SIXTH INTERNATIONAL SYMPOSIUM ON THE ORDOVICIAN SYSTEM

GUIDEBOOK FOR FIELD EXCURSION 1

THE CAMBRIAN - ORDOVICIAN BOUNDARY AT BLACK MOUNTAIN, WESTERN QUEENSLAND

by

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RECORD 1991/48
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
CANBERRA

Refer to this publication as:-
SHERGOLD, J.H., NICOLL, R.S., LAURIE, J.R. & RADKE, B.M., 1991. The Cambrian - Ordovician boundary at Black Mountain, western Queensland: Sixth International Symposium on the Ordovician System, Guidebook for Field Excursion 1. *Bureau of Mineral Resources, Geology and Geophysics, Record 1991/48*, 50p.

Editor: John R. Laurie, Onshore Sedimentary and Petroleum Geology Branch, Bureau of Mineral Resources, Geology and Geophysics.

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ITINERARY

Excursion starts in Mount Isa, Queensland on Wednesday, July 3 and finishes in Alice Springs on Sunday July 7. Travel from Mount Isa to Alice Springs will be by bus.

JULY 2.
Arrive in Mount Isa, accommodation at Overlander Motel

JULY 3.
0900 Assemble in Mount Isa at Overlander Motel, depart for Black Mountain via Boulia.
1600 Camp near creek, east of base of section.

JULY 4.
0800 To base of Black Montain section, examine lower part of section.
1200 LUNCH
1300 Continue examination of lower part of section
1630 Drive back to campsite

JULY 5.
0800 To top of Black Mountain section, examine upper part of section.
1200 LUNCH
1300 Continue examination of upper part of section
1600 Drive back to campsite

JULY 6.
0800 Strike camp and drive to Boulia
1100 Depart Boulia, drive towards Alice Springs
1200 LUNCH
1300 Continue towards to Alice Springs
1700 Camp along Plenty River Highway

JULY 7.
0800 Strike camp and continue towards Alice Springs
1200 LUNCH
1300 Continue towards Alice Springs
1700 Arrive Alice Springs, accommodation at Alice Sundown Motel

INTRODUCTION

The aim of this excursion is to demonstrate the Cambrian-Ordovician sequence at Black Mountain, situated in the southern Burke River Structural Belt, eastern Georgina Basin, 59 km NE of Boulia, in western Queensland. At this locality (Fig. 1), it is possible to examine a continuously exposed, measured section, containing in excess of 1 km of peritidal carbonates which straddle the Cambrian-Ordovician boundary at whichever horizon under current debate it may be eventually located. This section has been described lithostratigraphically in great detail (Radke 1980, 1981, 1982). A detailed trilobite biostratigraphy has been proposed for the lower (Late Cambrian) part of the section. A detailed conodont biostratigraphy was proposed originally for the upper part of the section (Druce & Jones 1971), but subsequently revised and extended to the base of the section (Nicoll & Shergold 1991). Results of recent (1989-90) magnetostratigraphic studies are currently being evaluated (Ripperdan, Kirschvink, Apollonov, Ma & Zhang 1990). At Black Mountain it is therefore possible to assess the relationships of stratigraphic units, discuss possible models of sedimentation, and evaluate the biostratigraphic succession.

This guidebook sets the Black Mountain section into a briefly described regional perspective; gives an up to date account of the litho- and biostratigraphy; gives a detailed description of the section on the ground; and presents an appendix of revised conodont determinations.

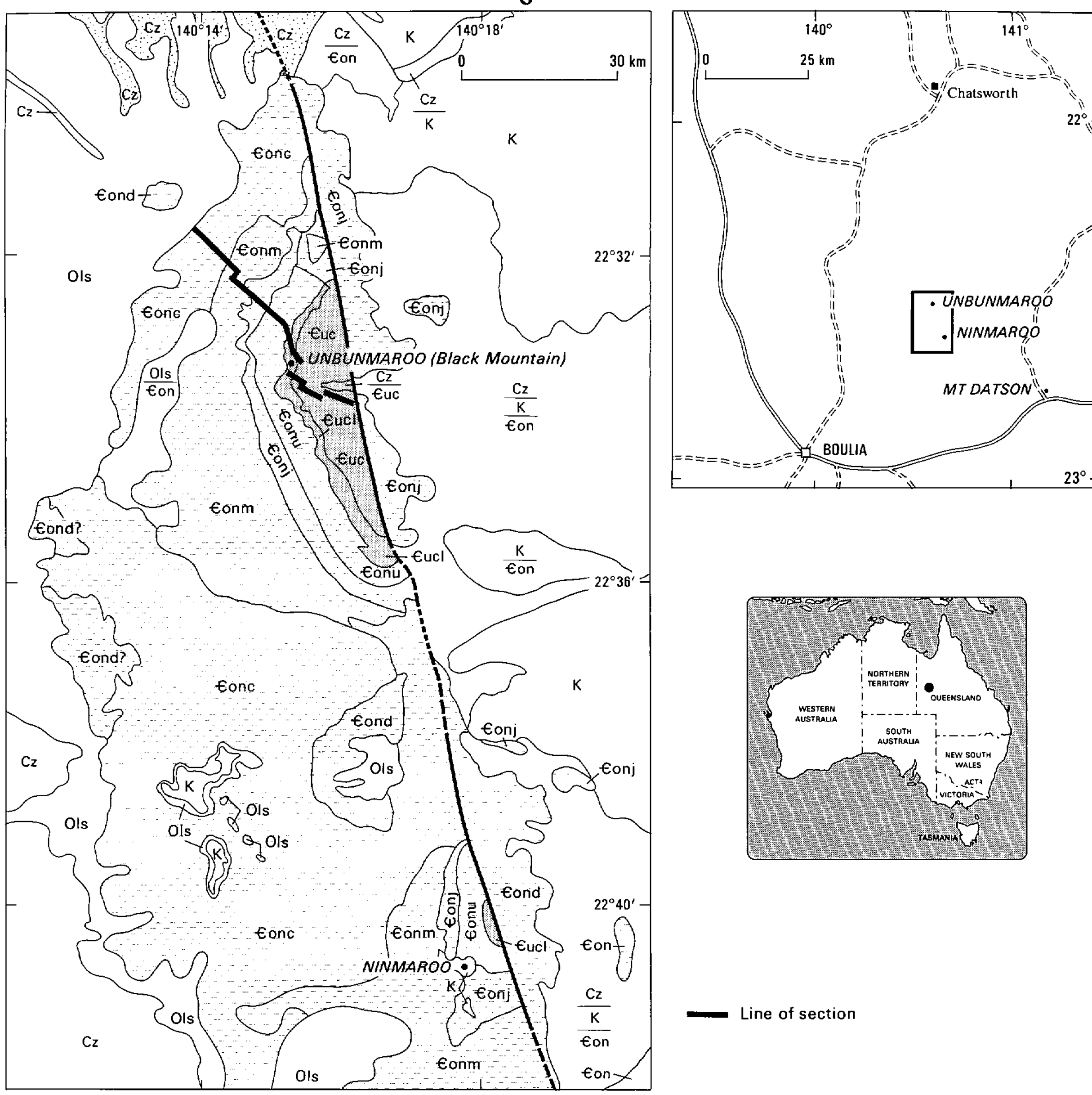
GEORGINA BASIN

Black Mountain lies in the southeastern quadrant of the Georgina Basin which occupies an area of approximately 325 000 sq km in western Queensland and the Northern Territory, and extends over twenty-one 1:250 000 scale Geological Series Sheet areas.

The basin contains predominantly marine Palaeozoic rocks, mainly carbonates in the north and east, and mixed carbonates and siliciclastics in the west, of Middle Cambrian to Lower Ordovician age. These rocks overlie paralic, neritic and glacigene clastic sediments (to the south, southeast and southwest), and terrestrial extrusive rocks to the north and northwest, of Late Proterozoic to Early Cambrian age, which crop out at the margins of the Basin.

To the northwest, the Lower Palaeozoic Daly River Basin is conterminous with the Georgina Basin, but a western appendage, known as the Wiso Basin, is separated by the Precambrian Tennant Creek Block. To the south and southwest the Georgina Basin is flanked by Precambrian metamorphic rocks of the Arunta Block, which separates it from the Proterozoic and Palaeozoic Amadeus Basin; the Proterozoic McArthur Basin lies to the north. To the northeast and southeast, the Georgina Basin is overlain respectively by the Mesozoic Carpentaria and Eromanga Basins.

Within the Georgina Basin, competent limestone units are, in general, flexed into broad shallow basins and domes with low flank dips. However, three major tectonic features occur around the eastern and southern margins of the Basin (Fig. 2): the Burke River Structural Belt, forming an eastern appendage to the Basin between Duchess and Boulia; the Toko Syncline and attendant folds and faults (Toomba, Craigie and Tarlton Faults), south of 'Tobermory', along the southern margin of the Basin; and the Dulcie Syncline with associated folds and faults in the vicinity of 'Huckitta', also on the southern margin. These structures strike north-northwest or northwest, the dominant strike direction of the underlying Precambrian. The Toko and Dulcie Synclines, and their associated structures, are thought to



		Cz	*Alluvium, sand, black and brown soil, clay*
CRETACEOUS		K	*Sandstone, ferruginous sandstone, conglomerate, siltstone, claystone*
ORDOVICIAN TO TERTIARY	Digby Peaks Breccia	OTb	*Silcrete, silicified ferruginized chert, breccia*
	Swift Formation	Ols	*Sandstone, siltstone, coquinite (all silicified in part), chert*
EARLY ORDOVICIAN	NINMAROO FORMATION	€on	*Limestone*
	Datson Member	€ond	*Thin bedded limestone or dolomite with interbedded chert*
	Corrie Member	€onc	*Limestone (pelmatozoan, peloid, clast and ooid grainstone) dolomitic sandstone, calcareous siltstone*
	Mort Member	€onm	*Limestone (intraclast, ooid and peloid grainstone calcareous siltstone)*
	Jiggamore Member	€onj	*Thin to thick bedded limestone (peloid and intraclast grainstone, micrite, two-toned limestone), calcareous siltstone*
	Unbunmaroo Member	€onu	*Medium to thick bedded limestone (intraclast and peloid grainstone, mudstone, stromatolitic boundstone), dolomite, calcareous siltstone*
LATE CAMBRIAN	CHATSWORTH LST — Lily Creek Member	€ucl	*Calcareous cross stratified sandstone, sandy limestone, calcareous siltstone*
		€uc	*Thin bedded light to medium grey limestone (peloid grainstone), limestone, calcareous siltstone*

Figure 1. Geology and location of Black Mountain (Unbunmaroo) and Ninmaroo inliers, and position of the Black Mountain Section (after Nicoll & Shergold, 1991).

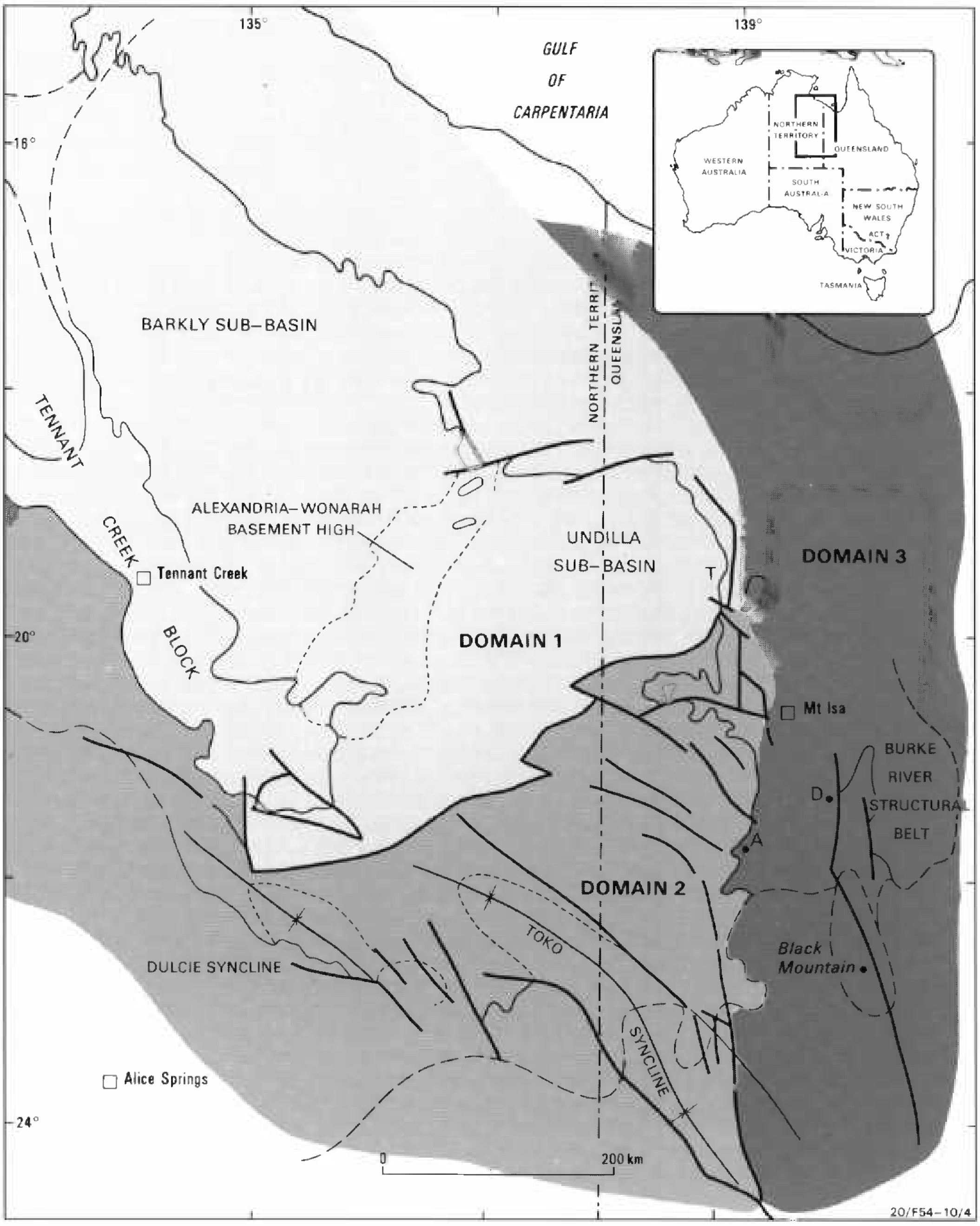


Figure 2. Principal structural features of the Georgina Basin and extent of geophysical domains (after Southgate & Shergold, 1991)

have formed during the Alice Springs Orogeny of Carboniferous age (Bradshaw & Evans 1988). Smith (1972) follows Öpik (1960) in thinking that the faults of the Burke River Structural Belt are related to Early Ordovician deformation. More recently, however, Southgate & Shergold (1991), have presented evidence from sequence stratigraphical analysis that suggests movement of the Mount Isa Block within the duration of what is currently defined as the Templetonian (Middle Cambrian) Stage (see Shergold 1989).

The base of the Georgina Basin sequence coincides with the base of Lower Cambrian (but probably not earliest Cambrian) sandstones in the southwest in the vicinity of the Dulcie Syncline (Fig 2). Elsewhere the sequence commences later, in the early Middle Cambrian (Ordian/Early Templetonian stratigraphic sequences of Southgate & Shergold, op. cit.). Complex basal Middle Cambrian lithofacies mosaics, containing a variety of rocks, such as peritidal and ramp carbonates, black shales, evaporites, phosphorites etc., are overwhelmed by clastic deposition from the late Templetonian to late Undillan Stages of the Middle Cambrian. Predominantly carbonate deposition occurring during the latest Middle and earliest Late Cambrian (Undillan-Mindyallan) was followed by a brief phase of deeper water carbonate sedimentation in the Georgina Basin during the Late Cambrian Idamean Stage. The interval post-Idamean (see Shergold 1982) through Warendian (early Ordovician) is characterised by shoaling shallow water carbonate sequences which became briefly emergent (e.g. aeolianites assigned to the Lily Creek Sandstone Member of the Chatsworth Limestone). This interval contains several yet undescribed sedimentary sequences constrained by such recognisable events as the Lange Ranch and Black Mountain Eustatic Events of Miller (1984) and the Kelly Creek Movement (Webby 1978). The last of these curtails Cambrian - early Ordovician deposition in the Burke River Structural Belt, but elsewhere along the southern margin of the Georgina Basin younger formations may extend into the Late Ordovician (Nicoll, Owen, Shergold, Laurie & Gorter 1988).

Overlying Devonian sedimentary sequences are preserved in the main synclinal regions, particularly the Toko and Dulcie Synclines. The distribution and relationship of the stratigraphic units of the Georgina Basin is summarised in Fig. 3 (after Freeman, Shergold, Morris & Walter 1990).

BURKE RIVER STRUCTURAL BELT

The dominant structural components of the Georgina Basin are shown on Fig. 2 (after Southgate & Shergold 1991). Domains 1-3 are geophysically discriminated regions based on Bouguer anomalies and total magnetic intensity contours, and on the gravity anomalies recognised by Tucker & others (1979).

The Burke River Structural Belt is a N-S aligned eastern appendage of the Georgina Basin which extends from Malbon to Springvale, a distance of 145 km. It contains approximately 2875m of Cambrian and lowest Ordovician rocks, unconformably overlain by thin veneers of Jurassic-Cretaceous (up to 325m) and Tertiary (40m) sediment (Fig. 3). This sediment package is preserved as a westerly thickening wedge (half graben) which extends in a N-S direction from Malbon to Springvale. The western margin of the Structural Belt is heavily faulted by a series of en echelon faults, the Camel, Pilgrim, and Black Mountain fault systems, mostly throwing down to the East, and is periclinally folded. The eastern margin is less disturbed structurally, or may be undisturbed. Surrounding Proterozoic rocks and interpretation of some of the structural elements of the Burke River area have been discussed

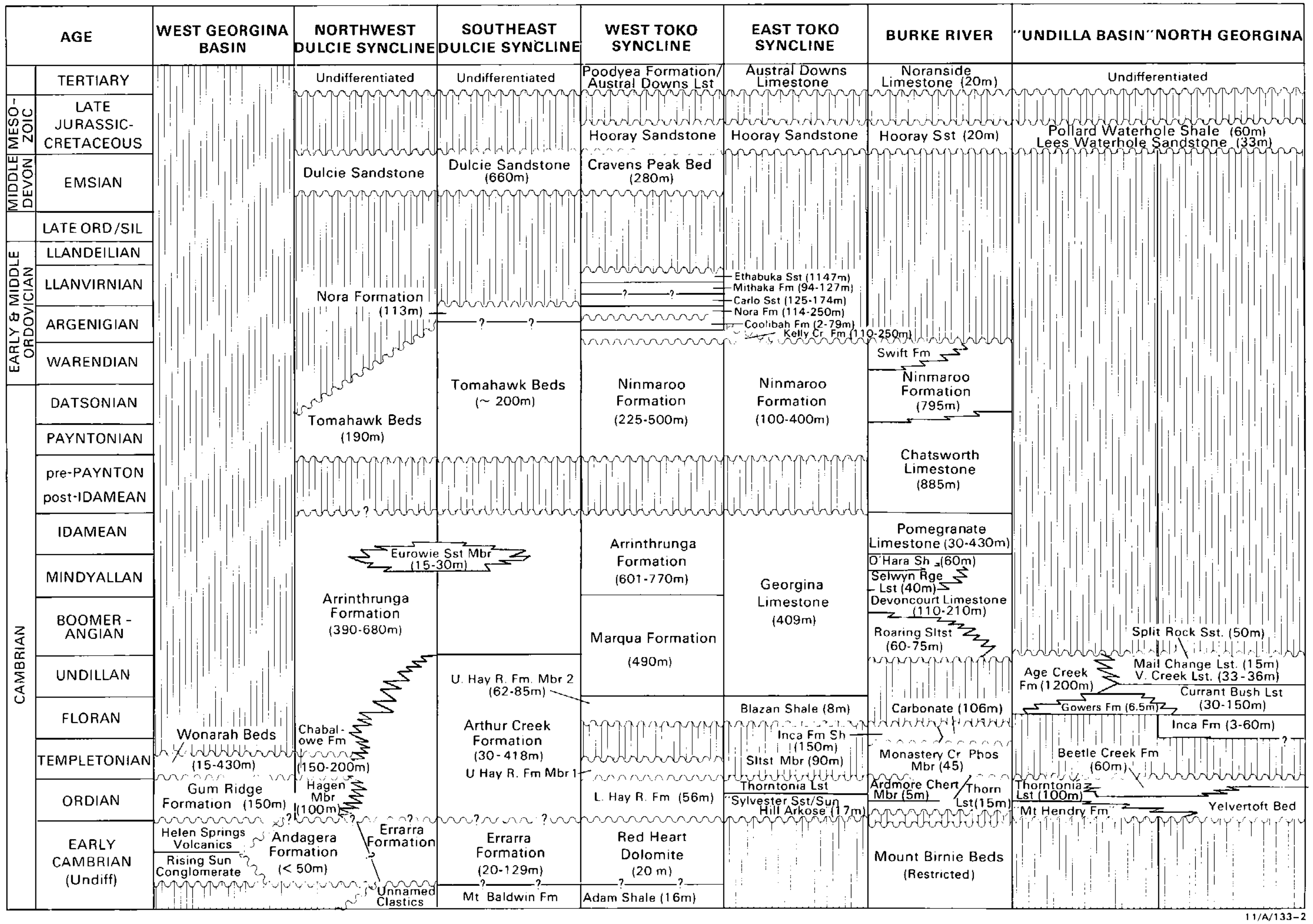


Figure 3. Stratigraphic units currently recognised in the Georgina Basin (after Freeman, Shergold, Morris & Walter 1990).

by Blake & others (1984).

According to Casey (1968), basement lineaments have controlled the distribution, faulting and folding of both Palaeozoic and Mesozoic sediments, and the whole area has been tilted to the south during the Tertiary. Casey (*op. cit.*) also records the faulting of Lower Cretaceous rocks implying post-Cretaceous movement in addition to that (presumably late Palaeozoic) responsible for the initial emplacement of the Structural Belt (See also de Keyser 1968; Russell & Trueman 1971). Contemporary activity is recorded by lines of mud springs for a distance of 90 km between Dribbling Bore and Elizabeth Springs along the southerly trace of the Black Mountain fault.

Early geological references to the Burke River area are given in explanatory notes for the Duchess and Boulia 1:250 000 Sheet areas by Carter & Öpik (1963) and Casey (1968) respectively. Most recent stratigraphic work stems from that of Whitehouse (1936, 1939) and Öpik (1956a, 1960, 1961b, 1963, 1967a, b), e.g. Cambrian stratigraphy (de Keyser 1973; de Keyser & Cook 1973), conodont biostratigraphy (Druce & Jones 1971; Nicoll 1990, 1991; Nicoll & Shergold 1991) trilobite biostratigraphy (Öpik *op. cit.*, 1961a 1970a, 1970b, 1975, 1979, 1982; Shergold 1969, 1972, 1975, 1980, 1982), bradoriids (Öpik 1968; Fleming 1973, 1975; Jones & McKenzie 1980), echinoderms (Jell, Burrett & Banks 1985; Smith & Jell 1990), and molluscs (Pojeta, Gilbert-Tomlinson & Shergold 1977).

The discovery of commercial grade phosphorite in the Middle Cambrian rocks of the Burke River Structural Belt in 1966 at Monastery Creek, spurred detailed mapping of the Cambrian rocks of the Burke River area (de Keyser 1968); a reappraisal of the stratigraphy of the phosphatic sequences (Russell 1967; Russell & Trueman 1971; de Keyser & Cook 1973; Shergold & Southgate 1986; Cook 1989 *inter alia*); detailed petrological and sedimentological studies (e.g. Nordlund & Southgate 1988; Soudry & Southgate 1988); and more recently a further set of micropalaeontological data is beginning to appear (e.g. Hinz, Kraft, Mergl & Müller 1990; Shergold 1991; Müller & Hinz (in press)). Much of this information has been recently synthesised in a sequence stratigraphic context by Southgate & Shergold (1991).

STRATIGRAPHIC PERSPECTIVES

The Burke River Structural Belt has also become the focus of recent Cambrian-Ordovician research in northern Australia because of its thick and relatively well exposed Middle Cambrian through Lower Ordovician carbonate sequences. At Black Mountain, the Cambrian-Ordovician transition is contained in two formations: a lower (Late Cambrian) Chatsworth Limestone, and an upper (Late Cambrian - Early Ordovician) Ninmaroo Formation.

CHATSWORTH LIMESTONE

The type section of the Chatsworth Limestone is at Lily Creek, 7 km East of Chatsworth Homestead, 54 km north of Black Mountain. The formation is regionally extensive, intermittently outcropping over a north-south belt 97 km long between Mount Murray, 23 km west northwest of Chatsworth, and the Boulia-Winton Highway, south southeast of Black Mountain. Its distribution and internal stratigraphy have been described by Shergold (1975, 1980, 1982), Shergold & others (1976), Kennard (in Shergold & Walter 1979), and reviewed by Shergold (in Druce & others 1982).

Prior to 1971 (Jones & others 1971), a carbonate formation lying below the Ninmaroo

Formation at Black Mountain, Ninmaroo, Mount Datson and Dribbling Bore in the South of the Burke River Structural Belt was referred to the Chatsworth Limestone with a measure of uncertainty. Subsequent sedimentological and palaeontological investigation have identified the formation as upper Chatsworth Limestone.

At Black Mountain the rocks referred to the upper Chatsworth Limestone are 420m thick, and are now divided into seven lithological units (A-G) by Druce & others (1982) (see Fig.4). The uppermost 40m (unit G) is regarded as representing the Lily Creek Sandstone Member, a regressive sandy limestone, originally described as aeolianite in the vicinity of the type section, which is time transgressive from north to south along the Burke River Structural Belt (Radke in Shergold & others 1976). The revised Chatsworth Limestone lithostratigraphy remains essentially as described by Druce & others (1982). Their account is repeated here enhanced by additional or revised palaeontological data (see also separate section on biostratigraphy). This part of the Black Mountain sequence was magnetostratigraphically sampled in 1989, reported upon by Ripperdan & others (1990) and circulated as a preprint.

Stratigraphy of the Chatsworth Limestone

Below we give lithological and palaeontological documentation of the upper Chatsworth Limestone. Ranges of quoted taxa refer to Black Mountain only (unlike fig. 4 in Druce & others 1982). Revisions and additions to taxa given in that paper are from Westrop (1986), Zhang & Jell (1987), Shergold & others (1988), Ludvigsen & others (1989), Shergold & others (1990).

The revised stratigraphy of the Chatsworth Limestone is as follows:

Unit A. This comprises the interval 0-40m from the base of the measured section. Lithostratigraphically it is characterised by interbedded skeletal grainstone, intraclastic grainstone, laminated silty micrite, and calcareous siltstone, deposited during the time span of the *Rhaptagnostus clarki patulus/Caznaia squamosa* Assemblage-Zone on the trilobite biochronological scale.

Eleven trilobite species have been described by Shergold (1972, 1975) : *Caznaia squamosa, Hapsidocare chydaeum,* idahoiid gen. et. sp. indet., *Koldinioidia* sp. cf. *K. cylindrica, Neoagnostus coronatus, Neoagnostus* sp. A, *Plecteuloma strix, Rhaptagnostus clarki patulus, R. elix, Sigmakainella primaeva, Wuhuia* sp. cf. *W. dryope* (Walcott).

Five species of conodonts were described by Druce & Jones (1971), both coniform species and westergaardodinids: *Furnishina furnishi* (Müller), *Proconodontus primitivus* (Müller), *P. rotundatus* (Druce & Jones), *P. tenuiserratus* Miller, *Prooneotodus tenuis* Müller, *Westergaardodina bicuspidata* Müller. Subsequently, Nicoll & Shergold (1991) recovered coniform elements throughout the Chatsworth Limestone, but no westergardodinids. This conodont assemblage is insufficiently differentiated for useful zonation on the conodont biochronological scale.

Unit B. This unit extends between 40-128m on the measured section and contains interbedded calcareous siltstone, mottled micritic limestone, and skeletal wackestone grainstone and clast grainstone, more thickly bedded than in Unit A.

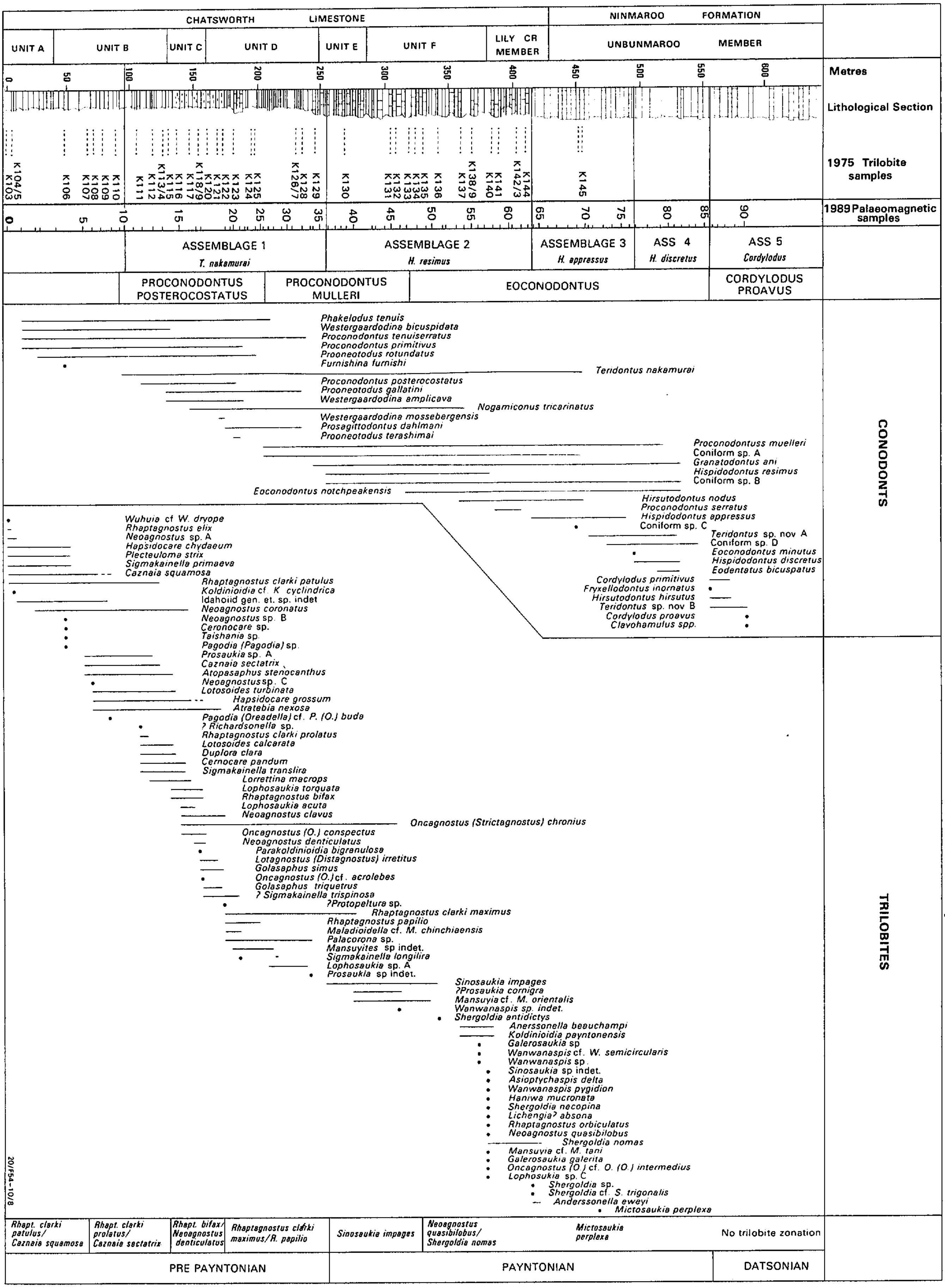


Figure 4. Correlation of lithostratigraphy, conodont and trilobite biostratigraphy and magnetostratigraphic sampling in the Chatsworth Limestone and Lower Ninmaroo Formation at Black Mountain (modified from Druce & others 1982).

Twenty seven trilobite species occur in Unit B : *Atopasaphus stenocanthus, Atratebia nexosa, Caznaia sectatrix, C. squamosa, Ceronocare pandum, Ceronocare* sp., *Duplora clara, Hapsidocare chydaeum, H. grossum,* idahoiid gen. et. sp. indet., *Koldinioidia* sp. cf. *K. cylindrica, Lorrettina macrops, Lotosoides calcarata, L. turbinata, Neoagnostus coronatus, Neoagnostus* sp. B, *Neoagnostus* sp. C., *Pagodia (Pagodia)* sp., *P. (Oreadella)* sp. cf. *P. buda* (Resser & Endo), *Plecteuloma strix, Prosaukia* sp. A, *Rhaptagnostus clarki patulus, R.c. prolatus, ?Richardsonella* sp., *Sigmakainella primaeva, S. translira, Taishania* sp. These species indicate deposition of Unit B during the span of the *Rhaptagnostus clarki prolatus/Caznaia sectatrix* Assemblage-Zone on the trilobite biochronological scale.

Seven conodont species are also reported from Unit B, including all of those listed from Unit A. Additionally, *Proconodontus posterocostatus* Miller and *Teridontus nakamurai* (Nogami) make their first appearances. The latter defines the first diagnostic conodont faunal assemblage in the Chatsworth Limestone, Assemblage 1 (of Nicoll & Shergold 1991), and the former indicates that this equates with the first diagnostic conodont Subzone (*Proconodontus posterocostatus*) recognised by Miller (1975, 1978, 1980) in western North America. This is an important datum for Late Cambrian correlation, permitting the correlation of endemic trilobite biofacies between Asia, North America and Australia (Shergold 1988).

Unit C. This unit outcrops between 128-158m on the measured section. It is characterised by skeletal packstone and grainstone, and laminated micritic limestone, in a predominantly calcareous siltstone sequence which also contains discontinuous layers of orange-brown chert (unit 2 of Shergold 1975).

There are 34 determinable species of trilobites which indicate deposition within the trilobite assemblage-zone of *Rhaptagnostus bifax/Neoagnostus denticulatus.* Ten of these species extend from earlier units : *A. stenocanthus, A. nexosa, C. pandum, D. clara. H. grossum, L. macrops, L. calcarata, L. turbinata, N. coronatus, R. c. prolatus* and *S. translira.* Occurring for the first time are: *Golasaphus simus, G. triquetrus, Lophosaukia acuta, L. torquata, Lotagnostus (Distagnostus) irretitus, Neoagnostus clavus, N. denticulatus, Oncagnostus (O.) conspectus, O.(O.) acrolebes, O. (Strictagnostus) chronius, Parakoldinioidia bigranulosa, Rhaptagnostus bifax,* and *Sigmakainella trispinosa.* The occurrence in Unit C of provincialised early asaphid trilobites and Saukiidae together with globally distributed species of agnostid trilobites gives great potential for the international correlation of this Australo-Sinian biofacies.

Of the nine conodont taxa reported, however, three occur for the first time: *Problematoconites perforata* Müller, *Proconodontus tricarinatus* (Nogami) and *Westergaardodina amplicava* Müller. The continuing occurrence of *Proconodontus posterocostatus* and *Teridontus nakamurai* indicate that this conodont assemblage remains within the *P. posterocostatus* Subzone of Miller (1975) and Assemblage 1 of Nicoll & Shergold (1991).

Unit D. The interval 158-248m on the measured section comprises thinly bedded micritic limestone with siltstone interlaminae and layers of skeletal and clast grainstone, skeletal packstone and wackestone, with sandier horizons becoming more common towards the top of the unit.

Deposition commenced late in the span of the *R. bifax/N. denticulatus* A.-Z. and continued into that of *Rhaptagnostus clarki maximus/R. papilio.*

Seventeen species of trilobites occur, eight extending from earlier units : *A. nexosa, G. simus, G. triquetrus, L. (D.) irretitus, N. clavus, N. coronatus, O. (S.) chronius*, and *S. trispinosa.* Of the nine new taxa, an olenid trilobite, *Protopeltura* sp., and the agnostoids *Rhaptagnostus clarki maximus* and *R. papilio* have considerable correlation potential. Associated taxa are, however, provincialised : *Lophosaukia* sp. A, *Maladioidella* sp. cf. *M. chinchiaensis* (Endo), *Mansuyites* sp. indet., *Palacorona* sp., *Prosaukia* sp. indet., and *Sigmakainella longilira.*

Unit D is enriched in conodonts, sixteen taxa occurring including seven new arrivals. First appearing in Unit D are : *Granatodontus ani* (Wang), *Proconodontus muelleri* Miller, *Prooneotodus terashimai* (Nogami), *Prosagittodontus dahlmani* Müller and *Westergaardodina mossebergensis* and coniform element A of Nicoll & Shergold (1991). The occurrence of *P. muelleri* is considered to permit the correlation of the terminal part of Assemblage 1 (of Nicoll & Shergold 1991) with the *P. muelleri* Subzone, thought to represent the second diagnostic latest Cambrian conodont biostratigraphic unit in North America (Miller 1975, 1978, 1980).

Both trilobites and conodonts become scarce in the uppermost part of Unit D and an almost total faunal reorganisation, previously recognised by Druce & others (1982) but inadequately documented, occurs.

Unit E. Unit E (unit 4 of Shergold 1975) comprises sandy, cross-laminated, locally bioturbated micritic limestone which contains interbeds of clast grainstone and calcareous siltstone. The unit is severely impoverished faunally, the trilobites listed coming from a single skeletal grainstone layer.

Only six species of trilobites have been reported, including *Oncagnostus (Strictagnostus) chronius* and *Rhaptagnostus clarki maximus* ranging from Unit D, *Sinosaukia impages* and *Mansuyia* sp. cf. *M. orientalis* (Endo) which range through it, and *?Prosaukia cornigra* and *?Wanwanaspis* sp. indet. which are confined to it. These trilobites were considered by Shergold (1975) to represent a pre-Payntonian Zone of *Sinosaukia impages.* However, agnostoids apart, none of the listed taxa are useful biostratigraphically. Essentially, the trilobite fauna of Unit E bridges the earlier pre-Payntonian occurrences, and the typical Payntonian fauna that succeeds.

Previous conodont sampling from Unit E failed to yield fauna to Druce & Jones (1971). More recent processing (Nicoll & Shergold 1991) has revealed the occurrence of seven long ranging taxa : *Granatodontus ani, Proconodontus muelleri, P. tricarinatus, Teridontus nakamurai* and coniform element A are known from Unit D or earlier, and they range through Unit E and beyond. Occurring for the first time, however, are *Hispidodontus resimus* and coniform element B. The first occurrence of *Hispidodontus* is considered biostratigraphically significant and to characterise Assemblage 2 at Black Mountain. The continuing presence of *Proconodontus muelleri* suggests that the FAD of *Hispidodontus* occurs within the later part of the *P. muelleri* Subzone of Miller (1975, 1978, 1980). The conodonts therefore place the trilobite biostratigraphy in a more meaningful context and the combination may eventually prove significant for interprovincial correlation.

Unit F. This unit contains alternating calcareous siltstone and skeletal clast grainstone, wackestone, packstone and lime mudstone over the interval 285-380m on the Black Mountain section. Characteristically the sequence is thick-bedded, with some siltstone beds up to 4m thick, and was deposited from late in the *Sinosaukia impages* Assemblage-Zone to early in the *Neoagnostus quasibilobus/Shergoldia nomas* A.-Z. on the trilobite scale, and within the time span of Assemblage 2 (*Hispidodontus resimus*) - mostly early *Eoconodontus* Zone time on the international conodont scale.

Fossils are relatively uncommon in the lower beds of Unit F, but those in the upper part contain twenty two trilobite taxa of almost total Australo-Sinian provenance (saukiid-tsinaniid biofacies of Shergold 1988), all but two of which (*Mansuyia* sp. cf. *M. orientalis* and *Sinosaukia impages*) occur for the first time: *Anderssonella beauchampi, Asioptychaspis delta, Galerosaukia galerita, Galerosaukia* sp. indet., *Haniwa mucronata, Koldinioidia payntonensis, Lichengia? absona* (Shergold), *Lophosaukia* sp. C, *Mansuyia* sp. cf. *M. tani* Sun, *Neoagnostus quasibilobus, Oncagnostus (O.)* sp. cf. *O. intermedius* (Palmer), *Rhaptagnostus orbiculatus, Shergoldia antidictys, S. necopina* (Shergold), *S. nomas* (Shergold), *Sinosaukia* sp. indet., *Wanwanaspis pygidion, W.* sp. cf. *W. semicircularis* (Kobayashi), *Wanwanaspis* sp. and *Wanwanaspis* sp. indet.

In addition nine species of conodonts belonging to Assemblage 2 of Nicoll & Shergold (1991) occur: *Eoconodontus notchpeakensis* (Miller), *Granatodontus ani* (Wang), *Hirsutodontus nodus* (Zhang & Wang), *Hispidodontus resimus, Proconodontus muelleri* Miller, *P. tricarinatus* (Nogami), *Teridontus nakamurai* (Nogami) and coniform elements A and B. Only three of these taxa were originally recorded from Unit F at Black Mountain by Druce & Jones (1971).

Unit G. The uppermost lithological unit of the Chatsworth Limestone at Black Mountain, between 380-420m, has been correlated with the Lily Creek Sandstone Member (Radke & others 1980), and the upper part of Unit 5 of Shergold (1975). It is characterised by thickly bedded cross-stratified sandy micritic limestone with thin interbeds and lenses of calcareous siltstone and skeletal grainstone.

In terms of trilobites, the Lily Creek Sandstone Member is impoverished. Only four taxa are recorded, of which three occur for the first time : *Anderssonella eweyi, Shergoldia nomas* (Shergold), *S.* sp. cf. *S. trigonalis* (Kobayashi) and *Shergoldia* sp. nov. (Zhang & Jell 1987). Probably these indicate an early Payntonian age, late in the *Neoagnostus quasibilobus/Shergoldia nomas* A.-Z.

However, eight species of conodonts have been reported by Nicoll & Shergold (1991), where only a single taxon, *Teridontus nakamurai*, had been recovered by Druce & Jones (1971). These occur late in the span of Assemblage 2 (*Hispidodontus resimus*) of Nicoll & Shergold (1991), in the early part of the *Eoconodontus* Zone: *Eoconodontus notchpeakensis, Granatodontus ani, Hirsutodontus nodus, Proconodontus muelleri, P. serratus* Miller, *Teridontus nakamurai* and coniform elements A and B.

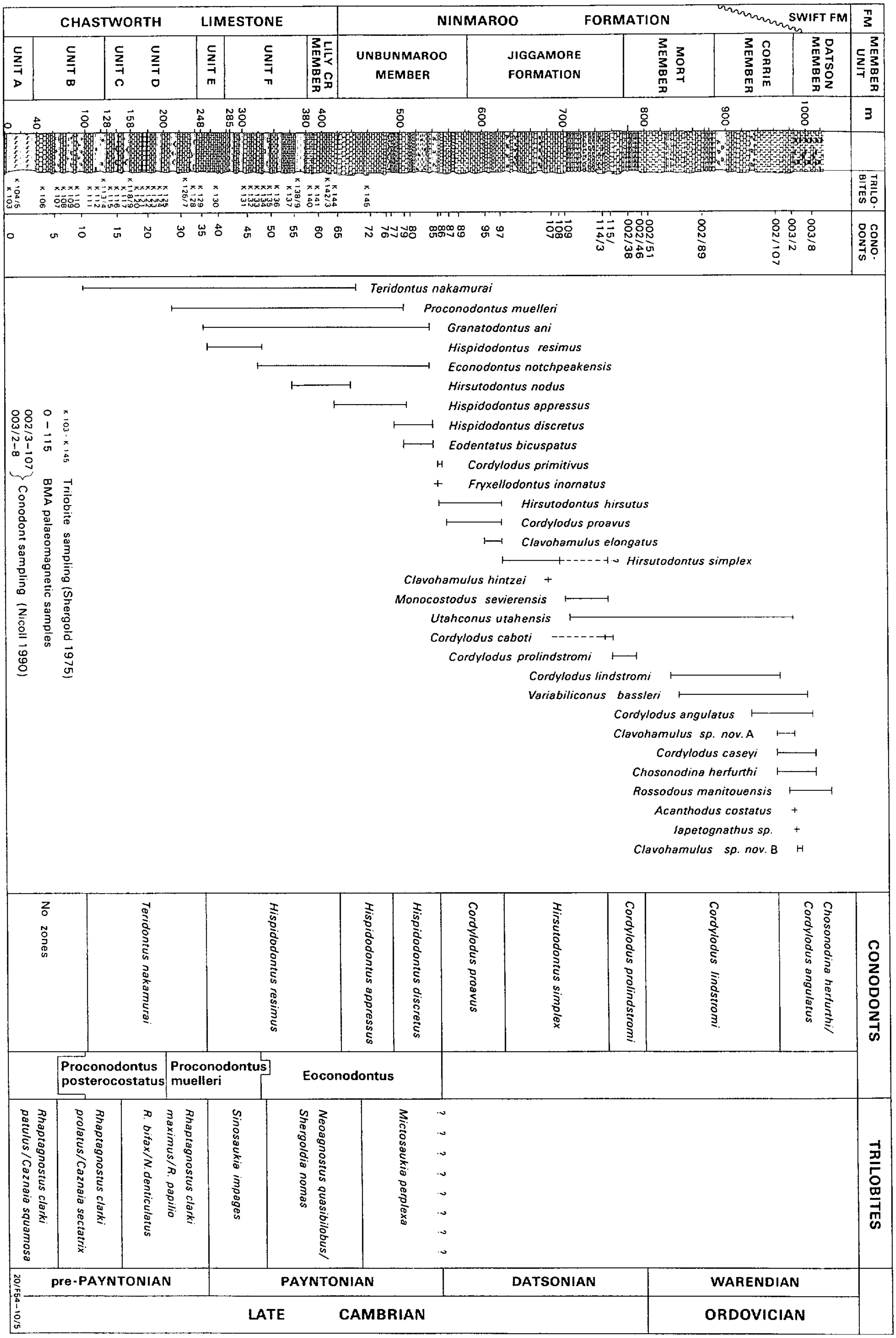


Figure 5. Ranges of essential conodont taxa in the Chatsworth Limestone and Ninmaroo Formation.

Miller (1977 in litt., 1984; also Druce & others 1982; Nicoll & Shergold 1991) reported the occurrence of '*Oneotodus nakamurai*' and *Hirsutodontus hirsutus* from one metre below the top of the Lily Creek Member of the Chatsworth Limestone and at 18m above the base of the overlying Ninmaroo Formation. Another species, assigned to *Hirsutodontus* (aff. *H. simplex*), was also reported at 67, 76 and 81m above the base of the Ninmaroo Formation. On the basis of these determinations, which would normally indicate the presence of the early *Cordylodus proavus* Zone, the top of the Lily Creek Member and overlying basal Ninmaroo Formation were considered by Druce & others (1982), Webby & others (1983), and Shergold (1989), to have a Datsonian age since that stage was originally defined (Jones & others 1971, p.17) by the first appearance of 'diagnostic conodonts of the *Cordylodus proavus* Assemblage-Zone'. Recent research (Nicoll & Shergold 1991), however, has demonstrated Miller's determinations to be in error, and that stratigraphic conclusions drawn from them have led to serious aberrations in correlation.

Essentially, the findings of Nicoll & Shergold (1991), based on stratigraphically closely spaced samples which had been collected and cored for palaeomagnetic analysis, are summarised in Figs 4 - 6. Specimens referred by Miller to the genus *Hirsutodontus* actually represent the newly described genus *Hispidodontus*, as justified by Nicoll & Shergold (op. cit.), of which four time successive species characterise their assemblages 2-5, and in the *Cordylodus proavus* Zone do overlap the earliest species of *Hirsutodontus*. As the trilobites initially indicated to Shergold (1975), the Lily Creek Member of the Chatsworth Limestone lies well below any of the stratigraphic levels currently under consideration for use in the definition of the Cambrian-Ordovician boundary in shelly platformal carbonate sequences, and is truly latest Cambrian in age.

NINMAROO FORMATION

The Ninmaroo Formation (Whitehouse 1936, emended by Casey 1959) extends as a thick sequence of carbonates over much of the southern and southeastern Georgina Basin. Its type section is at Black Mountain (Unbunmaroo), where there is a continuous section 610m thick, and where five successive lithostratigraphic members are recognised: Unbunmaroo, Jiggamore, Mort, Corrie, and Datson Members. Detailed mapping in the southern Burke River Structural Belt shows that a consistent lithofacies pattern exists from Mount Merlin in the north to Mount Datson in the south (Radke 1981), and that these lithofacies approximate closely to the members recognised at Black Mountain. The three uppermost members are essentially those recognised by previous workers (Jones & others 1971; Smith 1972). The lower two members are equivalent to the variegated limestone/dolomite member of Jones & others (1971). The lowest member is equivalent to units 1 and 2 of Smith (1972).

The Ninmaroo Formation comprises a sequence of repeatedly interbedded carbonates and silty carbonates. Predominant carbonate types include biostromal and rare biohermal, mounded and laminar cryptalgal carbonate, ooid grainstone, peloidal and pelletal grainstone to wackestone, with variegated "two-tone" overprints on the muddier limestones, flat-pebble conglomerate and intraclast-rich grainstone, coarse well-sorted echinodermal grainstone, mixed skeletal limestones with varying textures, and sandy carbonate.

This thick sediment package, comprises an mixture of very thin complete and incomplete cyclic units which were very sensitive to local conditions, and resulted from shoaling processes in very shallow, predominantly non-tidal, metahaline to hypersaline conditions. Radke (1980) recognised three types of cycle containing a diversity of sediments. These were differentiated on the basis of dominant component rock types: A-cryptalgal (subtypes include A1-cryptalgal domes, A2-cryptalgal domes and cryptalgalaminites, and A3-cryptalgalaminites); P-peloid, and SO-skeletal-ooid cycles.

Accumulation of these shoaling-upward deposits in varying order and frequency has produced larger-scale sequences that are subdivided into lithofacies on the basis of dominant rock type. The lithofacies recognised in the type section of Radke (1981) are:

0-30m	lo	Ooid carbonate lithofacies
30-370m	llp	Peloid carbonate dominant lithofacies
370-440m	lllc	Flat-pebble conglomerate carbonate lithofacies
440-450m	lo	Ooid carbonate lithofacies
450-500m	lllc	Flat-pebble conglomerate carbonate lithofacies
500-520m	Vs	Skeletal carbonate dominant lithofacies
520-550m	lo	Ooid carbonate lithofacies
550-590m	Vs	Skeletal carbonate dominant lithofacies
590- + m	llps	Peloid and skeletal carbonate lithofacies

Thicknesses of intervals are rounded to the nearest 10m.

Subdivision

Previous studies on the Ninmaroo sequence have subdivided the Formation with a general consistency except in the lower part of the sequence (Table 1 of Radke, 1981, Figure 3 of Druce & others 1982). Informal units 1, 2, and 3 of Brown (1961) and Casey (1968) were combined by Jones & others (1971) into a 'Variegated Limestone/Dolomite Member'. Druce & others (1976) combined Units 1 and 2 of Brown (1961) into the 'Unbunmaroo Member'. Although they recognised the distinction of Brown's units, his Unit 1 was too thin to be practicable for the purposes of 1:100,000 scale mapping. Since 1976, this subdivision into five members has been used by Shergold & others (1976) and Druce & others (1982). With the repetitive interbedded nature of the sequence and gradational changes, boundaries of the members are not distinct and there has been some debate on selection of member boundaries in the sequence. The subdivision of Druce & others (1982) accommodated the general consensus at that time. We would now suggest placing the boundary between the Jiggamore and overlying Mort Member at 375m, whereas Druce & others (1982) placed it at 351m. Horizon 375m is the uppermost horizon of abundant muddier carbonates with "two-tone" overprints.

UNBUNMAROO MEMBER

Lithostratigraphy

The Unbunmaroo Member comprises 69-250m of medium to thick-bedded limestone peloidal clast and peloidal grainstone, sandy peloidal grainstone, and thrombolitic biostromes. Evidence of former sulphates (gypsum crystals and anhydrite nodules) are relatively common in the limestones and chert nodules. A massive, cross-stratified peloidal and ooid grainstone, sandy in places and locally dolomitized, occurs at the base: within this bed are biohermal mounds of stromatolitic boundstone. In the type section (Radke 1981), this member is 165m thick.

The Unbunmaroo Member conformably overlies the Lily Creek Sandstone Member of the Chatsworth Limestone at Black Mountain, Ninmaroo, Mount Datson, and possibly at Dribbling Bore. In the Lily Creek area to the north, mapping suggests there is an unconformity, identified in stratigraphic drilling as a karst surface.

The base of the Unbunmaroo Member, and thus the Ninmaroo Formation in the Burke River area, lies within the Payntonian Stage at Black Mountain and Ninmaroo. Early Datsonian conodonts occur 9m above the base of this member at Mount Datson and immediately below it at Dribbling Bore (Shergold 1975, figs. 7-8).

Discussion of sedimentation

The lowermost 30m thick bed is the ooid carbonate lithofacies (lo) of Radke (1980), and includes poorly-developed skeletal-ooid (SO) cycles up to 4.5 metres thick. This lithofacies has distinctive cross-stratification with trough-shaped bases, moderately angled foresets, and sets up to 1m thick. The presence of herringbone cross-lamination indicates tidal conditions. The skeletal debris comprises, in decreasing abundance, pelmatozoans, trilobites, brachiopods, rostroconch, nautiloid and other molluscs, and conodonts. Random pseudomorphs after anhydrite nodules and thin collapse breccias indicate a limited evaporitic overprint. This sequence is interpreted as a barrier shoal complex with active ooid formation, that delineated a significant transition from open-marine to warmer, more tidally restricted, and shallower conditions with extensive shoals.

The overlying 135m is incorporated in the peloid-carbonate dominant lithofacies (llp) (Radke 1980) which comprises peloid carbonate (P) cycles and three variations of cryptalgal carbonate (A1, A2, A3) cycles. This lithofacies accumulated under increasingly metahaline conditions. As a result, nonskeletal sediments predominate, but there still survived a varied but low abundance fauna of trilobites, ellesmeroceroid nautiloids, rostroconch molluscs, brachiopods, chitons, gastropods, pelmatozoans, ostracodes, ichnofossils, and calcareous sponges. Cryptalgalaminites and thrombolitic biostromes are recurrent in the sequence, as a distinctive characteristic of the member. There is increased evidence of an evaporitic overprint within the shoaling-upward cycles. 'Two-tone' limestone fabrics are repeatedly abundant, but not as distinctive in thickness as in the Jiggamore Member. 'Two-tone' or 'variegated' limestone is indicative of hypersaline to evaporitic overprinting. Evidence of tidal conditions, including channels and herringbone lamination, ceases just above the upper boundary of this member until well into the Corrie Member.

Fauna and age

Of the skeletal elements noted above little has been described. Trilobites are extremely rare in the Unbunmaroo Member at Black Mountain, only a single taxon, *Mictosaukia perplexa* occurring in a thin chert layer at horizon K145 (Fig.4) (Shergold 1975). More commonly occurring are nautiloids (undescribed); sclerites of the polyplacophoran *Chelodes whitehousei* Runnegar & others (1979); and the rostroconch molluscs described by Pojeta & others (1977): *Apoptopegma dickinsi, Bransonia chapronierei* and *Eopteria struszi.*

Some twenty one species of conodonts have now been identified, mostly as a result of recent resampling, e.g. the collective fauna from samples BMA 65-90 of Nicoll & Shergold (1991), which are equivalent to trough samples 74-101 of Druce & Jones (1971), includes: *Clavohamulus* spp., *Cordylodus primitivus* Bagnoli & others, *C. proavus* Müller,

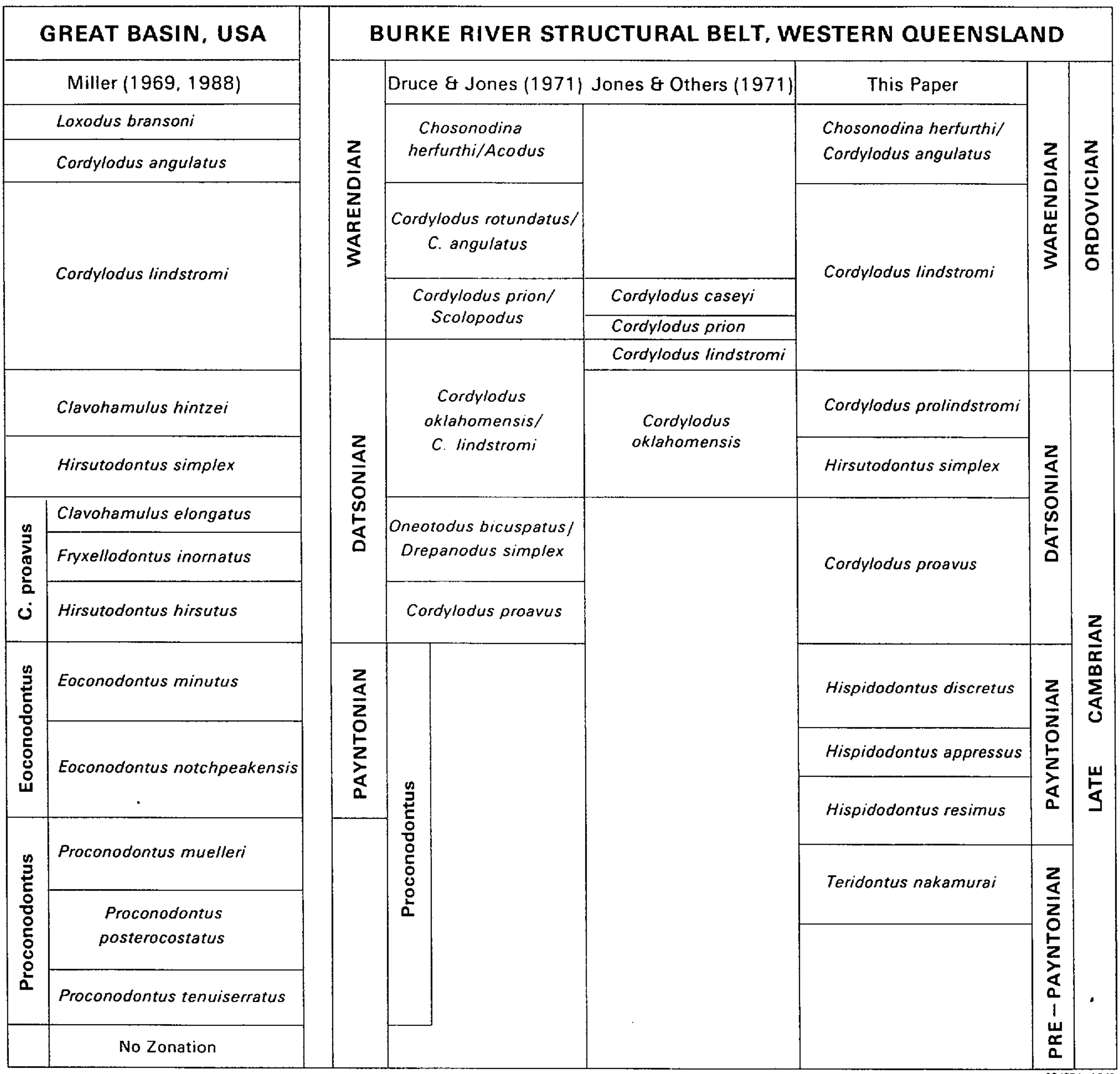


Figure 6. Australian - North American conodont biostratigraphic correlations.

Eoconodontus minutus (Miller), *E. notchpeakensis, Eodentatus bicuspatus* Nicoll & Shergold, *Fryxellodontus inornatus* Miller, *Granatodontus ani, Hirsutodontus hirsutus* Miller, *H. nodus, Hispidodontus appressus, H. discretus, H. resimus, Proconodontus muelleri, Teridontus nakamurai, Teridontus* n.sp. A, *T.* n.sp. B, and coniform elements A, B, C and D (Nicoll & Shergold 1991).

These conodonts represent the combined Assemblages 3 (*Hispidodontus appressus*), 4 (*H. discretus*) and 5 (*Cordylodus proavus*) discriminated by Nicoll & Shergold (1991) which span the late *Eoconodontus* and early *Cordylodus proavus* Zones recognised by Miller (op. cit.) globally. In Australian biochronologic terminology the Unbunmaroo Member of the Ninmaroo Formation is largely of Payntonian and earliest Datsonian ages.

JIGGAMORE MEMBER

Lithostratigraphy

The Jiggamore Member varies from 92 to 210m thick in the Burke River area. At Black Mountain, it is 210m thick within the interval 165-375m from the base of the Ninmaroo Formation. It is characterised by the predominance of 'two-tone' limestone, and comprises thin to thick-bedded limestone (clast peloidal and peloidal grainstone, ooid grainstone, and micrite, frequently bioturbated), dolostone, and dolomitic breccia. Diagnostic 'two-tone' patterns in these carbonates are a conspicuous diagenetic overprint which has gradational limits. The unit is regionally stratiform, but its boundaries may be discordant on a small scale.

Discussion of sedimentation

The Jiggamore Member is a continuation of the peloid carbonate-dominant lithofacies (Radke 1980) from the Unbunmaroo Member but there are subtle changes; the sudden increase in abundance of 'two tone' overprints in the lower 30m of the Jiggamore Member, the absence of evidence for tidal conditions, the relative increase in abundance of A2 and A3 algal cycles, and changes in the sparse fauna. Echinodermal debris increases in relative abundance in this member.

Fauna and age

Trilobites, conodonts and rostroconch molluscs have been described from the Jiggamore Member by Shergold (1975), Druce & Jones (1971), and Pojeta & others (1977) respectively. Additionally, polyplacophoran sclerites assigned to *Chelodes whitehousei* (Runnegar & others 1979) occur, together with undescribed ellesmeroceratid nautiloids, quantities of echinodermal material, various problematica and stromatolites.

Taxa identified to date include the trilobite *Leiostegium (Leiostegium) floodi* and indeterminate and undetermined leiostegiid fragments (Shergold 1975). Ribeirioid and conocardioid rostroconchs include *Eopteria struszi, Euchasma caseyi, Ribeiria* sp., *Ptychopegma burgeri* and *Wanwania drucei.* (Pojeta & others 1977).

Conodont determinations by Druce & Jones (1971) have been considerably updated by Miller (1980), Chen & Gong (1986) and Nicoll (1990). Taxa now identified are: *Acanthodus uncinatus* Furnish, *Cordylodus angulatus* Pander (=*C. intermedius* of Druce & Jones 1971), *C.* sp. nov. A (=*C.* aff. *caboti* Barnes & others, =*C. oklahomensis* of Druce & Jones 1971), *C. proavus, C. prolindstromi* Nicoll (1991), *Hirsutodontus rarus* Miller, *H. simplex* (Druce

& Jones), *Monocostatus sevierensis* (Miller), *Oneotodus bicuspatus* Druce & Jones, *Semiacontiodus nogamii* Miller, *Teridontus gracilis* (Furnish), *T. nakamurai* (Nogami) and *Utahconus utahensis* Miller.

The Jiggamore Member was deposited during a time span extending from late in the *Cordylodus proavus* Zone into the *Cordylodus prolindstromi* Zone. It thus contains the biostratigraphically important datum based on the co-occurrence of *C. caboti* (as interpreted by Nicoll 1990), *C. proavus, C. prolindstromi, Hirsutodontus simplex, Utahconus utahensis* and *Monocostatus sevierensis* which appears to have a wide distribution in carbonate platform sequences, perhaps globally. The first appearance of *C. lindstromi sensu stricto* occurs in the overlying Mort Member of the Ninmaroo Formation. Nicoll (1991) has demonstrated that the earliest occurrences of *C. lindstromi* are actually that of the related but separate species *C. prolindstromi.*

MORT MEMBER

Lithostratigraphy

The overlying Mort Member, ranging from 40-130m thick, is 111m thick in the type section, within the interval 375-486m from the base of the Ninmaroo Formation. It comprises thin-bedded, flat-pebble limestone conglomerate and intraformational breccia, together with peloidal ooid and peloidal clast grainstone. Stromatolitic and thrombolitic biostromes are distinctive beds. The characteristic of this member is the predominance of flat-pebble conglomerates which were formed by the exfoliation of algal mounds and the breakup of hardgrounds during periods of high energy conditions. The Mort Member lies conformably between the underlying Jiggamore Member and the overlying Corrie Member. The upper boundary is defined by a bed of flat-pebble conglomerate with a distinctive red-green clast colouration in a yellow-orange cloudy cement matrix.

Discussion of sedimentation

This member comprises the flat-pebble conglomerate carbonate lithofacies of Radke (1980) with a thin, central incursion of ooid carbonate lithofacies. The sequence is still cyclic, with a predominance of modified P cycles in which only the basal flat-pebble lag is well preserved, contributing to the increased abundance of this lithology. All cryptalgal carbonate cycles are recognised, but types A2 and A3 are relatively more abundant (Radke 1980). Shoal relief was lower with less accumulated fine sediment. This appears to have influenced the corresponding reduction in evaporitic overprints. In summary, shallow submarine induration along with the increased formation and accumulation of ooids has produced this distinctive member.

Fauna and age

Only indeterminate trilobite fragments have been recovered so far from low in the Mort Member (Shergold 1975). *Chelodes whitehousei*, the polyplacophoran mollusc described by Runnegar & others (1979) ranges from the Jiggamore Member, as do the rostroconch molluscs, *Wanwania drucei* and *Pauropegma jelli* (see Pojeta & others 1977). Undescribed gastropods, nautiloid cephalopods, inarticulate brachiopods, and stromatolites occur more rarely than in the Jiggamore Member.

The Mort Member is dated mainly by the occurrence of conodonts. Druce & Jones (1971) and Druce & others (1982) reported the simple cone form genera *Scolopodus bassleri* (Furnish), *Semiacontiodus nogamii* Miller, *Teridontus gracilis* (Furnish), and *Utahconus utahensis* Miller. Associated cordylodids have been treated in terms of assemblages by Nicoll (1990, 1991), and Nicoll & Shergold (1991): *Cordylodus prolindstromi* and *C. lindstromi* are the only common cordylodid species found in the Mort Member.

The first appearance of *Cordylodus lindstromi* occurs 32m above the base of the Mort Member (407m above the base of the Ninmaroo Formation) in sample GB 90-002/54. It characterises the upper part of the member to the near exclusion of other cordylodids, save one occurrence of *C. angulatus* in the topmost beds. Nicoll (1990) regards *C. prion* Lindström *sensu* Druce & Jones (1971) as a synonym of *C. lindstromi,* hence the *C. prion/Scolopodus* Assemblage-Zone recognised by Druce & Jones is not biostratigraphically viable. The Mort Member therefore spans a time interval from late in the middle *Cordylodus lindstromi* Zone to late in the *Cordylodus lindstromi* Zone (*sensu* Nicoll 1990).

CORRIE MEMBER

Lithostratigraphy

The Corrie Member comprises medium- to thick-bedded encrinite (echinodermal skeletal grainstone), together with ooid and peloidal grainstone, skeletal peloidal clast grainstone, and cross-stratified dolomitic sandstone, 98.7-210m thick. In the type section, it is 98.7m thick, within the interval 486-584.7m from the base of the Ninmaroo Formation. The distinctive and characteristic rock type is white to pale yellow echinodermal limestone, which weathers spheroidally and has a uniform crystalline appearance. In places, the Corrie Member has been deeply weathered, resulting in the silicification of the skeletal grainstones and the development of chert lenses. A regolith developed over this unit has been mapped separately as the Swift Formation (see also Datson Member).

Discussion of sedimentation

The Corrie Member comprises a variety of lithofacies, but the skeletal carbonate one is dominant, although the ooid carbonate lithofacies is also locally abundant. Conditions apparently changed gradually from deposition of the Mort Member and there is a transitional 14m of flat-pebble conglomerate carbonate lithofacies. This relates to evidence of structural influence on sedimentation, the growth of the Black Mountain dome during late Mort and early Corrie deposition. In the Corrie skeletal-ooid carbonate cycles, basal erosional surfaces show linear features like rillenkarren that align down dip (Radke 1980, fig. 3). This orientation corresponds to thrombolite mound alignment in the upper Mort Member.

With increasing shelf gradients, whether local or regional, salinity appears to have reduced significantly, with a consequent proliferation of fauna. The massive echinodermal beds probably reflect selective winnowing and accumulation, and there was corresponding formation of ooids under these conditions. Only skeletal-ooid carbonate (SO) and cryptalgal carbonate (A3) cycles are recognised in this sequence, the latter forming a thick and distinctive "birdseye" horizon in the upper part of the member.

Fauna and age

The rostroconch mollusc *Pauropegma jelli* Pojeta & others (1977) and the trilobite *Asaphellus* sp. undet. (Shergold 1975) occur sparsely in the Corrie Member which is especially characterised by silicified articulate brachiopods referrable to *?Apheoorthis* sp..

The age of the member is given more specifically by conodonts. Nicoll (1990, 1991) has given revised determination of the cordylodids which include the overlap of ranges of *Cordylodus lindstromi* (*sensu* Nicoll 1990), *C. angulatus*, *C. caseyi* Druce & Jones and *Cordylodus* sp. nov B (Nicoll 1991). These are associated with *Acanthodus costatus* Druce & Jones, *Chosonodina herfurthi* Müller, *Clavohamulus* sp. nov. A (Nicoll, in prep). Druce & Jones (1971) and Druce & others (1982) additionally recorded the form genera "*Acontiodus*" *staufferi* Furnish, *Drepanodus acutus* Pander, *D. suberectus* (Branson & Mehl), *D. tenuis* Moskalenko, *Oistodus inaequalis* Pander, *O. lanceolatus* Pander, *Scolopodus bassleri* (Furnish), *S. gracilis* Ethington & Clark, *S. quadraplicatus* Branson & Mehl, *S. transitans* Druce & Jones, *S. triplicatus* Ethington & Clark, *Semiacontiodus iowensis* (Furnish), *S. nogamii* Miller, *Teridontus gracilis* (Furnish) and *Utahconus utahensis* Miller.

DATSON MEMBER

Lithostratigraphy

The Datson Member comprises thin- to thick-bedded limestone or dolostone (skeletal grainstone, boundstone, peloidal grainstone, clast grainstone, lime mudstone), and chert. This member is 24.3m thick at Black Mountain, within the interval 584.7 - 609m, but has a maximum thickness of 295m at Mount Datson. Because of its general exposure off the domal structures and its proximity to the Swift weathering surface, it is characterised by dolomitisation and silicification overprints.

The Datson Member conformably overlies the Corrie Member. The boundary is sharp and distinctive because of the immediate change to thin-bedded and laminar peloid and skeletal carbonate (IIps) of Radke (1980). A regolith comprising red soil with numerous chert fragments derived from the Corrie and Datson Members has been mapped as the Swift Formation, but correlates with the Digby Peaks Breccia and unconformably overlies the Datson Member.

Fauna and age

The fauna is dominated by trilobites, with less common rostroconch molluscs, siliceous sponges?, brachiopods, bellerophontid gastropods, hyoliths, calcareous algae, conodonts, nautiloids, and bryozoans. Burrows are locally well-preserved in the unit.

To date, only a single trilobite, *Warendia bidecorata* Gilbert-Tomlinson (1969) has been described. Undescribed, although of very common occurrence, is a species of *Asaphellus*. More rarely, the trilobite assemblage also contains a metagnostid, harpidid, remopleuridacean and protopliomeroid, among others yet undetermined. All taxa occurring appear to have close relationships with previously described Chinese material considered to have a terminal Tremadoc age (see Peng 1990).

Associated conodonts, originally described by Druce & Jones (1971), have been reanalysed by Nicoll (1991). Among taxa recognised by the latter are: *Cordylodus angulatus*, *C. caseyi*, *Chosonodina herfurthi* and *Clavohamulus* sp. nov. B. Druce & Jones (1971). Druce & others (1982) also recorded *Acanthodus costatus*, *Acodus oneotensis*, *Drepanodus acutus*, *D. subarcuatus* Furnish, *D. suberectus*, *Oistodus inaequalis*, *O. lanceolatus*, *Oneotodus variabilis*, *Scolopodus asymmetricus* Druce & Jones, *S. bassleri*, *Semiacontiodus iowensis*, *S. nogamii* and *Teridontus gracilis*. Possibly only three of these taxa, *A. oneotensis*, *D. subarcuatus* and

S. asymmetricus characterise the Datson Member which has been referred to the *Chosonodina herfurthi / Acodus* Zone by Druce & Jones (1971) but which we now prefer to regard as the *Cordylodus angulatus / Chosonodina herfurthi* Assemblage-Zone (see above).

THE TYPE SECTION OF THE NINMAROO FORMATION AT BLACK MOUNTAIN

LOCATION OF TYPE SECTION

The type section at Black Mountain offers the thickest exposed sequence of Ninmaroo Formation with the least structural complications, and with minimal dolomitisation. The section generally follows ridge tops to optimise accessibility and minimise scree cover. To maintain continuity, several laterals were necessary to avoid structural complications. Black Mountain (Fig.1) is a faulted peridomal structure with apparent continuous reduction of dip of beds off structure. On the mesoscale, gullies normal to strike tend to follow faults of small displacement. In the upper section, there is apparent faulting parallel to strike which may have had thrust components at some stage of dome development. The section (Fig.7) minimises structural complications, although some are still evident. Additionally, at the mesoscale, dips are erratic as is most apparent on dip slopes where "egg carton" folding is observed with an approximate 2 metre wavelength.

The type section, described by Radke in 1981, was originally measured in 1976, and there has been significant deterioration and loss of marking since this time. During integration of biostratigraphic and palaeomagnetic sampling of the Ninmaroo Formation in 1989 and 1990 on the Radke section, relocation, remeasuring and remarking was attempted for particularly important stratigraphic intervals.

The type section, section GEO202 of Radke in Shergold & others (1976), comprises eight legs.

LEG 1

Approximately 50m to the north of the trig station on Black Mountain (Unbunmaroo) there is a steep gully incising the highest and most prominent thick scarp. The section starts at the bottom of this gully, at the base of the Ninmaroo Formation, directly on top of the uppermost bed of Chatsworth Limestone. The conformable contact is on top of a distinctive thick orange-brown bed of dolomitised, cross-stratified sandy grainstone. This bed is the uppermost and thickest of several similar recurring beds.

The section starts at the base of the scree slope overlying this distinctive Chatsworth bed, and proceeds up the northern side of the gully to a light blue-grey fenestrate mudstone at 33m.

LATERAL TO NORTH for approximately 30m.

LEG 2

This leg proceeds in a north-westerly direction up to a crest and then along a descending ridge to a saddle where a distinctive and prominent thin bed of ooid grainstone with white flat pebbles marks the top of this leg at 104.5m (paint marked 102.5m).

LATERAL TO NORTH for approximately 50m to next saddle.
This lateral crosses a small fault that displaces beds a distance of several metres.

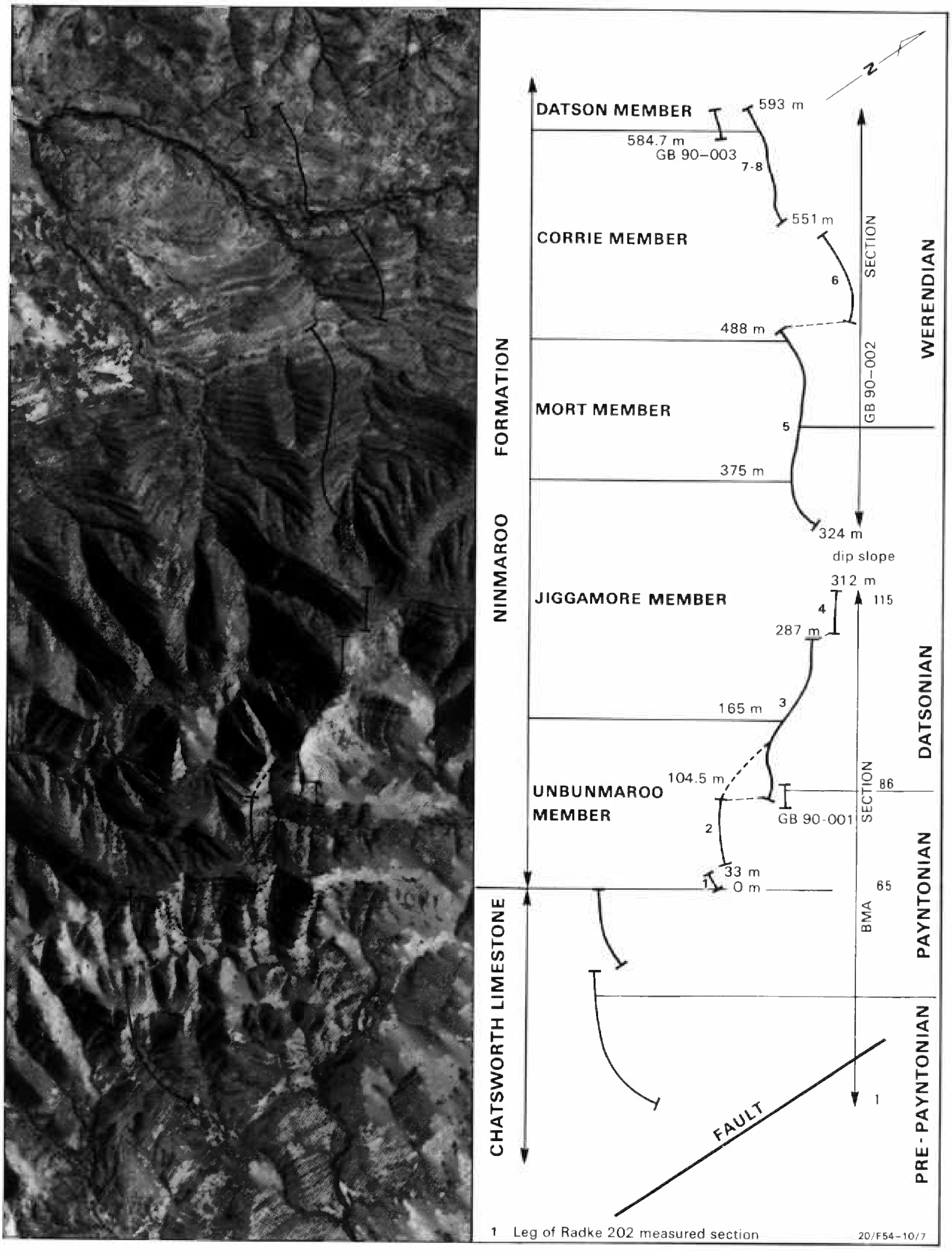


Figure 7. Detailed location of the Black Mountain Cambrian-Ordovician transition section.

LEG 3

The section continues from the distinctive bed with white flat pebbles (metal stake in place) directly up slope in a northwesterly direction, following the ridge-top to 287m, a prominent bed of light brownish grey ooid grainstone with biostromal patches of boundstone. A metal stake marks this bed.

LATERAL TO NORTH for approximately 100m to a low stone cairn on this same bed.

LEG 4

This leg continues along a bearing of 310°M, to a prominent medium bed of interbedded flat-pebble conglomerate and bioturbated two-tone mudstone at 312m. A metal stake marks this horizon.

LATERAL DOWN-DIP SLOPE
From the top of Leg 4 at 312m, the metal stake at the start of Leg 5 can be seen approximately 250m distant on a bearing of 290°M.
NOTE: The type section published in Radke (1981) has a thickness error between Legs 4 and 5. Horizon 312m of Leg 4 is equivalent to Horizon 324m at the start of Leg 5. The section has been repainted as originally marked in 1976.

LEG 5

A metal stake marks recommencement of the section at 324m. This stake is on a steep northerly slope of the ridge. The section proceeds on a bearing of 310 degM generally following the ridge top of a westward descending spur to a metal stake at 487.5m. This horizon is a distinctively thick bed of encrinite (skeletal grainstone) on a low scarp just beyond a small creek.

LATERAL TO NORTH for approximately 150m to another metal stake.

LEG 6

Section recommences at a metal stake on top of the encrinite bed, marked 488m, and continues on a bearing of 310°M to 549.5m, also marked by a metal stake.

LATERAL
From the top of Leg 6, the metal stake at the base of Leg 7 is across the creek on a bearing of 245°M.
The area between Leg 6 and Leg 7 has apparent monoclinal faulting with associated localised dolomitisation and steepening of dip. There is a significant reduction in dip from Leg 6 (15-20°) to Leg 7 (6°).

During remarking of the section, an apparently less disturbed sequence 15m thick was measured in a creek to the south, between horizons 549.5m and 551m. This adds 13.5m to the section.

LEG 7

From the metal stake at 551m, the section continues at 305°M up the creek bank to 570m (marked by another metal stake). From this point, one can proceed direct to the top of the section on a bearing 285°M. However, this direct route misses some better exposures.

LATERAL TO NORTH for approximately 30m.

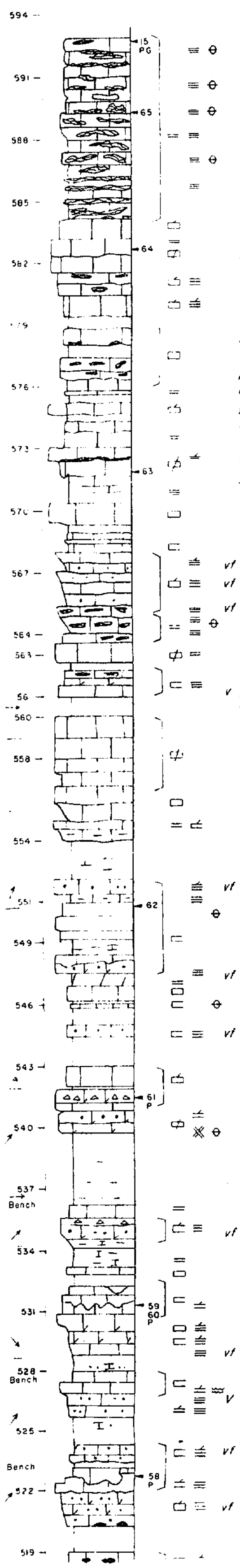
LEG 8

(No metal stake). Proceed up rise on bearing of 320°M from 570m to 578m at the top of a gentle dip slope. The marked section has a slight change in direction to the southwest to the level of 581.5m.

(581.5m mark lies at 270°M from 578m mark. Section runs at 45 degrees to dip direction). From 581.5m, the section line runs at 250°M (45° to dip direction) to the top of the section (metal stake) at 593m. The distinct base of the Datson Member is at 584.7m.

Figure 8 (opposite and following pages). Detailed graphic log of Black Mountain section of Ninmaroo Formation (from Radke 1981).

SECTION GEO 202



Grnst, skltl [vc] si Biotrbn
vp brn Grnst ? pldl [vf],(lamd) si rexlzd, Cht Nod

vp brn

vp orn Grnst? Pckst? pldl [f-vf]; Lamd; Grnst, skltl Cht
lt gy Grnst? Pckst, pldl [vf], (skltl) vf rexlzd
ltgy - ltolvgy Grnst, pldl [vf]; interlamd Pckst, pldl [vf-m], Grnst, skltl [vc] si, cpctd
lt gy Grnst, pldl [vf],(skltl), interbdd Grnst, skltl [f-vc], pldl [vf] si Lam, v fn 2 tone Lam

lt gy Grnst, skltl [f], overlying Grnst, skltl [m-vc], pldl, (srt) si, Mn
v lt gy Grnst, skltl [m-c],pldl [m]; Xstrat [to 1metre, asymptotic festoons] (si) Mn,py
yel gy - vlt gy Mdst, skltl; grading thru Pckst, skltl to Grnst, skltl, pldl, clost [Mdst],
repetitive grading, Grnst dom to top si Foss, (py), Mn, cpctd
vlt bn gy Grnst, skltl [f], red at top md pnk dol 2 tone Lam Cht Nod in Mdst interbeds
pnk gy Grnst, skltl [f]; rexlzd Intbdd Grnst, clost [lrg lath], eroded

pnk gy Grnst, skltl [lath,f]; srt rexlzd; Cht Nod [orig fabric]

p red Grnst, skltl [lath,vf], srt 2 tone; cht Nod [orig fabric]; f rexlzd
Grnst? skltl [c] f rexlzd
yel gy Grnst, skltl [m-c], srt si Foss; Styl ; si patches
lt olv gy Grnst? pldl [vf], lamd
Mdst, skltl, overlying Pckst, skltl; grading to skltl Grnst
wh Grnst, f skltl, xstrat eroded, overlain by Grnst, clost [mud], pldl, + skltl Grnst
yel gy Wckst? pldl [sm], alg, fnstrt vug [calc after evap]; py

wh, Grnst? sklt [f] f rexlzd, Styl; calcreted

vp red Grnst, skltl f rexlzd
vf vp red Grnst, skltl [m]; xstrat, intbdd with Grnst, sd, skltl [f]; rexlzd
vf vp red Grnst, Lamd, sd, skltl? f rexlzd, wthrd

vf vp red Grnst ?, sd Lam; Karst karren, skltl infil
v lt gy Grnst, skltl [f, plaks], srt rexlzd; Cht Nod [orig textures]
v lt gy Grnst, skltl [f], srt, uni rexlzd Cht Nod
Grnst, skltl [c gran], srt Xstrat [10cm sets] si Foss
Grnst, ooid [f], skltl [lath]
pk gy - vlt gy Grnst, skltl [sm lath] f rexlzd; styl, Cht Nod
v pk gy Mdst? rexlzd; gy orn 2 tone Lam
vlt p red Grnst, skltl [m-vc]; overlying Grnst (si Foss), Style
vlt yel gy Grnst, skltl [plates]; srt si Foss, irreg red altern Ptch
vp red, mtl Grnst, skltl [vc], uni, fri; wthrd, mtl red blk Mn?

vp red, wh mtl Grnst, skltl [vc-gran]; uni; wthrd red altered Mtx

vp red Grnst? skltl [c-vc]; fri, (por); wthrd rexlzd, si Foss

vp red Grnst, skltl [m-vc], (srt) rexlzd, wthrd, cpctd

v lt yel Marl, fri, por
vf v p red Grnst, sd, ooid, clost [sm]; Lamd; xlamd; soft sed. folds
v lt gy Wckst? (skltl), (fiss); (fri): cpctd
vlt gy Wckst? grading to Bndst, lamd, alg; eroded, overlying Pckst, skltl, clost
v lt gy Grnst?, clost [laths] vf rexlzd, cpctd; Style

pk gy Grnst, skltl [c], clost [rndd Lath, f sd ooid Grnst]; grades to biot rbtd ooid Grnst
vf yel gy Grnst, ooid [vf], sd; xlamd; eroded dol
v lt grn Grnst, skltl [vc]; fri (si Foss); sph wthring
pk gy Grnst, skltl [c]; fri; wthrd

vf lt olv gy Grnst, ooid [vf], sd

Grnst, ooid [f-vf], srt; xstrat [lrg, low angle, 10cm set]
lt olv gy Grnst, ooid [f-vf]; xstrat; clost patch 2 tone Lam, dol + calcite
v lt olv gy Grnst, ooid [f], uni, srt; xstrat [3cm set] (Style)
pk gy Grnst; ooid, skltl; xstrat [3-5cm sets, trough, erosional] por rexlzd, v lt brn mtx, 2 tone

yel gy Grnst, clost [rndd Lath, f ooid Grnst], pldl [m-c, elong]; (srt)
lt olv gy Grnst, ooid, clost [sm], skltl, xstrat [over a karstic surface]
vf pk gy Grnst, vf sd, ooid [vf], (skltl), srt; Xstrat [3cm sets, eroded festoon, unidirnl → 210°]

yel gy intbdd sh Dole, Grnst, ooid [f] dol
v lt gy Grnst, clost [rndd, eg, 4mm D, f ooid Grnst], ooid [c] p om red calc cmt

v lt orng gy Grnst, ooid [f], uni; karst; overlying vc skltl Grnst
v lt olv gy Grnst, ooid [f], srt; xstrat [4-6cm sets, mod angle] por

v lt orng Grnst, ooid [f], uni; herringbone Xlamd dol, vf xl
vf v lt olv gy Grnst, ooid [f], srt rexlzd

v p red Grnst, skltl [c], srt fri, wthrd
v lt olv gy Grnst, ooid [vf], (skltl); srt ; Xstrat [6cm sets]
V yel gy Grnst, sd, ooid?; lamd cpctd, sl rexlzd
v lt olv gy Grnst, ooid [vf], sd

vf v lt olv gy Grnst, sd, ooid? [vf], xlamd dol laterally; vf rexlzd
lt gy Grnst, vc, clost [rndd lath, vf Grnst, ooid], skltl si Foss; Styl
pk gy Grnst, ooid [sph, superficial, f-m], skltl [frag], Xstrat [5-8cm sets erosional, herringbone] Styl
vf gy orn pk Grnst, sd, ooid? [vf], skltl; Xstrat [3-5cms sets, mod angle, altng low angle sets] Cht Nod

v lt gy Grnst, skltl, ooid [f-m]; Grnst, skltl [vc] patches Styl, Cht Nod

5
285

← Lateral

→ Lateral

5
Lateral

Thrust
Strike
← FAULT

FAULT
Alteration

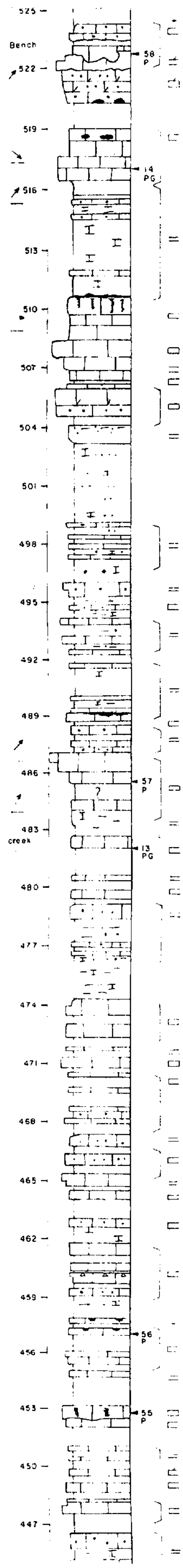
Karst

Fault

Karst

Sharp
← contact

165



vf v lt olv gy Grnst, sd, ooid? [vf], xlamd : dol laterally, vf rexlzd
lt gy Grnst, vc, clast [rndd lath, vf Grnst, ooid], skltl : si Foss, Styl
pk gy Grnst, ooid [sph, superficial, f-m], skltl [frag], Xstrat [5-8cm sets erosional, herringbone] Styl — ∗165
vf gy orn pk Grnst, sd, ooid? [vf], skltl; Xstrat [3-5cms sets, mod angle, altng low angle sets] Cht Nod

v lt gy Grnst, skltl, ooid [f-m]; Grnst, skltl [vc] patches Styl, Cht Nod
Grnst, ooid [f-m, abraded, skltl nuclei], srt : rexlzd
v lt bm gy Grnst, skltl [f-m, rndd], (ooid); "millet seed" : cpctd, 2 tone
(vf) v lt orn Grnst, skltl [f rndd frags, some coated]; uni
vf vp red Grnst, skltl [skltl nuclei] : cpctd; rexlzd Lam

vp orn Grnst, skltl [f rndd frags], ooid [skltl nuclei], srt, intbdd vf sd Grnst
v lt gy Grnst, skltl [vc], (clast) [rndd, skltl Grnst] : wthrd cpctd, si
vp red Grnst, skltl [vc]; uni; fri : wthrd, (si Foss)

v lt gy Grnst, skltl [vc]; uni; (fri); (si grains)
lt gy, gy orn pk, Grnst, f, ooid, skltl, sd, srt : rexlzd, grades up to vf Grnst, lamd — •Karst ?
v lt gy, orn pk Grnst, ooid [f, elong], skltl?, srt, mtl dol, Styl, rexlzd
gy orn pk Grnst, sd, vf pldl?; Xstrat [4cm sets, sep by vsd Lam], cpctd — ∗
vf lt orn Grnst, sd, pldl [vf] fri

vf lt gy Grnst, sd, vf pldl, Lamd; (biotrbn)
vf lt olv gy intbdd Grnst, vf, sd, pldl, (biotrbn), Grnst, skltl, pldl

vf lt olv gy intbdd Xstrat Grnst, vf pldl, sd, (skltl) and Grnst, skltl, (clast), pldl
vf lt olv gy Grnst, sd, pldl [vf]
lt pk red Grnst, clast [vari, rndd, lath, Grnst?], pldl
lt pk gy Grnst, clast [vf Grnst], sd, pldl? : si repl Mtx, veining, py
lt gy Grnst, ooid [f], clast [v sm], skltl; lamd : si skltl grains
lt olv gy intbdd Mdst, Grnst, clast [Mdst, skltl Wckst], skltl; Grnst, ooid [f], skltl

lt gy Mdst, eroded overlain by Grnst, clast [Mdst, lath], skltl : py
lt gy Grnst, skltl [frag], pldl, srt : si base; Styl contact — •Karst ?
vp red Grnst, ooid [vf], (clast) [ptchy] : wthrd
(vf) v lt olv gy Grnst, vf pldl?, sd
(vf) v lt olv gy Grnst, f sd, ooid? [f], (clast); eroded; Grnst, clast [rndd Grnst lath] Vugs under clasts — Lateral
vp red Grnst, skltl [frag], srt; por

lt bn gy Grnst, skltl [Rib, skltl, mudfilled frags], (clast) rndd : wthrd
lt brn Grnst, skltl [c-vc]; fri, wthrd
lt brn gy Grnst, vf, pldl; uni

Grnst, clast [rndd lath, Fe rich], Mtx [vf calcite] : vugs under clasts

vp red Grnst, skltl [frags], uni; overlies karst?, wthrd surface — •Karst ?
vf v lt grn gy Grnst, clast [sd Grnst, rndd laths], sd, pldl? : cpctd
lt gy orn pckst skltl Grnst
vf v lt grn gy Grnst, sd, pldl [vf], (clast); lamd, intbdd Grnst, clast [sd Grnst]

vf vf v lt grn gy Grnst, clast [rndd lath, sd f Grnst], pldl?, sd, intbdd xlamd sd Grnst, pldl, Hg

v p red Grnst, skltl, clast [f Grnst], fri, por wthrd
vp red Grnst, ooid, clast, intbdd vf Grnst, pldl biotrbtd wthrd
vp red Grnst, ooid [m], Ptches clast Grnst : wthrd
lt gy Grnst, vf ooid, skltl, 2 tone Lam, pk orn
lt gy Grnst, ooid [m], clast [ooid Grnst, rndd], skltl, intbdd Grnst, skltl, ooid, clast and Biotrbtd Pckst? : pk orn 2 tone bands

v p orn Grnst, clast [rndd lath, f Pckst-Grnst], skltl, pldl? : rexlzd, wthrd
vf lt olv gy Grnst, ooid [f], sd, uni clast Patches : rexlzd
v lt olv gy Grnst, clast [rndd sm lath, pldl skltl Grnst], ooid, skltl : Vug under clast, orn calcite infil
vf v lt olv gy Grnst, clast [rndd lath, f Grnst], sd pldl, grades to lamd pldl skltl Grnst : Vugs under clasts
lt brn gy Grnst, clast [vari, rndd laths, f Grnst-Pckst], sd pldl Mtx : rexlzd
vf Grnst clast [lrg rndd laths, vf sd pldl Grnst], skltl; grades up to lamd Grnst
lt gy Grnst-Pckst pldl, (skltl) 2 tone, yel orn mtl in Biotrbn
v lt olv gy Grnst, pldl [vf], skltl [frag], srt, Lamd, (Biotrbn)
v lt brn gy Grnst, clast [rndd laths, pldl Grnst], skltl; size decrease up : wthrd rexlzd

vf lt brn gy Grnst, clast [lrg vari rndd laths, vf sd Grnst], pldl : si Rexlzd

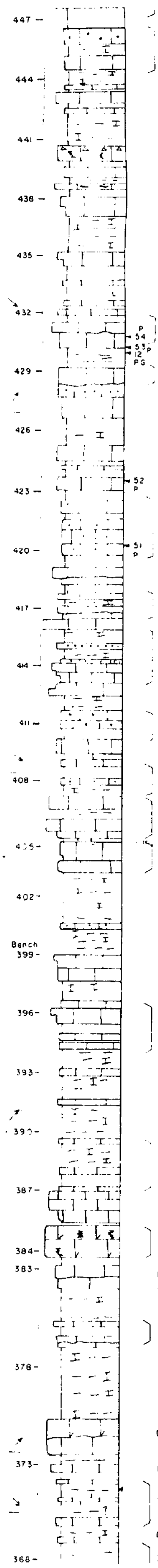
Grnst, clast [rndd lath, f pldl Grnst], pldl [f]
lt gy Grnst, pldl [vf] srt; unif; clast Patches : biotrbtd
v p yel Mdst, biotrbtd, intbdd vf pldl skltl Grnst; grade into Wckst 2 tone Brec
vf lt gy Grnst, clast [rndd lath, f sd Grnst], mtx [vf sd] : (py) in mtx, rexlzd

lt gy
m bm gy Bndst?, stromat [tabular, domed]; clast Grnst at base silicified

lt brn gy Grnst, clast [lath, ooid skltl Grnst, rndd], skltl; (srt)
lt gy orn Grnst, ooid [f-m], clast [lath, rndd vf Grnst], skltl : Vug under clasts
lt gy orn Grnst, clast [rndd, lath, vf Grnst], ooid?; vugs under clasts

m olv gy Bndst, alg pldl, ooid, md, skltl, mtl [biostrome] : 2 tone mt; si foss — ∗
m brn gy Grnst, ooid [c], clast?, fnstrl?; rexlzd, orn pk calc altrn, cpctd, Styl

lt brn gy Grnst, clast [vari, rndd-ang, pldl Grnst], skltl, pldl? : rexlzd; orng altrn of vug cement
lt gy Grnst, ooid [f], skltl [frag], sd; clast Patch
Wckst-Pckst, (skltl), biotrbtd, mtl : 2 tone Lam + biotrbn altrn
lt gy Grnst, ooid, skltl, clast grades ink ooid Grnst, biotrbtd : 2 tone bands
lt gy Grnst, ooid, skltl, clast [f skltl Pckst] (si Foss)
v lt brn gy Grnst, ooid, skltl, clast [rndd-ang, f Grnst] : rexlzd, gy orn altrn
lt gy Grnst, ooid [m], clast [lath, rndd, sd f Grnst], skltl : Styl
vf lt gy Grnst, sd, pldl, lamd, xlamd, (biotrbtd); parting lineation 310° : chlorite



v lt brn gy Grnst, ooid, skltl, clast [rndd-ang, f Grnst]: rexlzd; gy orn altrn
lt gy Grnst, ooid [m], clast [lath, rndd, sd f Grnst], skltl: Styl
vf lt gy Grnst, sd, pldl, lamd, xlamd, (biotrbtd); parting lineation 310°: chlorite
m gy Grnst, ooid, pldl [elong], skltl; Bndst? patches
lt olv gy Grnst, vf ooid?, (clast)
lt gy Grnst, clast [lath, lrg, rndd, f pldl Grnst], pldl [f]; srt: Vug under clasts
m olv gy Grnst, clast [irreg, rndd, skltl Mdst, f pldl Grnst], pldl, skltl, (srt), Vug [sm] under clasts

lt olv gy Bndst, [ooid, pldl, skltl, 'rnd'] domed: si Foss; dol Patch

v lt brn gy Bndst, biostrome [ooid, pldl, skltl, 'md']; domed: (vug); si Foss

m olv gy Grnst, f pldl, intbdd Mdst, skltl, Grnst, clast [irreg], pldl, (skltl): cpctd, styl or 2 tone contacts, B.O orng
Dol altrn Patch

m lt brn gy Grnst, clast [f skltl Pckst], skltl, pldl: vugs under clast; calc + dol infil
m olv gy Pckst? pldl [f], skltl, (biotrbtd), patch Grnst, clast
v lt olv gy Grnst, clast [subeq, subrndd, vari, skltl Pckst], skltl, pldl, (srt) si Foss
m brn gy Grnst, Pckst, f pldl, skltl, uni [v biotrbtd?] sl rexlzd
m brn gy Grnst, clast [vari, rndd, skltl + pldl Pckst], pldl [f], skltl: cpctd
lt olv gy Pckst? pldl [f], biotrbtd; intbdd Mdst: lt brn altrn in Biotrbn
vf v lt olv gy Grnst, clast [lrg lath, sd Grnst], intbdd Lamd sd f pldl Grnst: chlorite? flecks
v lt olv gy Grnst, clast [lath, vf Grnst]
vf v lt gy Grnst, lamd, pldl, sd; overlying Grnst, clast [rndd, Grnst], pldl Vugs under clasts
v lt gy Grnst, clast [lath, lrg, ooid, pldl Grnst], ooid: cpctd; (py)

— Fault

lt brn Grnst, clast [lath, rndd, vf Grnst + skltl Wckst], ooid [f], skltl rexlzd, 2 tone, py, vug
lt brn gy Grnst, clast [rndd, vf Grnst], ooid [vf], skltl? rexlzd
lt gy Grnst, clast [lath, vf Grnst]; intbdd Grnst, vf sd pldl: rexlzd, 2 tone
vf v lt brn gy Grnst, vf, sd, pldl, ooid, xlamd, (biotrbtd); intbdd Grnst, clast, ooid

lt yel gy Grnst, sd, pldl [f], intbdd Grnst, clast [rndd lath, sd Grnst]
vf yel gy Grnst, vf, sd, pldl?; overlain by Grnst, clast [sd f Grnst], skltl: wthrd Mtx
m lt gy Grnst, ooid [f], srt rexlzd; wthrd Patch
lt olv gy Grnst, clast [rndd-ang, skltl Wckst], skltl, pldl rexlzd Mtx
lt olv gy Grnst, clast [rndd to ang skltl Wckst], pldl; Vug under clasts
v lt olv gy Grnst, clast [rndd, skltl, Wckst], pldl [f]; intbdd vf skltl pldl Grnst
lt olv gy Bndst [domed, elongate 1.5m]; Wckst, pldl, Skltl, adj Grnst, clast si Foss
vf wh, Frt qtzose
vf lt gy Grnst, ooid [vf], Lamd, overlain by Grnst, clast [f, ooid Grnst]
lt gy Grnst, clast [rndd, lath, Grnst?] rexlzd [vf], Vugs under clasts
v lt olv gy Grnst, vf ooid, skltl, Lamb, (biotrbtd), overlying Grnst, (clast), pldl

vf v lt olv gy Grnst, clast [rndd, lath, v pldl sd Grnst, (py)], (pldl) [vf] Vugs under clast
Grnst, ooid [f-m], patches Grnst, clast, ooid
v lt brn Grnst, ooid [c, sph], (srt) sl rexlzd
m gy Grnst, ooid [m], clast [md, rndd], skltl, overlying Grnst, ooid, skltl
vf lt olv gy Grnst, clast [rndd laths, sd pldl Grnst], pldl [vf], overlying Grnst, skltl
m brn gy Grnst, ooid, clast [sm]; grades up to Bndst? ooid, mix, skltl, mtl [biostrome] si Foss
lt gy Grnst, ooid [f], grades to c, eroded, overlain by ooid, clast, skltl Grnst
lt gy Grnst, clast [lrg, rndd, lath, sd Grnst], (skltl), grades up to f pldl Grnst
vf m olv gy Grnst, clast [lrg rndd sd f Grnst, Mdst], ooid, skltl
m gy Grnst, f pldl, skltl, srt bit odour
lt gy Grnst, pldl [m], clast [vc, ang], srt xlamd, sl rexlzd

vf v lt gy Grnst, sd, pldl [vf], srt

lt gy Grnst, clast [rndd, eq, pldl Grnst + Mdst], pldl [vf], intbdd Lamd Mdst + vf skltl pldl Grnst, Wckst cpctd

lt gy Grnst, pldl [vf], intbdd Grnst, clast [lrg Grnst] rexlzd, vf, 2 tone Lom

m olv gy Bndst, brec, Grnst, clast [rndd, Mdst], pldl [vf]

m olv gy Bndst, Instrt, Mdst, Lamd Brec [dol]

lt olv gy Grnst, pldl [vf], xlamd rexlzd, (py)

lt brn gy Grnst, clast [rndd, pldl] rexlzd, cpctd Vug, calc, py, Spn?

v lt brn gy Bndst, alg, pldl [m], skltl py [ptch]
Grnst, vf pldl, cross-lamd
m olv gy Grnst, ooid [m], srt, bit odour, dol, 2 tone
m olv gy Bndst, skltl, pldl, ooid, md, (srt), mtl si vug, B.O
v lt olv gy Grnst, clast [rndd, lath, pldl Grnst], pldl [vf]: vugs under clast rexlzd, si nautiloids, dol lens + wisps
Bndst, skltl, pldl [ang]
lt olv gy Grnst, pldl [ang, m], clast [sm, ang] ooid, [m], xstrat B.O, rexlzd
lt orng gy Grnst, vf pldl? rexlzd, bit odour
v lt olv gy Grnst, clast [lath, lrg, Grnst skltl, pldl] rexlzd
v lt olv gy Grnst, m, skltl, ooid?; srt, rexlzd, si; (bit odour)

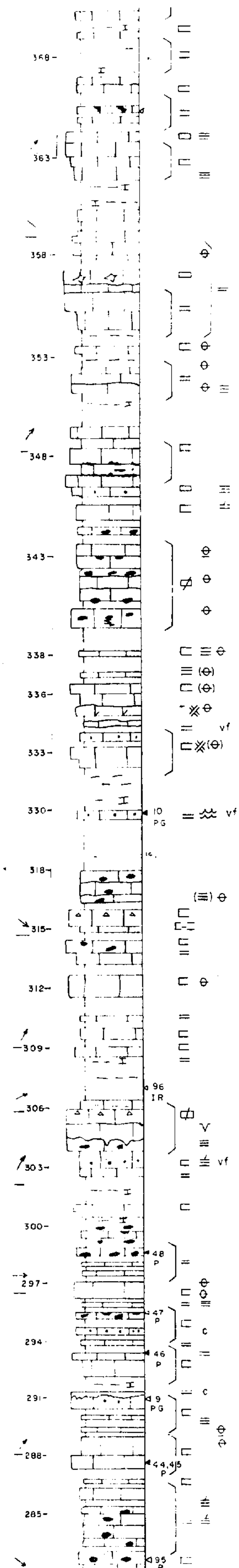
lt olv gy Grnst, clast [rndd, Mdst + Grnst], pldl cpctd
v lt olv gy Grnst, pldl [c to f], Pckst cpctd

Fault?

v p yel brn Bndst, [domed biostrome, 2m D], skltl, ooid, pldl, clast Styl, 2 tone Nod

v lt olv gy Bndst, tabular [ooid, skltl, pldl], ((srt)) si Foss
lt olv gy Grnst, clast, pldl
lt olv gy Grnst, clast [rndd, Mdst]; eroded, overlain by Grnst, clast, pldl, skltl vugs under clasts

lt brn gy Grnst, clast [rndd lath, Mdst], pldl? [vf] mtx, Vug under clasts
lt gy Mdst, (biotrbtd) [spar filled], cpctn, wavy, 2 tone Lom



lt brn gy Grnst, clast [rndd lath, Mdst], pldl? [vf] mtx, Vug under clasts
lt gy Mdst, (biotrbtd) [spar filled], cpctn, wavy, 2 tone Lam

lt gy Grnst, vf pldl, skltl to Mdst, (biotrbtd) vf rexlzd, 2 tone

lt olv gy Grnst, ooid [vf], srt, unif Cht
v lt gy Grnst, clast [rndd, m, Mdst], skltl cpctd, sparry patches
lt gy Grnst, vf, grading up to biotrbtd Mdst 2 tone, yel gy Lam + biotrbn
v lt brn gy Grnst, v f pldl, ooid?; grading up to biotrbtd Mdst rexlzd, (2 tone)
lt olv gy Mdst, intbdd pldl Grnst brec, 2 tone, bit odour
lt olv gy Mdst, biotrbtd [lrg, Grnst infil], intbdd Grnst, ooid, skltl bit odour

lt gy Wckst?, skltl mcrtzd, Lam, Vn, yel gy 2 tone

lt gy Grnst, clast [at base], pldl [vf], Wckst, skltl 2 tone Lam, yel gy

lt gy Wckst; skltl, pldl [vf] Nod, yel gy 2 tone Lam
m lt gy Mdst, biotrbtd, Wckst, skltl, pldl, Grnst, pldl pk gy 2 tone Lam, vug calc infil
lt gy Grnst, skltl [complete + frags], ooid?, clast [subrndd] B O, rexlzd

lt gy Grnst, pldl [f], sklt [frag] Lamd, 2 tone bands
lt brn gy Grnst, vf pldl, skltl, grdtnl to Mdst 2 tone cpctn

lt olv gy Mdst, (biotrbtd) [lrg, sm] vp orn 2 tone Lam, grdtnl
v lt brn gy Mdst; eroded overlain by Grnst, clast [rndd, lrg, skltl Wckst] gy
lt gy Mdst, eroded + overlain by Wckst, skltl, biotrbtd Nod 2 tone
v lt brn gy Grnst, pldl? [f], xstrat [3 cm sets]; grades into biotrbtd Mdst, Stylo Lam

Grnst, clast, overlying Grnst, ooid [f], pldl grading to Pckst 2 tone Lam
v lt gy Bndst? [tabular biostrome], adj Grnst; pldl, ooid [m], clast [3 mm]; srtl
repeated 6cm bands si Foss; vug + intconn F

v lt gy Grnst, skltl, clast [rndd Grnst], pldl B.O., vugs under clasts [F?]
v lt gy Grnst, pldl? [vf], sd, lamd cpctd, nodular at base; Styl
lt brn gy Grnst, pldl [vf], xstrat, lenses Grnst, clast, pldl cpctd
lt gy Grnst, pldl [f]; intbdd Mdst wavy cpctn Lam

lt gy cycles-Grnst, vf pldl; grading to (biotrbtd) Mdst; eroded and repeated 2 tone Lam

lt gy Mdst, biotrbtd, intbdd Bckst, pldl [vf] vf rexlzd; styl cpctd, vp orn 2 tone Lam, Nod

v lt olv gy Grnst, ooid [m], clast [ooid Grnst] at base; upper mtl Wckst/Bndst, ooid, skltl; vug, irreg, lvg calcite infil

lt brn gy Pckst?, pldl [vf], Lamd p orng mtl rexlzd
lt olv gy Mdst, (biotrbtd); intbdd Grnst, pldl [vf], (clast) cpctd; Styl
lt brn gy Grnst, clast [lrg, rndd, Mdst + f pldl Grnst]; intbdd Mdst, biotrbtd cpctd; gy
m lt brn gy Grnst, pldl [vf], clast [f pldl Grnst] B O cpctd
lt olv gy lt brn gy; intbdd; Grnst, vf pldl? cpctd; 2 tone Lam
v lt olv gy Grnst, pldl [vf], sd, grades into Mdst (biotrbtd) cpctd
v lt olv gy Grnst, clast [sd, pldl Grnst] cpctd; no mlt; 2 tone; styl
lt olv gy Mdst, (biotrbtd); overlain by pldl Grnst
lt olv gy Grnst clast [rndd, lat Mdst] → Lateral

Grnst, ooid [m-c], clast [rndd, Mdst]; adj Grnst, sd [c], clast [Mdst, skltl; wckst], ooid, pisolite

Fault?

lt gy Mcrt, Lamd 2 tone Lam + Brec
lt gy Mdst, Wckst, biotrbtd vf rexlzd, cpctd, 2 tone, Cht Nod
v lt olv gy Bndst, bioshome [domed, shomot, 30 cm D]: adj Brec rexlzd — Lateral
m gy Mdst?, Wckst? Lenses rexlzd, 2 tone bands [30%]
m lt gy Bndst, domed [50 cm D], alg gy orn uni 2 tone [70%] cpctd
lt olv gy clast [v lrg rndd + skltl pldl Grnst] Vugs under clasts; orng cml

lt gy Grnst, clast [rndd lath, Mdst + pldl Grnst], skltl; intbdd Mdst, f pldl Cunst cyclic 2 tone within biotrbtd Mdst

m lt gy Grnst, clast [ooid Grnst, rndd lath], ooid BO
pk gy Grnst, skltl; fri wthrd rexlzd
v lt brn gy Grnst, vf, ooid; to Bchst, skltl, eroded; Grnst, clast, skltl; 2 tone Lam

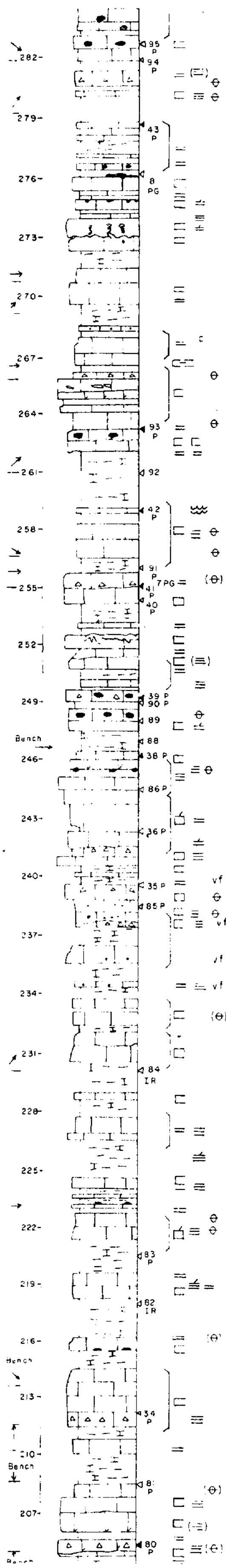
m gy Grnst, skltl [frag], clast [lath subang, Pckst] BO si
m olv gy Bndst? skltl; Chaotic 2 tone breccia of top fn interbands Mdst, desiccn cracks [Grnst infil] 2 tone
v lt brn gy Grnst, skltl [frag], ooid, (clast) rexlzd; vug, si foss
m gy Bnst; intbdd Grnst, clast 2 tone, Brec; nodules; rexlzd
m gy intbdd Grnst, pldl, sd, Xlamd; Grnst, clast [sd, f Grnst]; erosional
m gy Grnst, clast [lrg, sd Grnst, rndd, laths], imbrctd

lt olv gy Grnst, pldl [f], clast [rndd, lrg laths, Mdst], skltl vib
v lt brn Mcrt oph, rexlzd; Cht Nod
lt olv g Grnst ooid, clast [ooid Grnst]; sol Stromat [Skltl Wckst] Cht
v lt olv gy Grnst, clast [lrg, rndd, vf pldl skltl Grnst], pldl, clast vug

m olv gy Mdst, biotrbtd [sm + lrg]; (eroded Grnst) 2 tone [70%]
lt olv gy Mcrt; Lamd rexlzd, 2 tone; cpctd
m olv gy Bndst, stromat [clmnr, 6 cm D], Wckt-Mdst mtx (si), Vugs
lt gy Grnst, ooid [c] to grapestone; m clast + sd bands Styl
lt olv gy Grnst, pldl? [vf], skltl cpctd; B O
v lt olv gy Pckst, pldl, skltl, grading to Wckst, skltlt, to Grnst, clast, skltl Vugs, F?
v lt olv gy intbdd Grnst, pldl [vf] ooid [vf], skltl; Grnst, clast [rndd, ooid Grnst] Vug, 2 tone

m gy Grnst, ooid [m, sph + superficial] Cht, B O; Styl cpctd at base
lt olv gy Grnst pldl [f], ooid, clast bands [pldl, ooid Grnst] Vugs, vadose?
v lt olv gy Grnst, pldl? [vf], skltl [frags]; (clast bands) cpctd; si rexlzd
m olv gy intbdd Grnst, clast & ooid Grnst; Mdst, biotrbtd [vf] cpctd, 2 tone
m olv gy Grnst, ooid [vf], (Lamd) rexlzd; yel gy bands
lt brn gy Grnst, ooid [m-c], (skltl); Patches Bndst?, ooid, skltl, alg? Vugs, m pnk + wh

v lt olv gy Grnst, ooid [vf], skltl, xlamd; intbdd Grnst clast Vug, lrg, Calcite intbdd 2 tone Lam
v lt gy Grnst, ooid [vf]; intbdd with Grnst, clast [rndd, ooidd Grnst], ooid, Styl, vug
v lt olv gy Grnst, ooid [vf], srt, bndd; intbdd biotrbtd Mdst, intbdd Grnst, clast random ms Vug calc infil
v lt olv gy clast [lath, rndd, 1-3 cm, ooid Grnst] Vug under clasts; F?
v lt gy Grnst, pldl [vf], srt v fn Lam 2 tone intbdd
m olv gy Wckst?, pldl [vf]; slumpstrures md orng pk 2 tone Lam, Brec [nodule]
v lt brn Grnst, clast [Mdst, lath, rndd] skltl interbanded 2 tone Lam



v lt olv gy clast [lath, rndd, 1-3 cm, ooid Grnst]: Vug under clasts, F ?
v lt gy Grnst, pldl [vf], srt: v tn Lam 2 tone intbdd
m olv gy Wckst?, pldl [vf]; slumpstrures: md orng pk 2 tone Lam, Brec [nodule]

v lt brn Grnst, clast [Mdst, lath, rndd] skltl: interbanded 2 tone Lam
v lt brn Grnst, pldl [vf], srt: interbanded 2 tone
m lt gy Mdst, Wckst: rexlzd, cpctd 2 tone wavy Breccia, Vug, irreg, calcite
m lt gy wckst, vf, (Lamd): 2 tone wavy bands [p red] cpctn

lt brn gy, gy orng pk Grnst, ooid, skltl, clast, oncolitic; Bndst ?:
lt brn Grnst, clast [rndd, subeq, lrg, Mdst + f pldl Grnst], skltl, pldl: Vugs underclasts
lt olv gy Grnst, clast [lrg, vari, Mdst + ooid Grnst]; intbndd vf pldl Grnst + skltl Grnst: Vug under clast si Foss
lt brn gy Grnst, ooid [c], skltl, clast [f pldl Grnst, rndd]; grades to Bndst ? skltl, ooid: vug, calc infil: si Foss
lt brn gy Grnst, pldl ? [vf]: cpctd: 2 tone Lam
pk gy Grnst, intbdd f pldl skltl Grnst; [lrg, rndd, Pckst]; si Foss. vugs under clasts
lt gy Pckst ? pldl [vf], ooid ? (clast) [sm, lath] rexlzd, cpctd, 2 tone gyon: dol vug
lt orn Grnst, ooid [m-c], skltl, clast: rexlzd; si Foss
lt gy Grnst, clast [lrg, lath, rndd, Mdst, sd Grnst]: cpcld; Vug, si infill

gy pk Grnst, pldl [vf]: rexlzd; 2 tone
v lt brn gy Grnst, pldl [elong, c, rndd], clast; intbdd Grnst, pldl [vf]: 2 tone rexlzd zones
lt olv gy pldl [vf], ooid [vf], clast [sm, rndd, Grnst]: rexlzd, Vug, F, infil

m orn pk Grnst, sd, clast
lt gy Grnst, clast [sm, lath, ang-rndd, Mdst-Grnst], pldl [vf]: rexlzd
v lt olv gy Grnst, clast [lrg, rndd, lath, Mdst + ooid [f]: Vugs under clasts
m lt gy Mdst ?: rexlzd; lt gy orn 2 tone bands; cpcld; Brec
lt brn gy Bndst, stromat [fnstrt Mdst], domed, Clmnr: Cht
m lt gy Grnst, clast [rndd, lrg, eg-lath, pldl Grnst], pldl: Vug [under gains, dolcr F infil]
lt brn gy Mdst, biotrbtd [(lrg) + vsm]: (2 tone Lam), orn; B O.

lt brn gy Grnst, clast [rndd, lrg, Mdst + f Grnst], pldl [m]; (srt): B O; (si)
lt m gy Wckst ?, pldl [vf] ?

v lt olv gy Grnst, clast, pldl [vf], eroded [soln]; Grnst, ooid, pldl, clast, infilling Vug in lower Grnst
v lt olv gy Wckst ?; intbndd Grnst, clast, pldl [vf]: (rexlzd): 2 tone Lam; Vugs
lt olv gy Wckst? pldl: rexlzd, 2 tone wisps of gy orn, 2mm wh dol nodules
v lt olv gy Mdst, Wckst, biotrbtd, pldl [vf]: rexlzd; m orng pk 2 tone bands

lt olv gy Mdst, fnstrt: 2 tone bands and Brec
lt olv gy Wckst ?, clast [v 5 m], pldl, skltl; fnstrt [soil ?]: dol Fnstr [gy pk]
lt brn gy Grnst, ooid [m], clast, skltl; erosional; Stromat [Clmnr, fnstrt]: Si Foss

lt brn gy Grnst, ooid [f]; bnds of Grnst, clast [rndd Grnst], ooid: Vugs
lt olv gy Grnst, clast [ooid Grnst], pldl: cpctd; vug, dol + calc infill; si; Styl
m gy Grnst, ooid [f], clast [lrg, rndd, Grnst + Mdst], (srt): B.O; si
m brn gy Grnst, pldl [vf], (clast) [sm, ang-rndd] (skltl): cpctd; (rexlzd); B O

lt brn gy Grnst ?, vf pldl; ptch Grnst, clast: (dol); cpctd; rexlzd
m gy Mdst; Grnst, vf pldl overlying: 2 tone cpctn; B.O
m gy Bndst [fnstrt Md], wavy, tabular, c̄ Brec: B.O.; cht Nod
lt gy Mdst, (biotrbtd); eroded c̄ overlying pldl Grnst: p red mtl 2 tone; cht Nod
v lt brn gy Grnst, clast [lrg, rndd, Mdst, sm], pldl [lrg] granding up pldl Grnst: B O

m olv gy Bndst ? md, clast, Skltl; chaotic: md orn pk Ptch, vug infill, B.O, si foss fnstrt bands
m lt gy Mdst ?, Wckst, bands; some eroded infils by Grnst, clast: cpctd; 2 tone
lt brn gy Mdst ?, (Lamd): 2 tone; rexlzd; cpctd

m brn gy Bndst [fnstrt Md]; Lam: cpcld Lam; 2 tone; B O

v lt olv gy Mcrt [2 tone] overlain by Grnst, clast ?: Vug, dol, Lacy [yel orn]
lt olv gy Grnst, ooid [f]; xstrat; overlying Grnst, clast [vari], Vug, dol or F infill
lt olv gy Pckst ? vf pldl; grading to Mcrt: rexlzd: 2 tone Lam + Brec, repeated
m lt gy Grnst, clast [rndd, lrg + sm], grading to Mdst rind; eroded. cyclic
lt gy Grnst, clast [lrg, rndd, sol Grnst]: dol Mtx
Grnst, Clast [lrg, rndd, vari], skltl, pldl; Mdst, biotrbtd: Brec 2 tone
lt gy Grnst, sd, pldl, Lamd: cpctd; sl rexlzd
v lt gy, orn Grnst, sd: dol, Brec at base; cpctd

Mdst, bands clasts: rexlzd; 2 tone in Mdst
lt gy Grnst, clast [lrg, lath, rndd, sd Grnst], sd, vari, Xstrat: (2 tone)
lt olv gy Grnst, sd, pldl ? [vf], (clast)

olv gy Wckst ? pldl [vf], skltl [frags], : 2 tone wisps, Foss si
lt gy Bndst ? pldl [vf], skltl [frags; pokes Wckst si Foss
lt gy Grnst, clast [lrg, lath, rndd], (pldl): Vugs under clasts
lt gy Grnst, clast [lrg, lath, rndd, Lamd sd Grnst], pldl [f], (skltl), imbrctd: Vugs under clasts [yel calc infil]

lt brn gy Grnst, clast [lrg, lath, rndd, xlamd Grnst], pldl, (skltl)
lt brn gy Grnst, pldl [elong, rndd], clast [rndd, lath, vari]: B O
v lt gy Mcrt: rexlzd; 2 tone banded, gy orng
lt olv gy Grnst [f], (clast) [lath, rndd, Mdst]
lt olv gy Mcrt; fiss: rexlzd, (py)

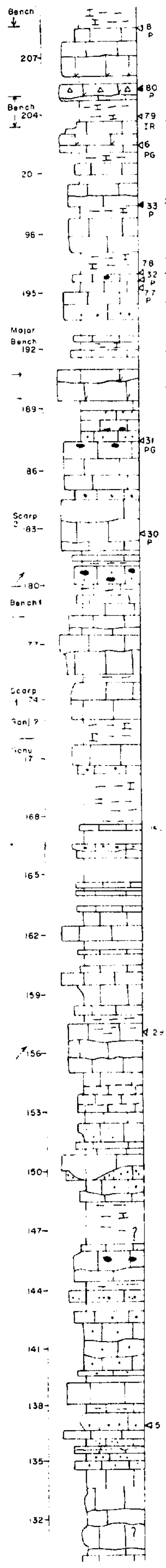
lt olv gy Mdst ? - Pckst, pldl ?: rexlzd; gy orng 2 tone Lam + Brec
m gy Grnst, clast [lrg rndd, Mdst + Grnst], pldl [m-c]; (srt): B O; Cht
v lt gy Mdst, biotrbtd; eroded + overlain by Grnst, pldl, clast: xstrat to Mdst 2 tone
yel gy Mdst, fnstrt, Lamd: 2 tone Lamd, lt orn, within Mdst

m brn gy Grnst, ooid [m], clast [rndd, Mdst, Grnst], fnstrt [lrg, horiz]: B O
v lt gy Grnst, clast [lrg, rndd, Wckst ?], ooid [vf]; grades up to pldl Pckst-Wckst, repeated: Vugs under clasts, F infil; rexlzd Lam

lt brn gy Mdst, biotrbtd; eroded & overlain by Grnst, clast [rndd, Mdst], pldl
m brn gy Bndst, stromat [tabular, stratiform, undulose, gently convex fnstrt Mdst]: B O; Cht

Grnst, Mcrt intbdd 2 tone
lt gy Grnst, pldl [f], Lamd; grades up to Pckst ?: 2 tone, rexlzd, yel gy
v lt gy Pckst, skltl, pldl; to Grnst, pldl, clast [lath, subang, sm, Mdst]: Vug under clasts, F ?
m brn gy Pckst, pldl, skltl, (clast); to Mdst: clast bands rexlzd: cpctr brec bands
m olv gy Grnst, pldl [f], ooid ?; clast [ang + rndd, eq, sd Grnst, Mdst]; srt: B O

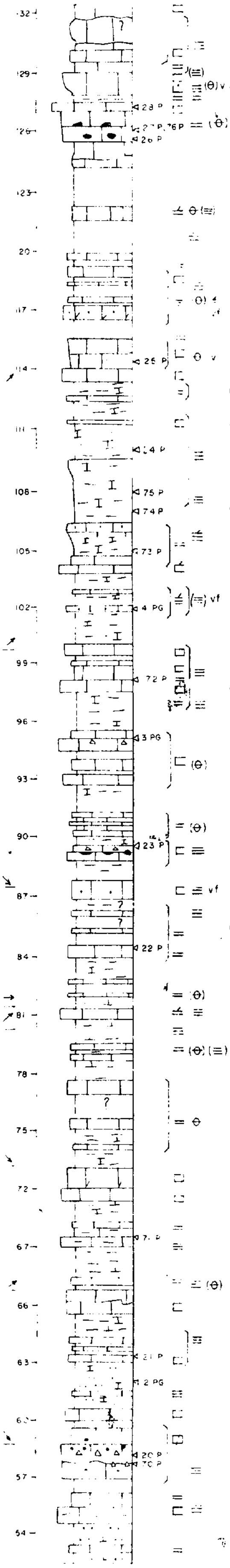
v lt gy Mdst, biotrbtd, overlying Grnst, clast [tn laths; irrg]; srt: cpctd
lt olv gy Grnst-Wckst-Mdst: 2 tone; yel, orng Lam; Styl
m lt olv gy Grnst-Pckst, pldl, clast: yel orn 2 tone dol Lam irreg
lt olv gy Grnst, clast, pldl, skltl; fri: B O.; Vug, calc infil
lt olv gy Mdst, (biotrbtd): rexlzd: 2 tone bands, dol, orng
lt gy Grnst, clast [irreg, rndd, Mdst, lath], pldl, skltl



v lt gy Mdst, biotrbtd, overlying Grnst, clast [tn laths; irrg]; srt : cpctd
lt olv gy Grnst - Wckst - Mdst : 2 tone ; yel, orng Lam; Styl
m lt olv gy Grnst - Pckst, pldl, clast : yel orn 2 tone dol Lam irreg
lt olv gy Grnst, clast, pldl, skltl; fri : B.O.; Vug, calc infil
lt olv gy Mdst, (biotrbtd) : rexlzd : 2 tone bands, dol, orng
lt gy Grnst, clast [irreg, rndd, Mdst, lath], pldl, skltl
v lt gy Mdst to pldl Grnst, intbanded : Styl, sutured. Grnst, ooid, m gy, overlying
lt orng
v lt gy Pckst, Mdst, pldl : cpctd; Styl [vert + horiz]; dol 2 tone
v lt gy Mdst, (fnstrt), alg?; Grnst, clast : cpctd ; 2 tone; rexlzd
lt gy Grnst, pldl, clast, Skltl; Grnst, pldl; Wckstr, pldl : 2 tone inwcksto; v m Lam
lt olv gy Grnst, pldl, (clast), (Lamd) : cpdtn Lam + m tl
lt gy Grnst, clast, pldl : rexlzd to top; banded brec
lt brn gy Mdst; eroded, overlain by Grnst, clast, pldl, grades to Pckst, pldl; ... B C
m lt gy Bndst [stromat, clmnr ; Mdst, fnstrt, Lamd], tabular B C, Cht Mcrt rexlzd B C
v lt gy Mdst ? (fnstrt); grd m [ ] to Grnst, pldl [vf]; rexlzd; cpctd
v lt gy Grnst, vf sd, pldl, XLamd; intbdd Mdst : rexlzd
lt olv gy Grnst, clast [eq., rndd, gran, Mdst], pldl, ooid : fri B C
lt gy Grnst, clast [gran, rndd], pldl, ooid ; srt B O
v lt gy Mdst; eroded, infilling Grnst, clast, pldl; Pckst; cycwi : (rexlzd)
p pk Grnst ?, XStrat : rexlzd, porcellaneous; Syneresis in 2 tone
v lt gy Grnst, vf : Mdst ? 2 tone banding ; B O
lt gy Mcrt [Grnst ?] 2 tone, cpctd
f lt gy Grnst, pldl [f] sd, intLamd Mdst [biotrbld] : 2 tone
v lt gy Mdst, intbdd with Grnst, clast [lath, sm], pldl : 2 tone, F infil of biotrbn
v lt gy Mdst, (skltl); Wckst (rexlzd); (2 tone) banding
m brn gy Mdst, biotrbtd [tn, vert] (2 tone)
lt brn gy Grnst, clast [Mdst + sd Grnst, rndd, lath], pldl : cpctd
lt gy Grnst, pldl, intbdd Mcrt ; vf rexlzd; 2 tone, (py)
lt brn gy, Grnst, pldl [vf] Wckst ? intrbdd : cpctd ; 2 tone, pk gy, Lamd : (py)
m lt olv gy intbdd Wckst + Grnst, pldl; Mcrt : 2 tone ; cpctd ; (Cht Nod)
m lt gy Grnst, sd, pldl [vf], XLamd, intbdd Mcrt : 2 tone, cpctd, Cht Nod; B O
m lt gy Grnst, clast [eq, rndd ~ 2 mm] pldl [m], (Srt)
m lt gy Grnst, clast [eq, rndd, ? - 4 mm], pldl [f]; (srt); sharp contact
v lt gy Grnst, clast, pldl, grading up to Wckst with eroded surface ; cyclic
v lt gy Grnst, clast [Lamd Mdst, Laths, sm], pldl; erosional chanel
wh, lt olv gy Mdst, Lamd : v cpctd ; vf cpctd ; vf cpctn Lam

cf 98m

v lt gy Mdst, biotrbtd; Grnst, pldl, clast : 2 tone bands, lt gy orn, replacing Mdst
v lt gy Grnst, clast, pldl ; vf rexlzd
v lt gy Grnst, clast, pldl, gradis three Pckst, skltl to Mdst : vf rexlzd eroded; repeate x 4
v lt gy Grnst, vf, sd; overlying Grnst, clast
, cpctd; rexlzd
v lt gy Grnst ? : rexlzd [f]; joint 2 tone
lt gy Grnst, clast [rndd, sd Grnst], pldl; grades up to Xstrat Grnst, sd, pldl 2 tone ?
v lt gy Grnst, pldl, clast [m-c]
v lt gy Grnst, ooid [f, tn Lam]; srt ; biotrbtd [yel calc infil]
lt yel brn Grnst, pldl [vf] uni; Xstrat [sets 2 - 8 cm] : 2 tone bands [1 - 15 cm]
lt yel Mdst ? [2 tone], overlying Grnst, clast, pldl, fnstrt; B.O
lt gy
lt gy Grnst, clast [rndd Mdst], pldl Pckst], pldl; vari
lt olv gy Pckst, pldl, fnstrt : 2 tone ; cpctd ; Lamd ; F in vert frac ; py
v lt gy Grnst, pldl [m - vf] graded to Mdst; eroded overlain by Grnst, clasts pldl
v lt gy Grnst, clast, pldl, fining up to Mdst [indurated eroded], cycle repeated : super inposed
2 tone with Mdst
lt gy Bands Grnst, pldl [m] grading up to Mdst; erosione base intbdd 2 tone
lt gy Grnst, pldl [f], clast [vc, lath]; Xstrat ; srt intbdd decalc Mdst
lt gy Grnst, pldl [f], clast [vc], Xsrat, srt, intbdd with Mdst, desicca cracks · decalcified
lt brn gy Grnst pldl [vf], clast [c], sd; srt, (Xstrat) : sl rexlzd
m orn gy Grnst, clast [vc lath, lrg, alg + f pldl Grnst], srt, vari
v lt gy Grnst, clasts, at base, pisolitic, grapestone, pldl, clast : indurated Lam
m lt gy Grnst, sd, pldl [vf]; Xstrat [low angle]; eroded top
m lt gy Grnst; sd, pldl [vf]; overlyn Grnst, clast ; rexlzd
v lt gy Grnst, sd, pldl [vf]; intbdd Mdst (fnstrt) rexlzd, B.O.
decalcified 2 tone ?
m gy Mdst; Pckst, skltl [inCht] : m olv gy 2 tone; Cht Nod
m gy intlamd pldl Grnst + Wckst, grdln : Vug, sm F ? ; 2 tone
m gy Mdst ? uni : vf rexlzd ; m olv gy 2 tone ; frac in Mdst
v lt gy Grnst ?, sd pldl [vf], Lamd; Xstrat [10cm sets] : rexlzd ; Styl
lt gy Grnst, sd, pldl [vf]; overlying Grnst, clast [rndd, eq], pldl [c]
lt gy Grnst, pldl [vf], sd, xlamd, Lamd : cpctd; sl rexlzd
m lt gy Grnst, sd, pldl [vf] ?, Lamd, xLamd; intbdd Grnst, clast [sd Grnst], pldl : cpctd
m lt gy Grnst + Pckst, pldl ? (biotrbld); eroded, overlain by Grnst, clast [pldl]
lt brn gy Grnst, pldl, clast [rndd], skltl; intbdd Wckst, ooid, skltl : Vugs under clasts : 2 tone
with desic Crks
m brn gy Grnst, pldl, (clast), (Skltl), fnstrt ; intbdd Bndst, pldl, fnstrt
lt brn gy Grnst, pldl [vf]; Xstrat, homog + biotrbld at top
lt brn gy Grnst, pldl [vf], sd : rexlzd; 2 tone pk gy Lam
lt m gy Grnst, clast [lath, lrg, rndd, sd Grnst + Mdst], imbricate ; Xstrat : Styl
m lt gy Grnst, sd, pldl [vf], Xlamd, biotrbld, eroded, overlain by clast Grnst
lt gy Grnst, sd, pldl [vf]; Xlamd : (py), vf dissem
m brn gy Grnst, clast, [rndd Mdst + sd pldl Grnst]; (srt) : sm Vug, F infill
: 2 tone ?
v lt gy Mdst; Mdst, (fnstrt) : 2 tone Lam dominant, lt yel orng
m lt g. Mdst, (fnstrt) [elongate] · m yel orn Lam [tn 2 tone] · F in Vug



v lt gy Mdst; Mdst,(fnstrt)·2 tone Lam dominant, lt yel orng
m lt gy Mdst,(fnstrt)[elongate]:m yel orn Lam [tn 2 tone]:F in Vug
lt gy Grnst, clast [alg]; overlain by Mdst; overlain by Grnst, clast [sm]:F vugs in Grnst
(Θ) v lt gy Wckst ? (biotrbtd), dessicn cracked ; xstrat Grnst above : rexlzd, 2 tone
lt orng Grnst, clast [alg coated, alg Lam, laths]; altng Mdst [infil of sm vugs
(Θ) m lt gy Mdst; Mdst, fnstrt [elong], Lamd ; Grnst ooid : v cpctd [lt orn 2 tone] : cht Nod

v lt gy Grnst, ooid, clast [rndd, lrg, ooid Grnst], pldl : vf rexlzd
: 2 tone

lt gy Grnst, pldl, skltl
lt gy Grnst, pldl, [f, elong], skltl [rndd frags]: rexlzd ; (B O)
lt brn gy Grnst ?, pldl : vf rexlzd ; (Styl); (B O.) ; F ?
2 tone
m lt gy lt orn gy Mdst; Grnst, pldl, fnstrt [patches]: Vug, calc + vf py; B O
v lt gy Grnst, pldl ?, Xstrat, Lamd, (biotrbtd) m rexlzd, dol : vf dissempy
m lt brn gy Grnst, pldl ? [vf], clast [lrg, lath, pldl Grnst], skltl [frags] Vug, calc
m lt brn gy Wckst ?, pldl ? [vf]: rexlzd, vf; B O.
v p orng Mdst ? relict wisps 2 tone
lt olv gy Mdst ?, Lamd, biotrbtd, syneresis · vp orng 2 tone Mcrt replacement; styl, sutured [2-5-10 cm amplitude]
v lt olv gy Grnst, pldl, skltl; faint Lam, rexlzd

v lt orn Wckst, pldl, fnstrt : (rexlzd); Vug, soln, m s, spar[wh]
m lt gy Mdst : pk gy Lam [2 tone]; rexlzd

wh Marl [decalcifield Lst ?]; fri
lt gy Grnst ? ooid ?, sd, skltl : rexlzd; decalcified, dol on Lam; (py)
lt yel Grnst ?, lenses; vfxL dol; Vug, sm, ms dol infil
lt gy Grnst, clast [lrg, rndd Mdst, Grnst], pldl [vari] rexlzd to top
lt gy Grnst, ooid [sph, m], clast [rndd, eq to lath, Mdst]; Xstrat [3-5 cm]: cpctd — Lateral
wh Claystone, fiss ; fri
lt gy Grnst ? pldl [f]((skltl)): sl rexlzd
vf lt gy Grnst, sd, pldl ? (skltl): sl rexlzd ; styl enhanded Lam

v lt yel brn Grnst, pldl, clast [rndd, lath], to Wckst, pldl; vari : Vug, Brec @ top
lt olv gy Wckst
lt olv gy Wckst ? pldl: vf rexlzd ; 2 tone Lam, yel gy mtl banded
v lt yel brn Grnst, clast [lath rndd, pldl Grnst to 3cm], pldl [f], skltl
lt gy Bndst ? Grnst, clast [ang, equant], pldl, skltl : 2 tone Brec bands ; sl foss sec. 202/
lt yel gy Mdst, (fnstrt); Wckst, pldl [vf] ?, intbd with shale
calcreted surface
lt yel gy Pckst ?, pldl, sklt [compl + frags]: 2 tone wisps [yel, calc]; rexlzd
v lt yel orng Grnst, ooid, (skltl), srt ; up to Pckst-Grnst, pldl, ooid, (skltl): 2 tone Brec
(Θ) lt gy Wckst, skltl; overlying Grnst, clast, pldl : Styl contact; 2 tone in Wckst
lt gy Wckst, skltl, pldl; Grnst, pldl, clast [vari, equant], skltl intbdd : B.O, vug, calcite infil

lt yel gy; Grnst, f pldl at base [biotrbtd] to Grnst, pldl, clast [irreg], skltl @ top
(Θ) lt gy Wckst ?, fnstrt, biotrbtd : 2 tone mott [fnstr + Biotrbn preserved as spav infil]
lt gy Grnst, pldl + Grnst, clast, pldl : sl rexlzd ; 2 tone Brec [calc, mtx]
m yel brn Bndst [pldl, md, skltl], ((srt)): Sl foss ; Vug, irreg, dol or calc + py infil

vf lt gy Grnst, pldl ? [vf] skltl frags at top : vf rexlzd, cpctn Lam c̄ sol conc
m brn gy Grnst ? pldl ? : vf (rexlzd); cpcln Lam conc with f dol rombos concentrated
v lt gy Mdst, fnstrt ; thrombolites : 2 tone cpcln band
m lt gy Grnst, clast, grading to Brndst ? fnstrt, skltl : overlying 2 tone brec
lt olv gy Grnst, clast [lrg, vari, rndd, wckst ?], (pldl), (skltl): Vug under clasts

(Θ) m gy Grnst, pldl [f], skltl [frags]; biotrbtd [wert, conical]: rexlzd [f]
lt brn gy Grnst, pldl [f-m], (clast); srt ; overlyin clast, pldl Grnst ; Xstrat [5-10 cm sets]
wh Claystone, fri, fiss
(Θ) (≡) yel gy, v lt gy Wckst ?, pldl ? [vf], fnstrt [horiz, elong], Mdst intbdd : rexlzd, (py)

lt gy, lt yel gy Grnst, pldl [vc, irreg] to clast [irreg, sm, srt]; clast patches

Θ lt gy Wckst ? pldl [f], Lamd @ base, homog + biotrbtd at top
m gy Wckst ?, vf ; adj Grnst, clast [Wckst], pldl : rexlzd
lt gy, yel gy Bndst ? [pldl] domes · retiakate, irreg yel gy 2 tone, dol ; (frac), F infil ?
adj Grnst, clast : 2 tone alteration
lt gy Grnst, clast [irreg, equant, rndd, Wckst], pldl ; some Alg Wckst pods : Styl
at base, clasts [lath, 3cm, rndd Mdst]: fracturing
lt brn gy Wckst ?, vf, fnstrt [horiz elong, spar filled]:(B O.)
lt brn gy Wckst ?, pldl ?, Lamd ; fiss : rexlzd, vf ; cpld ; B.O ; Vug, spav, calc

(Θ) lt yel gy Mdst, Grnst [pldl]; intbdd + overlain by Grnst, clast dol ; F ? in biotrbn
lt gy Grnst, pldl [vari, orng-rndd], clast [Mdst ? rndd], (srt) : py cf 202/18
lt gy Grnst, pldl [vari, rndd], ooid ? (skltl) : srt grdtnl : (Styl)

lt gy, lt olv gy Pckst ?, Lamd : 2 tone Lam, grdtnl
lt gy, lt olv gy Pckst ? fnstrt, Lamd : 2 tone ; grdtnl Lam ; (py)
calcreted rubble

lt gy Grnst, pldl [vari], clast [sm, rndd, Pckst], fnstrt : Vug, orng, calc
lt gy Grnst, pldl [f-m], (skltl); with patches clast [irreg, Mdst]: 2 tone at base

lt brn gy Bnds [vari fabric], md pldl, skltl : Vug [irreg]; sl Nautiloids
: Brec ; vug sl + calc infil
brn gy Grnst ; Bndst ? vugs, irrg, sl : rexlzd ; 2 tone, dol brec ; Styl
lt gy Wckst ? - Mdst : 2 tone ; rexlzd ; Styl : sl foss

lt-m gy Grnst, pldl [vf], clast ; intbdd Mdst, Skltl : F ? or dol in mtx
lt m gy Grnst, pldl, Wckst, Skltl ; with erosive pkches of Grnst, clast, Skltl 2 tone, B O.
lt gy Grst, clast, pldl, skltl : grades into Wckst ; skltl : sl Foss ; 2 tone
lt gy Grnst, clast [rndd, skltl, pldl Grnst], Skltl : mtx cspar ; F ? ; sl foss
lt gy Grnst ? pldl [vf]: Grnst clast pldl : rexlzd : 2 tone : cpctn dol B ? F ?

lt gy Grst, clast, pldl, skltl: grades into Wckst, skltl: sl foss, 2 tone

lt gy Grnst, clast [rndd, skltl, pldl Grnst], Skltl: mtx cspar; F ?; sl foss

lt gy Grnst ? pldl [vf]; Grnst, clast, pldl : rexlzd; 2 tone; cpctn; dol; B.O., F ?

lt gy Bndst, stromat [md]; adj + overlying Grnst, clast [Bndst, rndd], Skltl
lt gy Grnst, ooid [m], (clast) [sm]: Xstrat, 20 cm, set : vf rexlzd; Styl

p orn fri, fiss

md orn pk Mdst ? skltl : rexlzd; '2 tone' as below; py

v lt gy Mdst, f biotrbtd, (skltl); intbdd Grnst, clast [mdst], pldl; 2 tone brec; py

lt gy; Mdst (skltl) 2 tone m red orn bands; cpcld; py
m brn gy Mdst; intbdd Grnst, clast [rndd, Mdst], pldl, (skltl) B.O.; cpctd
m red gy Grnst, pldl [c], clast [c, rdd, red]
m olv gy Grnst, pldl [m]; overlain by Grnst, pldl, clast [rndd, lath, Mdst]: B.O, py
m olv gy Mdst? skltl, uni : aph, rexlzd; B.O.

brn gy Mcrd, pldl (vf), Lamd : cht Nod; F in veins; B.O : cpctn Lam

v lt gy Grnst, Pkst, pldl [vf]
lt gy Grnst ? pldl [vf], Lamd; overlain by Grnst, clast [rndd, 3-3 cm], pldl [lrg]: py in cmt
lt yel gy Grnst, pldl [vf], srt : (B.O.)
v lt gy Lamd : tn Lam of pk gy calcite 2 tone : Styl
v lt gy Wckst ? (biotrbtd) Lamd of lt pk gy : calcite - 2 tone
md brn gy Grnst, clast [rndd - ang, irreg, Mdst, reddish], pldl : (srt)
lt brn gy Bndst, stromat ? [domed], md, skltl, pldl, clast : B.O.
lt brn gy Grnst; Pckst, clast [rndd, irreg, red Mdst 5-1 mm] pldl, (skltl); (srt)

lt gy Grnst, pldl, clast, Skltl [si], (srt); overlying Pckst, pldl [f], Lamd
lt gy Grnst, grapeshore [ooid nuclei], pldl; styl
lt gy Wckst ? (clast)
gy orng Grnst, ooid [dol], pldl [vf]; Xstrat [8-3 cm sets]; intbndd Mdst ?, biotrbtd
lt bl gy Mdst ? (fnstrt); Lamd: intlamd yel calc bands, bifurcate
Styl Lam

lt orng Grnst, pldl [vf], skltl, sd : Styl, Lam
v lt gy brn Grnst, pldl [vf], sd; unif; (sd xlam, cpctn

calcrete; calc Sltst

lt orng Grnst, pldl [c], clast [rndd, 3-4 mm lath], (skltl) : srt : (Styl)

lt orng Grnst, ooid, Grnst, skltl; ooid [dol], (clast); xstrat : Styl

lt orn yel Grnst, ooid [f], (skltl); srt; xstrt [5 cm] Styl

lt yel gy Grnst, pldl [f]; horiz lamd : rexlzd; styl enhanced

lt yel orng Grnst, ooid, (skltl); xstrat [5-10 cm sets, mod angle,
herringbone : f rexlzd; styl Lam, sl Lam

lt yel brn Grnst, ooid, (skltl), Xstrat : dol repl ooids; f rexlzd; (styl)

lt orng pk Grnst, ooid, skltl [rndd]; Xstrat, vari from 40 cm
sets to 15 cm festoons with
erosive tops. skltl debris
at base
rexlzd, m; dol ?; Styl, Lamd; (py)

dk yel orng Grnst, ooid [m, spn, dol]: sl Rings; vug, calc; (py)

lt orng Grnst, pldl [sm], skltl orn Dol [repl grn]; (py)
Xstrat [30 cm sets, erosive base, mod angle]

lt yel fri f rexlzd; por

lt orng Grnst, ?, pldl [vf], sd; (Lam), sd, v tn : f rexlzd

lt md gy + lt orn Grnst, sd, pldl [f, uni]: sl rexlzd

grdtnl alteration

Lateral

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APPENDIX: CHECK LIST OF BLACK MOUNTAIN CONODONTS AND RECENT SYNONYMIES

This list is centred about the conodonts originally described by Druce & Jones (1971) from Black Mountain, and material subsequently described by Nicoll (1990, 1991) and Nicoll & Shergold (1991). Recent synonymies for selected groups of taxa have been adopted from An (1982), Bagnoli, Barnes & Stevens (1987), Chen & Gong (1986), Landing, Barnes & Stevens (1986), Miller (1980, 1984), Wang (1985) and Zhang & Xiang (1983).

Acanthodus costatus Druce & Jones

Acanthodus uncinatus Furnish
[= New gen A., n. sp. A plus *Drepanodus simplex sensu* Druce & Jones 1971]

Acodus oneotensis Furnish
[= *Oneotodus*? Landing & others 1986; = *Rossodus manitouensis* Repetski & Ethington, 1983]

Chosonodina herfurthi Müller

Clavohamulus elongatus Miller

Clavohamulus hintzei Miller

Clavohamulus sp. n. A

Clavohamulus sp. n. B.

Ceolocerodontus burkei Druce & Jones
[*Proconodontus muelleri* Miller or other species of *Proconodontus* like *P. posterocostatus*, *P. serratus* and *P. tenuiserratus*, fide Miller (1980)].

Coelocerodontus primitivus (Müller)

Coelocerodontus rotundatus Druce & Jones
[= *Prooneotodus rotundatus* (Druce & Jones) fide Chen & Gong (1986)]

Coelocerodontus tricarinatus (Nogami)
[= *Nogamiconus tricarinatus* (Nogami) fide Miller (1980)]

Cordylodus angulatus Pander

Cordylodus caboti Bagnoli, Barnes & Stevens

Cordylodus caseyi Druce & Jones

Cordylodus intermedius Furnish

[= *Cordylodus angulatus* Pander, Nicoll (1990)]

Cordylodus lindstromi Druce & Jones

Cordylodus oklahomensis Müller
[= *Cordylodus* sp. nov. A : Nicoll (1990); = *Cordylodus* sp. nov. cf. *C. caboti* Bagnoli & others; herein]

Cordylodus prion Lindström
[= *Cordylodus lindstromi* Druce & Jones, Nicoll (1990)]

Cordylodus primitivus Bagnoli, Barnes & Stevens

Cordylodus proavus Müller

Cordylodus sp. cf. *C. proavus* Müller
[= ?*Cordylodus proavus* Müller, Nicoll (1990)]

Cordylodus prolindstromi Nicoll

Cordylodus rotundatus Pander
[= *Cordylodus angulatus* Pander fide Nicoll (1990)]

Cordylodus sp. nov. A (Nicoll)

Cordylodus sp. nov. B (Nicoll)

Drepanodus acutus Pander

Drepanodus simplex Branson & Mehl
[= *Monocostodus sevierensis* (Miller) fide Miller (1980); = New gen. A, n. sp. A]

Drepanodus subarcuatus Furnish

Drepanodus suberectus (Branson & Mehl) fide Landing & others (1986)

Drepanoistodus suberectus (Branson & Mehl)

Eoconodontus minutus (Miller)
[formerly *Oistodus* and *Cambrooistodus* fide Miller (1980)]

Eoconodontus notchpeakensis (Miller)
[formerly *Proconodontus* fide Miller (1980)]

Eodentatus bicuspatus Nicoll & Shergold

Fryxellodontus inornatus Miller

Furnishina furnishi Müller
[fide Wang (1985)]

Granatodontus ani (Wang)

Hirsutodontus hirsutus Miller

Hirsutodontus nodus (Zhang & Xiang)
[formerly *Teridontus nakamurai nodus* Zhang & Xiang (1983), = *Dasytodus* Chen & Gong (1986)]

Hirsutodontus simplex (Druce & Jones)
[formerly *Sagittodontus* fide Miller (1980)]

Hirsutodontus sp. nov. A.

Hirsutodontus sp. nov. B.

Hispidodontus appressus Nicoll & Shergold

Hispidodontus resimus Nicoll & Shergold

New genus and species A

New genus and species B

Oistodus inaequalis Pander
[= *Rossodus manitouensis* Repetski & Ethington, 1983]

Oistodus lanceolatus Pander
[= *Rossodus manitouensis* Repetski & Ethington, 1983]

Oneotodus bicuspatus Druce & Jones

Oneotodus datsonensis Druce & Jones
[= *Semiacontiodus nogamii* Miller fide Miller (1980)]

Oneotodus erectus Druce & Jones
[= *Semiacontiodus nogamii* Miller fide Miller (1980)]

Oneotodus gallatini Müller
[= *Prooneotodus gallatini* (Müller) fide Miller (1980)]

Oneotodus gracilis (Furnish)
[= *Teridontus gracilis* (Furnish) fide Chen & Gong (1986)]

Oneotodus nakamurai Nogami

[= *Teridontus nakamurai* (Nogami) fide Miller (1980)]

Oneotodus tenuis Müller
[= *Phakelodus tenuis* (Müller) fide Miller (1984); = *Rossodus tenuis* (Müller) fide Repetski & Ethington (1983)]

Oneotodus terashimai Nogami
[= *Prooneotodus terashimai* (Nogami) fide Wang (1985)]

Oneotodus variabilis Lindström

Phakelodus tenuis (Müller)

Problematoconites perforata Müller
[= *Prooneotodus gallatini* (Müller) fide Chen & Gong (1986)]

Proconodontus gallatini (Müller)
[= *Prooneotodus gallatini* (Müller) fide Chen & Gong (1986)]

Proconodontus muelleri Miller

Proconodontus posterocostatus Miller

Proconodontus primitivus (Müller)

Proconodontus rotundatus (Druce & Jones)
[= *Prooneotodus rotundatus* (Druce & Jones) fide Chen & Gong (1986)]

Proconodontus serratus Miller

Proconodontus tenuiserratus Miller

Proconodontus tricarinatus (Nogami)
[= *Nogamiconus tricarinatus* (Nogami) fide Miller (1980)]

Prooneotodus gallatini (Müller)

Prosagittodontus dahlmani (Müller)

Rossodus manitouensis Repetski & Ethington
[formerly *Acodus*]

Rossodus tenuis (Müller)
[formerly *Phakelodus*]

Sagittodontus dahlmani Müller
[= *Prosagittodontus dahlmani* (Müller) fide An (1982), Chen & Gong (1986)]

Sagittodontus furnishi (Müller)
[= *Furnishina furnishi* Müller fide Wang (1985)]

Scandodus furnishi Lindström
[= *Utahconus utahensis* (Miller) fide Miller (1980)]

Scolopodus asymmetricus Druce & Jones

Scolopodus bassleri (Furnish)

Scolopodus gracilis Ethington & Clark
[= *Variabiloconus bassleri* (Furnish) fide Landing & others (1986)]

Scolopodus iowensis (Furnish)
[= *Semiacontiodus iowensis* (Furnish) fide Landing & others (1986)]

Scolopodus quadraplicatus Branson & Mehl

Scolopodus staufferi (Furnish)

Scolopodus transitans Druce & Jones

Scolopodus triplicatus Ethington & Clark
[= *Variabiloconus bassleri* fide Landing & others 1986]

Scolopodus warendensis Druce & Jones
[= *Variabiloconus bassleri* fide Landing & others 1986]

Strigaconus simplex Druce & Jones
[= *Hirsutodontus simplex* (Druce & Jones) fide Miller (1980)]

Teridontus nakamurai (Nogami)

Teridontus sp. nov. A.

Utahconus utahensis (Miller)

Variabiloconus bassleri (Furnish)

Westergaardodina amplicava Müller

Westergaardodina bicuspidata Müller

Westergaardodina mossebergensis Müller