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CAMBRIAN STRATIGRAPHY OF THE CAMOOWEAL REGION

(PROGRESS REPORT)

by

A.A. Öpik

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INTRODUCTION

The 1953 field reports refer to several rock units of the Cambrian sequences of the Undilla Basin without defining the units. These units were established in previous years, but all the records and prepared reports were destroyed in the autumn of 1953. The author used this nomenclature in his field reports on the assumption that it would be known to prospective readers. In the present report the definitions are given in a brief and preliminary form.

The field maps show the distribution of the rock units, but, as the field reports contain no explanatory sections, these are presented here.

The study of the collections included the examination of the lithology and definition and determination of the vertical distribution of fossils. The results of the lithological examination will be given later. The vertical distribution of genera and species of fossils, however, shows the existence of a sequence of biozones (species-zones); it indicates the presence of four fossil stages in the Middle Cambrian sequence and is presented in Chart 2. The fossil list is incomplete, and the nomenclature applied is not final.

FORMATIONS OF THE CAMOOWEAL REGION

AGE: MIDDLE CAMBRIAN

C A L C A R E O U S F O R M A T I O N S :-

(1) Thorntonia Limestone: thick-bedded, visibly crystalline limestones, primary and secondary dolomites, some layers with abundant chert nodules, silicification common. Arenitic beds show oblique stratification and slumping. In the lower half of the sequence areally extended Girvanella "pudding"-beds are predominant; in upper levels encrinitic limestone and dolomite are widespread.

(2) Currant Bush Limestone (former field name "Lower V-Creek Limestone"): bituminous, smelly, flaggy limestones, oolitic, lutitic, visibly crystalline, with layers and strings of chert, and with thin laminae of siliceous shale in places. Interbeds and large slump-bodies of Age-Creek lithology are common in the north of the Undilla Basin. The fauna contains all the agnostids of the Inca Formation, sponges, polymerid trilobites, etc.

(3) Vee (V-)Creek Limestone: flaggy and laminated, even shaly, marly limestone with two or three bands, one or two feet thick, of Mail-Change-type limestone in the upper half. Very few chert bands and nodules may occur, and there are a few oolitic bands. Slumped beds of Age-Creek lithology are present, even at V-Creek itself.

(4) Mail Change Limestone: thick-bedded, lutitic, often laminated limestone with regular layers of visibly crystalline limestone

nodules. It is a two-colour rock, with a pink, red, or yellow matrix and mostly grey nodules. The name refers to Mail Change on the old Burketown Road, at the ruins of Old Morestone in Mail Change paddock. The type outcrop is Scrubby Creek Crossing at Mail Change Waterhole. The rock is sandy in the west of the Undilla Basin. Mail Change Limestone is resistant and forms low but extended bastions and mesas.

(5) Age Creek Formation: calcarenites and dolarenites, often oolitic, sometimes with conglomeratic bands, and all containing visible amounts of fine quartz sand. Interbeds of fine-grained sandstones and flaggy calcareous lutites are present also. Cherts and chert nodules are absent but for a thin band (60 feet thick) of thin-bedded limestones with chert beds and nodules near the base of the sequence in the Opal Creek area. Thus the dominant rocks are sandy limestones, sandy dolomites, and sandy dolomitic limestones, with subordinate sandstones, which cannot all be covered by a single lithological term and must therefore be described as a formation. The name refers to Age Creek, a left-bank tributary of the O'Shannassey River downstream from Morestone Station, and the high rocks at the junction of the streams are selected as the type locality. The field names have been:- "Morestone structures", at an early stage of study, and "Bells", "Bell rocks", and "Bells formation", later. The term "Bells" refers to the clear, loud ringing of the rocks when hit with the hammer, and, to a lesser degree, when walked upon. The distribution of the rocks in the Formation is not in blankets, but in more-or-less linear belts. A western belt extends south (south-south-west) of Morestone, and a northern belt from Morestone in an east-south-easterly direction towards Thorntonia. North-west from Morestone the two belts merge together and form a syncline open to the south-east. The base of the western belt is seen to overlie, and even overlap, the Camooweal Dolomite (See "Cambrian and Pre-Cambrian relationship" below); in the west the northern belt overlies the same Dolomite, whereas in its eastern segment it overlies the Thorntonia Limestone and the associated "Girvanella puddings". A very pronounced attitude is developed. The strike coincides with the described directions of the belts; the dips are correspondingly (and roughly) east and south-south-west, between five and twenty-five degrees. Generally speaking, the rocks dip towards Undilla, which is considered to be the "geographical centre of the basin" (Undilla Basin). The structural centre of the basin seems to be 7-8 miles east-south-east of Morestone, with a thickness admittedly over 4,000 feet. Thicknesses of the Age Creek Formation are variable: at Morestone it is over 4,000 feet; south of it more than 2,000 feet are seen. The northern belt decreases in thickness to the east, being nearly 700 feet at Redbank Creek, and several miles farther to the east it disappears completely. The thicknesses are calculated from the attitude along transverse sections three to five miles long (attitude-thicknesses; cumulative thicknesses), but these cannot be interpreted as thicknesses of the pile of rocks at given points, which may be, in effect, greater or smaller. They can be described also as the sum of thicknesses of each bed as seen on the surface along the traverse, without knowledge whether these partial thicknesses are constant or not along the line of the section. The relationship of the Age Creek rocks to the "normal" units of the Undilla Basin is an edgewise intertonguing and interbedding. The interbeds of "Age-Creek lithology" within the "normal" units have even reached the Undilla area. In the north, the Age Creek Formation corresponds to the full sequence from the upper half of the Thorntonia Limestone up into the Mail Change Limestone, and the western belt may correspond at its base even to the lower half of the Thorntonia Limestone. In some parts the Mail Change Limestone is interbedded with the top of the Age Creek Formation; in others it overlaps some beds of the latter. The Split Rock Sandstone (see below), however, overlaps everything. The Age

Creek Formation is, generally speaking, "unfossiliferous", but contains several bands rich in brachiopods and, in one case (the type locality), trilobite fragments also. Besides, quite fossiliferous interbeds of "normal" lithology (mainly of the Currant-Bush type) occur at various horizons, so that various parts of the Age Creek Formation can be correlated without much difficulty with the stratigraphical levels of the Basin.

S H A L Y F O R M A T I O N S :-

(6) Inca Creek Formation: siliceous shale, with several limestone members and chert interbeds, and calcareous siltstone (at Old Yelvertoft). On the 40-Mile Plain (Bore 79 on the Barkly Highway), the Inca Formation contains several beds of low-grade "kerosene shale". The fauna consists dominantly of agnostids and sponges.

(7) Border W.H. (Waterhole) Chert: interbedded siliceous shale and chert.

(8) Lancewood Shale: indistinctly laminated sandy shale and siltstone. In all inspected outcrops the rock is lateritized, and thus it is not evident whether it is calcareous or not, or whether it is dominantly a shale or a siltstone.

S A N D Y F O R M A T I O N :-

(9) Split Rock Sandstone: predominantly fine-grained, quartzose, reddened, friable sandstone. Siltstone and impure calcareous nodule-beds are developed near the base at Waroona Creek and in the southern part of Morestone Station.

C O M P O S I T E F O R M A T I O N :-

(10) Beetle Creek Formation: siliceous shale, siltstone, fine-grained sandstone, and thin beds of silicified limestone, in the upper part, and conglomerates with arkosic matrix and thin lenses of silicified limestone (in places with Girvanella), in the lower part. It is essentially the "Templeton Series", the "Dinesus-Stage", of Whitehouse, and comprises also a minor but consistent development of Redlichia-fauna in the lower part of the shale and in the upper part of the conglomerates. The "Yelvertoft Beds" (David, 1932) refer to these Redlichia-bearing strata, but the type locality (at Hall's Memorial on the Barkly Highway) has been practically all quarried away for road-metal.

The mutual relationship of the formations is shown in Chart 1, in which the given section is, however, insufficient to explain the situation completely in respect of the Undilla Basin. The section represents the rock bodies of the Basin approximately between the 700'- and 800'-isopachs. Towards the east the V-Creek Limestone thins out rapidly and is replaced by the Split Rock Sandstone. Towards the west the thickness of V-Creek Limestone increases, and the total thickness increases significantly, as has already been demonstrated in the field reports.

The map of the solid geology is in preparation and will be exploited in its turn for the construction of sections.

UNDILLA BASIN

The term "Undilla Basin", for the occurrence of the Cambrian rocks in the Morestone-Undilla area, was first applied by the author in the reports for 1952. Its structure was outlined in the field reports for 1953 and an isopach chart given. The Basin can be described as consisting of normal marine sediments with two margins preserved in the form of the western

and northern belts of the Age Creek Formation; this formation was deposited on the slopes of the subsiding basin, and the subsidence, which lasted for nearly three-quarters of Middle Cambrian time, is reflected in the attitude of this marginal formation. The Basin is sunken into a continental border of Cambrian time, and this border can be described, perhaps, as the then eastern edge of the Shield. Speaking in terms of M. Kay, the Undilla Basin is structurally an autogeosyncline, but of dimensions so small that the designation "geosyncline" acquires in this connexion a diminutive sense.

FORMATIONS OF THE DUCHESS (DEVONCOURT, O'HARA, SELWYN RANGE) REGION

For the sake of correlation, following the observations of 1952, the formational composition of the Cambrian sequence of the Selwyn Range region is given and is shown as an inset on Chart 1.

(1) Devoncourt Limestone (at base): well-bedded, bituminous, smelly limestone, referred to by Whitehouse as the "Phoidagnostus-Stage". The thickness is 300-400 feet.

(2) Selwyn Range Limestone: calcilutite and laminated impure marly and shaly limestones, with interbeds of Mail-Change-type lithology. It is over 200 feet thick and conformably overlies the Devoncourt Limestone.

(3) "Pituri" Formation: bedded chert (at base), quartzose sandstone, siliceous siltstone and shale, over 150 feet thick. The name refers to the "Pituri Series" of Whitehouse and is tentative. Its age is lower Upper Cambrian; the Selwyn Limestone and the Devoncourt Limestone are Middle Cambrian.

The subdivision shown above, which is also shown on the charts, is incomplete and was amplified during the 1954 field season. The data are not yet compiled, nor are the fossils determined, but the following additions are already available:

(i) The lower part of the Devoncourt Limestone is a non-calcareous siltstone, a separate formation, (Roaring Bore Siltstone) which rests on 20-40 feet of "sub-Cambrian" sediments, the latter, in turn, grading into the decomposed scree of the basement. The fauna of the siltstone is essentially the same as in the Devoncourt Limestone (Centropleura, Papyriaspis, Phoidagnostus, etc.).

(ii) The "Pituri" Formation is certainly not the "Pituri sandstones and shales" of Whitehouse (1936). In future this sequence will be referred to as the "O'Hara Shale". It has been observed that in the southern parts of the Duchess 4-mile Sheet a limestone with Olenus and Glyptagnostus overlies the O'Hara deposits. Whitehouse (1936), however, places the "Pituri sandstones and shales" above similar limestones in the Glenormiston area. "Pituri Series" may be used for the time being to cover the whole of the Upper Cambrian sequence in north-western Queensland.

ZONES

The scale of zones of the middle and upper portions of the Middle Cambrian is essentially the Swedish scale of Tullberg elaborated in recent years by Westergaard. The zones of the

Addition to Page 4 (Devoncourt Limestone and Roaring Siltstone).

In the Charts the Devoncourt Limestone and the Roaring Siltstone are shown as being of a punctuosus - parvifrons age in conformity with the "Pholdagnostus Stage" (Whitehouse, 1936, 1939). The real age is the brachymetopa and laevigata Zones. The brachymetopa Zone is represented by Acontheus and Ptychagnostus aculeatus (Angelin) in the Roaring Siltstone. Above it, in the Devoncourt Limestone, Leiopyge laevigata laevigata and Leiopyge laevigata cf. armata are common.

lower (but not yet the lowermost) Middle Cambrian refer to endemic Australian forms (Dinesus, Xystridura, Redlichia idonea) and are adapted from Whitehouse.

The vertical distribution of agnostids gives the best scale, for the following reasons: (1) agnostids are interfacial; (2) they are very abundant; and (3) they are practically universal. Other fossils (polymerid trilobites, brachiopods) are more facies-bound, but when their ranges are tested (especially by means of agnostids) they can be conveniently used for correlation.

It is noticeable that the margins of the species-zones overlap, and, consequently, clean-cut zone-"boundaries" do not exist, even in the type region in Sweden. In Sweden (Andrarum and the Island of Oeland), the agnostid species chosen as indices by Tullberg are those whose ranges more or less meet, but even here some overlap occurs. Subsequent investigations of the ranges of the agnostids by Westergaard demonstrate that even in the type area considerable overlap of ranges does occur (See: parvifrons, nathorsti, and brachymetopa, in the list of fossils, below). Thus in a type area of zoning, narrow local zone-boundaries are reasonable though not absolute; elsewhere this local scale must show variations owing to the variations of environments influencing the local longevity of species, and to migration.

STAGES (OR "FAUNIZONES")

The distribution of the ranges of fossils in Chart 2 demonstrates the existence of four faunal stages (or faunal assemblages) in the Middle Cambrian of north-western Queensland. The reality of these stages is seen from the clustering of the fossil-ranges on the chart. The lowermost Stage (I) is represented by Redlichia; above it follows Stage II, in which the fossils cluster on the gibbus and lower atavus bands; Stage III seems to coincide approximately with the "Anomocare-confertum Stage" of Whitehouse, if the identification of this species is here correct; Stage IV, the uppermost, is covered essentially by Papyriaspis (the "Papyriaspis-Stage" of Whitehouse) and by a number of short-ranging forms.

The position and ranges of the Middle Cambrian stages proposed by Whitehouse can be traced from the ranges of the corresponding index-fossils on the Chart, with the result that the real sequence of his trilobite stages is different, and some stages correspond to sub-zones.

It is hoped that subsequent study will help to narrow down the "boundaries" between the stages, and a geographical nomenclature of the stages is planned.

LIST OF FOSSILS AND THEIR STRATIGRAPHICAL AND PALAEOGEOGRAPHICAL SIGNIFICANCE

In Chart 2 the fossil names are arranged in the order of their first appearance, to exhibit their stratigraphical value, whereby the existence of more or less time-bound assemblages ("faunizones") becomes apparent. The following list of the same fossils is arranged alphabetically to facilitate reference and to explain the significance of each of the fossils. There is no need for a third, biosystematic, arrangement of the same fossils at the present stage of study. The explanations in the fossil list contain many hints leading to important palaeogeographical conclusions and aspects of correlation, and results which will be amplified and discussed on other occasions are already indicated here.

Several forms already known and described are not shown on the Chart for one or other of the following reasons: (1) identification is difficult; (2) the range is uncertain; (3) the fossils have not yet been found; and (4) literature is not available.

A number of new records for Australia are shown on the Chart; some are named by species, most only by genera, and even the generic names are not final. A great number of the fossils collected are not yet named at all, either on generic or specific levels, and are the subject of further study. The time-consuming study and description of fossils must be extended over a longer period.

The new records in the Chart, however, confirm the presence in Australia of forms from all known Cambrian provinces, and these forms may be exploited for interprovincial correlation on a world scale. The aspects of such a correlation are discussed in the next section. An adequate treatment of Australian Cambrian palaeogeography is in progress.

Acrothele - A universal genus, or group of genera, of inarticulate brachiopods. There are many species, of which some are abundant and have a narrow stratigraphic range. (See also: Lingulodiscina, Brachiopoda.)

Acrotreta - A universal genus, or group of genera, of inarticulate brachiopods, generally ranging from the base of the Cambrian into the Ordovician. Many species occur in the Cambrian of northern Australia, in excellent preservation. Diagnosis is, however, difficult. One species is described by Chapman as "Acrothele bulboides", from Beetle Creek. Identification of this form is uncertain. (See also: Brachiopoda.)

Agnostus seminula Whitehouse - A rare species of Ptychagnostus ("Triplagnostus") from the Inca Formation. At its type locality on the Paradise Road it occurs in association with P. gibbus, P. atavus, and Hypagnostus vortex. The "Agnostus-seminula Stage" of Whitehouse has accordingly a very narrow range and may be a local zone or subzone. Province: Acado-Baltic kinship.

Agraulos Corda - The name refers to the occurrence of the trilobite A. cf. difformis (Angelin) in association with Centropleura in the Devoncourt Limestone. Province: Acado-Baltic.

Amphoton serotinum Whitehouse - A bathyuriscid trilobite of another genus near to Poliella Walcott. The real range is uncertain.

Amphoton spinigerum Whitehouse - A bathyuriscid trilobite originally described from the Split Rock Sandstone and subsequently assigned by Kobayashi to the genus Sunia. The nearest genus is the Acado-Baltic Dolichometopus. The Victorian Dolichometopus possibly belongs to the same species.

Anomocare? angustum Whitehouse - The trilobite was originally described from cranidia only. From a number of pygidia, free cheeks, and well-preserved cranidia, from various localities, it is now placed in Mapania Resser and Endo. Province: Oriental (Cathayan), Manchuria.

Anomocare confertum Whitehouse - The nominate trilobite of the "Anomocare Stage" of Whitehouse, thought to be the top of the Middle Cambrian sequence. Identification from the original description is difficult. Most probably it is not strictly an Anomocare (Acado-Baltic Province) but belongs to the kinship of Koptura (Oriental Province, Manchuria).

Aojia Resser and Endo - A genus of trilobites covering many species, known as yet only from Manchuria (Oriental Province) in higher levels of the Middle Cambrian. Two species have been observed in Australia; one is very abundant in the Split Rock Sandstone. Its next younger relative may be the Australian Upper Cambrian Idamea Whitehouse.

archaeocyathids - Insufficiently preserved (completely silicified) archaeocyathids occur in the Thorntonia Limestone, but well-preserved material originates from the nearly comtemporaneous Soudan Limestone in the Northern Territory, where Archaeocyathus cf. atlanticus Billings is present, pointing towards eastern Canada and eastern U.S.A. There is as yet no observed similarity to the South Australian forms.

Asthenopsis Whitehouse - The name refers to the trilobite A. levior Whitehouse and another, new, species of the same range. A third, slightly older, species seems to be present also. This genus of trilobites practically coincides with the European Solenopleura. Province: Acado-Baltic.

atavus - Ptychagnostus atavus is the nominate trilobite species of the Swedish atavus-Zone, or, more correctly, the Zone of Tomagnostus fissus and Ptychagnostus atavus (according to Westergaard). Pt. atavus was first discovered in Australia by Whitehouse, and the correctness of the identification was checked by Grönwall (Copenhagen) and Westergaard (Stockholm, 1946). It is abundant and widespread in Queensland. Tomagnostus is known to occur in north-western Queensland, but the species have not yet been identified. Pt. atavus is a "pillar" of the Middle Cambrian Acado-Baltic stratigraphy; it was formerly believed to occur below the gibbus-Zone, but is now known to occur above Pt. gibbus. The atavus-Zone coincides with the Zone of Paradoxides hicksi. See also: parvifrons.

Aulacodiscus - See Opsidiscus.

bathyuriscids (trilobites) - (See also: Amphoton). Several species ranging from the base of the gibbus-Zone up into the top of the Middle Cambrian sequence. Some of them recall Poliella Walcott, but represent what is probably an endemic development (with intergenal spines) together with Fouchouia, mentioned by Whitehouse as occurring in the Thorntonia area; Fouchouia-like forms are widespread in north-western Queensland.

Biconulites - A very widespread hyolithid genus, unknown as yet only in Victoria and Tasmania. The only described Australian species is B. hardmani from the Ord River. The Queensland material is not yet identified specifically. Provincial relations: Palestine; China.

Brachiopoda - The knowledge of Australian Cambrian brachiopods is very scanty indeed. Only two species have been described as yet (by Chapman, 1929) from Queensland and the whole of northern Australia. The present collection from Queensland (and the Northern Territory) contains a great variety of forms, and many of them are well preserved and abundant. A preliminary examination reveals the presence of forms of the Oriental and Rocky Mountain Provinces, with coincidences even on specific levels. With the help of the brachiopods the differential correlation of the Age Creek Formation and the units of the Undilla Basin may be ventured. Besides, several abundant and short-lived species can be applied for regional zoning. (See also: Acrothele, Acrotreta, Iphidella, Lingulella, Micromitra, Nisusia, "oboloids", Paterina superba, syntrophoids, Wimanella.)

brachymetopa - The nominate trilobite species of the Swedish upper Middle Cambrian Zone with Solenopleura brachymetopa. The species itself is not yet known in Australia. The zone is based strictly on the occurrence of S. brachymetopa, without which the identification of the zone is circumstantial. According to Westergaard, Pt. lundgreni and G. nathorsti reach the basal part of the brachymetopa-Zone, and here Leiopyge laevigata, the marker of the next higher zone, makes its first appearance.

Cedaria? - Trilobites of the character of the genus Cedaria, associated with Pseudagnostus, Crepicephalus ?, etc., occur in the lower levels of the beds of "Pituri" at Devoncourt (See inset on Chart 1). Above it follows the Pituri fauna (see Eugonocare). The Cedaria-fauna is the basal zone of the Upper Cambrian of the North American Pacific provinces. In Australia it is above the laevigata-fauna, the latter being therefore upper Middle Cambrian.

Centropleura - The name of this trilobite is mentioned in the inset on Chart 1. It is believed to be an Acado-Baltic, Arctic, genus of Europe, Siberia, and eastern North America. One species (C. neglecta, Opik) has been described from Victoria. The new, "subtropical", discovery, which includes a complete specimen, seems to be very close to the Swedish C. angustata and C. loveni. Associated forms are: Agraulos, Phoidagnostus, Phalacroma, Diplagnostus, Tomagnostus, and, perhaps, some Oriental forms. The trilobite occurs in the Devoncourt Limestone.

Clappaspis Deiss - A trilobite genus of the Middle Cambrian of western U.S.A. (Rocky Mountain Province), a junior synonym of Lyriaspis Whitehouse. It is the nominate genus of the Clappaspis-Subzone of the North American Correlation Chart No. 1 (Howell and others, 1944), where it is very high in the sequence. The authors of the chart, however, have not considered the occurrence of five species of Clappaspis in the Spence Shale of Montana, which belongs to a considerably older zone (Zacanthoides-Anoria Zone). The Australian Lyriaspis ties up the Spence-Shale fauna with the lower part of the Australian gibbus-time (before atavus). (See also: oryctocephalids.)

Conchostraca - Numerous in the Redlichia-time. The species seem to be of short range but are rare in younger beds. No generic identifications have been attempted as yet.

"Conocoryphe" - What is evidently a blind trilobite of the Conocoryphe-group occurs as a reliable associate of "Anomocare cf. confertum". It is a small form and not very common, and the genus is not yet identified.

Crepicephalina Resser and Endo - A single species of this trilobite genus is abundant in the Split Rock Sandstone in many localities all over the sequence. The genus was originally established in Manchuria, but the author considers that some of the forms attributed to Crepicephalus in U.S.A. may belong to it, as, for example, C. camiro Walcott. In the Split Rock Sandstone a Crepicephalus s.s. may be present also, as well as in the lowermost Upper Cambrian of the Selwyn Range. In any case, both Crepicephalus and Crepicephalina suggest Pacific American and Oriental communications at the end of Middle Cambrian and the beginning of Upper Cambrian time in Australia.

Cymbionites etc. - The name refers to the occurrence of the cystids Cymbionites Whitehouse and Peridionites Whitehouse (1941) in the Thorntonia Limestone. They are also present in the Soudan Limestone in the Northern Territory.

Dinesus Etheridge (Whitehouse, 1939) - The nominate trilobite genus of the Dinesus-Stage of Whitehouse. D.ida Eth. is too rare to be a convenient index-fossil, especially in field work, but its occurrence in Queensland and at Heathcote, Victoria, renders it very important for stratigraphic correlation.

Diplagnostus - A group of agnostid trilobites, in Europe restricted to the upper half of the Middle Cambrian, but in Queensland already appearing with Ptychagnostus gibbus. One species, Enetagnostus humilis Whitehouse, is described from Queensland, from the "Phoidagnostus-Stage". It seems that the Queensland Diplagnosti represent a group very near to the Acado-Baltic D. planicauda. (See also: "Oidalagnostus".)

Dolichometopus - See: Amphoton spinigerum.

Doryagnostus - The name refers to Ceratagnostus magister Whitehouse, where Ceratagnostus is a slightly younger synonym of Doryagnostus Kobayashi. According to Westergaard, D. magister "does not seem to be specifically distinct from (the Scandinavian) D. incertus", a guide-fossil of the punctuosus-Zone. The identity of D. magister and D. incertus was later confirmed by material exchanged between Westergaard and the author. In Australia Doryagnostus also occurs together with Pt. punctuosus, but survives longer, being very abundant in the nathorsti-Zone. Province: Acado-Baltic, of course.

Dorypyge - The name refers to a group of trilobite species described by Whitehouse (1945), for which he also gives the correct stratigraphic position. In addition, it has also been found in the Split Rock Sandstone by the writer, confirming an early observation by W.E. Shevill (fide Whitehouse, 1936, p.73).

Elrathina - This trilobite has not yet been found in Queensland, except for a not-too-well preserved occurrence on the Barkly Highway near Inca Creek, where it occurs together with Pagetia and Xystridura, just below a shale with Pt. gibbus and atavus. A very well-preserved and diagnostically new species is present on the Sandover River in the Northern Territory. It is a common genus of the Rocky Mountain Province in the lower half of the Middle Cambrian, but well above its base.

Eugonocare Whitehouse - A trilobite genus of the lower Upper Cambrian fauna, described by Whitehouse from Glenormiston and Pituri. It is the index-genus of the Eugonocare-Stage of Whitehouse. (See also: Cedaria ?.)

Eurostina - This, the nominate trilobite genus of the "Eurostina-Stage" of Whitehouse, refers essentially to E. trigona Whitehouse from Alroy Downs in the Northern Territory. The species is widespread in the Northern Territory, but the occurrence of the genus in Queensland is not quite certain; the material is not yet exhaustively examined. The Eurostina-Stage was later (apparently) suppressed by Whitehouse himself, and quite correctly. Provincial relations are unknown, unless an undiscovered synonymy with a Rocky Mountains or Mexican form is recognized.

gibbus - See: Ptychagnostus gibbus.

Girvanella Nicholson and Etheridge - Sphaeroidal calcareous inclusions interpreted as algae, of world-wide distribution in Palaeozoic time and very common in the Cambrian. In Australia it was recorded in the Cambrian by Etheridge Jr. Girvanella is widespread in the limestones and dolomites of the lower part of the Cambrian sequence of northern Australia.

Goniagnostus nathorsti Brogger - (See: nathorsti). Goniagnostus Howell, described as an independent agnostid genus, is perhaps no more than a subgenus of Ptychagnostus Jaekel.

Goniagnostus purus Whitehouse - A common, and, as yet, endemic, trilobite species in Queensland. It seems to branch off the gibbus-line, and its upper limit in the sequence may be higher, as shown in Chart 2.

Helcionella - A large group of gastropods with many species in Queensland and the Northern Territory. Helcionella is also present in South Australia and Victoria.

Hypagnostus - This trilobite genus is well represented in Queensland. Two species, H. vortex Whitehouse and H. clipeus Whitehouse, are described. (See also: parvifrons.) Relationship: The Australian forms (except H. clipeus) seem to belong to the Acado-Baltic group of H. truncatus, and not to H. parvifrons.

Hypagnostus clipeus Whitehouse - See: Hypagnostus.

Hypagnostus vortex Whitehouse - See: Hypagnostus.

Idamea Whitehouse - A trilobite of the lower Upper Cambrian Pituri fauna in Australia. (See: Aojia; Eugonocare.)

Iphidella - A genus of inarticulate brachiopods related to Paterina, and accepted as a form of the Rocky Mountain Province. (See also: Brachiopoda.)

Kootenia - The name refers to the trilobites Notasaphus modicus Whitehouse from Queensland and N. fergusoni Gregory from Victoria. However, the range shown on the chart also covers unidentified species in the Currant Bush Limestone and in the Soudan Limestone of the Northern Territory. The range of the genus is too wide to be of any use for correlation within the Middle Cambrian, in spite of a "Glossopleura-Kootenia Zone" in the North American Chart. The genus is practically universal, common in America and rare in Europe and Australia. Notasaphus is a junior synonym of Kootenia, because the Australian forms belong to the American (Pacific) group of K. dawsoni, which is the genotype of Kootenia. By stressing this the palaeogeographic value of "Notasaphus" gains more significance.

Koptura Resser and Endo - A group of trilobite forms with bifurcate pygidia, comprising Koptura itself and also forms like Anomocare? confertum, and, perhaps, grading into Crepicephalina. A number of species within this group has been collected, but they are not yet properly sorted. Relationship: evidently Pacific in its widest sense. (See: Koptura lisani.)

Koptura lisani (Walcott) - An upper Middle Cambrian species, described originally from Manchuria as Anomocare. It is found in two localities in the upper part of the V-Creek Limestone on Morestone.

laevigata - The nominate species of the uppermost Middle Cambrian trilobite zone (of Leiopyge laevigata) in Sweden. (See: Leiopyge laevigata. var.)

Lancastria - The writer interprets the trilobite Paradoxides peregrinus Whitehouse as the thorax and pygidium of a Lancastria Walcott and suggests that the cranidium described as Oryctocephalus discus Whitehouse also belongs to it. Lancastria is a very rare Lower Cambrian trilobite from eastern North America. However, the genus is common in the lower Middle Cambrian of Siberia, disguised under the junior synonym of Oryctocephalops Lermontova. Oryctocephalus also occurs in Queensland, but the material collected seems to be different from O. discus. (See also: oryctocephalids.)

Leiopyge laevigata var. - The reference is to Leiopyge laevigata rugifera Westergaard, represented by several specimens in a locality of the upper V-Creek Limestone. This agnostid trilobite occurs in the Leiopyge-laevigata Zone of Sweden, and there are passage-forms between this variety and the type variety of laevigata. Leiopyge exilis Whitehouse ("Phoidagnostus-Stage," Duchess) represents a group different from laevigata.

Lingulella - A genus of inarticulate brachiopods of the widest range (Cambrian-Ordovician) and stratigraphically insignificant. The species of the genus have, however, a narrow range and may be exploited in regional stratigraphy. (See also: Brachiopoda.)

Lingulodiscina - Under this name a species of Acrothele has been recorded by Whitehouse from the Split Rock Sandstone. It is already present in the Mail Change Limestone. It is a ubiquitous guide-fossil.

Lisania cf. ajax Walcott - a trilobite seemingly related to the upper Middle Cambrian Oriental species, L. ajax Walcott, and not uncommon in the Split Rock Sandstone. A Lisania is also mentioned by Whitehouse from the "Phoidagnostus-Stage". Apart from the Australian records, no Lisania is known to occur outside China.

lundgreni - See: nathorsti.

Lyriaspis Whitehouse - Refers to L. alroiensis (Etheridge) and L. sigillum Whitehouse, but more species are present. For stratigraphic value, see: Clappaspis.

Mapania angusta (Whitehouse) - (See: Anomocare? angustum.) The chart shows the range of the species M. angusta; older species of Mapania seem to be present also, but are not yet examined.

"Menocephalus" - The name refers to the occurrence of two trilobites in the Split Rock Sandstone, of which one is similar to "Menocephalus" acanthus Walcott, and the other to "Levisia" adrastia Walcott, from the upper Middle Cambrian of Shantung, China. They may coincide even on specific levels with the Australian forms. These Chinese forms have been transferred by Kobayashi (1935) into a new genus, Menocephalites.

Micromitra - A genus of inarticulate brachiopods of the Pacific Province in its widest sense. Several species are present in north-western Queensland; some are abundant. (See also: Brachiopoda.)

nathorsti - Refers to the trilobite Goniagnostus nathorsti, the second nominate species of the Zone with Ptychagnostus lundgreni and Goniagnostus nathorsti of the Middle Cambrian of Sweden. For brevity the zone is designated "nathorsti" in the charts. The occurrence of Pt. lundgreni in Queensland is not yet certain. In Sweden, each species, taken alone, has a wider range than that of the zone, which is marked by the overlap of their ranges. The presence of Pt. nathorsti in Queensland was admitted as possible by Whitehouse and later by Westergaard. The latter mentions that outside the type area the species has a wider stratigraphic range. Ample material from a number of localities in Queensland confirms the presence of the species in Queensland, and its wider range. It is another "pillar" of the Acado-Baltic Province.

Nepea narinosa Whitehouse - A trilobite genus, and species, confined to Australia. The range of the species as given in the chart is true, and is derived from a number of observations. Whitehouse, however, considers that Nepea appears earlier, just after the disappearance of Xystridura. (See: nepeids.)

nepeids - A group of trilobite species, related to . Nepea narinosa Whitehouse, but generically (or subgenerically) distinct from the latter. The range of the "nepeids" plus the range of Nepea narinosa together make the range of "Nepea" as wide as suggested by

Whitehouse. The "nepeids" appear slightly earlier than Pt. gibbus, in an interbed in the lower levels of the Age Creek Formation, north of Opal Creek. Morphologically, the "nepeids" most closely resemble Alokistocare americanum (Walcott). (See: Nepea narinosa.)

Nisusia - An articulate, orthoid, brachiopod genus, widespread in Lower and Middle Cambrian time. A specific discrimination of the Queensland forms is not yet attempted.

"No-basal-lobes" - This unorthodox designation refers to an agnostid that might be intermediate between Ptychagnostus and Phalacroma. Any generic, or specific, name would at this stage be an unwanted nomen nudum. The forms are very abundant, widespread in limestones and shales, and of a short range. "Specialité de la maison".

Notasaphus - See: Kootenia.

"oboloids" - Relatively large, thick-shelled, inarticulate brachiopods are infrequent associates of Redlichia and also occur in beds just above it. Their generic position is not yet clear; for example, one widespread form may be designated Obolus cf. obscurus Walcott, from the lower Middle Cambrian of China. Its associate here and there is "Ptychoparia" lilia Walcott.

oelandicus - The nominate trilobite species of the lower Middle Cambrian Stage with Paradoxides oelandicus in Sweden, which is followed conformably upwards by the gibbus-fauna. The basal Middle Cambrian is missing in Sweden, and in Wales, between the top of the Lower Cambrian (with Protolenus) and the equivalent of the oelandicus-Stage, a break occurs, indicating the absence of the lowermost Middle Cambrian. Forms of the oelandicus-fauna have not yet been identified in Australia, though are not impossible. Protolenus is unknown in northern Australia. The Queensland "Dinesus-Xystridura" fauna seems to cover the upper half of the oelandicus-Stage and older levels of the gibbus-Zone, for which fossil evidence is available in the Northern Territory. The most important consequence of this aspect is the lower Middle Cambrian age of the Redlichia-bearing beds in northern Australia. (See also: oryctocephalids.)

"Oidalagnostus" - The name refers to Diplagnostus-like trilobites with a trispinose pygidium, comparable with Oidalagnostus? dubius Westergaard from the upper Middle Cambrian of Sweden. A true Oidalagnostus occurs at the top of the Middle Cambrian in Tasmania (Barker's Creek fauna, Dundas).

Opsidiscus Westergaard - A Pagetia-like trilobite, commonly known by the invalid name "Aulacodiscus", and previously found only in the upper Middle Cambrian of Sweden.

oryctocephalids - The term covers several stratigraphically and palaeogeographically important genera (and species) of trilobites, which all have a similar range and a wide geographical distribution. In Queensland, one species is described as Oryctocephalus discus Whitehouse, which, together with Paradoxides

peregrinus Whitehouse, may belong to Lancastria (q.v.). An undescribed (specifically unidentified) true Oryctocephalus is also present. In the Northern Territory (Sandover-, "Argadargada"-fauna), Oryctocephalus, Oryctocare, Oryctocephalites typicalis Resser, and a new genus, are abundant, indicating a reliable correlation with the "Spence"- and "Ptarmigania"- faunas of the Rocky Mountains and certain faunas widespread in Siberia (Compare: Clappaspis, above). The associated agnostids indicate a correlation with the upper part of the oelandicus-Stage and lower gibbus-time.

Pagetia - Specimens of trilobite genus Pagetia are usually referred to Pagetia significans (Etheridge), described from the Northern Territory. However, several species occur in the Northern Territory and Queensland, not all of which are exactly contemporaneous, though they fall into the range for the genus shown in the chart. Every Australian form of Pagetia as yet seen belongs to a close group not represented elsewhere. Province: Pacific (including Oriental).

Papyriaspis Whitehouse - A well-known trilobite, the nominate fossil of the "Papyriaspis-Stage" of Whitehouse. The range shown in the chart covers the distribution of the species P. lanceola Whitehouse; an older species occurs in the Devoncourt Limestone and is followed (in the Selwyn Range Limestone) by P. lanceola.

Paradoxides peregrinus Whitehouse - See: Lancastria.

parvifrons - Refers to the trilobite Hypagnostus parvifrons, the index-fossil of the corresponding zone in Sweden. H. parvifrons has not yet been found in Australia, but H. clipeus Whitehouse is a younger species of this group of forms. In the type area of the Middle Cambrian agnostid zones in Sweden, the species H. parvifrons is already present, according to Westergaard, in the lower portion of the atavus-Zone, and thus the parvifrons-Zone has to be identified by the extinction of Pt. atavus. This extinction must be certain, and the possibility of an accidental absence of Pt. atavus in a given outcrop must be allowed for.

Paterina superba Walcott - a rare species of inarticulate brachiopods of the lower Middle Cambrian of the Rocky Mountains of North America. In Queensland it is recorded in the Age Creek Formation, in intertongues of Currant Bush Limestone in the Age Creek Formation, and in the Currant Bush Limestone of the "Border Rift".

Pelagiella - A gastropod genus ranging form Lower to Upper Cambrian; the stratigraphic value of the species is not yet tested.

Peronopsis scutalis (Salter) - An agnostid of the Scandinavian and English Middle Cambrian, ranging from the gibbus-Zone into the atavus- Zone. It is common in the Northern Territory on the Sandover River, which is important for the correlation of the Northern Territory and Queensland deposits.

Phalacroma - See: Phalacroma marginatum.

Phalacroma marginatum Brögger - An agnostid trilobite, common within the range shown on the chart. Its range in Australia is similar to that in Sweden, i.e., over the nathorsti-Zone and reaching into the brachymetopa-Zone, representing, so to speak, the latter in Australia. Phalacroma dubium Whitehouse, originally recorded from the "Phoidagnostus-Stage", has a wider range, which, because of the rarity of the species, cannot be fixed. Phalacroma cf. nudum (Beyrich) occurs, according to Whitehouse, in the V-Creek Limestone. The name "Ph. nudum", however, has been applied to several species now recognized as independent, amongst them also Ph. nudum marginatum, to which Whitehouse's observation may refer. More species of Phalacroma are present in the Queensland collections, awaiting examination.

Phoidagnostus limbatus Whitehouse - The nominate form of the "Phoidagnostus-Stage" of Whitehouse. This agnostid trilobite is common in the Devoncourt Limestone east of Duchess but is not yet observed with certainty in the Undilla Basin.

Ptychagnostus atavus (Tullberg) - See: atavus.

Ptychagnostus convexus Westergaard - An agnostid of the Swedish atavus-Zone. "Convexus" in this fossil list represents a large group of species usually referred to as "Triplagnosti with effacing furrows" and well represented in the Acado-Baltic Province. A number of species of the same group is also present in the Undilla Basin. Convexus is named here as an example of this Acado-Baltic group in Australia.

Ptychagnostus gibbus (Linnarsson) - The nominate agnostid species of the corresponding Scandinavian Middle Cambrian Zone, which in older literature is also called the "Zone with Ctenocephalus exsulans" or "exsulans-limestone". The occurrence of Pt. gibbus in Australia was first recorded by Whitehouse and has been confirmed by Westergaard, to whom the present writer sent material for identification. Pt. gibbus is usually referred to the genus Triplagnostus (q.v.). The gibbus-Zone is below the zone with Ptychagnostus atavus, in Australia and in Sweden. Tullberg believed the reverse, which was also adopted by Whitehouse.

Ptychagnostus punctuosus (Angelin) - The type-species of the agnostid genus Ptychagnostus Jaekel. The species punctuosus is the nominate index-fossil of the corresponding Middle Cambrian zone in Scandinavia. In Queensland it is not abundant but is nevertheless widespread.

Ptychoparia lilia Walcott - A species of a ptychoparid genus established on a single fragmentary cranidium. The Australian specimen is just such a fragment, found in the upper half of the Thorntonia Limestone. The Chinese (Shan-si) specimen is associated with Obolus obscurus Walcott. (See: "oboloids".)

punctuosus - The nominate agnostid species of the punctuosus-Zone of Scandinavia. (See: Ptychagnostus punctuosus.)

Redlichia - A trilobite of the Cambrian of eastern and southern Asia and Australia. The Redlichia-fauna marks the Cambrian deposits of those regions above the "Protolenus"-fauna. Most authors regard the genus as "upper Lower Cambrian" in age, but present evidence in northern Australia indicates that its age is lower Middle Cambrian. Admittedly there are also upper Lower Cambrian species of the genus in other regions. (See also: R. chinensis; R. idonea.)

Redlichia chinensis Walcott - The range of the species covers the three uppermost Redlichia-zones in Korea, all of which are above the late Lower Cambrian "Protolenus" Shale, and ought to be regarded as lower Middle Cambrian. Various authors interpret the species chinensis in various ways, some splitting it into several species, and others treating it as a single species. Amongst a great number of Redlichia idonea Whitehouse from Hall's Memorial on the Barkly Highway two specimens are present which belong to the R. chinensis "group of species", or to the species itself. This occurrence can be correlated with the highest, or the second highest Redlichia-zone of the Korean sequence. The "second highest", the R.-nakamurai Zone, is the most probable (Compare Saito, 1934). (See also: R. idonea.)

Redlichia idonea Whitehouse 1939 - A widespread and abundant species in Queensland. According to Whitehouse, it is near Redlichia nobilis in Saito's interpretation, which occurs in association with R. chinensis in the lower Redlichia shale of Korea (in the lowermost of the four Redlichia-zones). R. idonea is certainly younger, as shown in the chart (overlap with range of Pagetia, and close contact with the range of the "oryctocephalids"). In Korea the youngest Redlichia-zone (with R. walcotti) is followed by the "Ptychoparia" beds, with Oryctocephalus, Pagetia, Helcionella, and agnostids, similar to the Australian assemblage.

Solenagnostus acuminatus Whitehouse- A species of Ptychagnostus related to Pt. gibbus and abundant in the Inca Formation. According to Whitehouse, it also occurs in the "Phoidagnostus-Stage". The range of the species is not yet examined, except for the occurrence in the Incas.

Solenoparia - A genus of Solenopleura-like trilobites widespread in eastern Asia. The representatives of the genus in Queensland are not yet studied.

Solenopleura - A genus of trilobites originally described from the Acado-Baltic Middle Cambrian. Asthenopsis is also a Solenopleura in a wider sense. The material differing from Asthenopsis has not been studied in any great detail.

Stenotheca - A gastropod genus, the Australian species of which (Queensland and the Northern Territory) are not yet studied. There may be more than one genus present.

syntrophoids - Brachiopods of the superfamily Syntrophoidea are rare in the Middle Cambrian of northern Australia, and are not yet identified generically. (See: Brachiopoda.)

Tomagnostus - See: atavus.

Triplagnostus Howell - An agnostid genus with Agnostus (or Ptychagnostus) gibbus Linnarsson as the type. The present author regards the genus as a synonym of Ptychagnostus. However, the name "Triplagnostus" in connexion with gibbus is also extremely popular in stratigraphic literature and has to be referred to. Stratigraphic misunderstandings have arisen when "Triplagnostus" and T. gibbus are regarded as equivalents.

Wimanella - A genus of articulate, orthoid, brachiopods. Specific relationship of the Australian material is not yet established.

Xystridura Whitehouse - A genus of paradoxidid trilobites in the lower Middle Cambrian of Australia. Several species occur in Queensland, and even more in the Northern Territory. The genus has a similar range to Redlichia, but survives the latter. It is an endemic Australian group. However, its occurrence in Siberia is indicated by a fragment described by Lermontova and placed in the different (but related) genus Bergeroniellus. Paradoxidids are usually regarded as indicators of the Middle Cambrian.

ASPECTS OF INTERPROVINCIAL CORRELATION IN THE MIDDLE CAMBRIAN

The palaeozoogeographical provinces in question are: (1) the Acado-Baltic (Richter) or Atlantic Coastal (Walcott) Province; (2) the Rocky Mountain Province of North America; (3) the Oriental or Cathayan Province, which covers Manchuria, China, Korea, and southern Asia; and (4) the Siberian province.

The most prominent attempt at correlation is the North American Chart No. 1 (Howell and others, 1944), which puts together the Acado-Baltic sequence of the Atlantic coast of North America and the Cambrian of the Pacific provinces which comprise the Rocky Mountains. In the North American Chart the following re-arrangements are necessary: (1) in the Acado-Baltic column the junction-lines between the Zones of Paradoxides hicksi and P. oelandicus must be brought down to the level of the Pacific Zacanthoides-Anoria Zone, and the Atlantic sequence must be shown as uninterrupted; and (2) the Paradoxides-zones should be replaced by agnostid zones and subsequently correlated with them. The Paradoxides-zones as shown on the Chart do not represent the sequence in any European type area but are in reality a compromise between the "European" and the American Acadian sequences. The ranges of the species of Paradoxides vary in different parts of Europe, and the species shown in the chart are not ubiquitous: even more differences in the ranges of the species may be expected on the opposite coasts of the Atlantic Ocean; besides, the identification of species is based on material of unequal quality. It seems that the Paradoxides-zones of Chart No. 1 have lost the character of species-zones and are treated as narrow "fossil bands" telescoped together, without consideration being given to the matter between the "zones", which may, or may not, be fossiliferous.

For the standard column of zones of North America no general suggestions can be made. Changes in the lower half of the Middle Cambrian have already been proposed by Lochman, Rasetti, and, perhaps, others. Some are also indicated in this paper (e.g. above, under Clappaspis). Another example is the "Elrathia-Triplagnostus-Clappaspis Zone", where an undescribed "Triplagnostus" seems to have been correlated with the zone-fossil Triplagnostus gibbus, disguised under Paradoxides hicksi.

The main difficulties of correlation have originated in the incompatible methods of "European" and "American" Cambrian study. In Europe, the stratigraphy has been in the foreground, and the ranges of the species have been studied. In America, the fauna described has been referred to formations as "stratigraphic units", which now necessitates a complete re-study to achieve a knowledge of the real ranges of the fossils. Thus, the Middle Cambrian sequence of the Acado-Baltic Province is ready for stratigraphical correlations; the Pacific American sequences are moving in the direction of a similar readiness.

The Middle Cambrian fossils of China, Manchuria, and Korea, have also been studied and described on a purely formational basis and are not ready for a detailed correlation. Some aspects of the zoning have been established by Saito (1934), Sun, and especially Kobayashi; but the fundamental work of Endo and Resser (1937) is strictly "American", and their formations give only a very general picture of the real Middle Cambrian faunal sequence. Howell's (1947) Cambrian correlation between China and North America volens nolens follows similar lines.

The Australian Middle Cambrian sequence, for the reasons stated above, cannot be linked up with the American or the Asian formations. However, the faunal contents of the localities in Asia, carefully recorded by Walcott (1913) and others, can be interpreted in terms of the ranges of genera and species observed in Australia, when all the Australian fossils are adequately described.

Some important consequences of the stratigraphical details of the charts accompanying this paper deserve mention:-

(1) The lowermost Middle Cambrian is absent. Redlichia idonea and the associated R. chinensis occur clearly above the base of the Middle Cambrian and cannot be considered as Lower Cambrian; according to Saito, R. chinensis has a wider range downwards, but as long as it remains above the "Protolenus"-Zone it is still Middle Cambrian.

(2) The Leiopyge-laevigata Zone can be conveniently regarded as upper Middle Cambrian, because in Australia the fauna there is definitely of this character. This is also shown in the North American Chart No. 1, whereas in a later attempt Howell (1947) regards it as the base of the Upper Cambrian and an equivalent of the Cedaria-Zone. In north-western Queensland, at the base of the "Pituri" (inset on Chart 1), Cedaria-like trilobites occur in association with Acado-Baltic trilobites of lower Upper Cambrian character, above, and indeed well above, what can be interpreted as the "laevigata-fauna". Recently, Wilson (1954) has correlated the laevigata-Zone of Europe with the American Crepicephalus-Zone, which is above the Upper Cambrian Cedaria-fauna. The only evidence for such an interpretation is the occurrence of a single genus, Nasocephalus, below the laevigata-Zone in Sweden and in the Cedaria-Zone of Texas. Hence, Nasocephalus is a genus of wide range, not appropriate for long-range correlation on the zone level.

CAMBRIAN AND PRE-CAMBRIAN RELATIONSHIP

The Cambrian sequence of north-western Queensland is, in a regional sense, nearly horizontal and is separated from the

Pre-Cambrian rocks by a great break and a tectonic unconformity. The Constance Beds in the north represent a younger part of the Pre-Cambrian sequence in the region. The Pilpah Sandstone in the south may be a part of the bulk of older Pre-Cambrian rocks not differentiated in Chart 1. Between the older, mostly metamorphosed, Pre-Cambrian basement and the fossiliferous Cambrian deposits, a very extensive blanket of non-fossiliferous dolomite intervenes, which has been designated "Camooweal Dolomite" by the writer. The Dolomite is approximately horizontal and is unconformable against the basement. The Cambrian overlaps the Dolomite non-conformably, and areal unconformities are also present. By Australian standards the Camooweal Dolomite must be regarded as late Pre-Cambrian in age, although the possibility of its representing a not-yet-determined part of the Lower Cambrian cannot be denied. The outcrops along the Georgina River at Camooweal (Lake Francis and Lake Mary) form the type locality of the Camooweal Dolomite. The rock is a thick-bedded, often arenitic, dolomite with horizons of chert nodules. Some horizons seem to indicate an evaporitic origin. Formerly it has been regarded as Middle Cambrian, or even Upper Cambrian, in age. The thickness as seen from numerous bore-logs is possibly 800-1,000 feet. The Camooweal Dolomite is the main rock of the pastoral area of the Barkly grass plains (Barkly Tableland).

EXPLANATION OF CHARTS

CHART 1

Middle Cambrian formational sequence in north-western Queensland. (Semi-diagram to show the distribution of formations and the sequence of zones.)

The thicknesses are only approximate because of the necessity of subordinating the deposits to the zoning. The total thickness on the Forty-Mile Plain (from a bore-log) is 800 feet; the Age Creek Formation is 700 feet thick. The thickness of the Split Rock Sandstone is slightly exaggerated. In the Undilla Basin, moving west and toward the viewer, the thicknesses of the Age Creek Formation, Currant Bush Limestone, and V-Creek Limestone, increase greatly. In the opposite direction, the V-Creek Limestone thins out, being apparently replaced by a thin sequence of cherts and siltstone and even grading into the Split Rock Sandstone. For geographic details see the Sketch Map.

CHART 2

Vertical distribution of fossils, zoning, and stages, of the Middle Cambrian and the lower Upper Cambrian sequence in north-western Queensland. (Although the outlines of the formations (from Chart 1) are here indicated, the fossil ranges are explicitly not connected with the formations as such. The arrangement is:- occurrence in vertical section interpreted as distribution in the course of time. The stratigraphic equivalence of the Currant Bush Limestone (fauna "complete") and the Inca Formation (no polymerid trilobites, agnostids only) is testified by the equal abundance and ranges of the same agnostid species.)

The zones (species-zones) and their index-fossils represent the Scandinavian (Westergaard, Tullberg) scale, with the following Australian peculiarities: (1) Ptychagnostus gibbus and P. atavus overlap, and each has a wider range; (2) Ptychagnostus punctuosus and Goniagnostus nathorsti overlap, because punctuosus reaches a higher level, and, moreover, even in Scandinavia, nathorsti shows a variation in range; (3) Hypagnostus parvifrons is not yet identified, but the gap between atavus and punctuosus represents the zone; (4) the Zone with

Solenopleura brachymetopa is a local Swedish development; the species itself is not present in Australia, and the zone coincides with the lower part of the next higher zone, that of Leiopyge laevigata; and (5) fossils of the oelandicus-Stage are not yet identified, and the correlation is palaeontologically circumstantial.

SKETCH MAP - NORTH-WESTERN QUEENSLAND AND NORTH-EASTERN NORTHERN TERRITORY.

The map shows the positions of the localities mentioned in the text, including the type localities of the Cambrian formations. "Y. Dip" is an abbreviation of "Yelvertoft Dip." The position of the sections, Charts 1 and 2, is marked as a wide belt, indicating that the sections do not refer to single outcrops, but are combined from several outcrops.

The following remarks may co-ordinate the map with Charts 1 and 2: (1) The Cambrian deposits at Border Waterhole extend as a narrow belt along Lancewood Creek into the Northern Territory for several miles. (2) The Lawn Hill-Riversleigh Area section (Chart 1) also covers the area between Riversleigh and Redbank Creek. (3) "Redbank Creek Area on Thorntonia "refers to the section immediately south of Redbank Creek. (4) "Undilla Basin between Undilla and West Thornton River" refers to the eastern border of the Undilla Basin, from Redbank Creek to the Barkly Highway, and the area between V-Creek and West Thornton River (Thorntonia is on this river). (5) The Forty-Mile Plain section is combined from surface outcrops and the log of the 79-Mile Bore, situated about eight miles west of Inca Creek along the Barkly Highway. The Plain itself and the 79-Mile Bore are not marked on the map. (6) The Whistlers Creek Area section is simplified by omitting several Pre-Cambrian highs protruding through the Cambrian sediments. (7) "Pilpah Range Area" refers to outcrops north of the Pilpah Range proper around some Pre-Cambrian highs. The difference of the upper level of Inca Shale on the two sides of a high only some hundreds feet wide has been actually observed. (8) "Barkly Downs" refers to the area south of the Pilpah Range. There is no Cambrian present, and a horizontal blanket of Camooweal Dolomite is pierced by topographic highs of folded Pre-Cambrian Pilpah Sandstone.

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Wilson, J.L., 1954 - Late Cambrian and early Ordovician trilobites from the Marathon Uplift, Texas. J. Paleont., 28 (3), 249-285, pl. 24-27.

14th February, 1955.

MIDDLE CAMBRIAN FORMATIONS IN QUEENSLAND BETWEEN BORDER WATERHOLE IN THE NORTH AND BARKLY DOWNS IN THE SOUTH ON A LINE 180 MILES LONG

ZONES AND RANGES OF INDEX FORMS

REDLICHIA
DINESUS-XYSTR.
GIBBUS
ATAVUS
PARVIFRONS
PUNCTUOSUS
NATHORSTI
BRACHYMETOPA
LAEVIGATA

LAEVIGATA
BRACHYMETOPA
NATHORSTI
PUNCTUOSUS
PARVIFRONS
ATAVUS
AGNOSTUS SEMINULA
GIBBUS
DINESUS-XYSTRIDURA
REDLICHIA
OELANDICUS STAGE
Basal Middle Cambrian missing

Border Waterhole

Cambrian Rocks Preserved in a Graben

Lancewood Shale
Border Waterhole Chert
Camooweal Dolomite
pC
Constance Pre-Cambrian

Lawn Hill-Riversleigh Area

Inset: Cambrian Sequence East of Duchess

Pituri
Selwyn Range Limestone
Devoncourt Limestone with Centropleura

Thorntonia Limestone and Girvanella "Puddings"

Redbank Creek Area on Thorntonia

Age Creek Formation

Undilla Basin between Undilla and West Thornton River

Mail Change
Split Rock Sandstone
V-Creek Limestone
Currant Bush Limestone
Inca Creek Formation
Beetle Creek
Pre-Cambrian

Forty Mile Plain East of Camooweal

Whistlers Creek Area South of Barkly Highway

Pilpah Range Area

Pilpah Sandstone
Pre-Cambrian

Q42-4

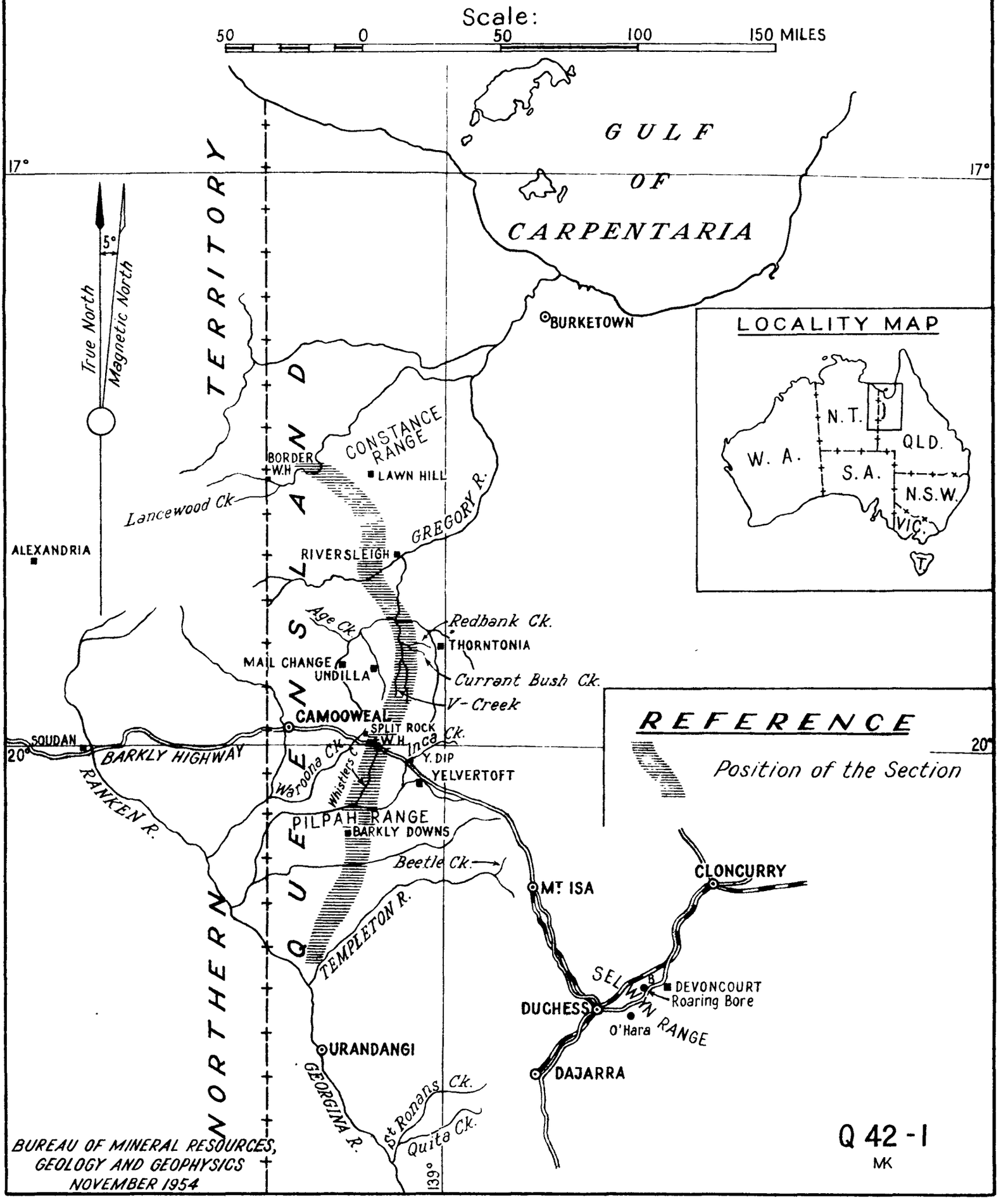
Barkly Downs

Camooweal Dolomite
pC
Pilpah Sandstone
Pre-Cambrian


RANGES OF FOSSILS IN THE CAMBRIAN OF NW QUEENSLAND
STAGES OR FAUNI-ZONES
ZONES AND RANGES OF INDEX FORMS
REDLICHIA
DINESUS-XYSTRID.
GIBBUS
ATAVUS
PARVIFRONS
PUNCTUOSUS
NATHORSTI
BRACHYMETOPA
LAEVIGATA
REDLICHIA CHINENSIS
REDLICHIA IDONEA
BICONULITES
HELCIONELLA
WIMANELLA
ARCHAEOCYATHIDS
CYMBIONITES ETC.
"OBOLIDS"
PAGETIA
DINESUS
XYSTRIDURA
PTYCHOPARIA LILIA
KOOTENIA
STENOTHECA
ORYCTOCEPHALIDS
LYRIASPIS
EUROSTINA
ELRATHINA
PELAGIELLA
PERONOPSIS SCUTALIS
PATERINA SUPERBA
SYNTROPHOIDS
PTYCHAGN. GIBBUS
AGNOSTUS SEMINULA
"NO BASAL LOBES"
SOLENAGN. ACUMINATUS
PTYCH. ATAVUS
HYPAGNOSTUS VORTEX
GONIAGN. PURUS
PTYCH. CONVEXUS
NEPEIDS
IPHIDELLA
MICROMITRA
DIPLAGNOSTUS
HYPAGNOSTUS
ANOMOCARE CONFERTUM
NISUSIA
"CONOCORYPHE"
PTYCHAGN. PUNCTUOSUS
OPSIDISCUS
KOPTURA
SOLENOPARIA
SOLENOPLEURA
ASTHENOPSIS
HYPAGNOSTUS CLIPEUS
"OIDALAGNOSTUS"
PAPYRIASPIS
DORYAGNOSTUS
PHOIDAGNOSTUS LIMBATUS
GONIAGN. NATHORSTI
PHALACROMA MARGINATUM
MAPANIA ANGUSTA
NEPEA NARINOSA
AOJIA
DORYPYGE
KOPTURA LISANI
CREPICEPHALINA
AGRAULOS
AMPHOTON SEROTINUM
LEJOPYGE LAEVIGATA VAR.
AMPHOTON SPINIGERUM
LISANIA CF AJAX
"MENOCEPHALUS"
BATHYURISCIDS
CEDARIA ?
IDAMEA
EUGONOCARE
ACROTRETA
ACROTHELE
LINGULELLA
CONCHOSTRACA
UPPER CAMBRIAN
IV
LAEVIGATA
BRACHYMETOPA
NATHORSTI
PUNCTUOSUS
PARVIFRONS
III
ATAVUS
AGNOSTUS SEMINULA
GIBBUS
II
DINESUS-XYSTRIDURA
REDLICHIA
OELANDICUS STAGE
I
Q42-3
MK JULY 1954

SKETCH MAP
N.W. QUEENSLAND AND N.E. NORTHERN TERRITORY

GEOLOGY BY A.A. ÖPIK



BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS
NOVEMBER 1954

Q 42 - 1
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1954/31

LIST OF FORMATIONAL NAMES, SUBMITTED TO THE COMMITTEE OF STRATIGRAPHIC NOMENCLATURE, QUEENSLAND.

Camooweal-Urandangi-Mt. Isa Area.

Age Creek Formation. New name and unit.
Age Creek, a left hand tributary of the O'Shannassey River, on Morestone. Dolomite, limestone and sandstone. Middle Cambrian.

Beetle Creek Formation. Beetle Creek, west of Mt. Isa. Conglomerate, chert, siliceous shale, minor interbeds of silicified limestone and sandstone. Lower Middle Cambrian.
Application as a formational name is new. Previously used as a locality name or as informal "Beetle Creek beds".

Blazan Shale. New name and unit.
Blazan Creek, a left-hand tributary of the St. Romans Creek, Kallala, Urandangi sheet. Siliceous shale with chert interbeds and a conglomerate at the base. Middle Middle Cambrian.
Confirmation of this geographic name is being requested from the Lands Department.

Border Waterhole Chert. New unit and name. Border Waterhole Musslebrook, Lawn Hill Sheet. The locality is on the Northern Territory - Queensland Boundary; the formation extends in both directions. Nodular ("brecciated") chert, solid chert beds, siliceous shale, and (near the top) limestone with over 50% chert nodules and interbeds. Lower Middle Cambrian (Xysteridura fauna).

Camooweal Dolomite. Township of Camooweal. Dolomite. Late Pre-Cambrian (older than known fossiliferous Cambrian). The name is new. Previously confused with "Georgina Limestones", "Georgina Series", "Barkly Group".

Currant Bush Limestone. New unit and name.
Currant Bush Creek, on Thorntonia Station. Various limestones with thin shale interbeds. Middle Middle Cambrian.

Devoncourt Limestone. New unit and name.
Devoncourt Station, east of Duchess. Hard, slightly bituminous limestone with marly interbeds. Middle Cambrian. It contains the fauna of the "Phoidagnostus Stage" of Whitehouse.

Inca Creek Formation. New unit and name.
Inca Creek on Yelvertoft Station. Siliceous shale, siltstone, cherts and limestone. Middle Middle Cambrian.

Lancewood Shale. New unit and name.
Lancewood Creek and Waterhole on Gallipoli Station, Northern Territory. However, the unit extends into Queensland. Completely lateritized shale and siltstone, sandy, and calcareous near the base. Middle Middle Cambrian.

Lee Sandstone. New unit and name.
Lee's Waterhole, headwaters of the O'Shannassey River, east of Camooweal. Sandstone with plants. Mesozoic.

Mail Change Limestone. New unit and name. Mail Change on Morestone (A paddock, ruins, and the Mail Change Waterhole). Lutitic, often laminated limestone (calcilutite). Upper Middle Cambrian.

O'Hara Shale. New unit and name.
O'Hara Station on Burke River (also O'Hara's Gap, Selwyn Range). Shale with minor chert and sandstone interbeds. Lower Upper Cambrian.

Poland Shale. New unit and name.
Poland Waterhole (Rockholes), head of Little Waroona Creek, east of Camooweal. Siliceous radiolarian shale. Mesozoic.

Pomegranate Limestone. New unit and name.
Pomegranate Creek on Chatsworth Station. Marly limestone with harder interbeds. Upper Cambrian.

Quita (Creek) Formation. New name and unit.
Quita Creek, Kallala Station, Urandangi Sheet. Limestone and calcareous shale. Upper Middle Cambrian.

Roaring Siltstone. New unit and name.
Roaring Bore on Devoncourt Station. Siltstone with some cherts and sandstone interbeds. Middle Cambrian.

Selwyn Limestone. New name and unit.
Selwyn Range, on Devoncourt Station. Limestone (calcilutite) and marls. Upper Middle Cambrian.

Split Rock Sandstone. New unit and name.
Split Rock Waterhole on Waroona Creek east of Camooweal. Sandstone and siltstone. Uppermost Middle Cambrian. Split Rock is the locality of the "Amphoton Stage", of Whitehouse. It has not been used, however, in any formal way in the sense of the Stratigraphic Code.

Steamboat Sandstone. New unit and name.
Steamboat, a hill on Kallala Station, Urandangi Sheet. Sandstone and calcareous sandstone. Middle Cambrian. Confirmation for the use of this geographic name is being requested from the Lands Department, Queensland. Name is well known in the district but does not appear in published maps.

Thorntonia Limestone. New unit and name.
Thorntonia Station. Thick bedded limestone with chert nodules. Lower Middle Cambrian.

Vee (v-) Creek Limestone. New unit and name.
V-Creek on Thorntonia Station. Flaggy limestone and marl. It is essentially the "Papyriaspis Stage" of whitehouse. Upper Middle Cambrian.

SEQUENCE OF THE UNITS.

Camooweal Region. Discending order.

Split rock sandstone is the top, and almost the top of Middle Cambrian.

5. Mail Change Limestone.
4. Vee Creek Limestone.
3. Currant Bush Limestone.
2. Inca Creek Formation (replacing lower levels of the Currant Bush Limestone in the south, and missing in the north).
1. Beetle Creek Formation, Thorntonia Limestone and Border Waterhole Chert, all more or less contemporaneous developments.

Age Creek Formation replaces all the units 1-5 on the slopes of the Undilla Basin.

Urandangi Region.

5. Steamboat Sandstone, on top. Upper Middle Cambrian.
4. Quita Formation.
3. Blazan Shale.
   An erosional break intervenes, corresponding to the zones with Ptychagnostus gibbus and atavus.
2. Beetle Creek (shale, chert), residuals only.
1. Thorntonia Limestone, residuals only.

Duchess Region.

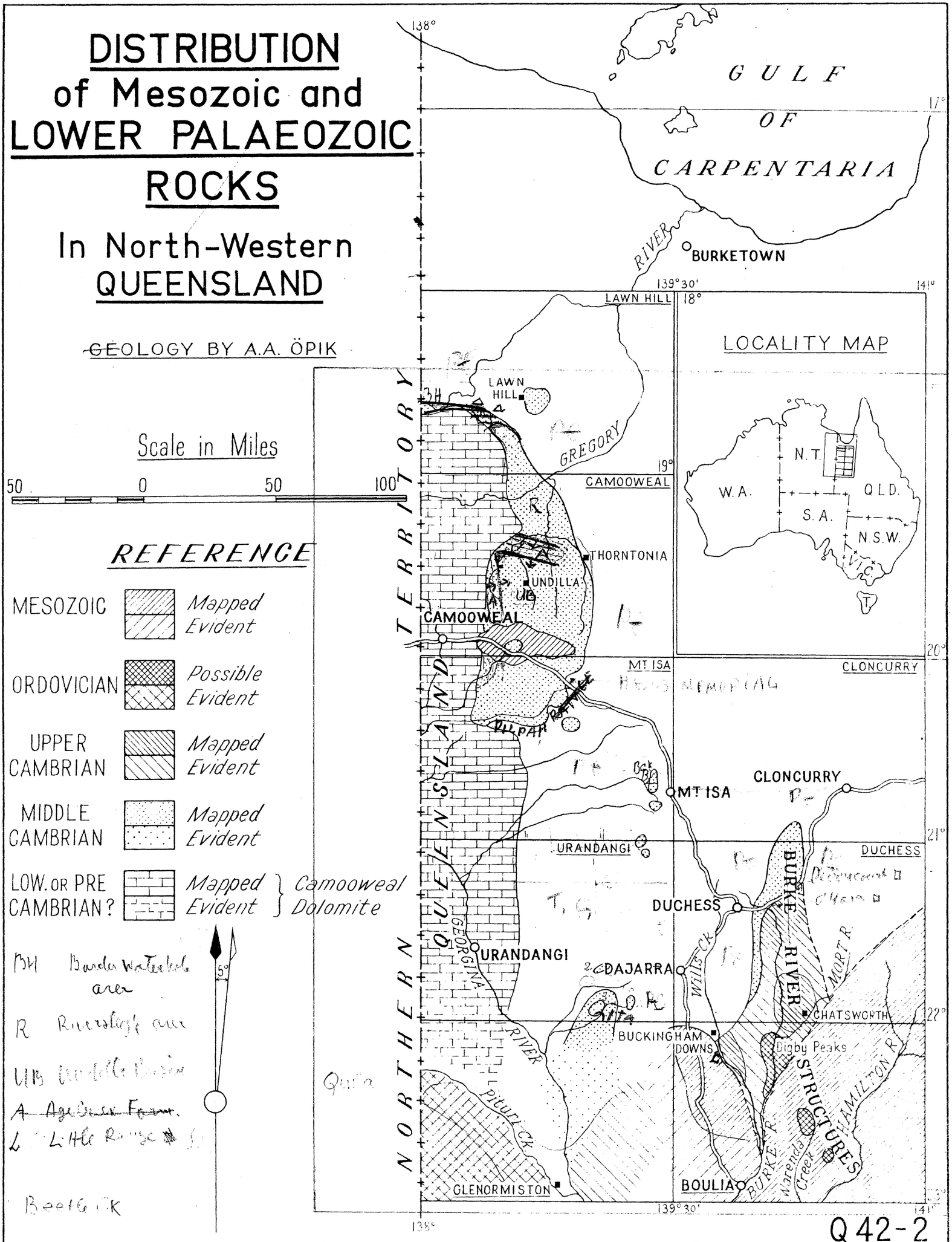
4. O'Hara Shale (lower Upper Cambrian).
   A break seems to be evident, upper Middle Cambrian might be missing.
3. Selwyn Limestone (the age is near to Vee Creek Limestone).
2. Devoncourt Limestone.
1. Roaring Bore Siltstone.

Equivalents of the Beetle Creek Form. etc., of the Inca Creek Form., and of lower part of Currant Bush Limestone are missing.

Pomegranate Limestone is above the O'Hara shale (by fossil evidence), but the field relationship needs some more study. The thicknesses at this stage are omitted 1) because a considerable variation in lateral direction is present (for example, Inca Formation is between 0-200 feet thick) and 2) because A.A. Öpik prefers to give final figures in the future without committing himself to data which may have to be changed later. However, most of the field data are already available in the reports of 1953 sent to the Geological Survey of Queensland.

DISTRIBUTION of Mesozoic and LOWER PALAEOZOIC ROCKS In North-Western QUEENSLAND

GEOLOGY BY A.A. ÖPIK



Scale in Miles

50 0 50 100

REFERENCE

MESOZOIC	Mapped	Evident
ORDOVICIAN	Possible	Evident
UPPER CAMBRIAN	Mapped	Evident
MIDDLE CAMBRIAN	Mapped	Evident
LOW. OR PRE CAMBRIAN?	Mapped	Evident } Camooweal Dolomite

BH Border watershed area

R Riverslope area

UB Undilla Basin

A Age Creek Fm.

L Little Range

Beetle Ck

Quita

Bureau of Mineral Resources, Geology and Geophysics. November 1954

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MK

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