmatite*
Pegmatite vein
DD *Diamond drillhole*
Au *Minor mineral occurrence; Au-Gold, Be-Beryllium, Ce-Cerium, Cn-Corundum, Cr-Chromium, Cu-Copper, Ep-Epidote, Ky-Kyanite, Mi-Mica, Mo-Molybdenum, Nb-Niobium, Ni-Nickel, Pb-Lead, Py-Pyrite, RE-Rare earths, Sp-Chrome spinel, Ta-Tantalum, Tm-Tourmaline, U-Uranium, W-Tungsten, Zn-Zinc*
Mine
Abandoned mine
Prospect
Abandoned prospect
Costean
0401 *Data point*
Windpump
Bore
Abandoned bore
T *Water tank*
E *Earth dam*
WH *Waterhole*
Spring
Road
Track
Fence
LG *Landing ground*
Indiana *Homestead*
Yd *Yard*
abd *Abandoned*

Some structural symbols are combined on the map
All symbols reduced (x4) to 1 100 000 specifications

INDEX TO 1 25 000 COMPILATION SHEETS





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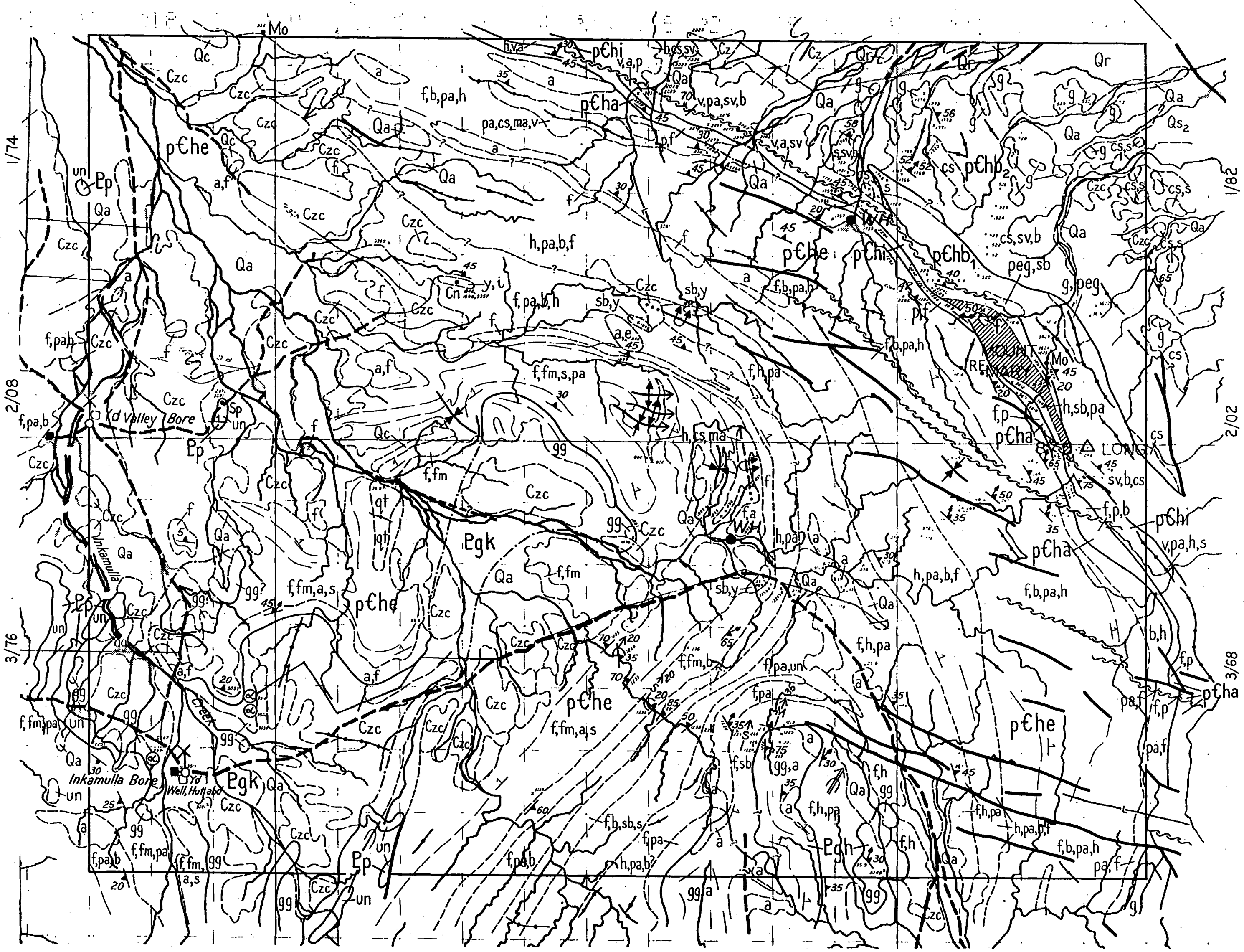

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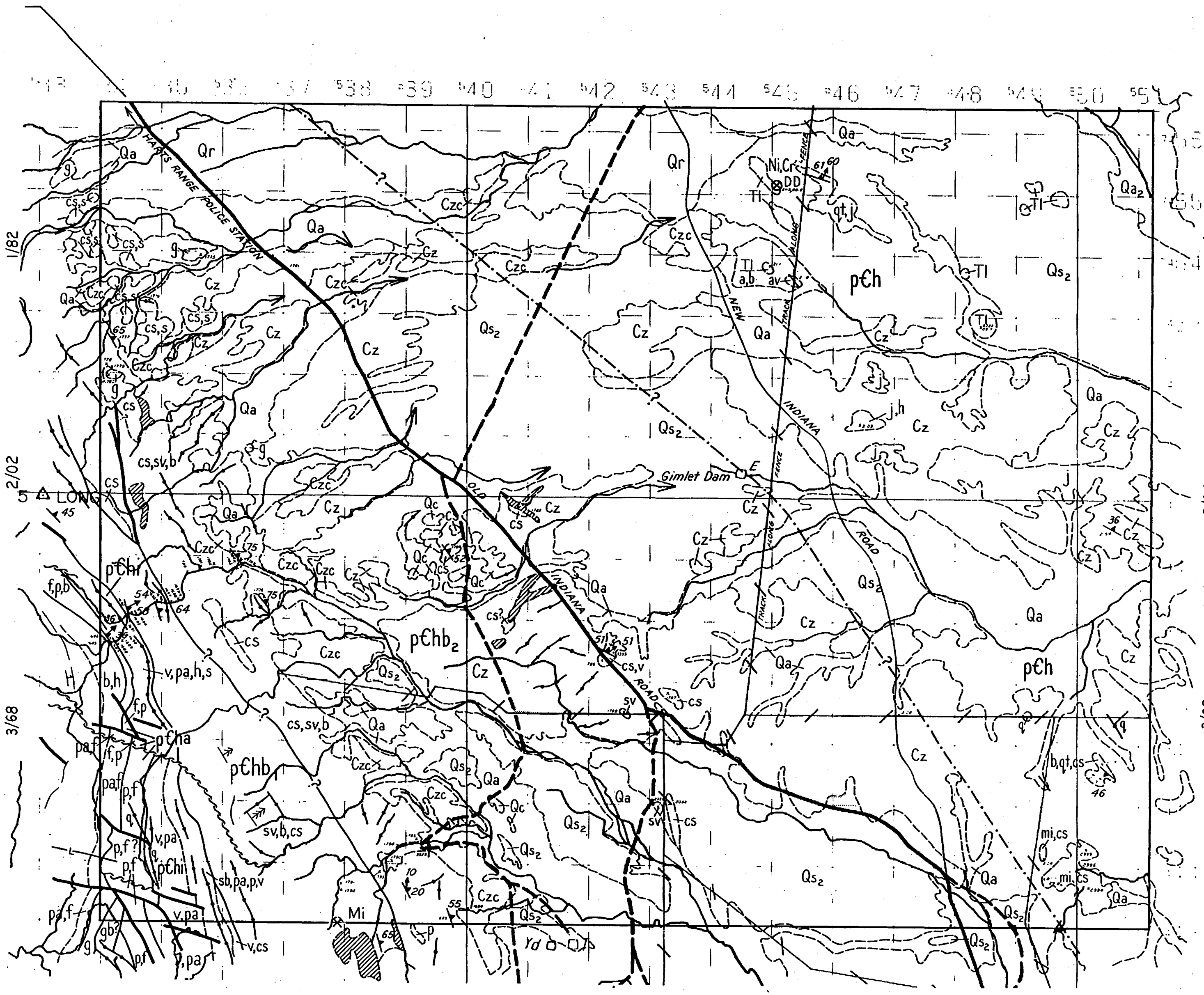

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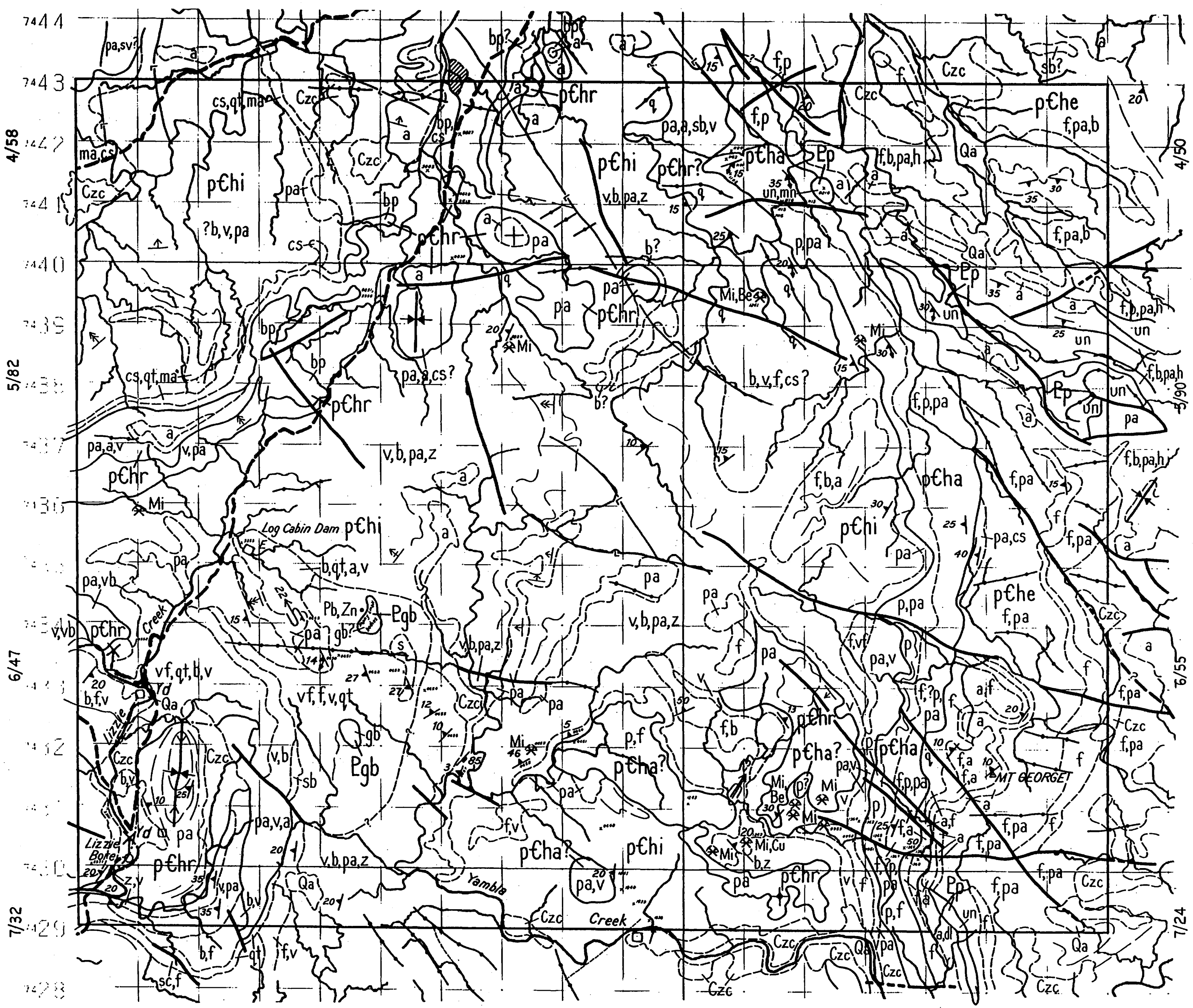

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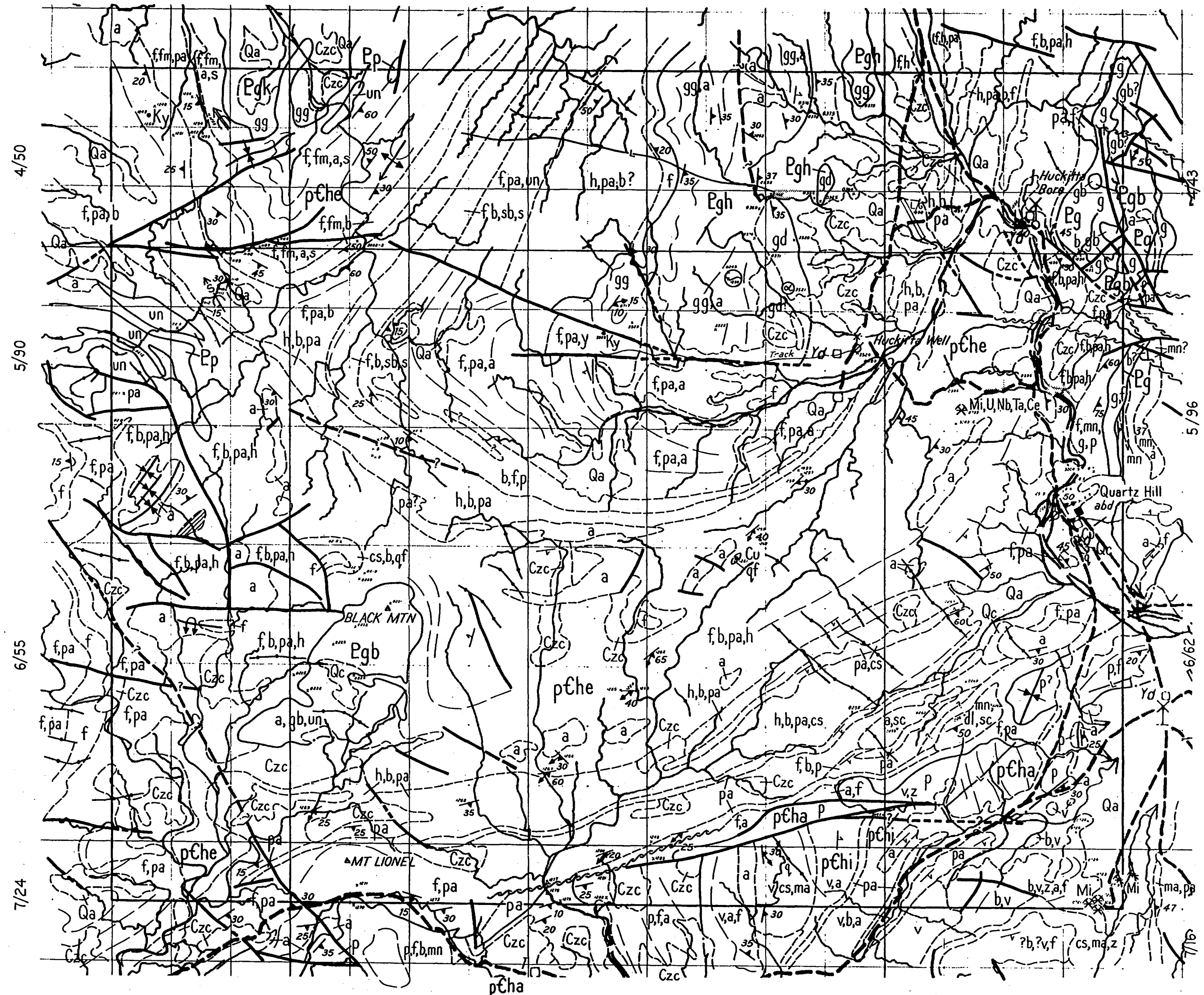

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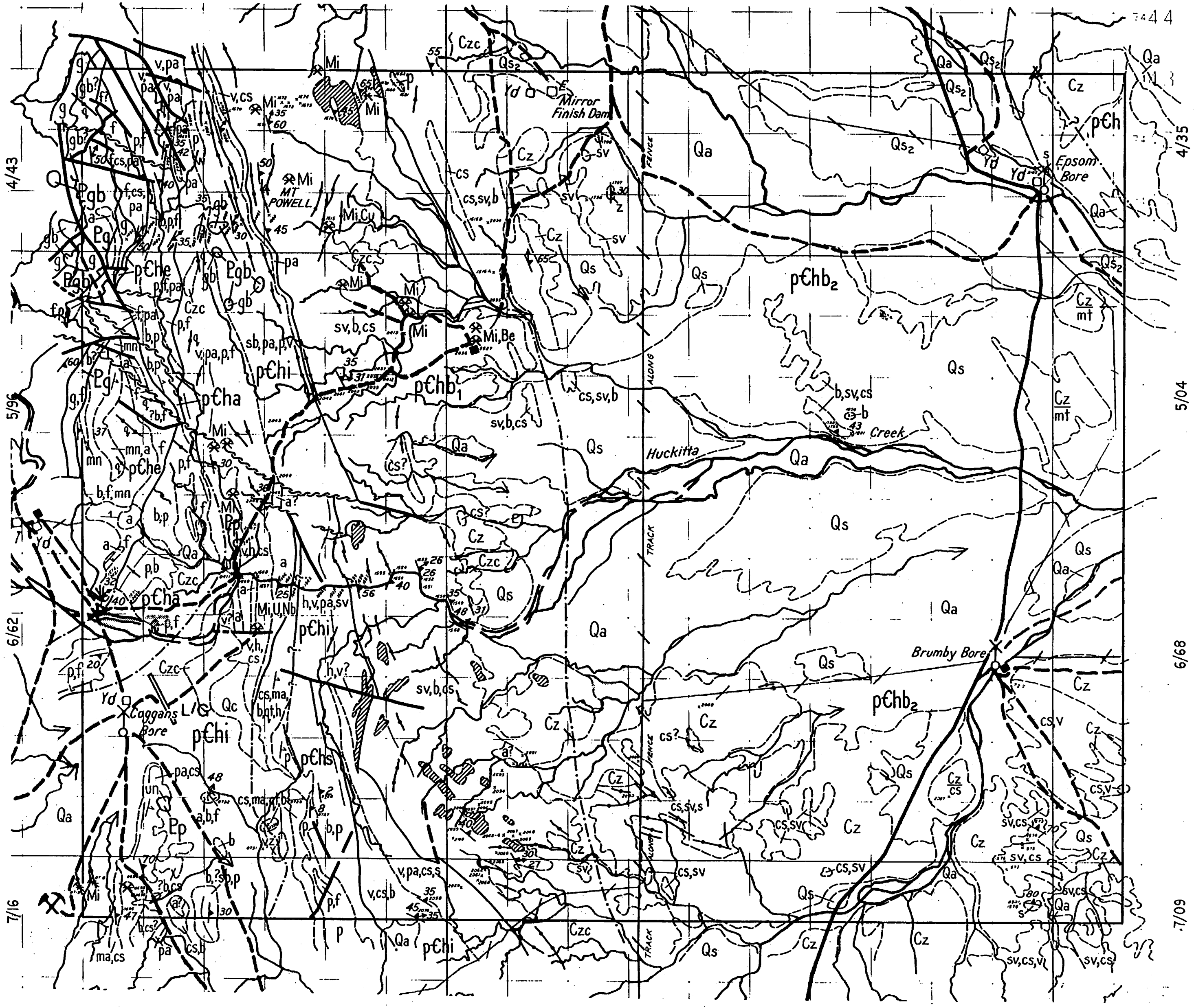

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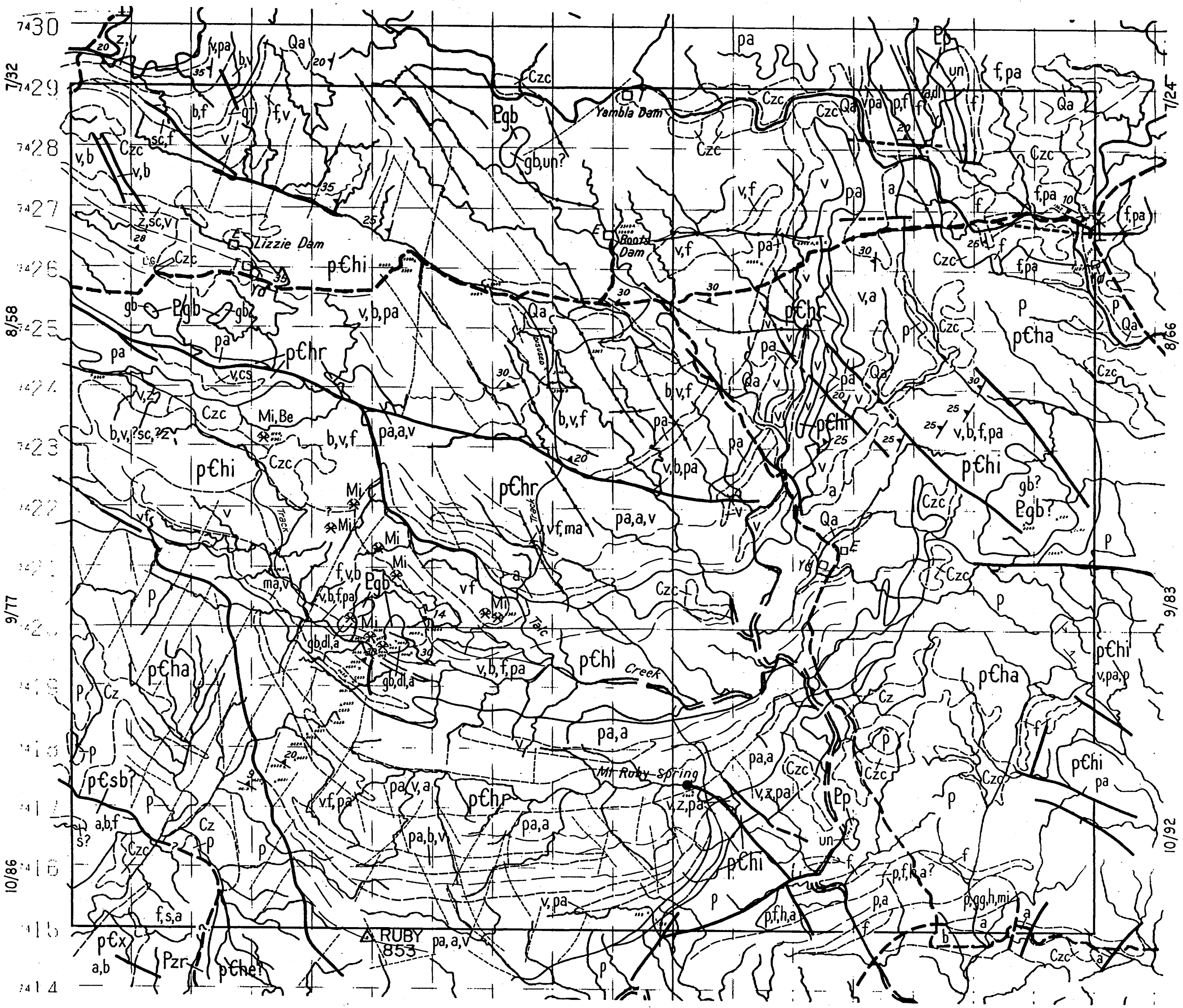

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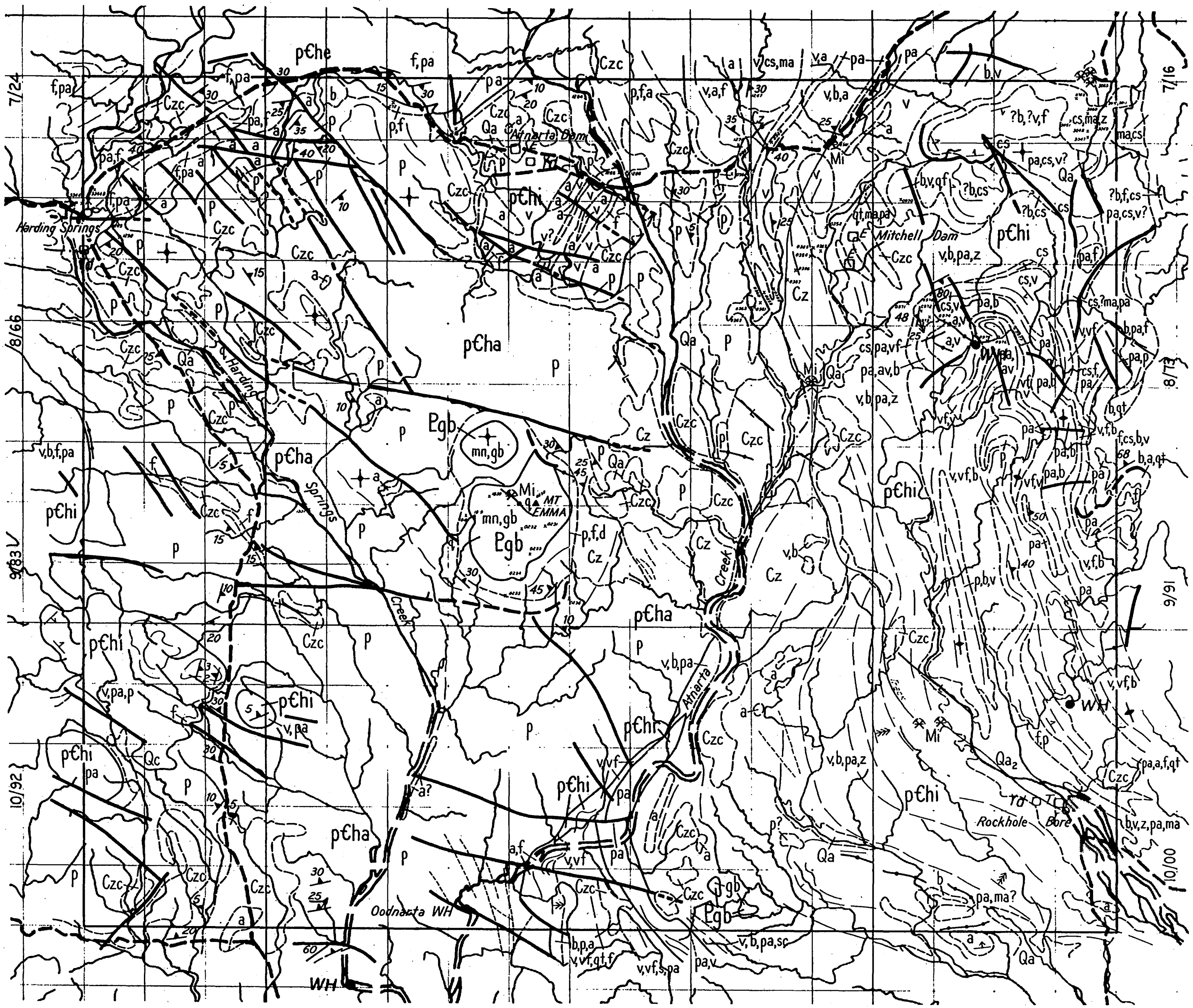

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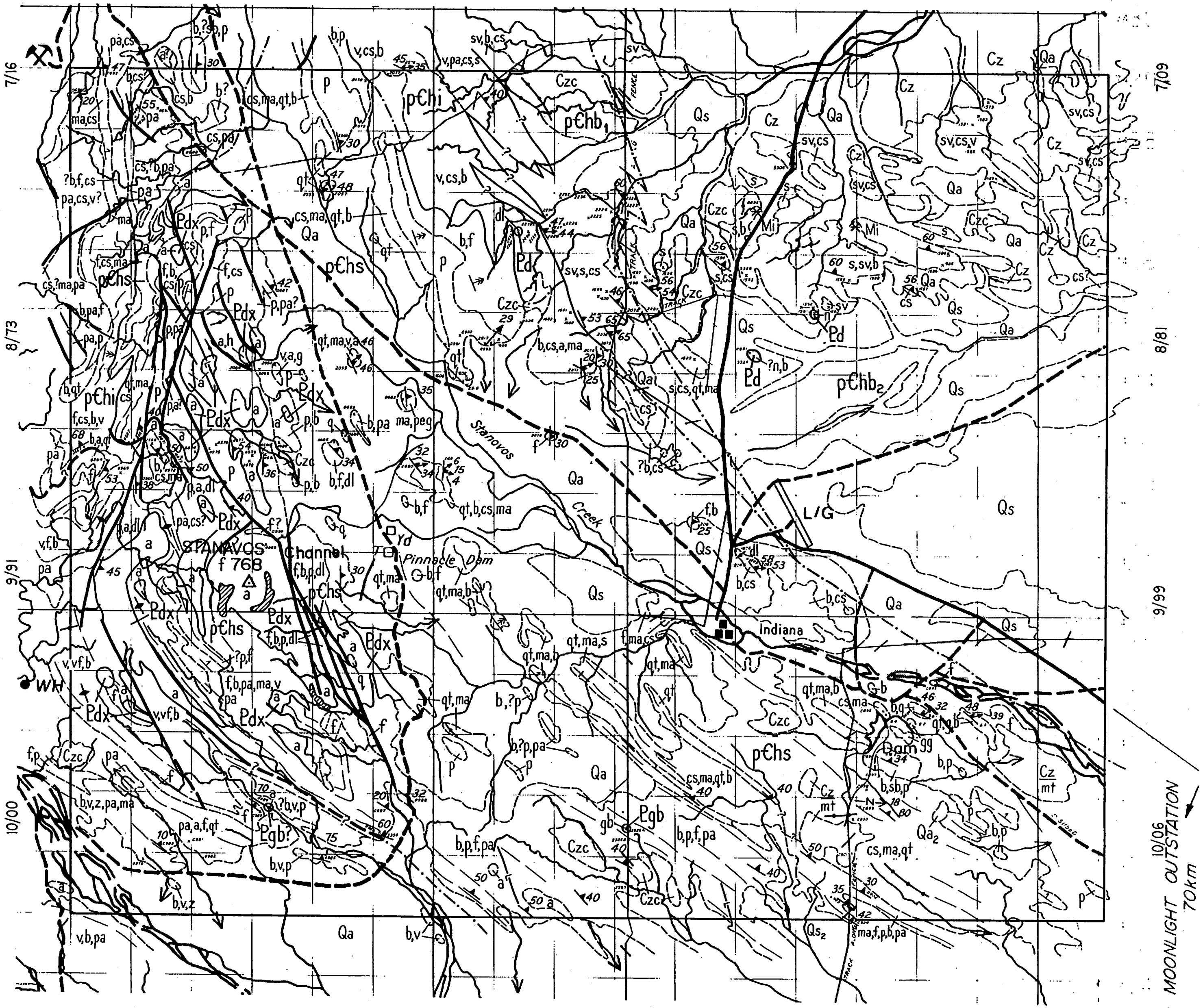

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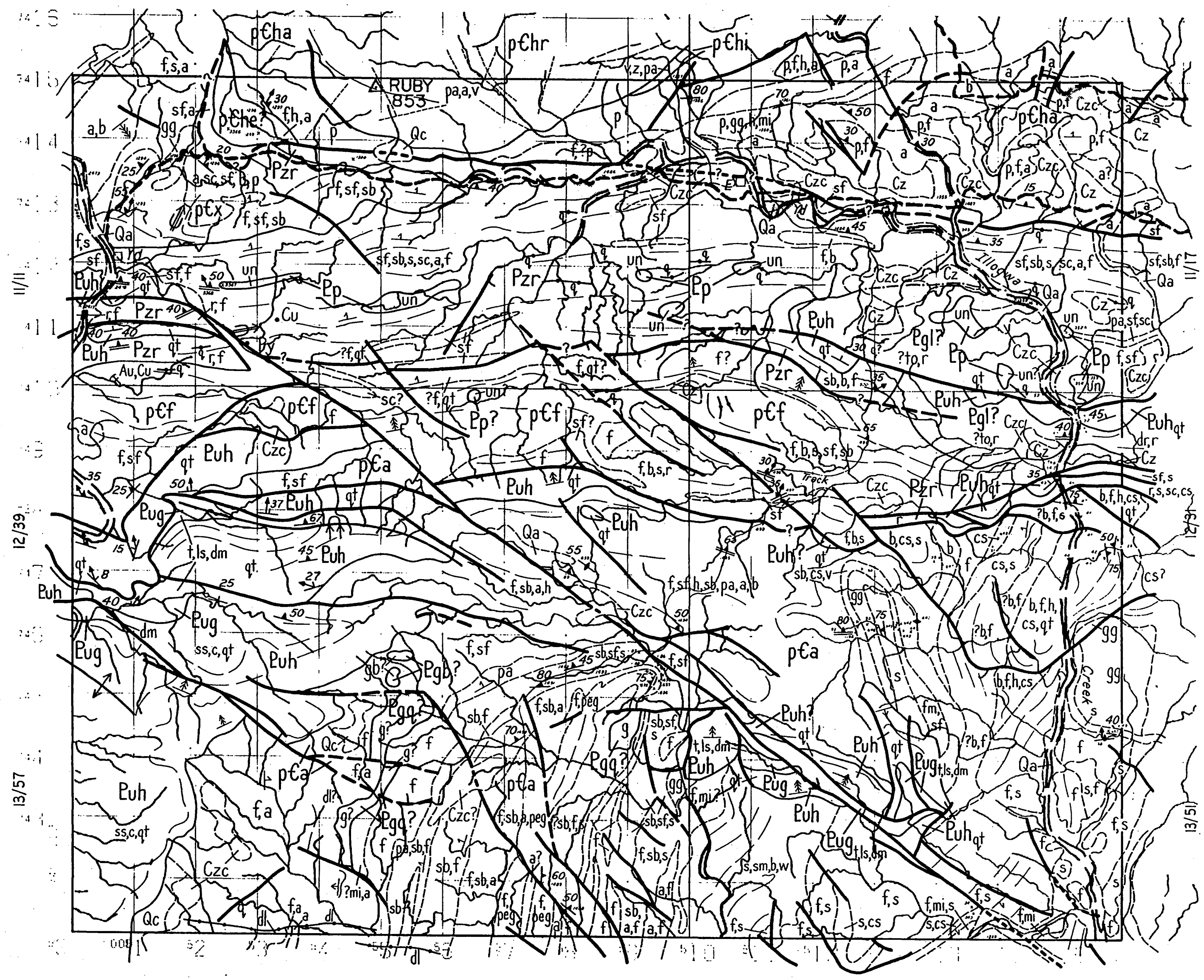

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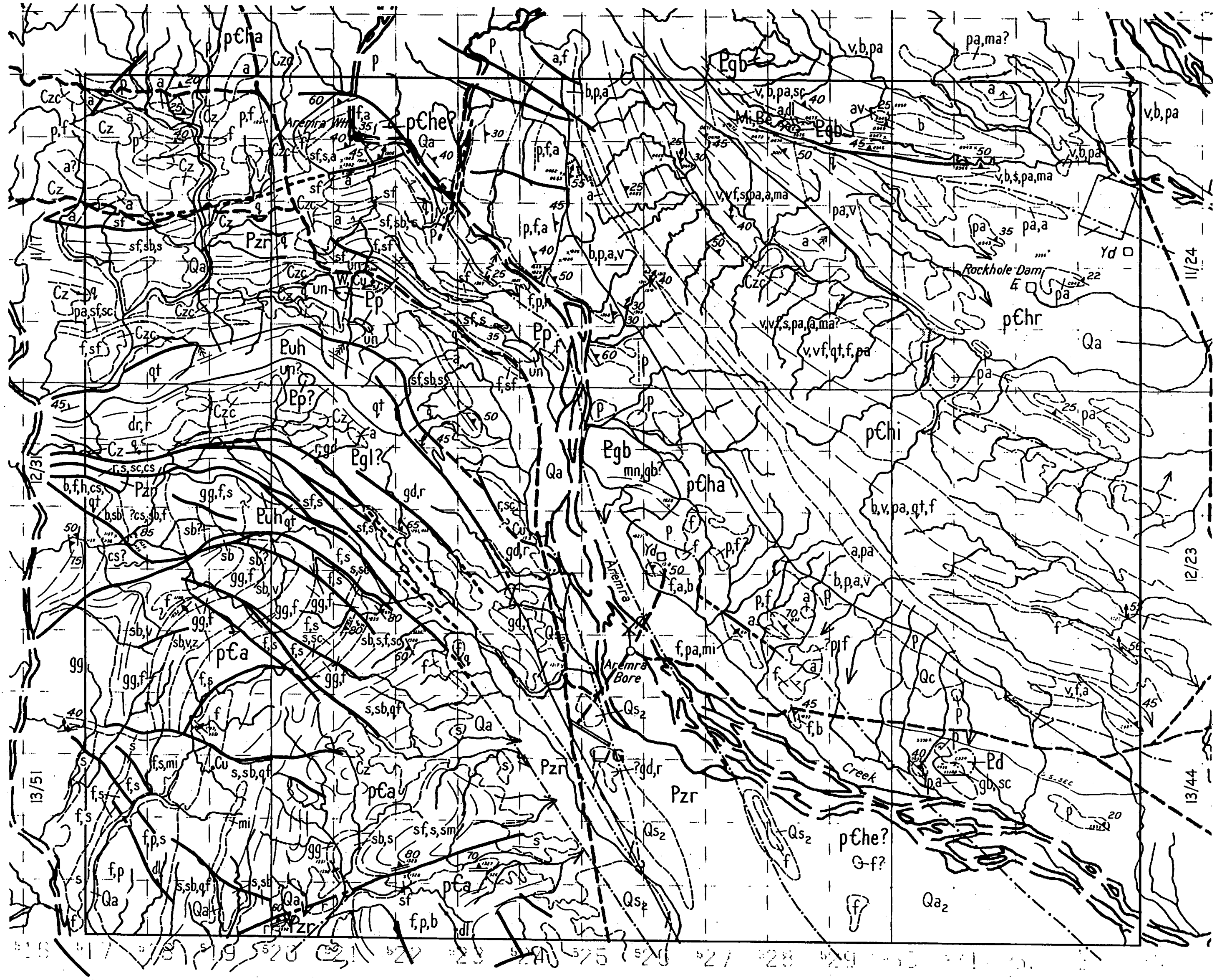

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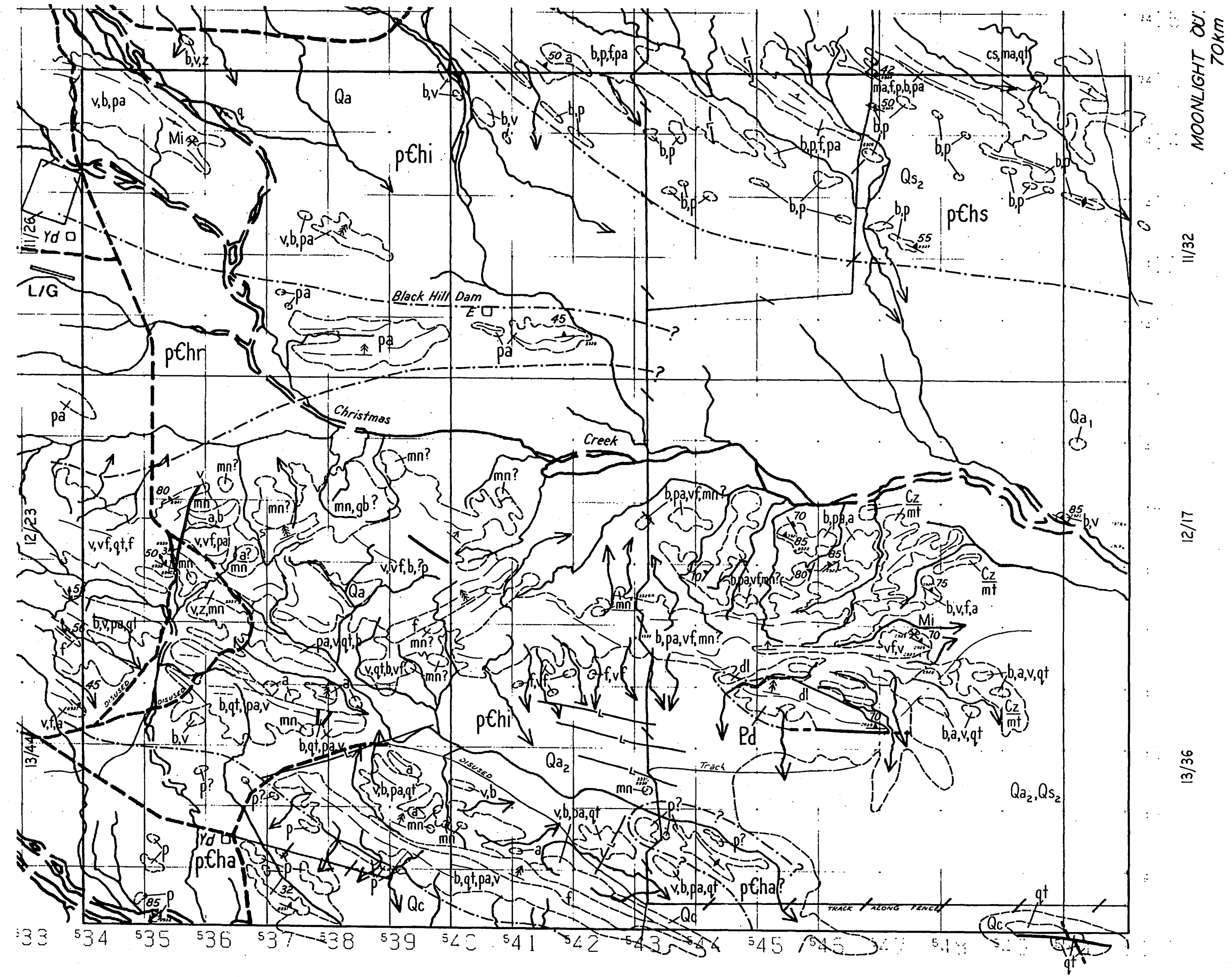

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REFERENCE TO ACCOMPANY COMPILATION SHEETS FOR THE LIMBLA 1:100 000 MAP AREA

CAINOZOIC	QUATERNARY		Qa	Alluvium; sand, silt, clay, gravel Locally subdivided into Qa_1-claypans; Qa_2-alluvium in and along creeks. Qa_3-flood-out plains
			w	Weathered rock related to Recent erosion
			Qc	Colluvium, eluvium, scree; cobbles, sand, silt, clay
			Qs	Aeolian quartz sand. Locally subdivided into Qs_1-sand plains with dunes; Qs_2-sand plains lacking dunes
			Cz	Slightly weathered rock related to Czc
			Czc	Fanglomerate, dissected alluvium and colluvium
	TERTIARY		T	Moderately to slightly weathered rock, silicified cap to sandstone, calcrete on limestone and dolomite
			Tla	Undifferentiated deeply weathered rock (ferricrete, laterite, minor silcrete)
			Tlf	Laterite profile with well-developed ferruginous, mottled and leached zones, ferricrete consistently present
PALAEOZOIC			Pzr	Retrogressed greenschist facies rock (r), minor to rare sf, sb, f, cs, a
PROTEROZOIC	LATE PROTEROZOIC	Julie Formation	Ᵽuj	Pale brown to red-brown sandstone overlain by oolitic dolomite
		Pertatataka Formation	Ᵽup	Laminated siltstone and shale, some sandstone
		Walde Pedlar Member	Ᵽul	Thin-bedded to laminated sandstone
		Pioneer Sandstone	Ᵽux	Sandstone, feldspathic sandstone, minor granule conglomerate
		Olympic Formation	Ᵽuf	Diamictite, overlain by green shale
		Aralka Formation	Ᵽuk	Laminated grey-green siltstone and shale with beds of limestone, some oolitic or stromatolitic
		Limbla Member	Ᵽum	Fine, cross-laminated sandstone (festoon cross-bedding)
		Ringwood Member	Ᵽur	Calcarenite, limestone, dolomite (some oolitic and stromatolitic)
		Areyonga Formation	Ᵽua	Siltstone with some erratics, feldspathic sandstone, conglomerate, diamictite (▵▵▵), rare dark grey cap dolomite
		Bitter Springs Formation Loves Creek Member	Ᵽue	Basal thick stromatolitic limestone and dolomite overlain by thinner unit of dolomite and limestone contained in pink siltstone marked with cream "reduction" spheres Also spilite (sp)
			$Ᵽug^3$	Interbedded carbonate and siltstone
			$Ᵽug^3$	Sandstone overlain by dolomite and sandstone
		Gillen Member	$Ᵽug^3$	Interbedded carbonate and siltstone
			$Ᵽug^2$	Sandstone and interbedded siltstone overlain by intercalated limestone and siltstone
			$Ᵽug^1$	Interbedded grey limestone and siltstone
		Heavitree Quartzite	Ᵽuh	Sandstone, conglomerate, quartzite
			Ᵽd	Dolerite, including dl dykes
			Ᵽgb	Metamorphosed and partly metamorphosed gabbro (gb)
		Atneequa Granitic Complex	Ᵽgq	Granodiorite (gd), granite (g), diorite (dr), granitic gneiss (gg), amphibolite (a); minor to rare r, mi, b, f, to
		Division 3	pЄq	Cleaved quartzite, schist and slate
	EARLY PROTEROZOIC ?	Division 2	pЄs	Gneiss (b), migmatite (mi), mafic schist (sc)
		HARTS RANGE GROUP: Irindina Gneiss	pЄhi	Quartzofeldspathic gneiss (f), biotite gneiss (b), quartzite (qt), layered amphibolite (pa), minor v
		HARTS RANGE GROUP: Bruna Gneiss	pЄha	Megacrystalline-feldspar gneiss (p)
		HARTS RANGE GROUP: Entia Gneiss	pЄhe	Quartzofeldspathic gneiss (f)
		Albarta metamorphics	pЄa	Quartzofeldspathic gneiss (f), biotite and muscovite-biotite schist (sb, s), massive and layered amphibolite (a, pa); minor to rare cs, qf, p, b, qt, mi, g, gg, sm, sf, h, peg, r

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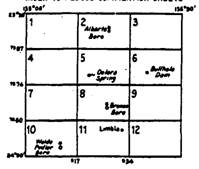


METAMORPHIC AND IGNEOUS ROCK TYPES

- a Amphibolite
- b Biotite gneiss CI > 10
- br Carbonate breccia of sedimentary or diagenetic origin
- cs Calc-silicate rock
- dl Dolerite
- dr Diorite
- f Quartzofeldspathic gneiss
- fe Ferricrete
- g Granite, adamellite, includes retrogressively metamorphosed equivalents
- gb Metamorphosed and partly metamorphosed gabbro and norite
- gd Granodiorite, includes retrogressively metamorphosed granodiorite
- gg Granitic gneiss, granodiorite gneiss
- h Hornblende gneiss
- mi Migmatite
- p Megacrystalline-feldspar gneiss
- pa Mafic calc-silicate rock, para-amphibolite, quartz amphibolite
- peg Pegmatite
- q Vein quartz
- qf Quartz-magnetite rock, hematite-quartz rock
- qt Quartzite
- r Metamorphically retrogressed rock, generally greenschist facies
- s Muscovite-biotite schist or gneiss
- sb Biotite schist
- sc Chlorite schist, tremolite-actinolite schist
- sf Quartzofeldspathic schist
- sm Muscovite schist, sericite schist
- sp Spilite
- to Tonalite, includes retrogressively metamorphosed tonalite
- v Garnet-bearing biotite gneiss
- w Staurolite schist

Ᵽue Stratigraphic unit symbol eg Loves Creek Member

sp Rock type symbol eg spilite

Rock types for unlabelled outcrops in Proterozoic units are specified in the lithological reference eg $Ᵽug^3$-Interbedded carbonate and siltstone

Lithological boundary

Stratigraphic boundary

Extrapolated stratigraphic boundary

Disconformity

Normal fault, containing q-quartz, qf-partly ferruginous quartz

Fault showing relative horizontal displacement

Fault (u, d indicate relative movement, up, down)

Shear zone, schist zone

Anticline

Syncline

Overturned anticline showing dip of axial surface and trend and plunge of axis

Antiform

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

Minor anticline

Minor syncline

For folds, arrow indicates trend, and value indicates plunge of axis

Trend of plunge of bedding-cleavage intersection

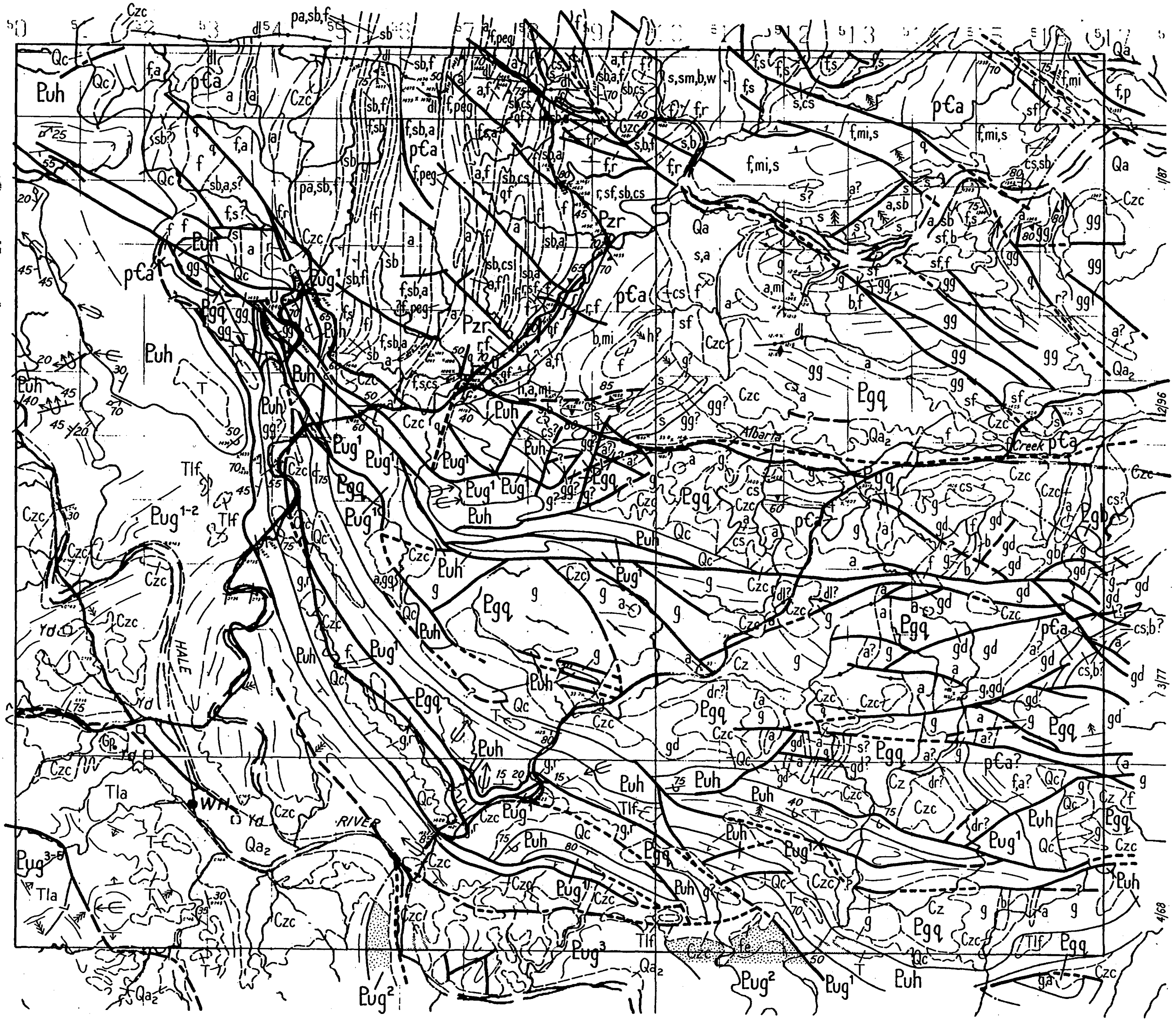
STRUCTURAL AND TOPOGRAPHIC SYMBOLS

- Strike and dip of strata
- Strike and dip of strata, facing not known
- Vertical strata
- Horizontal strata
- Strike and dip of overturned strata
- Strike and dip of strata } showing proved direction of facing based on sedimentary structures
- Vertical strata } showing proved direction of facing based on sedimentary structures
- Strike and dip of overturned strata } showing proved direction of facing based on sedimentary structures
- Strike and dip of strata, dip not estimated } airphoto interpretation
- Strike and dip of strata, dip < 5° } airphoto interpretation
- Strike and dip of strata, dip 5°-15° } airphoto interpretation
- Strike and dip of strata, dip 15°-45° } airphoto interpretation
- Strike and dip of strata, dip > 45° } airphoto interpretation
- Trend-line } airphoto interpretation
- Trend-line showing dip } airphoto interpretation
- Lineament } airphoto interpretation
- Joint pattern } airphoto interpretation
- Strike and dip of foliation
- Vertical foliation
- Late stage schistosity associated with retrograde metamorphism
- Dyke, dl-dolerite, q-quartz, unlabelled dykes are pegmatite
- Stromatolite locality
- Measured section with reference number (Freeman No 3)

- BMR Illogwa Creek drillhole No 6
- Cu Minor mineral occurrence, Cu-Copper, Fe-Iron, Gy-Gypsum, Py-Pyrite, U-Uranium, Zn-Zinc
- Data point
- Windpump
- Bore
- Water tank
- Earth dam
- WH Waterhole
- Spring
- Road
- Vehicle track
- Fence
- LG Landing ground
- Limbla Homestead
- Yd Yard
- Sand dune
- Trigonometrical station showing elevation in metres
- abd Abandoned
- pd Position doubtful

Some symbols are combined on the map

All symbols in reference are drawn to 1 100 000 specifications (4 times smaller than on compilation sheets)



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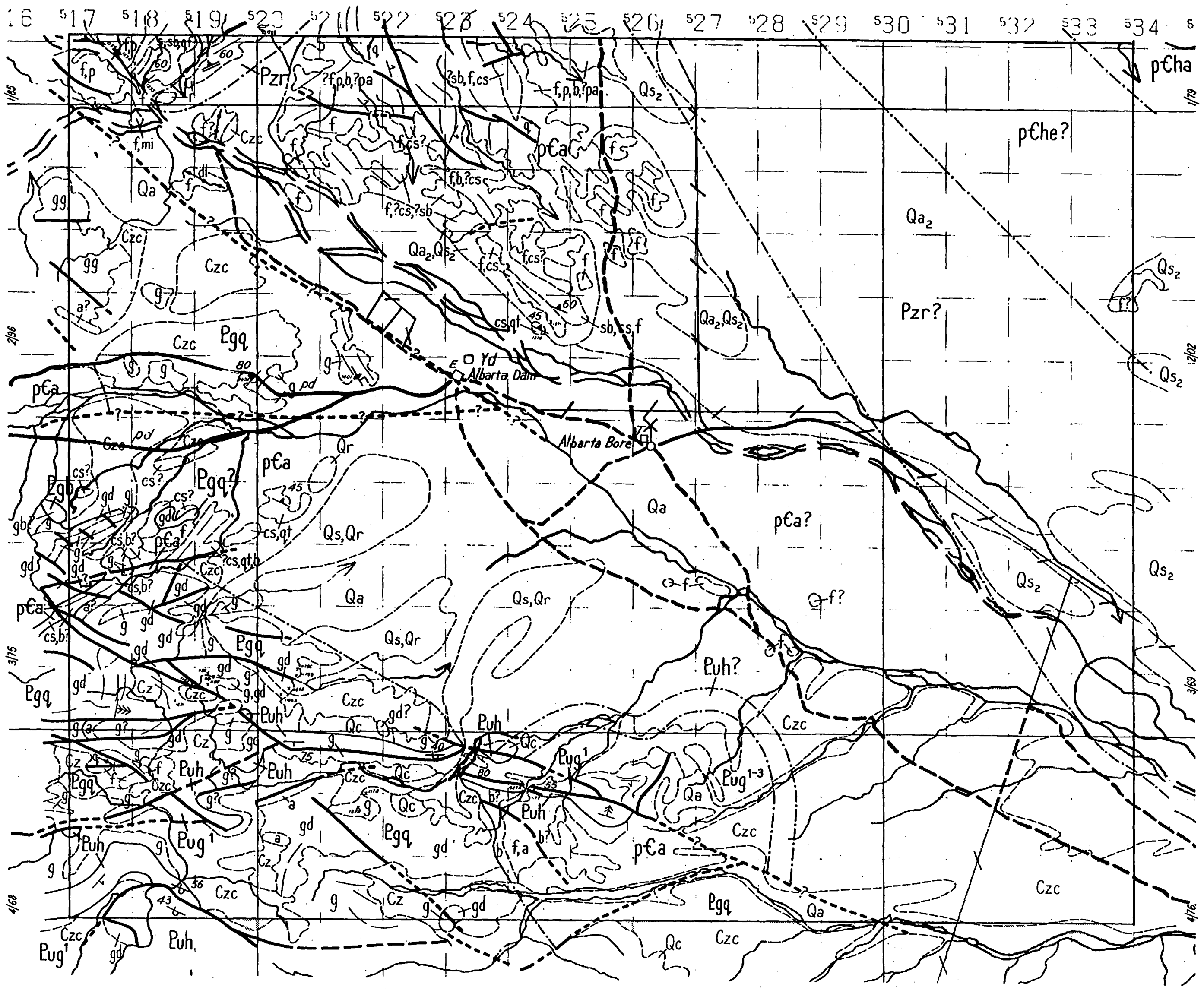

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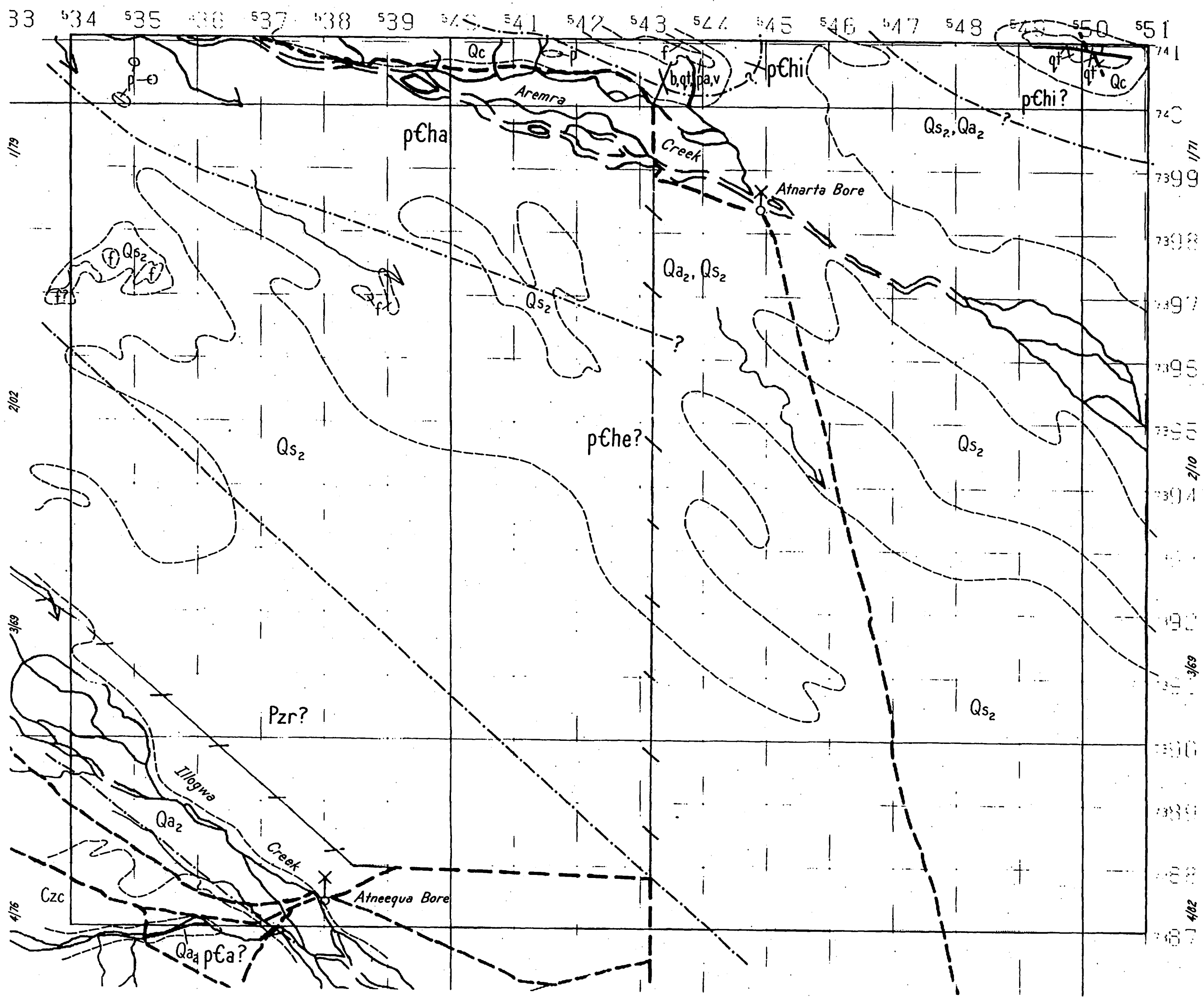

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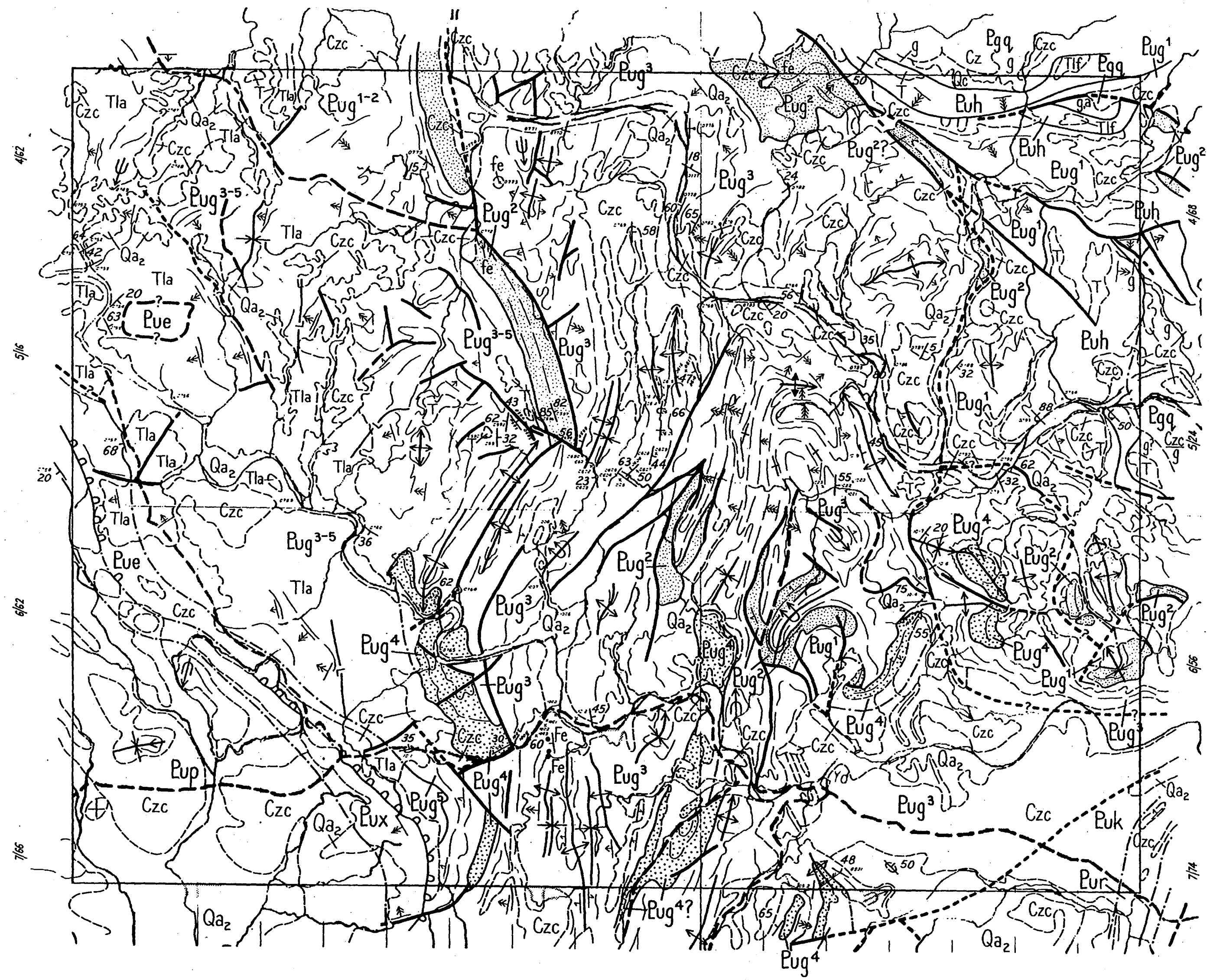

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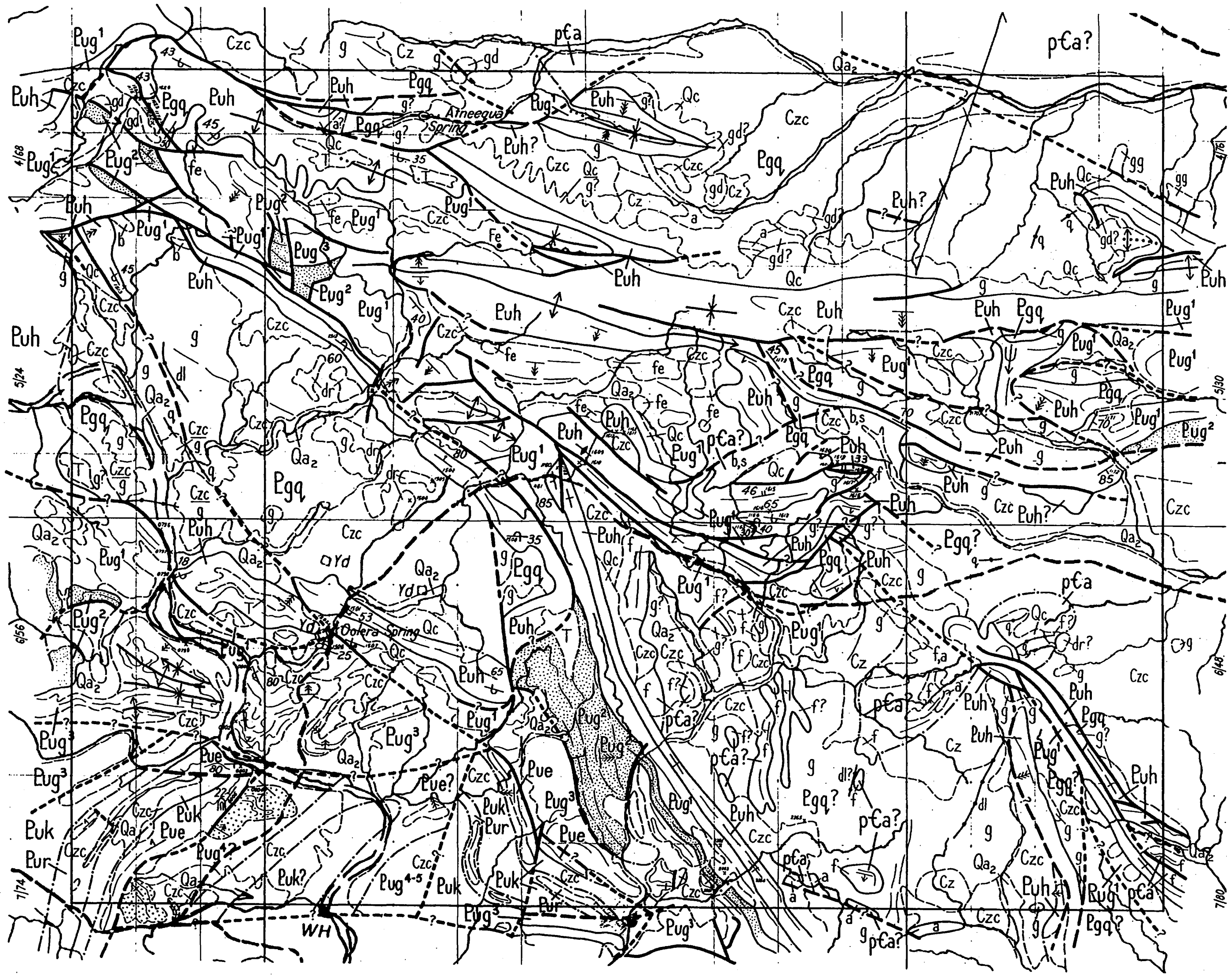

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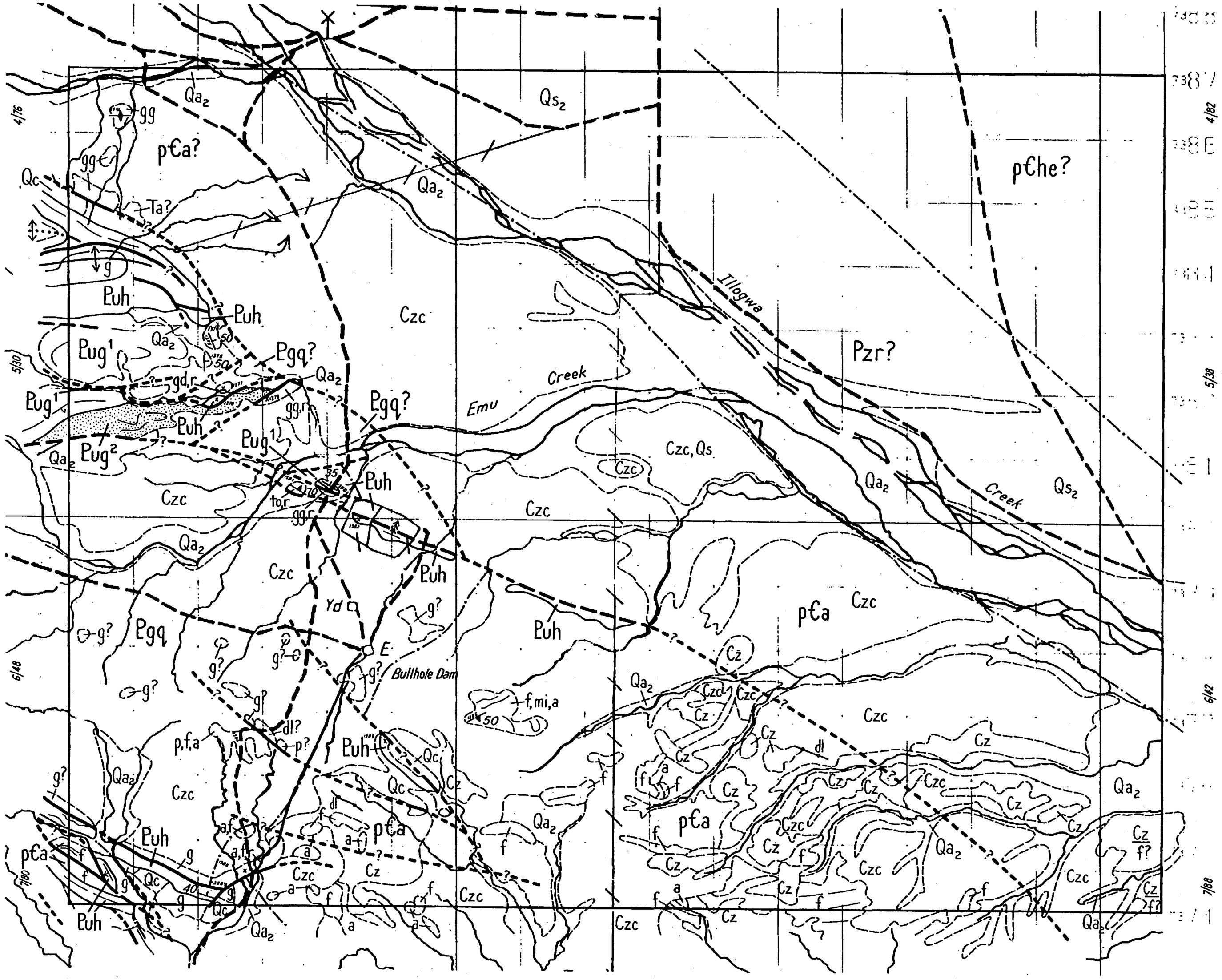

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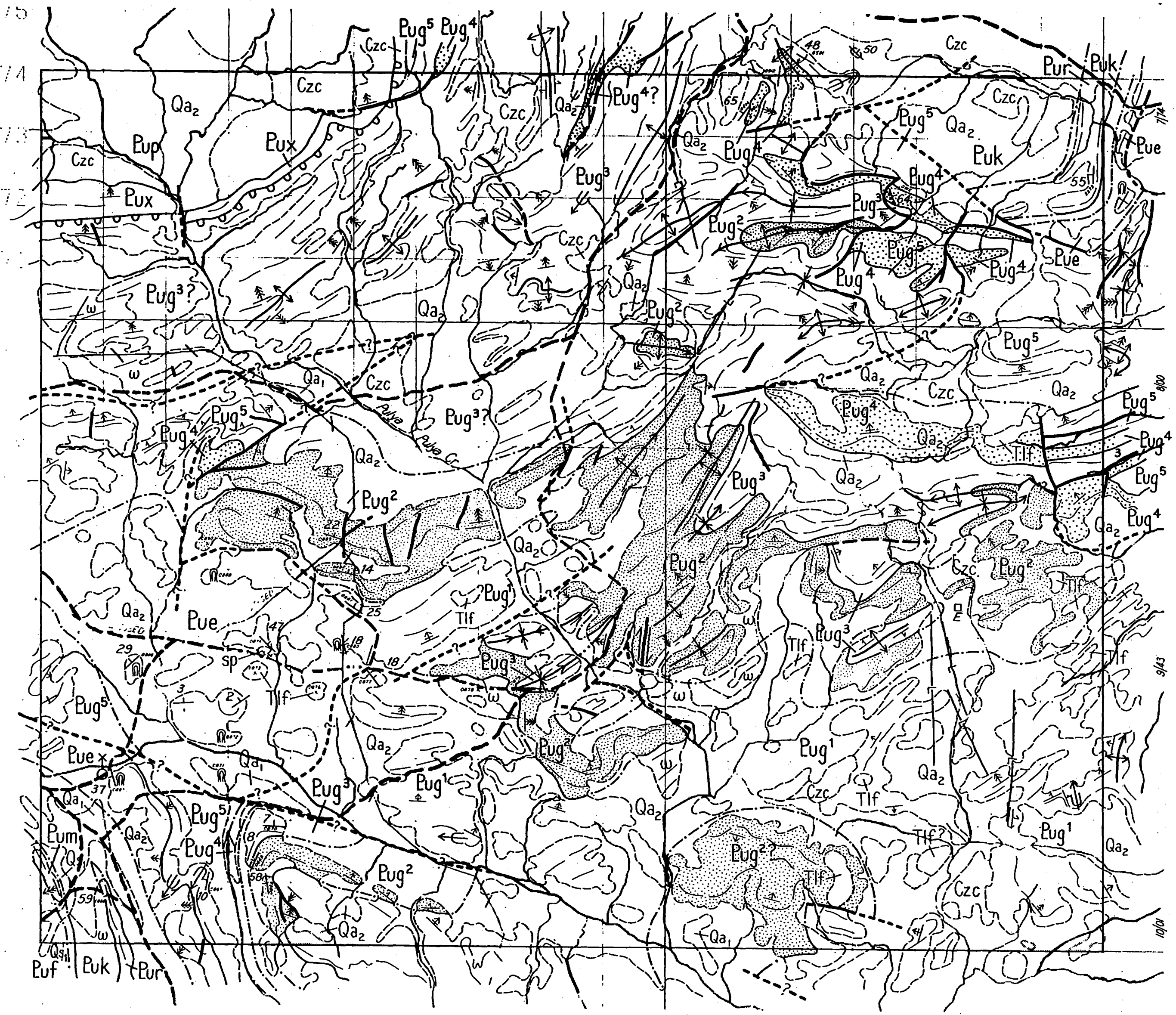

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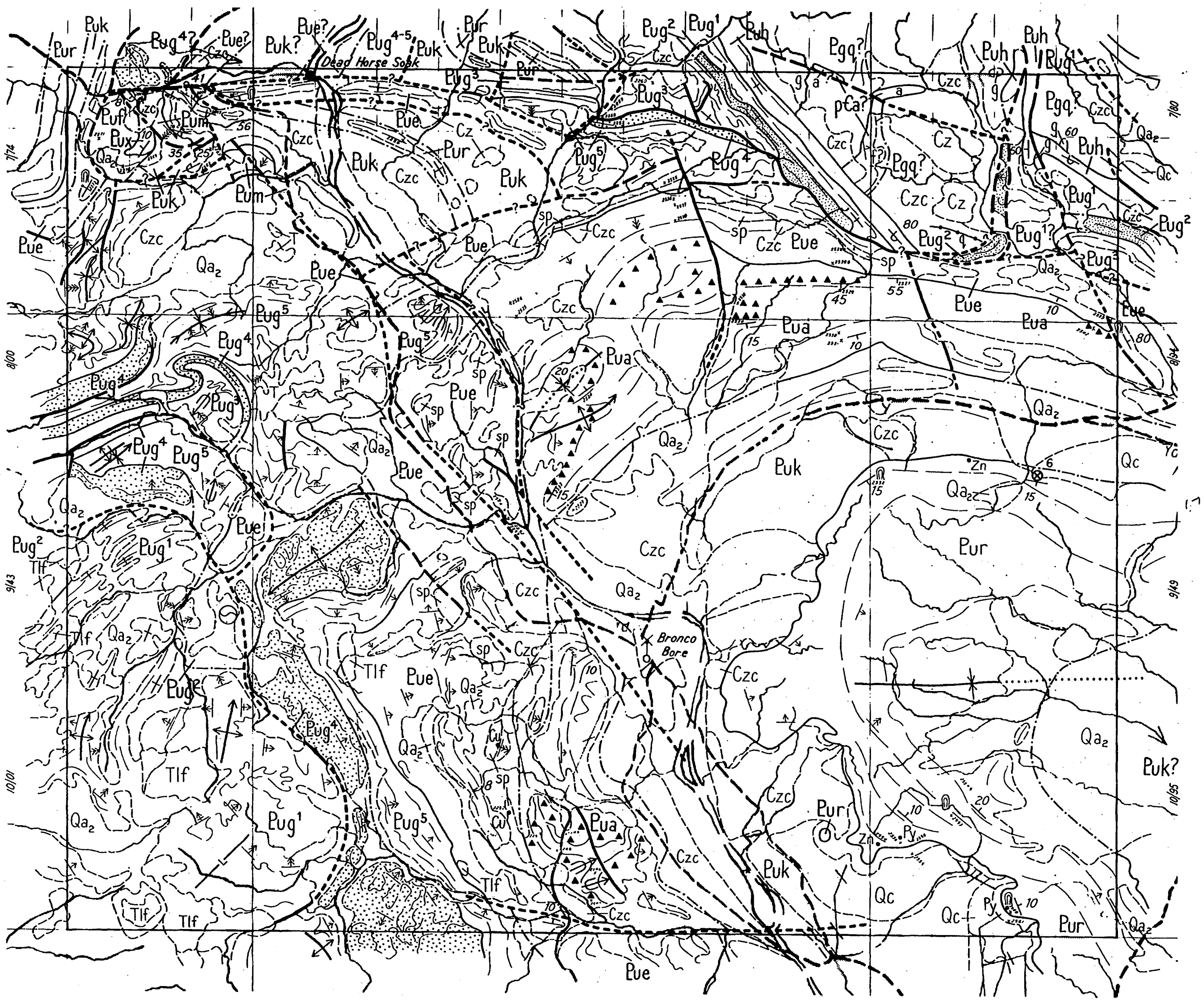

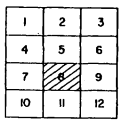

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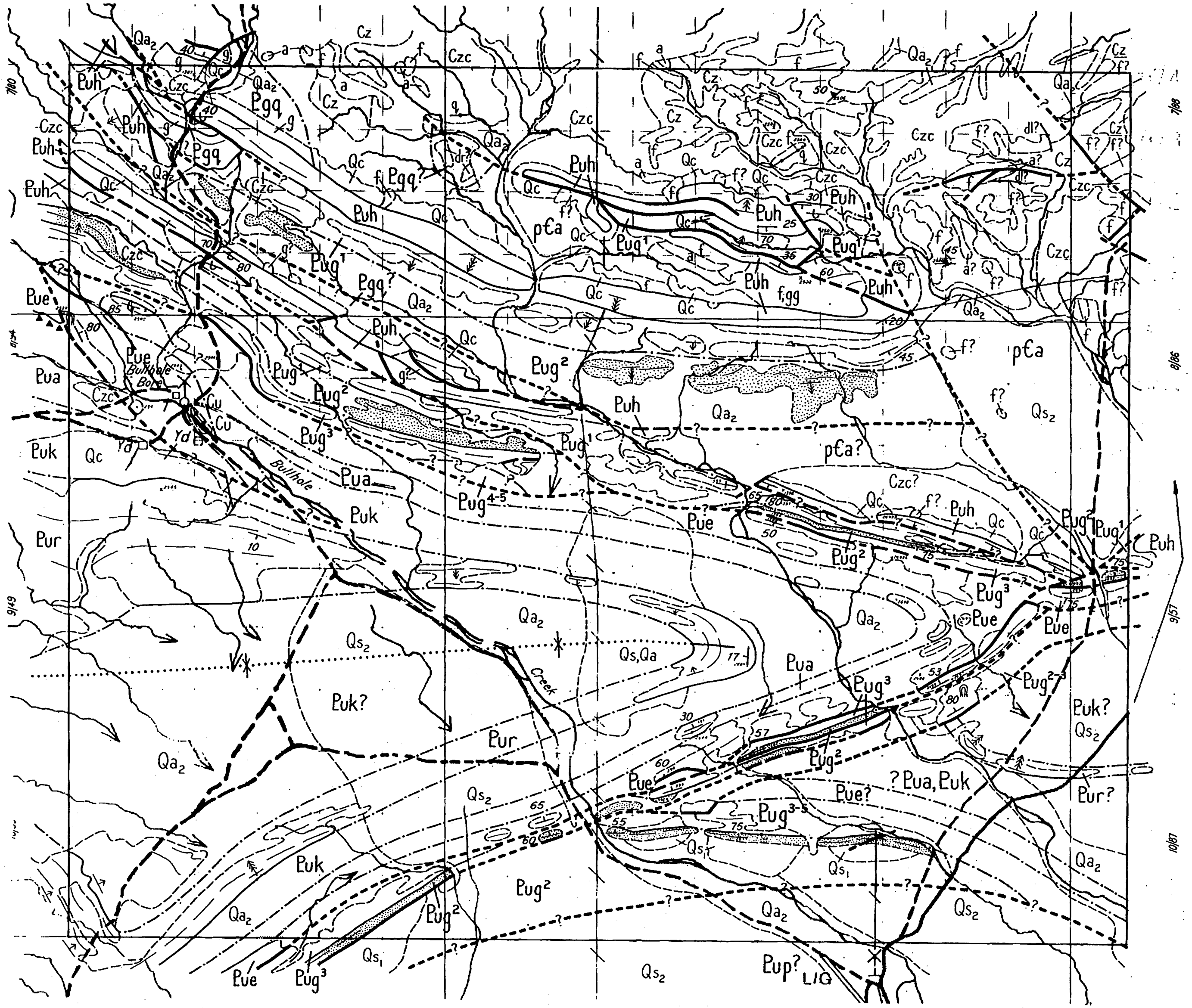

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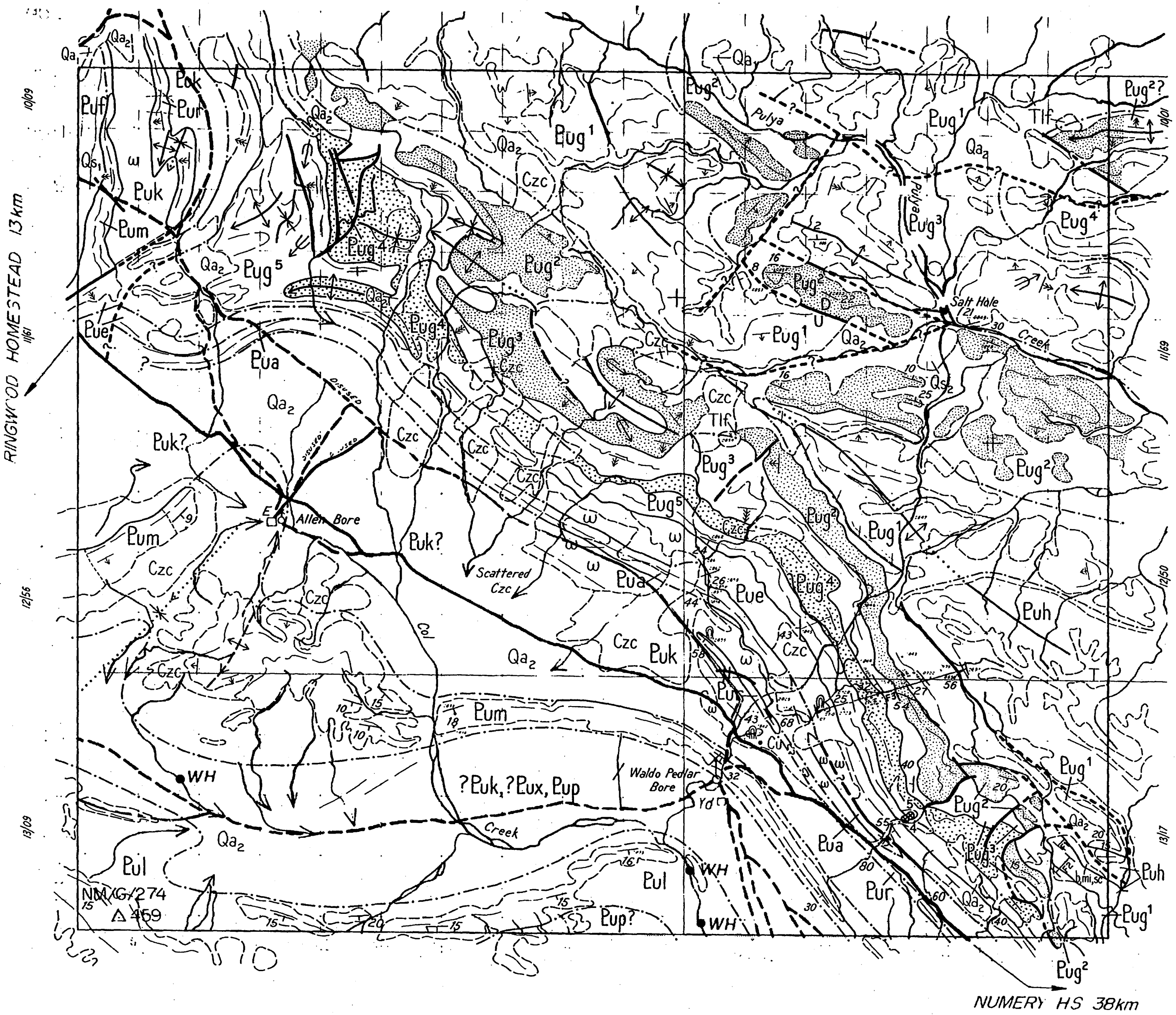

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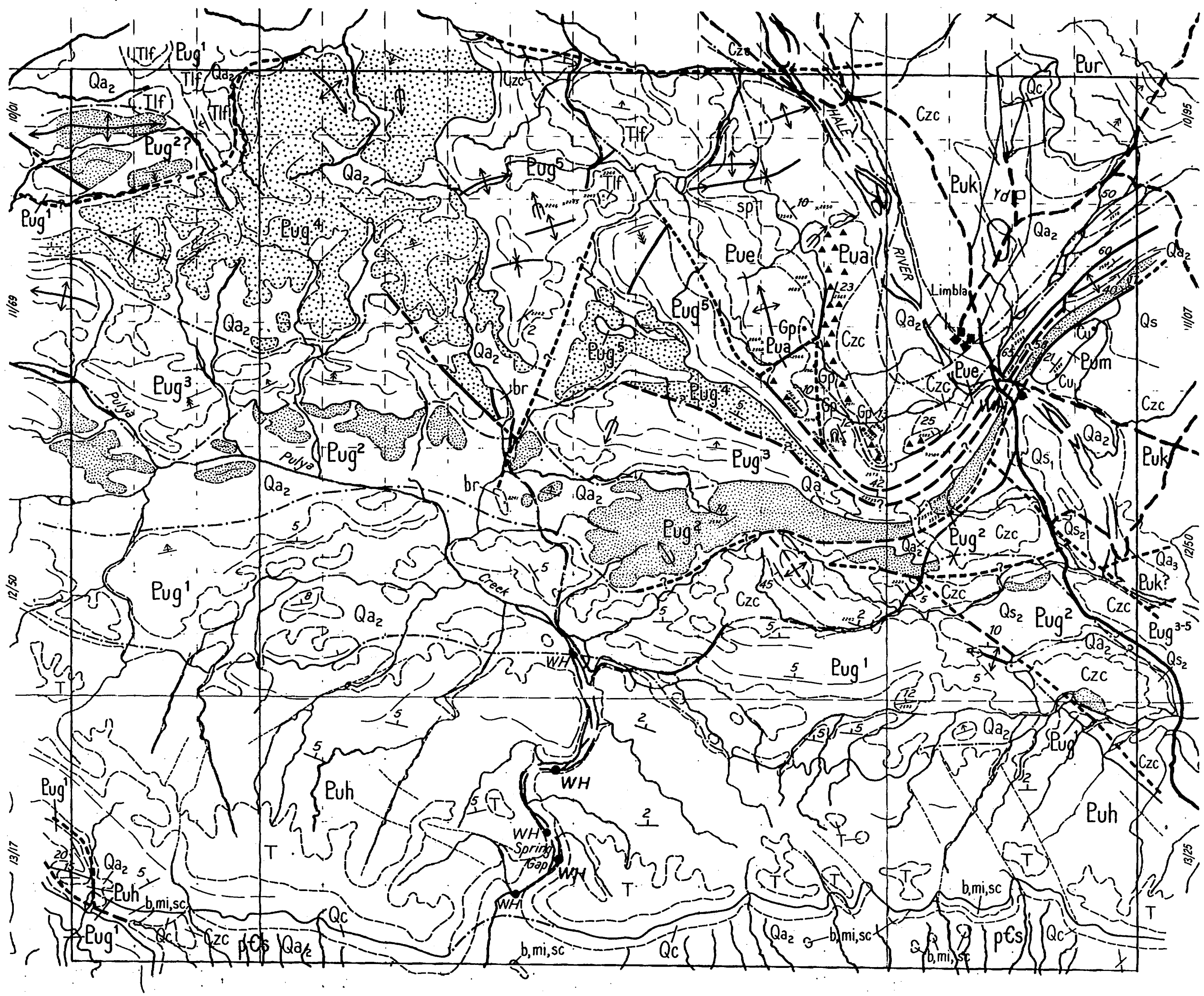

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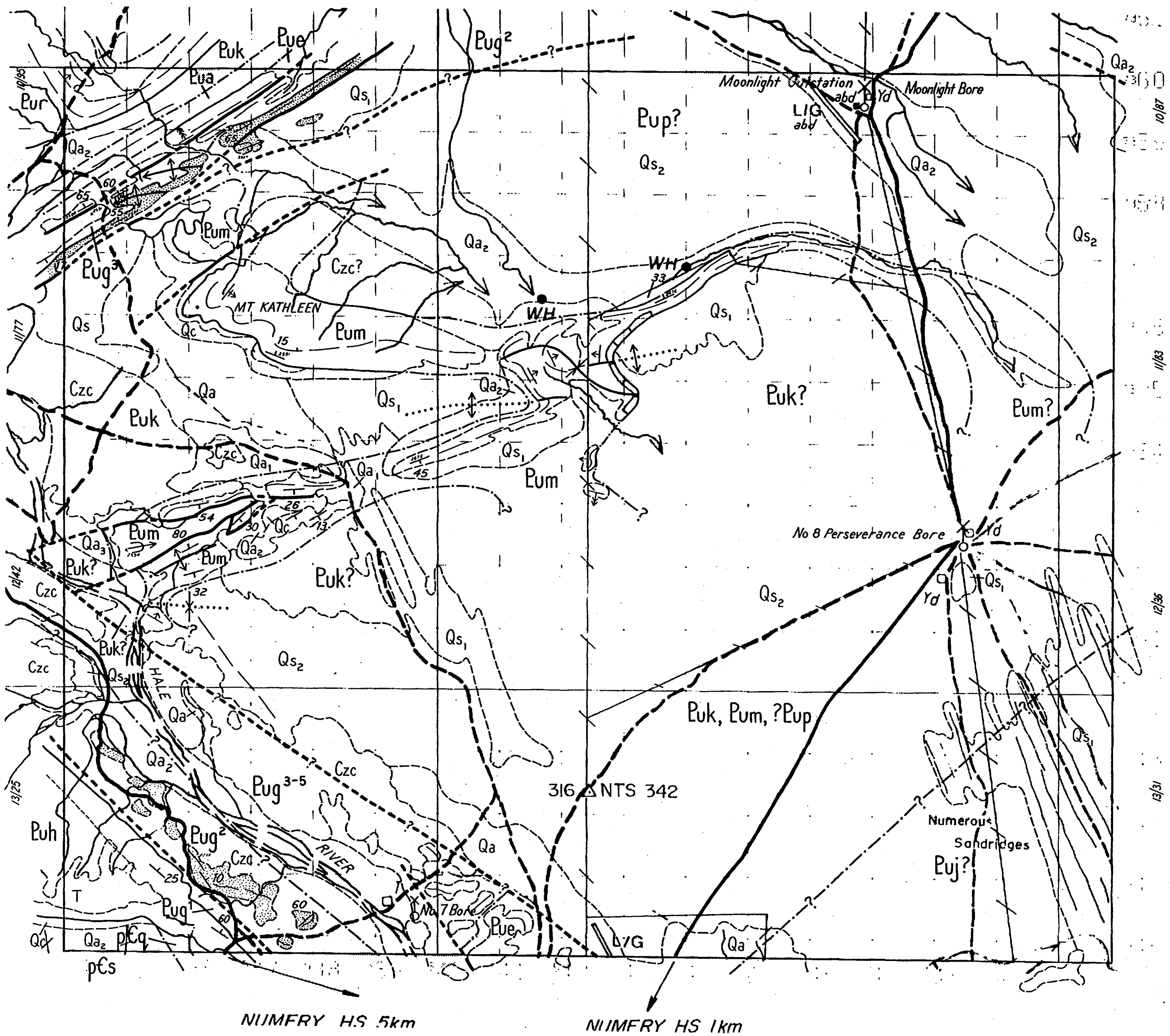

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