UPPER PERMIAN AND TRIASSIC CONODONT BIOSTRATIGRAPHY OF THE CACHE CREEK GROUP, MARBLE RANGE, SOUTH-CENTRAL BRITISH COLUMBIA

by

JOANNA MARIA BEYERS

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Department of GEOLOGICAL SCIENCES

The University of British Columbia
Vancouver, Canada

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ABSTRACT

Two Upper Permian and seven Triassic conodont faunas occur in the limestones, cherts and argillites of the Cache Creek Group, which underlies the Marble Range in south-central British Columbia. The oldest fauna is Guadalupian in age with species of *Sweetognathus* at Hat Creek-Marble Canyon, and *Neogondolella phosphoriensis* west of Clinton. The youngest Permian fauna, from the Jesmond area, includes three morphotypes of *Iranognathus* ex gr. *nudus* that are distinguished on the basis of carina morphology, a new species of *Iranognathus*, subspecies of *Neogondolella subcarinata, N. orientalis* and *N.* n.sp. *A*. The fauna is probably early to middle Dorashamian/Changxingian in age, but may be as old as late Dzhulfian. Adenticulate elements of *Isarcicella isarcica* constitute Fauna 3 in upper Griesbachian strata along Porcupine Creek. Fauna 4A from Marble Canyon, characterized by *'Neogondolella' carinata, Neospathodus dieneri* and *N. peculiaris*, is middle Dienerian in age, and Fauna 4B, from Cornwall Hills, recognized by the presence of *Neospathodus* sp. cf. *N. peculiaris* and *N.* sp. cf. *N. pakistanensis*, appears to straddle the Dienerian-Smithian boundary. Elements of Smithian Fauna 5 occur on Pavilion Mountain, near Jesmond and on Cornwall Hills. Key taxa include *Neospathodus novaehollandiae, Lonchodina nevadensis* and *Pachycladina obliqua. Neogondolella milleri* and *Platyvillosus costatus* allow recognition of a late Smithian subfauna 5B on Cornwall Hills. The youngest of the Scythian faunas is Spathian Fauna 6, known from the Jesmond fire lookout area. It consists of elements of *Neospathodus homeri* and *N. triangularis*. Undifferentiated Middle Triassic Fauna 7 is represented by poorly preserved species of *Neogondolella* found in cherts on the Cornwall Hills fire lookout road.

Faunas 8 and 9 are Late Triassic in age. The former, from Cornwall Hills, is thought to be Carnian in age, with species of *Metapolygnathus* and *?Neocavitella*. Early Norian Fauna 9, best represented in a sample from Oregon Jack Creek valley but with some elements found in the central area of the Marble Range, consists of *Epigondolella primitia, Neogondolella navicula, Metapolygnathus nodosus* and *M. echinatus*.

Conodont biostratigraphy shows that several interruptions in sedimentation or episodes of erosion occurred in the Marble Range during the Upper Permian-Triassic interval. At Jesmond, where the Permian-Triassic boundary is now well documented, an unconformity represents part of Dorashamian/Changxingian to ?early Smithian time. This hiatus may be narrower elsewhere in the Marble Range as Griesbachian strata have also been found. The second significant break in sedimentation appears to have taken place during the Middle Triassic, since strata of this age are known only from Cornwall Hills and Hat Creek junction, and on Pavilion Mountain Early Triassic limestone clasts occur in Late Triassic argillites. While carbonate sedimentation was dominant during the Late Permian and Early Triassic, Upper Triassic outcrop in the central and southern parts of the study area is primarily deeper water argillite with an admixture of volcaniclastic material, suggesting that the region underwent a change in environment or tectonic conditions. By the end of the Triassic, Cache Creek terrane ceased to be an oceanic carbonate platform.

ACKNOWLEDGEMENTS

I am indebted to many people. I wish to thank especially my supervisor, Michael J. Orchard, for his guidance and financial support, and the other members of my supervisory committee, W.R. Danner, G.E. Rouse and P.L. Smith for their advice and critical reviews. W.C. Barnes kindly read and commented on several chapters. The Geological Survey of Canada generously provided logistical support. I had access to laboratory, scanning electron microscope, photographic and drafting equipment, and the expertise of its staff. In particular I want to thank P. Krauss for photography and SEM photography. I also benefited from discussions with Survey staff members who took an interest in my work. N. Mortimer introduced me to the Pavilion area. T. Dickey and R. Manley assisted in the field. C. Davis drafted Figure 1.2; G. Hodge and M. Sullivan drafted Figure 1.3 and the text-figure sample location maps, as well as Figure 3.21. I gratefully acknowledge funding from the National Sciences and Engineering Research Council through a NSERC Grant to M.J. Orchard.

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I. INTRODUCTION

Cache Creek terrane is an oceanic carbonate platform distinguished from the volcanic island arc terranes adjacent to it on lithological and faunal grounds. Its oceanic character and position between the ancient and present-day margins of western North America have given "exotic" Cache Creek terrane a central role in the study of Cordilleran tectonics.

1. Geologic setting

Tectonically, Cache Creek terrane lies within the Intermontane physiographic belt of the Canadian Cordillera. In total, the Cache Creek Group rocks outcrop over a distance of more than 1000 km, from the "Atlin Terrane" of Wheeler *et al.* (1972) and Monger (1975) that crosses the British Columbia-Yukon border, through the Stuart Lake Belt of Armstrong (1949) in central British Columbia, to the type locality near the village of Cache Creek in the south (Figure 1.1). The association of well-bedded (ribbon) cherts, thick fusulinid limestones, and minor alpine-type ultramafics is characteristic of the Cache Creek terrane.

Marble Canyon fusulinids were pivotal in the development of the concept of far-traveled or suspect terranes. Fusulinids from Middle and Upper Permian rocks in northwestern North America were long noted for their similarity to Eastern Hemisphere (Tethyan) taxa. Thompson, Wheeler and Danner (1950) recognized an American Tethyan fauna dominated by genera of the subfamilies Verbeekininae and Neoschwagerininae with few Schwagerininae, and a non-Tethyan fauna dominated by schwagerinids but poor in verbeekinid and neoschwagerinid members.

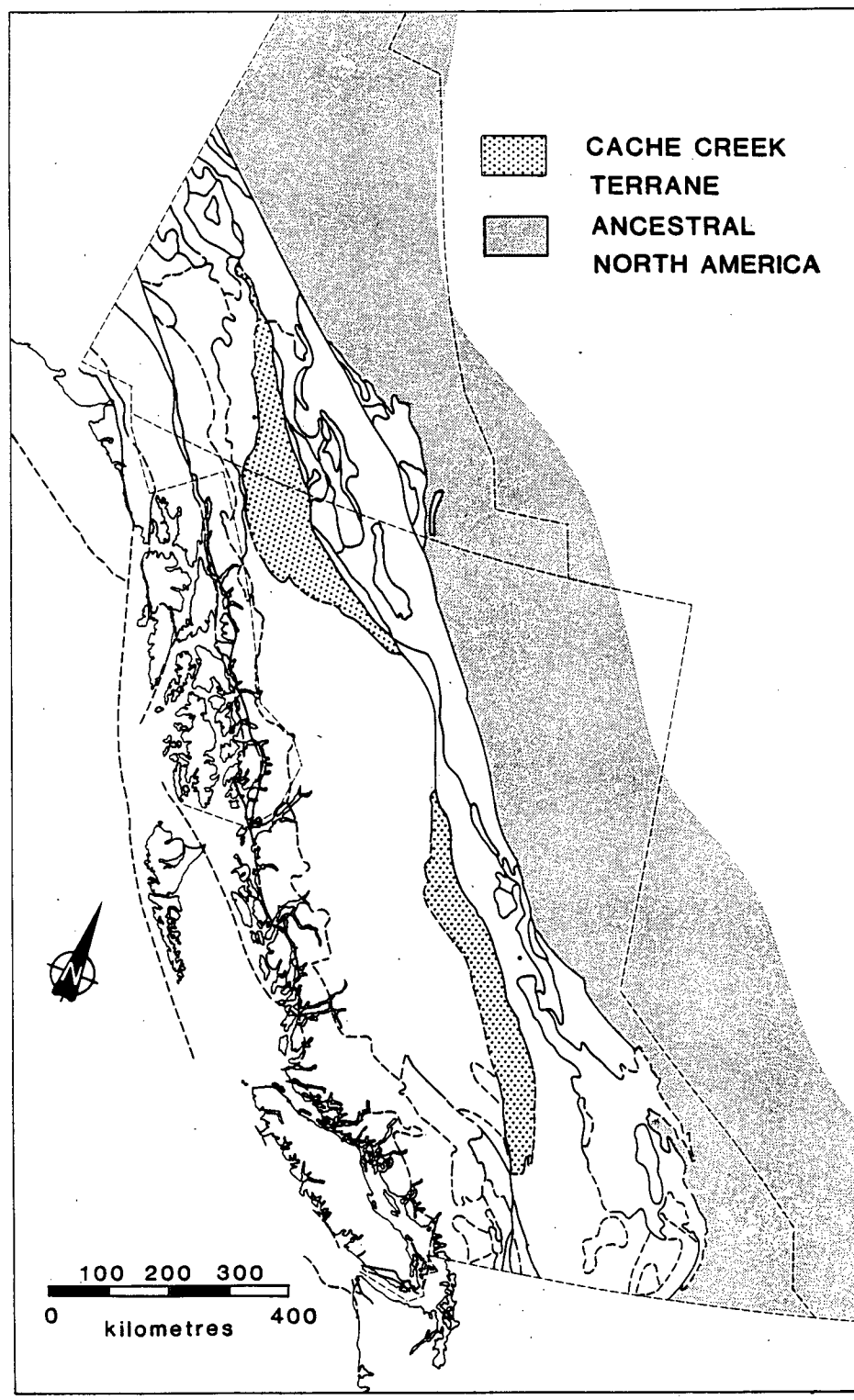


Figure 1.1: Outcrop area of Cache Creek terrane in Canadian Cordillera.

This latter assemblage, associated with brachiopods, bryozoans and solitary corals, is generally of low specific diversity and occurs in well-bedded, often argillaceous or tuffaceous, limestones of the western Canadian Cordillera and southeastern Alaska (Monger and Ross, 1971). The American Tethyan assemblage, of high fusulinid diversity and associated with crinoid debris and algae (Danner, 1965), is found in the Permian high-calcium limestones of the Cache Creek Group's central outcrop area in south-central British Columbia, *viz.* the Marble Canyon Formation. This conforms to the concept that faunal succession continues to be a key element in the characterization of any one terrane (Tipper, 1984). While stressing the possibility that the regional faunal differences reflect adaptation of fusulinids to different ecological conditions, Monger and Ross (1971) argued for a mobilistic view, in which large scale tectonic movements would have juxtaposed crustal fragments of differing geographic origin.

2. Biostratigraphy

Fossils have been invaluable in helping to unravel the region's long and complex sedimentation history. Historically, Cache Creek Group rocks were thought to be no younger than Permian. Brachiopods collected in 1871 by J. Richardson near Venables Creek, in the area southeast of Cornwall Hills, indicated a Late Paleozoic age (Selwyn, 1872). Fusulinids found in Marble Canyon confirmed this (Dunbar, 1932) and the Cache Creek Group, as redefined by Armstrong (1949, p. 50), was said to be "mainly of Permian age, but also probably in part of Pennsylvanian age".

In the group's eastern outcrop area near the settlement of Cache Creek,

limestone blocks encompassed in the sediments contain Mid to Upper Pennsylvanian and Lower Permian conodonts, but the matrix is Late Permian and Triassic in age (Orchard, 1984). Travers (1978) recorded the first known Triassic radiolarians and bivalves for the group in chert southeast of the village of Cache Creek, but this outcrop may be part of Quesnellia terrane (W.R. Danner, oral commun., 1989). Triassic pelecypods (*Halobia?*) were found on Cornwall Hills by Danner in 1981 (oral commun., 1989). Radiolarians from cherts and conodonts from limestone in this area represent Early, Middle and Late Triassic time (Orchard, 1984; Cordey, 1986; Orchard and Beyers, 1988).

3. Purpose and scope

The thrust of the thesis was intended to provide a biostratigraphic framework for the available sedimentological and structural data. Questions about the internal coherence of the stratigraphic units of the Cache Creek Group, and earlier observations regarding the presence of conodont faunas with American (non-Tethyan) and Asian (Tethyan) affinities in different stratigraphic units, the transition from shallow water carbonates to an argillaceous and volcanic facies in western sediments of the Cache Creek Group, and the stratigraphic history of Marble Canyon Formation strata, formed the background and context for the study (Trettin, 1980; Orchard, 1981, 1984).

Because the limestones near Jesmond in the northern Marble Range are unusually well exposed, they became the focus for much of the work, although the project included the entire Marble Range. Detailed taxonomic work of two Upper Permian conodont taxa from Jesmond was undertaken to clarify questions

of stratigraphic succession and timing of events at the close of the Paleozoic and the beginning of the Mesozoic eras, when continental shelf regions worldwide became emergent. The resultant biostratigraphy of Jesmond conodonts can facilitate correlation between allochthonous terranes, and serve as an Upper Permian-Lower Triassic faunal standard against which collections from coeval strata elsewhere in the Cache Creek terrane can be compared.

The area of study is located between latitudes 51°20' and 50°38', and longitudes 121°27' and 121°55', and forms part of south-central British Columbia's Interior Plateau in Ashcroft and Bonaparte Lake map sheets (Figure 1.2).

4. Methods

A total of six weeks were spent in the field during the summers of 1986 and 1987. Figure 1.3 (in pocket) shows the collection sites, as well as fusulinid, radiolaria and conodont localities of other workers. In the Ashcroft map sheet collections were made from the Cornwall Hills lookout area, the north side of the valley of Oregon Jack Creek, the north side of lower Hat Creek valley, the north side of Marble Canyon and the Pavilion Mountain area. In the Bonaparte Lake map sheet collections were made north of Clinton Creek valley, along the forestry lookout road on the mountain west of Clinton, on Mount Soues, near Mann Creek, along Porcupine Creek and Jesmond Creek, and along the Jesmond forestry lookout road. Because of the fragmentary nature of much of the outcrop and widespread low grade metamorphism and deformation (Duffell and McTaggart, 1952), many samples are from isolated localities, but where possible sections were measured. An attempt was made to make conodont sampling representative

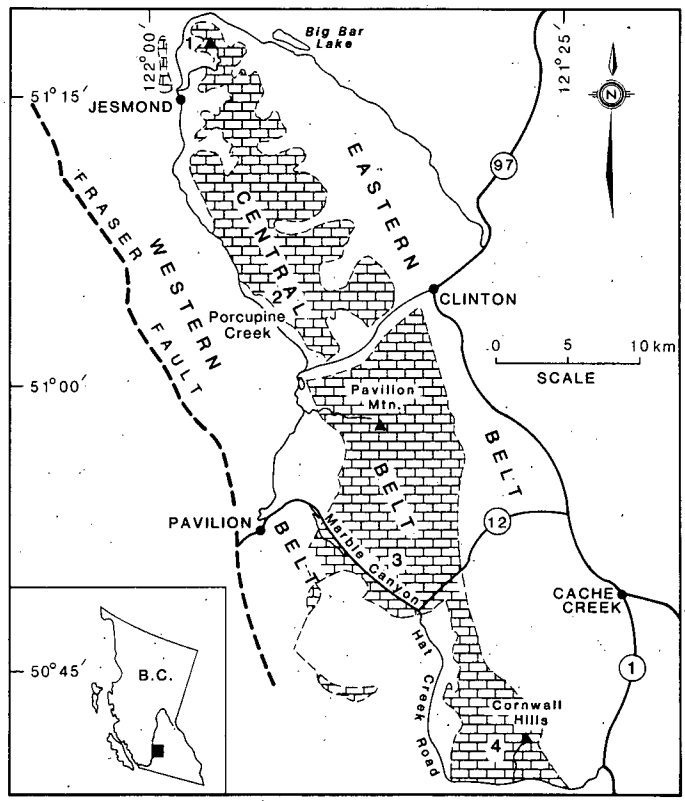


Figure 1.2: Location of study area.

of the Marble Canyon Formation, known also as the central belt of the Cache Creek Group. Some rocks from more western sediments along Pavilion Mountain road and in the Porcupine Creek area were included as they are readily accessible.

A total of 311 conodont samples were collected (Table 1). Most of these were carbonates but 6 were cherts. After processing and picking of the 1986 collections had been completed, the most productive were targeted for recollection in 1987. Existing conodont collections were also examined. Appendix A lists all samples, productive and barren, giving detailed information about location, weight, lithology, stratigraphic position and faunal content.

a. carbonates

Samples were reduced to chips two to three cubic cm in size. Buckets containing 1 kg of sample were filled with a mixture of water, buffer and acetic acid for a combined strength of 10% and left for one week. A minimum of 352 kg was thus processed. The residues were sieved through a 90 μm and a 1.00 mm sieve, and dried at 60°C. Initially, heavy fractions were obtained using tetrabromoethane at a specific gravity (SG) of 2.85, but later on it was found that a solution of 2.96 SG enhanced separation of the commonly dolomitic samples. Light fractions were checked routinely for conodonts, but only heavy fractions were carefully examined and their faunal elements picked. Many samples of the CH-S series on Cornwall Hills yielded a large magnetic fraction prior to heavy liquid separation. These were checked for conodont elements but none were found.

COMPOSITION	-A-		-B-		-C-		-D-	
	#	%	#	%	#	%	#	%
$CaCO_3$	305	98	164	54	107	46	34	11
SiO_2	6	2	3	50	3	50	--	--

TABLE 1. Breakdown of conodont samples according to composition and conodont productivity. A=Conodont Samples, B=Productive, C=Barren, D=Recollections.

b. chert

300 to 400 g of sample were processed in dilute 5% hydrofluoric acid over a period of 24 hours. The residues were sieved using 1.7mm, 180 μm and 75 μm sieves. The resulting fine fractions were then picked.

SEM micrographs were obtained with Cambridge Instruments Stereoscan 90 and Semco Nanolab 7, and printed on Polaroid 53 paper.

II. REGIONAL GEOLOGY

A. PREVIOUS WORK

Selwyn, then director of the Geological Survey of Canada, led a reconnaissance party from the Pacific coast to the Rocky Mountains in 1871, and named and described the Cache Creek Group the following year (1872, p. 54) in the first geologic work to deal with British Columbia. He recognized lower and upper components. The "Lower Group", with type locality near Cache Creek, is exposed from Martel on the Thompson River, north of Spences Bridge, to a few miles north of Clinton (Figure 1.3b), where they are covered by Cenozoic deposits. Rocks of this unit consist of "massive beds of grey sub-crystalline limestone, black flinty shale in beds of from one to three or four inches thick, chloritic and epidotic rocks with serpentine and soapstone" (Selwyn, 1872, p. 61). In the "Upper Group" massive, ridge-forming limestones are the main lithology, but minor shale, and "epidotic and chloritic rocks" (Selwyn, 1872, p. 60) are also present. This upper unit crops out from Blue Earth Creek south of the junction of Oregon Jack and upper Hat creeks as far north as Medicine Creek (Figure 1.3d), where it disappears for a short distance underneath Cenozoic lavas and sediments. It also occurs along lower Hat Creek and in Marble Canyon as a prominent and resistant range that can easily be followed into its northernmost outcrop area in south-central British Columbia. There it is bounded by the wide curve of Big Bar Creek and its lakes (Figure 1.3a).

G.M. Dawson, who produced the first geologic map of the area (Kamloops sheet, 1895), believed both of Selwyn's groups to constitute one unit (1879, p. 92B;

1896, p. 38B) and referred to them as Cache Creek Formation. Subsequently, Drysdale (1914) upgraded this to group level and Duffell and McTaggart (1952) introduced the term Marble Canyon Formation for the cliff-forming limestone unit, without specifying a type section. They mapped Ashcroft sheet on reconnaissance scale, and later Monger and McMillan (1984) remapped it at a scale of 1:125,000. Most recently, Mortimer (1987) mapped the geology west of Marble Canyon Formation in detail.

Several thesis projects have concentrated on other areas pertinent to the present study. Grette (1978) mapped Venables valley, the southernmost outcrop area of Cache Creek Group between Ashcroft and Spences Bridge; Ladd (1979) focused on a 14 km strip of Nicola-Cache Creek contact southwest of Ashcroft; and Shannon (1982) mapped the eastern belt in the type area. Mapping of the southwest portion of Bonaparte Lake sheet was undertaken by Trettin in 1961 and again in 1980; the former was part of the 1:250,000 Bonaparte Lake mapping project by Campbell and Tipper (1971). Trettin (1980) introduced the terms eastern, central and western belts for three lithologically distinct outcrop zones. The eastern belt includes Travers' (1978) block-in-matrix melange, the Greenstone Unit of Shannon (1981), and the aerially extensive limestones near Meadow Lake (Campbell and Tipper, 1971). Serpentinite bodies noted by Dawson (1879, p. 93B), Campbell and Tipper (1971, p. 67) and Shannon (1982) are also part of the eastern belt. The central belt consists of Trettin's (1961) Mount Soues Division (map unit 5 of Campbell and Tipper, 1971 and unit bc of Mortimer, 1987), the Marble Canyon Formation (map units 2 and 4 of Trettin, 1980) and overlying recessive cherts and argillites (Trettin's units 3 and 5).

Mortimer, Beyers and Orchard (in prep.) propose to exclude the recessive units and restrict Marble Canyon Formation to the ridge-forming limestone. Western belt rocks, originally known as Division I of the Pavilion Group (Trettin, 1961), comprise volcanics, argillites and cherts that crop out west of Marble Range. Stratigraphic nomenclature of the various authors is compared in Figure 2.1, and Figure 2.2 illustrates the geology of the Cache Creek Group in south-central British Columbia.

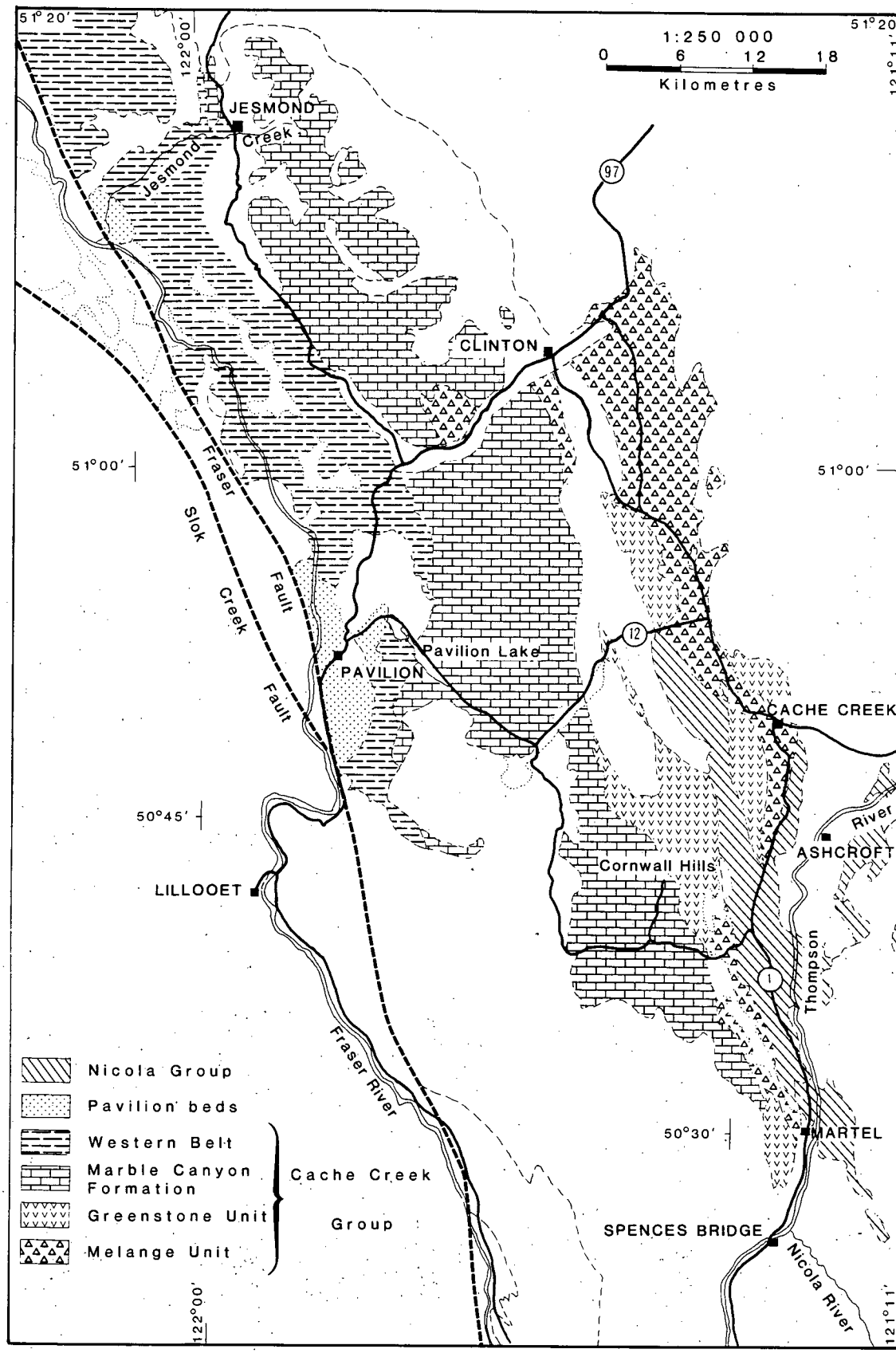
B. AGE

Selwyn (1872, p. 62) and Richardson had stated that the Venables Creek brachiopods "indicate a horizon between the base of the Devonian and the summit of the Permian". Richardson also collected fusulinids from Marble Canyon (Dawson, 1879, p. 88B) which were identified as *Loftusia* by W.J. Dawson (Duffell and McTaggart, 1952), a Late Cretaceous foraminifer. In 1877 G.M. Dawson (1879) visited Richardson's Marble Canyon locality and made another collection. He found *Loftusia*, which he had named *L. columbiana* (Dawson, 1879, p. 88B-89B), accompanied by fusulinids reminiscent of those he had collected the previous year near Stuart Lake, and consequently assigned a Carboniferous age to them (Dawson, 1879, p. 93B), accepting *L. columbiana* as an early form of Mesozoic *Loftusia* (Duffell and McTaggart, 1952). Staff (in Thompson and Wheeler, 1942) thought the genus belonged to the subfamily Neoschwagerininae, and Dunbar (1932), redescribing it as *Neoschwagerina columbiana*, now inferred an Early or Middle Permian age for the Marble Canyon limestone. Thompson and Wheeler (1942) described and illustrated the species and moved it to *Yabeina* Deprat. Because all previous material had been obtained from float, these

Figure 2.1: Stratigraphic nomenclature of Cache Creek Group rock units.

<table>
<tr><th colspan="2">CAMPBELL & TIPPER
1971</th><th colspan="3">TRETTIN
1961</th><th colspan="2">1980</th><th>MORTIMER
1987</th></tr>
<tr><td colspan="2"></td><td rowspan="2">PAVILION GROUP</td><td colspan="2">DIVISION II</td><td colspan="2">PAVILION BEDS</td><td>PAVILION BEDS</td></tr>
<tr><td colspan="2">UNITS 7 & 8</td><td colspan="2">DIVISION I</td><td colspan="2">WESTERN BELT
UNIT 6</td><td>UNITS mt, st, ta & lt</td></tr>
<tr><td colspan="2" rowspan="2">MARBLE CANYON
FORMATION
UNIT 6</td><td rowspan="2">MARBLE CANYON FORMATION</td><td>MEMBERS
II & IV</td><td rowspan="3">CENTRAL BELT</td><td>UNITS 3 & 5</td><td>UNIT ca</td></tr>
<tr><td>MEMBERS
I & III</td><td>UNITS 2 & 4</td><td>MARBLE CANYON
FORMATION
UNIT ml</td></tr>
<tr><td colspan="2">UNIT 5</td><td colspan="2">MOUNT SOUES
DIVISION</td><td>UNIT 1</td><td>UNIT bc</td></tr>
<tr><td colspan="2">UNIT 4</td><td colspan="3"></td><td colspan="2">EASTERN BELT</td><td></td></tr>
</table>

Figure 2.2: Geological map of the thesis area (after Campbell and Tipper, 1972, Trettin, 1980 and Monger & McMillan, 1984).


51°20′
122°00′
1:250 000
0 6 12 18
Kilometres
51°20′
121°11′
JESMOND
Creek
Jesmond
97
CLINTON
51°00′
51°00′
Fraser
Slok
Creek
Fault
Fault
Pavilion Lake
PAVILION
12
CACHE CREEK
50°45′
River
ASHCROFT
LILLOOET
Cornwall Hills
Thompson
1
Fraser River
50°30′
MARTEL
SPENCES BRIDGE
Nicola River
122°00′
121°11′
Nicola Group
Pavilion beds
Western Belt
Marble Canyon Formation
Greenstone Unit
Melange Unit
Cache Creek Group

authors, joined by Danner, reevaluated and reillustrated the Marble Canyon fauna, including *Y. columbiana*, from *in situ* limestones east of the southern entrance to the canyon (Thompson, Wheeler and Danner, 1950). The referral of *Neoschwagerina columbiana* to the genus *Yabeina* resulted in upward adjustment of the Marble Canyon limestone age. On the basis of relative evolution of shell structure, Thompson *et al.* (1950) thought the Marble Canyon *Yabeina* to be late Guadalupian (early Late Permian, see Figure 4.1a). Skinner and Wilde (1966) recognized as many as nine species of *Yabeina*, seven of them new. Study of new samples led Goto, Maruoka and Ishii (1986) to conclude that all nine species are referable to one species of *Lepidolina*, *L. columbiana.*

Thompson and Wheeler (1942, p. 705) remarked "that the sea of late Cache Creek time was the last known Paleozoic marine invasion of North America". Upper Permian limestones are known from elsewhere in the central belt (Trettin, 1961, 1980; Johnson and Danner, 1966). Trettin (1980, p. 15) reported a Late Permian neoschwagerinid from western belt beds east of the junction of Barney and Porcupine creeks, although this may be infolded central belt. Older Permian rocks in the Cache Creek Group are found in the eastern belt. Wolfcampian fusulinids are known from the Meadow Lake outcrop area (Danner and Nestell in Campbell and Tipper, 1971, p. 27), and from Hart Range southeast of Clinton where Leonardian and perhaps Guadalupian species also occur (Danner and Nestell 1966; Danner & Nestell, and Ross in Campbell and Tipper, 1971, p. 27). Middle to Late Pennsylvanian and Early Permian ages characterize limestone blocks from the Melange Unit, and Guadalupian conodonts were found in a fusulinid-crinoidal limestone within the Greenstone Unit and from bedded

limestones in chert (Orchard, 1984). Middle Permian fusulinids were found by Shannon (1982) in the eastern belt below eastern Cornwall Hills.

A Late Carboniferous to Late Permian age was thus firmly established for the southern Cache Creek Group throughout most of this century. Knowledge of Triassic strata dates back to Travers (1978, p. 116) who reported Late Triassic *Halobia* and four unnamed nasselarid species in supposedly eastern belt cherts just south of Cache Creek village. A Japanese team found both Permian and Triassic conodonts here (W.R. Danner, oral commun., 1989). Orchard (1984) reported (Guadalupian and) Ladinian or Carnian conodonts from the limestone and chert/phyllite matrix which surrounds older blocks of the Melange Unit. Lower Triassic strata are present in both central and western belts (Orchard, 1981; Orchard and Beyers, 1988), and Middle Triassic radiolarian cherts are known from Cornwall Hills (Cordey, 1986). The informally named "Pavilion beds" of Trettin (1980) which lie west of the western belt, have yielded Middle or Late Triassic conodonts (Rafek in Trettin, 1980, p. 16) and corals (Trettin, 1961, p. 34). Trettin (1980, p. 2) thought these sediments differed substantially in composition from Cache Creek rocks but Orchard (1981) included them in the group and Mortimer (1987) said that they are a more "volcanic/volcaniclastic part" of the western belt and not a separate unit. Jurassic radiolaria were recently discovered in the western belt, implying Cache Creek sedimentation persisted longer than had been suspected (Cordey *et al.*, 1987).

Appendix B gives information about all known published faunas from Cache Creek Group rocks in south-central British Columbia. Those collected or studied as

part of this study are detailed in Appendix A.

C. STRUCTURE

Dawson (1896, p. 40B) proposed a synclinal structure in which the Marble Canyon limestone was flanked on either side by older sediments. Duffell and McTaggart (1952, p. 17) found support for this interpretation in bedding attitudes but pointed out that an alternative explanation might be that "the Cache Creek Group consists of two successions of argillites, cherts, greenstones, minor limestones, and quartzites, separated by a thick series of Marble Canyon limestones". Trettin (1961, p. 23, 25) determined that the contact between the western beds (Division I of Pavilion Group) and Marble Canyon Formation is gradational, with the proportion of interbedded limestone decreasing in a westward direction. This westward transition could represent a facies change so that Division I would be in part coeval with the Marble Canyon Formation, or the beds might overlie the formation and be entirely younger. Cherts and argillites of Trettin's (1980) map units 3 and 5 which overlie the Marble Canyon Formation (units 2 and 4) were not considered part of the western beds (map unit 6). Trettin's (1980) preferred structural interpretation is that a thrust fault repeats units 2 and 3 so that unit 5 becomes the stratigraphic equivalent of map unit 6. Mortimer (1987) supported this view, and showed clearly that the contact between units 5 and 6 is depositional and not faulted.

Paleontological data show a consistent westward younging of strata (Danner and Nestell, 1966; Campbell and Tipper, 1971; Orchard and Beyers, 1988), also refuting the syncline hypothesis. The Greenstone Unit, eastern belt, is in steep

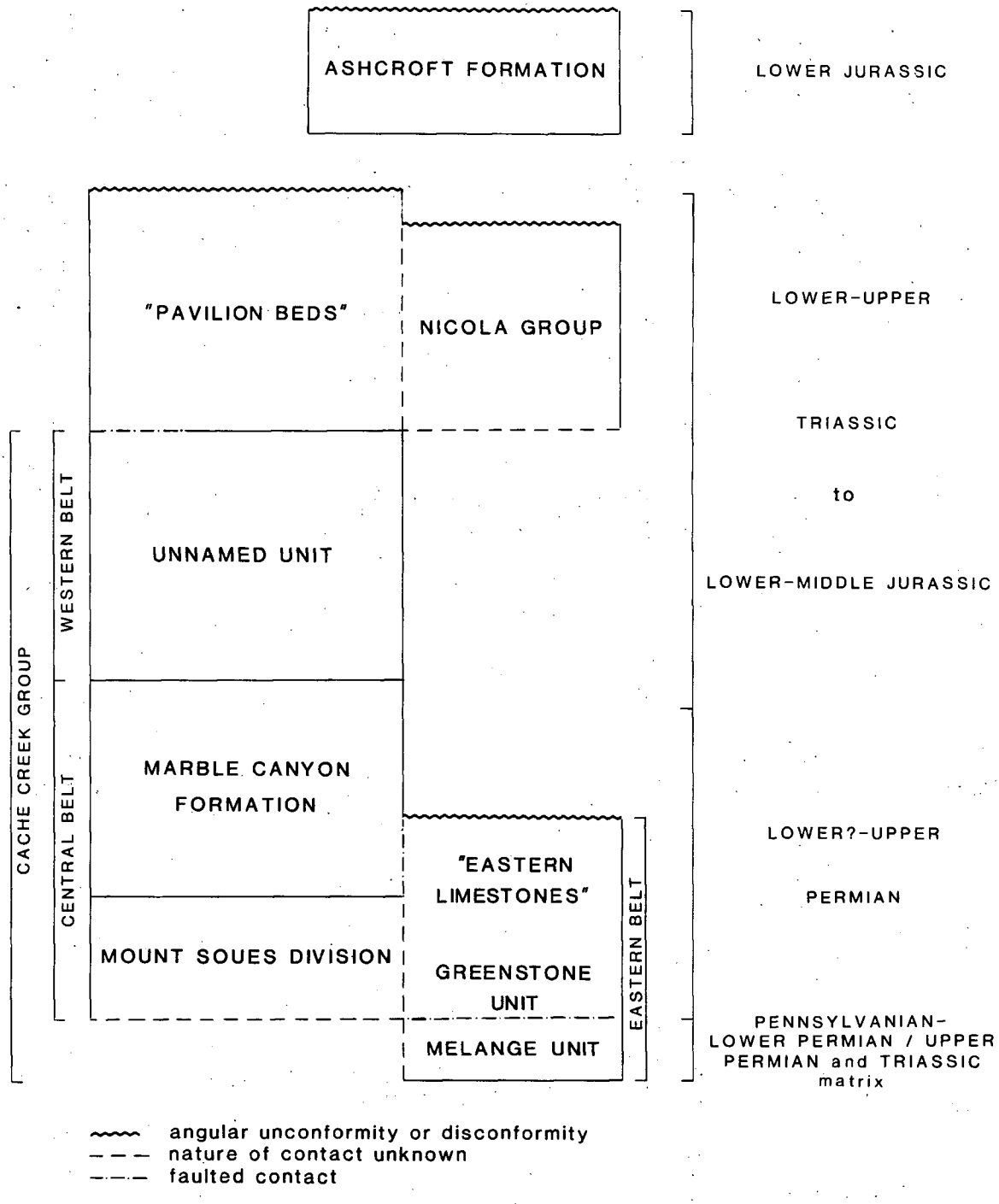
fault contact with central belt limestones (Campbell and Tipper, 1971; Shannon, 1981). The contact between Melange and Greenstone units may be stratigraphic (Shannon, 1981) but was shown as faulted by Monger and McMillan (1984) and Travers (1982). A summary stratigraphic column of Cache Creek Group sedimentation is presented in Figure 2.3.

Trettin (1980, p. 11) summed up the deformation history of the Marble Range suggesting "an early phase of extensive thrust faulting, followed by folding along northwesterly trending axes, in turn followed by faulting with vertical and horizontal displacements and the development of a broad, northwesterly plunging anticlinorium". The severity of deformation has resulted in exaggerated thickness estimates of the Marble Canyon Formation. Duffell and McTaggart (1952, p. 17) for instance, gave a figure of 6,000 ft or 1800 m. Trettin (1980, p. 6) showed that west of Clinton thickness varies from area to area, but obtained measurements greater than 250 m. Mortimer (1987, p. 2) estimated Marble Canyon Formation thickness at 400 m. Measurements obtained in this study are discussed in Chapter 3.

D. ACCRETION AND TECTONIC MODELS

Monger and Ross (1971) separated oceanic Cache Creek Group rocks from island arc-related Nicola volcanism to the east and suggested an accretionary, mobilist mechanism for their present juxtaposition. Since then the eastern belt of the Cache Creek Group has often been interpreted as an Upper Triassic accretionary subduction complex (Travers, 1978; Monger *et al.*, 1982; Shannon, 1982), subsequently thrust over Quesnellia (Shannon, 1982; Travers, 1982). Discovery of

Figure 2.3: Summary regional stratigraphic column of Cache Creek Group and younger rocks (after Monger, 1982, Mortimer, 1987 and Shannon, 1982).


ASHCROFT FORMATION
LOWER JURASSIC
"PAVILION BEDS"
NICOLA GROUP
LOWER-UPPER
TRIASSIC
to
LOWER-MIDDLE JURASSIC
UNNAMED UNIT
MARBLE CANYON FORMATION
"EASTERN LIMESTONES"
LOWER?-UPPER
PERMIAN
MOUNT SOUES DIVISION
GREENSTONE UNIT
MELANGE UNIT
PENNSYLVANIAN-LOWER PERMIAN / UPPER PERMIAN and TRIASSIC matrix
CACHE CREEK GROUP
WESTERN BELT
CENTRAL BELT
EASTERN BELT
angular unconformity or disconformity
nature of contact unknown
faulted contact

Early to Middle Jurassic radiolarians in the western belt suggests that Cache Creek terrane sedimentation continued after deposition of Nicola Group rocks (Quesnellia terrane) ceased and requires amalgamation of the terranes to the North American continental margin at a later date (Cordey *et al.*, 1987). Penetrative deformation in Late Jurassic time by Mount Martley pluton and Tiffin Creek stock provides a minimum age for Cache Creek terrane deformation (Mortimer and van der Heyden, in prep.). Cordilleran-wide Middle Jurassic deformation has been linked to juxtaposition of terranes during closure of the Bridge River-Cache Creek ocean (Mortimer, 1986; Rusmore *et al.*, 1988).

The significance of the eastern belt Melange Unit is unknown. Orchard (1984) pointed to the American midcontinent affinity of Permian conodonts in both blocks and matrix, whereas Late Permian Marble Canyon Formation fauna have Asiatic affinity. Orchard (1984, p. 201) stressed that in the absence of coeval faunas, provinciality or cosmopolitanism cannot be convincingly demonstrated, and that in addition different environments (reflected by the variety in lithologies) may exert a direct influence on conodont distribution. Alternatively, the unit may be Quesnellia-related as suggested by Shannon (1982, p. 59-60) and Orchard (1984).

No fossils younger than Late Triassic are known from the eastern belt. This suggests that formation of the Melange Unit in a subduction zone environment came to an end by that time as the Cache Creek-Quesnellia ocean basin closed. Thrusting during Middle to Late Jurassic time placed Cache Creek rocks on top of Quesnellia, perhaps prior to lithification of Early to Middle Jurassic strata of the Ashcroft Formation (Travers, 1978). Sediments of this formation are the

oldest to overlie both Cache Creek and Nicola Group strata (Monger, 1985), placing an upper limit on timing of their amalgamation. The absence of eastern belt fossils younger than Late Triassic may be due to the small number of samples, exacerbated by the extinction of age-diagnostic conodonts at the end of the Triassic. A third possible time for Melange formation is Early Cretaceous, which is the radiometric age obtained for a Nicola schist which lies along strike from the Melange Unit (Mortimer and van der Heyden, in prep.). Without a firm understanding of the minimum age of formation of the Melange Unit, it is not likely that the relationships among Cache Creek Group rocks can be deciphered and hence an understanding of the tectonic history of terrane accretion must remain largely rudimentary. No model, for instance, has accounted for the limestones of the eastern belt ("eastern limestones" of Hart Range, Scottie Creek, Meadow Lake) and their relation to subduction/accretion mechanisms in this region.

III. DESCRIPTION OF LOCALITIES

In this chapter sample localities, their lithology and stratigraphic context are described region by region from Jesmond in the north to Oregon Jack Creek in the south. Relevant to this discussion are the locality database in Appendix A and the thin section descriptions of Appendix C.

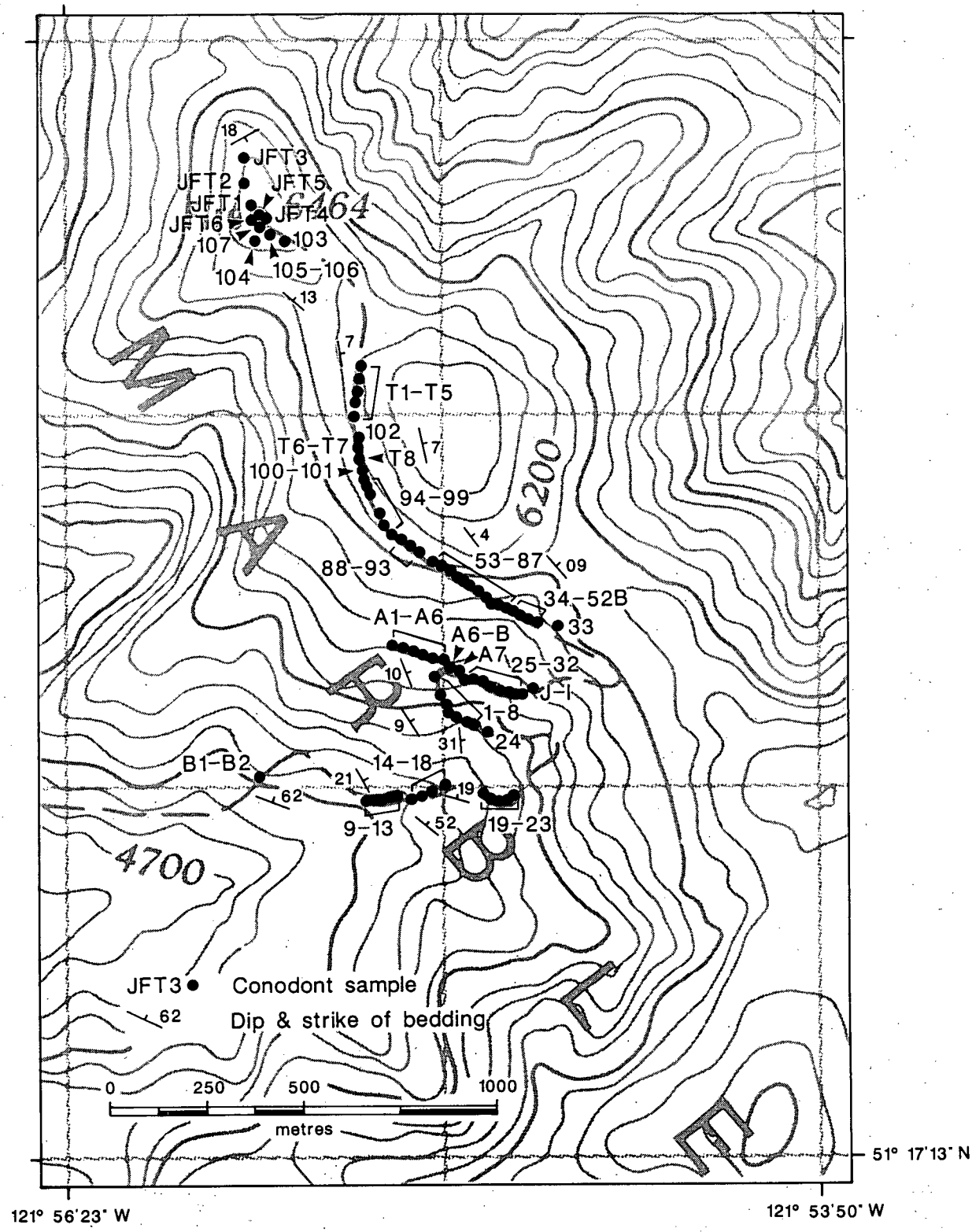
A. JESMOND AREA

1. Lookout access road

A dry weather, dirt road leaves the main gravel highway approximately 1.5 km north of the settlement of Jesmond. The turnoff onto the lookout branch which rises steeply but has a hard gravel surface, occurs 3 km from the highway. All distances are measured from this turnoff. Several switchbacks occur on the road; they provide additional reference points for the location of measured sections and samples that are indicated on Figure 3.1.

Spot samples and samples from three sections were collected between the turnoff and the third switchback, elevation 1800 m (5940 ft), 4.4 km along the road to the northeast. Samples J-B1 and J-B2 were taken from some of the lowermost outcrop, 2.5 km from the turnoff. Here nodules of silicified micrite and compositional banding define the bedding plane. The base of section 1 (Figure 3.2) occurs at 2.87 km from the turnoff. This section, which begins at JAR-17 and ends 200 m further along the road at JAR-23, was paced. The stratigraphic thickness was calculated to be 61.5 m, using the methods described by Compton

Figure 3.1: Sample localities and sections, Jesmond fire lookout access road.



JESMOND FIRE LOOKOUT ACCESS ROAD

(JAR, JR, J-A, J-B, J-T, JFT)

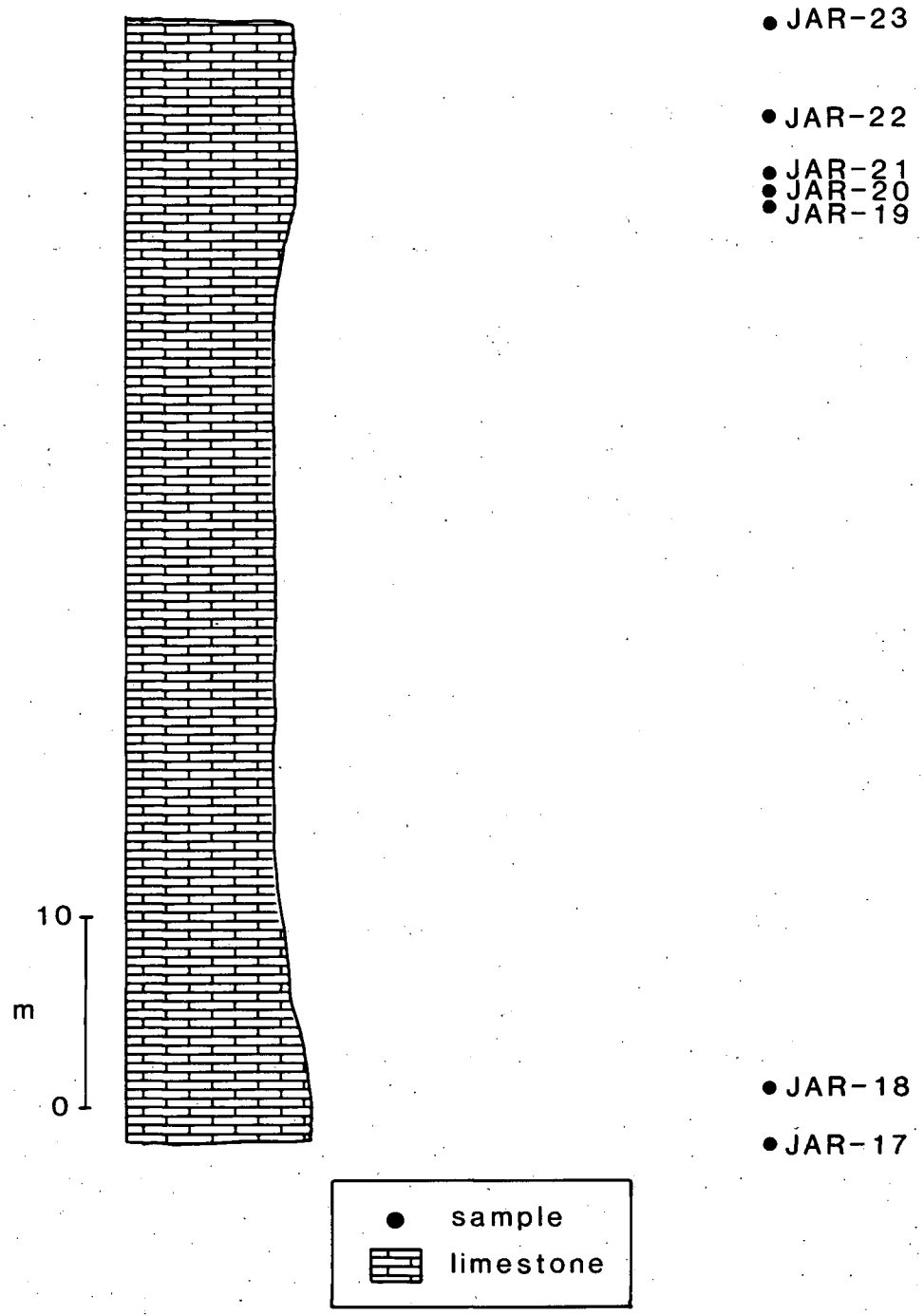


Figure 3.2: Schematic representation of section 1, Jesmond.

(1962, p. 240-241). Below the second switchback, 4.1 km from the turnoff, section 2 (Figure 3.3) includes samples JAR-2 to JAR-7 at the top. It has a calculated stratigraphic thickness of 7.5 m. Section 3 (Figure 3.4) is exposed above the second switchback, partially in a cut in the hillside (J-A1 to J-A7), and partially along the road (JAR-25 to JAR-32). This directly measured section is 84 m thick. A strike line extended from JAR-2 suggests that the base of section 2 correlates with section 3 at a position approximately equivalent to J-A4.

Outcrop in the interval outlined by sections 1 to 3 is characteristically poorly bedded and disrupted by covered intervals. Limestone weathers pale grey, ranges from medium to dark grey on fresh surfaces, and locally has a bituminous odour. It is invariably recrystallized, commonly occurs as secondary or "pseudo" micrite (Flügel, 1982, p. 111), and often contains calcite veins and pods. Selective dolomitization has left small, dark, micritic nodules and angular micrite fragments (Figure 3.5). These may be more numerous at the base of a bed (JAR-32), or show size grading (JAR-1, 32). Some of these nodules appear to be intraclasts (JAR-30). A thin section of sample J-I shows nodules of carbon-rich, algal and pelletal micrite, in a matrix of recrystallized dolomicrite.

Crinoids are usually the only fossils visible at the outcrop. Microfossils consist of ichthyoliths and conodonts. Conservative species of the conodont *Hindeodus* are found accompanied by species of *Iranognathus* and *Neogondolella.* A thin section of an intraclast in JAR-29 shows poorly preserved dasycladacean (green) algae, fusulinids and echinoderm debris in a carbon-rich pelmicrite (Figure 3.6).

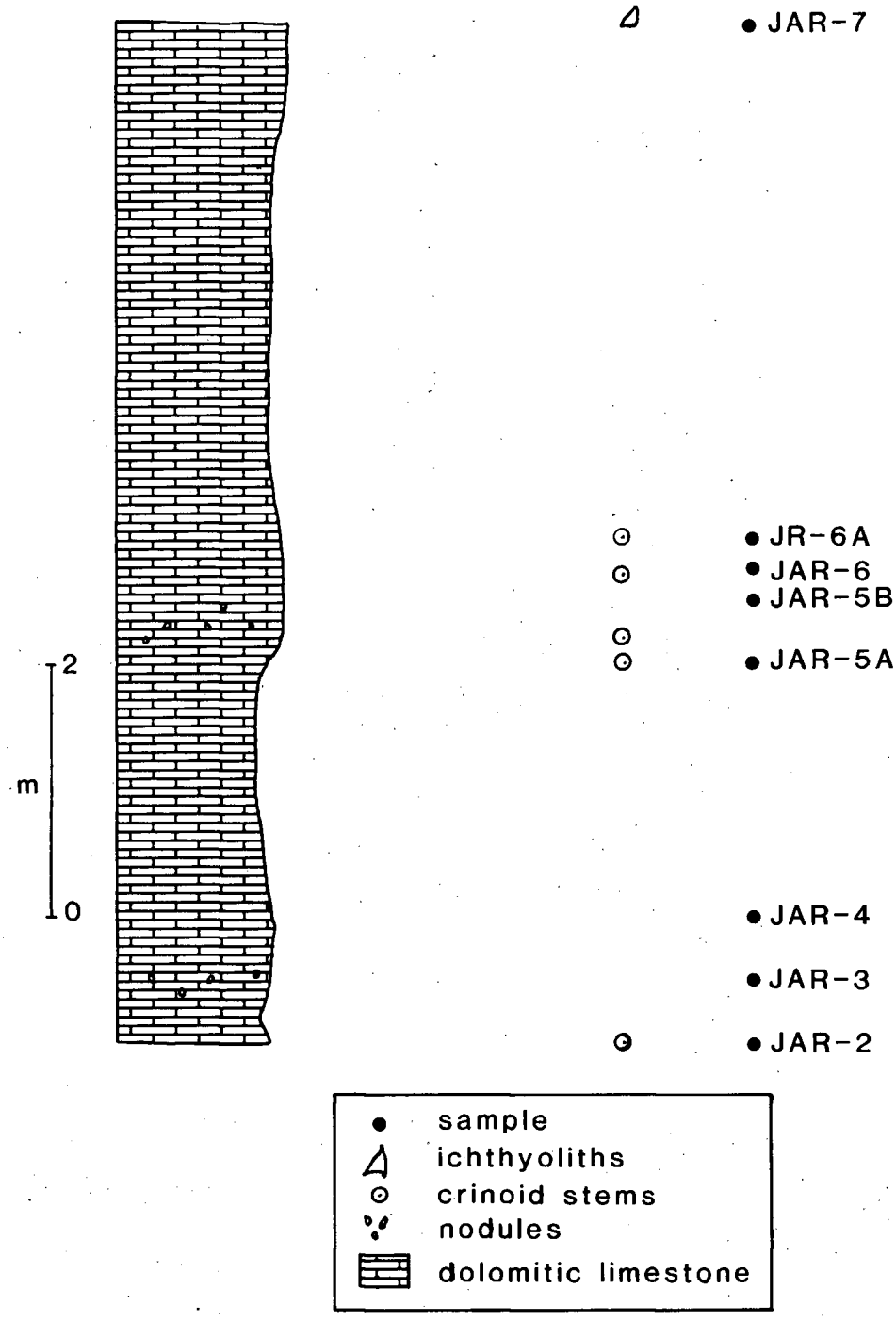


Figure 3.3: Schematic representation of section 2, Jesmond.

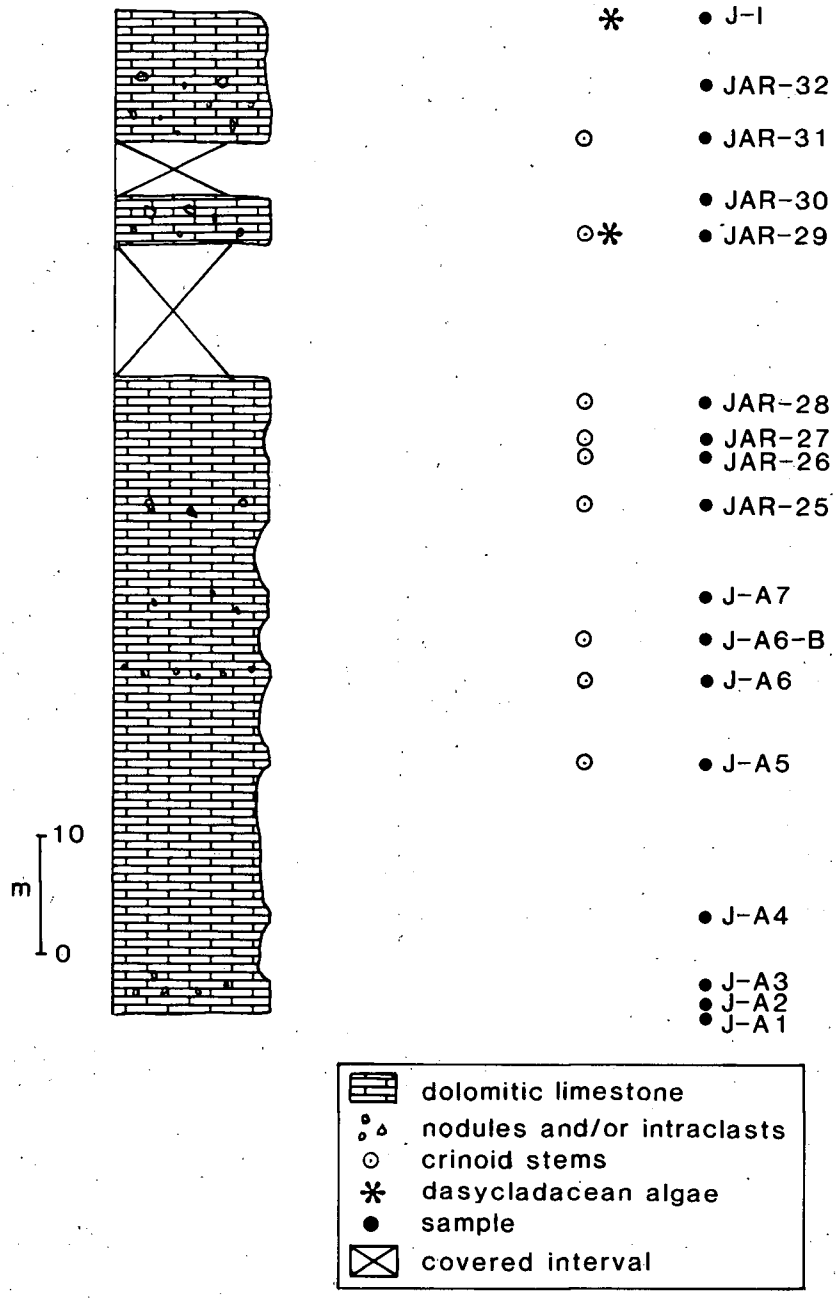


Figure 3.4: Schematic representation of section 3, Jesmond.

Figure 3.5: Micrite intraclasts and angular fragments and nodules in dolomitic matrix, section 3, Jesmond.

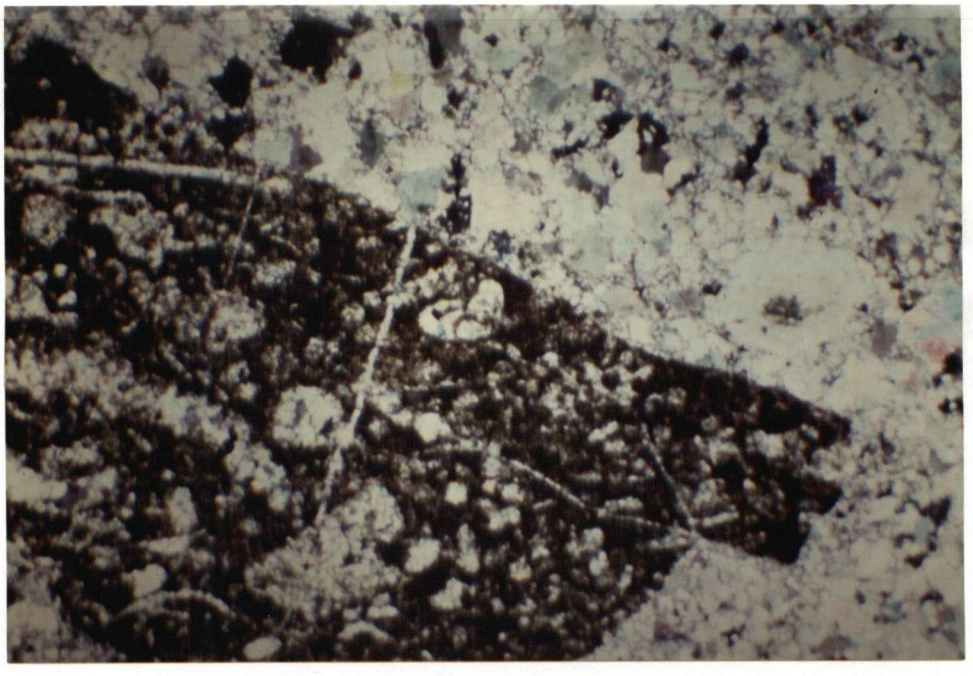


Figure 3.6: Photomicrograph in cross polarized light of dasycladacean micrite clast in dolomitic matrix, section 3, Jesmond. Magnification x24.

Located above the third switchback, section 4 (Figure 3.7) is separated by covered interval from section 3. This is a sequence of nearly continuous limestone, 85 m thick, and includes samples JAR-34 to J-T8. The limestone generally occurs in near-horizontal beds, 10 to 40 cm thick, but may be fissile and flaggy (Figure 3.8). Stylolites are commonly visible on the weathered surface (JAR-94, J-T1, J-T3), and elsewhere manganese dendrites occur (JAR-51, 73). Calcite encrustations (JAR-67, 74, 82), slickensided surfaces (JAR-52B, 101), narrow covered zones (e.g. between JAR-43 and 44), and minor displacements (JAR-48 - 49) on the order of centimetres, attest to the presence of numerous small local faults. Recrystallization is pervasive. Selective dolomitization produced a characteristic nodular appearance in the basal metres of the section. At locality JAR-86 nodules become more abundant towards the top of the bed. Brecciation and intraclasts were observed in thin section (JAR-97, J-T8).

Laterally discontinuous cryptalgal laminations (Figure 3.9) are visible in outcrop at localities JAR-97 to JAR-99 and at JAR-101 but a thin section is sometimes needed to discern them (J-T4). Fenestrae (bird's eyes), peloids and wavy laminations distinguish this structure. The dolospar-filled vugs may be related to early diagenetic methane generation.

Sample JAR-64 is a biomicrite. A thin section shows algal structures, unidentifiable bivalve shells, and circular shapes that may be wormtubes (W.R. Danner, oral commun., 1988). Microfossils in section 4 consist of ichthyoliths and ellisonid ramiform conodont elements that are succeeded by species of the conodont *Neospathodus*.

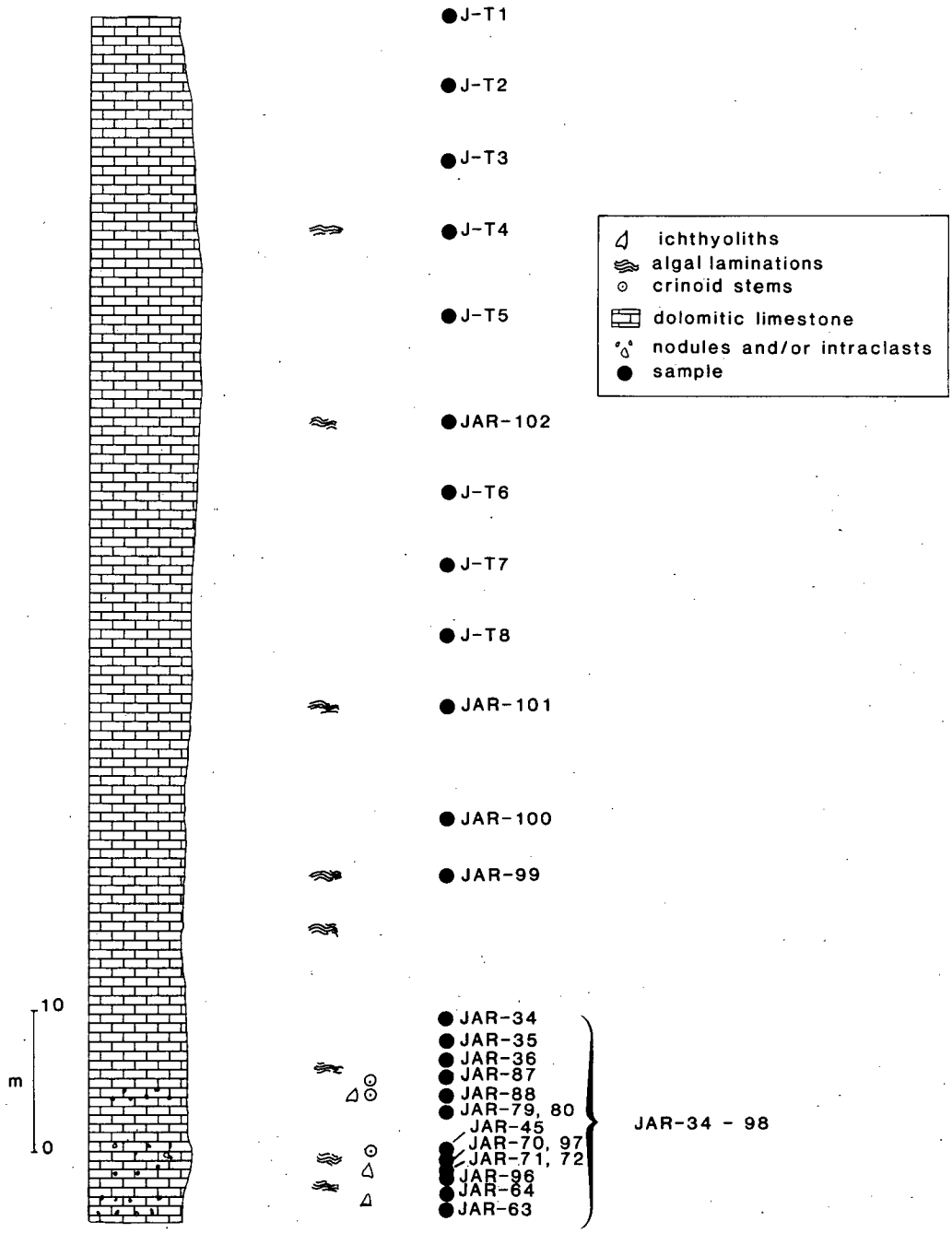


Figure 3.7: Schematic representation of section 4, Jesmond.

Figure 3.8: Well-bedded Triassic limestones of section 4, Jesmond.

Figure 3.9: Cryptalgal laminations in carbonates of section 4, Jesmond.

Spot samples were collected immediately below Jesmond fire lookout (JAR-103 to 107) and from the ridge on which it is situated (JFT-1 to 6). Outcrops of grey recrystallized limestone form bluffs at the summit. Micrite nodules are common and occur in a narrow band at locality JAR-105. At JAR-106 yellow-red bands occur parallel to bedding. A thin section, cut across the lowermost band, reveals a fine grained, muddy matrix grading downward into algal laminated and oncolitic structures, a sequence suggestive of a regressive event. Staining with potassium ferricyanide shows the mud is partially ferroan.

Faunas consist of probable gastropods in an algal micritic matrix, as seen in thin sections of hand specimen JFT-LEFT. Conodonts of the genus *Neospathodus* were recovered.

2. Big Bar Creek

Two samples were collected from outcrop on the west side of Jesmond road, 30 m north of where Big Bar Creek crosses it. The rock consists of fine grained, recrystallized and siliceous micrite. Only one of these samples (BigBarCk-2) contained conodonts but the elements recovered are not age-diagnostic.

3. Jesmond Creek

Medium grey, crinoidal, dolomitized and brecciated limestone forms sparse outcrop on the slopes north of and above Jesmond Creek. Chert nodules are common in a dark grey crinoidal micrite (JCk-2, JCk-3). JCk-1, a pelmicrite, contains an abundant conodont fauna.

B. CENTRAL MARBLE RANGE

Spot samples were collected from localities throughout the central Marble Range. They were of particular interest because it was felt that it might be possible to provide additional fossil control for Trettin's lithostratigraphic map units. Trettin (1980) identified six such units. Summarizing the main points from the account in Chapter 2 (Figure 2.1), units 2 and 4 are the massive limestones that characterize the Marble Canyon Formation and units 3 and 5 are an overlying recessive assemblage. Units 4 and 5 are thought to be thrust repetitions of units 2 and 3. Unit 6, consisting of volcanic rocks, chert, some limestone and pelite, makes up the western belt. Chert, basalt and limestone of unit 1 underlie the Marble Canyon Formation and occupy the cores of upright anticlines (Mortimer, 1987).

1. "Fiftyeight" (Mann) Creek

North of Clinton a disused logging road follows Mann Creek, between Fiftyseven and Fiftynine creeks. Float of andesite and basalt, as well as some granodiorite or diorite, occurs along the road's entire length, but phyllite, tuff or argillite were not seen. Because of the extent of Cenozoic cover, bedrock outcrop was encountered only once and from this a single, unproductive sample (58Ck) of light brown weathering, medium grey, silicified micrite, was collected. This locality lies outside of Trettin's (1980) mapped area, but by extrapolation would appear to lie within unit 3.

2. North of Porcupine Creek

Outcrop is located along a logging road that joins the main Jesmond highway 14.5 km north of its junction with the Kelly Lake-Clinton branch. Blasting has produced talus from a platy, fine grained limestone bluff immediately above it. This talus (NPorcCk-1; Trettin's unit 4) was thin-sectioned, revealing flattened oncolites and peloids or oöliths, often replaced by carbonate (Figure 3.10). NPorcCk-3 consists of thin layers of pink weathering limestone clasts alternating with layers of argillaceous aphanitic quartz and carbonate. Stylolites are evident in thin section. Although this locality falls within unit 4 on Trettin's (1980) map, it could also be assigned to unit 5. The contact between these map units appears to be gradational because to the southwest of unit 4 the massive limestone begins to occur as blocks and then as clasts in progressively greater amounts of argillite. Species of *Neogondolella* and *Epigondolella* occur in sample NPorcCk-4.

3. Porcupine Creek

A traverse along Porcupine Creek, 5.5 km north of the junction of Kelly Lake and Jesmond roads, cuts through two measured sections apparently forming the limbs of a synform within Trettin's (1980) unit 6. The first section (Figure 3.11) consists of thin bedded, light grey limestone, but further east siliceous argillite is part of the slickensided, jointed sequence of the second section (Figure 3.12). On the north side of the creek, limestone blocks occur in argillite (Figure 3.13).

Sample PorcCk-8 (from float) contains crinoid stems and other echinoderm plates in silicified micrite. The conodont fauna of sample PorcCk-1 (section 1) consists of

Figure 3.10: Photomicrograph in cross polarized light of flattened oncolites and/or oöliths in carbonates north of Porcupine Creek (NPORCCK-1). Magnification x30.

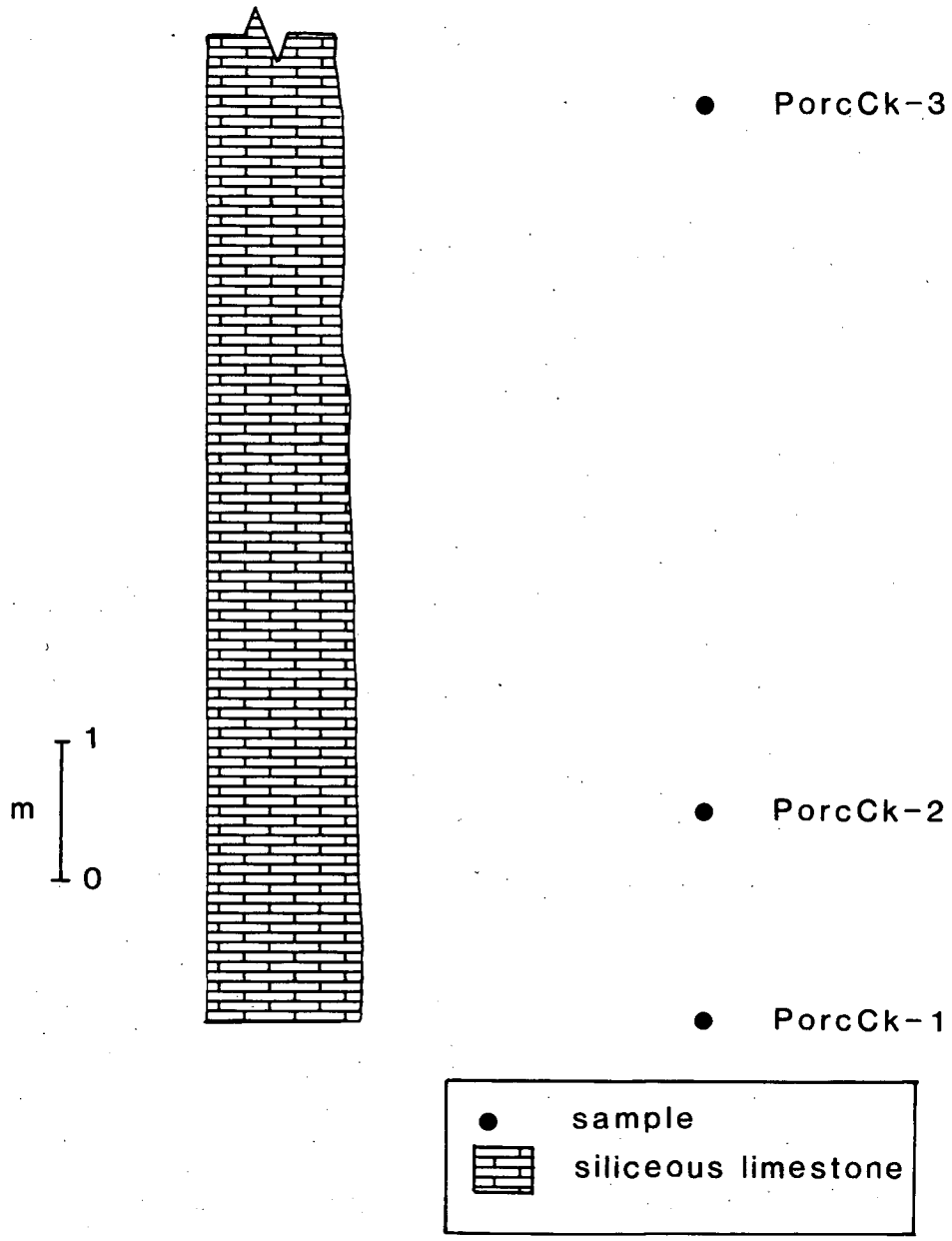


Figure 3.11: Schematic representation of section 1, Porcupine Creek.

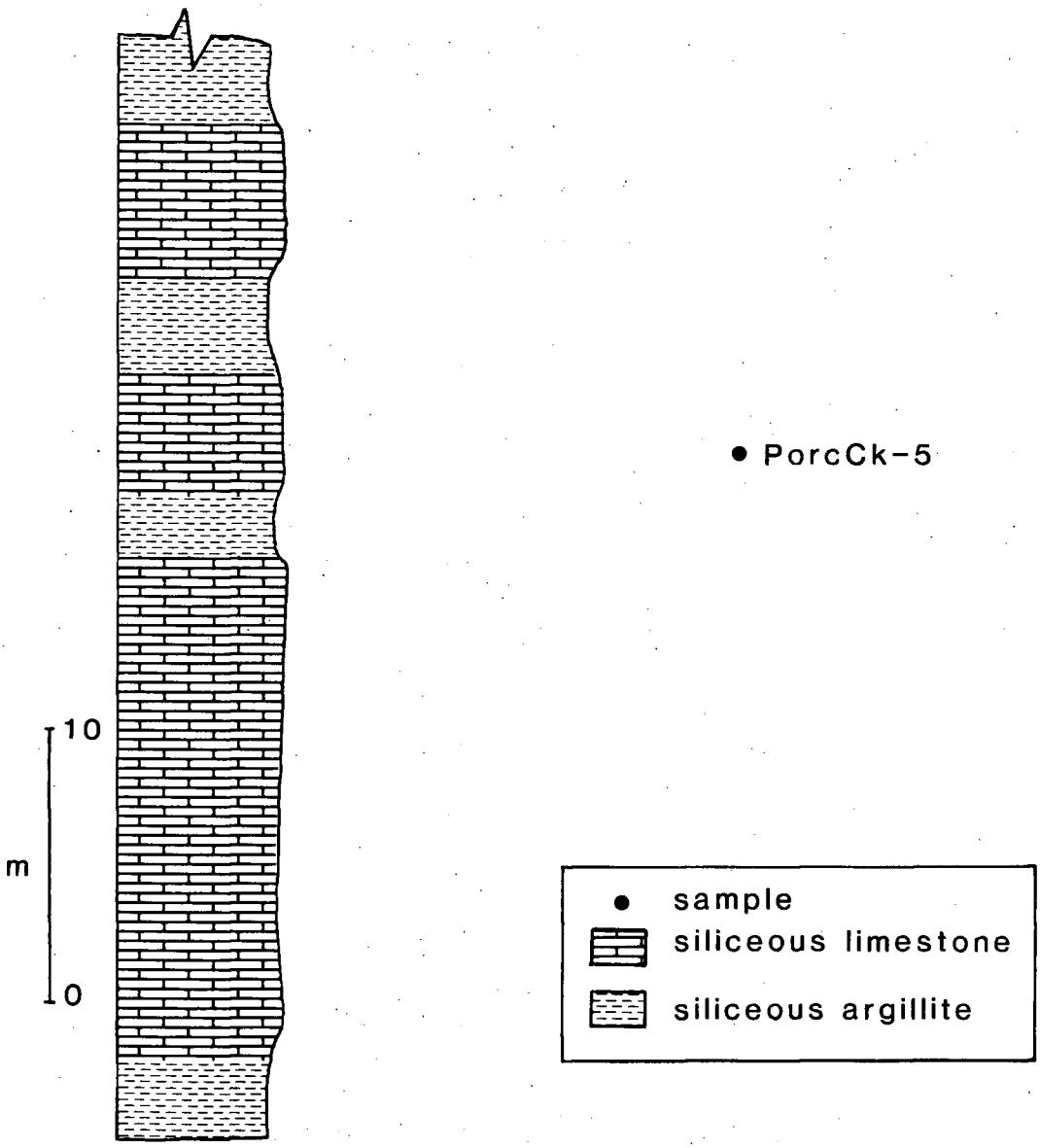


Figure 3.12: Schematic representation of section 2, Porcupine Creek.

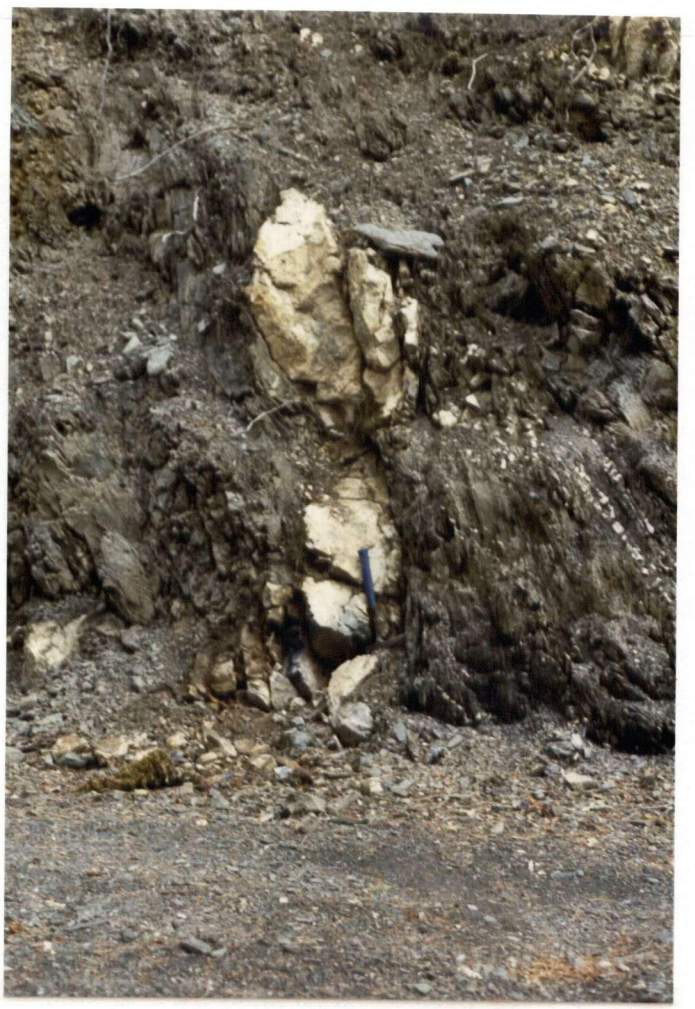


Figure 3.13: Limestone blocks in argillite, Porcupine Creek (near PorcCk-6).

elements of adenticulate *Isarcicella isarcica* and of *Hindeodus typicalis*, and that of PorcCk-5 in the second section, of species of *Neogondolella* and *Epigondolella*.

4. South slope of Mount Soues

At this locality (MtS) silicified micrite and overlying basalt, forming part of Trettin's (1980) unit 1, are found in association with the reddish chert that occurs as float on the lower slopes.

Trettin (1980, p. 3) remarks that unit 1 is unfossiliferous. However, in this study three conodont elements, probably referable to the Upper Permian, were recovered from the unit.

5. Clinton

A recrystallized, irregularly dolomitized limestone was sampled along the forestry lookout access road. Thin sections contain ?bryozoans, crinoids, gastropods and corals, the fusulinid *Yabeina* and the textularid *Glomospira?*, in a carbonate matrix.

C. PAVILION MOUNTAIN

Two sections were measured and sampled along Pavilion Mountain road and many spot samples were collected. Because carbonate is frequently recrystallized to marble and contains a prominent NW-SE trending cleavage and complex minor folds, it was expected that the high temperatures associated with this deformation would have destroyed conodont elements. Sampling in the area was therefore limited to the least recrystallized outcrops. Sample sites are marked on Figure

3.14.

1. "Conodont Corner"

4.9 km east of the junction of Kelly Lake and Pavilion roads at Hambrook Creek, limestone and tuffaceous argillite form a 42.5 m sequence (Figures 3.15-3.16) in the boundary area between central and western belts. Thin sections show microbrecciation of the limestone. Fractures are common and are quartz-filled (PVR-B) or carbonate-filled (PVR-D). The section's basal 5 m contains carbonates occurring as both clasts and as interbeds in argillite. Selective dolomitization (PVR-2) has produced a nodular lithology. PVR-3 contains both tuffaceous and calcareous clasts and/or nodules, in addition to oöliths.

Conodonts occur in the carbonates of both clasts and interbeds. Other fossils are few. Bivalve shell debris is visible in a thin section of PVR-A, and PVR-9 is sparsely crinoidal.

2. West of microwave tower

800 m west of the small tower that is located to the west of the main microwave tower, a second section was measured in a carbonate and argillite sequence, approximately 50 m thick (Figure 3.17). Accompanying planes of jointing and cleavage obscure bedding.

Limestone PVR-20 is dark grey and recrystallized, with many small, probably micritic, nodules, but no apparent clastic component, other than echinoderm debris. At other horizons the limestone is platy and commonly argillaceous. PVR-P

Figure 3.14: Sample localities and sections in the Pavilion Mountain area.

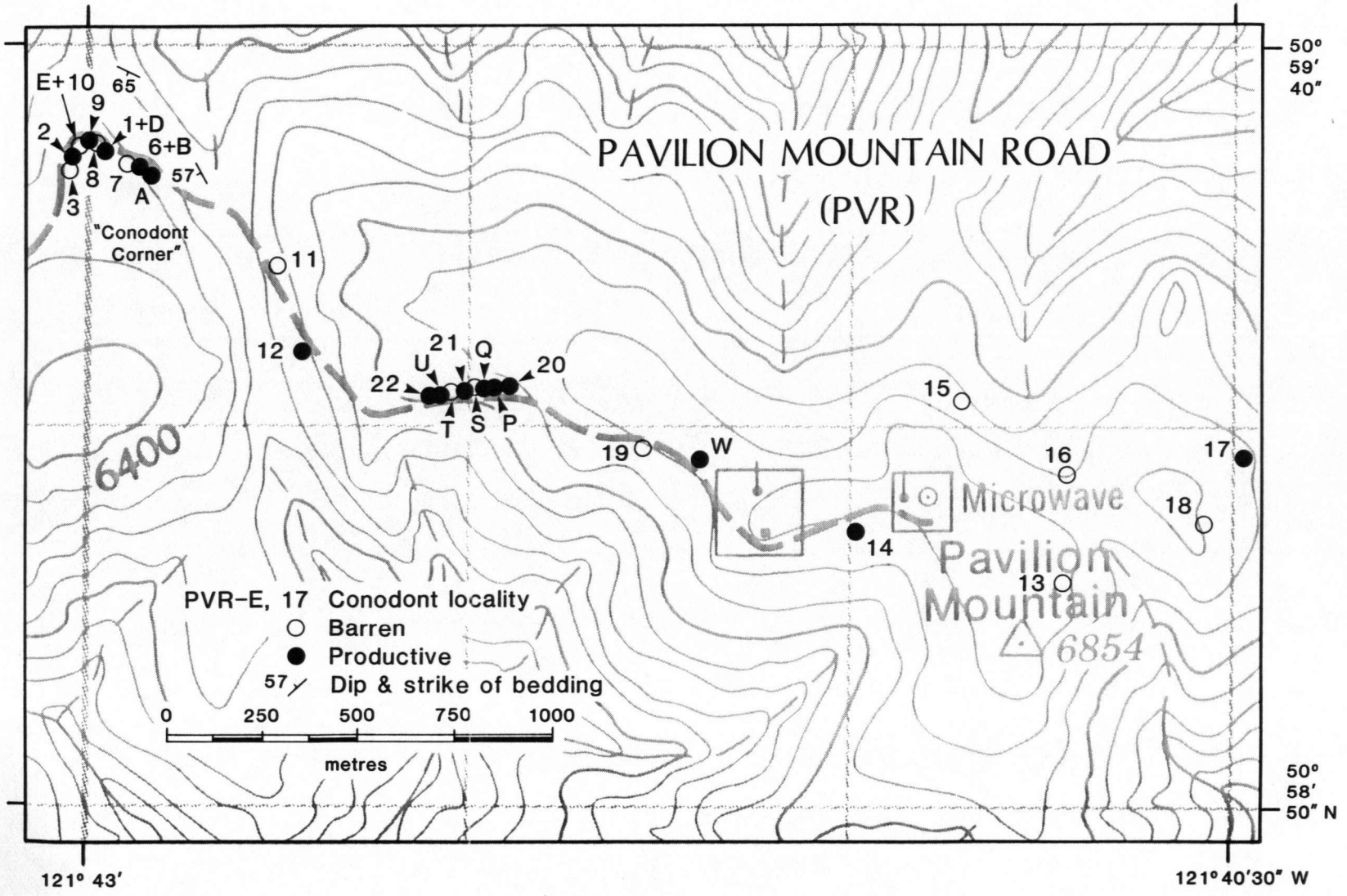

PAVILION MOUNTAIN ROAD
(PVR)
50° 59′ 40″
50° 58′ 50″ N
121° 43′
121° 40′30″ W
E+10
65
9
2
1+D
6+B
8
7
57
A
3
"Conodont Corner"
11
12
21
U
Q
22
20
T
S
P
19
W
15
16
17
18
14
13
Microwave
Pavilion Mountain
6854
6400
PVR-E, 17 Conodont locality
Barren
Productive
57 Dip & strike of bedding
0 250 500 750 1000
metres

Figure 3.15: Schematic representation of section at Conodont Corner, Pavilion Mountain road.

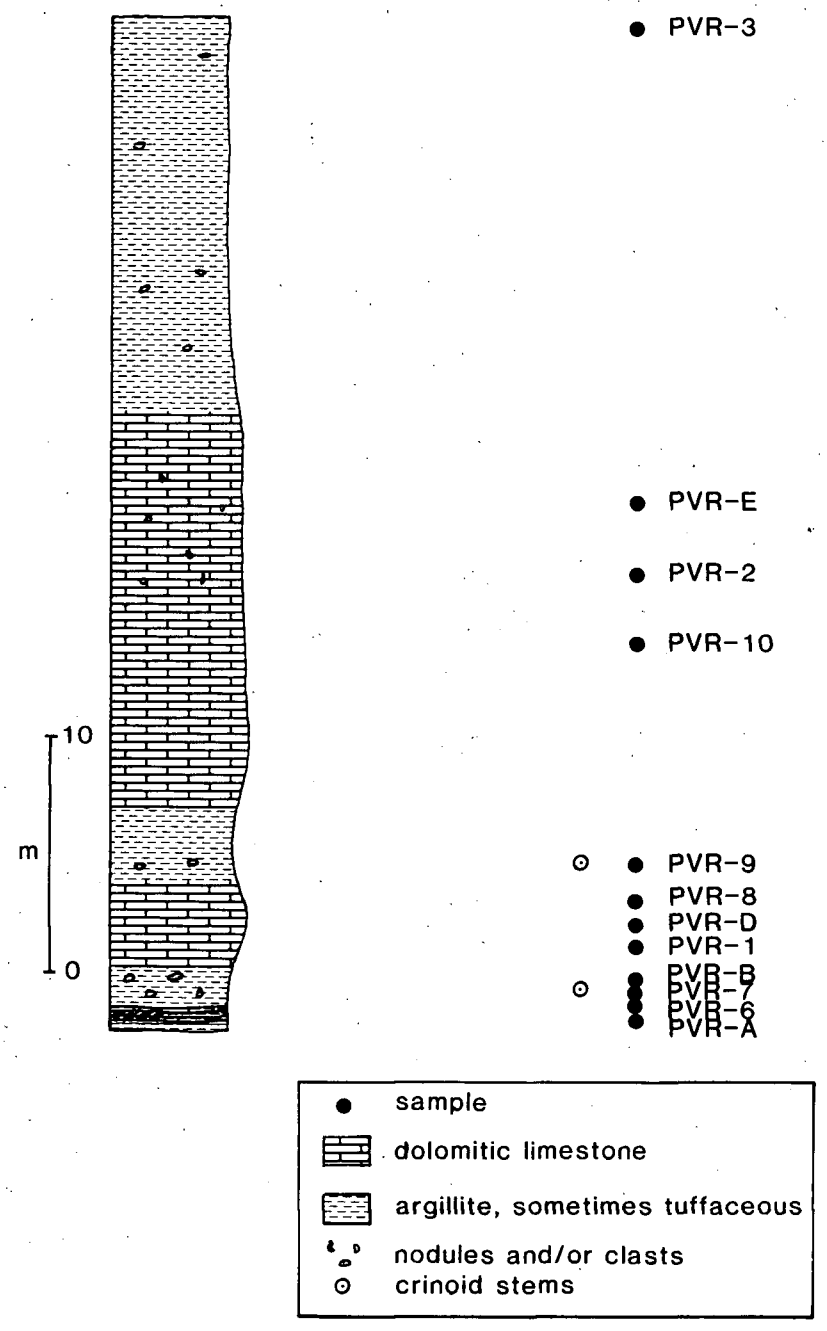
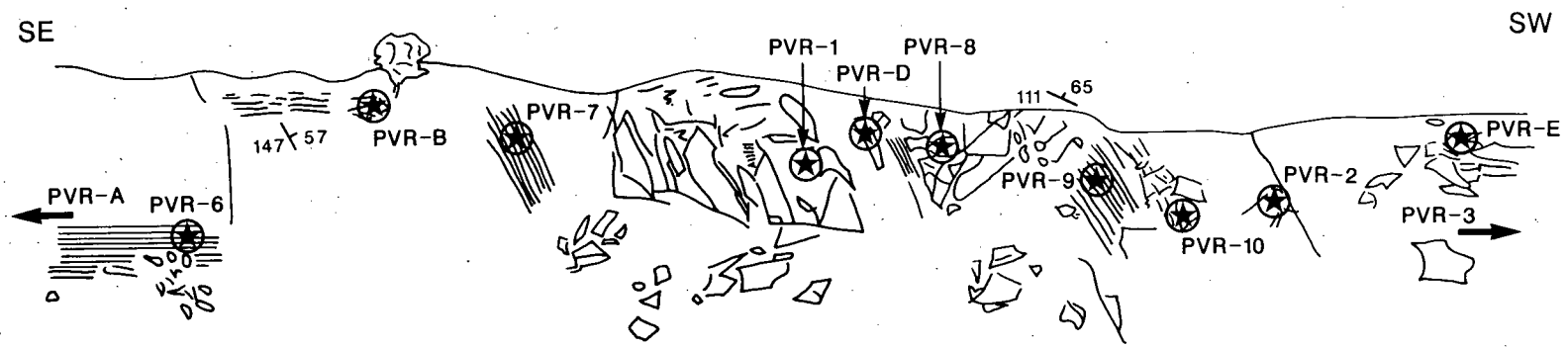

PVR-3
PVR-E
PVR-2
PVR-10
10
m
0
PVR-9
PVR-8
PVR-D
PVR-1
PVR-B
PVR-7
PVR-6
PVR-A
sample
dolomitic limestone
argillite, sometimes tuffaceous
nodules and/or clasts
crinoid stems

Figure 3.16: Sketch of outcrop at Conodont Corner, Pavilion Mountain road.



CONODONT CORNER, PAVILION MOUNTAIN ROAD

111 65 Strike and dip of bedding

PVR-7 Sample number

0 0.5 1.0
metres

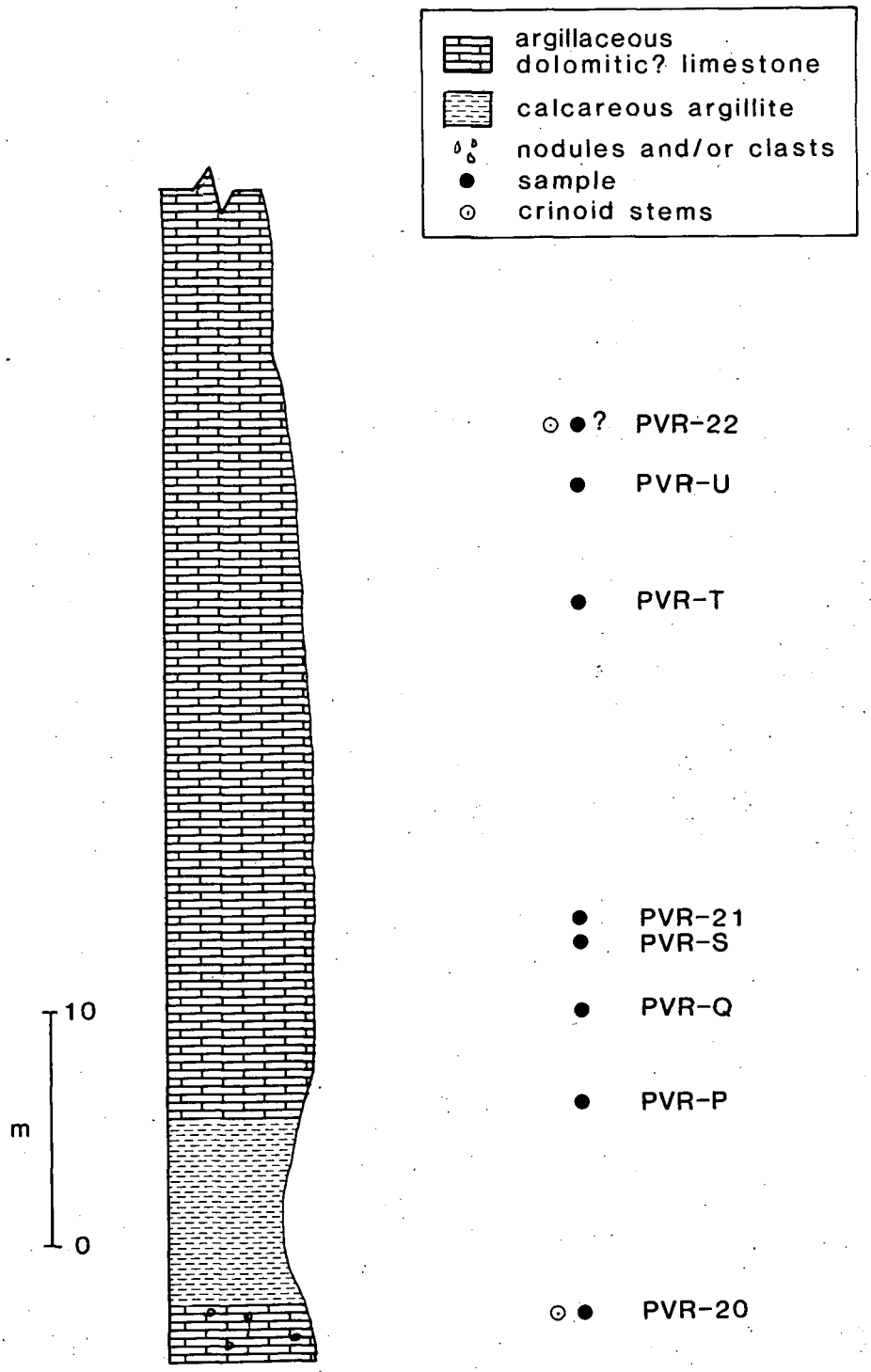


Figure 3.17: Section 2, Pavilion Mountain road. Thicknesses are approximate.

contains oöliths, while echinoid plates and crinoid stems are found in PVR-U and PVR-22. Conodonts occur through most of this section.

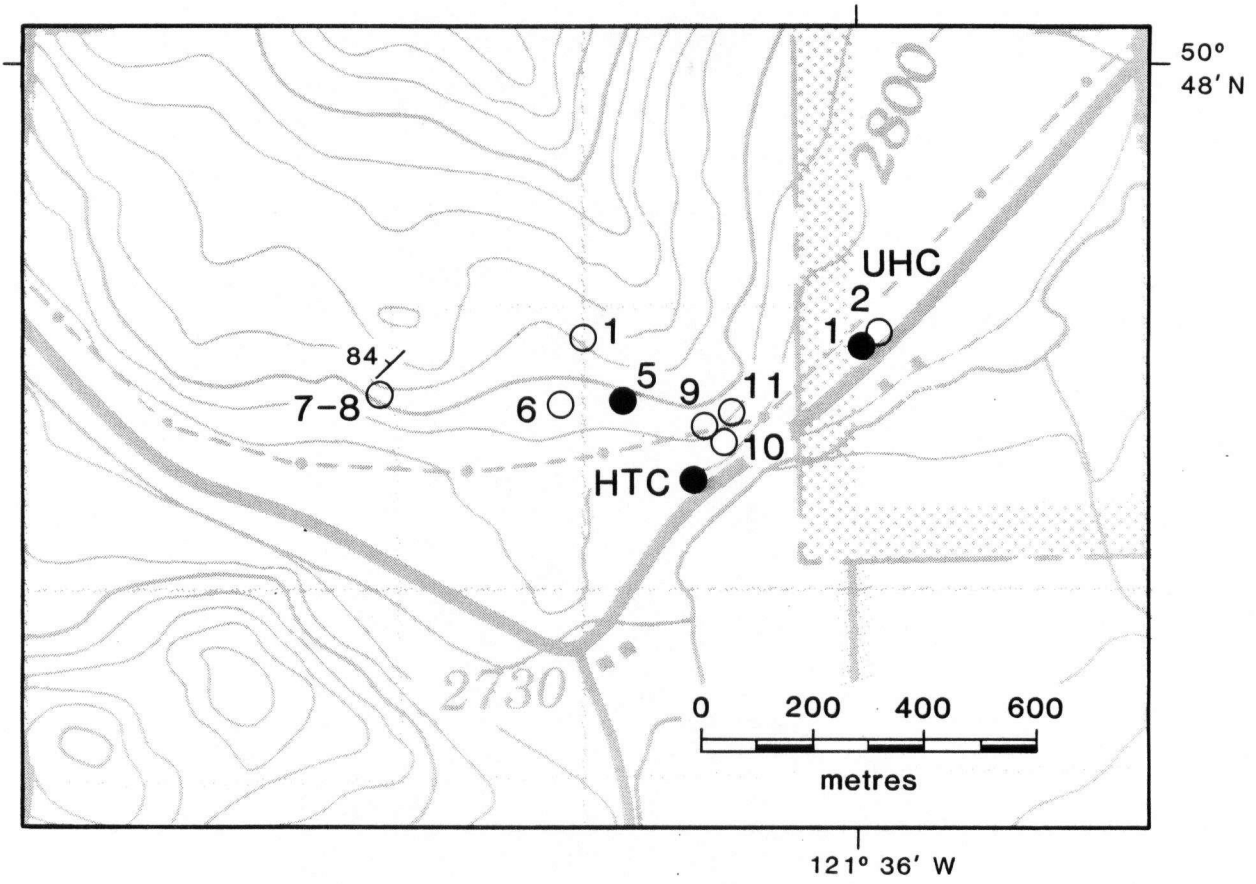
D. MARBLE CANYON

Samples from Marble Canyon (Figure 3.18) are from highly recrystallized and cleaved limestones due to the proximity of the Mount Martley pluton. Consequently, most proved barren of conodonts, except for HCJ-2 which contains a ramiform conodont, and HCJ-5, whose single platform element has a Conodont Alteration Index (CAI) of 7. HCJ-3 produced only ichthyoliths. Fissile, flaggy limestone is found interlayered with and pinching out between cliff-forming chert that has a distinctive red-ochre colour. Nearby a pink, coarse grained limestone occurs as interpillow carbonate and contains the fusulinid genera *Wutuella* and *Rauserella* (W.R. Danner, oral commun., 1988).

Two samples from the northwest side of Crown Lake are barren, as are the majority of those labeled "UHC" from Highway 12, east of the junction with Hat Creek road. Conodonts recovered from limestones near the south entrance to the canyon (M.J. Orchard's series HC and HTC, Appendix A) are associated with the fusulinid *Yabeina*. Sample HTC also contains *Glomospira* (Figure 3.19). Orchard (1981) recovered conodonts from the east wall of the canyon.

E. CORNWALL HILLS

Figure 3.18: Sample localities in the Hat Creek-Marble Canyon area.



HAT CREEK JUNCTION
(HCJ, UHC, HTC)

HCJ-6 Conodont sample

○ Barren

● Productive

^{84}/ Dip & strike of bedding

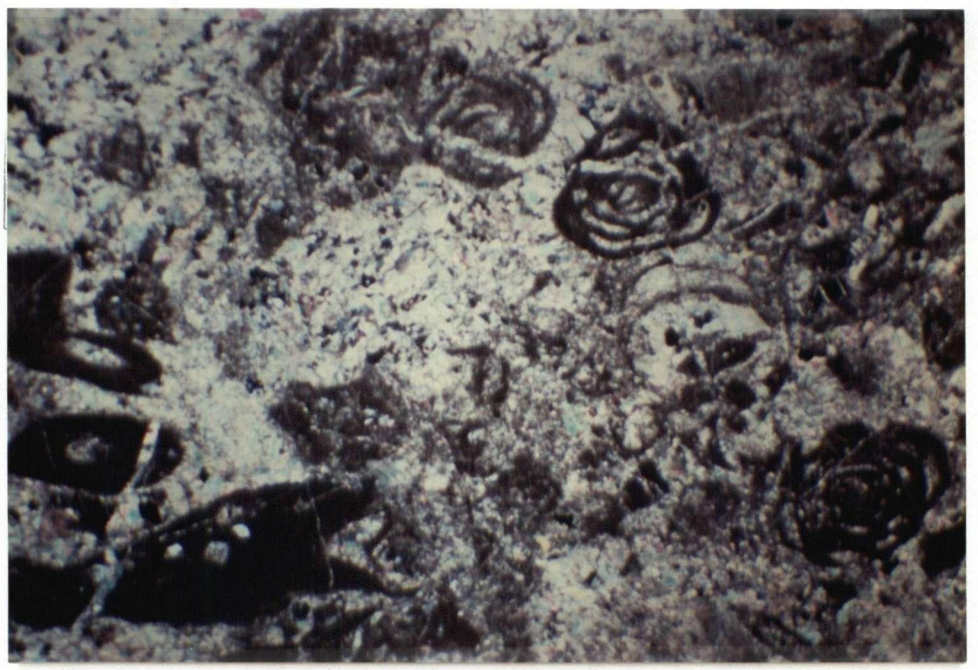


Figure 3.19: Photomicrograph of the textularid foraminifer *Glomospira* from limestone near southern entrance to Marble Canyon. Cross polarized light, magnification x24.

1. Access road and summit

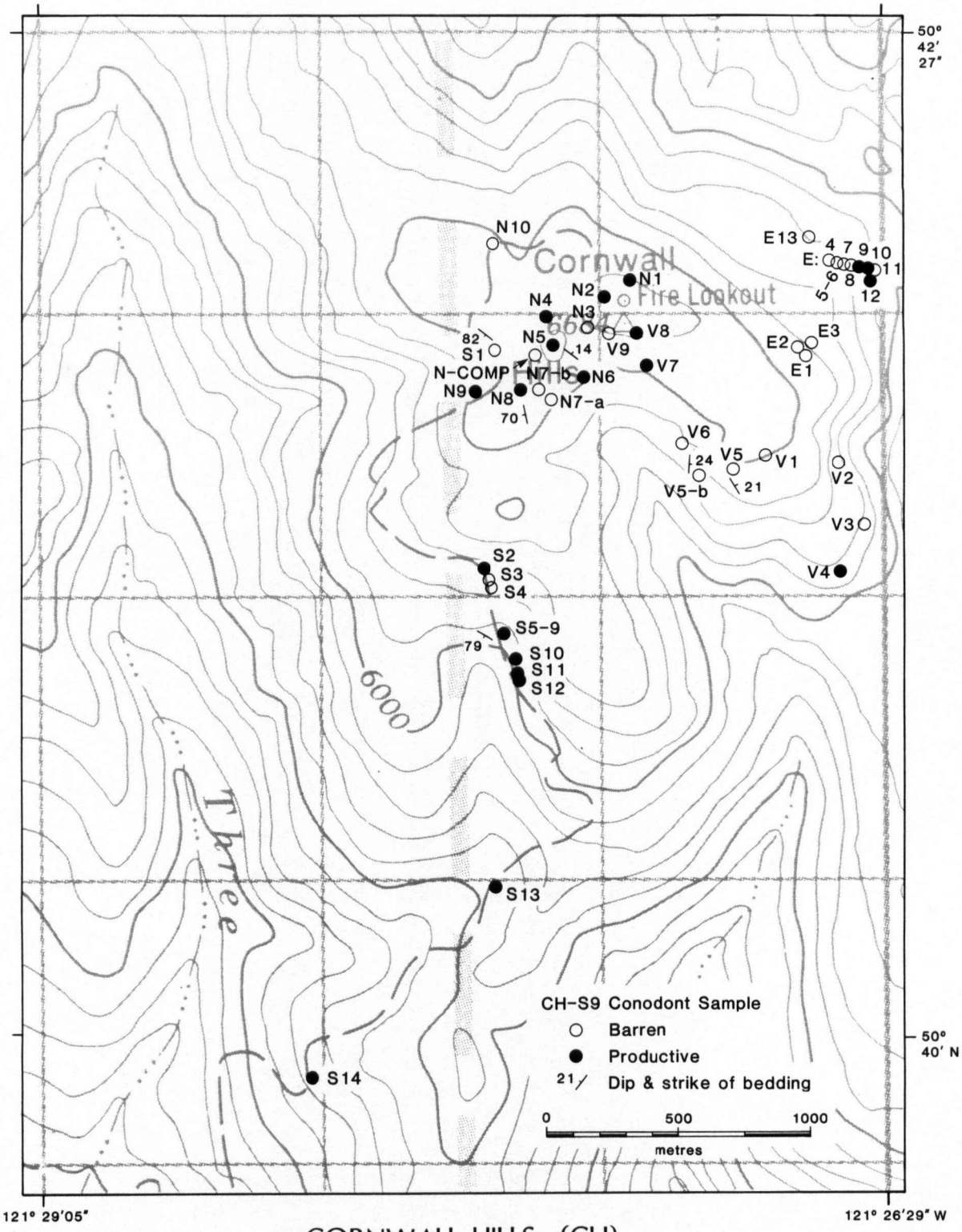
Volcanic flows, tuffaceous and argillaceous sediments, chert and limestone occur on Cornwall Hills. Complex structure and poor outcrop combine to complicate regional interpretation.

Four separate traverses correspond roughly to compass quadrants (CH-E, -N, -V, -S). Sample localities are plotted on Figure 3.20. CH-S, located along the dirt access road, is an odometer reading-supported, downhill traverse, detailed in Appendix D and sketched in Figure 3.21. As it was sometimes difficult to tell from outcrop alone whether carbonate associated with volcanic rocks was primary or secondary (replacement), rare examples of this type of lithology were collected for processing, and some were thin-sectioned.

Overturned folds in steeply dipping chert is well illustrated at and around locality CH-N8 where the greenish-grey radiolarian chert suddenly changes strike to produce a sharp "V". This style of deformation is probably common. Shortening is also evident from stylolites, widespread on Cornwall Hills (CH-V1, -S12, -E9, -N10). CH-E10 and -E11 have slickensided surfaces and CH-NE, from the slopes below the lookout, is a sheared carbonate. Limestone forms narrow low-lying ridges, and can be seen to underlie many slopes, but more often outcrop appears isolated.

At least three basalt flows, often replaced to varying degrees by carbonate, occur on Cornwall Hills: one is blue-green, another, easily distinguished, is light green in colour, and the third is grey with abundant calcite-filled amygdules. Where

Figure 3.20: Sample localities on Cornwall Hills.



CORNWALL HILLS (CH)

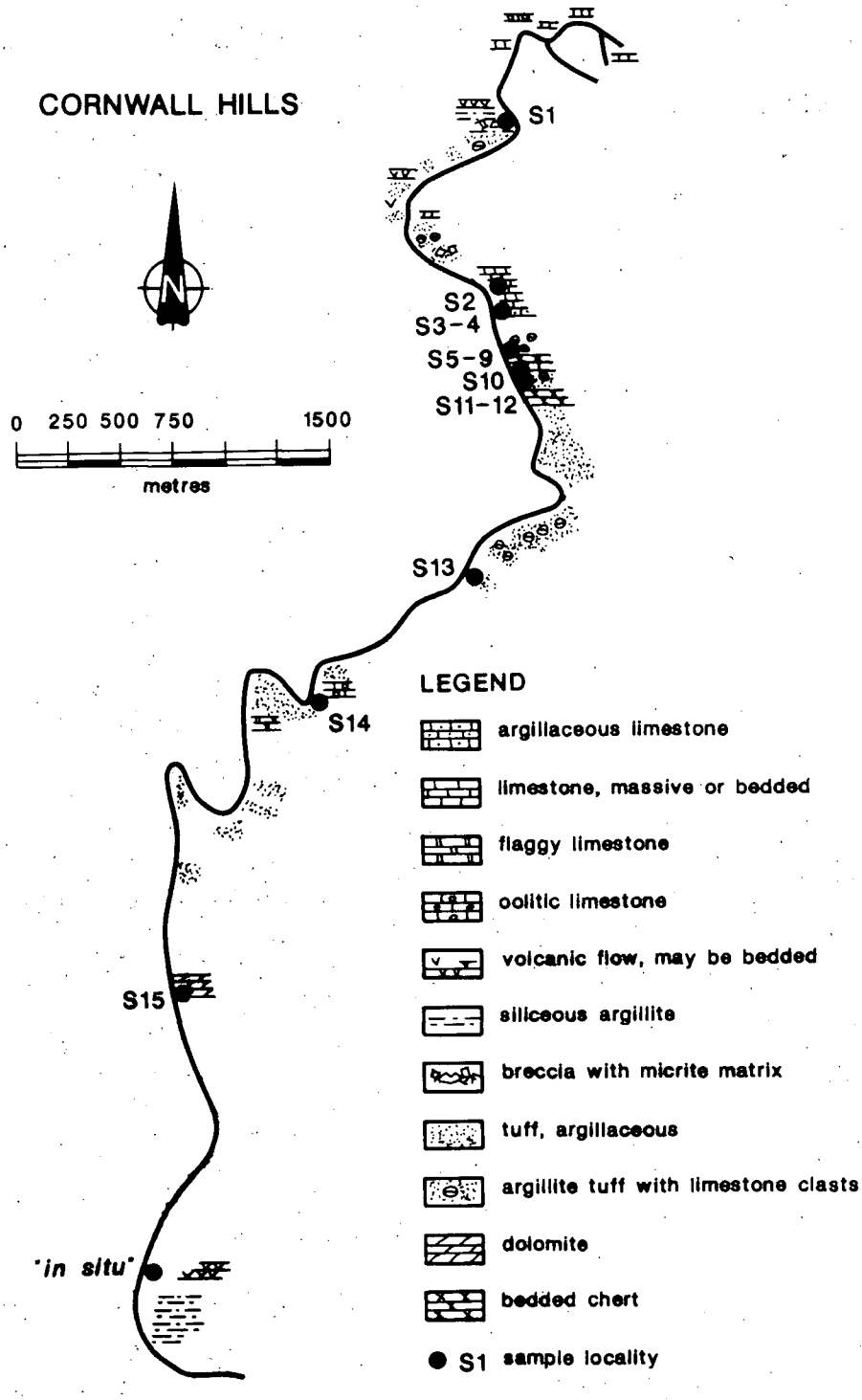


Figure 3.21: Odometer-supported traverse of the lookout road at Cornwall Hills (CH-S). Description of lithologies can be found in Appendix D.

associated with limestone the first two tend to floor the gulleys between limestone highs, forming a topography probably due to differential weathering. In this way the limestone at CH-N6 apparently overlies the blue-green basalt (I) of CH-N7-A, and similarly, the second type appears to underlie carbonate at CH-N2. The grey flow is known only from CH-S1, where it is in contact with the light green type (II) which it underlies. CH-N-COMP is a volcanic breccia composed of flow types I and II. Slumping or renewed volcanism may account for its origin, bringing together clasts of different parentage, without subjecting them to much transport. Fresh Tertiary ?andesite is present at the base of the hill above Oregon Jack Creek (hand sample "in situ").

Oöliths, visible in outcrop at CH-N10, at CH-N6, -V9, and at -V6 where they are algal-coated (oncolites), are found as clasts in a breccia to the south (sample CH3; Figure 3.22). The matrix is argillaceous, possibly with a volcanigenic component, and contains dolomite as shown in thin section. Smithian conodonts have been recovered from this breccia, but it is not known whether they are original to matrix or clasts (Orchard, 1981; Orchard and Beyers, 1988). CH-V5-B (Figure 3.23) and CH-V7 also contain oncolites in a micrite matrix. Crinoid stems are common; they are especially noteworthy at CH-E10 where they are very coarse. Other fossils observed in thin section are bryozoans (CH-V6), sea urchin spines, echinoderm plates, peloids and the long-ranging Triassic foraminifer *Mesoendothyra* (CH-V5-B).

Radiolarian cherts occur with muddy interbeds (one measured 7 mm thick- they probably represent periods without radiolarian blooms; CH-S11), interbedded with

Figure 3.22a: Breccia of limestone and oölitic limestone with argillaceous matrix, Cornwall Hills access road.

Figure 3.22b: Close up of limestone breccia showing oölitic clasts.

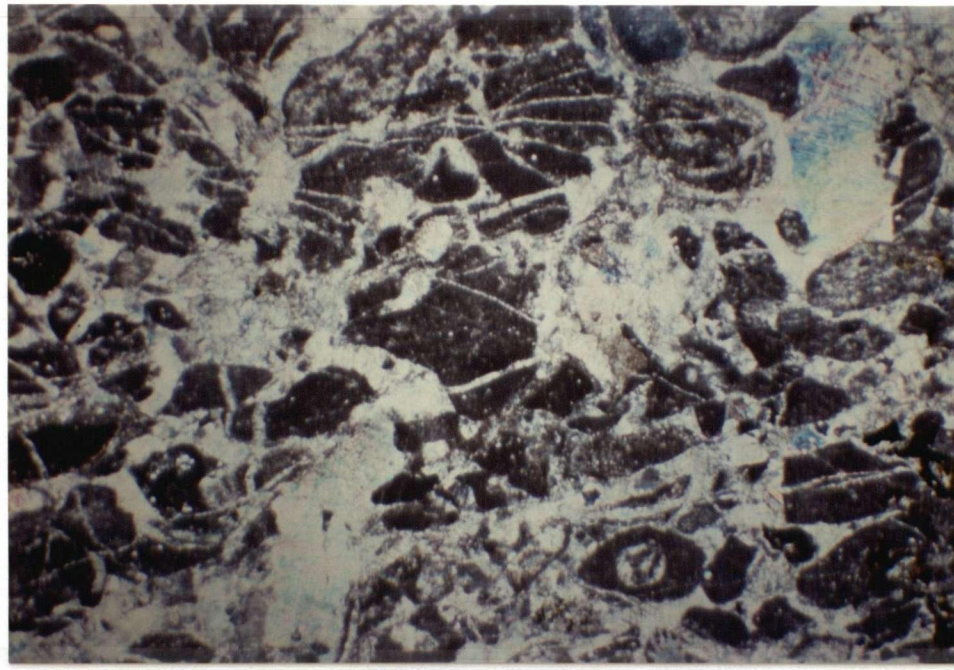


Figure 3.23: Oncolitic grainstone on Cornwall Hills (CH-V5-B). Photomicrograph in cross polarized light, magnification x24.

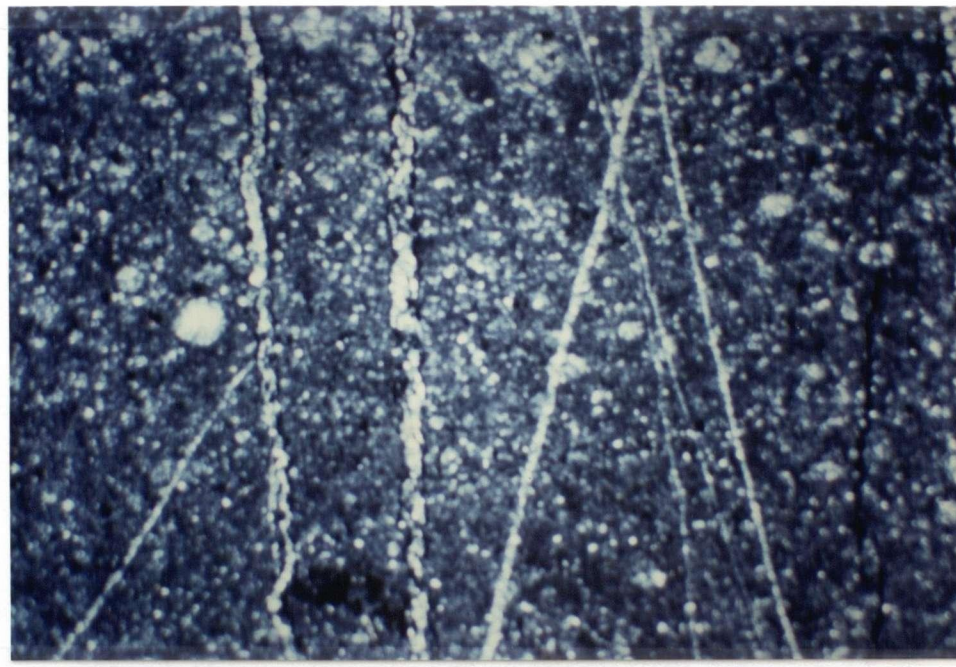


Figure 3.24: Photomicrograph in cross polarized light of fractured radiolarian chert on Cornwall Hills (CH-N8), showing spumellarian outlines. Magnification x24.

limestone (in the section CH-S5 to S9), and as isolated outcrop (at CH-V1 and CH-N8, Figure 3.24) at the summit. The radiolarians are not identifiable, but some of the cherts contain spumellarian outlines. Cordey (1986) reported radiolarians from bedded chert along the lookout access road (Appendix B). Conodonts were recovered from both chert and limestone in the present study.

2. Oregon Jack Creek

Recrystallized limestone crops out along the north side of Oregon Jack Creek. The micrite is often fractured (CHR-2, 7, 14). Stylolites (CHR-2), sheared sediments (CHR-9), and flattened oöliths in a layered fabric (CHR-10), also attest to deformation. CHR-6 and CHR-11 are breccias. The former is a solution breccia consisting of only one lithology (peloidal and oölitic micrite pseudoclasts) in a carbonate matrix. Fracturing is extensive and stylolites are pervasive, commonly truncating oöids and concentrating organic matter and clays. CHR-11 juxtaposes micrite intraclasts and fusulinid-bearing clasts. Transport is evident from abrasion of the unsorted constituents.

Crinoids and other echinoderm plates are again ubiquitous (CHR-4, 11, 12, 14). CHR-2 contains thin-shelled, pelagic bivalves (*Halobia?*), visible in thin section, in addition to conodonts. CHR-6 incorporates scarce sea urchin plates, oncolites, and *Tubiphytes*, an organism of uncertain affinity. Conodonts are found in CHR-10, a sample from float with source immediately above. Nearby, fusulinaceans (*Neoschwagerina* or *Yabeina*) occur in the recrystallized micrite of CHR-11 and in CHR-13, which is somewhat siliceous. Fusulinids in the cliffs where the valleys of Oregon Jack Creek and Hat Creek meet, resemble *Yabeina* in the rocks at

the Hat Creek turnoff by Marble Canyon.

IV. CONODONT BIOSTRATIGRAPHY

Age-significant conodonts were recovered from beds at most of the localities studied. They have been assigned to twelve Upper Permian and Triassic genera. Some taxa, which were represented in past collections made by M.J. Orchard but not found in this study, are included in the discussion. Stratigraphic occurrence of the conodont faunas is shown in Figure 4.1. Although most samples contained both platform and ramiform elements, multielement taxonomy was not attempted because of poor preservation through recrystallization and breakage.

Fossil zonations may be constructed through comparison with existing standards, or developed independently from sequential data. In the following discussion of conodonts from the Marble Range, several existing zonal schemes are employed. Of those available for the Lower Triassic, that of Sweet *et al.* (1971), using data from Pakistan, Kashmir and Nevada, is used as a standard. This is supplemented by the chronozonal scale of Sweet and Bergström (1986) which takes into account observations made by others in the intervening years, especially in the American Great Basin (e.g. Solien, 1979; Carr and Paull, 1983), and attempts through the technique of graphic correlation, to integrate first and last occurrences on a global scale. One drawback with this method is that no direct correlation with Lower Triassic stages can be made. Zonation for the Upper Permian is taken from Sweet (1988). Zonation for Middle and Upper Triassic strata is not central to this study, but that proposed by Orchard (1983) for the Norian is applicable. Conodont zonation is illustrated in Figure 4.2.

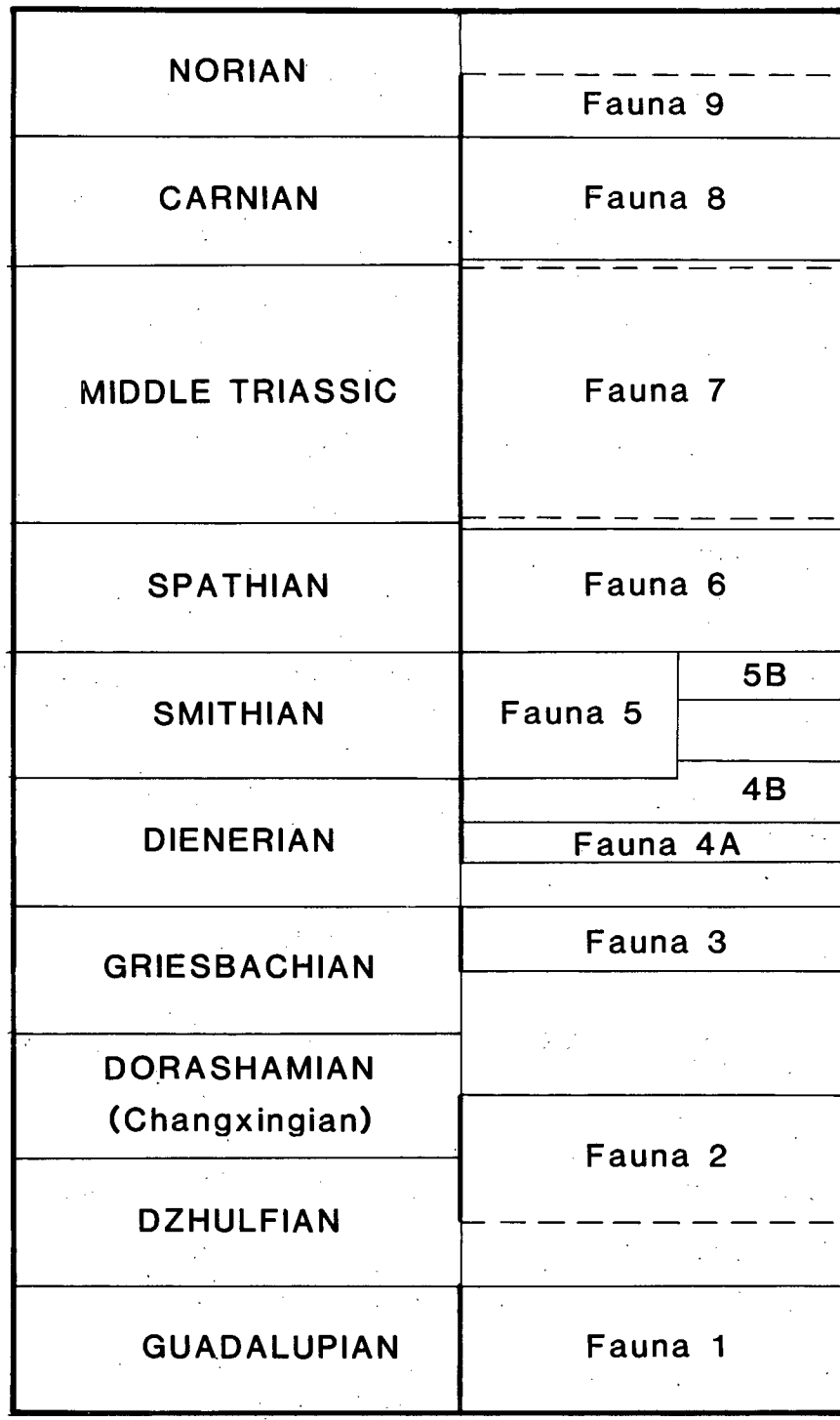


Figure 4.1: Stratigraphic distribution of conodont faunas in the central and western belts of the Cache Creek Group.

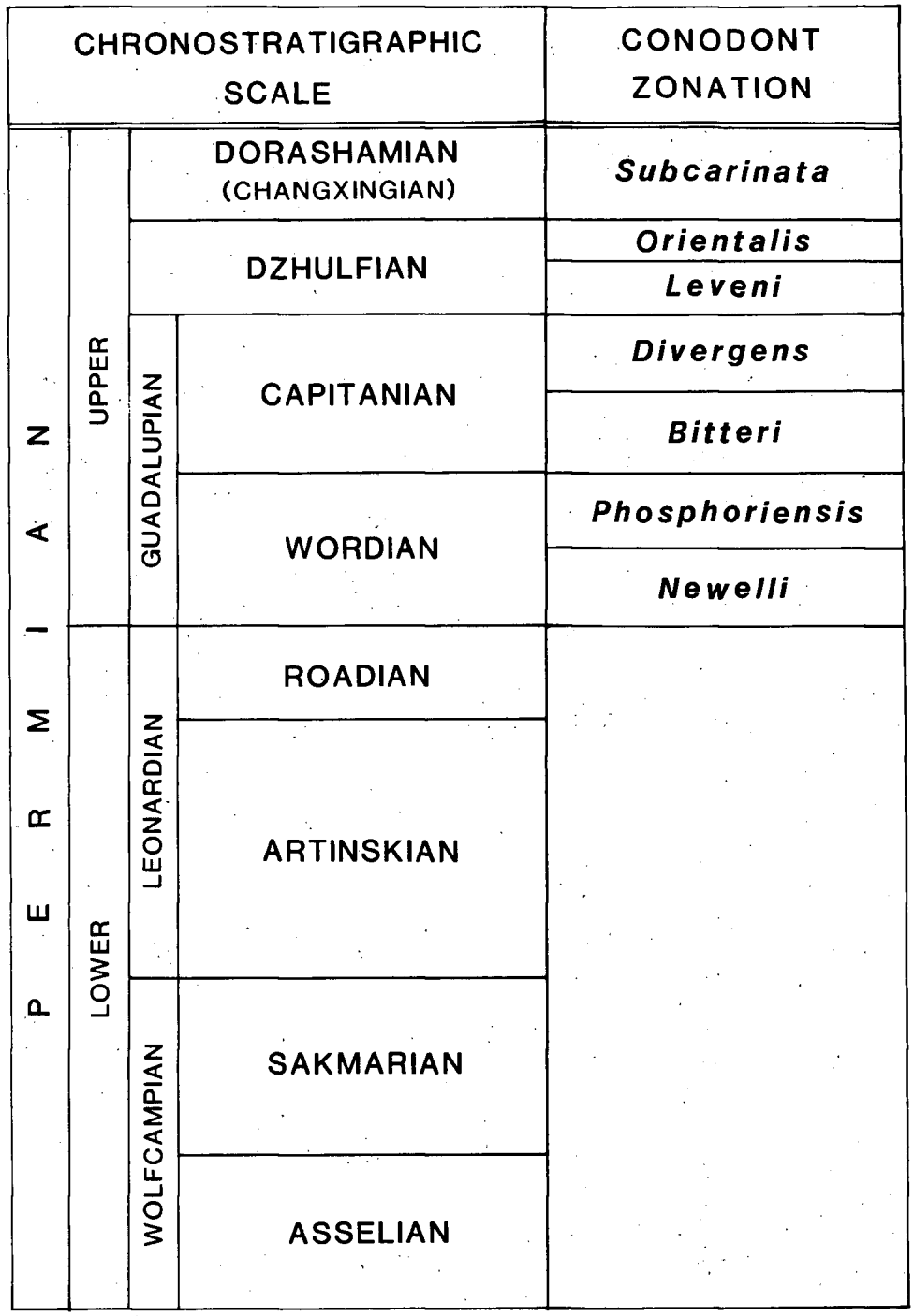


Figure 4.2a: Conodont zonation and chronostratigraphic scale for the Upper Permian. Zonation modified from Sweet, 1988; chronostratigraphy modified from Bamber *et al.*, 1989.

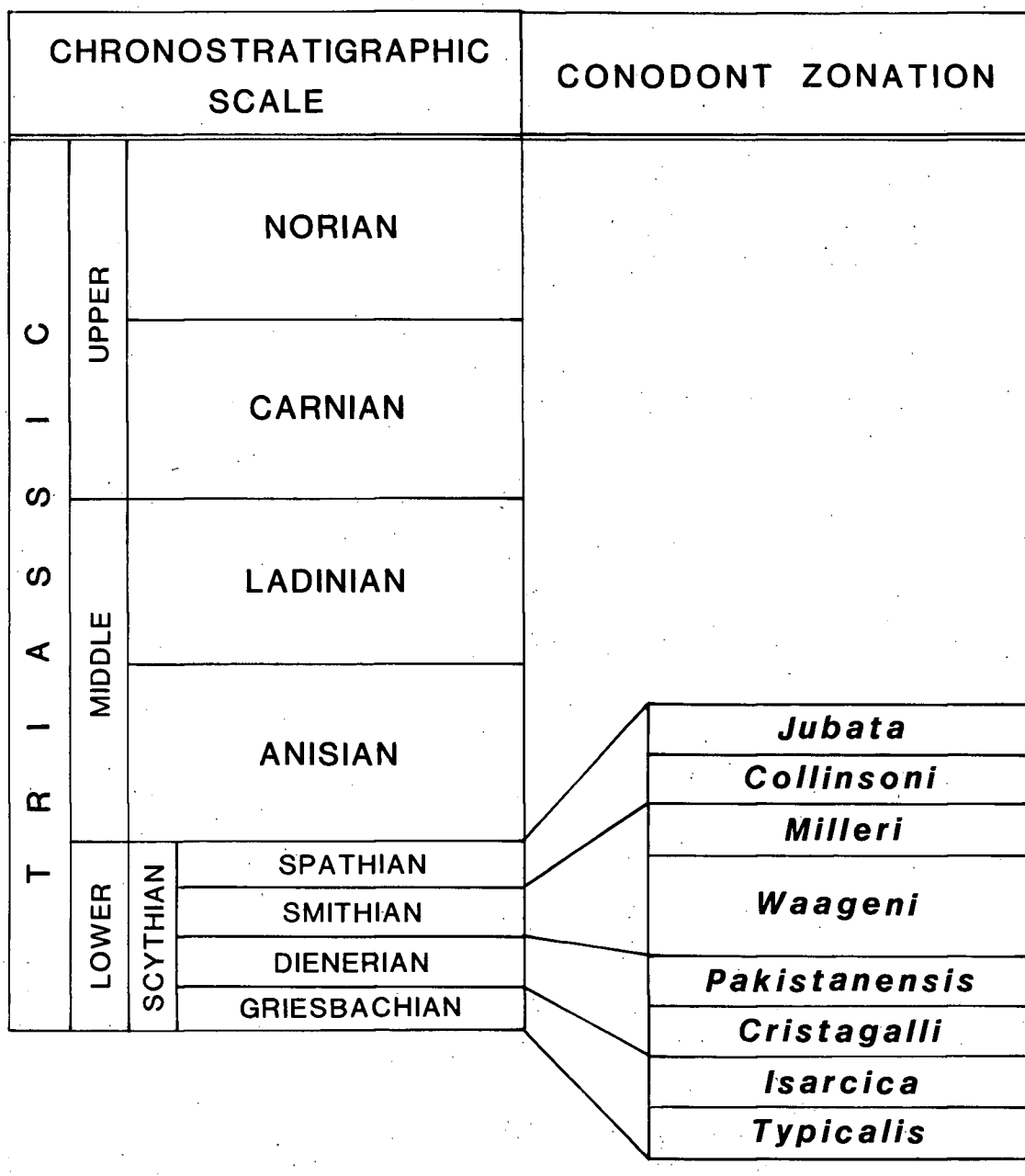


Figure 4.2b: Conodont zonation for the Lower Triassic and Triassic chronostratigraphic scale. Zonation modified from Sweet *et al.*, 1971, and Sweet and Bergström, 1986; chronostratigraphy modified from Sweet *et al.*, 1971.

A. UPPER PERMIAN CONODONT FAUNAS

1. Fauna 1

Components of the oldest Permian fauna are found on the mountain west of Clinton and in the Hat Creek-Marble Canyon area. In the Marble Canyon area indeterminate Upper Permian *Neogondolella* species, probably of the *serrata* complex, are associated with foraminifers *Yabeina* and *Glomospira*, and with sweetognathids that are similar to reworked elements found in Dienerian strata of the eastern canyon wall (Orchard, 1981), now considered part of the western belt (Mortimer, 1987). For the reworked fauna Orchard (1981) suggested an early Late Permian age (Abadehan), based on forms close to *Sweetognathus iranicus*. Hat Creek strata containing *Yabeina* are thought to be of comparable late Guadalupian age (Thompson, Wheeler and Danner, 1950).

A sample from west of Clinton (Cl-1) contains *Neogondolella phosphoriensis (=N. rosenkrantzi)*. First described from the Guadalupian of east Greenland (Bender and Stoppel, 1965), *N. phosphoriensis* is variously interpreted to have descended from *N. idahoensis* (Behnken, 1975) or from the younger *N. postserrata* (Kozur, 1978; Clark and Behnken, 1979). *Neogondolella phosphoriensis* was reported from the Phosphoria Formation in southeastern Idaho by Youngquist, Hawley and Miller (1951), who suggested ā Roadian (late Early Permian) to Wordian (early Late Permian) age. Detailed study of the conodont succession in the Meade Peak and Rex Chert members of the formation supports a Guadalupian age for the species (Behnken, Wardlaw and Stout, 1986), and Sweet (1988) showed a range that falls within the Phosphoriensis and Bitteri zones. Forms close to *N. phosphoriensis*

occur in the Melange Unit (Orchard, 1984); these were also assigned a Guadalupian age. The specimens from Clinton occur with *Yabeina* and *?Glomospira* which further supports a Guadalupian age.

2. Fauna 2

The youngest Permian fauna is recognized in sections 1, 2 and 3 along the lookout access road near Jesmond, above Jesmond Creek and at the base of the section near the microwave tower on Pavilion Mountain. Elements referred to *Iranognathus* ex gr. *nudus* are the main components. They are usually accompanied by *Hindeodus typicalis*, and by *Neogondolella subcarinata, N. orientalis,* and *N.* n.sp. *A.*

Hindeodus typicalis (*H. minutus* of different authors) is found throughout the Upper Permian Ali Bashi and Lower Triassic lower Elikah formations in northern Iran (Sweet, 1979). *Hindeodus typicalis* also spans the Permian-Triassic boundary interval in central Iran (Sweet, 1973; Kozur *et al.*, 1978), in the southern Alps of Italy, occurring in both the Permian Bellerophon and the Triassic Werfen formations (Perri and Andraghetti, 1987), at Guryul Ravine in Kashmir, and the type section in the Salt Range of Pakistan, where the species ranges from the Permian Chhidru into the Triassic Mianwali formations (Sweet, 1970a, 1970b). Sweet (in Teichert and Kummel, 1976) noted that this species dominated what he termed the "younger" of two faunas at Kap Stosch in east Greenland, present in the Permian Martinia shale facies and Triassic beds of the Wordie Creek Formation. However, at the Qiaoting section of south China, *H. minutus* is present only in the Permian Shangsi (=Changxingian, Clark and Wang, 1988)

Formation, and has not been reported from overlying Triassic strata (Wang *et al.*, 1987). In the Great Basin of the United States the species occurs well above the base of the Triassic Dinwoody in southwestern Montana (Schock *et al.*, 1981). The base of the Typicalis Zone at the base of the Triassic represents the range of *Hindeodus typicalis* above the last occurrence of Upper Permian *Neogondolella subcarinata.* Above the level of the first Triassic ammonoids, it is superceded by the Isarcica Zone of the upper Griesbachian (Sweet *et al.*, 1971; Paull, 1982; Sweet and Bergström, 1986).

Upper Permian and Triassic *Neogondolella* species are thought to have belonged to two lineages, both descended from a Wolfcampian ancestor (Clark and Behnken, 1971). The North American lineage (of Clark and Behnken, 1979) includes Lower Permian *N. idahoensis*, and the mostly Guadalupian *N. serrata* complex. A second lineage, termed Eurasian by Clark and Behnken (1979), but generally younger than most North American species, includes *N. leveni* and leads via *N. orientalis* to the Dorashamian *N. subcarinata* and its various subspecies (Kozur *et al.*, 1978). Both lineages are present in the Permian rocks of the Jesmond area. Clark and Wang (1988) have recently reported the presence of every species of the North American post-*bisseli* lineage in China, suggesting that their distribution was cosmopolitan.

Neogondolella orientalis occurs in sample J-B1, in section 1 and possibly in section 2 at Jesmond, as well as above Jesmond Creek. *N. subcarinata subcarinata* may be present 1.5 m above the base of section 1 but is otherwise known only from a locality at geographically lower outcrop (J-B1), where it is

accompanied by *N. orientalis*. A different subspecies, *N. s.* subspecies *A*, described previously as *N.* ex gr. *subcarinata* (Beyers and Orchard, 1989), was found 32 m above the base of section 3. In contrast, only one species with "American" affinity occurs in this area, but in greater abundance than any of the "Eurasian" species. *N.* n.sp. *A* is found in sections 1 and 2, in sample J-B1, and at Jesmond Creek (JCk-1). On Pavilion Mountain, 2 m above the base of a predominantly Triassic section west of the microwave tower, *N.* n.sp. *A* occurs with an element of the *Iranognathus nudus* group.

The first appearance of the predecessor of *N. orientalis*, *N. leveni*, at the transcaucasian sections in the ravine near the Dorasham II railway station and the village of Akhura, at Kuh-e-Ali Bashi near Julfa and at Kuh-e-Khambast in central Iran, determines the base of the Dzhulfian stage (Kozur *et al.*, 1978). At these four sections *N. orientalis* occurs at the level at which *N. leveni* disappears. On Hydra, Greece, *N. orientalis* occurs in upper Dzhulfian strata below the base of the Dorashamian (Nestell and Wardlaw, 1987). In south China the species ranges throughout much of the Wuchiaping and Changxing formations (Clark and Wang, 1988). The base of the Orientalis Zone coincides with the last appearance of *N. leveni* outside China (Clark and Wang [1988] report this species from the upper Changxing Formation at Xuanen, Hubei Province, south China) and its top with the first appearance of *N. subcarinata* (Sweet, 1988) and the ammonoid *Phisonites* (Kozur *et al.*, 1978). This event defines the base of the Dorashamian stage as established by Rostovtsev and Azaryan (1973), and corresponds to the base of the Changxingian in south China (Zhao Jin-ke *et al.*, 1981). A report of *Neogondolella s. subcarinata* from the uppermost Wuchiaping Formation near

Nanjiang in Sichuan Province of south China by Clark and Wang (1988), deviates from this convention, suggesting that the base of the Dorashamian and of the Changxingian may be only approximately correlative.

Neogondolella s. subcarinata was originally reported from the Ali Bashi Formation at Kuh-e-Ali Bashi (Teichert *et al.*, 1973). The species is known as well from the Akhura and Dorasham II sections in nearby Soviet transcaucasia, and from the section at Kuh-e-Khambast in central Iran (Kozur *et al.*, 1978). At all four of these localities *Phisonites* appears with *N. subcarinata* (Kozur *et al.*, 1978). In south China *N. subcarinata* and affiliated subtaxa are well represented, ranging to the top of the Permian as illustrated by Clark and Wang (1988). At another Chinese locality, the Selong section in Nyalam County, Xizang (Tibet) Province, the base of the Triassic [Ophiceras] Sakuntala Zone (top of the *Otoceras* bed) in the Lower Formation of the Tulong Group coincides with the top of the ranges of a *N. subcarinata* subspecies and a further related species, *N. deflecta* (Yao and Li, 1987). This anomaly appears related to the presence of an unconformity at the base of the *Otoceras* bed, resulting in a mixed Permian-Triassic fauna (Yao and Li, 1987; Tozer, 1988). Sweet's (1988) conclusion that the Subcarinata Zone should straddle the Permian-Triassic boundary apparently reflects the Selong interpretation that *N. subcarinata* ranges into the Lower Triassic. This zonal scheme is at odds with earlier ones in which the Typicalis Zone crosses the boundary (Sweet *et al.*, 1971). In this study the top of the Subcarinata Zone is understood to coincide with the last occurrence of *N. subcarinata* before the appearance of *Otoceras*. This level corresponds to the traditional base of the Triassic (Tozer, 1988).

Members of the Late Permian genus *Iranognathus* have previously been described from Iran and China. Wardlaw (1988) also reported "species of *Iranognathus*" from the Salt Range. Two species, *I. unicostatus* and *I. tarazi*, were originally described from Iran by Kozur *et al.* (1975). Later (Kozur *et al.*, 1978), the stratigraphic position of *I. tarazi* was shown to fall within strata below the base of the Dorashamian near Julfa and at Abadeh. Subsequently, the same species has been reported from the upper Wuchiaping and lower Shangsi formations in south China (Wang *et al.*, 1987). The absence of all but one ridge on the upper surface of the basal cup of *I. unicostatus*, a feature which sets it apart from *I. tarazi*, may be the expression of a morphological simplification in the genus. This trend may have continued to produce a third recently described Upper Permian species, *Iranognathus nudus*, which is characterized by the absence of ornamentation on the cup. This species occurs in cherty limestones of the Shangsi Formation in the Qiaoting section near the town of Nanjian, Sichuan Province, in south China (Wang *et al.*, 1987), where it is found throughout all but the uppermost few metres of the Shangsi Formation. This unit is overlain paraconformably by the Triassic (Wang *et al.*, 1987).

Uncertainty about the degree of morphological correspondence between the Chinese and Jesmond iranognathids has led to the present specimens being placed in a broader concept, the *I. nudus* group. In addition, a new species of *Iranognathus* (*I.* n.sp. *A*) is found at Jesmond. Co-occurrence of these elements with neogondolellids of the *subcarinata* group is important because it strengthens correlation with Changxingian strata.

The sporadic presence of *Neogondolella subcarinata* elements in association with *N. orientalis* at Jesmond suggests an early to middle Changxingian age. Alternatively section 2, which does not contain *N. subcarinata*, may be slightly older (upper Dzhulfian) than the other sections and the outcrop at J-B1, and in structural contact with them. However, the fact that *Iranognathus nudus* group elements accompany samples both with and without *N. subcarinata* suggests a similar, early to middle Dorashamian/Changxingian, age for all the sections, and argues against significant displacement.

Neogondolella n.sp. *A*, thought to represent a further development in the *serrata* complex, is found on the slopes above Jesmond Creek with *N. orientalis* and *I.* ex gr. *nudus*, indicative of an early to middle Dorashamian age for this species. Even so, because of uncertainty regarding the relationship of Jesmond iranognathids to the Chinese specimens, and the absence of *N. subcarinata* at Jesmond Creek, there is a possibility that the range of *I.* ex gr. *nudus* extends down into the upper Dzhulfian. Consequently, *N.* n.sp. *A* is referred to both Orientalis and Subcarinata zones.

Two components of Fauna 2 are therefore tentatively recognized. The oldest is upper Dzhulfian in age, corresponds to the Orientalis Zone, and consists of *Neogondolella* n.sp. *A*, *N. orientalis* and *I.* ex gr. *nudus*. The youngest component contains the same species but is accompanied by *N. subcarinata*. This component is early to mid Dorashamian/Changxingian in age, and lies within the Subcarinata Zone.

B. LOWER TRIASSIC CONODONT FAUNAS

Lower Triassic conodonts of the Marble Range are a varied group assigned to four faunas.

1. Fauna 3

Two elements of the adenticulate morphotype of *Isarcicella isarcica* (="*Anchignathodus parvus*") accompanied by platform (Pa) and ramiform elements of *Hindeodus typicalis*, occur in limestone at the base of section 1 at Porcupine Creek.

In material described by Staesche (1964), three morphotypes of *Isarcicella isarcica*, denticulate and adenticulate, occur together in the lower Seis beds of the Werfen Formation in South Tirol. Sweet (in Teichert, Kummel and Sweet, 1973) found denticulate and adenticulate elements in the lower 4.5 m of the Triassic Elikah Formation at Kuh-e-Ali Bashi and Paull (1982) also reported their co-occurrence in the Lower Triassic Thaynes Formation of the Terrace Mountains in Utah.

The adenticulate morphotype of *Isarcicella isarcica* was assigned to *Anchignathodus parvus* by Kozur and Pjatakova (in Kozur, 1975). In the Dorasham II, Julfa and Abadeh sections, "*A. parvus*" first appears above the base of the traditional Triassic (placed at the top of the *N. subcarinata* range), while the range of denticulate forms of *Isarcicella isarcica* either is encompassed by that of "*A. parvus*" or overlaps with it in the upper part of the latter's range (Kozur *et al.*, 1978). At Akhurah the denticulated forms do not occur, but in the Lower Triassic Dolomite Unit of the Kathwai Member of the Mianwali Formation in

Pakistan, Sweet (1970b) recovered only denticulated forms. At the Selong section in Tibet *"A. parvus"* is reported from the transitional bed with Late Permian *Neogondolella subcarinata* and *N. deflecta* (Yao and Li, 1987). As discussed above, the transitional bed at Selong contains a mixed fauna and appears to overlie Permian strata unconformably. If this is so, the mixing of elements of Permian and Triassic aspects would then be due to reworking and not to a gradual disappearance of surviving faunal elements from the Permian Period (Tozer, 1988). Because *"I. isarcica"* (exclusive of adenticulate forms) has a range that is both encompassed by that of *"A. parvus"* and overlaps with it, there appears to be little stratigraphic value in separation of the morphotypes. It should be noted that the third morphotype, with a denticle on either side of the symmetrical blade, is not always present in denticulate populations (Sweet in Ziegler, 1977, p. 226). Consequently, other factors are thought to be involved in the observed distributions. Except for the Selong occurrence for which a Permian age could be invoked, all others are clearly Triassic, occupying a rather well constrained horizon in the Lower Triassic. This suggests an Early, but not basal, Triassic age. The Isarcicella chronozone of Sweet and Bergström (1986) falls within the Griesbachian range of *Hindeodus typicalis*. Its base, defined by the first appearance of *Isarcicella isarcica*, lies above the traditional base of the Triassic.

2. Fauna 4

Several species of *Neospathodus* and one species of *Neogondolella* make up Fauna 4, which occurs in Marble Canyon, on Pavilion Mountain and in Cornwall Hills. *'Neogondolella' carinata, Neospathodus dieneri* and *N. peculiaris* were recorded by Orchard (1981) from the east wall of Marble Canyon. *Neogondolella carinata* is

also known from Cornwall Hills (sample CH1, Orchard collection) but there it occurs with *Neogondolella* elements of possible younger Triassic age. It has not been recovered elsewhere in the Marble Range. *Neospathodus* sp. *A* of Orchard (1981), which occurs in beds underneath those containing *N. dieneri* in Marble Canyon, is found on Pavilion Mountain with indeterminate neospathodids, but is part of a Cornwall Hills assemblage that will be discussed as Fauna 5. Elements referred to *Neospathodus* cf. *N. peculiaris*, *N.* cf. *N. dieneri*, and *N.* cf. *N. pakistanensis*, are found in another Cornwall Hills sample (CH-E12), assigned to Fauna 4B.

Neospathodus peculiaris is a species known from the upper Dienerian Cristagalli Zone of Sweet *et al.* (1971) in the type section in Pakistan (Sweet, 1970b), from the Dinwoody Formation in the Terrace Mountains (Paull, 1982), and from upper Griesbachian strata of the Blind Fiord Formation on Axel Heiberg Island (Mosher, 1973). *N. pakistanensis* was originally described from the Salt Range (Sweet, 1970b), and is also known to occur in Primor'e (Buryi, 1979), on Ellesmere Island (Mosher, 1973), and in Idaho (Paull, 1982).

The Pakistanensis Zone straddles the Dienerian-Smithian boundary and overlies the Cristagalli Zone (Sweet *et al.*, 1971). Orchard (1981) concluded that the Marble Canyon fauna with *'Neogondolella' carinata* is middle Dienerian in age. However, on Cornwall Hills, the co-occurrence of the two neospathodids and their morphological variation from the holotypes, suggest that the latter collection, lying at the limits of the *peculiaris* and *pakistanensis* ranges, is slightly younger in age, that is late Dienerian to very early Smithian. Placement of the Cornwall

Hills fauna into the subcategory 4B reflects this interpretation. It is not contradicted by the presence of the third element, *N.* cf. *N. dieneri*, similar to specimens from Gunong Keriang illustrated by Koike (1982), since *N. dieneri* ranges from the base of the Dienerian into the upper Smithian (Sweet *et al.*, 1971).

3. Fauna 5

Fauna 5 is represented by several genera that occur together in section 4 near Jesmond, and singly in isolated samples on Cornwall Hills. A few Fauna 5 elements are found also in the section at Conodont Corner on Pavilion Mountain. At Jesmond, Fauna 5 is characterized by a ramiform element assemblage which occurs in the basal 10.5 m of section 4. The component elements are referred to multielement *Ellisonia*, *Pachycladina*, and *?Furnishius*, and to the form genus *Lonchodina*. The majority of these elements, including the long-ranging ellisonids, are identified in Appendix A as undifferentiated "ramiform elements".

A broken specimen from 1 m above the base of section 4 has been assigned with question to the only species of *Furnishius*, *F. triserratus*. In North America the genus is known from the *Meekoceras* beds in Nevada from which it was originally described (Clark, 1959), from the Thaynes Formation of Utah (Paull, 1982; Solien *et al.*, 1979) and the *Wasatchites* bed of the Toad Formation in northern British Columbia (Mosher, 1973). In Asia, the genus is known from Malaya (as *Malaygnathus*; Igo and others, 1965 in Sweet *et al.*, 1971), and Kashmir (Srivastava and Mandwal, 1966).

Sweet *et al.* (1971) proposed a combined Parachirognathus-Furnishius Zone with base just above that of the Smithian. As these genera are strongly facies-dependent, the zone was abandoned in favour of the Waageni Zone whose base is defined by the first appearance of *Neospathodus waageni.* As interpreted by Carr and Paull (1983), this level corresponds to the base of the Smithian. Graphic correlation suggests that the range of *Furnishius* crosses the Spathian boundary (Sweet and Bergström, 1986).

One specimen from basal section 4 has been assigned to form taxon *Lonchodina nevadensis*, also described originally from the cephalopod (*Meekoceras*) bed in Dinner Springs Canyon, Nevada (Müller, 1956; Clark, 1959). This element has to my knowledge not been included in any later multielement apparatus reconstruction. It occurs in the Zafir Formation of Israel and Jordan and was included in a *Hadrodontina-Pachycladina* assemblage zone of presumably Smithian age (Hirsch, 1975, p. 44). Gedik (1975) placed *L. nevadensis* (preceded by "cf.") in synonymy with late Scythian *Hadrodontina anceps*. Koike (1982, p. 13) derived a late Smithian age for the thin-bedded limestone at Gunong Keriang, Malaya, in which *L. nevadensis* occurs, calling it *Parachirognathus* cf. *nevadensis*.

Pachycladina obliqua ranges throughout the lower part of Jesmond section 4. Another element from near the base of the section is referred to *P.* sp. *A*. A few elements of *P. obliqua* were recovered from sample CH-N2 on Cornwall Hills, and on Pavilion Mountain (22.5 m above the base of the Conodont Corner section) the species is associated with probable elements of *Hadrodontina.*

As first described from South Tirol (Staesche, 1964), *Pachycladina* consisted of several form species which Sweet (in Clark, 1981) combined into the seximembrate multielement *P. obliqua*. Perri and Andraghetti (1987) described *P. obliqua* from the upper Scythian Campil, Val Badia and Cencenighe members of the Werfen Formation. Outside of the Italian Alps component elements of *P. obliqua* are known from Turkey (as *Parachirognathus* species; Gedik, 1975), from the "late Lower to early Upper Scythian" *Pachycladina-Hadrodontina* assemblage zone of the Zafir Formation of Israel and Jordan (Hirsch, 1975), from Yugoslavia (as species of *Parachirognathus*; Budurov and Pantic, 1973 in Perri and Andraghetti, 1987), from Primor'e (as *Parachirognathus* and *Hadrodontina* species; Buryi, 1979), from Lichuan in Hubei Province (Wang and Cao, 1981), and from the upper Smithian limestone in Gunong Keriang, Malaya (as *Parachirognathus*; Koike, 1982). Solien (1979) reported *Pachycladina* form species from Smithian strata in Utah.

Species of *Neospathodus* dominate Fauna 5 on Cornwall Hills. *Neospathodus waageni* was previously reported by Orchard (1984) but has not been found in this study. The base of the Waageni Zone is defined by the first occurrence of *Neospathodus waageni* at or near the base of the Smithian. The first occurrence of *Neogondolella milleri*, which also occurs on Cornwall Hills, defines the top. The top of the Milleri Zone corresponds to the top of the Smithian (Carr and Paull, 1983; Sweet and Bergström, 1986), but the range of *Neogondolella milleri* is now thought to extend to the Lower-Middle Triassic boundary (Sweet and Bergström, 1986).

Another species of *Neospathodus*, found in a breccia on Cornwall Hills (CH3, Orchard collection), is *N. novaehollandiae* described from the Smithian Locker Shale of the Carnarvon Basin, Western Australia (McTavish, 1973). Subsequently, Goel (1977) reported it from Dienerian and Smithian strata at Khar, Spiti District. *Neospathodus* sp. *A* of Orchard (1981) is another element found in sample CH3 as well as in CH-N2, where it occurs with *Pachycladina obliqua.* Undescribed material from limestone olistoliths in the Hamrat Duru Group at Jabal Safra in Oman, contains comparable elements (Orchard collection). At Jabal Safra the species is associated with the lower Smithian ammonoid *Paranannites* (Tozer, 1989, in press). The Cornwall Hills association and the Marble Canyon occurrence suggest a Dienerian-Smithian range for this species. Indeterminate *Neospathodus* species of Early Triassic aspect occur in samples CH-E11, CH-E9, and CHR-10 from Oregon Jack Creek. A single specimen of *Platyvillosus* is found in sample CH3. In the chronozonational scheme of Sweet and Bergström (1986) the range of *P. costatus* is encompassed by the Milleri Zone, suggesting a Smithian age.

The age of Fauna 5 is Smithian. Within this faunal range a subrange (5B) can be distinguished, confined to the upper Smithian Milleri Zone, and recognized on the basis of *Neogondolella milleri* and *Platyvillosus costatus.*

4. Fauna 6

A further Lower Triassic fauna is recognized in the Marble Range. This fauna consists of *Neospathodus triangularis* and *N. homeri* and occurs in strata between 10.5 and 64 m of section 4 and in the vicinity of the lookout near Jesmond.

Neospathodus triangularis was first described from the upper Scythian Marmarotrapezakalke, 4 m above the base of section CM II on Chios, Greece (Bender, 1968). The species occurs in the Val Badia and Cencenighe members of the Werfen Formation (Perri and Andraghetti, 1987), in the Mianwali Formation of Pakistan (Sweet, 1970b), on Kocaeli Peninsula in Turkey (Gedik, 1975), and in a Campilian olistolith in Bulgaria (Ganev and Stefanov, 1967 in Ziegler, 1977).

The type *N. homeri* is from 6 m above the base of the upper Campilian Marmarotrapezakalke on Chios (Bender, 1968). Other known occurrences are the Campilian beds of the Werfen in South Tirol (Staesche, 1964), the Mianwali Formation in Pakistan (Sweet, 1970b), the Toad Formation in northern British Columbia (Mosher, 1973), the Great Basin in western United States (Sweet *et al.*, 1971), and Lichuan in western Hubei Province (Wang and Cao, 1981). Buryi (1979) records the co-occurrence of *N. triangularis* and *N. homeri* in Primor'e, eastern USSR.

Sweet *et al.* (1971) show first occurrences of *Neospathodus homeri* and *N. triangularis* at the base of the Spathian. In the chronozonal scheme of Sweet and Bergström (1986) the first appearance of *N. triangularis* and *Neogondolella jubata* define the base of the Triangularis Zone while *Neospathodus homeri* first occurs in the upper Triangularis Zone. This zone incorporates the upper part of the ranges of *Furnishius triserratus* and *Parachirognathus ethingtoni.* As noted by Gedik (1975) the association of *Neospathodus triangularis* with *Parachirognathus* and *Pachycladina* (*Parachirognathus* form species of Gedik) may indicate a range

for *Neospathodus triangularis* into the upper Smithian. Conversely, it may mean that it is the ranges of the other two genera that must be extended into the lower Spathian. Perri and Andraghetti (1987) postulate a range into the Spathian for *Pachycladina*. In the present study the base of the Spathian is placed at the first appearance of *N. triangularis*, 10.5 m above the base of section 4. Lack of other diagnostic species of *Neospathodus* prevents a more precise location of the Smithian-Spathian boundary. Until more data become available, Fauna 6 is assigned a Spathian age.

C. MIDDLE TRIASSIC CONODONT FAUNAS

1. Fauna 7

The interbedded cherts (CH-S11, -S12) along the lookout access road on Cornwall Hills yielded *Neogondolella* elements of probable Middle Triassic age. Cordey (1986) obtained similar results with radiolaria (Appendix B). Orchard (1986) recovered Middle Triassic *Neogondolella* cf. *N. excelsa* (sample CH14B; Appendix A). Except for a thin limestone at CH-S13, which contains a neogondolellid of Middle to Late Triassic age, only cherts record Middle Triassic time in the Marble Range. Fauna 7 is thus poorly constrained, but appears to be Middle Triassic in age.

D. UPPER TRIASSIC CONODONT FAUNAS

1. Fauna 8

Species of *Metapolygnathus* and *Neocavitella* comprise Fauna 8 from Cornwall Hills. Samples CH-V8 and CH-N9 each contain a broken element referred with question to *Neocavitella.* The genus was originally described from Julian-Tuvalian (lower-upper Carnian) strata on Trebević Mountain in the Yugoslavian Dinarides (Sudar and Budurov, 1979). An element similar to that in CH-V8 has been recovered from Bridge River sediments (M.J. Orchard, oral commun., 1989).

Metapolygnathus nodosus, originally described from upper Tuvalian-equivalent strata in Japan (Hayashi, 1968), occurs in sample CH-V7, and CH-V8 contains an indeterminate, probably Carnian, species of *Metapolygnathus*, supporting the Carnian age suggested by *?Neocavitella.* These occurrences indicate a Carnian age for Fauna 8.

2. Fauna 9

Elements of Fauna 9 are referred to the three cosmopolitan genera *Neogondolella, Metapolygnathus,* and *Epigondolella.* Faunal components are found in Oregon Jack Creek valley, on Pavilion Mountain, along Porcupine Creek and in the area north of Porcupine Creek. Sample CHR-2 on the Oregon Jack Creek road close to the turnoff onto the lookout branch contains a very rich and varied conodont fauna. This sample is early Norian on the basis of *Epigondolella primitia, Metapolygnathus echinatus, M. nodosus,* and *Neogondolella navicula.* Many of the other collections may be impoverished examples of this assemblage. The interbedded limestone at Conodont Corner, 0.5 m above the base of the section, yielded early Norian *Neogondolella* cf. *navicula* and *Epigondolella abneptis.* A

similar fauna occurs in sample PorcCk-5, east of the Griesbachian (Fauna 3) locality. A Late Triassic *Metapolygnathus* species was found in sample PVR-14 from Pavilion Mountain. Additional Late Triassic faunas from Pavilion Mountain (PVR-2 and PVR-22) contain *Epigondolella* elements of probable Norian age. Some of these appear weathered and have differing colours, suggesting reworking. Similarly, in a third collection (NPorcCk-4) *Epigondolella* occurs with a high-bladed neogondolellid of somewhat older aspect.

Fauna 9 is thus Norian in age. Although many collections can be assigned to the early Norian, more data are needed to assess the total range of this youngest Marble Range fauna.

V. PALEOENVIRONMENTAL ANALYSIS

A. INTRODUCTION

Among the organisms that contributed to the build-up of Marble Canyon Formation limestones, some have spatial distributions known to be indicative of a certain environment. In particular, these include dasycladacean algae, fusulinids, and the "algae" that formed laminated algal mounds. In addition, encrusting organisms, echinoids and mollusks also occur in the Marble Canyon Formation. In this chapter, I first review the environmental significance of the Marble Canyon faunas and floras. This is followed by a paleoenvironmental appraisal of the micrite nodules and intraclasts that typify many of the formation's limestones.

Provincialism among conodonts is thought to have been operative during the Ordovician, Early Devonian and Permo-Pennsylvanian periods. Clark and Wang (1988) do not support provincialism for the Upper Permian in China, and Clark and Hatleberg (1983) suggest cosmopolitanism also for the Early Triassic, a view put forward by Charpentier (1984) for the whole of this system. Other workers (Ryley, 1987) do recognize Triassic provincialism, but the conclusion either way may rest entirely on the degree of taxonomic refinement decided upon: present if species-level, absent if genus-level (Druce, 1973). Although conodont biostratigraphical zonations have been applied globally with such success that taxa were once thought to be facies independent (Lindström, 1976), there is now no doubt that environment does exert some control over conodonts. This will be examined below.

B. FAUNAL AND FLORAL CRITERIA

1. Fusulinids

Although some Early Permian subspherical fusulinids with inflated chambers may have had an adult pelagic stage, most were probably benthonic, closely associated with the marine carbonate substrate (Ross, 1982). In the study area recrystallization of limestones prevents analysis of species preference for a particular grain size.

Abundance of fusulinids locally and scarcity of cooler water brachiopods and bryozoans suggest a distribution within a warm water zone. Absence of corals in the region may mean that the water was too warm to sustain their growth.

The combination of fusulinids with algae points to a shallow water environment. Ross (1982, p. 169) states that "most fusulinacaeans lived at depths less than about 25 meters and the great majority lived at depths less than 10 meters". Stevens (1969) determined the minimal depth to have been 13 m in the Middle Pennsylvanian McCoy embayment of Colorado, and found that fusulinids are present in rocks calculated to have been at least 22 m deep.

Recent shallow marine calcareous foraminifers are known to host algal symbionts (zooxanthellae) and, although extrapolation into the remote past is tentative, fusulinaceans may have benefited from such symbiosis. Ross (1982, p. 175) points out that the Schwagerinid and Neoschwagerinid families developed a wall structure (keriotheca) in which a calcareous layer, the diaphacotheca, located

underneath the organic-rich tectum, thickens to form tubes and he suggests that the resultant tubiform spaces may have housed the symbionts. In *Yabeina* the keriotheca are very much reduced (Ross, 1982, p. 167), so that other factors must have contributed towards their success. However, the Marble Canyon fusulinid may belong to *Lepidolina* (Goto *et al.*, 1986), a Neoschwagerinid. The environmental information to be extracted from such associations, if they existed, lies in the photosynthetic activities of the zooxanthellae, which require shallow and clear waters through which light can easily penetrate. Distance from a clastic source enhances the clarity of water, as does the presence of a current. A moderately strong current also brings rich nutrient supplies to the pseudopodia of organisms that had developed in the course of their evolution very large tests, hampering mobility (Kahler, 1988). Fusulinaceans then would thrive in the warm, aerated, shallow waters of a carbonate shelf, or in lagoons that possessed a connection to the open sea.

2. Calcareous green algae

Codiaceans and dasycladaceans are the two carbonate-secreting families of green algae. Only dasycladaceans were found in the thin sections cut for this study, but codiaceans also occur in the Marble Range (W.R. Danner, oral commun., 1988). Recent representatives of both families are restricted to tropical and warm-temperate marine waters, prefering sandy and muddy substrates (Wray, 1978). Light intensity and its spectral composition are critical to their distribution. Green algae that absorb shallow-penetrating rays in the red interval of the electromagnetic band, are found at shallow depth. Codiaceans, while still within shallow water, have a greater depth range. Dasycladaceans occur from low

tide range to 10 or 12 m or deeper, and develop thickest stands around 5 or 6 m (Johnson, 1961, p. 35). Lagoons and subtidal settings protect against damage from wave energy. Selected descriptions of dasycladaceans in the geologic record, from the Upper Permian bedded shelf facies in the Tansill Formation adjacent to the Capitan limestone in Texas (Babcock, 1979, p. 426), from the Middle Triassic subtidal platform in the Austrian Carnic Alps where they are very abundant (Pfeiffer, 1988), and from hypersaline dolomicrites and marine biosparites in the Upper Permian Bellerophon Formation of the Italian Alps (Noé, 1987), serve to illustrate their facies-controlled distribution.

Dasycladaceans, most belonging to *Mizzia*, were described from two localities in map unit 4 of Trettin (1980) by Johnson and Danner (1966, localities 1 and 2), and Trettin (1980, p. 15) listed them and accompanying fusulinid species (localities F2 and F4). I have compiled them in Appendix B. In this study no generic level identification was attempted. Dasycladaceans were found only in the Permian biomicrites JAR-29 and J-I of Jesmond. The lack of calcareous green algae from most Permian and all Triassic rocks, especially biomicrites such as CH-V5-B, is conspicuous. Suitable Permian lithologies are present along the forestry lookout road on the mountain west of Clinton, along Jesmond Creek and in the western Oregon Jack Creek valley. Their absence is probably due to a combination of disarticulation of the plants upon death with subsequent minimal preservation of recognizable fragments, diagenetic recrystallization, and the region's strong tectonic overprint. In addition, selection of samples for thin-sectioning must miss many that do contain the plants. Further, many Triassic rocks in the Marble Range represent a shift from the clastic-free carbonate facies of the

Permian to an influx of volcanic and terrigenous clastic materials that signify a change to unfavourable growth conditions. Environmental unsuitability can be invoked as well for the shallow water carbonate at CH-V5-B. This limestone is a coated grainstone, suggesting that wave agitation was substantial.

3. Cryptalgal structures

a. Algal mats

Laterally discontinuous, laminated structures occur at many horizons throughout Triassic section 4 at Jesmond. Aitken (1967) reserved the term "cryptalgal" for sedimentary structures that result from the sediment-binding and/or carbonate precipitating activities of blue-green "algae" and contributors from among the true algae (Flügel, 1982, p. 357; Hofmann, 1969, p. 3). These structures can be laminated or not, in which case they are known as thrombolites (Aitken, 1967). Laminated mats are called stromatolites, and oncolites if they are mobile (Logan *et al.*, 1964), but some reserve the term stromatolite for curving structures of various shapes, basically hemispheric in form, and "algal mat" for irregular micritic laminations that have spar-filled cavities parallel to bedding plane (Flügel, 1982, p. 272). Following earlier work in the beginning of this century, Hofmann (1969) defined a stromatolite as a "millimetre- to decametre-sized organosedimentary structure whose growth is recorded by a succession of laminae" (Hofmann, 1969, p. 6), a usage which assumes that the particular environmental setting in which it occurs will dictate its shape (Hofmann, 1969, p. 3). In the present work both terms are used, "stromatolite" in the sense of Hofmann, and "algal mat" as a descriptive phrase that reflects the relative

flatness of the individual laminae.

Logan *et al.* (1974, p. 152) spelled out the characteristics of such structures as observed at Shark Bay: peloids, lamination with domes, bubbles, undulations and unconformities that mark the interaction of sediment particles and algal film (plexus, fenestrae), aragonite cement. While lamination is the product of variations in sediment input, currents, interaction between sediments and biota, and the effects of diagenesis (Logan *et al.*, 1974, p. 152), peloids, fenestrae and cementation result from diagenesis under hypersaline conditions with Cl^- concentrations of 31-39 per thousand or more in the aragonite-precipitation field (Logan, 1974, p. 198, 210). During diagenesis carbonate particles alter to cryptocrystalline aragonite, as the original mat is destroyed and voids left by boring algae are infilled, creating pellets (Logan, 1974, p. 210-213). Fenestrae (Logan, 1974, p. 213-214) mark the former positions of algal films, which are destroyed at the onset of fermentation. The resultant voids, also produced by CH_4 generation during decomposition, are maintained by aragonite cement precipitation. Depending on environment of deposition, fenestrae may be laminoid, irregular or tubular, and the voids vary in size from small to large.

The alternately dark and light laminated micrites from Jesmond, illustrated in thin section (e.g. JAR-97, J-T4), feature pelletal fabric, fenestrae and dolomite spar in floors and ceilings of some voids (Figure 5.1). Laminae, 1 to 3 mm thick, have little relief generally, but undulations and domes are present. The subparallel voids form a fine fenestral fabric indicative of smooth mats, confined to the lower intertidal zone in modern Hamelin Pool (Logan, 1974, p. 214).

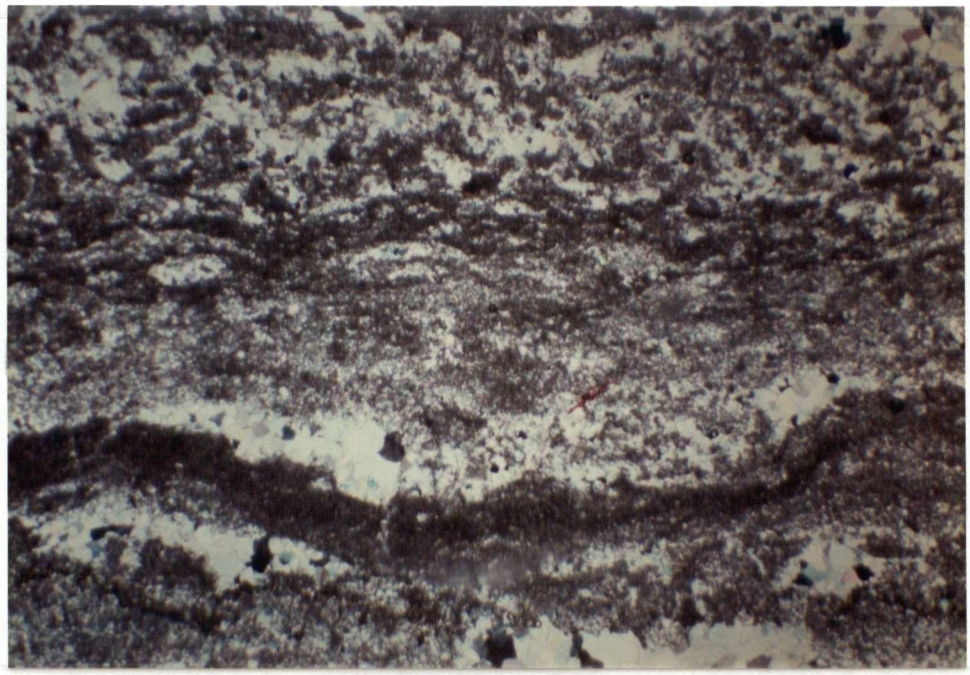


Figure 5.1: Photomicrograph of algal-laminated micrite, section 4, Jesmond, showing dolospar-filled fenestrae, smooth laminations, and pelleting. Cross polarized light, magnification x24.

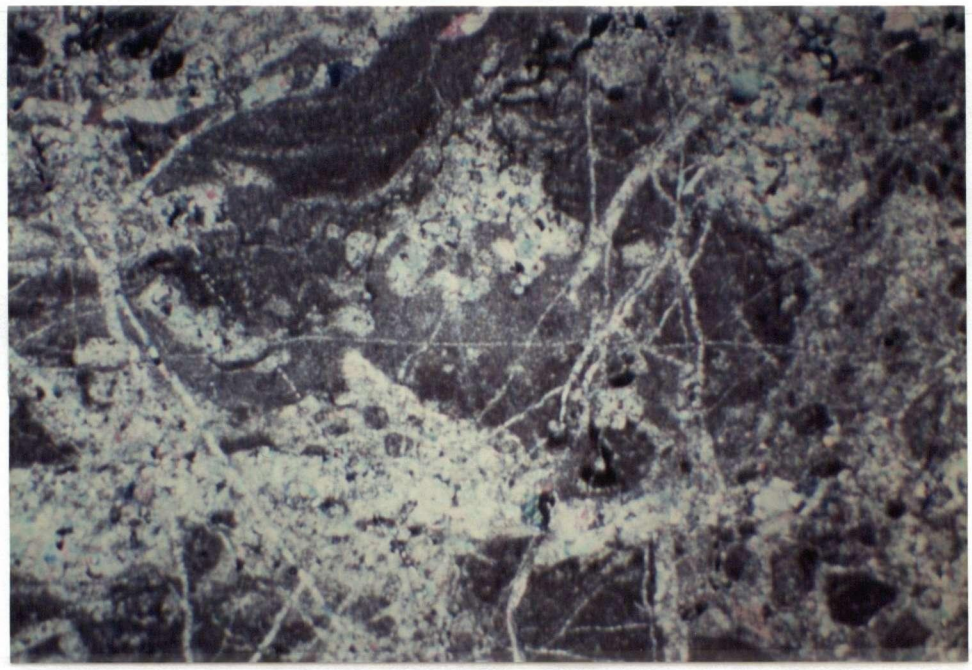


Figure 5.2: Photomicrograph of algal-encrusted solution breccia with *Tubiphytes* (upper left), Oregon Jack Creek road (CHR-6). Cross polarized light, magnification x24.

Emergence into the supratidal zone before burial probably did not take place as root molds (tubular fenestrae) have not been detected.

Preservation of the algal mats suggests a hypersaline setting, where scavengers and grazers are rare (Flügel, 1982, p. 471) and early cementation can take place, since high salinities concentrations put waters in or near the aragonite precipitation field, protecting them from wave erosion (Logan *et al.*, 1974, p. 144). Early cementation is also evidenced by the bird's eye vugs (=fenestrae) that would otherwise have collapsed during compaction (Shinn *et al.*, 1980, p. 120). Lack of anhydrite in these tidal deposits may be due to formation in a cooler, more humid climate as is the case in the Bahamas where gypsum forms during the dry season, but dissolves in the wet season (Shinn, 1983, p. 199).

The fine grained, partially dolomitic mud layer that lies above laminated strata at JAR-106 probably represents eolian deposition, where windblown dust composed of microcrystalline calcium carbonate, clays and dolomite, sticks to algal film and promotes the cells' growth, a situation directly comparable to the one in today's Persian Gulf except for the absence of quartz, at least at microscope scale (Shinn, 1983, p. 182).

b. Tubiphytes Maslov

This problematic organism occurs on the oölitic clasts of CHR-6, an *in situ* breccia, along with "algal" encrustation (Figure 5.2). Although best known from Permian strata, it has been reported from Upper Triassic reefs in the Alps (Flügel, 1979, p. 575) and from Upper Jurassic platform carbonates (sparite

facies; Flügel, 1979, p. 578). Permian examples include the Capitan reef limestone (Babcock, 1979, p. 426), and the reefs of western Hubei in China (Fan *et al.*, 1982). In the latter two cases *Tubiphytes* performs a sediment-binding, framework-forming function, but it can also be an important contributor to carbonate mud (Pfeiffer, 1988). Fan *et al.* (1982) state that in calm water it acts as a frame builder, whereas in turbulent zones it is an encruster. The latter appears to be the case at CHR-6, a breccia with oölitic clasts.

Maslov (in Johnson, 1963) thought that the genus belongs to the Cyanophytes. It has subsequently been placed with red algae and with calcareous sponges, as noted by Flügel (1982, p. 351) who comments that it must not be thought of as a hydrozoan, an idea endorsed by Johnson (1961, p. 286). Babcock (1979, p. 425) suggested that it differs from algal structure in morphological detail. Perhaps it is an encrusting foraminifer (Wilson and Jordan, 1983, p. 302). Whatever the affiliation, its association with oöliths in sample CHR-6 makes plausible a shallow subtidal to intertidal setting.

4. Echinoids

Of the Echinodermata, crinoid ossicles are abundant and widespread. Apart from rare shelly debris that suggests presence of brachiopods (section 3, Jesmond) or gastropods (vicinity of Jesmond fire lookout), they are the only macrofossils visible in outcrop. All appear to be circular. At Jesmond they are especially numerous in the dark grey micritic limestones of the uppermost Permian beds (e.g., JAR-31), and are found also at two horizons in the lower 10 m of the Triassic section. The dark grey, crinoidal lithology is encountered again along

Jesmond Creek (JCk-3). Rare in the central Marble Range, crinoids occur less sparsely in the Permian fusulinid-bearing rocks of Oregon Jack Creek and their Triassic counterparts on Cornwall Hills. CH-V5-B also contains sea urchin spines in an oncolitic grainstone, indicating a shallow water setting. Although Mesozoic and Recent crinoids have been displaced into a basinal environment, sessile Paleozoic types were shallow marine animals of the shelf and reef (Flügel, 1982, p. 320). Pelagic crinoids are known from the Triassic but like their descendants are found in basinal deposits (Flügel, 1982, p. 320), and none of the limestones in the study area can be shown to belong to this facies.

5. Mollusks

Two mollusk classes, Bivalvia and Gastropoda, are poorly represented in the Marble Range. Near Cornwall Hills, CHR-2 contains thin-shelled pelagic bivalves, probably *Halobia* (W.R. Danner, oral commun., 1988), a cosmopolitan, chiefly Mid- to Late Triassic genus. *Halobia?* also occurs in PVR-A, an Upper Triassic fractured and thin limestone interbedded with argillite. The fractured, recrystallized micrite of JFT-LEFT hosts globules that have a shape reminiscent of gastropods, but it is not certain that they are. Consistent lack of ammonoids supports the interpretation that a deeper water basinal facies is missing.

6. Conodonts

Conodonts are not known from fresh water deposits (Seddon and Sweet, 1971) and are therefore regarded as exclusively marine. They are thought to have been largely stenohaline (Clark, 1981), but exceptions are known or suspected. Except for marginal habitats with specialized faunas, there is much overlap between

biofacies, and congruence between lithofacies and biofacies is not consistent, as noted earlier by Klapper and Barrick (1978). Factors which control distribution are salinity, energy, turbidity, temperature and nutrient supply.

The most diverse conodont faunas derive from the poorly sorted, muddy, bioclastic packstones of the offshore shelf, an environment that tended to be shallow, nutrient-rich, and hydrographically stable (Solien *et al.*, 1979). In contrast, the inner shelf facies, adjacent to the very shallow, evaporitic terrestrial/marine borderland, is still a demanding environment with shallow water and fluctuating conditions of salinity, turbidity and temperature (Carr *et al.*, 1984). Valentine (1971) predicts for this sort of unstable environment large populations of little diversity.

The inner shelf facies of the Lower Triassic Thaynes Formation in Utah is characterized by *Parachirognathus, Ellisonia triassica* and *Pachycladina* (Clark and Carr, 1984). Wardlaw and Collinson (1984) recognize a nearshore facies in the Permian Phosphoria Formation of Wyoming with *Hindeodus, Stepanovites (=Ellisonia)* and *Neostreptognathodus.* Meek (1984) reports a general absence of conodonts from the Norian shallow inner shelf. Ramiform-only faunas are thought to be shallow water indicators, associated for example with corals, algae, brachiopods and bryozoans, whereas "single element" taxa are considered more typical of greater depth (Clark, 1974; Klenina and Ovnatanova, 1986).

Clastic environments such as those of the Lower Triassic Thaynes Formation (Solien *et al.*, 1979), the Early to early Middle Triassic Prida Formation of

Nevada (Carey, 1984) and Early Triassic strata of Spitsbergen and Nepal (Clark and Hatleberg, 1983) are barren of conodonts. As conodont concentration decreases with increase in sedimentation rate, clastic environments may dilute element yields sufficiently to result in barren samples, but Carey (1984) has suggested that the turbid water typical of clastic depositional sites was oppressive to them.

The supratidal and shallow subtidal habitats of the Ladinian of Nevada (Carey, 1984) likewise contained few conodont animals. Conodonts and bottom dwelling ostracodes are nearly mutually exclusive in rocks of Ladinian and Carnian age of Nevada (Mosher, 1971). The ostracodes occur in protected, muddy, shallow and possibly brackish water. Conodonts appear in the Carnian with the transition to higher energy, deeper, less turbid and more open water.

Hypersalinity is common with proximity to land and shoaling of the bottom. *Ellisonia* is linked to hypersaline and brackish conditions (von Bitter and Merrill, 1983). *Hindeodus* is a Late Permian candidate for the abnormal salinities regime (Clark, 1981); it is also known from lagoons (Wardlaw and Collinson, 1984). Conodonts are scarce in reefal limestones (Druce, 1973). Modern tropical reef flats are characterized by great diurnal fluctuations in temperature, salinity and dissolved oxygen, creating a very harsh environment (Jackson, 1977). Similar conditions in ancient reefs may have inhibited conodonts.

The available information thus points to shoreward decrease in diversity and often in number of conodonts, and to their absence landward of wave base in

the very shallow zones along a coast. Results of this study for the Marble Canyon Formation support the first part of this summary statement, but not the second.

The trend towards decreased diversity and abundance also operates basinward of the shelf (Babcock, 1976). Although *Neogondolella* is known from nearshore deposits (Carey, 1984), the genus frequently dominates the deeper water environments of the basin and the shelf, where Carey (1984) recognized it in Middle Triassic deposits of the lower Prida Formation in northwestern Nevada. Carey (1984) found the genus also in the basinal facies of the Carnian where it is associated with ammonoids, crinoids and posidoniid pelecypods. In the Norian a sparse *Epigondolella* fauna represents this habitat but it is also found in shallow marine shelf deposits. The Lower Triassic, basinward facies of the Thaynes Formation in the Great Basin is typified by species of *Neogondolella* and *Neospathodus* and by *Ellisonia gradata* (Clark and Carr, 1984).

C. NODULAR FABRICS AND BRECCIATION

Intraclasts, syndepositional breccia fragments derived from within the basin, occur mostly in subtidal channels and on supratidal flats. They commonly originate during desiccation and erosion of tidal and supratidal mud flats and algal mats (Shinn, 1983, p. 187). Logan (1974) reports breccias and intraclasts from the supratidal hypersaline crusts in Western Australia. The muddy dasycladacean-bearing clast known from Jesmond was probably storm-derived from a lagoon and redeposited in biomicrite of the shallow inner shelf.

Many of the breccias encountered during this study are composed of muddy micrite clasts in a matrix of microcrystalline, usually euhedral, dolomite (Figure 5.3). Erosion of mud polygons into shrinkage cracks in the supratidal zone and on upper intertidal flats creates a porous and permeable network enclosing the denser carbonate polygons. Concentrated dolomitizing solutions preferentially affect the less dense matrix. This "selective dolomitization" (Shinn, 1968) results in inclusion of flat micrite pebbles, limestone layers and lenses in a dolomitic matrix.

Some of the dark micrite nodules in the study area are graded. This fact may point to an intraclastic origin. Shinn (1983, p. 187) says that in contrast to intraclasts derived from the supratidal zone, the muddy subtidal and intertidal environments produce mud pellets and mud-sized grains that are often present in supratidal storm layers (Shinn, 1983, p. 177). Bioturbation can create similar effects, since reworking of the sediments makes them more porous. Dolomitization in this case ought to be confined to the burrows, and not the surrounding matrix. In the two instances where burrowing is evident, CHR-7 is infilled by sparry calcite (Figure 5.4), while in JR-64 dolomitization is confined to small, disc-like zones in a recrystallized and fractured, grainy biomicrite. The dolomitic, horizontal laminations at Jesmond, suggestive of an intertidal to supratidal setting, were probably not bioturbated. According to Shinn (1983, p. 177-179) the harsh conditions of this environment make it inhospitable to most organisms, preventing churning, disruption and destruction of lamination. However, pellet grading can result from bioturbation (W.C. Barnes, oral commun., 1989).

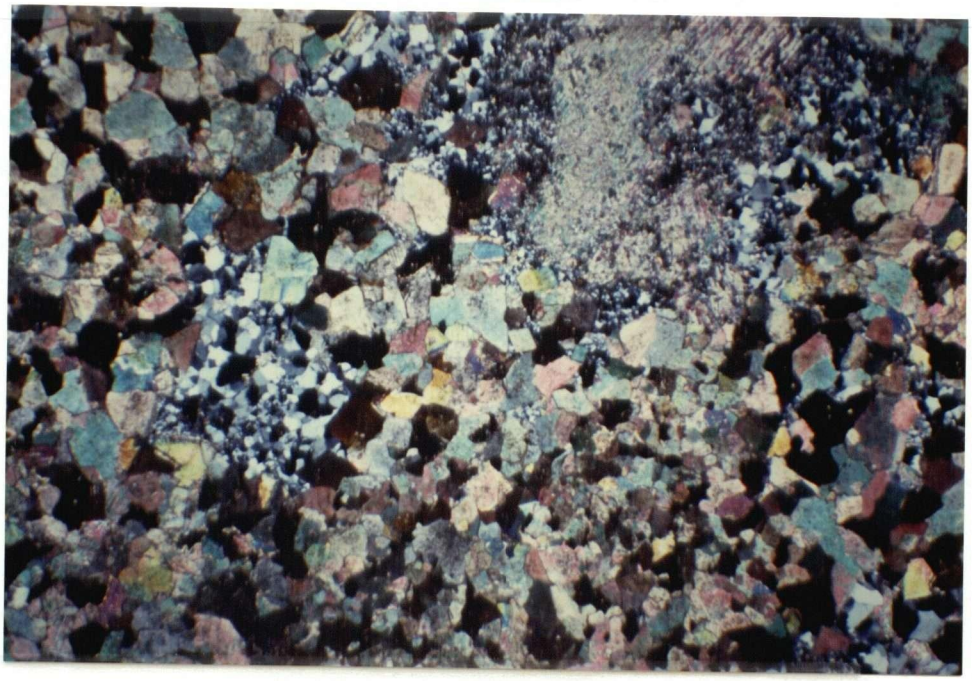


Figure 5.3: Photomicrograph of euhedral dolomite and partial silicification of echinoderm plate, from the mountain west of Clinton (CL-3). Cross polarized light, magnification x24.

Figure 5.4: Photomicrograph of spar-filled burrow in micrite, Oregon Jack Creek road (CHR-7). Cross polarized light, magnification x24.

A third type of brecciation can be called "solution breccia" ("pseudobreccias of the replacement type", Trettin, 1966). This category includes those micrites broken in place by fracturing and stylolites. Esteban and Klappa (1983, p. 39) list in-place non-tectonic fracturing and brecciation among those features commonly present in subaerial karst and caliche facies, but not diagnostic of them. Flügel (1982, p. 44) suggested that brecciation through vertical and horizontal calcite veining, offsetting particles formed *in situ* which possess morphological features "reminiscent of peloids, oncoids, and aggregate grains", is characteristic of caliches in the supratidal zone. However, no evidence of soil formation was observed, so that subaerial exposure may not be involved, and the possibility of submarine diagenesis should not be dismissed. Tectonism is another candidate, especially for CHR-6 which is near sheared sediments. Although Flügel (1982, p. 94) thought that formation of stylolites in limestones is a very early diagenetic effect, occurring just after deposition and requiring little tectonic input, nucleation of stylolites appears to be directly related to the degree of porosity. Once nucleated, stylolites can form throughout the diagenetic and deformational processes (J. Hammack, oral commun., 1989).

VI. SUMMARY AND CONCLUSIONS

A. CONODONT BIOSTRATIGRAPHY

Cherts and limestones of the central belt and eastern part of the western belt of the Cache Creek Group in south-central British Columbia are Upper Permian and Triassic in age. Nine conodont faunas are distinguished in this study.

Fauna 1 is Guadalupian in age, comprised of species of *Sweetognathus*, the *Neogondolella ?serrata* complex and *Hindeodus* near the southern entrance of Marble Canyon, and *Neogondolella phosphoriensis* west of Clinton. At both localities the conodonts are associated with Guadalupian fusulinids *Yabeina* and/or *Neoschwagerina*.

Fauna 2 consists of *Hindeodus typicalis*, subspecies of *Neogondolella subcarinata*, *N. orientalis*, *N.* n.sp. *A*, three morphotypes of the *Iranognathus nudus* group and *Iranognathus* n.sp. *A*. This association is fully represented only along the access road to the Jesmond fire lookout, but components of it are found on Pavilion Mountain and on the hill north of Jesmond Creek. The fauna is early to mid Dorashamian/Changxingian in age but may be as old as late Dzhulfian, because *Neogondolella subcarinata* is not always present and because elements thought to belong to the other guide species of the Changxingian, *Iranognathus nudus*, may differ from the Chinese holotype. Direct correlation of Marble Canyon Formation strata containing *Iranognathus* ex gr. *nudus* but lacking *Neogondolella subcarinata* with the Changxingian, therefore awaits confirmation that the Chinese and British Columbia material are the same.

A gap in the sedimentary record of the Marble Canyon Formation separates Permian from Triassic strata. In this study the oldest Triassic rocks were found along Porcupine Creek. They are late Griesbachian in age on the basis of Fauna 3, characterized by adenticulate forms of *Isarcicella isarcica*. This occurrence is the first record of Griesbachian strata in the Canadian Cordillera.

Middle Dienerian strata with *'Neogondolella' carinata*, *Neospathodus dieneri* and *N. peculiaris* are known from Marble Canyon (Fauna 4A), and late Dienerian to early Smithian strata containing *Neospathodus* cf. *N. peculiaris*, *N.* cf. *N. dieneri* and *N.* cf. *N. pakistanensis* (Fauna 4B), occur on Cornwall Hills.

Fauna 5, dominated by ellisonids along the Jesmond lookout access road and by species of *Neospathodus* on Cornwall Hills, is a varied assemblage. This fauna is Smithian in age on the basis of species of *Pachycladina*, *?Furnishius*, *Neospathodus novaehollandiae*, *Lonchodina*, and undifferentiated species of *Ellisonia*. *Neospathodus* sp. *A*, known from Dienerian or older strata in Marble Canyon, and from Lower Triassic rocks on Pavilion Mountain, is part of Fauna 5, and therefore appears to have a rather long range within the Scythian. A late Smithian subfauna (5B) on Cornwall Hills is characterized by *Platyvillosus costatus* and *Neogondolella milleri*.

Fauna 6, Spathian in age, occurs below and around the Jesmond fire tower and is typified by *Neospathodus homeri* and *N. triangularis*. Although it is possible that *N. triangularis* extends into the Smithian, in this study the Smithian-Spathian boundary has been placed at the first occurrence of *N.*

triangularis.

Fauna 7 is of undifferentiated, poorly constrained, Middle Triassic age, and appears restricted to a chert facies on the Cornwall Hills lookout access road. Neogondolellids are the only conodont elements found.

Two conodont faunas date widespread Upper Triassic strata on Pavilion Mountain, in the Porcupine Creek area, on Cornwall Hills and in the Oregon Jack Creek valley. The oldest of these, Fauna 8, is Carnian in age and is known only from Cornwall Hills. Species of *?Neocavitella* and *Metapolygnathus* comprise the assemblage.

Fauna 9 occurs on Pavilion Mountain, north of and along Porcupine Creek, and in the valley of Oregon Jack Creek just west of the turnoff onto the lookout road. The fauna is early Norian in age on the basis of species of *Epigondolella, Neogondolella* and *Metapolygnathus*.

B. DEPOSITIONAL HISTORY

Permian time

During the Late Permian extensive, shallow warm seas at a distance from clastic sources inundated the study area. Corals are lacking, but the clear, well-aerated waters of the inner shelf in the Hat Creek-Oregon Jack Creek-Clinton belt supported large fusulinacean populations. In the Clinton area water temperature may have been somewhat less with growths of bryozoans and corals. The shallow water zone extended to the north and northwest (Jesmond) but became

shallower after deposition of section 1 carbonates, as shown by nodular and brecciated lithologies. A seasonally interconnected network of lagoons, tidal flats, and more open, less restricted ocean existed, comparable to present-day situations in the Bahamas and Persian Gulf. Lack of anhydrite suggests that the end-Permian climate in this region was at least seasonally humid, resembling more the Bahamas than the Gulf. Small-scale fluctuations in water stands would account for the nonuniform distribution of nodules and breccias. Occasional storms stirred up sediments and transported the clasts, as exemplified by sample JAR-29 at Jesmond.

Hindeodus, thought to be a shallow water (lagoonal) and hypersalinity indicator when unaccompanied by other genera, occurs nearly always with *Iranognathus* for which no ecological data are available, and less often with *Neogondolella*. *Hindeodus* does occur alone in samples JAR-29, JAR-5A and JR-5X at Jesmond. In the Upper Permian Changxing Formation at the Qiaoting section near Nanjian in China's Sichuan Province, *Iranognathus* is found in Bed 56 with the same conodont genera as at Jesmond (Wang *et al.*, 1987). Immediately below in Bed 55 the genus is associated with ostracodes, fusulinids and other foraminifera, and with algae. This is also similar to the Jesmond occurrence and indicates a shallow (subtidal or lagoonal) setting for iranognathids. In addition, selective dolomitization and brecciation offer lithological support for their presence in the intertidal zone. Of the nodular limestones, the two samples with graded nodules are barren, only JAR-3 and J-B-I contain neogondolellids, and except for JR-5X, *Hindeodus* and *Iranognathus* occur together.

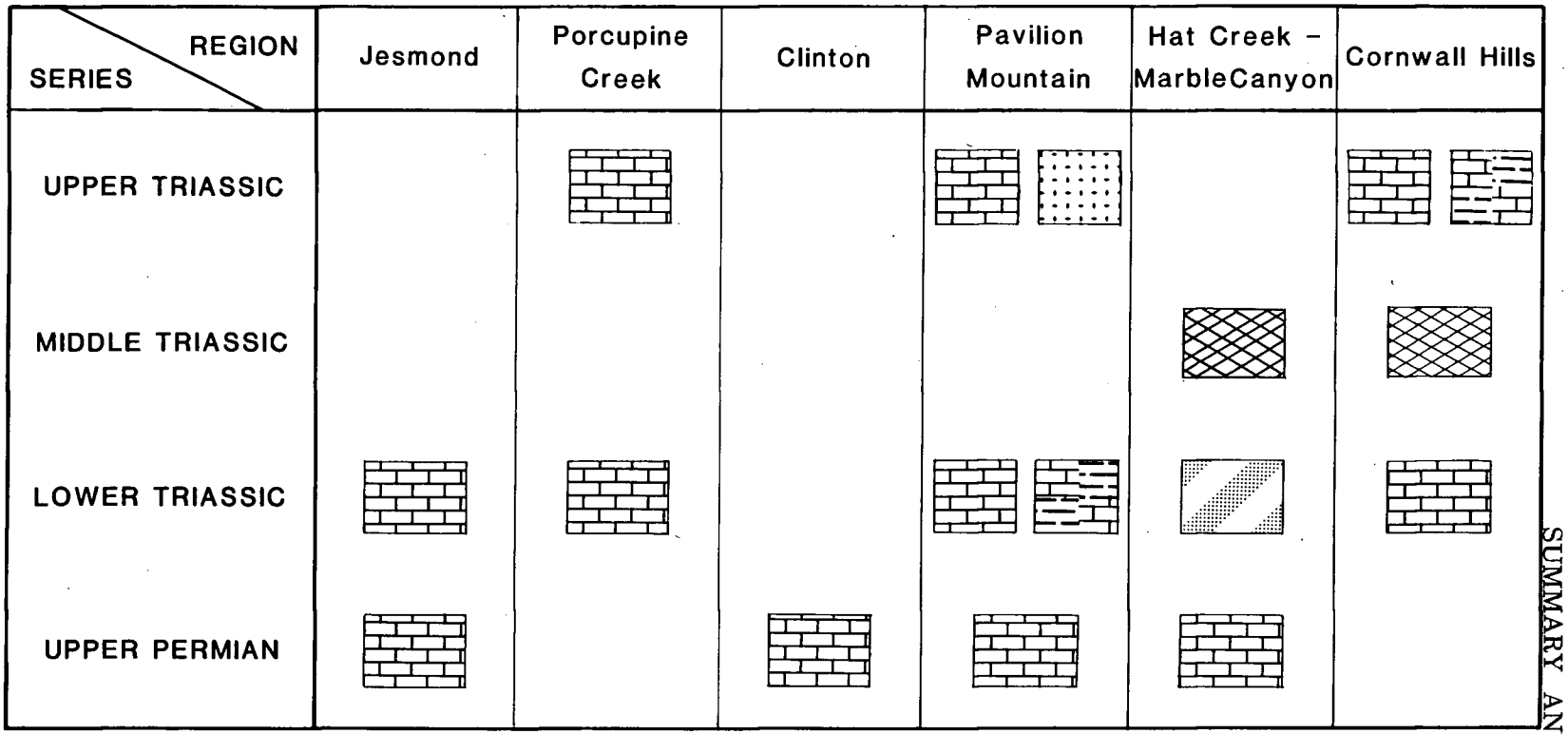
Triassic time

Early Triassic time throughout the Marble Range and Cornwall Hills saw continued shallow water conditions. Intertidal algal mats are barren of conodonts but nodular carbonate horizons at Jesmond are accompanied by an ellisonid/ramiform fauna, known from shallow and hypersaline regimes. Nodules and breccias suggest presence of this facies also to the south on Pavilion Mountain (e.g. PVR-1 and 2) and along Oregon Jack Creek (CHR-6).

Reworking of sediments appears to have been common. With the exception of one Late Permian record, reworked elements are Early and possibly Middle Triassic in age. Mixing of faunas is suspected on Pavilion Mountain and in the area north of Porcupine Creek. On Pavilion Mountain Lower Triassic clasts are shown to occur in Upper Triassic sediments, and a breccia on Cornwall Hills contains Smithian conodonts. The clastic nature of the lithologies in which the mixed faunas are found, and the overall scarcity of Middle Triassic rocks, suggests that Middle Triassic sediments were either not deposited or were eroded away during Middle to early Late Triassic time. The fact that chert is the chief and probably sole lithology to contain the Mid Triassic faunas points to a strongly reduced sedimentary regime during this time. In addition to a Middle? Triassic negative sedimentary budget, reworked Late Permian conodonts in Lower Triassic strata of Marble Canyon imply such a period of erosion locally during Late Permian and/or Early Triassic time (Orchard, 1981, 1984). A hiatus exists also at Jesmond for the earliest Triassic (early Scythian), and probably latest Permian, but reworked elements have not been found.

During Late Triassic time water depth increased, as shown by the absence of intertidal and lagoonal lithofacies and the appearance of *Halobia* or similar pelagic pelecypods in the Cornwall Hills and Pavilion Mountain areas. Upper Triassic strata on Cornwall Hills contain a greater proportion of carbonate, possibly in the form of limestone lenses, than age-equivalent rocks elsewhere in the Marble Range, where argillite and volcaniclastics are the dominant lithologies (Mortimer, 1987; Figure 6.1). The influx of clastics reflects a change in the tectonic environment of the Cache Creek Group. Until the late Early Triassic, sedimentation had been in the form of carbonate, with minor chert and less argillite. Either the topographic relief was very low, or sources of silt and mud were far away. The latter agrees with the traditional view of Cache Creek terrane as an oceanic carbonate body. The Late Triassic change in sedimentation may signify proximity to and possible interaction with other terranes in the Cordillera (Quesnellia and ?Bridge River), resulting in the deposition of overlying western belt and Pavilion beds sediments.

Figure 6.1: Summary diagram of depositional history for the Marble Range.


REGION
SERIES
Jesmond
Porcupine Creek
Clinton
Pavilion Mountain
Hat Creek – MarbleCanyon
Cornwall Hills
UPPER TRIASSIC
MIDDLE TRIASSIC
LOWER TRIASSIC
UPPER PERMIAN
chert
limestone interbedded with shale
limestone interbedded with argillite
limestone
limestone clasts in argillite

VII. SYSTEMATIC TAXONOMY

Most Marble Range conodont taxa are included in the following taxonomic notes. Exceptions are those that compare well with the original descriptions, or that were not sufficiently studied, such as Middle and Upper Triassic species, but their occurrences have been discussed in Chapter 4 and many are illustrated on the photographic plates.

GENUS *Furnishius* Clark, 1959

Type species *Furnishius triserratus* Clark, 1959

Furnishius? triserratus Clark

Plate 4, figure 6

Remarks: The pastinate element referred with question to *Furnishius triserratus* is broken at a point anterior of the junction of the two anterior bars, partly above the basal cavity. Elements of *Ellisonia* spp. sometimes show a splitting of the posterior and/or anterior processes, but this feature occurs at the end of these processes, and not near the basal cavity.

Occurrence: 1 m above the base of section 4 (JAR-63), Jesmond.

Material: 1 specimen.

GENUS *Hadrodontina* Staesche, 1964

Type species *Hadrodontina anceps* Staesche, 1964

Hadrodontina? sp.

Remarks: Two specimens whose denticles are broken but show denticle emplacement on the basal process similar to that of *Hadrodontina*, have been

referred with question to that genus.

Occurrence: At 22.5 m in the section at Conodont Corner, Pavilion Mountain (PVR-E, western belt).

Material: 2 specimens.

GENUS *Hindeodus* Rexroad and Furnish, 1964

Type species *Trichonodella imperfecta* Rexroad, 1957

(=*Spathognathodus cristulus* Youngquist and Miller, 1949)

Hindeodus typicalis (Sweet)

Plate 4, figures 1, 4

1970a *Anchignathodus typicalis* Sweet-

Sweet, Plate 1, figures 13, 22.

1970b *Anchignathodus typicalis* Sweet-

Sweet, Plate 1, figures 13, 20.

1970a *Ellisonia teicherti* Sweet-

Sweet, Plate 1, figures 3-4, 7-8, 12.

1970b *Ellisonia teicherti* Sweet-

Sweet, Plate 4, figures 20-28.

1973 *Ellisonia teicherti* Sweet-

Teichert, Kummel and Sweet, Plate 12, figures 1-5.

1975 *Anchignathodus minutus* (Ellison)-

Behnken, Plate 1, figures 16, 18; Plate 2, figure 12.

1975 *Anchignathodus minutus* (Ellison)-

Kozur, Plate 1, figures 1-7.

1975 *Anchignathodus minutus* (Ellison)-

Kozur, Mostler and Rahimi-Yazd, Plate 1, figures 2-3, 5, 7-11; Plate 2, figures 1, 8-9; Plate 7, figure 10.

1975 *Anchignathodus* cf. *minutus* (Ellison)-

Kozur, Mostler and Rahimi-Yazd, Plate 2, figure 7.

1980 *Anchignathodus minutus* (Ellison)-

Bando *et al.*, Plate 8, figures 4, 7; Plate 9, figure 10.

1981 *Anchignathodus minutus* (Ellison)-

Zhao Jin-ke, *et al.*, Plate 7, figures 1, 3.

1982 *Hindeodus typicalis* (Sweet)-

Paull, Figure 5, #5, 7, 10, 12-13, 15.

1986 *Anchignathodus minutus* (Ellison)-

Ritter, Plate 4, figures 1, 5.

1987 *Hindeodus typicalis* (Sweet)-

Perri and Andraghetti, Plate 32, figures 1-5.

1987 *Anchignathodus minutus* (Ellison)-

Yao and Li, figure 2, # 3.

1989 *Hindeodus minutus* (Ellison)-

Beyers and Orchard, Plate 1, figure 2.

Description: Pa element is scaphate, straight or slightly bowed, with a pronounced cusp that may be 2 or more times as high as the remaining denticles. The anterior edge is sometimes denticulated. Posterior of the cusp are 6-12 denticles, fused but with free tips, that decrease in size gradually towards the posterior end, or remain subequal in size and then decrease rapidly near the posterior end. The basal cup is long and narrow and occupies about three fourths of the element.

Remarks: The generic name was applied by Rexroad and Furnish (1964) to a bilaterally symmetric element whose type species in form taxonomy was *Trichonodella imperfecta* Rexroad. Baesemann (1973) showed that elements formally ascribed to several form genera and to *Hindeodus* constituted a seximembrate apparatus-species, in which the type species occupied the Sa position. He referred his multielement species to *Ozarkodina*. When Sweet (1976) combined *Anchignathodus typicalis* Sweet with *Ellisonia teicherti* Sweet the result was an apparatus similar to that of *Ozarkodina minuta* as predicted by Baesemann (1973), but Sweet (1976) judged the senior generic name to be *Hindeodus*. As Ziegler (1977) points out, *Hindeodus* and *Ozarkodina* differ in many respects, and they are clearly separated in the geologic column. Speciation of *Hindeodus* may depend on changes in the ramiform component of the multielement apparatus, because the Pa element is conservative in form (Ziegler, 1977).

Small elements with 6 or 7 denticles and a cusp only slightly higher than the posterior denticles are probably the juvenile population. In *H. typicalis* the basal margin is almost straight or curves gently toward the basal cup, whereas in *H. minutus*, an older species, the basal margin at the anterior end is sharply downturned. This feature readily distinguishes the two species. *H. typicalis* differs from *'Anchignathodus parvus'*, the adenticulate form of *Isarcicella isarcica*, in that the basal cup of the Pa element is longer, the denticles, including the cusp, are not inclined posteriorly as is common in *'A. parvus'*; as well, denticles are fused except at the tips. Ramiform elements belonging to *H. typicalis* were not tabulated in this study.

Occurrence: Jesmond Creek; sections 1, 2 and 3, and isolated samples along

Jesmond lookout road; Mount Soues; Porcupine Creek (PorcCk-1, western belt).

Material: 154 (Pa) specimens.

GENUS *Iranognathus* Kozur, Mostler and Rahimi-Yazd, 1975

Type species *Iranognathus unicostatus* Kozur, Mostler and Rahimi-Yazd, 1975

Diagnosis (original, German): The spathognathodiform element has a very strongly expanded basal cavity occupying more than two-thirds of the overall length of the conodont. Its surface carries one or more, usually smooth, ridge-like elevations. Somewhat less than one-third of the carina is free. The basal cavity grades into a broad basal groove beneath the free part of the denticulated carina. The denticles of the carina are stout, and may also be completely fused. Associated skeletal elements are unknown.

Diagnosis (revised): Scaphate element with a free blade and a large, flared basal cavity that occupies two-thirds or more of the entire element length. The surface of the cup may be unornamented or marked by one or more ridge-like elevations. Micropustules occur in a row of uniform width on the carina, which is commonly fused for part of its length.

Iranognathus ex gr. **nudus** Wang, Ritter and Clark

?1975 *Diplognathodus movschovitschi* Kozur and Pjatakova-Kozur, Plate 2, figures 3-4.

?1977 *Diplognathodus? movschovitschi* Kozur and Pjatakova-Sweet in Ziegler, Plate 1, figure 5.

?1980 *Diplognathodus movschovitschi* Kozur and Pjatakova-Bando *et al.*, Plate 8, figure 14.

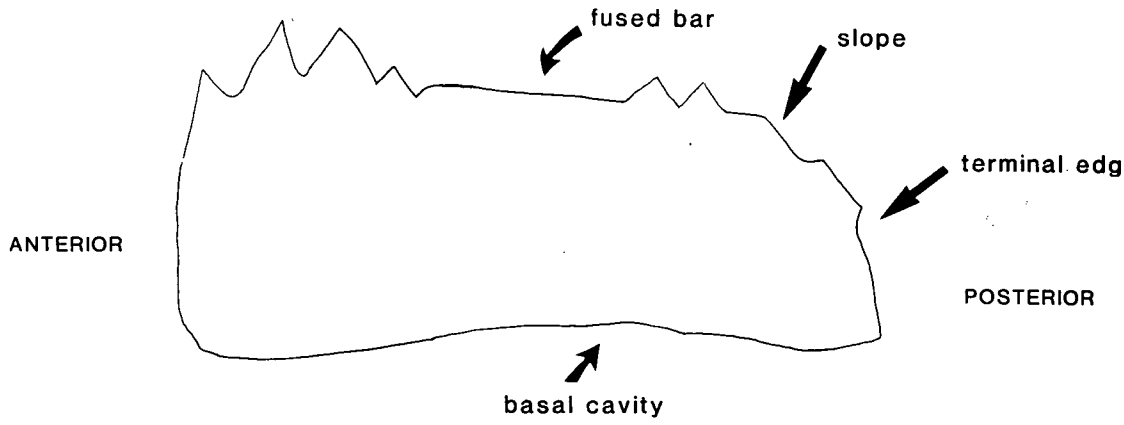


Figure 7.1: Terminology of *Iranognathus* ex gr. *nudus*.

1984 *'Diplognathodus' movschovitschi* Kozur and Pjatakova-Orchard, Plate 22.2, figures 3?-4, 8.

?1987 *Iranognathus nudus* Wang, Ritter and Clark-Wang, Ritter and Clark, Figure 6, #8-10.

1989 *Iranognathus* ex gr. *nudus* Wang, Ritter and Clark-Beyers and Orchard, Plate 1, figures 4, 6-7.

Diagnosis: Scaphate element with a denticulated free blade and a pustulose carina that is commonly fused into a bar (Figure 7.1). The basal cup is unornamented. The denticulated posterior slope has a steep terminal edge.

Remarks: Because the lateral profile of the holotype of *Iranognathus nudus* was not illustrated by Wang, Ritter and Clark (1987), it is not certain that the Marble Canyon Formation material is the same. This uncertainty is expressed by referring the British Columbia material to the *I. nudus* group. Although in upper view the Chinese and British Columbia specimens show similar free blade to element length relations and basal cavity shape, it has not been possible to compare denticulation and profile of the carina. The blister-like nodes on the outer side of the platform present on some of the *I. nudus* specimens of Wang *et al.* (1987), are absent.

Group elements differ from *Diplognathodus* in lacking a blade/carina that is divided into higher and lower parts, and in possession of pustules. These micropustules, sometimes obliterated due to recrystallization, indicate instead a relationship to the sweetognathids. Wang, Ritter and Clark (1987, p. 1055) stated that *Iranognathus nudus* differs from *Diplognathodus movschovitschi* in that "(t)he latter reportedly lacks the pustulose microstructure that is characteristic" of *I.*

nudus. But the two specimens apparently available to Kozur and Pjatakova are so badly broken and poorly illustrated that such a comparison cannot be made. Rather, the description of *D. movschovitschi* corresponds closely to *I.* ex gr. *nudus*. If *nudus* and *movschovitschi* can be shown to be the same, then *movschovitschi* will be the specific name with priority.

Three morphotypes are recognized in the Jesmond sections. Their distribution in this part of the Marble Range is tabulated in Figure 7.2. The morphotypes are differentiated primarily on the basis of carina fusion and are described in detail below. Assignment to species level is considered premature because relationships between the three morphotypes are not understood, and poor preservation means stratigraphic ranges cannot be reliably established. The common occurrence of morphotype *A* in the Jesmond area may mean that this form represents the mode of the population in the Marble Canyon Formation fauna. Furthermore, a conodont animal of the *Iranognathus* group may have possessed two dissimilar Pa elements, one more conservative (*A*), the other more variable.

Morphotype **A**

Plate 1, figures 1-6

Diagnosis: A morphotype of *I.* ex gr. *nudus* in which the carinal denticles are fused into a bar above the widest part of the basal cup. The posterior slope is gradual and denticulated. Pustules are well developed and can occur both on the bar and on the posterior denticles.

Description: A short free blade, about one third of the element's length, carries 4 to 6 discrete denticles diminishing in size posteriorly, except for the

anteriormost denticle which is smaller than the second. The thin, high and often slightly laterally curved carina is partly fused to form a bar which may arch slightly upward. The fused bar extends from a point anterior of the widest part of the basal cup, to a point opposite or more commonly, just posterior of it. Posterior of the bar, 4-6 arc-like denticles occur, the last one atop an abrupt terminal edge. The basal cup extends posteriorly beyond the carina. The usually symmetrical basal cup is oval- to heart-shaped, attaining greatest width in its anterior half, commonly with a pronounced flare. Width is equal, or almost equal, to length. Near the posterior end the inner cup margin veers inward toward the carina whereas the outer cup margin remains convex in shape. Micro-ornamentation occurs as pustules either on the bar, on the posterior denticles, or on both. Not all specimens show this feature, probably because of recrystallization.

Remarks: This form is thought to be equivalent to *I. nudus* of previous authors. Morphotype *A* differs from morphotypes *B* and *C* by the extent and uniform distribution of micropustules both on the bar and the denticulated portion of the carina.

Occurrence: Sections 1, 2 and 3, and sample J-B1, Jesmond.

Material: 86-110 specimens.

Morphotype **B**

Plate 1, figures 7-11

Diagnosis: A morphotype of *I.* ex gr. *nudus* with a very short fused bar located on the posteriormost part of the free blade and above the anteriormost part of the cup. As presently recognized, pustules are restricted to the

Figure 7.2: Distributional data for genera *Iranognathus* and *Neogondolella* in the Jesmond area.

GENUS	SAMPLE / SPECIES	JAR-2&2A	JAR-3	JAR-5B	JAR-6&6B	JR-6A	JAR-9	JAR-10	JAR-12&12A	JAR-13&13A	JAR-14&14A	JAR-15	JAR-17&17B	JAR-18&18A	JR-18B	JAR-20	JR-21B	JAR-22	JAR-30	JAR-31&31A	J-A1	J-A2	J-A3	J-A6	J-A6-B	J-A7	J-B1	JCK-1
IRANOGNATHUS	ex gr. ***nudus***																											
	morphotype A	17		2	15			1	1		1	1	1	5	3							2	2	11	7	5	12	
	morphotype B																			1			1					
	morphotype C	1												8													2	4
	morphotype ?A				1								1	6	2						1			8			3	2
	morphotype ?B																									1		
	morphotype ?C				1								2	2	1									1				
	n.sp. ***A***														1									1			1	
	sp. indet.	2	2		3		2		2	2	4			8	1							2		5	1	2	2	
NEOGONDOLELLA	***orientalis***														1		1										1	1
	?orientalis				1																							1
	aff. ***orientalis***																											2
	subcarinata subspp.																											
	s. subcarinata																										2	
	s. subsp. ***A***																								1			
	?subcarinata													1													1	
	n.sp. ***A***		2		29	4									2	1											3	20
	?n.sp. ***A***	1			1						1				2		2	1										
	sp. indet.					2			1		1			1	1		1		1		1			1				4
		SECTION 2											SECTION 1						SECTION 3									

denticulated carina, particularly between denticles.

Description: The free blade, about one-third of the total length, bears at least 2 denticles (it is broken in all specimens) which diminish in size posteriorly. Fusion is restricted to a very short bar that encompasses both the posterior blade and the anteriormost part of the carina. The basal cup appears to extend only marginally beyond the carina. Near the posterior end, the inner cup margin veers inward towards the carina while the outer margin maintains its convex shape. The greatest width of the cup occurs at a point one-third from its anterior end. Carinal pustules appear restricted to the spaces between denticles.

Remarks: Morphotype *B* is distinguished from morphotype *A* by restriction of the fused portion of the carina. The extent of denticulation is intermediate between that of morphotypes *A* and *C*.

Occurrence: Section 3, Jesmond.

Material: 2-4 specimens.

Morphotype **C**

Plate 2, figures 1-7

Diagnosis: A small morphotype of *I.* ex gr. *nudus* characterized by a fully denticulated carina. As presently recognized, pustules occur on the sloping posterior part of the carina.

Description: The free blade bears 3 to 4? denticles diminishing in size posteriorly from the second anteriormost denticle onward. The carina is fully denticulate with 6 to 8? denticles, 3 of which are on the posterior slope. The basal cup at the posterior end veers inward on both sides, and terminates anterior of the carina. Pustules occur on the posterior part of denticles in the

posterior half of the carina.

Remarks: As morphotype *C* representatives are smaller in size than those belonging to morphotype *A* and have a similar, but more restricted stratigraphic distribution, it is possible that the fully denticulated form is actually the juvenile population of morphotype *A*. It differs from the other two morphotypes in the lack of fusion and by extension of the carina beyond the basal cavity.

Occurrence: Sections 1, 2 and 3, and sample J-B1, Jesmond; also Jesmond Creek.

Material: 15-23 specimens.

Iranognathus n.sp. *A*

Plate 2, figures 8-11

Diagnosis: A species of *Iranognathus* with a denticulated free blade, stout denticles on the anterior carina, and a laterally deflected, short, fused bar at the posterior end of the scaphate element. Micropustules occur both on the bar and on adjacent denticle(s).

Description: The free blade carries 4 or 5 denticles that decrease in size posteriorly, except for the anteriormost one which is smaller than the second. The 3-4 carinal denticles posterior of the blade are antero-posteriorly extended. At a point two-thirds from the anterior end, the carina is laterally deflected. The deflected segment is fused into a short bar that terminates above the steep posterior edge. The posteriormost part of the carina is oriented parallel to the anterior part of the carina. Two short denticles are located on the posterior edge. The slightly asymmetrical, unornamented basal cup underlies two-thirds of the element. The cup's greatest width occurs in its anterior half. Small pustules are

present on the fused bar and adjacent denticle(s).

Remarks: This species differs from *I.* ex gr. *nudus* morphotypes in style of denticulation and in the lateral deflection of the fused carinal bar. The distinctive denticulation appears to be intermediate between species of *Iranognathus* and *Hindeodus*.

Occurrence: Section 3 and sample J-B1, Jesmond (Figure 7.2).

Material: 3 specimens.

GENUS *Isarcicella* Kozur, 1975

Type species *Spathognathodus isarcicus* Huckriede, 1958

Isarcicella isarcica (Huckriede)

Plate 4, figures 2-3

1958 *Spathognathodus isarcica* Huckriede-
Huckriede, Plate 10, figures 6-7.

1958 *Spathognathodus* cf. *minutus* (Ellison)-
Huckriede, Plate 10, figure 8.

1964 *Spathognathodus isarcicus* Huckriede-
Staesche, Figures 6, 60-64.

1970b *Anchignathodus isarcicus* (Huckriede)-
Sweet, Plate 1, figures 18-19.

1973 *Anchignathodus isarcicus* (Huckriede)-
Sweet, Plate 11, figures 5-7.

1975 *Anchignathodus parvus* Kozur and Pjatakova-
Kozur, Plate 1, figures 17, 19-20, 22.

1975 *Isarcicella isarcicus* (Huckriede)-

Kozur, Plate 1, figure 18.

1975 *Anchignathodus parvus* Kozur and Pjatakova-

Kozur, Mostler and Rahimi-Yazd, Plate 1, figures 12-15; Plate 7, figures 7, 9.

1975 *Isarcicella isarcicus* (Huckriede)-

Kozur, Mostler and Rahimi-Yazd, Plate 7, figures 3-6, 8.

?1975 *Anchignathodus turgidus* Kozur, Mostler and Rahimi-Yazd-

Kozur, Mostler and Rahimi-Yazd, Plate 7, figures 11-12.

1977 *Isarcicella isarcica* (Huckriede)-

Sweet in Ziegler, p. 225-227, Text-figure "Terminology of *Isarcicella* Kozur, 1975".

1980 *Anchignathodus parvus* Kozur and Pjatakova-

Bando *et al.*, Plate 9, figure 12.

1980 *Isarcicella isarcica* (Huckriede)-

Bando *et al.*, Plate 9, figure 11.

1982 *Isarcicella isarcica* (Huckriede)-

Paull, Figure 5, #14, 16-19.

1987 *Isarcicella isarcica* (Huckriede)-

Perri and Andraghetti, Plate 32, figures 6-7.

1987 *Anchignathodus parvus* Kozur and Pjatakova-

Yao and Li, Figure 2, #13.

1989 *Hindeodus 'parvus'* (Kozur and Pjatakova)-

Beyers and Orchard, Plate 1, figures 8-9.

Remarks: Three morphotypes of *Isarcicella isarcica* are known to exist: 1=no lateral denticles, 2=one or two denticles on one side of the blade, and 3=one denticle on either side of the symmetrical blade (Staesche, 1964). They have in common a thickened carina, expanded basal cavity and low number of carinal

denticles, usually from 4 to 6 in number, although there may be as many as 10. Only morphotype 1 has been found in the Marble Range.

Occurrence: Base of section 1, Porcupine Creek (western belt).

Material: 2 Pa specimens.

GENUS *Neogondolella* Bender and Stoppel, 1965

Type species *Gondolella mombergensis* Tatge, 1956

Neogondolellids recovered in the study area can be divided into three morphological groups. One group is slender lachrimiform in shape, the second broad quadrangular, and the third is regularly tapered, but posteriorly bulbous. To the first belongs *N.* n.sp. *A*, to the second, *N. orientalis* and *N. subcarinata*; *N. phosphoriensis* represents the third morphological group. Distributional data for neogondolellids of the Jesmond area are presented in Figure 7.2.

Neogondolella orientalis (Barskov and Koroleva)

Plate 3, figure 5

1970 *Gondolella orientalis* Barskov and Koroleva-Barskov and Koroleva, Figure 1, #1-4.

1973 *Neogondolella orientalis* (Barskov and Koroleva)-Teichert, Kummel and Sweet, Plate 13, figures 4-11; Text-figure 16A-D.

1975 *Gondolella orientalis* Barskov and Koroleva-Kozur, Plate 2, figures 5-8.

1981 *Neogondolella orientalis* (Barskov and Koroleva)-Wang and Wang, Plate 1, figures 16-17.

1981 *Neogondolella orientalis* (Barskov and Koroleva)-

Zhao Jin-ke *et al.*, Plate 5, figures 12-14, 17-18.

1984 *Neogondolella orientalis* (Barskov and Koroleva)-

Budurov, Gupta and Kachroo, Plate 1, figures 6-9.

1987 *Neogondolella orientalis* (Barskov and Koroleva)-

Nestell and Wardlaw, Figure 5, #1-9, 11-17; Figure 6, #2-4, 6, 9-10, 12-15; Figure 7, #16-18, 20.

Diagnosis (original, Russian in Ziegler, 1977): Platform is oval in outline. Inferior surface a broad low carina with small narrow groove. Median crest with flattened denticles, which merge anteriorly where they form a laminated, short, practically adenticulate free blade.

Diagnosis (revised): A species of *Neogondolella* with a broad quadrangular platform and pronounced brim posterior of the very low cusp.

Description (modified from Nestell & Wardlaw, 1987): The Pa element is broad, lachrimiform and arched, and widest posterior of the midpoint. At a point approximately one-third from the anterior end, the platform tapers strongly inward. The blade is not high, but is set off from the posterior denticles which are all very low and often fused. There is no free blade. The thickened platform margins are variably but distinctly upturned, forming a brim at the posterior end which encloses a low cusp. This cusp, located to the inner side of the midline, may be more pronounced than the denticle anterior to it. The posterior end is rounded to blunt. Adcarinal grooves are broad and shallow to moderately deep. The upper surface, except for carina and adcarinal grooves, is reticulated. On the lower surface the keel is wide and flat, and the elevated loop follows the platform outline.

Remarks: All Marble Canyon Formation specimens lack the blade, and many

have only the posterior end preserved. More complete elements show a range in platform outline from narrower and longer to shorter and wider, similar to the variety in the Hydra material (Nestell and Wardlaw, 1987). Two very narrow elements (JCk-1) with a large brim, of which only the posterior end has been preserved, have been referred to *N.* sp. cf. *N. orientalis.*

Occurrence: Jesmond Creek; section 1 and sample J-B1 on Jesmond lookout road.

Material: 4-6 specimens.

Neogondolella phosphoriensis (Youngquist, Hawley and Miller)

Plate 3, figures 6, 8, 13

1951 *Gondolella phosphoriensis* Youngquist, Hawley and Miller-Youngquist, Hawley and Miller, Plate 54, figures 10-12.

1965 *Gondolella rosenkrantzi* Bender and Stoppel-Bender and Stoppel, Plate 14, figures 7-11; Plate 16, figures 17, 19-26.

1976 *Neogondolella rosenkrantzi* (Bender and Stoppel)-Sweet in Teichert and Kummel, Plate 16, figures 10-13.

1979 *Neogondolella rosenkrantzi* (Bender and Stoppel)-Clark and Behnken, Plate 2, figures 1-4, 7-9.

1979 *Neogondolella rosenkrantzi* (Bender and Stoppel)-Clark *et al.*, Plate 1, figures 4-6.

1979 *Neogondolella rosenkrantzi* (Bender and Stoppel)-Wardlaw and Collinson, Plate 2, figures 1-14, 17-28.

1986 *Neogondolella phosphoriensis* (Youngquist, Hawley and Miller)-Behnken, Wardlaw and Stout, Figure 5, #1-3, 8-19, 22; Figure 6, #21-27.

non 1988 *Neogondolella rosenkrantzi* (Bender and Stoppel)-Clark and Wang, Figure 3, #12.

Diagnosis (revised): A species of *Neogondolella* with a wide, oval to triangularly shaped, regularly tapered platform, round to blunt and often bulbous at the posterior end, a large elongate cusp which does not project posteriorly, and regularly spaced denticles anterior of the cusp.

Description: The long platform, flat or slightly arched, is widest in the posterior half, and either tapers gradually towards the anterior or retains its width, narrowing strongly only in the anterior one-third. It may be constricted near the posterior end. In complete specimens the platform extends to the anterior end or around it so that it encloses the anteriormost denticle. The blade is medium high and carries 3-4 denticles. Posterior of the blade, the carina possesses approximately 17 denticles that decrease in size posteriorly and may be fused over part of its length. The cusp is elongate and pronounced. Posterolateral denticles and carinal extensions may be developed. A narrow brim extends posterior of the cusp or the accessory denticles. Adcarinal grooves are shallow, so that the platform margins are almost flat. Faint serrations are present on the upper surface of some elements in the anterior one-fourth of the platform. Except for the carina and adcarinal grooves, the platform is finely reticulate. On the lower surface, a small pit is surrounded by a slightly elevated loop which continues anteriorly as a narrow groove. The basal surface is wide posteriorly and follows the platform outline.

Remarks: Serrated platforms in the *serrata* complex have been considered of taxonomic importance in stratigraphically older members but not in younger ones (Clark and Behnken, 1979). Bando *et al.* (1980) separated serrated *'N.*

rosenkrantzi' from smooth forms and placed the former in the new species *N. behnkeni*. According to Wardlaw and Collinson (1979), smooth and serrated elements are ecological morphotypes, serrations being indicative of shallow and more restricted environments. *N. phosphoriensis* may resemble overmature specimens of *N.* n.sp. *A*, but differs in that the blade is lower, the platform wider and thinner, and the cusp is elongate and less distinct.

Occurrence: Clinton lookout road (Cl-1).

Material: 7-12 specimens.

Neogondolella subcarinata subcarinata Sweet

Plate 3, figures 1-2

1973 *Neogondolella carinata subcarinata* Sweet-
Teichert, Kummel and Sweet, Plate 13, figures 12-17; Text-figure 16E-H.

1975 *Gondolella carinata subcarinata* (Sweet)-
Kozur, Plate 2, figures 9-10.

1981 *Neogondolella subcarinata subcarinata* Sweet-
Wang and Wang, Plate 1, figures 4-5, 8.

1981 *Neogondolella subcarinata subcarinata* Sweet-
Zhao Jin-ke *et al.*, Plate 5, figures 1-5, 8-9.

1984 *Neogondolella carinata subcarinata* Sweet-
Budurov, Gupta and Kachroo, Plate 1, figures 1-5.

1988 *Neogondolella subcarinata subcarinata* Sweet-
Clark and Wang, Figure 3, #26.

Diagnosis: A species of *Neogondolella* with arched, short and broad quadrangular platform, a cusp which projects posteriorly, and a narrow posterior brim which

forms a faint buttress.

Remarks: The short, wide and arched platform in the Jesmond material differs from the Dorasham II specimens illustrated by Sweet (in Teichert *et al.*, 1973) only in the presence of a slight geniculation point. This results in a less smoothly downturned anterior platform margin when viewed in profile.

Occurrence: Sample J-B1 and ?section 1, Jesmond.

Material: 2-4 specimens.

Neogondolella subcarinata subspecies **A** Sweet

Plate 3, figures 3-4

1989 *Neogondolella* ex gr. *subcarinata* Sweet-Beyers and Orchard, Plate 1, figure 1.

Diagnosis: A subspecies of *Neogondolella subcarinata* with long, broad, subquadrangular platform strongly downturned posteriorly, a pronounced cusp and narrow posterior brim, and a geniculation point on the inner margin.

Description: *Neogondolella subcarinata* subspecies *A* has a high blade with semi-fused denticles that decrease in height posteriorly, becoming the low, fused carinal nodes of the platform. Anterior of the cusp are two or three denticles similar in size to the cusp. The latter is pronounced and inclined posteriorly, where it is surrounded by a very narrow brim. The platform, thick and widest at mid-length, possesses distinct adcarinal grooves. Near the posterior end it is sharply downturned. The inner margin abruptly narrows at a geniculation point located at about mid-length; the outer margin narrows abruptly at a point located about one third from the anterior end. Anterior of the inflection points both margins taper gradually inward.

Remarks: The strong geniculation point on the inner margin gives the element a superficial resemblance to *Neogondolella leveni*, but it differs from the latter by the greater width of the platform, by the asymmetrical nature of the taper, by the pronounced arching at the posterior end, the size of the denticles adjacent to the cusp, and by the length of the blade which is proportionately longer in *N. s.* subspecies *A*. In addition, the platform margins of this element are not as strongly upturned. The element resembles *N. s. changxingensis* in the outline of the posteriormost denticles anterior of the cusp, and in the possession of a sharp inflection point on the anterior platform margin, but differs from it in relative length of platform and blade.

Occurrence: Section 3 (J-A6-B), Jesmond.

Material: 1 specimen.

Neogondolella n.sp. **A**

Plate 3, figures 7, 9-12, 14

Diagnosis: A species of *Neogondolella* with long, slender lachrimiform platform and upturned margins at the rounded posterior end. The denticle anterior of the distinct cusp is always smaller than the cusp.

Description: Elements of *Neogondolella* n.sp. *A* have a slightly arched, symmetrical, narrow Pa element, rounded at the posterior end, but more blunt in overmature stages. It is widest in the posterior one-third, and narrows gradually towards the anterior in a taper that is mostly uniform but may be somewhat stronger on either side of the platform. There is no free blade. The high, convex blade carries 5-6 denticles. The 10-13 carinal denticles of the platform are laterally compressed and semi-fused with rounded tips. In mature to overmature

specimens the mid portion of the carina can be fused. The cusp, triangular to circular in cross section, is differentiated and prominent. It is preceded anteriorly by a very low denticle, anterior of which denticles increase in size towards the blade. The carina is straight or slightly curved, and in some specimens is asymmetrical at the posterior end. In this case the posteriormost platform appears downturned, and the last two denticles are fused into a cusp, which is then followed anteriorly by a much lower denticle. The platform margins are upturned at the posterior end, forming a slight depression for the cusp which is surrounded by a more or less thickened brim of variable width. The brim may be quite narrow, or even part of the cusp, which then projects posteriorly. The longitudinal grooves are narrow and of shallow to moderate depth. The platform margins and brim are reticulated, but the area surrounding the carina is smooth. Faint serrations may be present at the anterior end. On the lower surface a fairly wide loop arches around a small, elongate pit that becomes a narrow groove underneath the blade. The keel is low and longitudinally grooved.

Remarks: The narrow platform appears to link the species to the Late Permian *N. serrata* complex. *Neogondolella* n.sp. *A* resembles the older *N. aserrata* in platform shape and apparent lack of or weakness of anterior platform serrations, but differs from it in the presence of a brim, upturned around the distinct, rounded cusp, small size of the first denticle anterior of the cusp, lack of fusion of the posteriormost two denticles and absence of accessory denticles posterior of the cusp. These last features, as well as shape of the blade, roundness of the carinal denticles and lack of or weakness of the anterior serrations, serve to distinguish *N.* n.sp. *A* from *N. postserrata.* Carinal symmetry or lack of it with respect to the posterior margin has been used to differentiate species of the

complex (Clark and Behnken, 1979). Such statistical criteria are impossible to assess in small collections, and the feature may be triggered by external conditions, or related to ontogenetic development. Carinal symmetry and serrations are thus thought to be intraspecific morphological variation.

Occurrence: Sample J-B1 and sections 1 and 2, Jesmond; Jesmond Creek; Pavilion Mountain (western belt).

Material: 74-85 specimens.

GENUS *Neospathodus* Mosher, 1968

Type species *Spathognathodus cristagalli* Huckriede, 1958

Neospathodus sp. **A** Orchard

Plate 5, figures 2-3

1981 *Neospathodus* sp. *A*-

Orchard, p. 358.

Diagnosis: A short species of *Neospathodus* with an arcuate crest, a straight basal margin except for the posterior end, and upright denticles.

Description: The blade-shaped element is as high as it is long, or nearly so. The robust denticles are fused for two-thirds of their length, point straight up, and form an arcuate crest. The cusp, located at the posterior end, is wider but shorter than the anterior denticles. A longitudinal rib occurs a short distance above the straight basal margin. Underneath the posteriormost two denticles, the basal margin is sharply upturned. Where it encloses the deep basal cavity, the margin may curve slightly in lateral view, but it is essentially straight.

Occurrence: Cornwall Hills and Pavilion Mountain (western belt).

Material: 7 specimens.

Neospathodus sp. cf. **N. pakistanensis** Sweet

Plate 5, figure 5

Remarks: The element resembles *Neospathodus pakistanensis* in the long, straight basal margin which curves upward underneath the cusp and then downward, and in the possession of a very short posterior process, which has a denticle as well as a secondary outgrowth of the first posterior denticle. As in *N. pakistanensis*, the second denticle anterior of the cusp is the largest. The element differs from *N. pakistanensis* in that its length is somewhat shorter and its height somewhat greater.

Occurrence: Cornwall Hills (CH-E12).

Material: 1 specimen.

Neospathodus sp. cf. **N. peculiaris** Sweet

Plate 5, figure 10

Remarks: The element resembles *Neospathodus peculiaris* in the possession of a robust cusp but differs from it in the distinctly upturned basal margin underneath the cusp, which in the type specimen is straight. In addition, *N. peculiaris* has a broadly convex under surface.

Occurrence: Cornwall Hills (CH-E12).

Material: 1 specimen.

GENUS *Pachycladina* Staesche, 1964

Type species *Pachycladina obliqua* Staesche, 1964

Pachycladina obliqua Staesche

Plate 4, figures 7, 9-10, 13

1964 *Pachycladina lata* Staesche-

Staesche, Figures 18, 55.

1964 *Pachycladina inclinata* Staesche-

Staesche, Figures 17, 23, 33, 53-54; Plate 29, figures 5-6.

1964 *Pachycladina obliqua* Staesche-

Staesche, Figures 14, 21, 31, 46-47; Plate 29, figures 2-4.

1964 *Pachycladina symmetrica* Staesche-

Staesche, Figures 19-20, 30, 35, 48-51; Plate 29, figure 1; Plate 31, figure 4; Plate 32, figure 1.

1964 *Pachycladina tricuspidata* Staesche-

Staesche, Figures 16, 34, 52.

1964 *Pachycladina longispinosa* Staesche-

Staesche, Figures 15, 22, 32, 56-58; Plate 30, figure 2; Plate 31, figure 2.

1981 *Pachycladina obliqua* Staesche-

Clark, Figure W102, #4.

1987 *Pachycladina obliqua* Staesche-

Perri and Andraghetti, Plate 34, figures 1-7.

Description (Perri and Andraghetti, 1987): Robust elements bear large denticles that are generally laterally compressed, a wide lower surface that is cuneiform with midlateral ribs corresponding to the upper margins of the lower surface. Growth stripes visible on two thirds of the lower surface. Very small or quite invisible basal pit.

Remarks: Some of the specimens from Jesmond have an anterior lip, observed in both the Sc (*P. longispinosa* of Staesche) and Sa (*P. symmetrica* of Staesche) elements. The feature is similar to what Staesche called "Variante B" of *P.*

symmetrica, but is far more pronounced in the Jesmond material.

Occurrence: Section 4, Jesmond; Cornwall Hills (CH-N2); Pavilion Mountain (PVR-E, western belt).

Material: 48 specimens.

Pachycladina sp. **A**

Plate 4, figure 12

Description: This species of *Pachycladina* is characterized by a robust, diamond-shaped blade with 9 laterally compressed, posteriorly inclined, stout and short denticles of roughly equal height. The lower surface has a midlateral rib at the base of the denticles corresponding to the upper margin of the lower surface. Growth lines surround a very small basal pit. The lower margin is upturned posteriorly, and corresponds to the "lip" of *P. obliqua* (*P. symmetrica*) described by Staesche (1964). The anterior surface is smooth and curved posteriorly.

Remarks: *Pachycladina* sp. *A* resembles *Parachirognathus geiseri* Clark in outline but differs from it in mode of denticulation and in the lack of a straight lower edge which is instead distinctly upturned. It differs from *Pachycladina obliqua sensu* Sweet in the approximately equal height of all denticles and therefore in the lack of a distinct cusp, and in the incorporation of the anterior process (lip) into the lower surface (blade), forming the upturned edge.

Occurrence: 1 m above the base of section 4, Jesmond.

Material: 1 Sa specimen.

PLATE 1

All views are upper unless stated otherwise.

Figures 1-6. *Iranognathus* ex gr. *nudus* Wang, Ritter & Clark, Morphotype *A*. 1-3. x100, from C-149752. 4. Lateral view, x90, from C-149752. 5. Lateral view, x100. from C-149757. 6. Close up of carina, x400, from C-149752.
Figures 7-11. *Iranognathus* ex gr. *nudus* Wang, Ritter & Clark, Morphotype *B*. 7. Lateral view, x150, from C-157219. 8. Lateral view, x100, from C-149782. 9. x100, from C-149782. 10. x125, from C-157219. 11a. Close up of carina, anterior view, x400, from C-149782. 11b. Close up of carina, posterior view, x400, from C-149782.

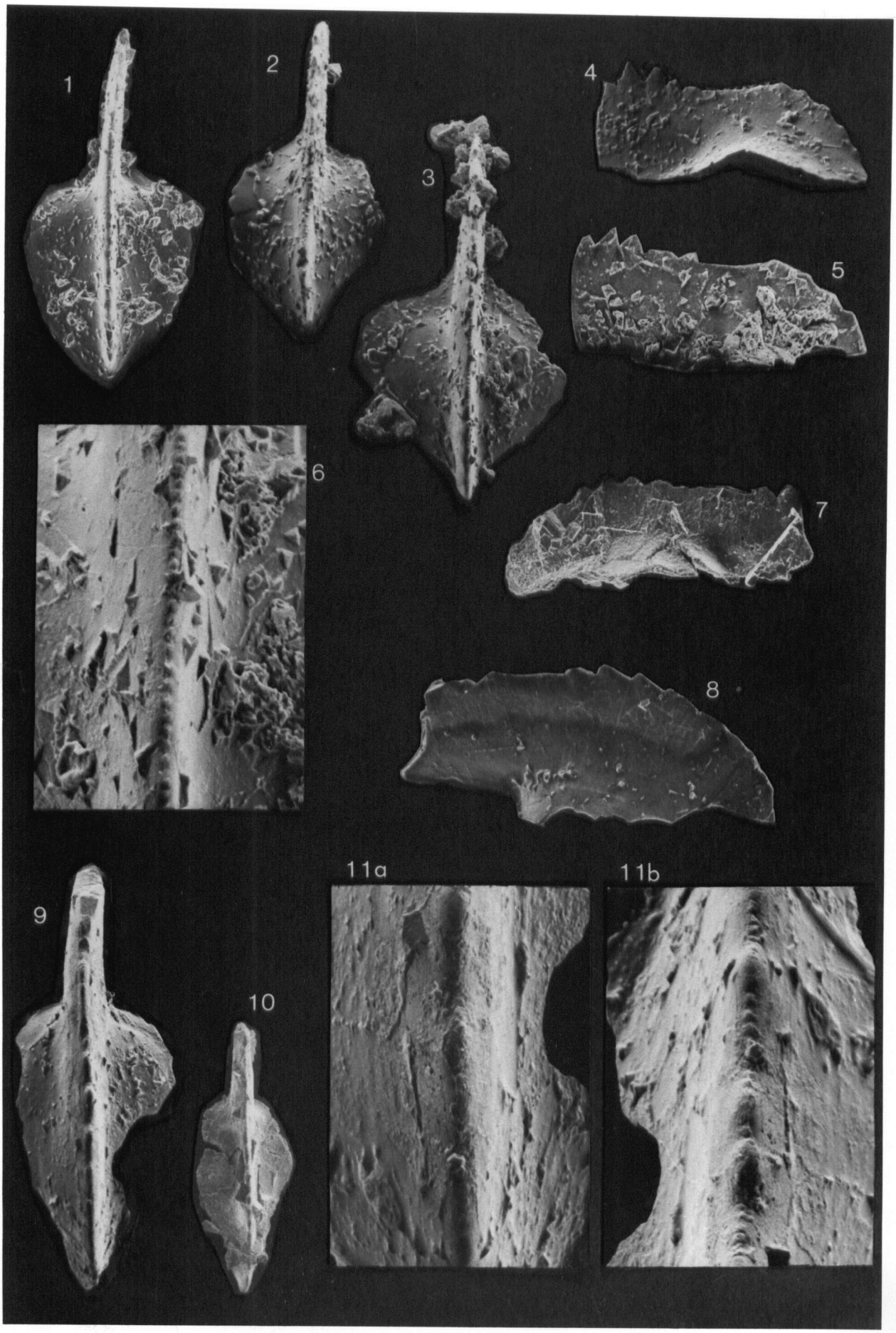

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PLATE 2

All views are upper unless stated otherwise.

Figures 1-7. *Iranognathus* ex gr. *nudus* Wang, Ritter & Clark, Morphotype *C*. 1. x250, from C-149752. 2. x250, from C-157815. 3. x250, from C-157808. 4. Lateral view, x150, from C-157808. 5. Lateral view, x100, from C-157204. 6. Lateral view, x250, from C-149752. 7. Close up of carina, x477, from C-149752. **Figures 8-11.** *Iranognathus* n.sp. *A*. 8. Lateral view, x110, from C-157222. 9. Close up of carina in oblique view, x210, from C-157222. 10. x100, from C-157204. 11. x100, from C-157222.

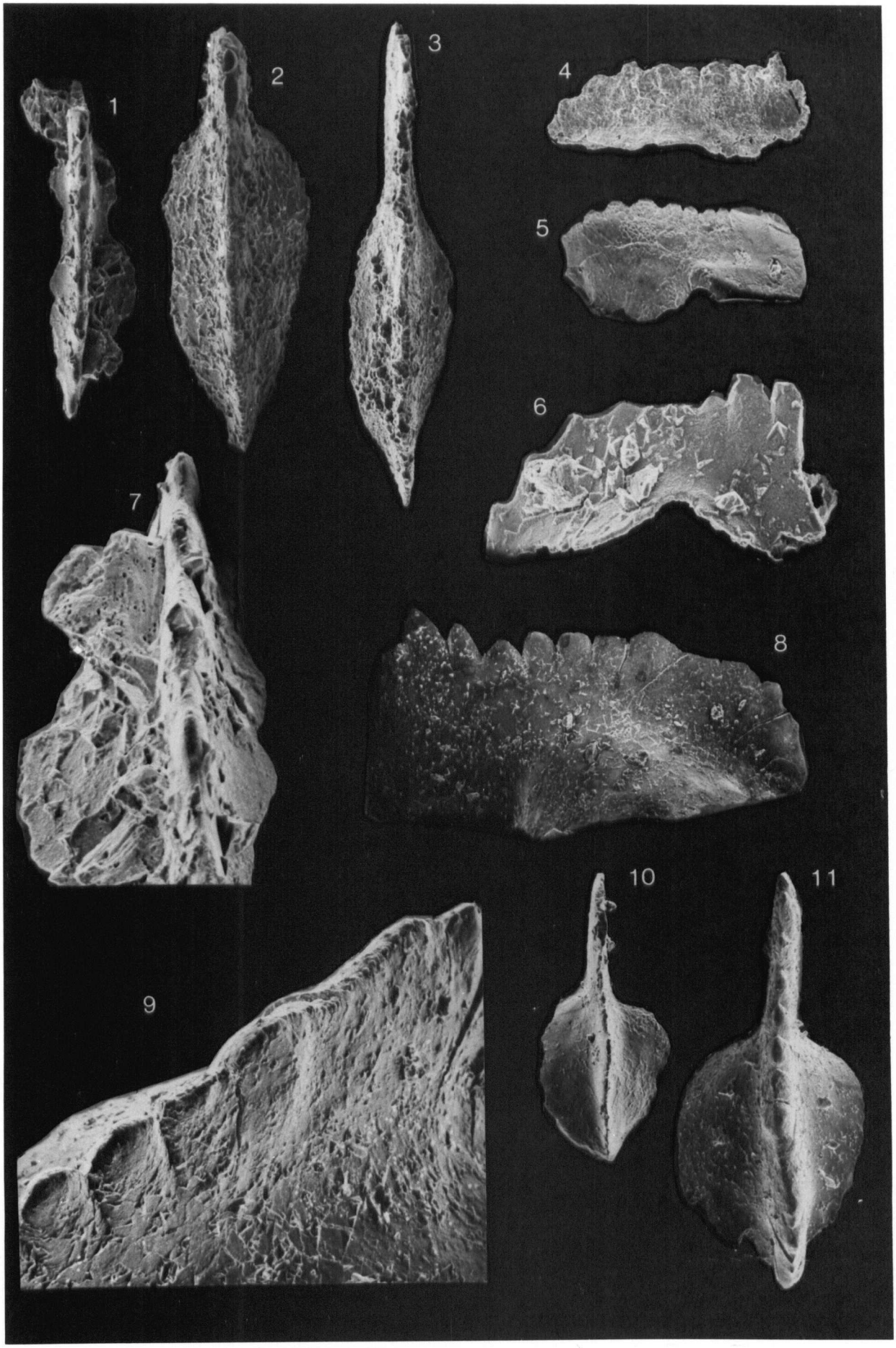
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PLATE 3

All views are upper unless stated otherwise.

Figures 1-2. *Neogondolella subcarinata subcarinata* Sweet. 1. x60, from C-157808. 2. Lateral view, x70, from C-157808.
Figures 3-4. *Neogondolella subcarinata* subspecies *A* Sweet. 3. Lateral view, x60, from C-157223. 4. x60, from C-157223.
Figure 5. *Neogondolella orientalis* (Barskov & Koroleva). Specimen with anteriormost portion missing, x70, from C-157808.
Figures 6, 8, 13. *Neogondolella phosphoriensis* (Youngquist, Hawley & Miller). x60, from C-117776. 13. Anterior fragment.
Figures 7, 9-12, 14. *Neogondolella* n.sp. *A*. 7. Close up of posterior half in oblique view, x150, from C-149757. 9. This specimen is similar to *N. leveni*, x70, from C-157212. 10, 12. x60, from C-149757. 11. x70, from C-149757. 14. Lower view of specimen 10, x125, from C-149757.

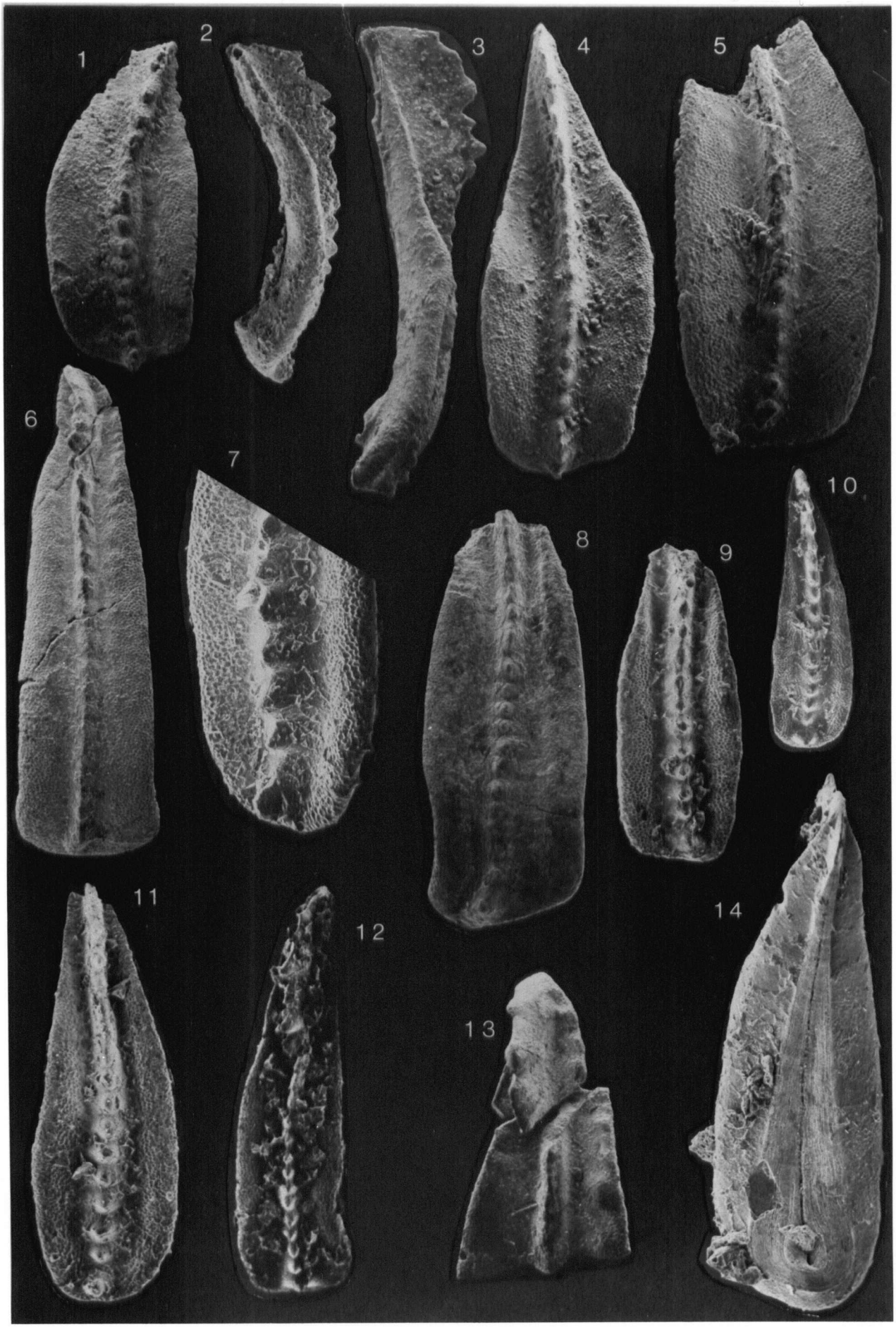
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PLATE 4

Figures 1, 4. *Hindeodus typicalis* (Sweet). 1. Lateral view, x80, from C-149752. 4. Lateral view, x70, from C-149752.
Figures 2-3. *Isarcicella isarcica* (Huckriede). Lateral view, x100, from C-157820.
Figures 5, 8. *Neocavitella?* sp. 5. Lateral view, x140, from C-157881. 6. Lateral view, x140, from C-157870.
Figure 6. *Furnishius? triserratus* Clark. Inner view, x70, from C-149815.
Figures 7, 9-10, 13. *Pachycladina obliqua* Staesche. 7. Inner view of Sc element, x70, from C-149832. 9. Posterior view of Sa element with lip, x40, from C-149812. 10. Anterior view of Sc? element with lip, x40, from C-149802. 13. Posterior view of Sb element, x70, from C-149832.
Figure 11. *Lonchodina nevadensis* Müller. Inner view, x 50, from C-149822.
Figure 12. *Pachycladina* sp. A. Posterior view of Sa element, x40, from C-149815.

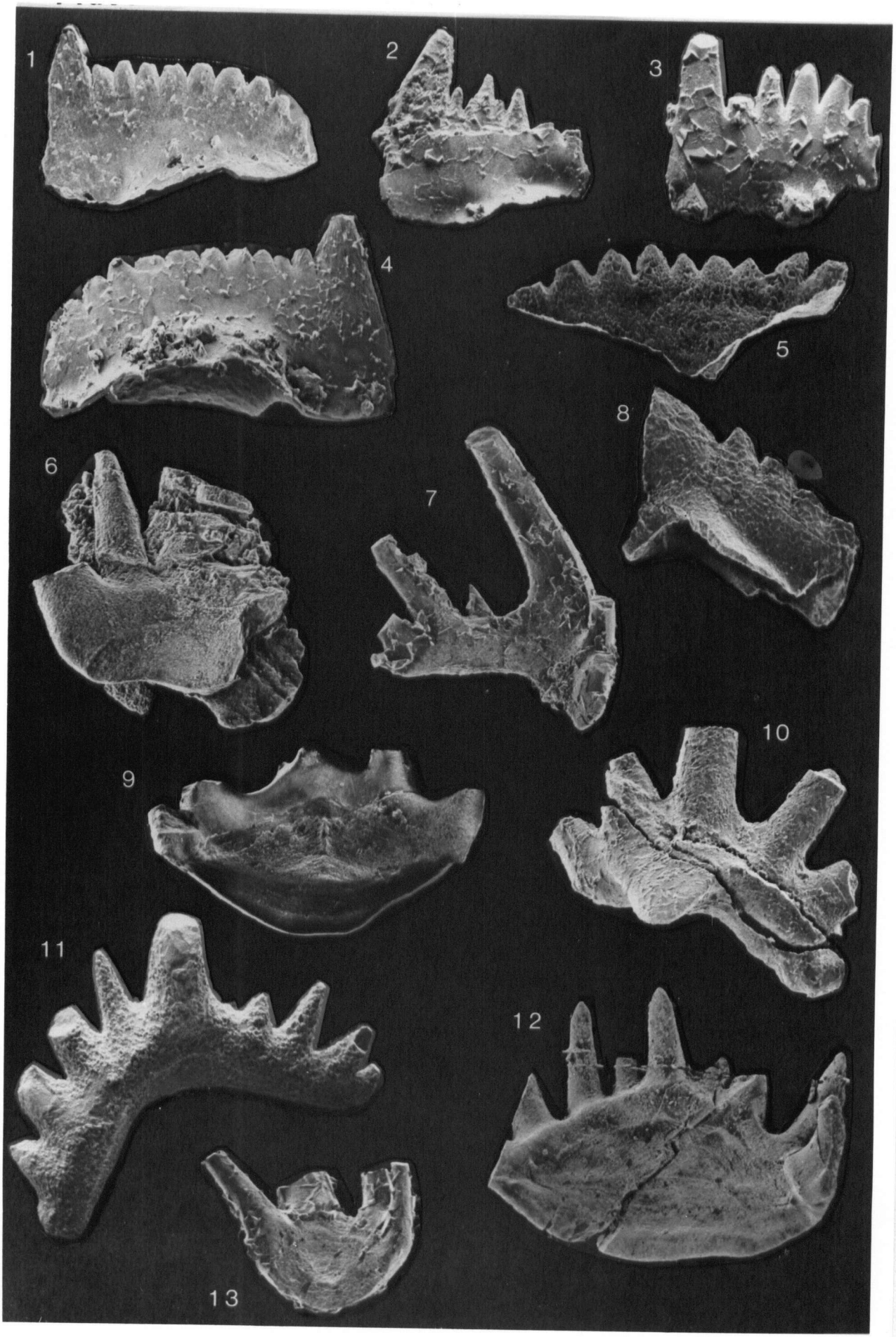
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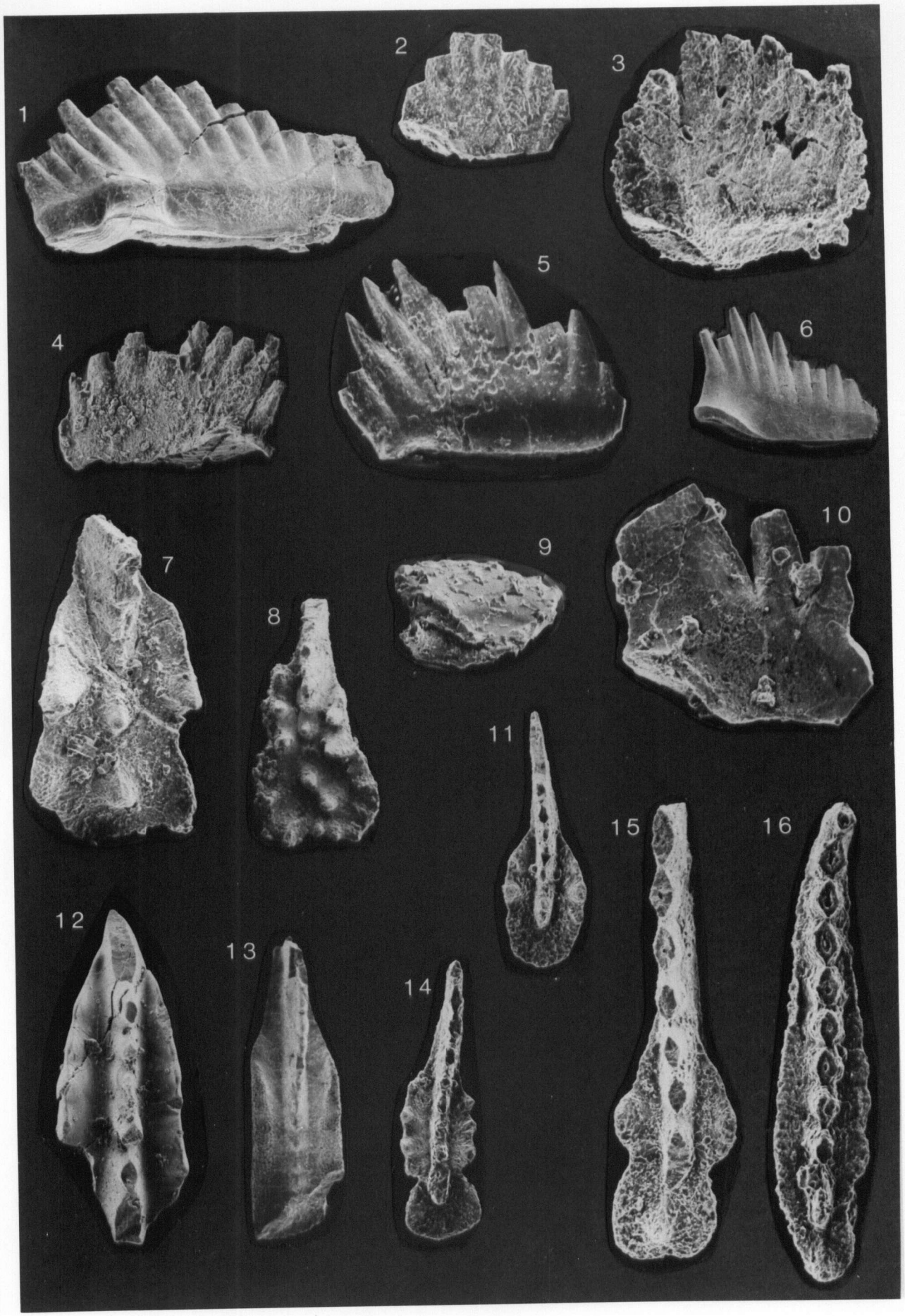
PLATE 5

All views are upper unless stated otherwise.

Figure 1. *Neospathodus novaehollandiae* McTavish. Lateral view, x60, from C-118474.
Figures 2-3. *Neospathodus* sp. *A*. 2. Lateral view, x70, from C-157873. 3. Lateral view, x70, from C-157843.
Figure 4. *Neospathodus homeri* (Bender). Lateral view, x100, from C-118494.
Figure 5. *Neospathodus* sp. cf. *N. pakistanensis* Sweet. Lateral view, x140, from C-157860.
Figure 6. *Neospathodus dieneri* Sweet. Lateral view, x80, from C-087055(e).
Figures 7-8. *Epigondolella abneptis* (Huckriede). 7. x140, from C-157824. 8. x65, from C-157824.
Figure 9. *Neospathodus triangularis* (Bender). Oblique lower view, x100, from C-149839.
Figure 10. *Neospathodus* sp. cf. *N. peculiaris* Sweet. Lateral view, x200, from C-157860.
Figure 11. *Metapolygnathus echinatus* Hayashi. x100, from C-117780.
Figure 12. *Neogondolella milleri* Müller. x80, from C-118479.
Figure 13. *Metapolygnathus* sp. x70, from C-157870.
Figure 14. *Epigondolella primitia* Hayashi. x100, from C-117780.
Figure 15. *Metapolygnathus nodosus* Hayashi. x200, from C-117780.
Figure 16. *Neogondolella navicula* (Huckriede). x160, from C-117780.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APPENDIX A: LOCALITY AND SAMPLE INFORMATION

Samples are from the Marble Canyon Formation (central belt) of the Cache Creek Group in south-central British Columbia, unless stated otherwise.

A. JESMOND: NTS 92P/5, BONAPARTE LAKE

GSC sample number: C-149751
field number: J. Beyers, 1986; 86OF-B-JAR-1
latitude, longitude: 51°17'52.3", 121°54'37.1"
UTM: Zone 10: 575975 m E., 5683300 m N.
geographic description: by 2nd switchback on Jesmond lookout access road, 4.1 km from turnoff onto lookout road
stratigraphic description: probably float
lithology: light grey, pale weathering, nodular limestone
weight: 3.396 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149752
field number: J. Beyers, 1986; 86OF-B-JAR-2
latitude, longitude: 51°17'51.5", 121°54'35.8"
UTM: Zone 10: 576000 m E., 5683275 m N.
geographic description: Jesmond fire lookout access road, 50 m downhill from 2nd switchback; elevation 1682 m (5550 ft)
stratigraphic description: at 0 m in section 2, 0.5 m below Orchard's JLO-7; bedding 42 cm thick, attitude 150/09 NE
lithology: light weathering, medium grey, slightly recrystallized, very crinoidal micrite
weight: 3.095 kg
fossils: crinoids
conodont fauna: *Hindeodus typicalis* (6)
Neogondolella n.sp. *A* (juv.) (1?)
Iranognathus ex gr. *nudus* (A:17, C:1)
Iranognathus sp. indet. (2)
ramiform elements (40)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157216
field number: J. Beyers, 1987; 87OF-B-JR-2A
weight: 11.100 kg
fossils: crinoids
conodont fauna: *Hindeodus typicalis* (1)

ramiform elements (4)
period or epoch: Permian
age: indeterminate
remarks: Recollection of JAR-2.
****

GSC sample number: C-149753
field number: J. Beyers, 1986; 86OF-B-JAR-3
latitude, longitude: 51°17'50.7", 121°54'35.8"
UTM: Zone 10: 576000 m E., 5683250 m N.
geographic description: Jesmond access road, 9 m SE of JAR-2
stratigraphic description: at 0.5 m in section 2
lithology: pale weathering, finely recrystallized carbonate with occasional micrite nodules and/or clasts about 1 cm in diameter
weight: 3.443 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (1+1?)
Iranognathus sp. indet. (2)
Neogondolella n.sp. *A* (2)
ramiform elements (8)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-149754
field number: J. Beyers, 1986; 86OF-B-JAR-4
latitude, longitude: 51°17'50.7", 121°54'35.8"
UTM: Zone 10: 576000 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 1 m in section 2; bedding attitude 175/31 NE
lithology: light grey, slightly recrystallized, lumpy micrite
weight: 1.691 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149755
field number: J. Beyers, 1986; 86OF-B-JAR-5A
latitude, longitude: 51°17'49.1", 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road, 12 m SE of JAR-4
stratigraphic description: at 3 m in section 2
lithology: medium grey, recrystallized, light brown weathering carbonate with dendritic Mn stain
weight: 3.446 kg
fossils: crinoids
conodont fauna: *Hindeodus typicalis* (4)
ramiform elements (3)
period or epoch: Permian
age: indeterminate

****

GSC sample number: C-157213
field number: J. Beyers, 1987; 87OF-B-JR-5A(1)
weight: 4.501 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-5A.
****

GSC sample number: C-157214
field number: J. Beyers, 1987; 87OF-B-JR-5A(2)
latitude, longitude: 51°17'49.1", 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 2
lithology: medium grey, dolomitic, crinoidal limestone
weight: 3.350 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157215
field number: J. Beyers, 1987; 87OF-B-JR-5x
latitude, longitude: 51°17'49.1", 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road
stratigraphic description: between JAR-5A and JAR-5B; bedding attitude 151/11 NE
lithology: recrystallized, crinoidal limestone with angular clasts and/or nodules
weight: 3.993 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (3)
ramiform elements (1)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-149756
field number: J. Beyers, 1986; 86OF-B-JAR-5B
latitude, longitude: 51°17'49.1"; 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 2
lithology: medium grey, grey weathering carbonate
weight: 3.529 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (5)
ramiform elements (5)
period or epoch: Permian

age: indeterminate
****

GSC sample number: C-149757
field number: J. Beyers, 1986; 86OF-B-JAR-6
latitude, longitude: 51°17'49.1", 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road, 13.5 m SE from JAR-5B
stratigraphic description: at 3.8 m in section 2; bedding attitude 175/06 NE
lithology: grey weathering, fine grained, medium to dark grey carbonate with chunks of calcite
weight: 4.232 kg
fossils: crinoids
conodont fauna: *Neogondolella* n.sp. *A* (25+1?)
N. orientalis (1?)
Iranognathus ex gr. *nudus* (A:15+1?, C:1?)
Iranognathus sp. indet. (3)
Hindeodus typicalis (11)
ramiform elements (174+)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157211
field number: J. Beyers, 1987; 87OF-B-JR-6B
weight: 12.000 kg
fossils: none
conodont fauna: *Neogondolella* n.sp. *A* (4)
Hindeodus typicalis (3)
ramiform elements (21)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Recollection of JAR-6.
****

GSC sample number: C-157212
field number: J. Beyers, 1987; 87OF-B-JR-6A
latitude, longitude: 51°17'49.1", 121°54'33.8"
UTM: Zone 10: 576040 m E., 5683200 m N.
geographic description: Jesmond access road
stratigraphic description: at 6 m in section 2; bedding attitude 175/06 NE
lithology: dark grey, slightly recrystallized, crinoidal limestone
weight: 3.604 kg
fossils: none
conodont fauna: *Neogondolella* n.sp. *A* (4)
Neogondolella sp. indet. (2)
Hindeodus typicalis (3)
ramiform elements (10)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2

****

GSC sample number: C-149758
field number: J. Beyers, 1986; 86OF-B-JAR-7
latitude, longitude: 51°17'47.8", 121°54'33.3"
UTM: Zone 10: 576050 m E., 5683160 m N.
geographic description: Jesmond access road, 130 m SE of second switchback
stratigraphic description: at 8 m in section 2
lithology: pale weathering, light grey, slightly recrystallized, medium coarse-grained carbonate
weight: 3.863 kg
fossils: ichthyoliths (1)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-149759
field number: J. Beyers, 1986; 86OF-B-JAR-8
latitude, longitude: 51°17'47.4", 121°54'30.7"
UTM: Zone 10: 576100 m E., 5683150 m N.
geographic description: Jesmond access road, 170 m SE of second switchback
lithology: light grey, medium coarse limestone
weight: 4.673 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-149760
field number: J. Beyers, 1986; 86OF-B-JAR-9
latitude, longitude: 51°17'41.1", 121°54'46.4"
UTM: Zone 10: 575800 m E., 5682950 m N.
geographic description: 2.7 km from turnoff onto lookout road
lithology: medium to dark grey, recrystallized limestone with calcite veining
weight: 1.759 kg
fossils: none
conodont fauna: ramiform elements (1)
Iranognathus sp. indet. (2)
period or epoch: Late Permian
age: indeterminate

****

GSC sample number: C-149761
field number: J. Beyers, 1986; 86OF-B-JAR-10
latitude, longitude: 51°17'41.1", 121°54'46.4"
UTM: Zone 10: 575800 m E., 5682950 m N.
geographic description: Jesmond access road, 2.73 km from turnoff onto lookout road
stratigraphic description: bedding attitude 148/21 NE
lithology: medium grey, pale brown weathering carbonate with calcite pods
weight: 2.148 kg
fossils: none

conodont fauna: ramiform elements (2)
Iranognathus ex gr. *nudus* (A:1)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157210
field number: J. Beyers, 1987; 87OF-B-JR-10A
weight: 6.812 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-10.
****

GSC sample number: C-149762
field number: J. Beyers, 1986; 86OF-B-JAR-11
latitude, longitude: 51°17'41.1", 121°54'46.4"
UTM: Zone 10: 575800 m E., 5682950 m N.
geographic description: Jesmond access road, 8 m uphill from JAR-10
lithology: dark grey, pale weathering, recrystallized, bituminous carbonate
weight: 2.388 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (1)
ramiform elements (2)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-149763
field number: J. Beyers, 1986; 86OF-B-JAR-12
latitude, longitude: 51°17'41.1", 121°54'46.4"
UTM: Zone 10: 575800 m E., 5682950 m N.
geographic description: Jesmond access road, 9 m NE of JAR-11
lithology: pale weathering, medium grey, coarsely recrystallized, bituminous and dolomitic carbonate with thin but fairly dense calcite veining
weight: 2.539 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
Iranognathus ex gr. *nudus* (A:1)
Iranognathus sp. indet. (2)
ramiform elements (5)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157209
field number: J. Beyers, 1987; 87OF-B-JR-12A
weight: 9.492 kg
fossils: none
conodont fauna: none

period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-12.
****

GSC sample number: C-149764
field number: J. Beyers, 1986; 86OF-B-JAR-13
latitude, longitude: 51°17'41.1", 121°54'42.5"
UTM: Zone 10: 575875 m E., 5682950 m N.
geographic description: Jesmond access road, 2.78 km from turnoff onto lookout road
lithology: light grey weathering, dark grey, strongly bituminous, dolomitic micrite, with calcite veins up to 5 cm wide
weight: 2.817 kg
fossils: ichthyoliths (1)
conodont fauna: *Hindeodus typicalis* (2)
Iranognathus sp. indet. (2)
ramiform elements (6)
period or epoch: Late Permian
age: indeterminate
remarks: Very small faunule.
****

GSC sample number: C-157208
field number: J. Beyers, 1987; 87OF-B-JR-13A
weight: 7.210 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-13.
****

GSC sample number: C-149765
field number: J. Beyers, 1986; 86OF-B-JAR-14
latitude, longitude: 51°17'41.0", 121°54'39.9"
UTM: Zone 10: 575925 m E., 5682950 m N.
geographic description: Jesmond access road, 2.81 km from turnoff onto lookout road
stratigraphic description: bedding about 20 cm thick, attitude 141/77 NE
lithology: pale weathering, dark grey, recrystallized, thinly veined, somewhat bituminous carbonate
weight: 2.666 kg
fossils: none
conodont fauna: *Neogondolella* n.sp. *A* (1?)
Neogondolella sp. indet. (1)
Iranognathus ex gr. *nudus* (A:1)
Iranognathus sp. indet. (4)
ramiform elements (10+)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157207
field number: J. Beyers, 1987; 87OF-B-JR-14A
weight: 7.120 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-14.
****

GSC sample number: C-149766
field number: J. Beyers, 1986; 86OF-B-JAR-15
latitude, longitude: 51°17'41.0", 121°54'39.9"
UTM: Zone 10: 575925 m E., 5682950 m N.
geographic description: Jesmond access road
stratigraphic description: bedding attitude 140/46 NE
lithology: medium to dark grey, recrystallized, mildly bituminous carbonate with thin calcite veins
weight: 3.305 kg
fossils: ichthyoliths (2+)
conodont fauna: *Iranognathus* ex gr. *nudus* (A:1)
ramiform elements (2)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-149767
field number: J. Beyers, 1986; 86OF-B-JAR-16
latitude, longitude: 51°17'41.0", 121°54'39.9"
UTM: Zone 10: 575925 m E., 5682950 m N.
geographic description: Jesmond access road, 9 m NE of JAR-15
stratigraphic description: bedding attitude 131/52 NE
lithology: pale weathering, medium to dark grey, recrystallized and thinly veined carbonate
weight: 2.448 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149768
field number: J. Beyers, 1986; 86OF-B-JAR-17
latitude, longitude: 51°17'41.8", 121°54'36.0"
UTM: Zone 10: 576000 m E., 5682975 m N.
geographic description: Jesmond access road, 2.87 km from turnoff onto lookout road
stratigraphic description: at 0 m in section 1; bedding attitude 108/04 NE
lithology: fissile, grey, slightly bituminous carbonate with calcite recrystallization pods
weight: 2.027 kg
fossils: ichthyoliths (1)

conodont fauna: *Iranognathus* ex gr. *nudus* (A:1+1?, C:2?)
ramiform elements (3)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157205
field number: J. Beyers, 1987; 87OF-B-JR-17B
weight: 3.869 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-17.
****

GSC sample number: C-157206
field number: J. Beyers, 1987; 87OF-B-JR-17A
latitude, longitude: 51°17'41.8", 121°54'36.0"
UTM: Zone 10: 576000 m E., 5682975 m N.
geographic description: Jesmond access road, 2.87 km from turnoff onto lookout road
stratigraphic description: 1 m above JAR-17; bedding attitude 108/04 NE
lithology: medium grey limestone with calcite veins
weight: 3.914 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149769
field number: J. Beyers, 1986; 86OF-B-JAR-18
latitude, longitude: 51°17'41.8", 121°54'36.0"
UTM: Zone 10: 576000 m E., 5682975 m N.
geographic description: Jesmond access road, 2.89 km from turnoff onto lookout road; elevation 1606 m (5300 ft)
stratigraphic description: at 3 m in section 1; bedding attitude 108/19 NE
lithology: pale weathering, medium grey, thinly veined carbonate
weight: 3.362 kg
fossils: ichthyoliths (1), ostracodes (1)
conodont fauna: *Hindeodus typicalis* (31)
Neogondolella subcarinata? (1)
Neogondolella n.sp. *A* (1?)
Iranognathus ex gr. *nudus* (A:5+6?, C:8+2?)
Iranognathus sp. indet. (8)
ramiform elements (27+)
period or epoch: Late Permian
age: (late Dzhulfian)-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157203

field number: J. Beyers, 1987; 87OF-B-JR-18A
weight: 15.800 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-18.
****

GSC sample number: C-157204
field number: J. Beyers, 1987; 87OF-B-JR-18B
latitude, longitude: 51°17'41.8", 121°54'36.0"
UTM: Zone 10: 576000 m E., 5682975 m N.
geographic description: Jesmond access road, 2.89 km from turnoff onto lookout road; elevation 1606 m (5300 ft)
stratigraphic description: 0.5 m below JAR-18; bedding about 30 cm thick, attitude 108/19 NE
lithology: medium grey, recrystallized limestone
weight: 2.894 kg
fossils: ichthyoliths (3), crinoids, sea urchin plates (1)
conodont fauna: *Neogondolella* n.sp. *A* (3+1?)
Neogondolella orientalis (1)
Neogondolella sp. indet. (1)
Hindeodus typicalis (11)
Iranognathus ex gr. *nudus* (A:3+2?, C:1?)
Iranognathus n.sp. *A* (1)
Iranognathus sp. indet. (1)
ramiform elements (15+)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-149770
field number: J. Beyers, 1986; 86OF-B-JAR-19
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.
geographic description: Jesmond access road, 3.06 km from turnoff onto lookout road
stratigraphic description: at 48.7 m in section 1
lithology: pale weathering, light grey carbonate
weight: 2.133 kg
fossils: crinoids
conodont fauna: *Hindeodus typicalis* (1)
ramiform elements (2)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-149771
field number: J. Beyers, 1986; 86OF-B-JAR-20
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.

geographic description: Jesmond access road, about 20 m NE of JAR-19
stratigraphic description: at 49.5 m in section 1
lithology: light brown weathering, fine grained micrite
weight: 1.683 kg
fossils: crinoids
conodont fauna: *Neogondolella* n.sp. *A* (1)
Hindeodus typicalis (1)
ramiform elements (2)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-149772
field number: J. Beyers, 1986; 86OF-B-JAR-21
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.
geographic description: Jesmond access road, 1 m NE of JAR-20
stratigraphic description: at 50.5 m in section 1; bedding attitude 112/14 NE
lithology: pale grey weathering, light grey, fine grained carbonate
weight: 1.792 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (2)
ramiform elements (3)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-157201
field number: J. Beyers, 1987; 87OF-B-JR-21A
weight: 15.400 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-21.
****

GSC sample number: C-157202
field number: J. Beyers, 1987; 87OF-B-JR-21B
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.
geographic description: Jesmond access road, 1 m from JAR-20
stratigraphic description: at 51 m in section 1; bedding attitude 112/14 NE
lithology: pale grey weathering, light grey, fine grained limestone
weight: 4.001 kg
fossils: none
conodont fauna: *Neogondolella orientalis* (1)
Neogondolella n.sp. *A* (2?)
Neogondolella sp. indet. (1)
Hindeodus typicalis (3)
ramiform elements (17+)
period or epoch: Late Permian

age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-149773
field number: J. Beyers, 1986; 86OF-B-JAR-22
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.
geographic description: Jesmond access road, 14 m NE of JAR-21
stratigraphic description: at 53.5 m in section 1
lithology: pale grey weathering, light grey, fine grained carbonate
weight: 2.271 kg
fossils: none
conodont fauna: *Neogondolella* n.sp. *A* (1?)
ramiform elements (1)
period or epoch: Late Permian
age: probably late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2?
****

GSC sample number: C-149774
field number: J. Beyers, 1986; 86OF-B-JAR-23
latitude, longitude: 51°17'40.9", 121°54'27.0"
UTM: Zone 10: 576175 m E., 5682950 m N.
geographic description: Jesmond access road, 20 m NE of JAR-22
stratigraphic description: at 58.5 m in section 1
lithology: pale grey weathering, light grey, fine grained carbonate
weight: 1.516 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149775
field number: J. Beyers, 1986; 86OF-B-JAR-24
latitude, longitude: 51°17'47.4", 121°54'30.7"
UTM: Zone 10: 576100 m E., 5683150 m N.
geographic description: Jesmond access road, 10 m SE of JAR-8
lithology: light grey, recrystallized, fine grained limestone
weight: 1.310 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157217
field number: J. Beyers, 1987; 87OF-B-J-A1
latitude, longitude: 51°17'54.0", 121°54'42.2"
UTM: Zone 10: 575875 m E., 5683350 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 0 m of section 3
lithology: dark, fissile, recrystallized limestone with calcite veins

weight: 4.030 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
Hindeodus typicalis (19)
Iranognathus ex gr. *nudus* (1?)
ramiform elements (54+)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157218
field number: J. Beyers, 1987; 87OF-B-J-A2
latitude, longitude: 51°17'54.0", 121°54'42.2"
UTM: Zone 10: 575875 m E., 5683350 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 1 m in section 3
lithology: medium grey limestone with micritic nodules
weight: 2.906 kg
fossils: none
conodont fauna: *Hindeodus typicalis* (2)
Iranognathus ex gr. *nudus* (A:2)
Iranognathus sp. indet. (2)
ramiform elements (4)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157219
field number: J. Beyers, 1987; 87OF-B-J-A3
latitude, longitude: 51°17'53.2", 121°54'38.3"
UTM: Zone 10: 575950 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 3.5 m in section 3
lithology: medium grey, recrystallized limestone
weight: 2.140 kg
fossils: none
conodont fauna: *Iranognathus* ex gr. *nudus* (A:2, B:1)
Hindeodus typicalis (2)
ramiform elements (3)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157220
field number: J. Beyers, 1987; 87OF-B-J-A4
latitude, longitude: 51°17'53.2", 121°54'38.3"
UTM: Zone 10: 575950 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 8.5 m in section 3; bedding attitude 160/08 NE; may be along strike from JAR-2

lithology: thick bedded, recrystallized, light weathering limestone
weight: 1.087 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157221
field number: J. Beyers, 1987; 87OF-B-J-A5
latitude, longitude: 51°17'53.1", 121°54'35.8"
UTM: Zone 10: 576000 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 21.5 m in section 3; bedding attitude 158/10 NE
lithology: light grey, thick bedded, micritic, recrystallized, sparsely crinoidal limestone
weight: 3.259 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157222
field number: J. Beyers, 1987; 87OF-B-J-A6
latitude, longitude: 51°17'53.1", 121°54'34.5"
UTM: Zone 10: 576025 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 28.5 m in section 3
lithology: dark grey, crinoidal micrite, brecciated or with micrite nodules
weight: 3.706 kg
fossils: crinoids
conodont fauna: *Iranognathus* ex gr. *nudus* (A:11+8?, C:1?)
Iranognathus n.sp. *A* (1)
Iranognathus sp. indet. (5)
Neogondolella sp. indet. (1)
Hindeodus typicalis (12+1?)
ramiform elements (61+)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157223
field number: J. Beyers, 1987; 87OF-B-J-A6-B
latitude, longitude: 51°17'53.1", 121°54'34.5"
UTM: Zone 10: 576025 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 32 m in section 3
lithology: crinoids and other echinoderm debris in micrite
weight: 1.321 kg
fossils: crinoids, sea urchin plates (1)
conodont fauna: *Neogondolella subcarinata* subsp. *A* (1)

Iranognathus ex gr. *nudus* (A:7)
Iranognathus sp. indet. (1)
Hindeodus typicalis (9)
ramiform elements (27+)
period or epoch: Late Permian
age: early-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Thin section cut.
****

GSC sample number: C-157224
field number: J. Beyers, 1987; 87OF-B-J-A7
latitude, longitude: 51°17'53.1", 121°54'34.5"
UTM: Zone 10: 576025 m E., 5683325 m N.
geographic description: Jesmond access road, from hill above second switchback
stratigraphic description: at 35.5 m in section 3
lithology: dark grey, crinoidal limestone, more dolomitized than J-A6
weight: 2.120 kg
fossils: crinoids
conodont fauna: ramiform elements (13)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149776
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-25
latitude, longitude: 51°17'52.3", 121°54'33.2"
UTM: Zone 10: 576050 m E., 5683300 m N.
geographic description: Jesmond access road, 200 m NE of second switchback; elevation 1721 m (5680 ft)
stratigraphic description: at 43.5 m in section 3
lithology: pale grey weathering, light grey, brecciated, slightly recrystallized, crinoidal limestone
weight: 1.194 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157225
field number: J. Beyers, 1987; 87OF-B-JR-25A
weight: 3.820 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-25.
****

GSC sample number: C-149777
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-26
latitude, longitude: 51°17'50.6", 121°54'28.1"
UTM: Zone 10: 576150 m E., 5683250 m N.

geographic description: Jesmond access road
stratigraphic description: at 47.5 m in section 3; bedding about 40 cm thick, attitude 153/29 NE
lithology: pale grey to light brown weathering, crinoidal, medium grey limestone
weight: 2.243 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-149778
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-27
latitude, longitude: 51°17'50.6", 121°54'28.1"
UTM: Zone 10: 576150 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 49 m in section 3, separated stratigraphically from JAR-26 by 1.5 m of non-exposure
lithology: ochre weathering, medium grey limestone with fossil debris
weight: 1.411 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149779
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-28
latitude, longitude: 51°17'50.6", 121°54'28.1"
UTM: Zone 10: 576150 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 52 m in section 3
lithology: pale grey weathering, medium grey, crinoidal limestone; recrystallized but less pronounced than at JAR-25
weight: 1.589 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149780
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-29
latitude, longitude: 51°17'50.6", 121°54'28.1"
UTM: Zone 10: 576150 m E., 5683250 m N.
geographic description: Jesmond access road; elevation 1727 m (5700 ft)
stratigraphic description: at 66 m in section 3, separated by covered interval from JAR-28
lithology: pale grey weathering, medium grey dolomicrite with intraclasts in recrystallized micrite matrix
weight: 1.505 kg
fossils: ichthyoliths (1?)

conodont fauna: *Hindeodus typicalis* (1)
period or epoch: Permian
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-149781
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-30
latitude, longitude: 51°17'50.6", 121°54'28.1"
UTM: Zone 10: 576150 m E., 5683250 m N.
geographic description: Jesmond access road; elevation 1727 m (5700 ft)
stratigraphic description: at 69 m in section 3
lithology: pale grey weathering, medium grey carbonate with up to 20 cm long, angular to subrounded intraclasts
weight: 1.530 kg
fossils: ichthyoliths (1)
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-149782
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-31
latitude, longitude: 51°17'50.6", 121°54'25.5"
UTM: Zone 10: 576200 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 74 m in section 3, separated by covered interval from JAR-30
lithology: medium grey, nodular carbonate weathers brown with shelly fragments
weight: 2.553 kg
fossils: crinoids
conodont fauna: *Iranognathus* ex gr. *nudus* (B:1)
Hindeodus typicalis (1)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157806
field number: J. Beyers, 1987; 87OF-B-JR-31A
weight: 1.780 kg
fossils: crinoids
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-31.
****

GSC sample number: C-149783
field number: J. Beyers, 1986; 86OF-B-SW2-JAR-32
latitude, longitude: 51°17'50.6", 121°54'25.5"
UTM: Zone 10: 576200 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 78.5 m in sction 3

lithology: maroon-grey weathering, bituminous, grey limestone with angular intraclasts
weight: 1.723 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157995
field number: J. Beyers, 1987; 87OF-B-J-I
latitude, longitude: 51°17'50.6", 121°54'25.5"
UTM: Zone 10: 576200 m E., 5683250 m N.
geographic description: Jesmond access road
stratigraphic description: at 84 m of 84 m section 3
lithology: dolomitic, nodular, recrystallized micrite
weight: 4.950 kg
fossils: crinoids (2-holed), sea urchin spines (1)
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform elements (1)
period or epoch: Permian
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-149784
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-33
latitude, longitude: 51°17'55.4", 121°54'17.6"
UTM: Zone 10: 576350 m E., 5683400 m N.
geographic description: Jesmond access road, about 15 m above road
lithology: pale weathering, light grey, crinoidal limestone
weight: 2.054 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149785
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-34
latitude, longitude: 51°17'56.2", 121°54'21.5"
UTM: Zone 10: 576275 m E., 5683425 m N.
geographic description: Jesmond access road; elevation 1800 m (5940 ft)
stratigraphic description: at 14.5 m in section 4 which starts beyond the third switchback (4.36 km from turnoff onto lookout road) and leads to flat area below Jesmond fire lookout
lithology: medium grey, fissile carbonate
weight: 1.438 kg
fossils: sphaeromorph
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149786
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-35
latitude, longitude: 51°17'56.2", 121°54'21.5"
UTM: Zone 10: 576275 m E., 5683425 m N.
geographic description: Jesmond access road
stratigraphic description: at 13 m in section 4
lithology: medium grey, fissile carbonate
weight: 1.662 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (3)
ramiform elements (8)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157804
field number: J. Beyers, 1987; 87OF-B-JR-35A
weight: 1.820 kg
fossils: none
conodont fauna: ramiform elements (4)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-35.
****

GSC sample number: C-157805
field number: J. Beyers, 1987; 87OF-B-JR-35B
latitude, longitude: 51°17'56.2", 121°54'21.5"
UTM: Zone 10: 576275 m E., 5683425 m N.
geographic description: Jesmond access road
stratigraphic description: at 12.5 m in section 4
lithology: medium grey, fissile carbonate
weight: 4.220 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149787
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-36
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 11.5 m in section 4
lithology: pale weathering, light grey, fissile carbonate
weight: 2.241 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (3)
ramiform elements (41)
period or epoch: Early Triassic
age: Spathian

conodont assemblage: Fauna 6
****
GSC sample number: C-157803
field number: J. Beyers, 1987; 87OF-B-JR-36A
weight: 15.000 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-36.
****
GSC sample number: C-149788
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-37
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 9 m in section 4; bedding attitude 139/14NE
lithology: pale grey weathering, medium grey, crinoidal, fine grained carbonate
weight: 1.658 kg
fossils: none
conodont fauna: fragment indet. (1)
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-149789
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-38
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 10 m in section 4; beds up to 90 cm thick
lithology: light grey, fine grained, recrystallized limestone, crinoidal towards top of bed
weight: 2.069 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-149790
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-39
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 9.5 m in section 4; beds 40-90 cm thick, attitude 135/10 NE
lithology: light grey, fine grained, recrystallized limestone, crinoidal towards top of bed
weight: 2.318 kg
fossils: none
conodont fauna: none

period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149791
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-40
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 8 m in section 4; beds 18 cm thick, slickensided with drusy calcite mineralization
lithology: medium grey carbonate
weight: 1.901 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (Sa:1)
ramiform elements (7)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-149792
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-41
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 6.5 m in section 4; bedding attitude 141/09 NE
lithology: light brown weathering, light grey, recrystallized limestone with thin calcite veining
weight: 1.923 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149793
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-42
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road; elevation 1773 m (5850 ft)
stratigraphic description: at 5 m in section 4; beds 15-20 cm thick, attitude 140/19 NE
lithology: medium grey carbonate with micrite nodules or clasts up to 12x6 cm in size, but mostly small
weight: 2.017 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149794
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-43

latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 5 m in section 4
lithology: dark, lumpy carbonate, sheared on exposure plane
weight: 1.609 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (1)
ramiform elements (2)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
remarks: A narrow fault zone is located between JAR-43 and 44, with attitude 090/80 S.
****

GSC sample number: C-149795
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-44
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road; elevation 1788 m (5900 ft)
stratigraphic description: at 6.5 m in section 4; bedding attitude 165/19 NE
lithology: pale weathering, light grey, fine grained, recrystallized carbonate with calcite-filled veins
weight: 1.385 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149796
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-45
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road; elevation 1788 m (5900 ft)
stratigraphic description: at 5 m in section 4; bedding attitude 172/13 NE
lithology: medium grey, thin-bedded, crinoidal carbonate
weight: 1.305 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (2)
ramiform elements (12)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157802
field number: J. Beyers, 1987; 87OF-B-JR-45A
weight: 6.200 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate

age: indeterminate
remarks: Recollection of JAR-45.
****

GSC sample number: C-149797
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-46
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road; elevation 1788 m (5900 ft)
stratigraphic description: at 5 m in section 4; beds up to 20 cm thick, attitude 172/11 NE
lithology: pale brown weathering, pale grey, very recrystallized carbonate
weight: 1.588 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (1)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-149798
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-47
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 4
lithology: brownish-green weathering, pale grey carbonate with numerous small micrite nodules
weight: 1.275 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149799
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-48
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 5 m in section 4; beds 15 cm thick, attitude 140/09 NE
lithology: light grey, fine grained, recrystallized carbonate
weight: 1.728 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (4)
ramiform elements (9+)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157801
field number: J. Beyers, 1987; 87OF-B-JR-48A

weight: 7.200 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-48.
****

GSC sample number: C-149800
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-49
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 4; beds about 10 cm thick
lithology: brown weathering, friable, nodular limestone
weight: 1.628 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149801
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-50
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 4
lithology: medium grey, nodular limestone
weight: 1.609 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149802
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-51
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 3.5 m in section 4
lithology: ochre weathering, Mn-stained, fine grained, medium grey carbonate with some recrystallization and thin calcite veins
weight: 1.639 kg
fossils: ichthyoliths (1)
conodont fauna: *Pachycladina obliqua* (Sc:1)
ramiform elements (2)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157250

field number: J. Beyers, 1987; 87OF-B-JR-51A
weight: 6.000 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-51.
****

GSC sample number: C-149803
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-52A
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 2 m in section 4; bedding attitude 152/11 NE
lithology: medium grey carbonate with dark grey micrite nodules
weight: 1.974 kg
fossils: ichthyoliths (1)
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149804
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-52B
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 2 m in section 4
lithology: ochre weathering, bituminous, slickensided micrite
weight: 1.812 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149805
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-53
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 2.5 m in section 4; beds 12 cm thick
lithology: medium grey, recrystallized and calcite-veined limestone
weight: 2.630 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149806
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-54
latitude, longitude: 51°17'57.9", 121°54'25.3"

UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 2.5 m in section 4
lithology: medium grey, recrystallized limestone with pitted surface
weight: 1.702 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149807
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-55
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4
lithology: fine grained, highly recrystallized carbonate with 2 mm wide veins and small micrite nodules
weight: 1.704 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149808
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-56
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4
lithology: red ochre weathering, fine grained, recrystallized carbonate
weight: 1.841 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149809
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-57
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road; elevation 1818 m (6000 ft)
stratigraphic description: at 1 m in section 4; beds about 10 cm thick
lithology: light grey, slightly bituminous limestone
weight: 1.258 kg
fossils: ichthyoliths (1)
conodont fauna: ramiform elements (6)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149810
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-58
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 0 m in section 4
lithology: ochre weathering micrite
weight: 1.476 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149811
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-59
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1 m in section 4
lithology: ochre weathering, medium grey, recrystallized, fine grained carbonate
weight: 1.124 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149812
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-60
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1 m in section 4; bedding attitude 140/09 NE
lithology: ochre weathering, medium grey, fine grained carbonate
weight: 1.365 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (Sa:1)
ramiform elements (50)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157849
field number: J. Beyers, 1987; 87OF-B-JR-60A
weight: 7.400 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-60.
****

GSC sample number: C-149813
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-61
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4
lithology: grey to light brown weathering, recrystallized, nodular micrite
weight: 1.543 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149814
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-62
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4; bedding attitude 161/04 NE
lithology: light grey, fine grained, recrystallized, dolomitic carbonate with calcite encrustations
weight: 1.744 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149815
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-63
latitude, longitude: 51°17'57.9", 121°54'25.3"
UTM: Zone 10: 576200 m E., 5683475 m N.
geographic description: Jesmond access road
stratigraphic description: at 1 m in section 4; bedding attitude 146/06 NE
lithology: dark grey to green weathering dolomite
weight: 1.314 kg
fossils: none
conodont fauna: *Furnishius? triserratus* (1)
Pachycladina n.sp. (1)
ramiform elements (2)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157248
field number: J. Beyers, 1987; 87OF-B-JR-63A
weight: 6.500 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

remarks: Recollection of JAR-63.
****

GSC sample number: C-149816
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-64
latitude, longitude: 51°17'58.7", 121°54'27.9"
UTM: Zone 10: 576150 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 2.5 m in section 4
lithology: medium grey, grainy, nodular biomicrite with grooved and pitted surface
weight: 1.226 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (2)
ramiform elements (15)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157247
field number: J. Beyers, 1987; 87OF-B-JR-64A
weight: 7.000 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (2)
ramiform elements (4)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
remarks: Thin section cut. Recollection of JAR-64.
****

GSC sample number: C-149817
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-65
latitude, longitude: 51°17'58.7", 121°54'27.9"
UTM: Zone 10: 576150 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 3 m in section 4; beds 10-20 cm thick, attitude 161/09 NE
lithology: light grey, fine grained carbonate
weight: 1.628 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149818
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-66
latitude, longitude: 51°17'58.7", 121°54'27.9"
UTM: Zone 10: 576150 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 2.5 m in section 4
lithology: dark grey to green weathering, fine grained carbonate

weight: 1.304 kg
fossils: none
conodont fauna: ramiform elements (14)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149819
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-67
latitude, longitude: 51°17'58.7", 121°54'27.9"
UTM: Zone 10: 576150 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 3 m in section 4; bedding attitude 157/03 NE
lithology: medium grey, coarsely recrystallized, drusy, nodular, and dolomitic limestone
weight: 1.552 kg
fossils: none
conodont fauna: ramiform elements (4)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149820
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-68
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 3 m in section 4
lithology: medium grey, nodular, dolomitic limestone
weight: 1.744 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149821
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-69
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road; elevation 1821 m (6010 ft)
stratigraphic description: at 3.5 m in section 4
lithology: pale to medium grey weathering, medium grey, very fine grained, lightly recrystallized, dolomitic limestone with calcite veins less than 1 mm thick
weight: 1.591 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149822
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-70
latitude, longitude: 51°17'58.8", 121°54'31.8"

UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 4.5 m in section 4; beds greater than 20 cm thick, attitude 152/13 NE
lithology: pale grey weathering, medium grey carbonate, with 2 mm wide calcite veins
weight: 1.816 kg
fossils: none
conodont fauna: *Lonchodina nevadensis* (1)
ramiform elements (18)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157246
field number: J. Beyers, 1987; 87OF-B-JR-70A
weight: 20.000 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-70.
****

GSC sample number: C-149823
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-71
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 4 m in section 4; bedding attitude 146/04 NE
lithology: pale weathering, medium grey, fine grained, recrystallized carbonate
weight: 1.248 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (1)
ramiform elements (9)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-149824
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-72
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 4 m in section 4; bedding attitude 163/10 NE
lithology: light brown weathering, light grey, nodular and slightly recrystallized limestone
weight: 1.424 kg
fossils: ichthyoliths (1)
conodont fauna: ramiform elements (24)
period or epoch: indeterminate

age: indeterminate
****

GSC sample number: C-157245
field number: J. Beyers, 1987; 87OF-B-JR-72A
weight: 8.200 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (3)
ramiform elements (13)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
remarks: Recollection of JAR-72.
****

GSC sample number: C-149825
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-73
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 2 m in section 4
lithology: light brown weathering, light grey, nodular, slightly recrystallized limestone
weight: 1.341 kg
fossils: ichthyoliths (1)
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149826
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-74
latitude, longitude: 51°17'58.8", 121°54'31.8"
UTM: Zone 10: 576075 m E., 5683500 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4; bedding attitude 163/22 NE
lithology: ochre weathering, light grey, shaly, coarsely recrystallized limestone with carbonate encrustation
weight: 1.704 kg
fossils: ichthyoliths (7)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149827
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-75
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 1.75 m in section 4; beds 10+ cm thick, attitude 143/03 NE
lithology: ochre weathering, medium to dark grey, shaly, dolomitic limestone
weight: 1.581 kg

fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149828
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-76
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 1 m in section 4; beds about 5 cm thick, attitude 149/03 NE
lithology: light brown to rusty pink weathering, light grey, recrystallized, nodular limestone
weight: 1.141 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149829
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-77
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 0 m in section 4; bedding attitude 144/02 NE
lithology: pale weathering, crumbly, thin bedded, grey micrite
weight: 1.393 kg
fossils: ichthyoliths (5)
conodont fauna: fragment indet. (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149830
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-78
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 5.5 m in section 4
lithology: pale weathering, grey carbonate with micrite nodules
weight: 1.539 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149831
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-79
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.

geographic description: Jesmond access road
stratigraphic description: at 8 m in section 4
lithology: orange-brown weathering, light grey, fine grained, recrystallized carbonate
weight: 1.478 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (4)
ramiform elements (54)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157244
field number: J. Beyers, 1987; 87OF-B-JR-79A
weight: 4.120 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (2)
ramiform elements (24)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
remarks: Recollection of JAR-79.
****

GSC sample number: C-149832
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-80
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 8 m in section 4
lithology: pale weathering, light grey, recrystallized carbonate
weight: 1.770 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (Sb:1)
ramiform elements (169)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157243
field number: J. Beyers, 1987; 87OF-B-JR-80A
weight: 7.210 kg
fossils: none
conodont fauna: ramiform elements (21)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-80.
****

GSC sample number: C-149833
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-81
latitude, longitude: 51°18'00.4", 121°54'33.0"

UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 7 m in section 4; from outcrop level with road
lithology: pale grey weathering, medium grey, recrystallized, dolomitic carbonate
weight: 1.184 kg
fossils: none
conodont fauna: fragment indet. (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149834
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-82
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road
stratigraphic description: at 9 m in section 4
lithology: light brown weathering, medium grey, calcite-encrusted, recrystallized limestone
weight: 1.726 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (3)
ramiform elements (19)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-149835
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-83
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road; elevation 1833 m (6050 ft)
stratigraphic description: at 9 m in section 4; beds about 2 cm thick, attitude 142/04 NE
lithology: light to medium grey, recrystallized, dolomitic carbonate
weight: 1.752 kg
fossils: ichthyoliths (1)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149836
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-84
latitude, longitude: 51°18'00.4", 121°54'33.0"
UTM: Zone 10: 576050 m E., 5683550 m N.
geographic description: Jesmond access road; elevation 1833 m (6050 ft)
stratigraphic description: at 9 m in section 4; beds about 2 cm thick, attitude 136/19 NE
lithology: light brown weathering, fissile, flaggy, pale grey carbonate
weight: 1.391 kg
fossils: ichthyoliths (2)

conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: This sample corresponds to MJO's JLO5.
****

GSC sample number: C-149837
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-85
latitude, longitude: 51°18'02.1", 121°54'36.8"
UTM: Zone 10: 575975 m E., 5683600 m N.
geographic description: Jesmond access road
stratigraphic description: at 9 m in section 4; beds 20 cm thick
lithology: fractured, medium grey, fine grained, dolomitic limestone
weight: 1.759 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149838
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-86
latitude, longitude: 51°18'02.1", 121°54'36.8"
UTM: Zone 10: 575975 m E., 5683600 m N.
geographic description: Jesmond access road
stratigraphic description: at 9 m in section 4; beds about 1 cm thick, attitude 144/03 NE
lithology: pale weathering, medium grey, fine grained, nodular, flaggy and dolomitic limestone; nodules become abundant toward top of bed
weight: 1.764 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149839
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-87
latitude, longitude: 51°18'02.1", 121°54'36.8"
UTM: Zone 10: 575975 m E., 5683600 m N.
geographic description: Jesmond access road
stratigraphic description: at 10.5 m in section 4
lithology: pale weathering, medium grey, fine grained dolomitic limestone
weight: 2.166 kg
fossils: none
conodont fauna: *Neospathodus triangularis* (1)
ramiform elements (1)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-149840
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-88

latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road
stratigraphic description: at 9 m in section 4; bedding attitude 160/31 NE
lithology: pale to ochre weathering, dark grey, dolomitic and nodular limestone
weight: 2.221 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (3)
ramiform elements (29)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157242
field number: J. Beyers, 1987; 87OF-B-JR-88A
weight: 7.600 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-88.
****

GSC sample number: C-149841
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-89
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road
stratigraphic description: at 9.5 m in section 4
lithology: medium brown weathering, medium grey, somewhat nodular limestone
weight: 1.850 kg
fossils: none
conodont fauna: ramiform elements (8+)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149842
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-90
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road; elevation 1835 m (6055 ft)
stratigraphic description: at 10 m in section 4
lithology: ochre weathering, medium grey, recrystallized, ?crinoidal limestone
weight: 2064 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (2)
ramiform elements (2)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-149843
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-91
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road; elevation 1838 m (6065 ft)
stratigraphic description: at 9.5 m in section 4; bedding attitude 148/03 NE
lithology: light grey to orange weathering, recrystallized, fine grained limestone with thin 1 mm calcite veins
weight: 1.765 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149844
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-92
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road; elevation 1835 m (6055 ft)
stratigraphic description: at 6 m in section 4; bedding attitude 158/12 NE
lithology: pale weathering, medium grey, fine grained, recrystallized carbonate
weight: 1.607 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149845
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-93
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road; elevation 1836 m (6060 ft)
stratigraphic description: at 5.5 m in section 4; bedding attitude 166/04 NE
lithology: pale weathering, medium grey, somewhat nodular, dolomitic and recrystallized limestone
weight: 1.637 kg
fossils: ichthyoliths (2)
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149846
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-94
latitude, longitude: 51°18'03.7", 121°54'39.4"
UTM: Zone 10: 575925 m E., 5683650 m N.
geographic description: Jesmond access road; elevation 1836 m (6060 ft)
stratigraphic description: at 7 m in section 4
lithology: grey weathering, coarsely recrystallized, light to medium grey, sheet-like limestone with stylolites and compositional (algal?) banding
weight: 2.123 kg

fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149847
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-95
latitude, longitude: 51°18'04.5", 121°54'41.9"
UTM: Zone 10: 575875 m E., 5683675 m N.
geographic description: Jesmond access road; elevation 1840 m (6070 ft)
stratigraphic description: at 1 m in section 4
lithology: medium grey, finely recrystallized limestone with dendritic Mn stain
weight: 1.823 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149848
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-96
latitude, longitude: 51°18'07.0", 121°54'44.5"
UTM: Zone 10: 575825 m E., 5683750 m N.
geographic description: Jesmond access road; elevation 1842 m (6080 ft)
stratigraphic description: at 3 m in section 4
lithology: pale weathering, light grey, finely recrystallized limestone with Mn stain
weight: 2.311 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149849
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-97
latitude, longitude: 51°18'07.0", 121°54'44.5"
UTM: Zone 10: 575825 m E., 5683750 m N.
geographic description: Jesmond access road; elevation 1852 m (6110 ft)
stratigraphic description: at 4.5 m in section 4; attitude of laminations 174/06 NE
lithology: light grey, recrystallized, algal-laminated limestone with rip-up clasts; laminations are flat and most pronounced towards top of the bed
weight: 1.699 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-149850
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-98

latitude, longitude: 51°18'07.0", 121°54'44.5"
UTM: Zone 10: 575825 m E., 5683750 m N.
geographic description: Jesmond access road; elevation 1856 m (6125 ft)
stratigraphic description: at 11 m in section 4; algal laminations from less than 1 mm to 3 mm thick, attitude 180/06 E
lithology: pale grey weathering, light grey, finely recrystallized, algal-laminated limestone with Mn stain; laminations are wavy but become discontinuous towards top of the bed
weight: 1.880 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149851
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-99
latitude, longitude: 51°18'09.4", 121°54'47.0"
UTM: Zone 10: 575775 m E., 5683825 m N.
geographic description: Jesmond access road; elevation 1860 m (6140 ft)
stratigraphic description: at 24.5 m in section 4
lithology: grey-ochre weathering, recrystallized carbonate; lower part is algal-laminated
weight: 1.881 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149952
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-100
latitude, longitude: 51°18'09.4", 121°54'47.0"
UTM: Zone 10: 575775 m E., 5683825 m N.
geographic description: Jesmond access road; elevation 1864 m (6150 ft)
stratigraphic description: at 28.5 m in section 4
lithology: massive, light grey, fine grained, Mn-stained, recrystallized carbonate
weight: 1.937 kg
fossils: none
conodont fauna: *Neospathodus homeri* (1)
ramiform elements (8)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-149853
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-101
latitude, longitude: 51°18'09.4", 121°54'47.0"
UTM: Zone 10: 575775 m E., 5683825 m N.
geographic description: Jesmond access road; elevation 1870 m (6170 ft)
stratigraphic description: at 36.5 m in section 4; bedding attitude 168/07 NE
lithology: ochre weathering, recrystallized, light grey carbonate, with Mn dendritic

stain and slickensided surface; algal-laminated and recrystallized
weight: 2.101 kg
fossils: none
conodont fauna: *Neospathodus homeri* (1)
ramiform elements (1)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157241
field number: J. Beyers, 1987; 87OF-B-JR-101A
weight: 8.200 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-101.
****

GSC sample number: C-157240
field number: J. Beyers, 1987; 87OF-B-J-T8
latitude, longitude: 51°18'11.1", 121°54'46.9"
UTM: Zone 10: 575775 m E., 5683875 m N.
geographic description: Jesmond access road
stratigraphic description: at 41.5 m in section 4
lithology: recrystallized micrite clasts in sparry dolomitic matrix
weight: 3.202 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157239
field number: J. Beyers, 1987; 87OF-B-J-T7
latitude, longitude: 51°18'11.1", 121°54'46.9"
UTM: Zone 10: 575775 m E., 5683875 m N.
geographic description: Jesmond access road
stratigraphic description: at 46.5 m in section 4
lithology: grey micrite
weight: 2.136 kg
fossils: none
conodont fauna: *Neospathodus triangularis* (1)
ramiform elements (3)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157238
field number: J. Beyers, 1987; 87OF-B-J-T6
latitude, longitude: 51°18'11.1", 121°54'46.9"

UTM: Zone 10: 575775 m E., 5683875 m N.
geographic description: Jesmond access road
stratigraphic description: at 51.5 m in section 4
lithology: grey micrite
weight: 3.092 kg
fossils: ichthyoliths (1)
conodont fauna: *Neospathodus homeri* (2)
Neospathodus triangularis (1+1?)
Neospathodus sp. indet. (1)
ramiform elements (10)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-149954
field number: J. Beyers, 1986; 86OF-B-SW3-JAR-102
latitude, longitude: 51°18'11.9", 121°54'48.2"
UTM: Zone 10: 575750 m E., 5683900 m N.
geographic description: Jesmond access road; elevation 1876 m (6190 ft)
stratigraphic description: at 56.5 m in section 4; bedding attitude 170/06 NE
lithology: ?algal-laminated, medium grey, dolomitized limestone
weight: 1.992 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157237
field number: J. Beyers, 1987; 87OF-B-J-T5
latitude, longitude: 51°18'11.9", 121°54'48.2"
UTM: Zone 10: 575750 m E., 5683900 m N.
geographic description: Jesmond access road
stratigraphic description: at 64 m in section 4
lithology: grey micrite
weight: 2.018 kg
fossils: none
conodont fauna: *Neospathodus triangularis* (2)
ramiform elements (11)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157236
field number: J. Beyers, 1987; 87OF-B-J-T4
latitude, longitude: 51°18'16.7", 121°54'46.8"
UTM: Zone 10: 575775 m E., 5684050 m N.
geographic description: Jesmond access road
stratigraphic description: at 70 m in section 4
lithology: very fine grained micrite with algal laminations
weight: 2.499 kg

fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157235
field number: J. Beyers, 1987; 87OF-B-J-T3
latitude, longitude: 51°18'16.7", 121°54'46.8"
UTM: Zone 10: 575775 m E., 5684050 m N.
geographic description: Jesmond access road
stratigraphic description: at 75 m in section 4
lithology: dark grey, recrystallized and dolomitized micrite with stylolites
weight: 4.001 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C157234
field number: J. Beyers, 1987; 87OF-B-J-T2
latitude, longitude: 51°18'16.7", 121°54'46.8"
UTM: Zone 10: 575775 m E., 5684050 m N.
geographic description: Jesmond access road
stratigraphic description: at 80 m in section 4
lithology: fine grained micrite
weight: 4.689 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157233
field number: J. Beyers, 1987; 87OF-B-J-T1
latitude, longitude: 51°18'16.7", 121°54'46.8"
UTM: Zone 10: 575775 m E., 5684050 m N.
geographic description: Jesmond access road, at first outcrop below flat area, elevation 1924 m (6350 ft)
stratigraphic description: at 85 m (top) in section 4; bedding attitude 172/07 E
lithology: grey, stylolitic micrite
weight: 3.359 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149955
field number: J. Beyers, 1986; 86OF-B-FA-JAR-103
latitude, longitude: 51°18'27.8", 121°54'55.6"
UTM: Zone 10: 575600 m E., 5684390 m N.

geographic description: Jesmond access road, above flat area; elevation 1924 m (6350 ft)
lithology: pale weathering, light to medium grey carbonate with micrite nodules and calcite pods
weight: 1.992 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157232
field number: J. Beyers, 1987; 87OF-B-JR-103A
weight: 8.110 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-103.
****

GSC sample number: C-149956
field number: J. Beyers, 1986; 86OF-B-FA-JAR-104
latitude, longitude: 51°18'29.0", 121°55'03.3"
UTM: Zone 10: 575450 m E., 5684425 m N.
geographic description: Jesmond access road beyond flat area; elevation 1935 m (6385 ft)
lithology: pale grey weathering, medium grey limestone
weight: 1.994 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149957
field number: J. Beyers, 1986; 86OF-B-FA-JAR-105
latitude, longitude: 51°18'29.8", 121°54'58.1"
UTM: Zone 10: 575550 m E., 5684450 m N.
geographic description: Jesmond access road; elevation 1950 m (6435 ft)
lithology: pale weathering, medium grey, fine grained, limestone with subangular 3-6 mm nodules or clasts that occur mostly in a 1.5 cm wide band
weight: 2.100 kg
fossils: none
conodont fauna: ramiform elements (1+)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: none
field number: J. Beyers, 1986; 86OF-B-FA-JAR-106
latitude, longitude: 51°18'29.8", 121°54'58.1"
UTM: Zone 10: 575550 m E., 5684450 m N.
geographic description: Jesmond access road, below fire lookout

stratigraphic description: bedding attitude 131/13 NE
lithology: from dark grey outcrop with 1-2 mm calcite veins; yellow-red, very fine grained, dolomitic carbonate layers, 3-12 cm thick, occur parallel to bedding above algal-laminated micrite
weight: unknown
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Hand specimen only.
****

GSC sample number: C-149958
field number: J. Beyers, 1986; 86OF-B-FA-JAR-107
latitude, longitude: 51°18'31.4", 121°54'59.4"
UTM: Zone 10: 575525 m E., 5684500 m N.
geographic description: Jesmond access road; elevation 1956 m (6455 ft)
lithology: from dark grey bluff of coarsely recrystallized, dark grey carbonate
weight: 2.023 kg
fossils: none
conodont fauna: ramiform elements (20+)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157231
field number: J. Beyers, 1987; 87OF-B-FA-JAR-107A
weight: 10.200 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JAR-107.
****

GSC sample number: C-149959
field number: J. Beyers, 1986; 86OF-B-JFT-1
latitude, longitude: 51°18'33.8", 121°55'06.0"
UTM: Zone 10: 575500 m E., 5684575 m N.
geographic description: Jesmond fire lookout; bearing 346° to tower; elevation 1955 m (6450 ft)
stratigraphic description: bedding attitude 060/12 SE just E of this locality
lithology: from bluff; dark grey recrystallized carbonate with calcite pods and veins
weight: 1.886 kg
fossils: ichthyoliths (2), crinoids
conodont fauna: *Neospathodus homeri* (2)
ramiform elements (2)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157227

field number: J. Beyers, 1987; 87OF-B-JFT-1A
weight: 9.200 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JFT-1.
****

GSC sample number: C-149960
field number: J. Beyers, 1986; 86OF-B-JFT-2
latitude, longitude: 51°18'34.7", 121°55'01.9"
UTM: Zone 10: 575475 m E., 5684600 m N.
geographic description: Jesmond fire lookout; bearing to lookout 161°; elevation 1915 m (6320 ft)
lithology: from bluff; grey weathering, Mn stained, medium grey, dolomitic carbonate
weight: 1.855 kg
fossils: none
conodont fauna: *Neospathodus homeri* (2)
Neospathodus triangularis (1?)
ramiform elements (3)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157228
field number: J. Beyers, 1987; 87OF-B-JFT-2A
weight: 12.100 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JFT-2.
****

GSC sample number: C-149961
field number: J. Beyers, 1986; 86OF-B-JFT-3
latitude, longitude: 51°18'37.1", 121°55'01.8"
UTM: Zone 10: 575475 m E., 5684675 m N.
geographic description: Jesmond fire lookout; elevation 1909 m (6300 ft)
stratigraphic description: bedding attitude 060/18 SE
lithology: from bluff; medium grey weathering, fine grained, light grey, recrystallized carbonate
weight: 1.963 kg
fossils: ichthyoliths (1)
conodont fauna: *Neospathodus homeri* (1)
ramiform elements (11+)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-157229
field number: J. Beyers, 1987; 87OF-B-JFT-3B
weight: 5.000 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JFT-3.
****

GSC sample number: C-149962
field number: J. Beyers, 1986; 86OF-B-JFT-4
latitude, longitude: 51°18'31.4", 121°54'56.8"
UTM: Zone 10: 575575 m E., 5684500 m N.
geographic description: Jesmond fire lookout; bearing 137° to lookout; elevation 1955 m (6450 ft)
lithology: grey weathering, dark grey, coarsely recrystallized limestone
weight: 1.720 kg
fossils: none
conodont fauna: fragment indet. (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157230
field number: J. Beyers, 1987; 87OF-B-JFT-4A
weight: 7.010 kg
fossils: ichthyoliths (1)
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of JFT-4.
****

GSC sample number: C-149963
field number: J. Beyers, 1986; 86OF-B-JFT-5
latitude, longitude: 51°18'31.4", 121°54'56.8"
UTM: Zone 10: 575575 m E., 5684500 m N.
geographic description: Jesmond fire lookout; elevation 1958 m (6460 ft)
lithology: light grey weathering, with highly pitted surface, dark grey recrystallized carbonate
weight: 1.960 kg
fossils: none
conodont fauna: *Neospathodus triangularis* (1)
ramiform elements (15)
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-149964
field number: J. Beyers, 1986; 87OF-B-JFT-6
latitude, longitude: 51°18'31.4", 121°55'02.0"
UTM: Zone 10: 575475 m E., 5684500 m N.

geographic description: Jesmond fire lookout; bearing 019° to lookout
lithology: light grey, recrystallized limestone
weight: 1.753 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157808
field number: J. Beyers, 1987; 87OF-B-J-B1
latitude, longitude: 51°17'44.5", 121°54'59.2"
UTM: Zone 10: 575550 m E., 5683050 m N.
geographic description: 1.85 km SW of third switchback along Jesmond access road, 2.5 km from turnoff onto lookout road
stratigraphic description: bedding 20 cm thick, attitude 111/62 NE; bedding plane defined by siliceous nodules and compositional banding
lithology: siliceous, dark grey limestone
weight: 3.210 kg
fossils: ichthyoliths (1)
conodont fauna: *Neogondolella subcarinata subcarinata* (2+1?)
Neogondolella orientalis (1)
Neogondolella n.sp. *A* (3)
Iranognathus ex gr. *nudus* (A:12+3?, C:2)
Iranognathus n.sp. *A* (1)
Iranognathus sp. indet. (2)
Hindeodus typicalis (4)
ramiform elements (37)
period or epoch: Late Permian
age: early-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157809
field number: J. Beyers, 1987; 87OF-B-J-B2
latitude, longitude: 51°17'44.5", 121°54'59.2"
UTM: Zone 10: 575550 m E., 5683050 m N.
geographic description: 1.85 km SW of third switchback along Jesmond access road, 2.5 km from turnoff onto lookout road
stratigraphic description: beds 20 cm thick, attitude 111/62 NE; 10 m stratigraphically below J-B1
lithology: recrystallized, dark grey, partially dolomitized limestone
weight: 3.090 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. 50 m to SW of this outcrop bedding attitude changes to 065/16 NW.
****

GSC sample number: C-157815
field number: J. Beyers, 1987; 87OF-B-JCk-1

latitude, longitude: 51°16'13.4", 121°54'14.9"
UTM: Zone 10: 576450 m E., 5680250 m N.
geographic description: on hillside N of Jesmond Creek and W of major north-south gully; elevation 1485 m (4900 ft)
lithology: medium grey, crinoidal, dolomitized and brecciated limestone
weight: 4.636 kg
fossils: ichthyoliths (5)
conodont fauna: *Neogondolella orientalis* (1+1?)
Neogondolella sp. cf. *N. orientalis* (2)
Neogondolella n.sp. *A* (20)
Neogondolella sp. indet. (4)
Iranognathus ex gr. *nudus* (A:2?, C:4)
Hindeodus typicalis (10)
ramiform elements (39)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Thin section cut.
****

GSC sample number: C-157816
field number: J. Beyers, 1987; 87OF-B-JCk-2
latitude, longitude: 51°16'06.0", 121°54'26.8"
UTM: Zone 10: 576225 m E., 5679850 m N.
geographic description: on hillside N of Jesmond Creek and W of major north-south gully; elevation 1460 m (4820 ft)
lithology: silicified, light grey, fine grained, recrystallized micrite
weight: 3.934 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform elements (6)
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157817
field number: J. Beyers, 1987; 87OF-B-JCk-3
latitude, longitude: 51°15'57.4", 121°54'37.5"
UTM: Zone 10: 576020 m E., 5679750 m N.
geographic description: hillside N of Jesmond Creek, just W of JCk-2; elevation 1454 m (4800 ft)
stratigraphic description: bedding attitude 154/ 26 NE
lithology: secondary chert nodules replace dark grey, crinoidal micrite
weight: 1.440 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Chert nodules were also run for conodonts (barren). Thin section cut.
****

GSC sample number: C-157818

field number: J. Beyers, 1987; 87OF-B-BIGBARCK-1
latitude, longitude: 51°18'11.8", 121°59'07.7"
UTM: Zone 10: 570725 m E., 5683825 m N.
geographic description: 30 m N of where Big Bar Creek crosses Jesmond road, on W side of road
stratigraphic description: bedding attitude 010/06 NW
lithology: medium grey, fine grained, siliceous limestone
weight: 7.169 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157819
field number: J. Beyers, 1987; 87OF-B-BIGBARCK-2
latitude, longitude: 51°18'11.8", 121°59'07.7"
UTM: Zone 10: 570725 m E., 5683825 m N.
geographic description: 30 m N of where Big Bar Creek crosses Jesmond road, on W side of road
stratigraphic description: 4 m above BIGBARCK-1 bedding attitude 010/06 NW
lithology: medium grey, fine grained, siliceous limestone
weight: 3.936 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-118492
field number: M.J. Orchard, 1984; 84MJO-JLO1
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: at lookout, S side
lithology: thin limestone with gastropods
weight: 4.536 kg
fossils: none
conodont fauna: ramiform elements
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-118493
field number: M.J. Orchard, 1984; 84MJO-JLO2
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: Jesmond lookout access road above third switchback
stratigraphic description: about 30-40 m below JLO1
lithology: carbonate
weight: 9.072 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
ramiform elements (approx. 30)

period or epoch: Early Triassic
age: indeterminate
****

GSC sample number: C-118494
field number: M.J. Orchard, 1984; 84MJO-JLO3
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: 0.6 km from lookout
lithology: finely laminated limestone with shelly fragments
weight: 4.082 kg
fossils: ichthyoliths
conodont fauna: *Neospathodus homeri*
Neospathodus triangularis
ramiform elements
period or epoch: Early Triassic
age: Spathian
conodont assemblage: Fauna 6
****

GSC sample number: C-118495
field number: M.J. Orchard, 1984; 84MJO-JLO5
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: 1 km from lookout
lithology: thin (1-2 cm) marly beds for 1 m overlain by 2-5 cm beds of limier composition; composite at contact
weight: 4.762 kg
fossils: ichthyoliths
conodont fauna: ramiform elements
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-118496
field number: M.J. Orchard, 1984; 84MJO-JLO6
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: 1.8 km from lookout
lithology: dark limestone with calcite 'tubes'
weight: 5.273 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Corresponds to JFA4 of 1981.
****

GSC sample number: C-118497
field number: M.J. Orchard, 1984; 84MJO-JLO7
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: 2.1 km from lookout
lithology: crinoidal, bituminous limestone

weight: 17.917 kg
fossils: none
conodont fauna: *Iranognathus* ex gr. *nudus* (A, C?)
Hindeodus typicalis
ramiform elements
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Corresponds to JFA5 of 1981.
****

GSC sample number: C-118498
field number: M.J. Orchard, 1984; 84MJO-JLO8
latitude, longitude: 51°18', 121°54'30"
UTM: Zone 10
geographic description: 3.75 km from lookout
lithology: dark, partially silicified limestone interbedded with pale weathering limestone
weight: 4.309 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet.
Iranognathus sp. indet.
Hindeodus typicalis
ramiform elements
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Corresponds to JFA7 of 1981.
****

B. CENTRAL MARBLE RANGE: NTS 92P/4, BONAPARTE LAKE

GSC sample number: C-117776
field number: M.J. Orchard, 1986; 86OF-CL-1
latitude, longitude: 51°06'12.9", 121°39'56.3"
UTM: Zone 10: 593425 m E., 5661975 m N.
geographic description: lookout access road W of Clinton, 6.5 km from junction with Kelly Lake-Clinton road
stratigraphic description: bedding attitude 172/74 W
lithology: ?bryozons, crinoids, snails, *Yabeina*, *?Glomospira*, ?brachiopods and corals in recrystallized micrite
weight: 6.864 kg
fossils: ichthyoliths (6)
conodont fauna: *Neogondolella phosphoriensis* (7+5?)
period or epoch: Late Permian
age: Guadalupian
conodont assemblage: Fauna 1
remarks: Thin section cut.
****

GSC sample number: C-117777
field number: M.J. Orchard, 1986; 86OF-CL-2
latitude, longitude: 51°06'09.9", 121°40'11.8"
UTM: Zone 10: 593125 m E., 5661875 m N.
geographic description: lookout access road W of Clinton, 7.0 km from junction with Kelly Lake-Clinton road
lithology: calcite-veined carbonate
weight: 6.540 kg
fossils: none
conodont fauna: ramiform elements (8)
period or epoch: Permian
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-117778
field number: M.J. Orchard, 1986; 86OF-CL-3
latitude, longitude: 51°06'03.0", 121°40'45.4"
UTM: Zone 10: 592475 m E., 5661650 m N.
geographic description: lookout access road W of Clinton, 7.7 km from junction with Kelly Lake-Clinton road
lithology: pale grey, finely recrystallized, sparsely crinoidal dolomite
weight: 2.014 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157814
field number: J. Beyers, 1987; 87OF-B-58CK
latitude, longitude: 51°11'26.5", 121°46'43.2"
UTM: Zone 10: 585350 m E., 5671525 m N.
geographic description: logging road between Fiftyseven and Fiftynine creeks
lithology: light brown weathering, medium grey, silicified micrite
weight: 2.822 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157829
field number: J. Beyers, 1987; 87OF-B-MtS-LMST
latitude, longitude: 51°02'43.8", 121°44'20.3"
UTM: Zone 10: 588400 m E., 5655425 m N.
geographic description: Mount Soues, bearing 155° to large microwave tower on Pavilion Mountain and 216° to S end of Kelly Lake, elevation 1788 m (5900 ft)
stratigraphic description: contact with overlying basalt has varying strike 190 to 206°, dip 13° W
lithology: silicified micrite

weight: 3.173 kg
fossils: ichthyoliths (3)
conodont fauna: *Hindeodus typicalis* (2)
Neogondolella sp. indet. (1)
period or epoch: probably Late Permian
age: indeterminate
remarks: C-157828 is basalt sample with field number "J. Beyers, 1987; 87OF-B-MtS-BASALT".
****

GSC sample number: C-157810
field number: J. Beyers, 1987; 87OF-B-NPCK-1
latitude, longitude: 51°06'55.2", 121°51'47.4"
UTM: Zone 10: 579575 m E., 5663050 m N.
geographic description: road N of Porcupine Creek, 14.5 km N of junction of Kelly Lake and Jesmond roads, elevation 1597 m (5270 ft)
stratigraphic description: from bluff talus with source immediately above road
lithology: dark grey, cleaved, fine grained limestone, with flattened and stretched oöliths or pellets
weight: 2.635 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Trettin's (1980) unit #4.
****

GSC sample number: C-157811
field number: J. Beyers, 1987; 87OF-B-NPCK-2
latitude, longitude: 51°06'56.8", 121°51'42.2"
UTM: Zone 10: 579675 m E., 5663100 m N.
geographic description: road N of Porcupine Creek, 14.5 km N of junction of Kelly Lake and Jesmond roads
lithology: dark grey, recrystallized micrite
weight: 3.494 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Trettin's (1980) unit #4.
****

GSC sample number: C-157812
field number: J. Beyers, 1987; 87OF-B-NPCK-3
latitude, longitude: 51°07'33.1", 121°51'41.3"
UTM: Zone 10: 579675 m E., 5664220 m N.
geographic description: road N of Porcupine Creek, 14.5 km N of junction of Kelly Lake and Jesmond roads, 115 m from centre of previous and last bend in road as shown on map, elevation 1742 m (5750 ft)
lithology: pink weathering limestone clasts in sheared, siliceous argillite, alternating with thin calcareous layers
weight: 4.720 kg
fossils: none

conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Trettin's (1980) unit #5.
****

GSC sample number: C-157813
field number: J. Beyers, 1987; 87OF-B-NPCK-4
latitude, longitude: 51°07'25.5", 121°51'00.4"
UTM: Zone 10: 580475 m E., 5664000 m N.
geographic description: road N of Porcupine Creek, 14.5 km N of junction of Kelly Lake and Jesmond roads, elevation 1803 m (5950 ft)
lithology: massive, cleaved, fine grained, recrystallized micrite with siliceous stringers
weight: 4.004 kg
fossils: ichthyoliths (2), ostracodes (2)
conodont fauna: *Epigondolella* sp. indet. (2)
Neogondolella sp. indet. (3)
period or epoch: Late Triassic
age: probably Norian
conodont assemblage: Fauna 9?
remarks: Determinations by M.J. Orchard (1989). The *Neogondolella* elements appear to be older than the *Epigondolella* specimens.
****

GSC sample number: C-157820
field number: J. Beyers, 1987; 87OF-B-PORCCK-1
latitude, longitude: 51°04'17.6", 121°49'19.7"
UTM: Zone 10: 582525 m E., 5658225 m N.
geographic description: 2.9 km from beginning of dirt road which leaves Jesmond road 5.5 km N of its junction with Kelly Lake road (western belt)
stratigraphic description: at 0 m of stratigraphic section, beds from 6 to 10 cm thick, attitude has variable strike 036-048°, dip 19° SE
lithology: pink, light grey, ?dolomitized, recrystallized limestone
weight: 2.865 kg
fossils: none
conodont fauna: *Isarcicella isarcica* (2)
Hindeodus typicalis (3)
ramiform elements (4)
period or epoch: Early Triassic
age: late Griesbachian
conodont assemblage: Fauna 3
****

GSC sample number: C-157821
field number: J. Beyers, 1987; 87OF-B-PORCCK-2
latitude, longitude: 51°04'17.6", 121°49'19.7"
UTM: Zone 10: 582525 m E., 5658225 m N.
geographic description: 2.9 km from beginning of dirt road which leaves Jesmond road 5.5 km N of its junction with Kelly Lake road (western belt)
stratigraphic description: at 1.5 m in section; variable bedding strike 036-048°, dip 19° SE
lithology: medium grey, recrystallized micrite

weight: 2.990 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157822
field number: J. Beyers, 1987; 87OF-B-PORCCK-3
latitude, longitude: 51°04'17.6", 121°49'19.7"
UTM: Zone 10: 582525 m E., 5658225 m N.
geographic description: 2.9 km from beginning of dirt road which leaves Jesmond road 5.5 km N of its junction with Kelly Lake road (western belt)
stratigraphic description: at 6.5 m in section; variable bedding strike 036-048°, dip 19° SE
lithology: medium grey, recrystallized micrite
weight: 3.384 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157823
field number: J. Beyers, 1987; 87OF-B-PORCCK-4
latitude, longitude: 51°04'19.2", 121°49'17.1"
UTM: Zone 10: 582575 m E., 5658275 m N.
geographic description: Porcupine Creek road, at 3.0 km from junction with Jesmond road (western belt)
lithology: limestone block in argillite
weight: 2.621 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157824
field number: J. Beyers, 1987; 87OF-B-PORCCK-5
latitude, longitude: 51°04'26.4", 121°49'06.9"
UTM: Zone 10: 582770 m E., 5658500 m N.
geographic description: Porcupine Creek road, approx. 3.5 km from junction with Jesmond road (western belt), elevation 1479 m (4880 ft)
stratigraphic description: at 25 m in stratigraphic section which consists of a slickensided sequence of siliceous, jointed and folded, argillite and siliceous limestone; bedding contact attitude 129/76 S, jointing attitude 054/06 SE
lithology: siliceous carbonate
weight: 5.224 kg
fossils: none
conodont fauna: *Epigondolella abneptis* (37)
Neogondolella navicula (8)
ramiform elements (9)
period or epoch: Late Triassic

age: early Norian
conodont assemblage: Fauna 9
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157825
field number: J. Beyers, 1987; 87OF-B-PORCCK-6
latitude, longitude: 51°05'01.8", 121°48'48.0"
UTM: Zone 10: 583120 m E., 5659600 m N.
geographic description: Porcupine Creek road, across western side branch of the creek; elevation approx. 1588 m (5240 ft)
lithology: dark grey, recrystallized limestone
weight: 4.085 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157826
field number: J. Beyers, 1987; 87OF-B-PORCCK-7
latitude, longitude: 51°05'02.3", 121°48'38.7"
UTM: Zone 10: 583120 m E., 5659620 m N.
geographic description: Porcupine Creek road, across western side branch of the creek, but closer to junction with main arm of creek; elevation 1582 m (5220 ft)
stratigraphic description: limestone clast in argillite
lithology: dark grey, recrystallized carbonate
weight: 3.382 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157827
field number: J. Beyers, 1987; 87OF-B-PORCCK-8
latitude, longitude: 51°04'42.4", 121°48'46.9"
UTM: Zone 10: 583150 m E., 5659000 m N.
geographic description: Porcupine Creek road, between PORCCK-5 and crossing of main arm of creek; elevation 1564 m (5160 ft)
stratigraphic description: talus slope sample from cliff immediately above
lithology: pink weathering, crinoidal, siliceous and recrystallized micrite
weight: 5.616 kg
fossils: crinoids, ostracodes (1)
conodont fauna: *Ellisonia* sp. indet. (1)
Neogondolella sp. indet. (5)
Neospathodus? sp. (1)
ramiform elements (2)
period or epoch: probably Early Triassic
age: indeterminate
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

C. PAVILION MOUNTAIN: NTS 92I/13, ASHCROFT

GSC sample number: C-117771
field number: M.J. Orchard, 1986; 86OF-PVR-1
latitude, longitude: 50°59'06.1", 121°43'01.6"
UTM: Zone 10: 590050 m E., 5648725 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 3.5 m in Conodont Corner section
lithology: dark grey, recrystallized and brecciated micrite
weight: 1.747 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
ramiform elements (1)
period or epoch: Triassic
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-117772
field number: M.J. Orchard, 1986; 86OF-PVR-2
latitude, longitude: 50°59'06.2", 121°43'06.7"
UTM: Zone 10: 589950 m E., 5648725 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 19.5 m in Conodont Corner section
lithology: pale weathering, dolomitized, nodular micrite
weight: 1.404 kg
fossils: none
conodont fauna: *Epigondolella* sp. indet. (1)
Ellisonia sp. indet. (1)
ramiform elements (2)
period or epoch: Late Triassic
age: probably Norian
conodont assemblage: Fauna 9?
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-117773
field number: M.J. Orchard, 1986; 86OF-PVR-3
latitude, longitude: 50°59'04.6", 121°43'08.1"
UTM: Zone 10: 589925 m E., 5648675 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 42.5 m in Conodont Corner section
lithology: fractured, oölitic, tuffaceous and conglomeratic argillite, with light tuffaceous clasts and limestone clasts and/or nodules
weight: 2.174 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate

age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-149977
field number: J. Beyers, 1986; 86OF-B-PVR-6
latitude, longitude: 50°59'05.2", 121°42'56.5"
UTM: Zone 10: 590150 m E., 5648700 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 1.5 m in Conodont Corner section
lithology: friable, fissile argillite with small limestone clasts and ?bryozoan molds
weight: 1.565 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (2)
Neogondolella sp. indet. (1)
period or epoch: Early Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157837
field number: J. Beyers, 1987; 87OF-B-PVR-6A
weight: 4.500 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Middle-Late Triassic
age: indeterminate
remarks: Recollection of PVR-6. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-149978
field number: J. Beyers, 1986; 86OF-B-PVR-7
latitude, longitude: 50°59'05.3", 121°42'59.1"
UTM: Zone 10: 590100 m E., 5648700 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 1.8 m in Conodont Corner section
lithology: dissolution features and crinoid stems in micrite
weight: 1.722 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149979
field number: J. Beyers, 1986; 86OF-B-PVR-8
latitude, longitude: 50°59'07.6", 121°43'02.9"
UTM: Zone 10: 590025 m E., 5648770 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 5.5 m in Conodont Corner section
lithology: dark, very recrystallized, veined, fine grained micrite

weight: 20.408 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149980
field number: J. Beyers, 1986; 86OF-B-PVR-9
latitude, longitude: 50°59'06.9", 121°43'04.1"
UTM: Zone 10: 590000 m E., 5648750 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 7.5 m in Conodont Corner section; bedding attitude 111/65 SW
lithology: limestone clasts in argillite, with dissolution molds and crinoids
weight: 1.307 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157839
field number: J. Beyers, 1987; 87OF-B-PVR-9A
weight: 4.400 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of PVR-9.
****

GSC sample number: C-149981
field number: J. Beyers, 1986; 86OF-B-PVR-10
latitude, longitude: 50°59'06.3", 121°43'06.2"
UTM: Zone 10: 589960 m E., 5648730 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 16.5 m in Conodont Corner section
lithology: light grey, recrystallized, ?oölitic limestone
weight: 2.419 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-117774
field number: M.J. Orchard, 1986; 86OF-PVR-A
latitude, longitude: 50°59'04.4", 121°42'55.3"
UTM: Zone 10: 590175 m E., 5648675 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)

stratigraphic description: at 0.5 m in 43 m Conodont Corner section; thin limestone bed or lens in argillite sequence, bedding attitude 147/57 SW
lithology: recrystallized micrite with pelagic shell debris
weight: 1.747 kg
fossils: none
conodont fauna: *Epigondolella abneptis* (5)
Neogondolella sp. cf. *N. navicula* (3)
period or epoch: Late Triassic
age: early Norian
conodont assemblage: Fauna 9
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157838
field number: J. Beyers, 1987; 87OF-B-PVR-A-REC
weight: 4.400 kg
fossils: none
conodont fauna: "*Epigondolella*" sp. indet. (1)
Neogondolella sp. indet. (1)
period or epoch: Late Triassic
age: early Norian
conodont assemblage: Fauna 9
remarks: Recollection of PVR-A. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-117775
field number: M.J. Orchard, 1986; 86OF-PVR-B
latitude, longitude: 50°59'05.2", 121°42'56.5"
UTM: Zone 10: 590150 m E., 5648700 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 2 m in Conodont Corner section
lithology: limestone clast in argillite
weight: 1.957 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
period or epoch: probably Early Triassic
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157840
field number: J. Beyers, 1987; 87OF-B-PVR-D
latitude, longitude: 50°59'06.1", 121°43'01.6"
UTM: Zone 10: 590050 m E., 5648725 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 4.5 m in Conodont Corner section
lithology: dark grey, recrystallized micrite with 5 cm wide calcite veins
weight: 3.237 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate

age: indeterminate
****

GSC sample number: C-157841
field number: J. Beyers, 1987; 87OF-B-PVR-E
latitude, longitude: 50°59'06.3", 121°43'06.2"
UTM: Zone 10: 589960 m E., 5648730 m N.
geographic description: Conodont Corner, 5 km E of Hambrook Creek junction, Pavilion Mountain road (western belt)
stratigraphic description: at 22.5 m in Conodont Corner section
lithology: light grey, recrystallized dolomitic limestone with micrite nodules
weight: 4.739 kg
fossils: none
conodont fauna: *Pachycladina obliqua* (1)
Hadrodontina? sp. (2)
ramiform elements (3)
period or epoch: Early Triassic
age: probably Smithian
conodont assemblage: Fauna 5?
****

GSC sample number: C-149982
field number: J. Beyers, 1986; 86OF-B-PVR-11
latitude, longitude: 50°58'56.1", 121°42'38.8"
UTM: Zone 10: 590500 m E., 5648425 m N.
geographic description: 5.6 km E of Hambrook Creek junction, Pavilion Mountain road, about 3 m above road (western belt)
lithology: dark grey, crinoidal, veined and recrystallized limestone
weight: 1.929 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149983
field number: J. Beyers, 1986; 86OF-B-PVR-12
latitude, longitude: 50°58'48.8", 121°42'35.2"
UTM: Zone 10: 590575 m E., 5648200 m N.
geographic description: 5.8 km E of Hambrook Creek junction Pavilion Mountain road (western belt)
lithology: pale grey weathering, dark grey, fine grained, veined and recrystallized carbonate
weight: 1.975 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1+1?)
period or epoch: Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-149984
field number: J. Beyers, 1986; 86OF-B-PVR-13
latitude, longitude: 50°58'17.7", 121°40'54.8"

UTM: Zone 10: 592550 m E., 5647275 m N.
geographic description: Pavilion Mountain, bearing 304° to largest of microwave towers; elevation 2076 m (6850 ft)
lithology: medium grey, highly recrystallized limestone, from lower exposures which are less metamorphosed
weight: 1.968 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149985
field number: J. Beyers, 1986; 86OF-B-PVR-14
latitude, longitude: 50°58'32.6", 121°41'21.5"
UTM: Zone 10: 592020 m E., 5647725 m N.
geographic description: Pavilion Mountain, on straight line between the two towers; western face of outcrop
stratigraphic description: cleavage plane attitude 143/07 NE
lithology: medium grey, recrystallized carbonate
weight: 1.657 kg
fossils: none
conodont fauna: *Metapolygnathus* sp. indet. (2)
ramiform elements (4)
period or epoch: Late Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-149986
field number: J. Beyers, 1986; 86OF-B-PVR-15
latitude, longitude: 50°58'44.6", 121°41'09.4"
UTM: Zone 10: 592250 m E., 5648100 m N.
geographic description: Pavilion Mountain, bearing 200° to main tower; elevation 2009 m (6630 ft)
lithology: grey, highly recrystallized limestone, with solution features; outcrops form small, low level exposures on hillside
weight: 1.994 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149987
field number: J. Beyers, 1986; 86OF-B-PVR-16
latitude, longitude: 50°58'25.8", 121°40'54.5"
UTM: Zone 10: 592550 m E., 5647525 m N.
geographic description: Pavilion Mountain, bearing 261° to main tower; elevation 2030 m (6700 ft)
lithology: recrystallized limestone with micritic nodules
weight: 1.984 kg
fossils: none

conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149988
field number: J. Beyers, 1986; 86OF-B-PVR-17
latitude, longitude: 50°58'37.7", 121°40'28.6"
UTM: Zone 10: 593050 m E., 5647900 m N.
geographic description: Pavilion Mountain, bearing 261° to main tower; elevation 2030 m (6700 ft)
lithology: dark grey, recrystallized carbonate
weight: 1.966 kg
fossils: ichthyoliths (3)
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149989
field number: J. Beyers, 1986; 86OF-B-PVR-18
latitude, longitude: 50°58'32.9", 121°40'35.1"
UTM: Zone 10: 592925 m E., 5647750 m N.
geographic description: Pavilion Mountain, bearing 278° to main tower; elevation 2061 m (6800 ft)
lithology: hilltop outcrop of dark grey, recrystallized limestone
weight: 1.746 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149990
field number: J. Beyers, 1986; 86OF-B-PVR-19
latitude, longitude: 50°58'39.4", 121°41'49.3"
UTM: Zone 10: 591475 m E., 5647925 m N.
geographic description: 500 m W of small tower, Pavilion Mountain road
lithology: medium grey, nodular, crinoidal, cleaved limestone
weight: 1.762 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149991
field number: J. Beyers, 1986; 86OF-B-PVR-20
latitude, longitude: 50°58'45.3", 121°42'08.3"
UTM: Zone 10: 591100 m E., 5648100 m N.
geographic description: 800 m W of small tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 2 m above datum (0 m)
lithology: recrystallized, gritty, dark, nodular carbonate

weight: 1.948 kg
fossils: none
conodont fauna: *Neogondolella* n.sp. *A* (8+2?)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
****

GSC sample number: C-157847
field number: J. Beyers, 1987; 87OF-B-PVR-20A
weight: 5.200 kg
fossils: none
conodont fauna: *Iranognathus* ex gr. *nudus* morphotype indet. (1)
Neogondolella n.sp. *A* (5+1?)
Neogondolella sp. indet. (2)
period or epoch: Late Permian
age: late Dzhulfian-middle Dorashamian
conodont assemblage: Fauna 2
remarks: Recollection of PVR-20.
****

GSC sample number: C-149992
field number: J. Beyers, 1986; 86OF-B-PVR-21
latitude, longitude: 50°58'45.3", 121°42'13.5"
UTM: Zone 10: 591000 m E., 5648100 m N.
geographic description: 800 m W of small tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 19 m above datum
lithology: dark grey, cleaved limestone
weight: 1.410 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149993
field number: J. Beyers, 1986; 86OF-B-PVR-22
latitude, longitude: 50°58'45.4", 121°42'17.3"
UTM: Zone 10: 590925 m E., 5648100 m N.
geographic description: 800 m W of small tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 40 m above datum
lithology: grey weathering, dark grey, crinoidal carbonate, with calcite pods and ?clasts
weight: 2.419 kg
fossils: none
conodont fauna: *Epigondolella* sp. indet. (3)
ramiform elements (5)
period or epoch: Late Triassic
age: Norian
conodont assemblage: Fauna 9
remarks: Determinations by M.J. Orchard (1989).

****

GSC sample number: C-157842
field number: J. Beyers, 1987; 87OF-B-PVR-P
latitude, longitude: 50°58'45.3", 121°42'09.6"
UTM: Zone 10: 591075 m E., 5648100 m N.
geographic description: 800 m W of small microwave tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 11 m above datum
lithology: dark grey, recrystallized micrite; ?oölites
weight: 3.268 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-157843
field number: J. Beyers, 1987; 87OF-B-PVR-Q
latitude, longitude: 50°58'45.3", 121°42'09.6"
UTM: Zone 10: 591075 m E., 5648100 m N.
geographic description: 800 m W of small microwave tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 15 m above datum
lithology: dark grey, platy, argillaceous limestone with dissolution features
weight: 3.255 kg
fossils: none
conodont fauna: *Neospathodus* sp. *A* (1)
Neospathodus sp. indet. (8)
ramiform elements (6)
period or epoch: Early Triassic
age: Dienerian-Smithian

****

GSC sample number: C-157844
field number: J. Beyers, 1987; 87OF-B-PVR-S
latitude, longitude: 50°58'45.3", 121°42'09.6"
UTM: Zone 10: 591075 m E., 5648100 m N.
geographic description: 800 m W of small microwave tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 18 m above datum
lithology: dark grey, platy, argillaceous limestone
weight: 2.852 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-157845
field number: J. Beyers, 1987; 87OF-B-PVR-T
latitude, longitude: 50°58'45.4", 121°42'16.0"
UTM: Zone 10: 590950 m E., 5648100 m N.
geographic description: 800 m W of small microwave tower, Pavilion Mountain

road (western belt)
stratigraphic description: approx. 32.5 m above datum
lithology: dark grey, platy, argillaceous limestone
weight: 3.420 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157846
field number: J. Beyers, 1987; 87OF-B-PVR-U
latitude, longitude: 50°58'45.4", 121°42'16.0"
UTM: Zone 10: 590950 m E., 5648100 m N.
geographic description: 800 m W of small microwave tower, Pavilion Mountain road (western belt)
stratigraphic description: approx. 37.5 m above datum
lithology: dark grey, platy, argillaceous limestone
weight: 3.636 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157848
field number: J. Beyers, 1987; 87OF-B-PVR-W
latitude, longitude: 50°58'38.5", 121°41'42.9"
UTM: Zone 10: 591600 m E., 5647900 m N.
geographic description: 2.3 km E of centre of Conodont Corner and 7.5 km from Hambrook Creek junction, Pavilion Mountain road (western belt)
lithology: green to ochre weathering, dark grey, recrystallized, fine grained, argillaceous limestone
weight: 3.466 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Triassic
age: indeterminate
****

D. MARBLE CANYON-HAT CREEK: NTS 92I/13, ASHCROFT

GSC sample number: C-157835
field number: J. Beyers, 1987; 87OF-B-CRLK-1
latitude, longitude: 50°49'57.1", 121°41'34.4"
UTM: Zone 10: 592050 m E., 5631800 m N.
geographic description: across from Marble Canyon provincial campground, along shore of Crown Lake
lithology: light grey, highly recrystallized limestone
weight: 3.299 kg

fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C 157836
field number: J. Beyers, 1987; 87OF-B-CRLK-2
latitude, longitude: 50°49'57.1", 121°41'33.2"
UTM: Zone 10: 592075 m E., 5631800 m N.
geographic description: across from Marble Canyon provincial campground, along shore of Crown Lake
lithology: light grey, highly recrystallized limestone
weight: 2.783 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-158470
field number: M.J. Orchard, 1987; 87OF-HC-1
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 3.547 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (2)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-158471
field number: M.J. Orchard, 1987; 87OF-HC-2
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 3.941 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform elements (1)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-158472
field number: M.J. Orchard, 1987; 87OF-HC-3
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 3.872 kg

fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-158473
field number: M.J. Orchard, 1987; 87OF-HC-4
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 4.300 kg
fossils: ichthyoliths (2)
conodont fauna: *Sweetognathus* sp. indet. (2)
Neogondolella sp. indet. (1)
period or epoch: Permian
age: Guadalupian
conodont assemblage: Fauna 1
****

GSC sample number: C-158474
field number: M.J. Orchard, 1987; 87OF-HC-5
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 4.167 kg
fossils: ichthyoliths (2), crinoids
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform elements (1)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-158475
field number: M.J. Orchard, 1987; 87OF-HC-6
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 3.601 kg
fossils: ichthyoliths (1)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-158476
field number: M.J. Orchard, 1987; 87OF-HC-7
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate

weight: 3.326 kg
fossils: ostracodes (1)
conodont fauna: *Neogondolella* ex gr. *?serrata* (2)
period or epoch: Permian
age: probably Guadalupian
conodont assemblage: Fauna 1?
****

GSC sample number: C-158477
field number: M.J. Orchard, 1987; 87OF-HC-8
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 4.100 kg
fossils: ichthyoliths (3)
conodont fauna: *Sweetognathus* sp. indet. (2)
ramiform elements (1)
period or epoch: Late Permian
age: Guadalupian
conodont assemblage: Fauna 1
****

GSC sample number: C-158478
field number: M.J. Orchard, 1987; 87OF-HC-9
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 4.142 kg
fossils: none
conodont fauna: *Neogondolella* sp. (1)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-158479
field number: M.J. Orchard, 1987; 87OF-HC-10
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, E of Hat Creek road
lithology: carbonate
weight: 4.300 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149965
field number: J. Beyers, 1986; 86OF-B-HCJ-1
latitude, longitude: 50°48'05.2", 121°36'34.1"
UTM: Zone 10: 597990 m E., 5628450 m N.
geographic description: off Highway 12 near junction with Hat Creek road,

along trail, bearing 182° to junction; elevation 939 m (3100 ft)
lithology: sheared and recrystallized, light grey limestone with fusulinids on weathered surface
weight: 1.482 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149966
field number: J. Beyers, 1986; 86OF-B-HCJ-2
latitude, longitude: 50°48'49.6", 121°37'37.4"
UTM: Zone 10: 596725 m E., 5629800 m N.
geographic description: off Highway 12 near junction with Hat Creek road, along trail; elevation 1185 m (3910 ft)
lithology: light grey, coarsely recrystallized carbonate
weight: 1.809 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149967
field number: J. Beyers, 1986; 86OF-B-HCJ-3
latitude, longitude: 50°48'49.6", 121°37'37.4"
UTM: Zone 10: 596725 m E., 5629800 m N.
geographic description: off Highway 12 near junction with Hat Creek road, along trail, bearing 162° to open pit installation on Hat Creek road; elevation 1227 m (4050 ft)
lithology: pitted, grey weathering, medium grey, recrystallized limestone
weight: 1.614 kg
fossils: ichthyoliths (1)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149968
field number: J. Beyers, 1986; 86OF-B-HCJ-4
latitude, longitude: 50°49'31.8", 121°40'07.0"
UTM: Zone 10: 593775 m E., 5631050 m N.
geographic description: from bottom of cliff above talus slope, 5.5 km N of junction with Hat Creek road, along Highway 12
lithology: light brown to grey weathering, medium grey, massive, slightly sheared, recrystallized limestone
weight: 1.824 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149969
field number: J. Beyers, 1986; 86OF-B-HCJ-5
latitude, longitude: 50°48'01.9", 121°36'29.8"
UTM: Zone 10: 598075 m E., 5628350 m N.
geographic description: off Highway 12 near junction with Hat Creek road, along trail, bearing 192° to junction; elevation 894 m (2950 ft)
lithology: from limestone cliff; light grey to pink, recrystallized carbonate
weight: 2.006 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (2)
period or epoch: Permian
age: indeterminate
****

GSC sample number: C-149970
field number: J. Beyers, 1986; 86OF-B-HCJ-6
latitude, longitude: 50°48'01.2", 121°36'37.5"
UTM: Zone 10: 597925 m E., 5628325 m N.
geographic description: near trail into Marble Canyon, off Highway 12 at junction with Hat Creek road, elevation 903 m (2980 ft)
lithology: pink, interpillow, coarse limestone
weight: 2.010 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Stop #8 in Cache Creek fieldguide (W.R. Danner, 1985).
****

GSC sample number: C-149971
field number: J. Beyers, 1986; 86OF-B-HCJ-7
latitude, longitude: 50°48'02.1", 121°36'51.5"
UTM: Zone 10: 597650 m E., 5628350 m N.
geographic description: from bottom of cliff above talus slope, W of trail near junction of Hat Creek road and Highway 12; elevation 927 m (3060 ft)
stratigraphic description: bedding attitude 045/84 NW
lithology: red and ochre, deformed and folded chert
weight: 1.480 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Locality C08 of Cordey, 1986; localities BC-26 and 29 of Igo *et al.*, 1985.
****

GSC sample number: C-149972
field number: J. Beyers, 1986; 86OF-B-HCJ-8
latitude, longitude: 50°48'-2.1", 121°36'51.5"
UTM: Zone 10: 597650 m E., 5628350 m N.
geographic description: from bottom of cliff above talus slope, W of trail near junction of Hat Creek road and Highway 12; elevation 927 m (3060 ft)
lithology: ochre weathering, medium grey, fissile, fine grained and shaly

limestone, pinches out between chert layers
weight: 1.522 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149973
field number: J. Beyers, 1986; 86OF-B-HCJ-9
latitude, longitude: 50°47'59.5", 121°36'23.5"
UTM: Zone 10: 598200 m E., 5628280 m N.
geographic description: bearing 211° to junction of Hat Creek road and Highway 12, behind and W of HTC locality; elevation 879 m (2900 ft)
lithology: pitted, grey weathering, medium grey, recrystallized limestone
weight: 1.954 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149974
field number: J. Beyers, 1986; 86OF-B-HCJ-10
latitude, longitude: 50°47'58.5", 121°36'21.0"
UTM: Zone 10: 598250 m E., 5628250 m N.
geographic description: near HCJ-9, bearing 217° to junction; elevation 864 m (2850 ft)
lithology: medium to dark grey, recrystallized limestone
weight: 1.923 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149975
field number: J. Beyers, 1986; 86OF-B-HCJ-11
latitude, longitude: 50°48'00.9", 121°36'19.7"
UTM: Zone 10: 598275 m E., 5628325 m N.
geographic description: near HCJ-10, bearing 218° to junction; elevation 879 m (2900 ft)
lithology: medium to dark grey, recrystallized limestone
weight: 1.444 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-149976
field number: J. Beyers, 1986; 86OF-B-HCJ-12
latitude, longitude: 50°49'58.2", 121°42'02.5"
UTM: Zone 10: 591500 m E., 5631825 m N.

geographic description: on Highway 12, 6.81 km N of junction with Hat Creek road, across from Marble Canyon provincial park exit
lithology: pale weathering highly recrystallized limestone
weight: 2.156 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-117770
field number: M.J. Orchard, 1986; 86OF-HTC
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
lithology: *Yabeina* limestone
weight: 1.693 kg
fossils: none
conodont fauna: indeterminate fragments
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-118818
field number: M.J. Orchard, 1985; 85OF-HTC-3
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 2.2 m above datum (0 m)
lithology: carbonate
weight: 2.150 kg
fossils: ichthyoliths
conodont fauna: *Sweetognathus* sp. indet.
Neogondolella sp. indet. (1)
Hindeodus? sp.
ramiform fragments
period or epoch: Late Permian
age: Guadalupian
conodont assemblage: Fauna 1
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118819
field number: M.J. Orchard, 1985; 85OF-HTC-4
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 3.2 m above datum
lithology: carbonate

weight: 2.800 kg
fossils: ichthyoliths (1)
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform fragments
period or epoch: Permian
age: indeterminate
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118820
field number: M.J. Orchard, 1985; 85OF-HTC-5
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 4.7 m above datum
lithology: carbonate
weight: 2.100 kg
fossils: ichthyoliths
conodont fauna: *Sweetognathus* sp. indet. (1)
ramiform elements
period or epoch: Late Permian
age: Guadalupian
conodont assemblage: Fauna 1
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118821
field number: M.J. Orchard, 1985; 85OF-HTC-6
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 5.2 m above datum
lithology: carbonate
weight: 2.350 kg
fossils: ichthyoliths
conodont fauna: *Merrillina*? sp. (1)
Neogondolella sp. indet. (1)
Hindeodus sp. indet. (1)
ramiform elements (2)
period or epoch: Permian
age: indeterminate
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118822
field number: M.J. Orchard, 1985; 85OF-HTC-7
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 6.7 m above datum

lithology: carbonate
weight: 2.580 kg
fossils: ichthyoliths
conodont fauna: *Hindeodus* sp. indet. (1)
ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118823
field number: M.J. Orchard, 1985; 85OF-HTC-8
latitude, longitude: 50°47'56.9", 121°36'22.4"
UTM: Zone 10: 598225 m E., 5628200 m N.
geographic description: Highway 12, about 200 m E of junction with Hat Creek road
stratigraphic description: 7.7 m above datum and top of outcrop
lithology: carbonate
weight: 2.400 kg
fossils: ichthyoliths
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Permian
age: indeterminate
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-157830
field number: J. Beyers, 1987; 87OF-B-UHC-1
latitude, longitude: 50°48'04.2", 121°36'08.1"
UTM: Zone 10: 598500 m E., 5628430 m N.
geographic description: Highway 12, at 19.99 km W of junction with Highway 97
lithology: purplish, recrystallized, veined and fine-grained limestone
weight: 4.963 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157831
field number: J. Beyers, 1987; 87OF-B-UHC-2
latitude, longitude: 50°48'04.2", 121°36'08.1"
UTM: Zone 10: 598500 m E., 5628430 m N.
geographic description: Highway 12, at 19.99 km W of junction with Highway 97
stratigraphic description: about 10 m stratigraphically above UHC-1
lithology: slickensided carbonate
weight: 7.274 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****
GSC sample number: C-157832
field number: J. Beyers, 1987; 87OF-B-UHC-3
latitude, longitude: 50°48'23.0", 121°35'40.9"
UTM: Zone 10: 599020 m E., 5629020 m N.
geographic description: Highway 12, 1.85 km E of junction with Hat Creek road
lithology: light grey, massive, highly recrystallized, fine grained limestone
weight: 3.883 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-157833
field number: J. Beyers, 1987; 87OF-B-UHC-4
latitude, longitude: 50°48'36.5", 121°35'10.9"
UTM: Zone 10: 599600 m E., 5629450 m N.
geographic description: Highway 12, 2.5 km E of junction with Hat Creek road
lithology: light grey, coarsely recrystallized limestone
weight: 3.716 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-157834
field number: J. Beyers, 1987; 87OF-B-UHC-5
latitude, longitude: 50°49'27.6", 121°34'08.0"
UTM: Zone 10: 600800 m E., 5631050 m N.
geographic description: Highway 12, 4.65 km E of junction with Hat Creek road
stratigraphic description: within 2 m of exposed base of unit
lithology: dark grey, recrystallized carbonate from iron-rich, much weathered limestone
weight: 3.356 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-116501
field number: N. Mortimer, 1986; 86OF-NM-1A
latitude, longitude: 50°51'10", 121°42'44"
UTM: Zone 10: 590650 m E., 5634000 m N.
geographic description: Marble Canyon above Pavilion Lake, 200 m uphill from road cut at S end of lake
stratigraphic description: 0 to 1.5 m thick, tapering interbed of limestone; bedding-cleavage plane attitude 164/82 W

lithology: interbed of limestone with argillite and siliceous argillite above and below
weight: 2.080 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (2)
ramiform elements (1)
period or epoch: Early Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

GSC sample number: C-116504
field number: N. Mortimer, 1986; 86OF-NM-4A
latitude, longitude: 50°54'53", 121°41'56"
UTM: Zone 10: 591450 m E., 5640900 m N.
geographic description: Pavilion Creek drainage near logged areas
stratigraphic description: from structural top of approx. 50 m section of interbedded limestone and argillite; bedding attitude 178/68 W
lithology: platy limestone
weight: 2.080 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
ramiform elements (1)
period or epoch: Permian?
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

GSC sample number: C-116506
field number: N. Mortimer, 1986; 86OF-NM-10A
latitude, longitude: 50°52'49", 121°43'27"
UTM: Zone 10: 589750 m E., 5637100 m N.
geographic description: ridge S of Felix Creek, Marble Canyon
stratigraphic description: paced section, limestone conglomerate, from 0 to 60 m thick; clasts are polymictic, subrounded; end of limestone conglomerate body abuts against chert-argillite, is probably an olistostromal body; specimen taken 5 m from western edge
lithology: platy calcarenite, probably matrix to the conglomerate
weight: 1.910 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
ramiform elements (2)
period or epoch: Early Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

GSC sample number: C-116509
field number: N. Mortimer, 1986; 86OF-NM-11A
latitude, longitude: 50°55'58", 121°42'55"
UTM: Zone 10: 590250 m E., 5642900 m N.
geographic description: north tributary to Pavilion Creek
stratigraphic description: bedding attitude 020/78 E

lithology: grey, massive limestone with recrystallized crinoid fragments; to SE is float of chert and argillite, then interbedded argillite and marble
weight: 2.130 kg
fossils: organic fragments
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Permian?
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

GSC sample number: C-116508
field number: N. Mortimer, 1986; 86OF-NM-10E
latitude, longitude: 50°52'49", 121°43'11"
UTM: Zone 10: 590100 m E., 5637100 m N.
geographic description: first cliff-forming limestone on ridge S of Felix Creek, Marble Canyon, below large cliffs
stratigraphic description: approx. 120 m of chert, argillite, tuff and minor limestone; bedding attitude 163/67 W
lithology: carbonate
weight: 2.480 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (1)
period or epoch: Permian-Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

GSC sample number: C-116511
field number: N. Mortimer, 1986; 86OF-NM-13F
latitude, longitude: 50°52'46", 121°43'32"
UTM: Zone 10: 589650 m E., 5637000 m N.
geographic description: immediately downslope from NM-10A
stratigraphic description: limestone approx. 50 m thick, stratigraphically above NM-10A, overlain by basalt flow, in turn overlain by dominantly chert-argillite section
lithology: black, laminated limestone
weight: 2.050 kg
fossils: none
conodont fauna: *Neospathodus dieneri* (11)
ramiform elements (13)
period or epoch: Early Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1987).
****

E. SOUTHERN MARBLE RANGE: NTS 92I/11-12, ASHCROFT

GSC sample number: C-118472
field number: M.J. Orchard, 1984; 84MJO-CH1
latitude, longitude: 50°40', 121°28'

UTM: Zone 10
geographic description: Cornwall Hills access road, 0.19 km from top junction
lithology: carbonate
weight: 4.763 kg
fossils: none
conodont fauna: *Neogondolella carinata* (1)
Neogondolella sp. indet. (3)
Neospathodus sp. indet. (1+1?)
ramiform elements (7)
period or epoch: Middle? Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1984).
****

GSC sample number: C-118474
field number: M.J. Orchard, 1984; 84MJO-CH3
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 0.88 km from top junction.
lithology: carbonate breccia, with clasts of oölitic limestone
weight: 4.309 kg
fossils: phosphatic shells
conodont fauna: *Platyvillosus costatus* (1)
Neospathodus novaehollandiae (1)
Neospathodus sp. *A*
Neospathodus dieneri (2)
Neospathodus aff. *homeri* (4)
Neospathodus sp. indet. (4)
ramiform elements (2)
period or epoch: Early Triassic
age: Smithian
conodont assemblage: Fauna 5
remarks: Determinations by M.J. Orchard (1984).
****

GSC sample number: C-157807
field number: M.J. Orchard, 1987; 87OF-CH3-"0"
weight: unknown
fossils: none
conodont fauna: *Neospathodus* sp. indet. (3+1?)
period or epoch: Early Triassic
age: indeterminate
remarks: Recollection of 84MJO-CH3.
****

GSC sample number: C-157885
field number: M.J. Orchard, 1987; 87OF-CH5-REC
latitude, longitude: 50°41'27.0", 121°28'04.2"
UTM: Zone 10: 608225 m E., 5616350 m N.
geographic description: Cornwall Hills access road, 1.55 km from top junction
lithology: carbonate
weight: 7.200 kg
fossils: none

conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of 84MJO-CH5.
****

GSC sample number: C-118479
field number: M.J. Orchard, 1984; 84MJO-CH8
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 1.7 km from top junction.
lithology: rubbly, argillaceous limestone in argillite
weight: 3640 kg
fossils: none
conodont fauna: *Neogondolella milleri* (1+1?)
ramiform elements (3)
period or epoch: Early Triassic
age: late Smithian
conodont assemblage: Fauna 5B
remarks: Determinations by M.J. Orchard (1984).
****

GSC sample number: C-157886
field number: M.J. Orchard, 1987; 87OF-CH8-REC
weight: 9.200 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of 84MJO-CH8.
****

GSC sample number: C-118483
field number: M.J. Orchard, 1984; 84MJO-CH12
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 2.05 km from top junction
lithology: thin (1-5 cm) limestone in siliceous argillite
weight: 3.480 kg
fossils: none
conodont fauna: *Neospathodus dieneri* (2)
Neospathodus ?robustus (1)
Neospathodus sp. indet.
Ellisonia sp. indet.
ramiform elements (3+)
period or epoch: Early Triassic
age: Dienerian?
remarks: Determinations by M.J. Orchard (1984).
****

GSC sample number: C-157887
field number: M.J. Orchard, 1987; 87OF-CH12-REC
weight: 4.680 kg
fossils: none

conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Recollection of 84MJO-CH12.
****

GSC sample number: C-118486
field number: M.J. Orchard, 1984; 84MJO-CH14-B
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 2.3 km from top junction
stratigraphic description: radiolarian chert
lithology: chert
weight: 0.606 kg
fossils: none
conodont fauna: *Neogondolella* sp. cf. *N. excelsa* (14)
ramiform elements (10)
period or epoch: Middle Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1986).
****

GSC sample number: C-118487
field number: M.J. Orchard, 1984; 84MJO-CH15
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 2.5 km from top junction
stratigraphic description: 10 cm of carbonate breccia below 1 m of radiolarian chert
lithology: carbonate breccia
weight: 3.657 kg
fossils: ichthyoliths (2+)
conodont fauna: *Paragondolella?* sp.
Ellisonia sp. indet.
ramiform elements
period or epoch: Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1984).
****

GSC sample number: C-118488
field number: M.J. Orchard, 1984; 84MJO-CH16
latitude, longitude: 50°40', 121°28'
UTM: Zone 10
geographic description: Cornwall Hills access road, 3.1 km from top junction
stratigraphic description: limestone clasts in brown argillite
lithology: carbonate
weight: 2.210 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
period or epoch: Early Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1984).

****

GSC sample number: C-157849
field number: J. Beyers, 1987; 87OF-B-CH-E1
latitude, longitude: 50°41'42.1", 121°26'46.0"
UTM: Zone 10: 609750 m E., 5616850 m N.
geographic description: Cornwall Hills; elevation 1958 m (6460 ft)
lithology: small resistant hill of medium grey limestone
weight: 3.227 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C157850
field number: J. Beyers, 1987; 87OF-B-CH-E2
latitude, longitude: 50°41'42.1", 121°26'44.7"
UTM: Zone 10: 609775 m E., 5616850 m N.
geographic description: Cornwall Hills, 15 m W of E1
lithology: argillaceous micrite
weight: 2.945 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-157851
field number: J. Beyers, 1987; 87OF-B-CH-E3
latitude, longitude: 50°41'43.8", 121°26'48.5"
UTM: Zone 10: 609700 m E., 5616900 m N.
geographic description: Cornwall Hills, 5 m down and to N of E1 and E2; elevation 1952 m (6440 ft)
lithology: dark grey, medium grained, medium coarse to coarsely recrystallized limestone with calcite veining and apparent micrite nodules
weight: 3.463 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-157852
field number: J. Beyers, 1987; 87OF-B-CH-E4
latitude, longitude: 50°41'52.6", 121°26'43.1"
UTM: Zone 10: 609800 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: calcareous ?tuff with crystal molds and vesicular texture on weathered surfaces
weight: 3.980 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate

age: indeterminate
****

GSC sample number: C-157853
field number: J. Beyers, 1987; 87OF-B-CH-E5
latitude, longitude: 50°41'52.6", 121°26'40.5"
UTM: Zone 10: 609850 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: ochre weathering, light grey to pink, medium grained argillaceous limestone with 2-5 cm wide fracture? zones
weight: 4.124 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157854
field number: J. Beyers, 1987; 87OF-B-CH-E6
latitude, longitude: 50°41'52.6", 121°26'40.5"
UTM: Zone 10: 609850 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: ochre weathering, light grey to pink, medium grained argillaceous limestone with 2-5 cm wide fracture? zones
weight: 4.030 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157855
field number: J. Beyers, 1987; 87OF-B-CH-E7
latitude, longitude: 50°41'52.6", 121°26'39.3"
UTM: Zone 10: 609875 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
stratigraphic description: beds between 10 and 30 cm thick
lithology: pink, medium grained limestone
weight: 3.010 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157856
field number: J. Beyers, 1987; 87OF-B-CH-E8
latitude, longitude: 50°41'52.6", 121°26'38.5"
UTM: Zone 10: 609890 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
stratigraphic description: immediately adjacent to coarsely recrystallized limestone unit, which is separated from a crinoidal limestone by a 30 cm wide shear zone (036/90)
lithology: pink, medium grained limestone

weight: 3.310 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157857
field number: J. Beyers, 1987; 87OF-B-CH-E9
latitude, longitude: 50°41'52.6", 121°26'38.0"
UTM: Zone 10: 609900 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: pink to ochre weathering, sparsely crinoidal, stylolitic, coarsely recrystallized limestone
weight: 2.843 kg
fossils: none
conodont fauna: ramiform elements (6)
period or epoch: probably Triassic
age: indeterminate
****

GSC sample number: C-157858
field number: J. Beyers, 1987; 87OF-B-CH-E10
latitude, longitude: 50°41'52.5", 121°26'36.7"
UTM: Zone 10: 609925 m E., 5617175 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: very crinoidal, coarsely recrystallized and slickensided limestone
weight: 3.173 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
ramiform elements (6)
period or epoch: probably Early Triassic
age: indeterminate
remarks: Thin section cut. C-157859, field #CH-E11, is a hand sample of glassy basalt flow which adjoins the crinoidal unit.
****

GSC sample number: C-157860
field number: J. Beyers, 1987; 87OF-B-CH-E12
latitude, longitude: 50°41'50.1", 121°26'35.5"
UTM: Zone 10: 609950 m E., 5617100 m N.
geographic description: Cornwall Hills; on hillside above E10 and E11
lithology: medium coarse recrystallized limestone
weight: 1.586 kg
fossils: none
conodont fauna: *Neospathodus* sp. cf. *N. pakistanensis* (1)
Neospathodus sp. cf. *N. peculiaris* (1)
Neospathodus sp. cf. *N. dieneri* (1)
ramiform elements (342)
period or epoch: Early Triassic
age: late Dienerian-early Smithian
conodont assemblage: Fauna 4B
remarks: Very small faunule.

****

GSC sample number: C-157861
field number: J. Beyers, 1987; 87OF-B-CH-E13
latitude, longitude: 50°41'59.2", 121°26'46.7"
UTM: Zone 10: 609725 m E., 5617375 m N.
geographic description: Cornwall Hills; elevation 1903 m (6280 ft)
lithology: light grey weathering, medium grey, fine grained limestone
weight: 2.285 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Intrusive igneous float downhill from here.
****

GSC sample number: C-157872
field number: J. Beyers, 1987; 87OF-B-CH-N1
latitude, longitude: 50°41'50.7", 121°27'18.9"
UTM: Zone 10: 609100 m E., 5617100 m N.
geographic description: Cornwall Hills, immediately N of lookout and road; elevation 2021 m (6670 ft)
lithology: dark grey, sparsely crinoidal, medium coarse recrystallized limestone
weight: 2.950 kg
fossils: none
conodont fauna: *Metapolygnathus* sp. indet. (1)
period or epoch: Late Triassic
age: Carnian-early Norian
conodont assemblage: Fauna 8-9
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157873
field number: J. Beyers, 1987; 87OF-B-CH-N2
latitude, longitude: 50°41'49.1", 121°27'23.5"
UTM: Zone 10: 609010 m E., 5617050 m N.
geographic description: Cornwall Hills, bearing 106° to lookout; elevation 2015 m (6650 ft)
lithology: medium grey, recrystallized limestone
weight: 2.689 kg
fossils: ichthyoliths (1)
conodont fauna: *Neospathodus* sp. *A* (6)
Pachycladina obliqua (6)
ramiform elements (23)
period or epoch: Early Triassic
age: probably Smithian
conodont assemblage: Fauna 5
****

GSC sample number: C-157874
field number: J. Beyers, 1987; 87OF-B-CH-N3
latitude, longitude: 50°41'45.9", 121°27'26.7"
UTM: Zone 10: 608950 m E., 5616950 m N.
geographic description: Cornwall Hills, bearing 243° to lookout; elevation 2000

m (6600 ft)
lithology: basalt with scondary carbonate, similar to CH-V2
weight: 2.983 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157875
field number: J. Beyers, 1987; 87OF-B-CH-N4
latitude, longitude: 50°41'47.3", 121°27'34.3"
UTM: Zone 10: 608800 m E., 5616990 m N.
geographic description: Cornwall Hills, bearing 077° to lookout; elevation 1990 m (6570 ft)
lithology: grey, recrystallized, slightly bituminous micrite
weight: 3.515 kg
fossils: none
conodont fauna: ramiform elements (1 -lost)
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Outcrop of blue-green basalt with carbonate infilling nearby, 074° to lookout, elevation 1994 m (6580 ft)
****

GSC sample number: C-157876
field number: J. Beyers, 1987; 87OF-B-CH-N5
latitude, longitude: 50°41'43.6", 121°27'33.1"
UTM: Zone 10: 608825 m E., 5616875 m N.
geographic description: Cornwall Hills, bearing 252° to lookout; elevation 2006 m (6620 ft)
stratigraphic description: bedding attitude 128/14 NE
lithology: grainy, micritic, ?oölitic, locally crinoidal, somewhat dolomitized limestone, with variation in degree of dolomitization and number of crinoids along strike
weight: 2.891 kg
fossils: none
conodont fauna: *Metapolygnathus?* sp. (2)
Neogondolella? sp. (2)
ramiform elements (1)
period or epoch: Late Triassic
age: indeterminate
remarks: *Neogondolella* specimens have large brim. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157877
field number: J. Beyers, 1987; 87OF-B-CH-N6
latitude, longitude: 50°41'40.3", 121°27'28.1"
UTM: Zone 10: 608925 m E., 5616775 m N.
geographic description: Cornwall Hills, bearing 215° to lookout; elevation 1976 m (6520 ft)
lithology: medium grey, crinoidal, somewhat oölitic, slightly recrystallized

limestone
weight: 4.091 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet. (3)
period or epoch: Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157878
field number: J. Beyers, 1987; 87OF-B-CH-N7-A
latitude, longitude: 50°41'37.6", 121°27'33.3"
UTM: Zone 10: 608825 m E., 5616690 m N.
geographic description: Cornwall Hills, bearing 217° to lookout; elevation 1976 m (6520 ft)
stratigraphic description: limestone clast? in blue-green basalt
lithology: carbonate
weight: 2.838 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157879
field number: J. Beyers, 1987; 87OF-B-CH-N7-B
latitude, longitude: 50°41'38.8", 121°27'35.8"
UTM: Zone 10: 608775 m E., 5616725 m N.
geographic description: Cornwall Hills, just downslope and to NW of CH-N7-A, close to road
stratigraphic description: limestone clast? in fine grained, light green basalt
lithology: carbonate
weight: 5.360 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157880
field number: J. Beyers, 1987; 87OF-B-CH-N8
latitude, longitude: 50°41'38.8", 121°27'38.4"
UTM: Zone 10: 608725 m E., 5616725 m N.
geographic description: Cornwall Hills
stratigraphic description: bedding attitude 169/70 SW, becomes 141/81 SW to SSW of N8, 16 m downhill and along strike
lithology: grey radiolarian chert, fractured and quartz-infilled
weight: 4.300 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate

remarks: Thin section cut.
****

GSC sample number: C-157881
field number: J. Beyers, 1987; 87OF-B-CH-N9
latitude, longitude: 50°41'38.4", 121°27'47.3"
UTM: Zone 10: 608550 m E., 5616710 m N.
geographic description: Cornwall Hills, from bluffs about 15 m above road, bearing 047° to lookout
lithology: light to medium grey, crinoidal, dolomitized and recrystallized limestone
weight: 4.582 kg
fossils: none
conodont fauna: *Neocavitella?* sp. (1)
period or epoch: Late Triassic
age: probably Carnian
conodont assemblage: Fauna 8
remarks: CH-N-COMP (thin section cut) is hand sample of blue-green volcanic breccia with 2 lavas; location: 059° to lookout and elevation 1994 m (6580 ft). Blue-green basalt crops out also 6 m below base of CH-N9 bluffs.
****

GSC sample number: C157882
field number: J. Beyers, 1987; 87OF-B-CH-N10
latitude, longitude: 50°41'55.1", 121°27'44.2"
UTM: Zone 10: 608600 m E., 5617225 m N.
geographic description: Cornwall Hills, 0.88 km from top junction at lookout, bearing 100° to lookout; elevation 1982 m (6540 ft)
lithology: medium grey, oölitic, recrystallized micrite with stylolitic surface and minor crinoids
weight: 3.816 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. CH-NE-lookout (thin section cut) is hand sample of sheared carbonate, with secondary carbonate filling in depressions left by the shearing process.
****

GSC sample number: C-157883
field number: J. Beyers, 1987; 87OF-B-CH-S1
latitude, longitude: 50°", 121°27'43.3"
UTM: Zone 10: 608625 m E., 5616870 m N.
geographic description: Cornwall Hills access road, 0.75 km from top junction.
stratigraphic description: limestone clast? in basalt flow which is overlain by light green basalt flow; bedding attitude 125/82 SW
lithology: carbonate
weight: 2.610 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.

****
GSC sample number: C-157884
field number: J. Beyers, 1987; 87OF-B-CH-S2
latitude, longitude: 50°41'19.3", 121°27'47.9"
UTM: Zone 10: 608550 m E., 5616120 m N.
geographic description: Cornwall Hills access road, 2.10 km from top junction
lithology: dark grey, fine grained, finely crystalline micrite with stylolites and poorly preserved oöids
weight: 3.844 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-157888
field number: J. Beyers, 1987; 87OF-B-CH-S3
latitude, longitude: 50°41'17.0", 121°27'46.7"
UTM: Zone 10: 608575 m E., 5616050 m N.
geographic description: Cornwall Hills access road, 2.13 km from top junction
lithology: fractured, stylolitic and muddy limestone
weight: 2.680 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Photo by R. Manley.
****
GSC sample number: C-157889
field number: J. Beyers, 1987; 87OF-B-CH-S4
latitude, longitude: 50°41'17.0", 121°27'46.7"
UTM: Zone 10: 608575 m E., 5616050 m N.
geographic description: Cornwall Hills access road, 2.15 km from top junction
lithology: dark grey, argillaceous, finely crystalline limestone
weight: 2.096 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****
GSC sample number: C-157890
field number: J. Beyers, 1987; 87OF-B-CH-S5
latitude, longitude: 50°41'13.8", 121°27'45.6"
UTM: Zone 10: 608600 m E., 5615950 m N.
geographic description: Cornwall Hills access road, 2.30 km from top junction
stratigraphic description: chert interbedded with limestone; bedding attitude varies 110-130/79 S; 1 m above Orchard's CH-13 (datum)
lithology: carbonate
weight: 2.566 kg
fossils: none
conodont fauna: ramiform elements (3)

period or epoch: indeterminate
age: indeterminate
remarks: This fauna is similar to that of CH-E12.
****

GSC sample number: C-157891
field number: J. Beyers, 1987; 87OF-B-CH-S6
latitude, longitude: 50°41'13.8", 121°27'45.6"
UTM: Zone 10: 608600 m E., 5615950 m N.
geographic description: Cornwall Hills access road, 2.30 km from top junction
stratigraphic description: chert interbedded with limestone, bedding attitude varies 110-130/79 S; 2 m above datum
lithology: carbonate
weight: 2.023 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157892
field number: J. Beyers, 1987; 87OF-B-CH-S7
latitude, longitude: 50°41'13.8", 121°27'45.6"
UTM: Zone 10: 608600 m E., 5615950 m N.
geographic description: Cornwall Hills access road, 2.30 km from top junction
stratigraphic description: chert interbedded with limestone, bedding attitude varies 110-130/79 S; 3 m above datum
lithology: carbonate
weight: 3.210 kg
fossils: none
conodont fauna: ramiform elements (6)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157893
field number: J. Beyers, 1987; 87OF-B-CH-S8
latitude, longitude: 50°41'13.8", 121°27'45.6"
UTM: Zone 10: 608600 m E., 5615950 m N.
geographic description: Cornwall Hills access road, 2.30 km from top junction
stratigraphic description: chert interbedded with limestone, bedding attitude varies 110-130/79 S; 6 m above datum
lithology: carbonate
weight: 2.462 kg
fossils: crinoids
conodont fauna: ramiform elements (5)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157894
field number: J. Beyers, 1987; 87OF-B-CH-S9
latitude, longitude: 50°41'13.8", 121°27'45.6"
UTM: Zone 10: 608600 m E., 5615950 m N.

geographic description: Cornwall Hills access road, 2.30 km from top junction
stratigraphic description: chert interbedded with limestone, bedding attitude varies 110-130/79 S; 8.5 m above datum
lithology: carbonate
weight: 2.296 kg
fossils: none
conodont fauna: ramiform elements (3)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157895
field number: J. Beyers, 1987; 87OF-B-CH-S10
latitude, longitude: 50°41'08.1", 121°27'43.2"
UTM: Zone 10: 608650 m E., 5615775 m N.
geographic description: Cornwall Hills access road, 2.40 km from top junction
stratigraphic description: limestone block in deformed volcanics
lithology: recrystallized micrite
weight: 2.493 kg
fossils: none
conodont fauna: ramiform elements (1)
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Photo by R. Manley.
****

GSC sample number: C-157896
field number: J. Beyers, 1987; 87OF-B-CH-S11
latitude, longitude: 50°41'05.6", 121°27'42.0"
UTM: Zone 10: 608675 m E., 5615700 m N.
geographic description: Cornwall Hills access road, 2.45 km from top junction
stratigraphic description: bedded chert with muddy interbeds, bedding is variable and contorted
lithology: stylolitic, grey-green radiolarian chert
weight: 4.700 kg
fossils: none
conodont fauna: *Neogondolella* sp. indet.
ramiform elements (2)
period or epoch: probably Middle Triassic
age: indeterminate
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157897
field number: J. Beyers, 1987; 87OF-B-CH-S12
latitude, longitude: 50°41'05.6", 121°27'42.0"
UTM: Zone 10: 608675 m E., 5615700 m N.
geographic description: Cornwall Hills access road, 2.46 km from top junction
stratigraphic description: thin-bedded chert with muddy interbeds, bedding is variable and contorted
lithology: stylolitic, grey-green radiolarian chert
weight: 2.420 kg
fossils: none

conodont fauna: *Neogondolella* sp. indet. (3)
ramiform elements (1)
period or epoch: probably Middle Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157898
field number: J. Beyers, 1987; 87OF-B-CH-S13
latitude, longitude: 50°40'43.0", 121°27'46.5"
UTM: Zone 10: 608600 m E., 5615000 m N.
geographic description: Cornwall Hills access road, 3.5 km from top junction
stratigraphic description: limestone block in argillaceous matrix
lithology: stylolitic carbonate
weight: 2.962 kg
fossils: sea urchin plates (1), ichthyoliths (2)
conodont fauna: *Neogondolella* sp. indet. (3)
ramiform elements (1)
period or epoch: Middle to Late Triassic
age: indeterminate
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157899
field number: J. Beyers, 1987; 87OF-B-CH-S14
latitude, longitude: 50°40'21.5", 121°28'22.9"
UTM: Zone 10: 607900 m E., 5614320 m N.
geographic description: Cornwall Hills access road, 4.35 km from top junction
lithology: fractured, oölitic, crinoidal, recrystallized limestone
weight: 2.833 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157900
field number: J. Beyers, 1987; 87OF-B-CH-S15
latitude, longitude: 50°39'36.7", 121°28'53.4"
UTM: Zone 10: 607330 m E., 5612925 m N.
geographic description: Cornwall Hills access road, 6.8 km from top junction, about 30 m above road
lithology: light grey, recrystallized, dolomitic limestone
weight: 3.878 kg
fossils: none
conodont fauna: ramiform elements (2)
period or epoch: indeterminate
age: indeterminate
remarks: "in situ" (thin section cut) is hand sample at 7.85 km from an andesite or basalt Eocene (W.R. Danner, oral commun., 1989) flow with small eruptive centre nearby.
****

GSC sample number: C-157862

field number: J. Beyers, 1987; 87OF-B-CH-V1
latitude, longitude: 50°41'30.9", 121°26'54.0"
UTM: Zone 10: 609600 m E., 5616500 m N.
geographic description: Cornwall Hills, bearing 315° to lookout; elevation 1970 m (6500 ft)
lithology: highly fractured, stylolitic, greenish-black radiolarian chert
weight: 2.600 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157863
field number: J. Beyers, 1987; 87OF-B-CH-V2
latitude, longitude: 50°41'29.1", 121°26'41.3"
UTM: Zone 10: 609850 m E., 5616450 m N.
geographic description: Cornwall Hills; elevation 1897 m (6260 ft)
lithology: carbonate in green basalt
weight: 4.060 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157864
field number: J. Beyers, 1987; 87OF-B-CH-V3
latitude, longitude: 50°41'22.6", 121°26'39.0"
UTM: Zone 10: 609900 m E., 5616250 m N.
geographic description: Cornwall Hills; elevation 1879 m (6200 ft)
lithology: green carbonate replacement of plagioclase basalt or andesitic flow
weight: 2.544 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157865
field number: J. Beyers, 1987; 87OF-B-CH-V4
latitude, longitude: 50°41'17.0", 121°26'43.0"
UTM: Zone 10: 609825 m E., 5616075 m N.
geographic description: Cornwall Hills; elevation 1864 m (6150 ft)
lithology: dark grey, recrystallized nodular micrite
weight: 2.733 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-157866
field number: J. Beyers, 1987; 87OF-B-CH-V5
latitude, longitude: 50°41'29.4", 121°26'59.2"
UTM: Zone 10: 609500 m E., 5616450 m N.
geographic description: Cornwall Hills; elevation 1964 m (6480 ft)
stratigraphic description: bedding attitude 148/21 NE
lithology: grey, medium coarse, crystalline limestone
weight: 3.563 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157867
field number: J. Beyers, 1987; 87OF-B-CH-V5-B
latitude, longitude: 50°41'29.5", 121°27'07.3"
UTM: Zone 10: 609340 m E., 5616450 m N.
geographic description: Cornwall Hills; elevation 1927 m (6360 ft)
stratigraphic description: bedding attitude 004/24 NE
lithology: dark grey, dolomitized, crinoidal, coated (oncolitic) grainstone with sea urchin spines, echinoderm plates, pellets and *Mesoendothyra*
weight: 3.618 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157868
field number: J. Beyers, 1987; 87OF-B-CH-V6
latitude, longitude: 50°41'32.7", 121°27'09.2"
UTM: Zone 10: 609300 m E., 5616550 m N.
geographic description: Cornwall Hills, approx. 200 m S of CH-V7; elevation 1933 m (6380 ft)
lithology: dark grey, dolomitized, irregularly recrystallized, algal coated limestone, with bryozoans
weight: 3.116 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157869
field number: J. Beyers, 1987; 87OF-B-CH-V7
latitude, longitude: 50°41'40.6", 121°27'15.4"
UTM: Zone 10: 609175 m E., 5616790 m N.
geographic description: Cornwall Hills; elevation 1376 m (6520 ft)
lithology: grey, crinoidal, oncolitic limestone

weight: 3.507 kg
fossils: peloids (1)
conodont fauna: *Metapolygnathus nodosus* (10)
ramiform elements (1)
period or epoch: Late Triassic
age: late Carnian
conodont assemblage: Fauna 8
remarks: Determinations by M.J. Orchard (1989). Thin section cut. Gulleys run downhill in southwesterly direction along both sides of CH-V7 and V6 outcrops.
****

GSC sample number: C-157870
field number: J. Beyers, 1987; 87OF-B-CH-V8
latitude, longitude: 50°41'45.0", 121°27'17.8"
UTM: Zone 10: 609125 m E., 5616925 m N.
geographic description: Cornwall Hills; elevation 2021 m (6670 ft)
lithology: dark grey, dolomitized, crinoidal limestone
weight: 3.490 kg
fossils: ostracode (1)
conodont fauna: *Neocavitella?* sp. (1)
Metapolygnathus sp. indet. (4+1?)
ramiform elements (2)
period or epoch: Late Triassic
age: probably Carnian
conodont assemblage: Fauna 8
remarks: Determinations by M.J. Orchard (1989).
****

GSC sample number: C-157871
field number: J. Beyers, 1987; 87OF-B-CH-V9
latitude, longitude: 50°41'45.0", 121°27'21.6"
UTM: Zone 10: 609050 m E., 5616925 m N.
geographic description: Cornwall Hills; elevation 2000 m (6600 ft)
lithology: dark grey, dolomitized, crinoidal, oölitic limestone
weight: 3.570 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
****

GSC sample number: C-117779
field number: M.J. Orchard, 1986; 86OF-CHR-1
latitude, longitude: 50°38'39.8", 121°28'33.8"
UTM: Zone 10: 607750 m E., 5611175 m N.
geographic description: Hat Creek road, 100 m SW of junction with Cornwall Hills road, 13 km W of Highway 1 turnoff
lithology: fractured and recrystallized micrite
weight: 2.306 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

remarks: Thin section cut.
****

GSC sample number: C-117780
field number: M.J. Orchard, 1986; 86OF-CHR-2
latitude, longitude: 50°38'29.0", 121°29'14.9"
UTM: Zone 10: 606950 m E., 5610825 m N.
geographic description: Hat Creek road, 1.05 km from junction with Cornwall Hills access road
stratigraphic description: bedding attitude 106/35 S; at 1 m in 10 m section
lithology: pelagic, fractured, stylolitic and recrystallized limestone, with thin-shelled *Halobia?* pelecypods
weight: 1.689 kg
fossils: ichthyoliths (1)
conodont fauna: platform elements (99), ramiform elements (44)
Neogondolella navicula
Epigondolella primitia
Metapolygnathus echinatus
M. nodosus
period or epoch: Late Triassic
age: early Norian
conodont assemblage: Fauna 9
remarks: Thin section cut. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-150000
field number: J. Beyers, 1987; 87OF-B-CHR-2-REC
weight: 8.610 kg
fossils: none
conodont fauna: *Epigondolella primitia* (1)
Epigondolella sp. indet. (5)
ramiform elements (1)
period or epoch: Late Triassic
age: early Norian
conodont assemblage: Fauna 9
remarks: Recollection of CHR-2. Determinations by M.J. Orchard (1989).
****

GSC sample number: C-117781
field number: M.J. Orchard, 1986; 86OF-CHR-3
latitude, longitude: 50°38'29.0", 121°29'14.9"
UTM: Zone 10: 606950 m E., 5610825 m N.
geographic description: Hat Creek road, 1.05 km from junction with Cornwall Hills access road
stratigraphic description: from small limestone lens or clast, at 8 m in short section
lithology: carbonate, some calcite-replaced ?radiolarians
weight: 1.818 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.

****

GSC sample number: C-117782
field number: M.J. Orchard, 1986; 86OF-CHR-4
latitude, longitude: 50°38'23.6", 121°29'30.4"
UTM: Zone 10: 606650 m E., 5610650 m N.
geographic description: Hat Creek road, 1.4 km from junction with Cornwall Hills road
lithology: well-bedded, quartz-rich limestone, recrystallized along fractures, with echinoderm plates
weight: 1.982 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.

****

GSC sample number: C-117783
field number: M.J. Orchard, 1986; 86OF-CHR-5
latitude, longitude: 50°38'23.6", 121°29'33.4"
UTM: Zone 10: 606590 m E., 5610650 m N.
geographic description: Hat Creek road, 1.45 km from junction with Cornwall Hills road
stratigraphic description: at top of 30 m section of cherty argillite and interbedded radiolarian chert, chert bedding attitude 100/39 S
lithology: chert
weight: 1.695 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate

****

GSC sample number: C-117784
field number: M.J. Orchard, 1986; 86OF-CHR-6
latitude, longitude: 50°38'17.2", 121°29'43.3"
UTM: Zone 10: 606400 m E., 5610450 m N.
geographic description: Hat Creek road, 1.9 km from junction with Cornwall Hills road, above road
stratigraphic description: bedding attitude 130/53 NE
lithology: mottled grey, fine grained, dolomitized carbonate; platy and laminated, brecciated, fractured micrite, with algal encrusted grains, few sea urchin spines and *Tubiphytes*
weight: 1.931 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.

****

GSC sample number: C-117785
field number: M.J. Orchard, 1986; 86OF-CHR-7

latitude, longitude: 50°38'15.8", 121°29'57.4"
UTM: Zone 10: 606125 m E., 5610400 m N.
geographic description: Hat Creek road, 2.2 km from junction with Cornwall Hills road
lithology: massive, carbonate-veined, recrystallized and fractured micrite
weight: 1.564 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-117786
field number: M.J. Orchard, 1986; 86OF-CHR-8
latitude, longitude: 50°38'16.0", 121°30'16.5"
UTM: Zone 10: 605750 m E., 5610400 m N.
geographic description: Hat Creek road, 2.5 km from junction with Cornwall Hills road, 1.5 m above road
lithology: extensively veined carbonate
weight: 1.806 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-117787
field number: M.J. Orchard, 1986; 86OF-CHR-9
latitude, longitude: 50°38'31.4", 121°31'18.3"
UTM: Zone 10: 604525 m E., 5610850 m N.
geographic description: Hat Creek road, 4.0 km from junction with Cornwall Hills road
stratigraphic description: from base of cliff above talus slope
lithology: sheared and layered, muddy, recrystallized limestone
weight: 1.333 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-117788
field number: M.J. Orchard, 1986; 86OF-CHR-10
latitude, longitude: 50°38'29.9", 121°31'24.7"
UTM: Zone 10: 604400 m E., 5610800 m N.
geographic description: Hat Creek road, 4.0 km from junction with Cornwall Hills road, above road
stratigraphic description: from talus block, at base of slope
lithology: flattened and recrystallized oöliths in layered fabric of medium grey, fine grained micrite

weight: 1.674 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (3)
ramiform elements (2)
period or epoch: probably Early Triassic
age: indeterminate
remarks: Thin section cut.
****

GSC sample number: C-157983
field number: J. Beyers, 1987; 87OF-B-CHR-10-REC
weight: 4.300 kg
fossils: none
conodont fauna: *Neospathodus* sp. indet. (1)
period or epoch: probably Early Triassic
age: indeterminate
remarks: Recollection of CHR-10.
****

GSC sample number: C-117789
field number: M.J. Orchard, 1986; 86OF-CHR-11
latitude, longitude: 50°38'30.9", 121°31'40.0"
UTM: Zone 10: 604100 m E., 5610825 m N.
geographic description: Hat Creek road, 4.3 km from junction with Cornwall Hills road
stratigraphic description: from talus block
lithology: broken and abraded grains, mud intraclasts, pellets, recrystallized fusulinids (*Neoschwagerina* or *Yabeina*) and crinoids in micrite
weight: 4.243 kg
fossils: ichthyoliths (1)
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Fusulinid determinations by W.R. Danner. Thin section cut.
****

GSC sample number: C-117790
field number: M.J. Orchard, 1986; 86OF-CHR-12
latitude, longitude: 50°38'38.4", 121°32'00.6"
UTM: Zone 10: 603690 m E., 5611050 m N.
geographic description: Hat Creek road, 4.7 km from junction with Cornwall Hills road
stratigraphic description: from base of cliff above talus slope
lithology: crinoidal, recrystallized micrite
weight: 1.478 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Nearby talus contains fusulinids.
****

GSC sample number: C-117791
field number: M.J. Orchard, 1986; 86OF-CHR-13

latitude, longitude: 50°38'21.5", 121°34'20.7"
UTM: Zone 10: 600950 m E., 5610475 m N.
geographic description: Hat Creek road, 9.2 km from junction with Cornwall Hills road, where east-west valley opens up into Hat Creek valley; from just left of barbed wire fence
stratigraphic description: bedding attitude 056/52 NW
lithology: white weathering, dark grey, silicified, fusulinid (*Yabeina*) micrite
weight: 1.964 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. Fusulinid determination by W.R. Danner.
****

GSC sample number: C-117792
field number: M.J. Orchard, 1986; 86OF-CHR-14
latitude, longitude: 50°38'21.5", 121°34'20.7"
UTM: Zone 10: 600950 m E., 5610475 m N.
geographic description: Hat Creek road, 9.2 km from junction with Cornwall Hills road, where east-west valley opens up into Hat Creek valley; from just left of barbed wire fence
stratigraphic description: 12 m above CHR-13; bedding attitude 056/52 NW
lithology: recrystallized and fractured, fusulinid (*Yabeina?*), crinoidal limestone, brecciated with silica cement
weight: 1.891 kg
fossils: none
conodont fauna: none
period or epoch: indeterminate
age: indeterminate
remarks: Thin section cut. CHR-15 is hand sample from here.
****

APPENDIX B: REVIEW OF PUBLISHED FAUNA AND FLORA FROM CACHE CREEK GROUP

NOTE: Central belt localities are preceded by Δ, and keyed to Figure 1.3 by a sequential alphabetical-numerical designation.

Bamber, *in* Trettin, 1980

Locality N of Keatley Creek, about 5 km E of confluence with Fraser River. Shown as F1 in Mortimer 1987.
Triassic to Recent corals.

Campbell and Tipper, 1971, p. 28

Δ A1. C-68097, 300 yards E of Mount Soues, Marble Range.
Neoschwagerina sp., *Cancellina* sp., *Boultonia* sp., *Kahlerina* sp., *Schwagerina* sp., *Reichelina* sp., *Chusenella* sp., determinations by C.A. Ross.
Age: Late Permian, Guadalupian, probably Wordian.

Δ A2. C-68094, 200 yards E of Mount Soues, Marble Range.
Yabeina sp., *Neoschwagerina* sp., *Schwagerina* sp., *Chusenella* sp., *Nankinella?* sp., *Kahlerina?* sp., determinations by C.A. Ross.
Age: Late Permian, Guadalupian.

Δ A3. C-68096, 100 yards S of forestry lookout on mountain W of Clinton.
Codonofusiella sp., *Neoschwagerina* sp., *Schwagerina?* sp. or *Parafusulina?* sp., *Kahlerina?* sp., determinations by C.A. Ross.
Age: Late Permian, probably late Guadalupian.

Cordey, 1986, p. 598, 600-601

Δ B4. C02, 121°27'44"; 50°41'13", 2.2 km S of fire lookout on Cornwall Hills.
Eptingium manfredi, E. sp. cf. *E. manfredi, Baumgartneria retrospina, Staurosphaera(?)* sp., *Stylosphaera(?) spinulosa, S.(?) japonica, Triassocampe* sp.
Age: Middle-Late Triassic.

C03, 121°19'39"; 50°48'27", W side of settlement of Cache Creek.
Canesium sp., *Capnodoce fragilis, C. kochi, C. sarisa, C.* sp. cf. *C. fragilis, C.* sp. cf. *C. malaca, C.* sp. cf. *C. media, C.* sp. cf. *primaria, Capnuchosphaera* sp., *Eptingium* cf. sp. *E. manfredi, Gomberellus* sp., *Oertlispongus* sp., *Paleosaturnalis* sp., *Paroertlispongus* sp., *Paurinella* sp., *Plafkerium longidentatum, Renzium* sp., *Stylosphaera(?) japonica, S.(?) spinulosa, Tetraspongodiscus* sp., *Triassocampe* sp., *T. deweveri, T.* sp., *Welirella* sp., *Xipha* sp.
Age: Middle to Late Triassic.

C05, 121°26'15"; 50°53'10", on Highway 12, 3.0 km W of Highway 97.
Pseudoalbaillella scalprata, P. sp. cf. *P. longuscornis.*
Age: probably Early Permian.

Δ B5. C07, 121°32'05"; 50°51'10", on Highway 12, 11.2 km from Highway 97.
Follicuculus scholasticus, F. ventricosus.
Age: Late Permian chert pebble in Cretaceous conglomerate.

Δ B6. C08, 121°36'51"; 50°47'05", 300 m N of Highway 12, 20.1 km W of Highway 97.
Eptingium sp. cf. *E. manfredi, Stylosphaera(?) compacta, S.(?) japonica, S.(?)* sp. cf. *spinulosa, Triassocampe* sp., *T.* sp. cf. *T. deweveri.*
Age: Middle-Late Triassic.

Cordey, Mortimer, De Wever and Monger, 1987

R1, along the British Columbia Railroad above Kelly Creek.
Triassocampe sp.
Age: Middle to Late Triassic.

R2, in roadcut along Pavilion-Kelly Lake Road in Hambrook Creek drainage.
Hsuum sp., *Pantanellium* sp., *Paronaella* sp., *Praeconocaryomma* sp., *Triactoma* sp., *Zartus* sp.
Age: Pliensbachian to Bajocian.

R3, in roadcut along Pavilion-Kelly Lake Road in Hambrook Creek drainage.
Emiluvia sp., *Hsuum* sp., *Napora* sp., *Paronaella* sp.
Age: probably Early Jurassic.

R4, NE of Pavilion.
Triassocampe sp., *Pseudostylosphaera* sp. cf. *P. nazarovi, Eptingium(?)* sp. cf. *E. manfredi.*
Age: Middle to Late Triassic.

Δ C7. R5, above Marble Canyon, S of Pavilion Creek.
Triassocampe sp., *Pseudostylosphaera* sp. cf. *P. nazarovi, Eptingium*(?) sp. cf. *E. manfredi.*
Age: Middle to Late Triassic.

Danner, 1985

Field Trip Stop 2, W of Highway 1, S of Cache Creek, near northern cutoff to Ashcroft.
Parafusulina sp.
Age: Middle Permian.

Danner *in* Shannon, 1982

NW of Cornwall Hills lookout.
Halobia(?) sp.
Age: Triassic.

Danner and Nestell *in* Campbell and Tipper, 1971, p. 27

C-68103, SW quarter of lot 873, 7 mi from W end of Loon Lake.
Schwagerina? sp. or *Parafusulina?* sp. in clasts.
Age: Late Permian, may be as old as early Leonardian.

C-68093, W side of Bonaparte River, on road 1 mi S of Fifyseven Creek.
Pseudoschwagerina cf. *uddeni*, *Schwagerina* sp., *Pseudofusulina* sp.
Age: Early Permian, Wolfcampian.

Near C-68103, W of Loon Lake.
Pseudodoliolina sp., *Schwagerina* sp. or *Parafusulina* sp., *Schubertella* sp.
Age: probably late Leonardian or early Guadalupian.

Localities on road near W end of Meadow Lake; on hill 4 mi NW of W end of Meadow Lake; and 3 mi SE of Clink Lake.
Pseudoschwagerina sp., *Pseudofusulina* sp., *Triticites* sp., *Quasifusulina* sp., *Schwagerina* sp., *Chalaroschwagerina* sp., *Schubertella* sp., *Nankinella* sp.
Age: Early Permian, Wolfcampian.

Duffell and McTaggart, 1952, p. 23

Locality near Blue Earth Lake.
Yabeina sp., *Schwagerina* sp.
Age: Middle or Late Permian.

Δ D8. Locality near E end of Marble Canyon, just S of road junction at the bend in Hat Creek.
Neoschwagerina sp., *Yabeina* sp.
Age: Middle or Late Permian.

Igo *et al.*, 1985

BC-85 to 107, along Old Cariboo road, W of Cache Creek post office.
Radiolaria: *Capnodoce* sp.
Conodonts: *Cypridodella* sp., *Diplododella* sp., *Epigondolella bidentata, Grodella delicatula, Neogondolella navicula, N. polygnathiformis, N. steinbergensis, Neohindeodella benderi, N. nevadensis, N. koeveskalensis, N. suevica, Neoplectospathodus mülleri, Neospathodus conservativus, N. homeri, Prioniodina* sp., *Xaniognathus* sp.
BC-94 corresponds to Orchard's (1984) locality 14.
Age: Triassic.

BC-63, along farm road 500 m S of junction of Highways 1 and 97.
Epigondolella or *Neogondolella polygnathiformis, Neohindeodella dropla.*
Age: Late Triassic.

BC-64, about 30 m E of BC-63 in roadcut.
Anchignathodus sp., *Diplognathodus* sp. cf. *D. coloradoensis, Hindeodella* sp., *Neogondolella* sp., *Neostreptognathodus(?)* sp., *Ozarkodina* sp.
Age: Permian.

BC-31, on E slope of Campbell Hill, SW of Cache Creek.
Neogondolella sp., *Ozarkodina* sp.
Danner reports *Parafusulina* sp.
Age: Permian.

BC-15 to 19, from hill just N of Carquile.
conodonts: *Neogondolella* spp.
radiolaria: *Canoptum* sp., *Capnodoce* sp., *Capnodoce(?)* sp., *Hsuum(?)* sp., *Latenifistula* sp., *Triassocampe* sp., *Triassocampe(?)* sp., *Xipha pessagnoi.*
Age: Late Triassic, probably Norian.

Δ E9. BC-20, from roadcut along Highway 12, at SW end of Pavilion Lake.
Hsuum(?) sp., *Pantanellium* sp., *Xipha* sp.
Age: Late Triassic or Early Jurassic.

Δ E10. BC-26 and 29, at S end of Marble Canyon.
Cratognathus kocki, Didymodella alternata, Diplododella(?) petrae-viridis, Enantiognathus ziegleri, Neogondolella bulgarica, Neospathodus sp.
Age: Middle Triassic, probably Anisian.

Δ E11. BC-40, along logging road between Medicine Creek and Ambusten Creek.
Emiluvia sp., *Pseudostylosphaera japonica, P.* sp. *A, P.* sp. *B, Triassocampe deweveri, T.* sp. *A, Yeharaia elegans.*
Parafusulina and *Schwagerina* occur in associated limestones.
Age: Triassic, probably Anisian.

Johnson and Danner, 1966

Locality 1 (F2 of Trettin, 1980, Δ L33), on ridge about 1 mi E of Jesmond road, 1.25 mi NW of Porcupine Creek, upper part.
Mizzia velebitana, Gyroporella nipponica, Macroporella apachena, Macroporella sp., *Oligoporella expansa, Physoporella* sp.
Age: as for locality 2.

Locality 2 (F4 of Trettin, 1980, Δ L35), on ridge about 1 mi E of Jesmond road, 2 mi SE of Mount Bowman.
Mizzia velebitana, Macroporella apachena.
Age: Late Permian, (early Ochoan? -Dhzulfian-), on basis of associated fusulinids (p. 425).

Monger and McMillan, 1984 *in* Mortimer, 1987

Δ F12. CC19, (F5 of Mortimer, 1987), Marble Canyon, at elevation 6000 ft.
Mid-Permian fusulinids.

Δ F13. CC20, (F6 of Mortimer, 1987), Marble Canyon.
Mid- to Late Permian fusulinids.

Δ F14. CC21, (F7 of Mortimer, 1987), Marble Canyon.
Late Permian fusulinids.

Δ F15. CC22, (F8 of Mortimer, 1987), Marble Canyon.
Late Permian fusulinids.

Mortimer, 1987

Δ G16. NM85-51A, F9, Marble Canyon.
Late Permian fusulinids, determination by W.R. Danner.

Δ G17. NM86-1B, F10, Marble Canyon.
Mid to Late Permian fusulinids.

P07, F11, along the British Columbia Railroad, SW of Hambrook Creek and Kelly Creek junction.
Middle or Late Triassic radiolarians, determination by F. Cordey.

Orchard, 1984

C-87070, loc. 1, N of 20 Mile House.
Hindeodus spp., *Streptognathodus elongatus?*
Age: probably Virgilian-Wolfcampian.

C-87067, loc. 2, NE of 20 Mile House.
Gondolella magna s.l., *Hindeodus* spp., *Idiognathodus* aff. *I. claviformis.*
Age: probably Desmoinesian-Missourian.

C-87073, loc. 3, NE of 20 Mile House.
Diplognathodus sp?, *Hindeodus* spp., *Neogondolella denticulata, N. postserrata* s.l., *N.* sp. *C.*
Age: Guadalupian, Capitanian.

C-102500, loc. 4, NE of 20 Mile House.
Neogondolella postserrata s.l.
Age: Guadalupian.

C-87071, loc. 5, SE of Loon Lake turnoff, E side of Highway 97.
Neogondolella postserrata s.l., *N.* sp. *B?*
Age: probably Guadalupian.

Δ H18. C-102552, loc. 7, E of Robertson Creek, SW of Maiden Creek.
Middle Permian? radiolarians, determination by B. Murchey.

C-87650, loc. 8, W of Carquile, along Highway 12.
Early Permian radiolarians, determination by B. Murchey.

C-87072, loc. 9, SW of Carquile, along Bonaparte River.
Hindeodus spp., *Neogondolella postserrata* s.l., *N.* sp. *B.*
Age: probably Guadalupian.

C-87068, loc. 11, NW of Cache Creek, W side of Highway 97.
Idiognathodus aff. *I. claviformis?*

Age: Atokan-Wolfcampian.

C-87084, loc. 12, S of loc. C-87068.
Hindeodus spp?, *Neogondolella bisselli, Streptognathodus elongatus.*
Age: Wolfcampian.

C-87069, loc. 13, N of Cache Creek, E side of Highway 97.
Neogondolella bisselli?, Streptognathodus elongatus?
Age: Wolfcampian.

C-87066, loc. 14, village of Cache Creek.
Neognathodus cf. *N. roundyi, Streptognathodus elongatus.*
Age: probably Virgilian-Wolfcampian.

C-87074, loc. 16, SW of Boston flats.
Hindeodus spp.
Age: probably Mid to Late Permian.

C-87076, loc. 17, SW of Boston Flats.
Idiognathodus aff. *I. claviformis?*
Age: Atokan-Wolfcampian.

C-102551, loc. 18, NW of Ashcroft Manor, W of Highway 1.
'Paragondolella' sp(p).
Age: Ladinian-Carnian.

C-87649, loc. 19, NW of Ashcroft Manor, W of Highway 1.
Post-Wolfcampian Permian radiolarians, determination by B. Murchey.

C-103592, loc. 20, S of McLean Lake, W of Ashcroft Manor.
Neogondolella sp. *A.*
Age: probably Guadalupian (Wordian?).

Δ H19. C-87078, loc. 21, Cornwall Hills.
Neogondolella cf. *N. navicula, 'Paragondolella'* sp(p).
Age: Early? Norian.

Δ H20. C-87077, loc. 22, Cornwall Hills.
Neospathodus waageni.
Age: Smithian.

Δ H21. C-87651, loc. 23, W of Cornwall Hills, Hat Creek Valley area.
Post-Wolfcampian (Leonardian?) Permian radiolarians, determination by B. Murchey.

Δ H22. C-87652, loc. 24, W of Cornwall Hills, Hat Creek Valley area.
Leonardian? radiolarians, determination by B. Murchey.

Δ H23. C-87079, loc. 26, SW of Cornwall Hills, Hat Creek Valley area.
Epigondolella abneptis A.

Age: Early Norian.

Δ H24. C-87055, loc. 27, Marble Canyon (MaCa3, Orchard, 1981).
'Epigondolella' primitia.
Age: Dienerian.

Δ H25. C-87058, loc. 28, Marble Canyon (MaCa1, Orchard, 1981).
Hindeodus n.sp. *A?, 'Neogondolella'* n.sp. *A, Neospathodus* n.sp. *A.*
Age: Late Carnian-Early Norian.

Shannon, 1982, Figure 30

Locality 219 (loc. 13 of Orchard, 1984);
Locality 329 (loc. 11 of Orchard, 1984);
Locality 63 (loc. 12 of Orchard, 1984);
Locality 181 (loc. 9 of Orchard, 1984);
Locality Ashcroft Ranch (loc. 20 of Orchard, 1984);
Locality 149 (loc. 21 of Orchard, 1984);
Locality 327 (loc. 22 of Orchard, 1984);
Locality 240 (loc. 26 of Orchard, 1984);
Locality 355 (loc. 15 of Orchard, 1984);
Locality 238 (loc. 16 of Orchard, 1984);
Locality 353 (loc. 17 of Orchard, 1984);
Locality 65 (loc. 19 of Orchard, 1984);
Locality 192 (loc. 7 of Orchard, 1984);
Locality 223 (loc. 5 of Orchard, 1984);
Locality 239 (loc. 12 of Orchard, 1984);
Locality Loon 4 (loc. 1 of Orchard, 1984);
Locality Loon 1 & 2 (loc. 3 & 4 of Orchard, 1984).

On the basis of unspecified fusulinids (determinations by W.R. Danner) the following localities were found to be of Mid Permian age:
Locality 192 (loc. 7 of Orchard, 1984);
Locality 126, Scottie Creek, about 2 km N of confluence with Bonaparte River;
Locality Ashcroft Ranch (loc. 20 of Orchard, 1984);
Δ I26. Locality 296, W of Cornwall Hills, in Hat Creek Valley area.

Thompson and Wheeler, 1942

Δ J27. On N shore of the middle of the three Pavilion Lakes, from float.
Nankinella? sp., *Staffella?* sp., *Schwagerina pavilionensis, S. pavilionensis* var. *acris, Yabeina columbiana, Y. minuta.*
Age: late Guadalupian.

Thompson, Wheeler and Danner, 1950

Δ K28. BC-2, BC-3, BC-4, from the lower 300 to 400 ft of the steeply N-dipping limestones in cliffs 0.3 mi NE of the road fork at the eastern entrance of Marble Canyon.
Codonofusiella duffelli, Schwagerina acris, S. andersoni?, Yabeina columbiana, Y.

minuta, Yabeina? n.sp.
Age: Upper Permian Zone of *Yabeina.*

Δ K29. BC-5, from limestone about 2.65 mi from K28 on road towards Cache Creek.
Codonofusiella duffelli, Schwagerina acris, Yabeina columbiana.
Age: Upper Permian Zone of *Yabeina.*

Travers, 1978

006, SE of village of Cache Creek.
Halobia sp., determination by E.A. Pessagno Jr.
Age: Triassic, probably Ladinian or Carnian.

Trettin, 1980

Δ L30. C-36830, Mount Soues.
Boultonia? sp., *Neoschwagerina* sp., determinations by C.A. Ross.
Age: Late Permian, Guadalupian, probably Wordian.

C-36836, Mount Soues, from talus.
Yabeina sp., *Chusenella?* sp., *Parafusulina?* sp., determinations by C.A. Ross.
Age: Late Permian, Guadalupian, probably late Wordian.

Δ L31. C-82 (F1), about 1.1 km N of Forestry Lookout on mountain W of Clinton.
Schwagerina sp., *Neoschwagerina* spp., determinations by C.A. Ross.
Age: Late Permian, Guadalupian, Wordian.

Δ L32. C-36707, Porcupine Creek.
Palaeotextularia s.s. or *Deckerella* sp., *Hamigordius* sp., determinations by B.L. Mamet.
Age: Late Permian.

Δ L33. F2 (F1 of Trettin, 1961), first major ridge NE of Kelly Lake-Jesmond road.
Glomospira sp., *Schwagerina* sp., *Verbeekina* sp., *Yabeina* sp., determinations by W.R. Danner; dasycladacean algae from this locality are listed under the heading "Johnson and Danner, 1966".
Age: Late Permian.

Δ L34. F3 (F3 of Trettin, 1961), second major ridge NE of Kelly Lake-Jesmond road.
Codonofusiella sp., *Schwagerina acris, Textularia* sp., *Yabeina minuta,* determinations by W.R. Danner.
Age: probably late Guadalupian (Capitanian), late Akasakan or late early Guadalupian, late Wordian (C.A. Ross).

Δ L35. F4 (F2 of Trettin, 1961), second major ridge NE of Kelly Lake-Jesmond road, about 4 km SE of Mount Bowman.

Tetrataxis sp., *Yabeina* sp., determinations by W.R. Danner; dasycladacean algae from this locality are listed under the heading "Johnson and Danner, 1966".
Age: Late Permian, probably slightly older than F2 and F3.

Δ L36. C-65048 (F5), W side of Mount Kerr.
Schwagerina sp., *Yabeina parvula,* determinations by C.A. Ross.
Age: Late Permian, Guadalupian, probably late Wordian.

Δ L37. C-80 (F6), about 1.7 km S of peak of Mount Bowman, from float.
Neoschwagerina sp.
Age: Late Permian, Guadalupian, Wordian.

Δ L38. C-81 (F7), 1.45 km E of junction of Barney Creek and Porcupine Creek.
Neoschwagerina sp., determination by C.A. Ross.
Age: Early or Late Permian, late Leonardian or early Guadalupian (early Wordian).

APPENDIX C: THIN SECTION DESCRIPTIONS

84MJO-CH3 Breccia of oöpelmicrite and mud clasts.
Angular clasts of oöpelmicrite and mud in dolomitic micrite matrix. A few muddy clasts are in solution contact with oölitic clasts.

87OF-B-CH-E11 Glassy basic flow.

87OF-B-CH-N-COMP Volcanic breccia composed of clasts of two lavas (blue green and light green) of unknown basic composition.

87OF-B-CH-NE-"lookout" Sheared carbonate.
Depressions produced by this process were subsequently filled with carbonate.

87OF-B-CH-N4 Recrystallized micrite.

87OF-B-CH-N7-B Fine-grained, dark-green basalt.

87OF-B-CH-N8 Radiolarian chert.

87OF-B-CH-N10 Oömicrite.
Unsorted, aligned oöliths in micrite.

87OF-B-CH-S1 Basalt flow with abundant calcite-filled amygdules.

87OF-B-CH-S3 Stylolitic, recrystallized, dolopelmicrite.

87OF-B-CH-S10 Recrystallized pelmicrite.
Contains a few authigenic ?feldspar grains, pseudomorphic after ?dolomite.

87OF-B-CH-S11 Stylolitic, bedded radiolarian chert with muddy interbed.

87OF-B-CH-S-"in situ" Andesite.
Aligned plagioclase crystals in glassy matrix.

87OF-B-CH-V1 Recrystallized, highly fractured, stylolitic, radiolarian chert.

87OF-B-CH-V3 Carbonate-recrystallized, plagioclase-rich amygduloidal flow.

87OF-B-CH-V5 Recrystallized micrite.

87OF-B-CH-V5-B Oncolite packstone.
Fractured and recrystallized oncolitic, dolomitic micrite. Contains sea urchin spines and other echinoderm debris, pellets, *Mesoendothyra*.

87OF-B-CH-V6 Coated oöpelintramicrite.
Fractured and stylolitic, peloidal, algal-coated oölitic micrite with admixture of algal and muddy intraclasts.

87OF-B-CH-V7 Oncolitic limestone.

86OF-CHR-1 Fractured and recrystallized micrite.

86OF-CHR-2 Recrystallized pelecypod dolopackstone or dolograinstone.
Pelagic, thin-shelled *Halobia?* pelecypods in fractured, stylolitic, dolomitized recrystallized micrite.

86OF-CHR-3 Fractured and recrystallized micrite.
Contains calcite-replaced ?radiolarians.

86OF-CHR-4 Quartz-rich carbonate.
Contains echinoderm plates.

86OF-CHR-6 Poorly washed, peloidal biointrasparite.
Peloidal and *Tubiphytes*-encrusted algal intraclasts in sparry micrite. Solution breccia formed by fractures and stylolites.

86OF-CHR-7 Bioturbated recrystallized micrite.
Recrystallized and fractured micrite with spar-filled burrows.

86OF-CHR-8 Fractured, recrystallized micrite.

86OF-CHR-9 Tectonically layered, recrystallized, muddy micrite.

86OF-CHR-10 Dolomicrite.

86OF-CHR-11 Recrystallized intramicrite.
Broken and abraded peloidal and muddy intraclasts in recrystallized micrite that contains fusulinids and echinoderm plates. Stylolites concentrate organic matter and mud.

86OF-CHR-12 Recrystallized, sparse biomicrite.
Fractured, stylolitic and recrystallized micrite with crinoids.

86OF-CHR-13 Fractured, silicified biomicrite.
Contains recrystallized fusulinids.

86OF-CHR-14 Fractured micrite.
Partially replaced by microcrystalline quartz.

86OF-CL-1 Dolobiomicrite.
Medium to coarsely crystalline dolomite replaces micrite with *Yabeina* and *?Glomospira* and echinoderm plates.

86OF-CL-2 Peloidal, ?fusulinid, recrystallized biomicrite.

86OF-CL-3 Siliceous dolomicrite.
Anhedral, pressure-dissolved quartz replaces secondary, finely to coarsely crystalline, mostly euhedral dolomite in carbonate matrix.

86OF-HTC Recrystallized, packed biodolomicrite.
Slightly siliceous, dolomitic, recrystallized micrite with crinoids, algae, fusulinids and the textularid *Glomospira.*

87OF-B-J-A6-B Recrystallized sparsely crinoidal biopelmicrite.

86OF-B-JAR-29 Recrystallized biointradolomicrite.
Stylolitic, dolomitic micrite with admixture of muddy, dasycladacean-bearing, micrite intraclasts.

86OF-B-JAR-97 Dolomitic algal mat.
Laminae are fine-grained pelletal algal micrite. Cement in voids is primarily euhedral dolomite.

86OF-B-JAR-106 Algal carbonate.
Algal laminations with dolomite- and calcite-filled voids are overlain by calcareous, ?dolomitic eolian mud.

87OF-B-J-B2 Silicified, largely dolomitized, peloidal micrite.

87OF-B-JCk-1 Dolomicrite.
Angular, ?algal, muddy pseudoclasts, formed by evaporation deformation, in more porous dolomicrite.

87OF-B-JCk-2 Dolomitic micrite.

87OF-B-JCk-3 Micrite replaced by chert.

87OF-B-JFT-"LEFT" Fractured, muddy recrystallized biomicrite.

87OF-B-J-I Dolomitized and nodular biopelmicrite.
Microcrystalline dolomite surrounds and replaces muddy, micritic nodules. Micrite of the nodules contains peloids and many small circular shapes of unknown origin. Some of these are probably algal.

87OF-B-JR-64 Recrystallized bored biomicrite.
Fractured and recrystallized grainy micrite. Contains dolomite-filled borings, algal structures and pelecypod shells.

87OF-B-J-T4 Algal-laminated dolomitic pelmicrite.
Finely laminated, pelletal algal micrite. Void cement partially dolomitic.

87OF-B-J-T8 Recrystallized micrite.

87OF-B-MtS Silicified micrite.

87OF-B-NPorcCk-1 Crinoidal oöpelmicrite or grainstone.
Flattened oöliths or pellets in crinoidal micrite.

87OF-B-NPorcCk-3 Aphanitic quartz (argillite) alternates with thin layers of

pelmicrite.

87OF-B-PorcCk-8 Dolomitic oöpelmicrite.

86OF-PVR-1 Dolomitic solution microbreccia.

86OF-PVR-2 Dolomitic nodular micrite.
Partially dolomitic micrite in dolomitized matrix.

86OF-PVR-3 Oödolomicrite.
Oöliths and a few peloids in fractured, stylolitic and dolomitic micrite.

86OF-PVR-A Recrystallized packed biomicrite.
Fractured, stylolitic, recrystallized micrite with pelagic shell debris.

86OF-PVR-B Fossiliferous recrystallized sparry micrite.

87OF-B-PVR-E Dolomitic nodular micrite.
Partially dolomitic micrite in dolomitized matrix.

87OF-B-UHC-VOLC Glassy ?andesitic flow.

APPENDIX D: CORNWALL HILLS LOOKOUT ACCESS ROAD TRAVERSE

This odometer-supported, downhill traverse of the lookout access road at Cornwall Hills is illustrated in Figure 3.21. The odometer reads 0.0 km at the top junction by the lookout.

0.1 km: recrystallized, much weathered, medium grey limestone
0.22 km: grey limestone at 2nd junction from top; sample CH1 (MJO collection)
0.38 km: oölitic limestone; sample CH-N10
0.48 km: limestone, probably equivalent of CH-N5; sample CH2 (MJO collection)
0.75 km: calcareous (replacement) basalt flow with calcite-filled reddish amygdules; sample CH-S1
0.85-0.88 km: siliceous argillite, followed by limestone breccia of sample CH3 (MJO collection)
0.9 km: siliceous argillite followed by tuff
1.15 km: grey argillaceous tuff, with occasional limestone clasts
1.27-1.30 km: grey argillaceous tuff
1.35-1.38 km: argillaceous tuff, followed by blue-green basalt
1.44 km: greenish, highly weathered tuff
1.48-1.55 km: succession of white-weathering, light green-grey porphyry, basalt, siliceous argillite, and a darker, orange-brown weathering porphyritic deposit
1.55-1.56 km: limestone; samples CH5 (MJO collection) and CH5-REC
1.56-1.60 km: siliceous tuff
1.65-1.70 km: lithic (limestone) tuff; samples CH8 (MJO collection) and CH8-REC (at 1.70 km)
1.79-2.05 km: volcanigenic breccia
2.05-2.10 km: fine grained, dark grey micrite, with stylolites and poorly preserved oöids; sample CH-S2 (at 2.10 km)
2.13 km: fractured, stylolitic and muddy micrite; sample CH-S3
2.15 km: dark grey, fine grained, argillaceous micrite, with stylolites on weathered surface; sample CH-S4
2.20-2.29 km: siliceous lithic (carbonate) tuff
2.30-2.32 km: limestone beds interbedded with chert; samples CH-S5 to CH-S9
2.35-2.40 km: deformed beds of volcanigenics with occasional limestone clasts
2.4 km: recrystallized limestone block in deformed volcanic deposit; sample CH-S10
2.4-2.45 km: volcanigenic deposit
2.45 km: stylolitic, grey-green, bedded radiolarian chert with muddy interbeds; bedding is variable and contorted; sample CH-S11
2.46 km: thin bedded radiolarian chert, in contorted beds; sample CH-S12
2.48-3.00 km: volcanigenic deposit
3.1-3.45 km: limestone clasts in argillaceous tuff; sample CH16 (MJO collection; at 3.1 km)
3.5 km: very fine grained, fractured limestone block with stylolites on weathered surface, in argillaceous matrix; sample CH-S13
3.6 km: argillaceous tuff
4.34 km: argillaceous tuff

4.35 km: oölitic, crinoidal, brecciated? and recrystallized micrite; sample CH-S14
4.38-4.9 km: argillaceous tuff
4.9 km: flaggy limestone; sample CH17 (MJO collection)
5.2 km: argillaceous tuff
5.3 km: pale grey, white weathering tuff
5.35-5.4 km: argillaceous tuff
5.6 km: argillaceous tuff
6.2 km: argillaceous tuff
6.8 km: light grey, dolomitic, recrystallized micrite; sample CH-S15, approximately 30 m above road
7.2 km: dolomitic limestone; sample CH18 (MJO collection), at the "Mile 1" marker
7.85 km: Eocene andesite (basalt?); sample "in situ"
7.9-8.00 km: siliceous argillite
8.7 km: junction with Oregon Jack Creek road