

The Iverian, a proposed Late Cambrian Stage, and its subdivision in the Burke River Structural Belt, western Queensland

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The Iverian Stage is proposed for the concept of a post-Idamean/pre-Payntonian, Late Cambrian, interval in the eastern Georgina Basin, western Queensland. Designation and definition of this stage completes the local stadial biochronological scheme for the Upper Cambrian platform sequences of Australia and conterminous regions. Lithostratigraphic and biostratigraphic

material diagnostic of this stage in its type area is integrated and correlated within Australia and globally. In the interests of simplification and clarification, it is suggested that a generic zone concept be overlaid on the current assemblage-zone biostratigraphic scheme for the Iverian Stage.

Introduction

The Iverian Stage is proposed as a local stage of Late Cambrian age, named from the Parish of Iver in the County of Windsor, western Queensland, for the undifferentiated biostratigraphic interval originally designated as pre-Payntonian A and pre-Payntonian B (Jones & others, 1971), but currently informally known as post-Idamean/pre-Payntonian (Shergold, 1989, p. 13). Jones & others (1971) did not formally name this interval because of uncertainty about the temporal relationship of the lower Chatsworth Limestone, defined by Casey (1959) at Lily Creek, 3.5 km south of Chatsworth Homestead, and 'Chatsworth Limestone' occurring in the core of the periclinal structure at Black Mountain, 50 km to the south. It has since been demonstrated that the Lily Creek and Black Mountain sections overlap biostratigraphically (Shergold, 1980; and below). In 1971 it would not have been possible to satisfactorily define a base for any stage proposed for this interval since the relationships of faunas at the top of the Pomegranate Limestone, the *Irvingella tropica*/*Agnostotes inconstans* Zone of Öpik (1963), to those of the lowest Chatsworth Limestone, which was then undescribed, were not known.

Because *Agnostotes inconstans* does not occur at the type section for the Idamean Stage, at Browns Creek, south of Glenormiston and some 150 km west of Boulia, Henderson (1976b) considered a revised *Irvingella tropica* Zone as the youngest zone of the Idamean Stage. Subsequently, for essentially practical reasons, Shergold (1982) restricted the Idamean Stage by excluding the *Irvingella tropica* Zone, regarding it as the initial biostratigraphic division of a then un-nominated post-Idamean stage. This was an important step, as *Irvingella* has a cosmopolitan distribution which facilitates international correlation. Equally important, the redefinition of the Payntonian and Datsonian Stages at the top of the Cambrian on the basis of new and realigned conodont assemblages (Nicoll & Shergold, 1991; Shergold, Nicoll & others, 1991; Shergold & Nicoll, 1992) has clarified the concept of the Iverian/Payntonian boundary.

The need now to formally name the post-Idamean/pre-Payntonian interval and integrate all previous observations on it, is to complete the sequence of Australian Late Cambrian stages commenced by Öpik in 1963; to promote the use of an Australian timescale for the Cambrian in basin studies and sequence stratigraphic analyses (Shergold, 1989); and to provide an appropriate framework for

palaeogeographic reconstructions, map legends, and similar literature.

Concepts

Although the Iverian Stage is introduced and documented in accordance with the requirements of the Stratigraphic Nomenclature Committee of the Geological Society of Australia, its conceptualisation differs from definitions of stages published in the International Stratigraphic Guide (Hedberg, 1976) adopted by that Society. This is because the idea of a stage as a global chronostratigraphic unit (Hedberg, 1976) is unsustainable (e.g. Ludvigsen & Westrop, 1985). As acknowledged aggregates of zones (e.g. Jones & others, 1971; Hancock, 1977; Ludvigsen & Westrop, 1985), stages are clearly biostratigraphic units. Their dependence on zonal distribution patterns guarantees the local nature of stages. Tied to biofacies distributions influenced by sedimentary environment controls, both zones and stages are undeniably bound to rock sequences thus assuming stratigraphic and time contexts by virtue of succession. Accordingly, they inherit biochronological attributes to complement their biostratigraphic utility. Therefore, stages are regarded here as principally biochronological units, in general, facilitators of correlation at the most convenient level of resolution.

Definitions

The base of the Iverian Stage is defined by the first appearance of elements of the *Irvingella tropica* Zone in the top of the Pomegranate Limestone at Mount Murray (Fig. 2), where it occurs in measured sections 301 and 302, as documented by Shergold (1982). This datum also occurs at locality D120b (Öpik, 1963, figs 2–3; Shergold, 1982, fig. 1; herein Fig. 2), the type locality for *Irvingella tropica* Öpik, and where it is associated with *Agnostotes (A.) inconstans* Öpik. Section 302 at Mount Murray (Radke in Shergold, 1982, fig. 4), at 21°47.7'S, 139°59'E, is regarded here as the type section for the definition of the base of the stage. *Irvingella tropica* occurs in collection 302/3, 37 m above the base of the section and 3 m above 302/2, which contains elements of the late Idamean *Stigmatia diloma* Zone. The contact between the Idamean and Iverian Stages is considered to be conformable, within a sedimentary continuum, although on Figure 4 non-outcropping intervals are shown on Section 302.

The top of the Iverian Stage is defined by the appearance of the *Sinosaukia impages* trilobite assemblage-zone and the *Hispidodontus resimus* conodont zone. These mark the base of the Payntonian Stage as redefined by Shergold, Nicoll & others (1991) and Shergold & Nicoll (1992) at

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Black Mountain, some 90 km south-southeast of Mount Murray, at 22°32.17'S, 140°17.01'E. The Iverian/Payntonian contact lies between the *Rhaptagnostus clarki maximus*/*R. papilio* and *Sinosaukia impages* Assemblage-Zones. Lithostratigraphically, the boundary lies approximately at the base of Chatsworth Limestone Unit E (Shergold, *in* Druce & others, 1982, figs 4, 5), a massive cliff-forming sandy limestone at which the conodont *Hispidodontus resimus* Nicoll & Shergold first appears. Though lithostratigraphically abrupt, the stadal contact is thought to be conformable. No sedimentological studies have been undertaken to prove otherwise.

Between Mount Murray in the north and Black Mountain in the south, rocks assigned an Iverian age, representing the lower Chatsworth Limestone, crop out intermittently (Fig. 1). They are documented in the black soil plains near Chatsworth Homestead; in shallow stratigraphic coreholes, BMR Duchess #13 (Kennard & Draper, 1977), BMR Boulia #6 (Kennard & Draper, 1977) and its extension (Shergold & Walter, 1979); and in the measured type section of the Chatsworth Limestone at Lily Creek, south of Chatsworth Homestead (Shergold, 1980) and at Black Mountain (Shergold, 1975). Besides occurring in the core of the

Black Mountain pericline, Iverian rocks also crop out in the Momedah anticline at Momedah Creek, 19 km east-north-east of Black Mountain (Fig. 3). From disparate measured sections, they appear to be at least 725 m thick.

Lithostratigraphy

With the exception of the Momedah Anticline, Iverian rocks in each of the areas noted above — Mount Murray, the Chatsworth district, and Black Mountain — are represented by a series of upward-shallowing sequences. At Momedah, only superficial sedimentological observations have been made and not enough rock crops out for a detailed reference section.

At Mount Murray (Sections 301, 302), the earliest Iverian is represented on the type section (302) in the interval 37–107 m by mottled micritic carbonate pelletal wackestone and laminated pelletal skeletal grainstone, whose upper surfaces often bear silicified veneers. These rocks, referred to the uppermost Pomegranate Limestone, crop out as discrete layers, or groups of layers, separated by non-outcropping presumed clastic intervals. They pass upwards into a thick (255 m) sequence of interbedded muddy carbonate, intraclastic grainstone and dolostone referred to the basal Chatsworth Limestone (Shergold, 1982, *in* Druce & others, 1982).

Younger Iverian sequences are seen among scattered outcrops in the black soil plains north and northwest of Chatsworth Homestead and in the BMR stratigraphic coreholes noted above. The subsurface sequence found in BMR Duchess #13 is an alternation of pelletal grainstone, occasionally skeletal, and packstone, 70 m thick (Kennard & Draper, 1977; Druce & others, 1982). In BMR Boulia #6 (*ibid*) and its extension, Kennard (*in* Shergold & Walter, 1979) recognised three broad groups of rocks, 178 m thick in total, comprising an uppermost shelly grainstone and mudstone intercalation with intraclastic grainstone; a middle calcareous siltstone and shaly limestone; and a basal mudstone and micritic carbonate alternation (*in* Druce & others, 1982). Both upper and lower units have been recognised among the scattered outcrops on the black soil plains around Chatsworth. None of the coreholes penetrated recognisable Pomegranate Limestone, so the exact relationship between the basal Chatsworth Limestone at Mount Murray and that at the bottom of BMR Boulia #6 extension remains unclear.

BMR Boulia #6 and BMR Duchess #13 can be biostratigraphically correlated directly to the type section of the Chatsworth Limestone at Lily Creek (Shergold, 1980) where Radke (*in* Shergold & others, 1976; *in* Shergold, 1980) measured a 300 m section of peloidal, skeletal and intraclastic grainstone with interbedded calcareous siltstone and mudstone. This sequence is capped by a massive (12 m) calcareous sandstone unit, which has been separated as the Lily Creek Sandstone Member of the Chatsworth Limestone (Druce & others, 1981).

Biostratigraphically, it has been demonstrated (Fig. 4; Shergold, 1980) that the top of the sequence at Lily Creek overlaps the base of the Chatsworth Limestone sequence at Black Mountain, although the Lily Creek Sandstone Member is younger there. Late Iverian rocks in the basal 248 m of section at Black Mountain have been divided into four lithostratigraphic units (A–D; Shergold *in* Druce & others, 1982; Shergold, Nicoll & others, 1991), essentially the earlier units 1–4 of Shergold (1975).

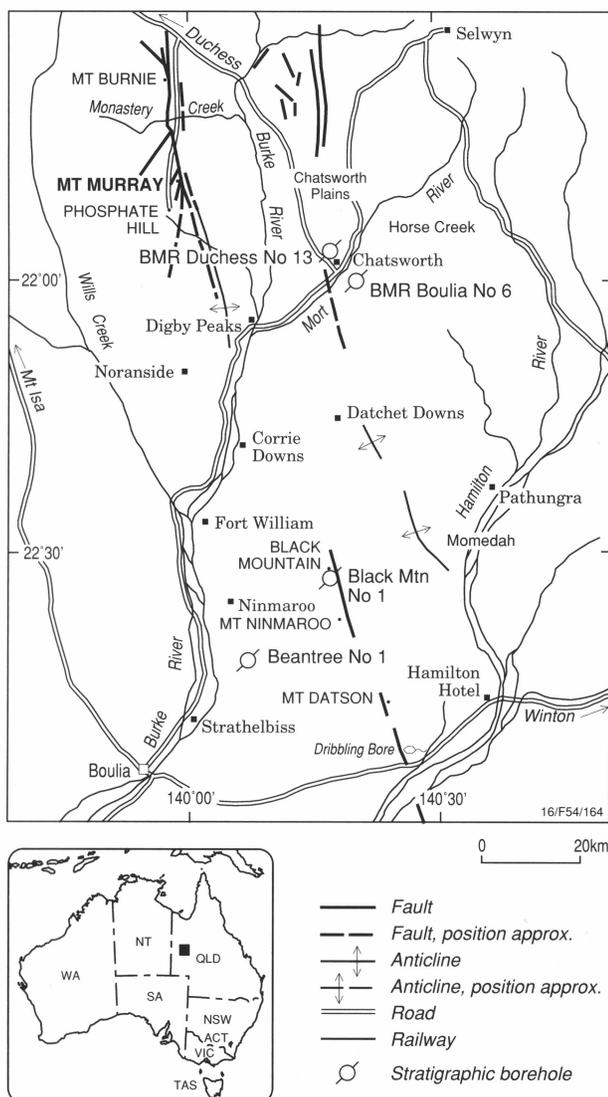


Figure 1. Distribution of the main Iverian sections and localities in the Burke River Structural Belt.

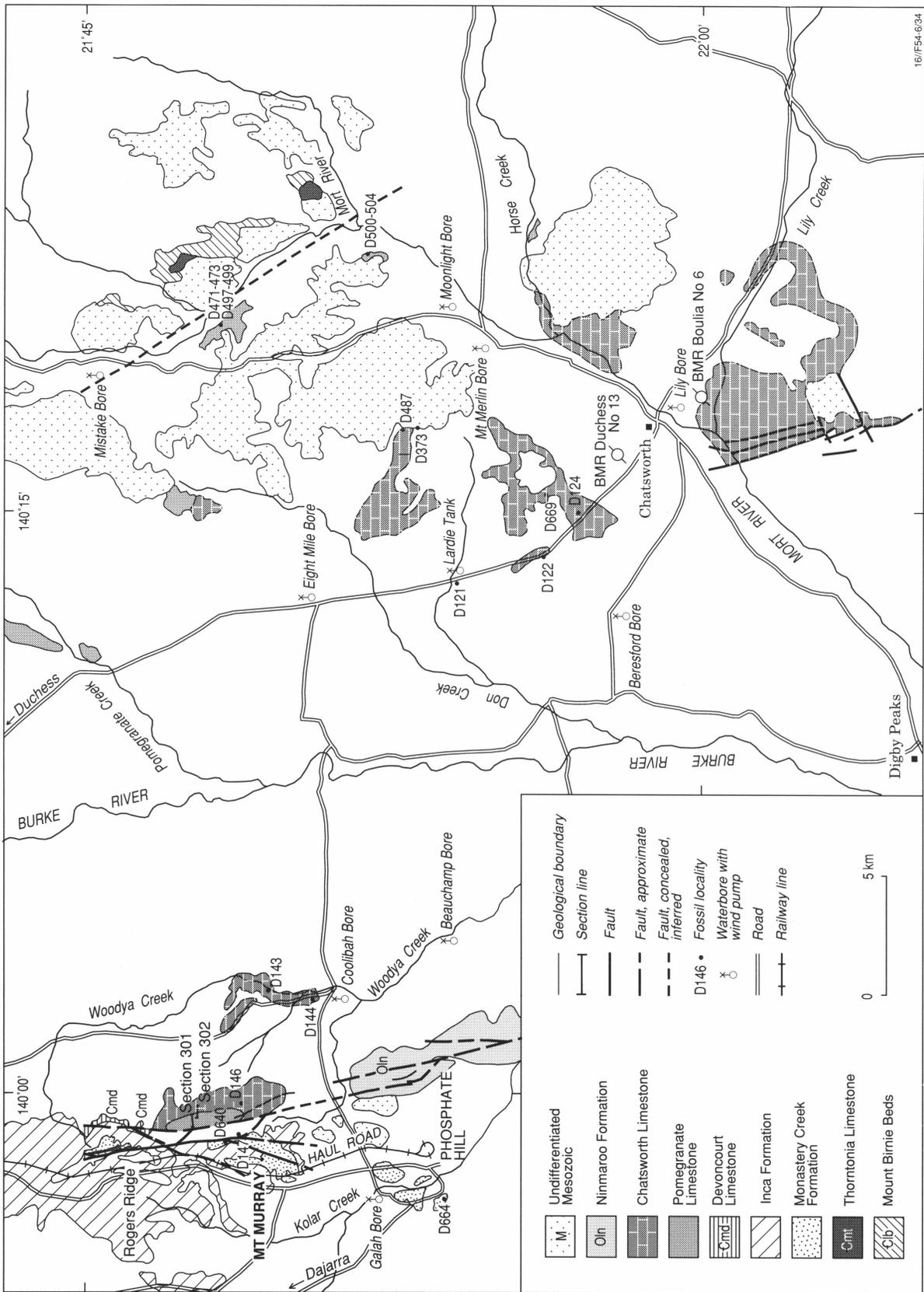


Figure 2. Location of the type section for the base of the Iverian Stage (section 302) at Mount Murray; Iverian sections and localities at Lily Creek, Horse Creek and on Chatsworth Plains; and locations of BMR stratigraphic coreholes.

Unit A (40 m) contains intercalated skeletal grainstone, intraclastic grainstone, silty micrite and calcareous siltstone; Unit B (40–128 m) comprises intercalated mottled micrite, skeletal wackestone and grainstone, and calcareous siltstone; Unit C (128–158 m) is a predominantly calcareous siltstone with layers of skeletal grainstone and

packstone, laminated micrite, and brown chert; and Unit D (158–248 m) contains rapid alternations of thin-bedded micrite, siltstone, skeletal grainstone, wackestone and packstone. Iverian sedimentation at Black Mountain is terminated by thick-bedded, cross-laminated micritic limestone and sandy limestone heralding typical Payntonian

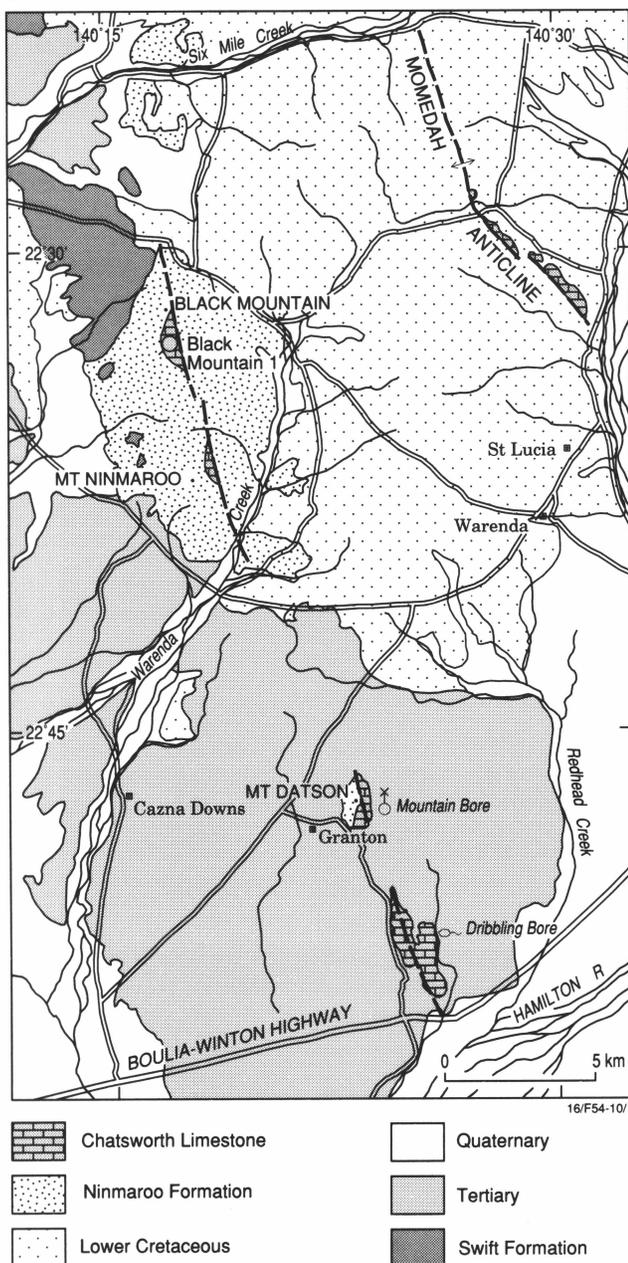


Figure 3. Location of Iverian sections at Black Mountain and Momedah Creek, southern Burke River Structural Belt.

lithofacies, as most recently reinterpreted by Shergold & Nicoll (1992).

Lateral equivalents of Unit D have been called Gola beds at Momedah Creek. The dominant and autochthonous lithology of these beds is fine to medium-grained, medium-dark grey sandy limestone with allochthonous pale, coarse-grained, intraclastic shelly grainstone interbeds, having a minimum thickness of 97 m (Shergold, 1972).

Throughout their extensive outcrop area in the southern Burke River Structural Belt, Iverian rocks show subtly distinctive lithofacies distributions within shallow subtidal to peritidal carbonate environments. These environments influence the faunal distributions.

Biostratigraphy

The Iverian Stage is palaeontologically clearly distinguish-

able from the preceding Idamean and following Payntonian Stages. With regard to trilobites, it is characterised by:

- the occurrence of the cosmopolitan genus *Irvingella* at its inception in Australia;
- the diversification of the agnostoid subfamily Pseudagnostinae (Diplagnostidae) during which *Pseudagnostus*, *Rhaptagnostus* and *Neoagnostus* separate and become biostratigraphically important;
- diversification of the Leiostegioidea, particularly the family Kaolishaniidae, and the first occurrence of the subsequently important Missisquoidae;
- the first occurrence of the Dikelocephaloidea, Remopleuridoidea and Shumardiidae;
- the separation of the true asaphids from ceratopygids.

Among non-trilobite faunas, the Iverian is further characterised by the occurrence of the first isorophid edrioasteroids, an early eocrinoid, and a primitive edrioblastoid (Jell & others, 1985; Smith & Jell, 1990). While Iverian conodonts are well known, particularly at Black Mountain (Druce & Jones, 1971), they appear not to be especially diagnostic biostratigraphically (Müller & Hinz, 1991).

In total, the Iverian Stage currently embraces ten trilobite assemblage-zones, of which the youngest two at Lily Creek (*Peichiashania tertia/P. quarta* and *Hapsidocare lilyensis*) and the oldest two at Black Mountain (*Rhaptagnostus clarki patulus/Caznaia squamosa* and *R. c. prolatus/C. sectatrix*) overlap (see cluster analyses in Shergold, 1980, and further discussion below). The separate status of the post-*Irvingella tropica* assemblage (designated by Shergold, 1982) is here reconsidered. Its fauna bridges the interval between the *Irvingella tropica* Assemblage-Zone, which precedes it, and the *Wentsuia iota/Rhaptagnostus apsis* Assemblage-Zone, which follows, and is not as readily distinguishable as previously thought (Shergold, 1982). Accordingly, it is here amalgamated with the fauna of the *Irvingella tropica* Zone.

The enumerated faunal assemblages succeed each other in regular chronological fashion. They represent recognisable biofacies of sedimentary environments, which have not been thoroughly sedimentologically investigated, within or near a carbonate shoal complex. Present knowledge is based on observations mostly incorporated into locality appendices and descriptions of sections (e.g. Radke *in* Shergold, 1975, 1980; *in* Shergold & others, 1976; *in* Druce & others, 1982; Kennard *in* Shergold, 1982); accounts of stratigraphic drilling (Kennard & Draper, 1977; Shergold & Walter, 1979); and a preliminary review of the sedimentology of the Chatsworth Limestone by Kennard (*in* Shergold & Walter, 1979).

The early Iverian faunas at Mount Murray effectively continue previously established Idamean lineages based mainly on cosmopolitan olenoidan trilobites because similar deep or cool water environments span the Idamean/Iverian boundary there. Near Chatsworth Homestead, faunas are from predominantly shallow subtidal environments and the assemblages represent more provincialised biofacies based on leiostegioidean, asaphoidean and ceratopygoidean genera. Similar but demonstrably younger environments at Black Mountain are also characterised by leiostegioideans and asaphoideans, but now in association with sauikiid dikelocephaloideans, remopleuridoideans and ptychoparioideans. Lateral equivalents, in presumed deeper water at Momedah Creek, are characterised by kaolishaniids and kainelloid remopleuridoideans.

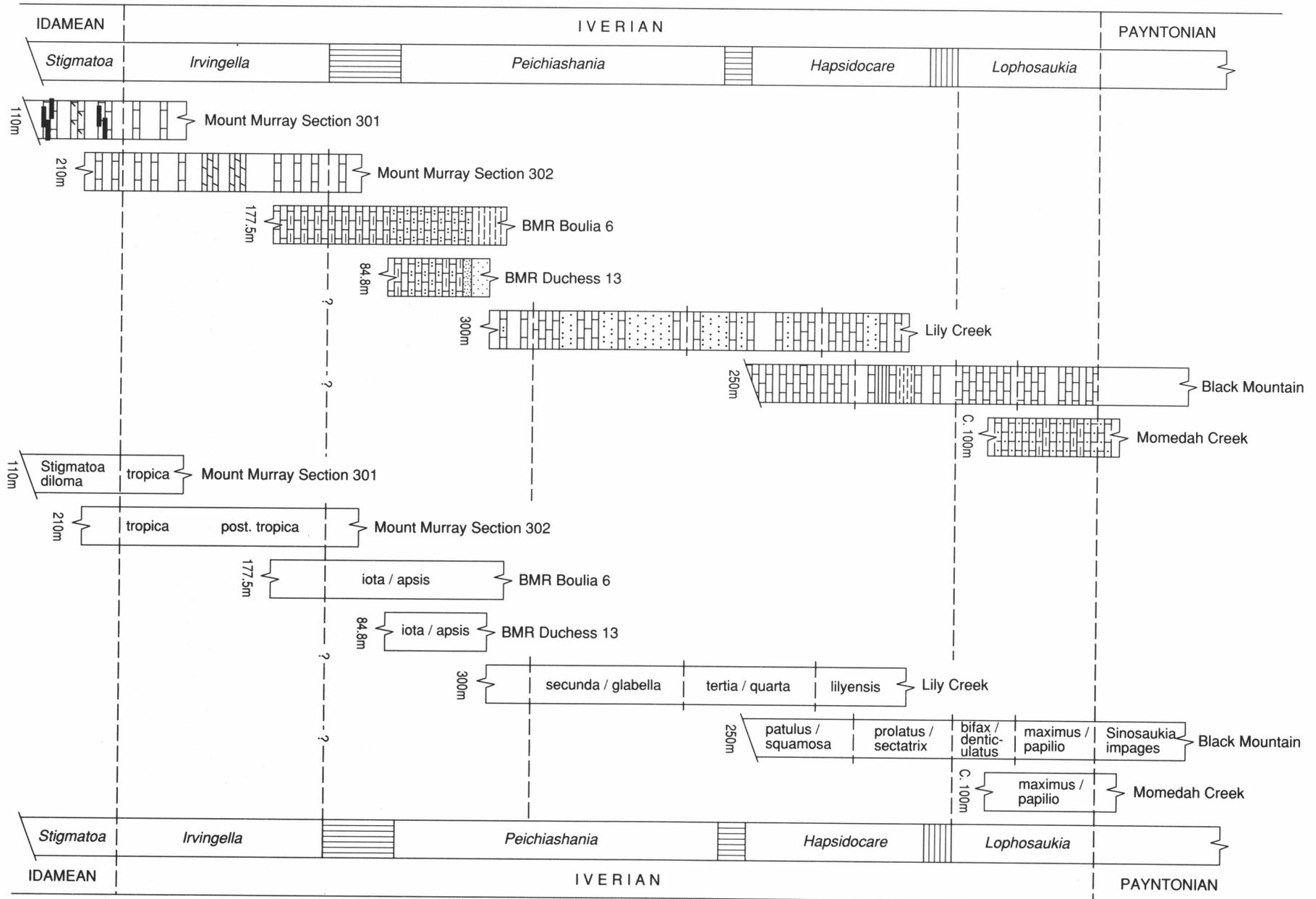


Figure 4. Spatial distribution of sections and zonal correlations.

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1. *Irvingella tropica* Zone

The Iverian Stage commences with the Zone of *Irvingella tropica* in the sense of Henderson (1976a, b), substituted for the *I. tropica* with *Agnostotes inconstans* Zone of Öpik (1963). The zone was formerly included by both Öpik and Henderson in the Idamean Stage because of the continuing occurrence of similar biofacies. Shergold (1982) justified the *I. tropica* Zone as post-Idamean on the documented co-occurrence of the taxa listed below, particularly *Irvingella tropica* and *Agostotes (A.) inconstans* which have both biostratigraphic and international correlation potential. At the type section for the base of the Iverian Stage, the *I. tropica* Zone, as indicated above, is succeeded by what Shergold (1982) considered as an un-named post-*tropica* assemblage, confined in Australia to the Georgina Basin. Here, it is regarded as a continuation of the *I. tropica* assemblage because it contains species of *Stigmatia* and *Mecophrys* related to those of the *I. tropica* assemblage. However, it also contains *Parakoldinioidia* cf. *typicalis* and asaphoideans and ceratopygoideans related more closely to forms occurring later in the *Wentsuia iota/Rhaptagnostus apsis* Assemblage-Zone. Thus this fauna bridges the interval between the *I. tropica* Zone at Mount Murray and the *Wentsuia iota/Rhaptagnostus apsis* Assemblage-Zone, penetrated by stratigraphic coreholes on the Chatsworth Plains and seen in outcrop in the basal 24 m of the Chatsworth Limestone type section at Lily Creek, south of Chatsworth Homestead.

Fauna recorded to date, combined from the Burke River Structural Belt and the Glenormiston area, 160 km to the west-southwest (Öpik, 1963; Henderson, 1976a; Shergold, 1982), and combining both zonal intervals, includes: *Agnostotes (Agnostotes) inconstans*, *Aphelaspis?* sp. B, asaphoidean gen. et sp. undet. B, ceratopygid gen. et sp. nov. C, *Chalfontia alta*, elviniid gen. et sp. undet. D, *Eugonocare tessellatum*, *Hercantyx rudis*, *Irvingella tropica*, *Mecophrys mecophrys*, *M. selenis?*, *Olenus* sp., *Oncagnostus (Oncagnostus)* sp. 1, *Oncagnostus (O.)?* sp., *Pagodia (Idamea) baccata*, *Parakoldinioidia* sp. aff. *P. typicalis*, *Proceratopyge (Proceratopyge) lata*, "Proceratopyge" sp. cf. "P." *chuhsiensis*, *Prochuangia* sp. undet., *Protelmmites burkensis*, *Pseudagnostus (Pseudagnostus) vastulus*, *Pseudagnostus (Pseudagnostus)* sp. IX, pteroccephaliid gen. et sp. undet. A, *Stigmatia sidonia* and *Stigmatia?* sp. undet. These taxa are listed in the Appendix which gives revised taxonomic determinations after the original descriptions.

2. *Wentsuia iota/Rhaptagnostus apsis* Assemblage-Zone

This zone contains 35 trilobite taxa described by Shergold (1980), as well as undescribed bradoriid ostracodes, inarticulate brachiopods, a species of *Billingsella*, pelmatozoan debris, poriferan spicules, dendroid graptolite fragments, and molluscs (Shergold, 1980). Trilobites include *Acmarhachis hybrida*, *Atopasaphus* sp. cf. *A. stenocanthus*, *Atopasaphus* sp. undet., asaphoidean undet., *Cermatops vieta*, *Cermatops* sp. indet., *Eugonocare?* sp. undet., *Guizhoucephalina?* sp. undet., *Haniwa varia*, *Innitagnostus medius*, *Leptoplastus?* sp. nov., *Lorrettina (Lorrettina) depressa*, *Lotosoides bathyora*, *Maladioidella doylei*, *Neoagnostus (Neoagnostus) felix*, *N. (N.) greeni*, *Norinia?* sp. undet., *Oncagnostus (Oncagnostus) aversus*, *Oncagnostus (O.)* sp. indet., *Onchonotellus* sp. undet., *Peichiashania prima*, *Peratagnostus* sp. cf. *P. nobilis*, *Plicatolina* sp. cf. *P. yakutica*, *Prochuangia glabella*, *Pseudagnostus (P.) aulax*, *P. (P.) mortensis*, *P. (P.) parvus*,

P. (P.) tricanthus, *Pseudagnostus (P.)* sp. VII, *Rhaptagnostus apsis*, *Rhaptagnostus* sp. cf. *R. impressus*, *Taenicephalites plerius*, *Wentsuia iota* and gen. et sp. undet. A. Some 40 per cent of these trilobites range into younger assemblage-zones.

3. *Peichiashania secunda/Prochuangia glabella* Assemblage-Zone

This zone is so far confined to the Lily Creek section, where it ranges over a 120 m interval. Twenty-three trilobite taxa occur: *Atopasaphus* sp. cf. *A. stenocanthus*, *Cermatops vieta*, *Cermatops* sp. undet., *Haniwoides varia*, *Iveria iverensis*, *Lorrettina (L.) depressa*, *Lotosoides bathyora*, *Maladioidella doylei*, *Neoagnostus (N.) felix*, *Oncagnostus (O.) aversus*, *Oncagnostus (O.)* sp. undet., *Parakoldinioidia* sp. cf. *P. bigranulosa*, *Peichiashania prima*, *P. secunda*, *P. tertia*, *Prochuangia glabella*, *Pseudagnostus (P.) aulax*, *P. (P.) parvus*, *P. (P.) tricanthus*, *Pseudagnostus (P.)* sp. VI, *Taenicephalites plerius*, *Wentsuia iota* and *Wuhuia silex*.

With the trilobites are undescribed inarticulate brachiopods, a gastropod, a monoplacophoran aff. *Proplina* sp., sponge spicules, calcispheres, conodonts and a range of echinoderms. Among the last, Jell, Burrett & Banks (1985) have described the oldest isorophid edrioasteroids *Chatsworthia spinosa* and *Hadrodiscus parma* associated with a primitive edrioblastoid — *Cambroblastus enubilatus*. These echinoderms originate from locality K204, which is 69 m above the base of the measured section.

4. *Peichiashania tertia/Peichiashania quarta* Assemblage-Zone

Six trilobite species persist into the overlying assemblage-zone of *Peichiashania tertia* with *P. quarta*. The index species *P. tertia* links assemblages characterised below by *P. secunda* and above by *P. quarta*. The *P. tertia/P. quarta* Assemblage-Zone is also confined to the Lily Creek section, where it ranges over an interval of 101 m. Twelve trilobite taxa occur: *Atopasaphus stenocanthus*, *Iveria iverensis*, *Lorrettina (L.) depressa*, *Lyriamnica antyx*, *Neoagnostus (N.)* sp. I, *Parakoldinioidia* sp. cf. *P. bigranulosa*, *Peichiashania tertia*, *P. quarta*, *Pseudagnostus (P.) parvus*, *Rhaptagnostus auctor*, *Taishania platyfrons* and *Wuhuia silex*.

The fauna also contains undetermined inarticulate brachiopods, a gastropod, a hyolith and echinoderm fragments.

5. *Hapsidocare lilyensis* Assemblage-Zone

Only two trilobite taxa continue into the *Hapsidocare lilyensis* Assemblage-Zone, the youngest assemblage to occur at Lily Creek, in the uppermost 55 m of section. Nine trilobites characterise this assemblage: *Atopasaphus stenocanthus*, *Hapsidocare lilyensis*, *Lorrettina (L.) licina*, *Lotosoides* sp. aff. *L. calcarata*, *Lyriamnica antyx*, *Neoagnostus (N.)* sp. II, *Oncagnostus (O.) conspectus*, *Plecteuloma strix*, *Prosaugia* sp. cf. *Prosaugia* sp. A. Non-trilobite components include *Billingsella* sp. and pelmatozoan debris.

The *H. lilyensis* Assemblage-Zone provides the correlation between the top of the Lily Creek section and the base of the measured section at Black Mountain, 34 km to the south, because it contains species occurring in both sections, or closely related species, e.g. *Atopasaphus stenocanthus*, *Plecteuloma strix*, *Lotosoides calcarata*, a

similar species of *Prosaugia*, and related species of *Hapsidocare* and *Lorrettina*. R-mode cluster analysis presented by Shergold (1980, fig. 6) shows the *lilyensis* assemblage to relate both to the *Rhaptagnostus clarki patulus/Caznaia squamosa* and *R. c. prolatus/C. sectatrix* Assemblage-Zones at Black Mountain.

Late Iverian rocks crop out in the core of the periclinal structure known as Black Mountain and in the Momedah Anticline at Momedah Creek, 19 km east-northeast of Black Mountain. A section measured at Black Mountain, initially for the collection of conodonts (Druce & Jones, 1971) and trilobites (Shergold, 1975), has been redocumented (Radke in Shergold, Nicoll & others, 1991) for the purpose of magneto-stratigraphic sampling (Ripperdan & Kirschvink, 1992). At the same time, its biochronology has been re-evaluated (Nicoll & Shergold, 1991; Shergold & Nicoll, 1992). Partly contemporaneous Chatsworth Limestone at Momedah Creek was originally investigated for conodonts by Druce & Jones (1971) and for trilobites by Shergold (1972).

Rocks of late Iverian age constitute the initial 240 m of Section 305 (=Section GEO202 of Radke in Shergold & others, 1976; in Shergold, Nicoll & others, 1991) at Black Mountain (collections K103-128 of Shergold, 1975). They embrace four further trilobite assemblages, characterised by rapidly evolving agnostoid trilobites of the subfamily Pseudagnostinae. These assemblages represent a more cosmopolitan ocean-facing biofacies than that seen at Lily Creek, which is restricted to taxa composing the Australo-Sinian shelf biofacies.

6. *Rhaptagnostus clarki patulus/Caznaia squamosa* Assemblage-Zone

This zone ranges over the initial 68 m of section. It contains 15 trilobite species including five agnostoids, a species of *Hapsidocare*, and *Plecteuloma strix*, which also occurs at the top of the Lily Creek section. The trilobite assemblage comprises *Caznaia squamosa*, *Ceronocare* sp., *Hapsidocare chydaeum*, indeterminate idahooid, *Koldinioidia* sp. cf. *K. cylindrica*, *Mendosina* sp., *Neoagnostus (N.) coronatus*, *Neoagnostus (N.)* spp. A, B, *Pagodia (Pagodia)* sp., *Plecteuloma strix*, *Rhaptagnostus clarki patulus*, *R. elix*, *Sigmakainella primaeva* and *Wuhuia* sp. cf. *W. dryope*.

Associated conodonts (Druce & Jones, 1971, revised by Nicoll in Shergold, Nicoll & others, 1991, fig. 4, Appendix) include *Furnishina furnishi* Müller, *F. primitiva* (Müller), *Proconodontus tenuiserratus* Miller, *Prooneotodus rotundatus* (Druce & Jones), *Rossodus tenuis* (Müller) and *Westergaardodina bicuspidata* Müller.

7. *Rhaptagnostus clarki prolatus/Caznaia sectatrix* Assemblage-Zone

The *R. c. prolatus/C. sectatrix* Assemblage-Zone has been identified in samples K107-115 (Shergold, 1975), ranging over section between 68.3 m and 140 m. It contains 21 trilobite species, four ranging from the previous assemblage: *Atopasaphus stenocanthus*, *Atratebia nexosa*, *Caznaia sectatrix*, *C. squamosa*, *Ceronocare pandum*, *Duplora clara*, *Hapsidocare grossum*, *Koldinioidia* sp. cf. *K. cylindrica*, *Lophosaukia torquata*, *Lorrettina (L.) macrops*, *Lotosoides calcarata*, *L. turbinata*, *Neoagnostus (N.) coronatus*, *Neoagnostus (N.)* sp. C, *Oreadella* sp. cf. *O. buda*, *Prosaugia* sp. A, *Rhaptagnostus bifax*, *R. clarki patulus*, *R. c. prolatus*, *Richardsonella?* sp. and *Sigmakainella translira*.

All listed conodonts of the previous assemblage, with the exception of *Furnishina furnishi*, continue and become associated with *Proconodontus posterocostatus* Miller, *Prooneotodus gallatini* (Müller), *Teridontus nakamurai* (Nogami) and *Westergaardodina amplicava* Müller.

8. *Rhaptagnostus bifax/Neoagnostus (N.) denticulatus* Assemblage-Zone

This is the penultimate Iverian assemblage-zone at Black Mountain. It characterises the section between 140 m and 172 m, having been identified in collections K116-120. Twenty-three trilobite species occur, of which 11 extend their ranges from earlier assemblages. Included are *Atopasaphus stenocanthus*, *Atratebia nexosa*, *Ceronocare pandum*, *Duplora clara*, *Golasaphus simus*, *G. triquetrus*, *Hapsidocare grossum*, *Lorrettina (L.) macrops*, *Lotagnostus (Distagnostus) irretitus*, *Lotosoides calcarata*, *L. turbinata*, *Lophosaukia acuta*, *L. torquata*, mansuyiind undet., *Neoagnostus (N.) clavus*, *N. (N.) denticulatus*, *Oncagnostus (O.) conspectus*, *Oncagnostus (Strictagnostus) chronius*, *Parakoldinioidia* sp. cf. *P. bigranulosa*, *Rhaptagnostus bifax*, *Sigmakainella translira* and *S? trispinosa*.

Nine conodont species have also been determined (Nicoll in Shergold, Nicoll & others, 1991): *Furnishina primitiva*, *Nogamiconus tricarinatus* (Nogami), *Proconodontus posterocostatus*, *P. tenuiserratus*, *Prooneotodus gallatini*, *P. rotundatus*, *Rossodus tenuis*, *Teridontus nakamurai* and *Westergaardodina amplicava*.

9. *Rhaptagnostus clarki maximus/Rhaptagnostus papilio* Assemblage-Zone

The youngest Iverian assemblage-zone is that of *Rhaptagnostus clarki maximus* with *R. papilio*, which occurs in samples K121-128, between 172 m and 240 m. At Black Mountain, the assemblage contains 16 trilobite and 14 conodont taxa, including species potentially valuable for international correlation. The trilobite association includes *Atratebia nexosa?*, *Golasaphus simus*, *G. triquetrus*, *Lophosaukia* sp. A, *Lotagnostus (Distagnostus) irretitus*, *Maladioidella* sp. cf. *M. chinchiaensis*, *Mansuyites?* sp. indet., *Neoagnostus (N.) clavus*, *Oncagnostus (Strictagnostus) chronius*, *Palacorona* sp. indet., *Prosaugia* sp. indet., *Protopeltura?* sp., *Rhaptagnostus clarki maximus*, *R. papilio*, *Sigmakainella longilira* and *S? trispinosa*. A previous reference to the occurrence of *Sinosaukia impages* at the top of the assemblage-zone (Shergold, 1975) cannot be sustained as the material is too fragmentary to determine.

The conodont assemblage comprises coniform genus A (Nicoll, 1991), *Furnishina primitiva*, *Nogamiconus tricarinatus*, *Proconodontus muelleri* Miller, *P. posterocostatus*, *P. tenuiserratus*, *Prooneotodus gallatini*, *P. rotundatus*, *P. terashimai* (Nogami), *Prosagittodontus dahlmani* (Müller), *Rossodus tenuis*, *Teridontus nakamurai*, and *Westergaardodina amplicava*, *W. mossebergensis* Müller.

The *maximus/papilio* Assemblage-Zone is also identified in the Gola Beds at Momedah Creek, but relationships to the biostratigraphic units immediately above and below are not established there. Twenty-five species of trilobites have been described (Shergold, 1972), associated with 12 conodont taxa, and inarticulate and articulate brachiopods. The trilobite assemblage contains eight agnostoid species. Four of these, including the two index species, occur in the *maximus/papilio* A.-Z. at Black Mountain, as do seven of

the 17 non-agnostoid taxa. Other taxa are represented by closely related species. However, the autochthonous sediments at Momedah Creek are particularly characterised by kainelloid trilobites which may indicate deeper water environments than at Black Mountain. Ten of the 14 conodont species also occur at Black Mountain, but the Gola Beds are notable for their lack of westergaardodidids.

The recorded trilobite assemblage at Momedah Creek includes *Atopasaphus petasatus*, *Crucicephalus ocellatus*, *Dellea? laevis*, *Duplora clara*, *Golasaphus momedahensis*, *Kaolishania australis*, *Koldinioidia cylindrica*, *Lophosaukia torquata*, *Lorrettina* (L.) *macrops*, *Lotagnostus* (*Distagnostus*) *ergodes*, *Mansuyites futilliformis*, *Mendosina laciniosa*, *Neoagnostus* (N.) *clavus*, *Oncagnostus* (O.) *acrolebes*, *O.* (O.) *junior*, *Palacorona bacculata*, *Rhaptagnostus clarki maximus*, *R. papilio*, *Rhaptagnostus* sp., *Richardsonella? kainelliformis*, *Richardsonella* sp., *Sigmakainella longilira*, *S. translira*, '*Tostonia*' sp., and *Trilobagnostus avius*.

The associated conodonts are *Furnishina furnishi*, *F. primitiva*, *Nogamiconus tricarinatus*, ?*Proacontiodus tortus* An [= *Sagittodontus eureka* Müller], *Proconodontus muelleri*, *P. posterocostatus*, *P. serratus* Miller, *P. tenuiserratus*, *Prooneotodus gallatini*, *P. rotundatus*, *Prosagittodontus dahlmani* and *Teridontus nakamurai*.

At Black Mountain, Iverian rocks are conformably overlain by the Chatsworth Limestone lithostratigraphic Unit E, with an apparent marked shift to a shallower sedimentary environment (Druce & others, 1982). This unit contains the *Sinosaukia impages* Assemblage-Zone, containing an impoverished fauna of six trilobites. Eight conodonts define the contemporaneous *Hispidodontus resimus* Zone (Nicoll & Shergold, 1991; Shergold, Nicoll & others, 1991; Shergold & Nicoll, 1992). These biostratigraphic units are now regarded as defining the base of the Payntonian Stage.

Correlation

Relationships of correlatable components of the Iverian faunas noted above have previously been explored by Shergold (1972, 1975, 1980, 1982) in analyses of the faunas of the uppermost Pomegranate Limestone, Chatsworth Limestone and Gola Beds. Some of those previous comments are collated here, revised and supplemented.

1. Australia

Rocks of Iverian age are undoubtedly best developed (approx. 725 m thick) and biostratigraphically documented in the Burke River Structural Belt, western Queensland. Elsewhere in the Georgina Basin, west of the Burke River area, only rocks of earliest Iverian age (*Irvingella tropica* Zone) have been identified with certainty. These occur in the top 30 m of the Georgina Limestone, at Browns Creek (Henderson, 1976b), south of Glenormiston Homestead (115 km west of Boulia), and at a depth of 22.9 m in GSQ Mount Whelan #1 stratigraphic corehole, approximately 45 km south of Glenormiston (Green & Balfe, 1980). In this general area, and in correlative rocks along the southern margin of the Georgina Basin to the west (e.g. Arrintheta Formation), according to seismic stratigraphic interpretations of Harrison (1979), the top of the Georgina Limestone is a truncation surface. A significant hiatus occurs between this and the overlying Ninmaroo Formation and correlatives elsewhere, of latest Cambrian and early Ordovician

age (i.e. late Payntonian and younger) (Shergold & Druce, 1980).

In the Amadeus Basin, this hiatus is partly filled by the upper Goyder Formation, an enigmatic dolomitic and kaolinitic sequence of equivocal age, currently thought to overlie disconformably the carbonate sequences of the lower Goyder Formation and correlatives which have a Mindyallan (*Glyptagnostus stolidotus* Zone) age (Kennard & Lindsay, 1991; Shergold, 1991a). In turn, the upper Goyder Formation is disconformably, or unconformably, overlain by the Pacoota Sandstone having a Payntonian (*Neoagnostus quasibilobus*/*Shergoldia nomas* A.-Z.) age (Shergold, 1991b; Shergold, Gorter & others, 1991). Thus, the age of the upper Goyder Formation is post-Mindyallan and pre-Payntonian, and may be either Idamean or Iverian. It contains a low diversity fauna characterised by 'parabolinoïd' trilobites, which differ from any known Idamean assemblages in the Georgina Basin. It may represent an as yet unrecognised lateral Idamean biofacies. However, the assemblage has some affinity with 'faunal sequence VII' (Öpik, 1969) in the Bonaparte Basin, which has parabolinoïd trilobites in a biostratigraphically similar position. Typical Idamean trilobite assemblages are also restricted in the Bonaparte Basin. According to Öpik (1969), aphelaspine trilobites occur 'but are inconclusive as regards their position within the stage'. As noted by Shergold (1991a), the upper Goyder trilobites also resemble some taxa occurring in northern Victoria Land, Antarctica, which have a suggested post-Idamean, hence Iverian, age (Shergold & Cooper, 1985).

The Iverian Stage is clearly present in the Bonaparte Basin. Apart from 'faunal sequence VII', based on parabolinoïd trilobites, likely to have some affinity with elements of the *Wentsuia iota*/*Rhaptagnostus apsis* A.-Z., the quoted occurrence of *Paramansuyella* in 'faunal sequence VIII' probably represents a taxon similar to *Peichiashania* as documented in the Chatsworth Limestone at Lily Creek (see Öpik, 1963, p. 22, locality D124; Shergold, 1980, p. 101). 'Faunal sequence IX', containing a kaolishaniid trilobite, may suggest correlation with late Iverian faunas such as those represented by Kaolishaniidae in the Gola Beds at Momedah Creek and Chatsworth Limestone at Black Mountain. Since the kaolishaniid faunal sequence in the Bonaparte Basin is overlain by younger sequences containing sauikiid and tsinaniid trilobites which suggest a Payntonian age, an almost complete Iverian Stage may be represented there. To date, only the *Irvingella tropica* Zone is unrecognised.

Iverian rocks of the Bonaparte Basin are dominantly sandstone deposited in shallow inner shelf environments, and their equivalents in the Georgina Basin are predominantly carbonate deposited in mid to outer shelf environments. Outer shelf and shelf margin correlatives apparently occur in Tasmania. In the Dundas Trough of northwest Tasmania, between biostratigraphically documented Idamean (Jago, 1974, Jago & Brown, in press) and Payntonian rocks (Jago & Corbett, 1990), are faunas assigned a post-Idamean age. These include the material from the Climie Formation at Dundas (Jago, 1978) and the Upper Huskisson Group — the Higgins Creek fauna — described by Jell & others (1991). The last authors also make a case for correlating the trilobite faunas of the Singing Creek Formation, a submarine clastic fan sequence in the Denison Range, southwest Tasmania (Adamsfield Trough: Jago, 1987). Jago & Brown (1989) further suggest a post-Idamean age for poorly preserved material from the Newton

Creek Sandstone of the Tyndall Range (Corbett, 1975).

A possibly contemporaneous basinal late Iverian biofacies has been reported from western New South Wales — Watties Bore faunas — by Webby & others (1988), but it is difficult to apply the shelf carbonate biochronology developed mainly in the Georgina Basin to them since there is little taxonomic correlation between the two areas. The upper faunas at Watties Bore, containing *Hysterolenus*, would seem to post-date the Iverian, but the lower one, dominated by ceratopygoideans and agnostoids, may be significantly older. The ranges of the associated taxa appear to be long and their relationships to shelf taxa not known in detail. They do, however, permit correlation with similar environments in China (western Zhejiang, north-west Hunan, Tianshan).

Earlier shelf margin or slope deposits have been identified in the Wagonga Beds on the New South Wales coast, at Burrewarra Point (Bischoff & Prendergast, 1987). Neither of the trilobites described, aff. *Innitagnostus*, aff. *Onchonotellus*, is age diagnostic, and the fauna, which also contains westergaardodinid conodonts, could be early Iverian, Idamean, or perhaps older.

2. Elsewhere

Outside Australia, the early Iverian is widely correlated by the occurrence of the cosmopolitan genus *Irvingella*. This, for example, permits correlation to northern Victoria Land, Antarctica, where a possible species of *Irvingella*, associated with species of *Olentella*, *Apheloides*? and *No-toaphelaspis*, inter alia, has been reported by Shergold & others (1976). These record a shelf edge (?) biofacies classifiable only with difficulty in terms of Georgina Basin biochronology.

Correlation with the Sino-Korean Platform, particularly sections in Liaoning, Hebei, Shandong and South Korea, and with western Nei Monggol and Tianshan belt of Xinjiang and southern Kazakhstan, is less difficult. However, as in central Australia, there are stratigraphic hiatuses in several places. In the Taitzuho valley of Liaoning, on the Jehol Block (Shakuotun), and in the Ordos Basin (northern Shaanxi), zones between the Gushanian (Mindyallan) and Fengshanian (Payntonian) are missing. In north Shanxi (Datong), Fengshanian is unconformable on Middle Cambrian, and in the Alashan (SW Nei Monggol) and western Tianshan, Upper Cambrian rocks are missing altogether (Kobayashi, 1967).

The most complete sequences seem to be in the Yokusen Geosyncline (Machari and Tsuibon facies) of South Korea (Kobayashi, 1935, 1960, 1962, 1966, 1967, 1971) where the many faunal elements in common with early Iverian assemblages of western Queensland have been documented at length by Shergold (1980, 1982). Relationships between the Korean *Eochuangia* Zone and the Australian *Irvingella tropica* through *Peichiashania tertia/P. quarta* interval are extremely close when synonymies and revised taxonomic concepts are considered. Other areas of the Sino-Korean Platform with relatively complete sequences containing common faunal elements with the Georgina Basin are in the Liaoning Peninsula (Kobayashi, 1931, 1933; Endo, 1937, 1939, 1944; Resser & Endo, 1937) and in Shandong and Hebei Provinces (Sun, 1924, 1935). The early Changshanian of these regions (Lu & Qian, 1983), like the Iverian, is recognised by the initial appearance of *Irvingella*, followed by species of *Maladioidella*, *Wentsuia*

and *Peichiashania* (Shergold, 1980). Late Iverian assemblages also have quite close relationships with the late Changshanian of the Siberian Platform. These have been discussed in depth by Shergold (1972, 1975; in Druce & others, 1982, fig. 5). Little consequential new information has been published to significantly alter the statements made in these papers.

Elsewhere in China, an apparently complete sequence occurs in the northwest of Nei Monggol at Ejin Qi (Lu & others, 1986). This sequence is remarkably correlatable with the late Iverian of the Georgina Basin, containing 13 genera in common with the Momedah anticline section. Among the agnostoid trilobites are three species referred to *Rhaptagnostus*, including *R. papilio* (Shergold); five species of *Neoagnostus*, including one quite similar to *N. (N.) clavus* (Shergold); two of *Oncagnostus*, listed as *Geragnostus (Micragnostus)*; and one species of *Lotagnostus (Distagnostus)*, resembling *L. (D.) irretitus* (Shergold). Among other taxa are species of *Onchonotellus*, *Atopasaphus*, *Golasaphus*, *Sigmakainella*, *Crucicephalus*, *Plecteuloma*, *Koldinioidia*, *Lorrettina* and *Richardsonella*. Furthermore, from conformably older strata, not described by Lu & others (1986), are quoted occurrences of species of *Mansuyia*, *Peichiashania*, *Irvingella* and *Pseudagnostus* which must be of early Iverian age. Thus, the whole of Iverian time is likely to be represented there.

Another complete Iverian section containing correlatable trilobites has been described from the western part of the northern Tianshan (Borohoro Shan), in Xinjiang (Xiang & Zhang, 1984). There, early Iverian is represented in the Gouzigou Formation by the *Agnostotes tianshanicus* Zone which contains common or similar species of *Agnostotes*, *Innitagnostus*, *Rhaptagnostus*, *Haniwoides* and the genus *Sayramaspis*, a composite of what in Australia has been referred to *Maladioidella*, *Cermatops* and *Norinia*? This zone is succeeded by that of *Lotagnostus (L.) punctatus*, containing a faunal assemblage remarkably similar to that described from northwest Tasmania by Jell & others (1991), and considered to have a biostratigraphic range from post-*Irvingella* to Payntonian. Essentially similar biofacies are also found in Anhui (Lu, 1956; Lu & Zhu, 1980), northwest Hunan (Peng, 1983, 1984), Jiangxi (Lin, 1986) and western Zhejiang (Lu & Lin, 1980, 1983, 1984).

Rocks of Iverian age certainly occur in neighbouring Kazakhstan and Kirghizia, as indicated by the occurrence of *Irvingella* and strikingly similar agnostoid faunas. However, in Maly Karatau particularly, non-agnostoid trilobites occurring through the interval between the assemblage-zones of *Ivshinagnostus ivshini-Lotagnostus scrobicularis* (Ergaliev, 1980) are predominantly of Siberian Platform provenance.

Irvingella also forms the basis for correlation with Yakutia where, in the Karaulakh Mountains and on the Olenek Uplift, Lazarenko (1966, 1972) has illustrated trilobites remarkably similar to *Maladioidella [Cedarellus felix]*, *Taenicephalites [Amorphella modesta]* and *Peratagnostus [Cyclopagnostus orientalis]* overlying sequences containing *Irvingella*. This Yakutian fauna also contains *Rhaptagnostus impressus* (Lermontova) also recorded in western Queensland and, in an immediately succeeding assemblage *Plicatolina perlata* Lazarenko, cranidially similar to *P. yakutica* Pokrovskaya, which is also recorded in Queensland.

Apart from the occurrence of the cosmopolitan *Irvingella*,

which permits almost global correlation of the base of the Iverian Stage, there is little faunal relationship with the Siberian Platform, northern Europe or North America. Faunas containing Iverian elements, e.g. *Maladioidella*, do extend westwards from the Tianshan, and have been recorded in central Turkey (Shergold & Sdzuy, 1984) and the Sierra de la Demanda, Logroño Province, Spain (Shergold & others, 1983).

Discussion

The Iverian Stage currently embraces two kinds of biostratigraphical zone: the range-zone of *Irvingella tropica* as its initial zone, followed by a succession of assemblage-zones. The first type of zone is based on the range of a single taxon, whereas those that follow are characterised by the overlapping ranges of associations of species, and are essentially Opeel-zones.

Historically, these zones were established during the time that the post-Idamean Late Cambrian was being pioneered by the Bureau of Mineral Resources Georgina Basin Project (1974–1980), and the local biostratigraphy was in the process of development and regarded as preliminary. The zonation developed then provided the first essential steps in the biostratigraphic synthesis of the Iverian interval. Mainly named by two associated or concurrently ranging index species, these assemblage-zones lack elegance and are often awkward to present graphically. Some of them have since been used elsewhere, and it is becoming clear that a simpler, more direct, zonal scheme should be explored, particularly with the recent promotion of a cohesive Australian Cambrian timescale (Shergold, 1989). As explained below, this does not necessarily entail the abandonment of the present scheme, which in practice serves its purpose in high resolution correlation.

Theoretically, it is possible to continue with the application of the single taxon zonal scheme adopted for the Mindyalian and Idamean Stages by Öpik (1963, 1967), since the Iverian Stage contains at least 93 trilobite taxa (see Appendix). In practice, in the Burke River Structural Belt, this is not so easy to attain, particularly at specific level, mainly because the assemblage-zone sequence has been established from three environmentally displaced sections, which makes difficult the precise resolution of the true ranges of potential index taxa. However, it is possible to work at generic level, as demonstrated below.

Post-dating the *Irvingella tropica* Zone (including here the taxa previously included in the post-*Irvingella* assemblage), early Iverian rocks in the vicinity of Chatsworth contain the mansuyioid genera *Peichiashania* and *Hapsidocare*. The latter permits correlation with concurrent species at Black Mountain, where the latest Iverian is discriminated by successive species of *Lophosaukia*.

However, the first appearances (FADs) of *Hapsidocare*, *Peichiashania* and *Lophosaukia*, although documented from current information, are likely to change with more intensive research. For example, the FAD of *Peichiashania prima* occurs near the base of BMR Duchess #13 corehole (at 82.80 m) and its range in this hole is limited to this occurrence. In BMR Boulia #6 it first appears at 43.85 m and has a similarly constrained range. In this latter hole, a further 100 m of strata bearing other elements of the *Wentsuia iota/Rhaptagnostus aphis* Assemblage-Zone were penetrated, so the actual first appearance of *P. prima* might well be expected at a significantly lower level in that

corehole.

Similarly, there is uncertainty about the total range of the youngest species of the *Peichiashania* lineage, *P. quarta*, in respect to the FAD of *Hapsidocare lilyensis* at Lily Creek. In fact, the latter appears some 64 m above the former. Furthermore, the exact amount of overlap suggested by the R-mode cluster analysis performed by Shergold (1980, fig. 6), which shows the *H. lilyensis* Assemblage-Zone sandwiched between assemblages containing *H. chydaeum* below and *H. grossum* above, is unknown. Unfortunately, adverse environmental conditions, represented by the early onset of the Lily Creek Sandstone Member of the Chatsworth Limestone, prevent the occurrence of associated taxa (like species of *Rhaptagnostus*) which would permit correlation of the Lily Creek and Black Mountain sections.

There is, however, good correlation between the last appearance of *Hapsidocare* and the FAD of *Lophosaukia* at Black Mountain, where these genera overlap over 10 m of section.

Peichiashania and *Hapsidocare*, together with many of their associated taxa, are useful for correlation only within the Australo-Sinian biofacies. *Lophosaukia* offers a little extra correlation potential since it has a wider geographical distribution, being recorded around the margins of the Siberian Platform in southern Kazakhstan and the Irkutsk Amphitheatre. For the wider international correlation of zones based on these genera it is necessary to identify the more cosmopolitan elements of the assemblages. *Irvingella* is such a genus, permitting the initial Iverian Stage to be widely correlated with Korean, Chinese, Kazakhstani, Siberian, north European, and North and South American biostratigraphic units. This is not possible with the proposed index taxa which follow *Irvingella*, which are more constrained by biofacies. However, they may be indirectly correlated by their stratigraphic sequences of agnostoid trilobites and the often close taxonomic relationships of these species elsewhere.

Key agnostoid taxa are species of *Agnostotes* and its subgenera, which are frequently associated with *Irvingella*, and the Pseudagnostinae. Among the latter, species of *Pseudagnostus*, rampant in the earlier Idamean, last appear at the top of the *Peichiashania secunda/Prochuangia glabella* Assemblage-Zone (Shergold, 1977, 1981). *P. (P.) parvus* has a long range, extending from a depth of 142.7 m in BMR Boulia #6 extension through to the last appearance datum of the genus, and has potential biostratigraphic use. Five species of *Neoagnostus* occur during the Iverian, but all have very limited stratigraphic ranges. Similarly, there are eight species of *Rhaptagnostus* having good correlation potential, but again with limited biostratigraphic ranges. The pseudagnosti that have previously given their names to assemblage-zones have been used because of their ready determination. Used in combination, their ranges have more stratigraphic significance than if used individually.

Summary

Undoubtedly, the assemblage-zone scheme used originally has the highest resolution for correlation. The alternative generic zone scheme suggested above is intended to simplify the terminology, involving the genera *Irvingella*, *Peichiashania*, *Hapsidocare* and *Lophosaukia* in stratigraphically ascending order. In this scheme:

- The *Irvingella tropica* Zone and post-*I. tropica* Assemblage-Zone, as documented above, are integrated into an *Irvingella* Zone.
- The lineage of the species *Peichiashania prima*-*P. secunda*-*P. tertia*-*P. quarta* forms the basis of the *Peichiashania* Zone. This lineage unites the *Wentsuia iota*/*Rhaptagnostus apsis*, *Peichiashania secunda*/*Prochuangia glabella* and *Peichiashania tertia*/*P. quarta* Assemblage-Zones. In the Burke River Structural Belt, there is an interzone of uncertain thickness between the *Peichiashania* Zone and that of *Irvingella*.
- The *Peichiashania* Zone is superseded by another, based on the concurrent ranges of species of *Hapsidocare*: *H. lilyensis* at the top of the Lily Creek section, and *H. chydæum* followed by *H. grossum* in the lower part of the Black Mountain section. Thus the *Hapsidocare* Zone binds the *H. lilyensis*, *Rhaptagnostus clarki* *patulus*/*Caznaia squamosa* and *R. c. prolatus*/*C. sectatrix* Assemblage-Zones. An interzone amounting to 64 m of the Lily Creek section is interposed between the *Peichiashania* and *Hapsidocare* Zones.
- Immediately following the *Hapsidocare* Zone is the initial part of the range of *Lophosaukia*, whose species form the lineage *L. torquata*-*L. acuta*-*Lophosaukia* sp. A (younger species occur in the Payntonian). These unite the *Rhaptagnostus bifax*/*Neagnostus denticulatus* and *R. clarki maximus*/*R. papilio* Assemblage-Zones at the top of the Iverian Stage. The FAD of *L. torquata* overlaps the last appearance of *Hapsidocare* between 128 and 138 m in the Black Mountain section.

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Appendix 1. Formal documentation of determined Iverian taxa

Trilobita

- Acmahachis hybrida* Shergold, 1980
Agnostotes (Agnostotes) inconstans Öpik, 1963
Atopasaphus petasatus Shergold, 1972
Atopasaphus stenocanthus Shergold, 1975
Caznaia sectatrix Shergold, 1975
Caznaia squamosa Shergold, 1975
Cermatops vieta Shergold, 1980
Ceronocare pandum Shergold, 1975
Chalfontia alta (Henderson, 1976)
Crucicephallus ocellatus Shergold, 1972
Dellea? laevis Shergold, 1972
Duplora clara Shergold, 1972
Eugonocare tessellatum Whitehouse, 1939
Golasaphus momedahensis Shergold, 1972
Golasaphus simus Shergold, 1975
Golasaphus triquetrus Shergold, 1975
Haniwa varia Shergold, 1980
Hapsidocare chydaeum Shergold, 1975
Hapsidocare grossum Shergold, 1975
Hapsidocare lilyensis Shergold, 1980
Hercantyx rudis Öpik, 1963
Innitagnostus medius Shergold, 1980
Irvingella tropica Öpik, 1963
Iveria iverensis Shergold, 1980
Kaolishania australis Shergold, 1972
Koldinioidia sp. cf. *K. cylindrica* (Shergold, 1972)
Lophosaukia acuta Shergold, 1975
Lophosaukia torquata Shergold, 1972
Lorrettina (Lorrettina) depressa Shergold, 1980
Lorrettina (Lorrettina) licina Shergold, 1980
Lorrettina (Lorrettina) macrops Shergold, 1972
Lotagnostus (Distagnostus) ergodes (Shergold, 1972)
Lotagnostus (Distagnostus) irretitus (Shergold, 1975)
Lotosoides bathyora Shergold, 1980
Lotosoides calcarata Shergold, 1975
Lotosoides turbinata Shergold, 1975
Lyriamnica antyx Shergold, 1980
Maladioidella doylei Shergold, 1980
Maladioidella sp. cf. *M. chinchiaensis* (Endo, 1937)
Mansuyites futilliformis Shergold, 1972
Mecophrys mecophrys Shergold, 1982
Mecophrys selenis Shergold, 1982
Mendosina laciniosa (Shergold, 1972)
Neoagnostus (Neoagnostus) clavus (Shergold, 1972)
Neoagnostus (Neoagnostus) coronatus (Shergold, 1975)
Neoagnostus (Neoagnostus) denticulatus (Shergold, 1975)

- Neoagnostus (Neoagnostus) felix* Shergold, 1980
Neoagnostus (Neoagnostus) greeni Shergold, 1980
Oncagnostus (Oncagnostus) aversus (Shergold, 1980)
Oncagnostus (Oncagnostus) conspectus (Shergold, 1975)
Oncagnostus (Oncagnostus) junior (Shergold, 1972)
Oncagnostus (Strictagnostus) chronius (Shergold, 1975)
Oreadella sp. cf. *O. buda* (Resser & Endo, 1933)
Pagodia (Idamea) baccata Öpik, 1967
Palacorona bacculata Shergold, 1972
Parakoldinioidia bigranulosa Shergold, 1975
Parakoldinioidia sp. cf. *P. typicalis* Endo, 1937
Peichiashania prima Shergold, 1980
Peichiashania secunda Shergold, 1980
Peichiashania quarta Shergold, 1980
Peichiashania tertia Shergold, 1980
Peratagnostus sp. cf. *P. nobilis* Öpik, 1967
Plecteuloma strix Shergold, 1975
Plicatolina sp. cf. *P. yakutica* Pokrovskaya, 1966
Proceratopyge (Proceratopyge) lata Whitehouse, 1939
“Proceratopyge” sp. cf. *“P.” chuhsiensis* Lu, 1956
Prochuangia glabella Shergold, 1980
Protlemnites burkensis Shergold, 1982
Pseudagnostus (Pseudagnostus) aulax Shergold, 1980
Pseudagnostus (Pseudagnostus) mortensis Shergold, 1980
Pseudagnostus (Pseudagnostus) parvus Shergold, 1980
Pseudagnostus (Pseudagnostus) tricanthus Shergold, 1980
Pseudagnostus (Pseudagnostus) vastulus Whitehouse, 1936
Rhaptagnostus apsis Shergold, 1980
Rhaptagnostus auctor Shergold, 1980
Rhaptagnostus bifax (Shergold, 1975)
Rhaptagnostus clarki maximus (Shergold, 1975)
Rhaptagnostus clarki patulus (Shergold, 1975)
Rhaptagnostus clarki prolatus (Shergold, 1975)
Rhaptagnostus elix (Shergold, 1975)
Rhaptagnostus sp. cf. *R. impressus* (Lermontova, 1940)
Rhaptagnostus papilio (Shergold, 1972)
Richardsonella? kainelliformis (Shergold, 1972)
Sigmakainella longilira Shergold, 1972
Sigmakainella primaeva Shergold, 1975
Sigmakainella translira Shergold, 1972
Sigmakainella? trispinosa Shergold, 1975
Taenicephalites pleris Shergold, 1980
Taishania platyfrons Shergold, 1980
Trilobagnostus avius (Shergold, 1972)
Wentsuia iota Shergold, 1980
Wuhuia sp. cf. *W. dryope* (Walcott, 1905)
Wuhuia silex Shergold, 1980

Conodonta

- Furnishina furnishi* Müller, 1959
Furnishina primitiva Müller, 1959
Nogamiconus tricarinatus (Nogami, 1967)
?Proacontiodus tortus An, 1983
Proconodontus muelleri Miller, 1969
Proconodontus posterocostatus Miller, 1980
Proconodontus serratus Miller, 1969
Proconodontus tenuiserratus Miller, 1980
Prooneotodus gallatini (Müller, 1959)
Prooneotodus rotundatus (Druce & Jones, 1971)
Prooneotodus terashimai (Nogami, 1967)
Prosagittodontus dahlmani (Müller, 1959)
Rossodus tenuis (Müller, 1959)
Teridontus nakamurai (Nogami, 1967)
Westergaardodina amplicava Müller, 1959
Westergaardodina bicuspidata Müller, 1959
Westergaardodina mossebergensis Müller, 1959

Echinodermata

- Cambroblastus enubilatus* Smith & Jell, 1990
Chatsworthia spinosa Smith & Jell, 1990
Hadrodiscus parma Smith & Jell, 1990
Ridersia watsonae Jell, Burrett & Banks, 1985