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DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 156

A STANDARD FOR TRIASSIC TIME

E. T. Tozer

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PREFACE

This bulletin provides a summary of the data on the sequence and distribution of Triassic ammonoids in Canada. These data permit the recognition of a new standard, based on a sequence of thirty-one ammonoid zones. The standard will provide a means of expressing accurately and without ambiguity the age of marine Triassic rocks in Canada.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, August 20, 1966

BULLETIN 156 — Eine Zeitnorm für den Verlauf des Trias.

Von E. T. Tozer

Eine Zusammenfassung der Angaben über die Reihenfolge und Verbreitung der Trias-Ammoniten in Kanada und Aufstellung von einunddreissig Ammonitenzonen. Viele der Leitformen — einschliesslich fünf neuer Ammonitenarten — sind abgebildet.

БЮЛЛЕТЕНЬ 156 — Стандарт триасового времени.

Э. Т. Тозер

Содержит сводку данных о последовательности и распределении триасовых аммоноидей Канады и определение тридцати одной аммонитовой зоны. Даются изображения многих важных окаменелостей, включая таковые пяти новых видов.

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A STANDARD FOR TRIASSIC TIME

Abstract

A summary of the data on the sequence and distribution of Triassic ammonoid faunas in Canada is provided. From these data a sequence of thirty-one ammonoid zones is recognized. The zones are grouped into stages and, where appropriate, substages. In the Lower Triassic four stages (Griesbachian, Dienerian, Smithian, and Spathian) are recognized; in the Middle Triassic, two (Anisian and Ladinian); in the Upper Triassic, three (Karnian, Norian, and Rhaetian). The sequence of stages, substages, and zones, provides a standard for expressing the age of marine Triassic rocks in Canada. Five new species of ammonoids are described (*Otoceras concavum, Olenikites pilaticus, Gymnotoceras chischa, Progonoceratites poseidon, Trachyceras obesum*).

Résumé

L'auteur résume les données existantes sur la succession et la répartition des faunes d'ammonoïdés du Trias au Canada. Ces données permettent de reconnaître une succession de 31 zones d'ammonoïdés. Les zones sont groupées en étages et, au besoin, en sous-étages. On reconnaît quatre étages dans le Trias inférieur (Griesbachien, Dienerien, Smithien, et Spathien); deux dans le Trias moyen (Anisien et Ladinien); trois dans le Trias supérieur (Carnien, Norien et Rhétien). La succession des étages, des sous-étages et des zones nous donne un étalon pour déterminer l'âge des roches marines du Trias au Canada. L'auteur décrit cinq nouvelles espèces d'ammonoïdés (*Otoceras concavum, Olenikites pilaticus, Gymnotoceras chischa, Progonoceratites poseidon, Trachyceras obesum*).

INTRODUCTION

In the Triassic, as in the Jurassic and Cretaceous, differences between successive ammonoid faunas provide the principal basis for dating rocks of marine deposition. This bulletin summarizes what is known regarding the sequence of Triassic ammonoid faunas in Canada and provides a standard, based on ammonoid zones, that can be used to express the age of marine Triassic rocks in Canada. The broader problems of the classification of the Triassic in North America are treated in a paper prepared with Dr. N. J. Silberling of the United States Geological Survey (Silberling and Tozer, *in press*).

The arrangement of ammonoid zones found in this bulletin, as in the paper prepared with Silberling, should not be regarded as a provincial classification, proposed in order to avoid coping with the problems of correlating with a well-established standard. For the Triassic there is no such standard. Some zones in the standard schemes (Mojsisovics, *et al.*, 1895; Spath, 1934; Kummel, 1957, p. L124) are apparently arranged in the wrong order (Tozer, 1965c). Others, mentioned below, are probably based on condensed sequences, and contain faunas of more than one age. The time is ripe for the erection of a new standard for the Triassic System, and it is hoped that the summaries of the North American sequence prepared by Silberling and the writer will further this end.

This bulletin represents an amplified revision of summaries previously prepared by McLearn (1953) and the writer (1961a).

Illustrations of most of the index ammonoids are provided on Plates I to X. Figures of a substantial number of other fossils will be found in the report on the Triassic in the series *Illustrations of Canadian Fossils* (Tozer, 1962). Many of the age determinations adopted in that report are now out of date and it should be used, in conjunction with this bulletin, mainly as a source of illustrations. A revised edition of this number of *Illustrations of Canadian Fossils* is in preparation. References to more detailed palaeontological reports will be found in the pages that follow.

This bulletin is concerned almost entirely with pelagic faunas, mainly with ammonoids, and to a lesser extent with the thin-shelled pelagic bivalves, such as *Claraia, Posidonia, Daonella, Halobia,* and *Monotis,* that commonly occur with the ammonoids. It has long been recognized that these bivalves are very useful for stratigraphic purposes. Ultimately they, like the ammonoids, will probably provide a refined zonal sequence for the Triassic.

MS. received March 1966; revised December 1966.

Benthonic Triassic faunas, including bivalves, brachiopods, corals, etc., are known from many localities, but as yet most are too imperfectly known for their stratigraphic significance to be accurately assessed. For this reason little mention will be made of the benthonic faunas.

Field Work and Acknowledgments

All field observations, unless otherwise stated, were made by the writer between 1953 and 1965. In 1953 field work was done in southern Yukon and on Vancouver Island; from 1954 to 1958 and in 1961, 1962, and 1964, in the Arctic islands; in 1960, and from 1963 to 1965 in northeastern British Columbia. A short visit was made to Tyaughton Creek, southwestern British Columbia, in 1963. Most of western British Columbia and the whole of northern Yukon have not been visited by the writer. From these areas the conclusions are based on studies made by the writer on material obtained by others.

Dr. N. J. Silberling gave valuable advice, information, and assistance in the field. A substantial increase in the data available resulted from field work done when he accompanied the writer to northeastern British Columbia in 1965. Thanks to his assistance the table of Canadian Triassic ammonoid zones as it stands now is based mainly on stratigraphic relationships observed in Canada, and this joint field work led for the first time to the recognition in sequence of the Anisian Caurus, Varium, and Deleeni Zones. It also led to the discovery of the Poseidon Zone in the Ladinian, and to an improved understanding of the Upper Ladinian and Karnian Zones. Dr. Silberling also assisted in the identification of the halobiid bivalves.

Collections for identification and unpublished stratigraphic data have been provided by numerous individuals, and these materials are gratefully acknowledged. They have been furnished by A. Sutherland Brown of the British Columbia Department of Mines and Petroleum Resources; geologists of Shell and Triad Oil Companies and of what was known in 1961 as Round Valley Oil Company; and the following officers of the Geological Survey: E. W. Bamber, R. B. Campbell, J. G. Fyles, H. Gabrielse, D. K. Gibson, L. H. Green, E. J. W. Irish, J. A. Jeletzky, E. W. Mountjoy, J. E. Muller, D. K. Norris, B. R. Pelletier, J. H. Roddick, J. G. Souther, G. C. Taylor, D. Tempelman-Kluit, R. Thorsteinsson, H. W. Tipper, and J. O. Wheeler. Important collections were also made by C. H. Crickmay, V. Dolmage and H. C. Gunning while working for the Geological Survey. The contributions made by Jeletzky, Pelletier, and Thorsteinsson have been invaluable. Jeletzky first established the sequence between what are now known as the lower and upper parts of the Suessi Zone, a sequence that has since been found to be applicable over a wide area. Pelletier made the collections that permitted the identification of the Chischa and Subasperum Zones. In the Arctic islands, Thorsteinsson discovered many of the Lower Triassic sections — subsequently studied by the writer — that have provided critical data. The writer also wishes to acknowledge his debt to the late F. H. McLearn who, until his death in 1964, was a constant source of advice and encouragement. Dr. McLearn's own important contributions are documented in detail in the pages that follow.

Dr. Bernhard Kummel of Harvard University generously provided photographs of type specimens of the Lower Triassic ammonoids from the Salt Range and Himalayas, described by Diener, Krafft, and Waagen.

The following persons kindly made available for study specimens of Triassic ammonoids housed in European Museums: Dr. Otto Renz (Naturhistorisches Museum, Basel); Professors H. K. Erben and Klaus Müller (Inst. für Paläontologie, Bonn); Dr. A. Tasnádi Kubacska (Magyar Allámi Földtani Intézet, Budapest); Mr. A. G. Brighton and Dr. C. L. Forbes (Sedgwick Museum, Cambridge); Professor Tove Birkelund (Mineralogisk Museum, Copenhagen); Professor J. Dufour (Technische Hogeschool, Delft); Dr. P. N. Varfolomeev (Central Geological Museum, Leningrad); Dr. G. G. Martinson and Dr. Helen S. Stankevich (Karpinsky Museum, Leningrad); Dr. M. K. Howarth (British Museum (Natural History), London); Dr. A. A. Shevyrev (Palaeontological Institute, Moscow); Dr. H. Zoebelein and Dr. U. Pflaumann (Bayerische Staatsammlung für Paläontologie, Munich); Dr. Harry Mutvei (Naturhistoriska Riksmuseet, Stockholm); Dr. K. Staesche and Dr. M. Warth (Staatliches Museum für Naturkunde, Stuttgart); Professor Dr. R. Sieber (Geologische Bundesanstalt, Vienna); Dr. Heinz Kollmann (Naturhistorisches Museum, Vienna); Professor Dr. H. Zapfe (Paläontologisches Institut der Universität, Vienna), Professor A. Gansser (Eidg. Technische Hochschule, Zurich).

At several institutions workers active in Triassic biostratigraphy kindly showed the writer their collections of recently obtained, undescribed material. No direct reference is made to such material in this report, but the opportunity to see these collections enabled the writer to check a number of identifications and conclusions. Professor R. Trümpy (Zurich) showed the writer collections from East Greenland and Portuguese Timor. Material from Spitsbergen was shown to the writer by Mr. W. B. Harland and Dr. J. R. Parker in Cambridge; by Marianna V. Korchinskya in Leningrad; and by Dr. O. Kulling in Stockholm. New collections from Northeastern Siberia were demonstrated in Leningrad by Dr. Yu. N. Popov, Mr. M. Vavilov, and Mr. Yu. Arkhipov. Dr. L. D. Kiparisova (Leningrad) showed new collections from Primor'ye, and Dr. A. A. Shevyrev (Moscow) demonstrated his collections from the Triassic rocks of the Southern U.S.S.R. Norian ammonoids from Czechoslovakia were seen, thanks to Dr. Vanda Andrusovova of Bratislava.

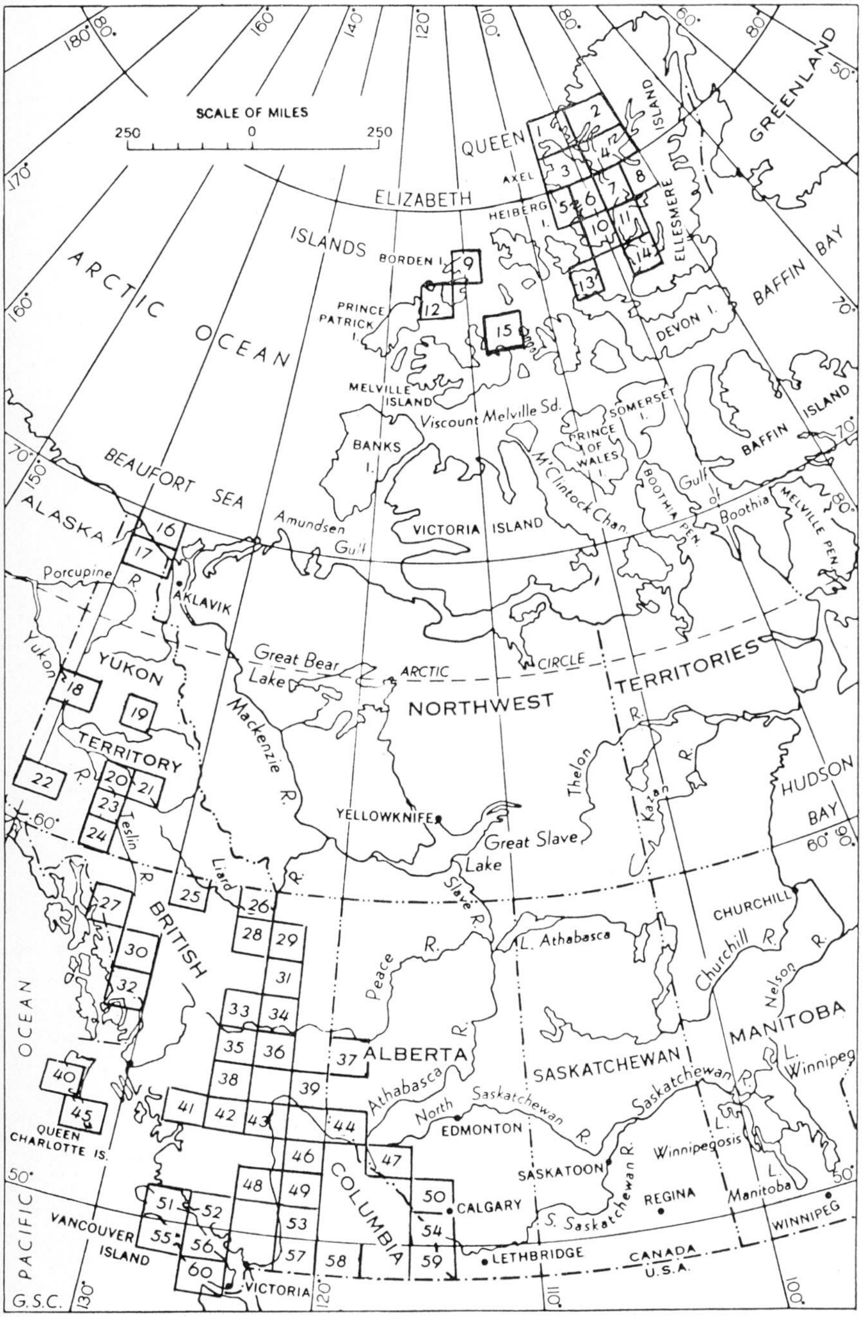
Dr. A. Tollmann and his wife, Dr. Edith Kristan-Tollmann, kindly provided an opportunity to examine classical Upper Triassic localities in Salzkammergut, Austria. Dr. Riccardo Assereto of Milan performed a similar service for the Middle Triassic formations of Lombardy.

DISTRIBUTION OF TRIASSIC AMMONOIDS IN CANADA

For the purpose of summarizing the data on the distribution of Triassic ammonoids in Canada four main regions may be distinguished: the Arctic islands, and the eastern, western, and northern parts of the Cordillera (Fig. 1). Marine Triassic rocks with ammonoid faunas are exposed in all four regions. Triassic rocks also occur at depth beneath the Western Plains of northern Alberta and northeastern British Columbia. Little is known of the faunas of the subsurface Triassic formations, but the few fossils that have been recorded clearly show that these formations are intimately related to the exposed rocks of the Eastern Cordillera (Hunt and Ratcliffe, 1959, p. 569). It is not the purpose here to describe in any detail the geology of the Triassic formations, however, the salient features within each region of exposures are briefly summarized (*see* Table I).

The Triassic rocks of the *Arctic islands* were deposited in the Sverdrup Basin. In the marine facies the record extends from the Lower Griesbachian to the Upper Norian. The sequence of Lower Triassic ammonoid zones is unusually complete, and it is for this segment of time that the section in the Arctic islands contributes data unavailable elsewhere. Definitions of the formations recognized in the Arctic islands will be found in reports already published (Tozer, 1961b; 1963c). The Bjorne and Blind Fiord Formations are essentially contemporary and of Lower Triassic age. The Bjorne beds, mainly sandstone and conglomerate, were deposited on the margins of the Sverdrup Basin; they have yielded a few Griesbachian ammonoids. The Blind Fiord rocks, composed of siltstone, shale, and sandstone, deposited within the Basin, contain the best known sequence of Griesbachian, Dienerian, and Smithian ammonoid zones. In places beds of Spathian age are also included in the Blind Fiord Formation.

The Schei Point Formation overlies the Bjorne and consists of calcareous siltstone, shale and sandstone with ammonoid faunas of Anisian, Ladinian, and Karnian age. The Blaa Mountain Formation, composed of shale, siltstone and sandstone, overlies the Blind Fiord beds within the Sverdrup Basin. In most places, five members have been distinguished within the Blaa Mountain Formation. The Lower Shale member (1) has ammonoid faunas of Spathian, Anisian, Ladinian, and Lower Karnian age. Ammonoid zonation shows that both the upper and lower boundaries of this member are diachronous. The Lower Calcareous member (2) in places includes beds of Upper Ladinian age but is more commonly wholly Karnian. The Middle Shale (3), Upper Calcareous (4), and Upper Shale (5) members all contain Karnian ammonoids.



1 Cape Stallworthy 560 D (A)
2 Otto Fiord 340 C (A)
3 Bukken Fiord 560 A (A)
4 Greely Fiord west 340 B (A)
5 Middle Fiord 59 G (A)
6 Strand Fiord 59 H (A)
7 Eureka Sound north 49 G (A)
8 Canyon Fiord 49 H (A)
9 Borden Island 79 F (A)
10 Glacier Fiord 59 E (A)
11 Eureka Sound south 49 F (A)
12 Ballantyne Strait 89 D (A)
13 Cornwall Island 59 C (A)
14 Baumann Fiord 49 C (A)
15 Domett Point 79 A (A)
16 Herschel Island 117 C (N)
17 Blow River 117 A (N)
18 Dawson 166 B & C (N)
19 Nash Creek 106 D (N)
20 Glenlyon 105 L (W)
21 Tay River 105 K (N)
22 Kluane Lake 115 F & G (W)
23 Laberge 105 E (W)
24 Whitehorse 105 D (W)
25 McDame 104 P (W)
26 Toad River 94 N (E)
27 Tulsequah 104 K (W)
28 Tuchodi Lakes 94 K (E)
29 Fort Nelson 94 J (E)
30 Telegraph Creek 104 G (W)
31 Trutch 94 G (E)
32 Iskut River 104 B (W)
33 Fort Grahame 94 C (W)
34 Halfway River 94 B (E)
35 Manson River 93 N (W)
36 Pine Pass 93 O (E)
37 Grand Prairie 83 M (P)
38 Fort Fraser 93 K (W)
39 Monkman Pass 83 I (E)
40 Graham Island 103 F (W)
41 Whitesail Lake 93 E (W)
42 Nechako River 93 F (W)
43 Prince George 93 G (W)
44 Mount Robson 83 E (E)
45 Moresby Island 103 C (W)
46 Quesnel Lake 93 A (W)
47 Brazeau 83 C (E)
48 Taseko Lakes 92 O (W)
49 Bonaparte Lake 92 P (W)
50 Calgary 82 O (E)
51 Alert Bay 92 L (W)
52 Bute Inlet 92 K (W)
53 Ashcroft 92 I (W)
54 Kananaskis Lakes 82 J (E)
55 Nootka Sound 92 E (W)
56 Alberni 92 F (W)
57 Hope 92 H (W)
58 Penticton 92 E (W)
59 Fernie 82 G (W)
60 Cape Flattery 92 C (W)

FIGURE 1. Map areas (NTSystem, 1:250,000) referred to in the text. (A) indicates that the Triassic rocks within the area are representative of the Arctic islands region; (E), the Eastern Cordillera; (W) the Western Cordillera; (N) the Northern Cordillera. The area marked (P) is the only one in the Interior Plains where Triassic ammonoids have been recovered from drill-holes.

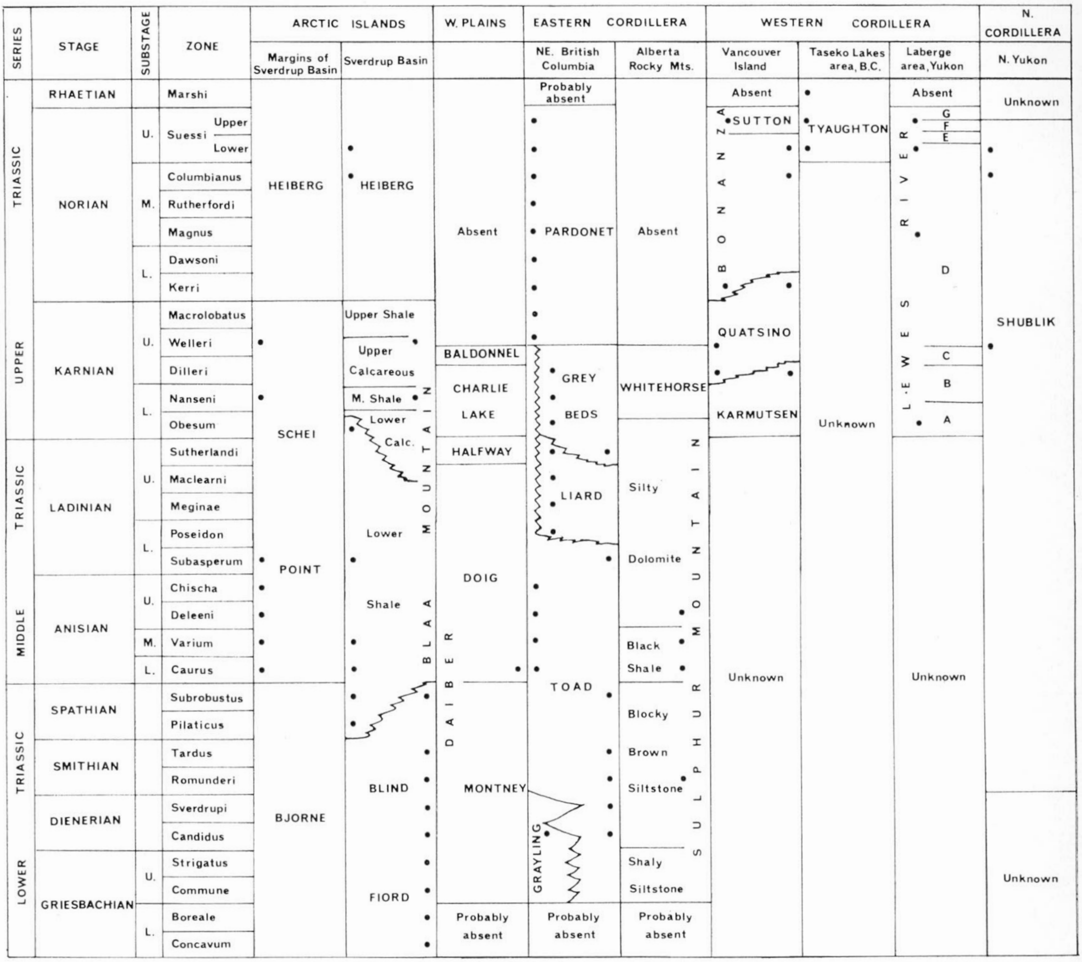


TABLE I. *Correlation Table Showing Names of Principal Triassic Formations.*
The names of many local rock units in the Western Cordillera are not included. Occurrences of faunas that permit the recognition of zones is indicated by dots (•).

The Heiberg Formation overlies both the Schei Point and Blaa Mountain Formations. The Heiberg consists mainly of sandstone, much of it of non-marine deposition, in which ammonoids are very rare. Middle and Upper Norian marine faunas occur in the lower part of the Heiberg. The upper beds are entirely non-marine and possibly include beds of Rhaetian age.

Triassic rocks of the *Eastern Cordillera* are exposed in the Foothills and Eastern Ranges of the Rocky Mountains, in western Alberta, and in northeastern British Columbia. All the rocks are sedimentary and marine. In northeastern British Columbia they provide a basis for the sequence of ammonoid zones from the Anisian to the Upper Norian. Lower Triassic ammonoids are also known.

This type of development, recording more or less continuous marine sedimentation from the Upper Griesbachian to the Upper Norian, is not known in areas west of the Rocky Mountains.

The nomenclature adopted for the Triassic formations in northeastern British Columbia is essentially that of Pelletier (1964, p. 4). In ascending order, above the Permian rocks, Pelletier recognizes the Grayling, Toad, Liard, Grey beds, and Pardonet Formations. These formations consist mainly of siltstone, fine-grained sandstone, and limestone. Study of directional current features by Pelletier (1965), and the distribution of the facies belts, leave no doubt that most or all of the clastic sediment was derived from the east or northeast. The Grayling, Toad, and Pardonet Formations contain only relatively fine grained clastic rocks. Coarser grained sediments occur in the Liard and Grey beds. The Liard Formation and Grey beds represent the wedges of clastic rock derived from the east. In the western Foothills these two formations lose their identity and merge with the Toad Formation. This is shown by the sections in the western parts of the Tuchodi Lakes and Toad River areas, where the Pardonet Formation rests directly upon the Toad.

The Grayling Formation consists of grey shale and sandstone and is typically developed in the Toad River area. Towards the south the Grayling beds lose their identity and their equivalents occur in beds that are inseparable from the Toad Formation (Pelletier, 1963, p. 75; Tozer, 1965a, p. 5). The Grayling Formation contains Griesbachian bivalves and Dienerian ammonoids.

The Toad Formation, in Toad River and Tuchodi Lakes areas, consists of dark grey calcareous siltstone and shale overlying the Grayling Formation. There the Toad contains faunas of Smithian, Spathian, and Anisian age. To the south in Halfway River area, where rocks of Toad lithology directly overlie the Permian, the formation contains Dienerian ammonoids as well as Smithian, Spathian, and Anisian faunas. South of Peace River, in Monkman Pass area, Lower Ladinian ammonoids (Subasperum Zone) occur in the Toad Formation. In the western parts of Toad River and Tuchodi Lakes areas, where the Liard Formation and Grey beds are not recognizable, the Toad Formation possibly includes beds of Upper Ladinian and Karnian age, but for this there is no palaeontological proof.

The Liard Formation consists of sandstone and siltstone, overlying the Toad. The boundary with the Toad is commonly transitional. As interpreted by Pelletier, the Liard includes the "Flagstones" and "Dark Siltstones", named by McLearn (McLearn and Kindle, 1950, p. 35) and the Mount Wright Formation of Colquhoun (1960, 1962). The Liard Formation contains ammonoid zones that range in age from Lower Ladinian (Poseidon Zone) to Upper Ladinian (Sutherlandi Zone).

The strata that overlie the Liard Formation have not been formally named. Pelletier (1964) uses the term Grey beds, proposed by McLearn. In Trutch area and the eastern part of Halfway River area Pelletier recognized three divisions within the Grey beds and has tentatively correlated them with the Halfway, Charlie Lake, and Baldonnel Formations, which were named for the subsurface formations that occur east of the Foothills (Hunt and Ratcliffe, 1959; Armitage, 1962). Pelletier draws the Liard–Grey beds boundary at the appearance of thick-bedded sandstone (Halfway). In Toad River, Tuchodi Lakes, and Trutch areas this sandstone appears immediately above the Upper Ladinian Sutherlandi Zone. To the south, on Peace River, in Halfway River area, the Sutherlandi Zone occurs in the lower part of the Grey beds. In Trutch and Halfway River areas the higher Grey beds, above the basal thick-bedded sandstone, include, first, a sequence of beds that include dolomite breccia. These beds are believed to represent an interval of evaporites and to be correlative with the Charlie Lake Formation. The highest Grey beds are commonly carbonates and are tentatively correlated with the Baldonnel Formation by Pelletier. No ammonoids are known from the presumed equivalents of the Charlie Lake and Baldonnel Formations. Bivalves and brachiopods, for example the Mahaffy Cliffs and *Lima poyana* faunas of McLearn, (McLearn and Kindle, 1950, p. 35) are known. These faunas are Karnian but their exact age is uncertain. The Grey beds are well developed around Ewe Mountain and Mount McLearn in Toad River area. The sequence consists of sandstone, siltstone, and limestone. These beds have not yet been subdivided, but the highest beds, as to the south, are mainly carbonates and are possibly correlative with the Baldonnel Formation. In this area the lower and middle parts of the Grey beds contain Karnian ammonoids (Obesum, Nanseni, and Dilleri Zones).

The Pardonet Formation overlies the Grey beds, or, in the westernmost sections, the Toad Formation. The Pardonet consists mainly of bituminous limestone and calcareous siltstone. Coquinoid rock composed of *Halobia* and *Monotis* shells is a substantial component. In Toad River area the lowest Pardonet beds are Upper Karnian (Welleri Zone); in Halfway River area to the south, the basal Pardonet strata are uppermost Karnian (Macrolobatus Zone) in some sections, as on the west side of Pardonet Hill. In other sections, for example the east side of Pardonet Hill and on Brown Hill, the basal beds are Lower Norian (Kerri Zone). The higher beds of the Pardonet Formation contain all the zones of the Norian.

The Triassic rocks of Alberta are assigned to the Sulphur Mountain and Whitehorse Formations. In this bulletin these formations are used in the interpretation of Manko (1960) and Gibson (1965) rather than that of Westermann (1962b). Both Manko and Gibson recognize four members within the Sulphur Mountain Formation. At the base, is the Shaly Siltstone member in which Griesbachian bivalves occur. The Blocky Brown Siltstone member contains Smithian ammonoids. The overlying Black Shale member and the Silty Dolomite member contain Anisian ammonoids. Dienerian and Spathian faunas have not been described from the Sulphur Mountain Formation, but there are unfossiliferous intervals in which they may yet be found. No ammonoids are known from the Whitehorse Formation, as defined by Manko and Gibson.

The Triassic rocks of what for present purposes is described as the *Western Cordillera* are exposed in the parts of western British Columbia and southern Yukon that lie west of the Rocky Mountain and Tintina Trenches. They include rocks of both sedimentary and volcanic origin. The Triassic rocks of the Western Cordillera, unlike those of all other regions in Canada, commonly include thick formations of bioclastic limestone, in part with corals and megalodont bivalves. The nature of the rock succession varies greatly from place to place. Eventually it will probably be possible to distinguish several individual troughs of deposition, such as the Whitehorse Trough which has already been segregated by Wheeler (1961). No Lower Triassic faunas have yet been found, but with the discovery by Kuenzi (1965) of Smithian ammonoids in northern Washington, 25 miles south of the International Boundary, it seems likely that they will eventually be found in the Western Cordillera. A few Middle Triassic (Ladinian) bivalves have been collected at widely scattered localities in the Western Cordillera. The only widely distributed ammonoid faunas are of Karnian and Norian age. The most important successions known are on Vancouver Island, in the Karmutsen, Quatsino, and Bonanza Formations (Jeletzky, 1950, 1954) and in the Lewes River Group of southern Yukon (Tozer, 1958; Wheeler, 1961). From the standpoint of compiling a standard for the Triassic the most significant information derived from the rocks of the Western Cordillera is the occurrence in the Tyaughton Group of Taseko Lakes area of marine Rhaetian ammonoids above Upper Norian strata. This is the only known occurrence of marine Rhaetian rocks in Canada.

The area defined as the *Northern Cordillera* includes the part of Yukon Territory northeast of the Tintina Trench. Most, if not all, of the Triassic rocks in this region are sedimentary and of marine deposition. The rocks in the Herschel Island and Blow River areas are assigned to the Shublik Formation by Mountjoy (*in press*). The rocks and faunas of this region are not well known but parts of the Smithian, Ladinian, Karnian, and Norian are represented, with ammonoids known from the Karnian and Norian. This region does not contribute data to the establishment of the faunal sequence and is only mentioned to show that occurrences of some of the zones can be recognized.

TRIASSIC STAGES, SUBSTAGES, AND AMMONOID ZONES OF CANADA

Thirty-one ammonoid zones are recognized in the Triassic of Canada (Table II). These are grouped into stages and substages in accordance with a scheme proposed for the Triassic of North America by Silberling and the writer (*in press*). For the Middle and Upper Triassic, stages defined in Europe have been used. In the Lower Triassic four stages, defined in Canada and readily recognized throughout the world, constitute the most satisfactory subdivisions for expressing age relationships.

The zones are arranged in sequence solely on the basis of stratigraphic observations made in North America. The data provided by the classical sections of Europe and Asia have, of course, been borne in mind and governed the application of the European stage names to the zonal sequence. The sequential arrangement of the zones, however, is in no way dependent upon data derived from Europe or Asia.

The ammonoid zones form the basis for the time scale. Because of recent discussion regarding the nature of fossil zones, it seems desirable to define the nature of the zones treated in this bulletin. The zones are bodies of rock characterized by an assemblage of ammonoids of which one characteristic species is chosen as index. This definition, it will be recognized, is a paraphrase of the oft-quoted definition of J. E. Marr (1898). The zones are thus empirical units: tangible bodies of rock, characterized by a fauna. They are not necessarily the biozones of the index species; this species merely provides the name. Because they are stratigraphic units, it seems desirable that each zone should have a type locality where its identification is beyond dispute. For this reason a type locality is given for each zone defined in Canada. For those zones defined in the United States and recognized in Canada, type localities have been given, or will be, by N. J. Silberling. Rocks remote from the type locality are assigned to the zone if they contain a fauna considered to be the same age as the fauna at the type locality. Commonly the type localities are in the sections where several zones are observed in sequence. Some are the type locality for the index species as well as for the zone; most are not. If future work should show, for example, that the beds at the type locality of the Caurus Zone are not the same age as the beds that contain undoubted examples of *Lenotropites caurus,* then the name of the zone will have to be changed.

In most sections there are rocks between the zones that are devoid of characteristic fossils. Those parts of the section without diagnostic fossils cannot be assigned to a zone. The alternative procedure — to include beds lacking the characteristic fauna in one or other of the adjacent zones — practised by some contemporary workers (e.g., Donovan, 1956, p. 198) is not followed. From this it should be clear that the zones, as arranged, are not regarded as forming a continuum. Future discoveries will probably reveal distinctive faunas that will form the basis for new zones between those now recognized. If and when such new zones are discovered, a decision may be necessary regarding the placing of the zone within the hierarchy of stages. Such decisions should be arbitrary. A new zone found between the Sverdrupi and Romunderi Zones might be regarded as either Dienerian or Smithian, depending upon the affinity of its fauna. At present it seems undesirable to adopt the alternative policy advocated by Callomon (1965), namely to define inflexibly the base of a stage such as the Smithian as the base of the Romunderi Zone.

Despite the fact that additions may be anticipated, the proposed standard providing thirty-one ammonoid zones as points of reference or "benchmarks" within the Triassic System is nevertheless more refined than any formerly proposed. Classification and subdivision of the Triassic has been handicapped by the absence of highly fossiliferous accessible sections, such as those in England and Germany that permitted the recognition of more than thirty zones within the Jurassic over a century ago.

According to the most recent estimates based on radiometric data the duration of the Triassic period was about 45 m.y. (Harland, *et al.,* 1964, p. 261). It follows that the probable duration of each ammonoid zone was less than 1.5 m.y.

Following the most recently proposed convention (Dean, Donovan, and Howarth, 1961; Callomon, 1965) the trivial name of the index species is used alone for the name of the zone. In this way the name "Strigatus Zone" may be used as a welcome alternative for *"Pachyproptychites strigatus* Zone."

The sequence of zones and their distribution in the four regions defined above are shown by Table II. Occurrence, or probable occurrence, of a zone is indicated by a number in the region column. The numbers refer to the annotations where full details regarding the occurrences are given. The main object of the annotations is to provide the evidence on which the zones are arranged in sequence, but they also provide a summary of the principal Triassic ammonoid occurrences in Canada. Where the same number appears opposite more than one zone, the annotation provides data that contribute towards establishing the zonal sequence. For example, annotation 17 describes the locality where the Concavum, Boreale, Commune, and Strigatus Zones have been observed in sequence; annotation 32 provides the comparable data for the Suessi and Marshi Zones. Where the zonal boundaries do not appear in a column the individual zones have not been discriminated. Thus, annotation 3 refers to the occurrence of a fauna younger than that of the Welleri Zone, but older than the Columbianus Zone; it does not indicate that all zones between the Welleri and Columbianus Zones are represented.

The data provided by the annotations have been brought together in summary form with a description of the successive stages, substages, and zones. These

SERIES	STAGE	SUB STAGE	ZONE	OCCURRENCE			
				ARCTIC ISLANDS	CORDILLERA		
					EAST	WEST	NORTH
UPPER TRIASSIC	RHAETIAN		*Choristoceras marshi*			32	
	NORIAN	UPPER NORIAN	*Rhabdoceras suessi*	1	18 19	32 33 34	44
		MIDDLE NORIAN	*Himavatites columbianus*	2	18 19 20	35	45
			Drepanites rutherfordi		20		
			Juvavites magnus		20	36	
		LOWER NORIAN	*Malayites dawsoni*	3	20		
			Mojsisovicsites kerri		20 21	37	
	KARNIAN	UPPER KARNIAN	*Klamathites macrolobatus*		21 22		
			Tropites welleri	4	22 23	40 38	46
			Tropites dilleri		23	39	
		LOWER KARNIAN	*Sirenites nanseni*	5 6	23	41	
			Trachyceras obesum	6	23	42	
MIDDLE TRIASSIC	LADINIAN	UPPER LADINIAN	*Paratrachyceras sutherlandi*		23 24		
			Maclearnoceras maclearni	6 7	24		
			Meginoceras meginae		24		
		LOWER LADINIAN	*Progonoceratites poseidon*		25	43	47
			Protrachyceras subasperum	8	26		
	ANISIAN	UPPER ANISIAN	*Gymnotoceras chischa*	9	27		
			Gymnotoceras deleeni	9	27 28		
		M. ANISIAN	*Anagymnotoceras varium*	10	28		
		L. ANISIAN	*Lenotropites caurus*	9 11	28		
LOWER TRIASSIC	SPATHIAN		*Keyserlingites subrobustus*	11 12 13	29		
			Olenikites pilaticus	12			
	SMITHIAN		*Wasatchites tardus*	13	30		
			Euflemingites romunderi	13 14	29 30		48
	DIENERIAN		*Paranorites sverdrupi*	14 15 16	29		
			Proptychites candidus	16	29 31		
	GRIESBACHIAN	UPPER GRIESBACHIAN	*Pachyproptychites strigatus*	16 17	31		
			Ophiceras commune	16 17			
		LOWER GRIESBACHIAN	*Otoceras boreale*	16 17			
			Otoceras concavum	17			

TABLE II. *Triassic Stages, Substages, and Ammonoid Zones.*

descriptions summarize the synonyms, faunal characteristics, distribution in Canada, and principal correlatives elsewhere, of the successive units. For the most part, the correlative units discussed are those that serve to relate the adopted standard to previously proposed schemes. To discuss all possible correlatives is beyond the scope of this bulletin.

Use of the annotations will be facilitated by the index, which lists the names of all ammonoids, stratigraphic units, and localities mentioned.

Lower Triassic Series

Griesbachian Stage

The type section of the Griesbachian Stage is in the Blind Fiord Formation of northwest Axel Heiberg Island (Tozer, 1965b). In terms of Spath's (1934, 1935) divisions of the Triassic, the Griesbachian is equivalent to the Otoceratan together with the part of the Gyronitan in which he placed the *"Vishnuites"* and *Proptychites* beds of East Greenland.

In both the Arctic islands and the Eastern Cordillera, Griesbachian strata rest disconformably upon Permian rocks. The physical evidence suggests that a hiatus separates the rocks of the Permian System from those of the Triassic. In the Arctic islands, the youngest Permian rocks beneath the Griesbachian formations are in places late Artinskian (R. Thorsteinsson, pers. com.), elsewhere they are Guadalupian (Nassichuk, *et al.,* 1966). Rocks of latest Permian age are absent in Canada. There is no evidence that earliest Triassic time is unrepresented in the Griesbachian Stage, because the Concavum Zone at the base of the Triassic sequence is probably as old as the *Otoceras woodwardi* Zone of the Himalayas, which is generally accepted as the basal Triassic zone. In other words, the period of time unrepresented by strata evidently falls within the Permian, not within the Triassic.

The available evidence suggests that the boundary between marine rocks of Permian and Triassic age invariably marks a hiatus, not only in Canada but throughout the world. Contrary to this interpretation it has been suggested by Ruzhencev, *et al.* (1965) that the section at Dzhulfa in Armenia provides a continuous sequence of marine sediments that express the passage between the Permian and the Triassic, with goniatites and rugose corals ranging up into the beds regarded as lowermost Triassic. The writer, however, shares the view expressed by Chao (1965), namely that much of the sequence regarded as Lower Triassic by Ruzhencev, *et al.,* is older than the beds that define the base of the Triassic System. The beds in question at Dzhulfa are those characterized by, in ascending order, the following ammonoids: *Tampophiceras, Dzhulfites, Bernhardites,* and *Paratirolites.* The bivalves *Claraia stachei* Bittner and *Claraia aurita* (Hauer) are recorded above *Paratirolites,* which leaves little doubt that the underlying ammonoid beds are Griesbachian or older. One specimen of *Pseudogastrioceras* is recorded as high as *Bernhardites*; this suggests that all the beds up to at least this level are Permian, not Triassic. Typical Griesbachian ammonoids such as *Otoceras* and *Ophiceras* are unknown at Dzhulfa, so there are no ammonoids to justify a correlation with either the *Otoceras woodwardi* Zone of the Himalayas or the equivalent Griesbachian zones of Canada. The type species of *Tompophiceras* and *Bernhardites* are Lower Triassic, but both genera are serpenticone ceratitids of a type that occurs in both Permian and Triassic strata and consequently their presence at Dzhulfa does not provide a clear indication of the age of the beds. In the past *Paratirolites* has generally been regarded as Lower Triassic, but not on good grounds, for the genus is unknown elsewhere. The absence of diagnostic Griesbachian ammonoids and the presence of *Claraia* above in itself suggests that the *Tompophiceras* to *Paratirolites* beds, inclusive, are older than the Woodwardi Zone, which is generally taken to define the base of the Triassic System.

Chao's (1965) important contribution to the solution of this problem is the discrimination of two Upper Permian ammonoid faunas in China. The younger fauna is characterized by *Pseudotirolites* and *Pleuronodoceras,* together with *Pseudogastrioceras*; the older fauna contains *Prototoceras* and *Araxoceras,* two genera that occur beneath *Tompophiceras* at Dzhulfa. The strata with *Pseudotirolites* are overlain by beds with *Ophiceras* and *Claraia* of Griesbachian age. Chao suggests that the older fauna, with *Araxoceras,* correlates with the beds regarded as uppermost Permian by Ruzhencev, *et al.* The *Pseudotirolites* beds of China are correlated with the *Tompophiceras, Dzhulfites, Bernhardites,* and *Paratirolites* beds of Dzhulfa, and are regarded as Permian not Triassic. Apparently Chao has discovered the important sequential data that resolve the problem. He has provided the evidence to show that the Permian–Triassic boundary at Dzhulfa does not record a transitional sequence, and his discoveries evidently show that Dzhulfa and China are the places where the Permian rocks beneath the sub-Griesbachian unconformity are younger than those preserved in any other part of the world.

An unbroken sequence from the Permian into the Triassic has been claimed for the succession in East Greenland, where brachiopods and bryozoans of Palaeozoic appearance occur in the same rock as ammonoids dated as lowermost Triassic (Trümpy, 1960, 1961). This interpretation has been questioned by Dunbar (1961), who, like Spath (1935, p. 48), believes that the brachiopods and bryozoans are derived fossils. *Cyclolobus* is recorded from the highest Permian of East Greenland, and *Otoceras* of earliest Triassic age from the overlying beds. In the past it has been assumed that *Cyclolobus* characterizes the highest Permian rocks, but this has now been questioned by Chao (1965), who correlates the *Cyclolobus* beds with the *Araxoceras* beds, that is to say with the penultimate, not the youngest, Permian fauna. If Chao is correct, the East Greenland succession, although perhaps complete for the lowermost Triassic, lacks the youngest Permian, and this vitiates the claim that East Greenland has both youngest Permian and earliest Triassic in the same section.

In conclusion, then, we are left without any sections that clearly provide a transition, in the marine facies, between the Permian and the Triassic. The section in the Salt Range (Pakistan) can no longer be regarded in this light; not only is the Lower Griesbachian unproven, but, in Chao's interpretation, Permian beds are also missing (cf. Schindewolf, 1954).

Lower Griesbachian Substage

The two Lower Griesbachian zones of *Otoceras concavum* and *Otoceras boreale* indicate, in a general way, correlation with the *Otoceras woodwardi* Zone of the Himalayas as defined by Diener (1912, p. 32). At Shalshal Cliff, Noetling (1905, pp. 128, 149) distinguished three zones within the Woodwardi Zone of Diener, all occurring in three feet of strata. They are, in ascending order, the zones of *Otoceras woodwardi, Episageceras dalailamae,* and *Ophiceras tibeticum.* Diener, noting the occurrence of *Otoceras woodwardi* in the highest of Noetling's three zones, refused to admit that they were more than "minute subdivisions of one single zone. . . ." In the Himalayas, *Otoceras* is unknown above the Woodwardi Zone (*sensu* Diener); in Canada, this genus does not occur above the Boreale Zone. It would appear that the youngest possible correlative for the Boreale Zone is the Tibeticum Zone (of Noetling). In view of this correlation the Lower Griesbachian Substage is synonymous with the Gangetic Substage of Waagen and Diener (1895).

Warren (1945, p. 486) has described the occurrence of ammonoids, tentatively assigned to *Otoceras, Ophiceras,* and *Proptychites,* from a bed of limestone in the Sulphur Mountain Formation of Alberta. The specimens are described as crushed and without suture lines. *Otoceras* suggests the occurrence of Lower Griesbachian; *Proptychites* may indicate the Upper Griesbachian, but until good specimens are found the exact age of this collection remains uncertain.

Concavum Zone

Index species: *Otoceras concavum* n. sp. (Pl. I, figs. 1-3)

Type locality: Griesbach Creek, northwest Axel Heiberg Island (ann. 17).

Occurrence: Arctic islands — Blind Fiord Formation, northwest Axel Heiberg Island.

Otoceras concavum is the only species known from this zone. Exact correlatives of the Concavum Zone are not known. In East Greenland the *Glyptophiceras* beds lie between the Foldvik Creek Formation (Upper Permian) and the Lower *Ophiceras* beds, with *Otoceras boreale* (Spath, 1935; Trümpy, 1961, p. 249). Thus the *Glyptophiceras* beds more or less occupy the position of the Concavum Zone. A correlation cannot be established, however, because (1) the *Otoceras* specimens known from the *Glyptophiceras* beds are too poorly preserved for comparison with *Otoceras concavum,* and (2) *Glyptophiceras triviale* Spath, the index fossil of the beds in Greenland, is unknown in Canada.

Boreale Zone

Index species: *Otoceras boreale* Spath, 1935, p. 9; lectotype, now chosen, Spath, 1935, Plate III, figures 1a, b. (Pl. II, figs. 1, 2)

Type locality: Griesbach Creek, northwest Axel Heiberg Island (ann. 17).

Occurrence: Arctic islands —-Blind Fiord Formation, Ellesmere and Axel Heiberg Islands; Bjorne Formation, Ellesmere Island (?).

The fauna of the Boreale Zone includes *Otoceras boreale* Spath, *Metophiceras* cf. *M. subdemissum* Spath, and *Ophiceras* sp. indet. The presence of *Otoceras boreale* indicates a correlation with the Lower *Ophiceras* beds (*Metophiceras subdemissum* Zone) of East Greenland (Spath, 1935; Trümpy, 1961, p. 249).

Upper Griesbachian Substage

In the Arctic islands this substage is characterized by the occurrence of abundant ophiceratids and the appearance of proptychitids and *Claraia stachei* Bittner. The restriction of *Claraia stachei* to the Upper Griesbachian in the Arctic suggests that the *Claraia* beds of the Grayling and Sulphur Mountain Formations of the Eastern Cordillera are Upper rather than Lower Griesbachian. This is a suggestion rather than a final conclusion, because Spath (1935, p. 105) records *Claraia stachei* as low as *Otoceras* in East Greenland, although all the specimens he chose to illustrate are from Upper Griesbachian equivalents. The Griesbachian *Claraia* beds provide the first link with the Alpine Triassic sequence, for *Claraia* is the index bivalve of the Seis Beds of the southern Alps.

Commune Zone

Index species: *Ophiceras commune* Spath, 1930, p. 24. (Pl. III, figs. 1a, b)

Type locality: Upper *Ophiceras* beds of East Greenland (Trümpy, 1961, p. 249).

Reference locality for Canada: Griesbach Creek, northwest Axel Heiberg Island (ann. 17).

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands.

The fauna of this zone is characterized by the occurrence of abundant ophiceratids, including *Ophiceras commune, Ophiceras decipiens* (Spath) (= *Vishnuites decipiens* Spath), *Discophiceras wordiei* Spath, *"Glyptophiceras" extremum* Spath, together with the bivalve *Claraia stachei* Bittner. The ophiceratids of the Commune and Strigatus Zones are highly variable. Provisionally *Ophiceras commune* and *Ophiceras decipiens* have been given rather a wide interpretation. In the faunal lists provided by the annotations the specimens listed as *Ophiceras commune* include some that are close to *Ophiceras greenlandicum* Spath. Those listed as *Ophiceras decipiens* include individuals that resemble *Ophiceras transitorium* Spath and *"Vishnuites" wordiei* Spath.

The fauna of at least the lower part of the Commune Zone in Canada indicates a correlation with the Upper *Ophiceras* beds of East Greenland (Spath, 1935; Trümpy, 1961). Spath (1935, p. 11) records *Otoceras boreale* from the Upper *Ophiceras* beds, but no specimens from this level were illustrated, and according to Dr. Trümpy (written com., 1966) it is probable that *Otoceras boreale* is restricted to the Lower *Ophiceras* beds, which as already noted appear to be equivalent to the Boreale Zone. The presence of *Ophiceras decipiens* in the Commune Zone suggests that equivalents of the *"Vishnuites"* beds of East Greenland may also be present. A case might be made for recognizing a zone of *Ophiceras decipiens* between the Commune and Strigatus Zones in some sections, e.g., on Griesbach Creek (ann. 17). However, ophiceratids with acute venters that closely resemble *Ophiceras decipiens* occur as low as the Boreale Zone (ann. 16) and this indicates that species of the *decipiens* group range through much of the Griesbachian.

Strigatus Zone

Index species: *Pachyproptychites strigatus* (Tozer) (1961b, p. 55). (Pl. III, figs. 2a, b)

Type locality: Griesbach Creek, northwest Axel Heiberg Island (ann. 17).

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands.

The base of this zone is drawn at the appearance of *Pachyproptychites strigatus*. Also present, ranging up from the Commune Zone, are *Ophiceras decipiens* (Spath) and *Claraia stachei* Bittner. The faunas of the Commune and Strigatus Zones are intimately related, and these zones commonly occur in sequences that are more or less continuously fossiliferous. It is unlikely that the first appearances of *Pachyproptychites strigatus,* recorded in the annotations, are exactly synchronous. Despite this shortcoming, discrimination of the Commune and Strigatus Zones is desirable to portray the observed relations, namely, the occurrence above the Boreale Zone, first, of beds with ophiceratids only (Commune Zone), then of ophiceratids and proptychitids in association (Strigatus Zone). In some sections the highest fossils obtained in the Strigatus Zone are *Ophiceras*; in others they are *Pachyproptychites*.

The abundance of *Ophiceras decipiens* suggests that the Strigatus Zone includes correlatives of the *"Vishnuites"* beds of East Greenland (Spath, 1935; Trümpy, 1961). The proptychitids of the Strigatus Zone, like the contemporary ophiceratids, are highly variable. The collections now available include specimens up to 190 mm in diameter (from locality 47525), with a whorl section at the aperture much like that of *Proptychites anomalus* Spath, described from the *Proptychites* beds of East Greenland. This suggests that the Strigatus Zone may include equivalents of the Greenland *Proptychites* beds, in addition to correlatives of the *"Vishnuites"* beds. It does not seem to be possible to achieve an exact correlation between Greenland and Canada but there seems little doubt that the Commune and Strigatus Zones together are more or less equivalent to the Upper *Ophiceras, "Vishnuites",* and *Proptychites* beds of Greenland. It was formerly suggested that *Proptychites* cf. *P. rosenkrantzi* Spath occurs in the Strigatus Zone, but the writer is no longer satisfied that this identification is correct (cf. Tozer, 1965b, p. 4).

Dienerian Stage

The type section of the Dienerian Stage is in the Blind Fiord Formation of northwestern Ellesmere Island (Tozer, 1965b; this bulletin, ann. 16). In Spath's terminology (1934, 1935), the Dienerian is equivalent to the upper part of the

Gyronitan and to much, or all, of the Flemingitan. The Griesbachian–Dienerian boundary is marked by the appearance of the Gyronitidae and is readily recognized not only in Canada but also in the Himalayas, where it occurs at the boundary between the *Otoceras* and *"Meekoceras"* beds (Diener, 1912); and in the Salt Range, between the *Ophiceras connectens* bed and the Lower Ceratite Limestone (Schindewolf, 1954; Kummel and Teichert, 1966).

Candidus Zone

Index species: *Proptychites candidus* Tozer (1961b, p. 57).
(Pl. IV, figs. 1a, b)

Type locality: Diener Creek, Ellesmere Island (ann. 16).

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands. Eastern Cordillera — Grayling and Toad Formations, northeast British Columbia.

This zone is marked by the occurrence of abundant *Proptychites* (*P. candidus* Tozer, *P. mulleri* Tozer, *P. newelli* Tozer, *P. kummeli* Tozer) together with Gyronitidae and related forms (*Prionolobus* cf. *P. lilangense* (Krafft), *P.* cf. *P. plicatus* (Waagen), *Xenodiscoides* cf. *X. radians* Waagen). *Discophiceras columbianum* (Tozer) and *Dunedinites pinguis* Tozer also occur. *Prionolobus* cf. *P. indoaustralicus* (Wanner) occurs in beds in British Columbia that probably represent this zone.

Prionolobus cf. *P. lilangense* suggests a correlation with the *"Meekoceras"* beds of Spiti in the Himalayas, and *P.* cf. *P. plicatus* with the Lower Ceratite Limestone of the Salt Range. Correlative beds are also present in the Candelaria Formation of Nevada (Muller and Ferguson, 1939; Silberling and Tozer, *in press*).

Sverdrupi Zone

Index species: *Paranorites sverdrupi* Tozer (1963a, p. 12). (Pl. IV, figs. 2a, b)
Type locality: Bluffs west of Lindström Creek, Otto Fiord, Ellesmere Island (ann. 14).

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands. Eastern Cordillera — Toad Formation, northeast British Columbia.

In the Arctic islands the fauna of this zone includes *Paranorites sverdrupi* Tozer, *P.* cf. *P. kingianus* (Waagen), *P. heibergensis* (Tozer), *Clypeoceras* n. sp., and *Pseudosageceras multilobatum* Noetling. From British Columbia the following are known: *Paranorites sverdrupi* Tozer, *P.* n. sp. aff. *P. inflatus* Spath, *Hedenstroemia* (or *Pseudosageceras*) sp., *"Dinarites"* cf. *D. minutus* Waagen.

The fauna of this zone evidently has affinities with assemblages in the Himalayas and the Salt Range. *Paranorites sverdrupi* closely resembles *"Proptychites" markhami* (Diener), from the *"Meekoceras"* beds of Shalshal Cliff in the Himalayas. *Paranorites heibergensis* resembles *Paranorites magnumbilicatus* (Waagen), described from the middle part of the Ceratite Sandstone of the Salt

Range. *Paranorites kingianus* (Waagen) was originally described from the upper part of the Ceratite Sandstone. *"Dinarites" minutus* Waagen is from a slightly lower level in the Salt Range, from the Ceratite Marls.

"Pachyproptychites" turgidus Popov, described from Tompo River in Siberia (Popov, 1961a), closely resembles *Paranorites sverdrupi* and probably indicates a correlative of the Sverdrupi Zone.

Ultimately it may be possible to distinguish subdivisions within the Sverdrupi Zone, for on Axel Heiberg Island the index species occurs at a slightly lower level than *Paranorites* cf. *P. kingianus, Paranorites heibergensis,* and *Clypeoceras* n. sp.

Smithian Stage

The type section of the Smithian Stage is in the Blind Fiord Formation of northwestern Ellesmere Island (Tozer, 1965b). This stage is equivalent to the Owenitan Division of Spath (1934) and to the *Arctoceras blomstrandi* Zone of Tozer (1965b). The boundary between the Dienerian and Smithian Stages corresponds, approximately, with that between the Indus (or Induan) and Olenekian Stages of Kiparisova and Popov (1956, 1961, 1964).

Romunderi Zone

Index species: *Euflemingites romunderi* Tozer (1961b, p. 51). (Pl. V, figs. 1, 2)

Type locality: Smith Creek, Ellesmere Island (ann. 13).

Synonym: *Meekoceras gracilitatis* Subzone (Tozer, 1965b). The new name is proposed in order that the zone may be defined in Canada, where the relations to adjacent zones are best displayed.

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands. Eastern Cordillera — Toad Formation, northeast British Columbia; Sulphur Mountain Formation, Blocky Brown Siltstone member, Alberta. Northern Cordillera — unnamed beds, Dawson area, Yukon (?).

The most common ammonoids of the Romunderi Zone are species of *Euflemingites, Arctoceras,* and *Juvenites.* Representatives of *Pseudosageceras, Dieneroceras, Flemingites* (?), *Anakashmirites, Meekoceras,* and *Prosphingites* are also known. The bivalve *Posidonia mimer* Oeberg is also very common, but probably ranges up into the Tardus Zone. The record of the Romunderi Zone from the Northern Cordillera is based solely on the occurrence of *Posidonia mimer* and is therefore questionable.

The beds assigned to the Romunderi Zone on Axel Heiberg Island, in British Columbia, and in Alberta lack the index species but contain a closely related form listed as *Euflemingites* cf. *E. cirratus* (White). It is probable that the beds with *Euflemingites* cf. *E. cirratus,* etc., differ in age from the typical occurrences of this zone, which are known only on Ellesmere Island. The available evidence, however, suggests that if there is a difference in age, it is slight, because the beds with *Euflemingites* cf. *E. cirratus* on Axel Heiberg Island overlie the Sverdrupi Zone, and in British Columbia they underlie the Tardus Zone.

The Romunderi Zone is more or less correlative with the *Meekoceras gracilitatis* beds in the Thaynes Formation of Idaho (Smith, 1932; Kummel, 1954), and with beds containing *Euflemingites romunderi* in the Shublik and Sadlerochit Formations of northern Alaska (Silberling and Patton, 1964, p. A145). From the recent work of Buchan, *et al.* (1965, p. 33) there seems to be no doubt that the Romunderi Zone is present in Spitsbergen, where it is represented by beds with *Euflemingites* and *Arctoceras* in the lower part of the Sticky Keep Formation.

In northeastern Siberia correlative beds are present within the *Paranorites* Zone (Popov, 1961a, p. 6), which was originally assigned to the Indus Stage but later to the Olenekian (Kiparisova and Popov, 1964).

Tardus Zone

Index species: *Wasatchites tardus* (McLearn) (=*Anawasatchites tardus* McLearn, 1945, p. 5). (Pl. V, figs. 3a-c)

Type locality: Toad River, 2 miles above Liard River, northeast British Columbia (ann. 30).

Synonym: *Wasatchites tardus* Subzone (Tozer, 1965b).

Occurrence: Arctic islands — Blind Fiord Formation, Ellesmere and Axel Heiberg Islands. Eastern Cordillera — Toad Formation, northeast British Columbia.

This zone is marked by an abundance of *Wasatchites,* which exhibit extraordinary variation. *Xenoceltites subevolutus* Spath is also of this zone, as are *X. warreni* McLearn and *X. robertsoni* McLearn. The last two are probably closer to the type of *Anakashmirites* than to that of *Xenoceltites*. *Arctoceras blomstrandi* (Lindström) and *Prosphingites* cf. *P. spathi* Frebold are associated with *Wasatchites* at one locality on Ellesmere Island. One specimen of *Anasibirites* cf. *A. crickmayi* Mathews and one of *Pseudosageceras* n. sp. are known from the Tardus Zone of British Columbia. The bivalve *"Pseudomonotis" occidentalis* (Whiteaves) is also characteristic of this zone.

The Tardus Zone is correlative with the *Stephanites superbus* Zone of the Salt Range (Waagen and Diener, 1895) and the *Anasibirites spiniger* Zone of Byans in the Himalayas (Diener, 1912, p. 35). Equivalents are also known in Idaho, Utah, Spitsbergen, Timor, and Japan (Tozer, 1961b, p. 32). *"Pseudomonotis" occidentalis* is closely related to *"P." himaica* Bittner, which occurs near the top of the *Hedenstroemia* beds of Spiti and Painkhanda in the Himalayas (Diener, 1912, pp. 16, 22). This suggests that the upper part of the *Hedenstroemia* beds includes equivalents of the Tardus Zone.

Spathian Stage

The type section of the Spathian Stage is in the Lower Shale member of the Blaa Mountain Formation. The type locality is at Spath Creek, Ellesmere Island, where the relationship with the overlying Anisian rocks is well displayed (ann. 11). No less important is the section southeast of Cape Stallworthy, Axel Heiberg

Island, where two Spathian zones — the Pilaticus and Subrobustus Zones — are in sequence (ann. 12).

In terms of the chronology proposed by Spath (1934) the Spathian Stage is equivalent to the Columbitan and Prohungaritan Divisions, in which he included the faunas characterized by *Tirolites, Columbites, Subcolumbites, Prohungarites,* and *Keyserlingites.* These faunas have enough in common to justify regarding them as representing a single stage. Furthermore they are very different from the faunas of the preceding Owenitan Division (or Smithian Stage). In consequence the boundary between the Smithian and Spathian is readily recognized throughout the world.

Pilaticus Zone

Index species: *Olenikites pilaticus* n. sp. (Pl. VI, figs. 1-5)

Type locality: Twenty miles SE of Cape Stallworthy, Axel Heiberg Island (ann. 12).

Synonym: *Nordophiceras pilatum* Zone (Tozer, 1965b).

Occurrence: Arctic islands — Blaa Mountain Formation, Lower Shale member, Axel Heiberg Island.

This rare zone, known only from one locality, contains small ammonoids that are probably referable to *Columbites. Olenikites pilaticus* closely resembles *Olenikites pilatus* (Hyatt and Smith), a member of the *Columbites* fauna of Idaho, with which a correlation may be made. The fauna of the *Columbites* beds includes *Tirolites illyricus* Mojsisovics (Smith, 1932) indicating at least an approximate correlation with the *Tirolites cassianus* Zone of the Mediterranean Region.

Subrobustus Zone

Index species: *Keyserlingites subrobustus* (Mojsisovics, 1886, p. 44). (Pl. VI, figs. 6a, b)

Type locality: Spath Creek, Ellesmere Island (ann. 11).

Occurrence: Arctic islands — Blind Fiord Formation and Lower Shale member, Blaa Mountain Formation, Ellesmere and Axel Heiberg Islands. This zone illustrates the diachronous nature of the boundary between the Blind Fiord and Blaa Mountain Formations. In some areas the Subrobustus Zone is in the upper Blind Fiord beds; elsewhere it is in the Lower Shale member of the Blaa Mountain Formation.

Eastern Cordillera — Toad Formation, northeast British Columbia.

A fairly large ammonoid fauna has now been described from this zone (Tozer, 1965a). Representatives of *Pseudosageceras, Preflorianites, Prosphingites, Isculitoides, Popovites, Zenoites, Monacanthites, Metadagnoceras, Keyserlingites, Olenikites, Svalbardiceras, Procarnites,* and *Leiophyllites* are known. Well-preserved ammonoids are rare, but the associated bivalve *Posidonia aranea* Tozer is an ideal index fossil for it is widely distributed in both British Columbia and the Arctic islands.

The presence of *Keyserlingites* and *Olenikites* permits a correlation with the fauna from Olenek River in Siberia made known in the last century (Mojsisovics, 1886, 1888), and apparently also with the so-called Lower Muschelkalk of the Himalayas, which has usually been regarded as Middle Triassic (Tozer, 1965a, p. 11). In the past the Olenek fauna has been placed at the top of the Lower Triassic (Spath, 1934, p. 27; Popov, 1961a, p. 6). More recently workers on the Siberian faunas have placed another zone, with *Prohungarites tuberculatus,* above the *Olenikites* Zone (Kiparisova and Popov, 1964, p. 97), but as yet the fossils have not been described. Ammonoids that resemble *P. tuberculatus* (i.e., *Pearylandites* aff. *P. troelseni* Kummel) occur in the Caurus Zone of Canada, which is classed as Anisian. This introduces the possibility that the highest beds of the Lower Triassic, in the sense of the Soviet authors, are equivalent to the lowest part of the Middle Triassic Series, as used in this bulletin.

Some of the ammonoids of the Subrobustus Zone (*Isculitoides, Zenoites,* and *Metadagnoceras*) indicate affinity with late Lower Triassic faunas in Idaho, Nevada, Albania, Chios Island, and Timor (Tozer, 1965a, p. 13).

Equivalents of the Subrobustus Zone are present in Spitsbergen, as shown by the occurrence of *Keyserlingites* (Frebold, 1929, 1931; Tozer, 1965a) and *Posidonia aranea* (Petrenko, 1963). *Posidonia aranea* also occur in Siberia (Vozin and Tikhomirova, 1964).

Procarnites modestus Tozer, which occurs in the Subrobustus Zone of British Columbia, is not a typical *Procarnites* but closely resembles *Megaphyllites immaturus* Kiparisova, from the late Lower Triassic *Subcolumbites* fauna of Primor'ye (Soviet Far East). A case can be made for assigning *Megaphyllites immaturus* and *Procarnites modestus* to the genus *Neopopanoceras* Spath, the type species of which is *Neopopanoceras haugi* (Hyatt and Smith) from beds in California that have generally been regarded as Lower Anisian. As mentioned below, in discussing the definition of the boundary between the Lower and Middle Triassic Series, recent work by N. J. Silberling has shown that the *Neopopanoceras haugi* beds of the western United States appear to be correlative with the Subrobustus Zone. Silberling has reached this conclusion from evidence provided both from the composition of the *Neopopanoceras* fauna and from the stratigraphic position of the enclosing beds. The resemblance between *Procarnites modestus* and *Neopopanoceras haugi* thus appears to have stratigraphic significance.

Middle Triassic Series

Anisian Stage

The type locality for the Anisian Stage is in Austria (*see* Kuehn, 1962, p. 20). In Austria and the neighbouring Alpine countries the lower part of the Anisian contains no ammonoid faunas. This means that in the type area it is impossible to define the base of the Anisian, and therefore the boundary between the Lower and Middle Triassic, in terms of ammonoid faunas. Ammonoid faunas believed to be of late Lower and early Middle Triassic age have been known from other parts of the world for many years. Examples are the *Olenikites* fauna of Siberia and the *Neopopanoceras haugi* fauna of California. Traditionally the *Olenikites* fauna has been regarded as Lower Triassic. This tradition is followed in dealing with the sequence in Canada, where the *Olenikites* fauna occurs in the Subrobustus Zone, the upper zone of the Spathian Stage, at the top of the Lower Triassic. In the past the *Neopopanoceras haugi* Zone has been taken to define the base of the Anisian (Spath, 1934, p. 35; Kummel, 1957, p. L124), but the recent work by N. J. Silberling showing that the Haugi Zone is more or less correlative with the Subrobustus Zone makes it necessary to regard the Haugi Zone as Lower, not Middle, Triassic (Silberling and Tozer, *in press*). In this bulletin, as in the paper prepared with Dr. Silberling, the base of the Anisian is taken at the *Lenotropites caurus* Zone, which immediately follows the Subrobustus Zone. The assignment of the Caurus Zone to the Anisian cannot be justified on the grounds of a straightforward faunal correlation because the typical Lower Anisian rocks of Western Europe are devoid of ammonoids. However, several characteristic Middle Triassic ammonoids — *Longobardites, Anagymnites, Sturia,* and *Parapopanoceras* — make their appearance in the Caurus Zone. Their presence and the position of the Caurus Zone with respect to the Subrobustus Zone are taken to justify placing the Caurus Zone at the base of the Middle Triassic. Definition of the Anisian substages is discussed by Silberling and Tozer (*in press*).

Lower Anisian Substage

Caurus Zone

Index species: *Lenotropites caurus* (McLearn) (= *"Hungarites" caurus* McLearn, 1948, Supplement, p. 1.) (Pl. VII, figs. 1a, b)

Type locality: East limb of anticline west of Mile Post 375, Alaska Highway, northeast British Columbia (ann. 28).

Occurrence: Arctic islands — Blaa Mountain Formation, Lower Shale member, Ellesmere Island; Schei Point Formation, Exmouth Island. Eastern Cordillera — Toad Formation, northeast British Columbia; Sulphur Mountain Formation, Black Shale member, Alberta. Western Plains — Doig Formation, northern Alberta.

The Caurus Zone is characterized by species of *Lenotropites, Groenlandites, Pearylandites, Grambergia,* and *Arctohungarites*. Among the ammonoids described by McLearn (1946a, 1946b, 1948, and *in press*) from the Toad Formation of British Columbia, *Lenotropites* is represented by *"Hungarites" caurus* McLearn, *"Hungarites" boreas* McLearn, and *"Hungarites" dawsoni* McLearn; *Grambergia* by *"Hungarites" ovinus* McLearn, *"Hungarites" mackenzii* McLearn, *"Hungarites" nahwisi* McLearn, and probably also *Longobardites mctaggarti* McLearn; and *Arctohungarites* by *"Hungarites" bufonis* McLearn. *Groenlandites* cf. *G. nielseni* Kummel and *Pearylandites* aff. *P. troelseni* Kummel are present in collections obtained recently. Also characteristic of the Caurus Zone are *Acrochordiceras americanum* McLearn, *Leiophyllites kindlei* McLearn and *Ussurites muskwa*

McLearn. The genus *Longobardites,* represented by specimens apparently conspecific with *Longobardites nevadanus* Hyatt and Smith, makes its appearance in the Caurus Zone. Species of *Parapopanoceras, Stenopopanoceras, Anagymnites,* and *Sturia* are also present. The Beyrichitidae, so abundant in the later Anisian zones, are unknown in the Caurus Zone.

Equivalents of the Caurus Zone appear to be widely distributed in northern latitudes. They include the *Pearylandites* beds of North Greenland (Kummel, 1953) and possibly also the *Koptoceras* beds of Spitsbergen (Frebold, 1929; Spath, 1951, p. 13). *Koptoceras undulatum* Spath (1951, p. 12) (=*Eutomoceras* aff. *E. laubei* Meek of Frebold, 1929, pl. II, fig. 5) is possibly congeneric with *Lenotropites caurus.* However, this cannot be established definitely, because all known specimens of *Koptoceras* are crushed and do not show suture lines. Without the suture line it is impossible to say whether *Koptoceras* is related to *Lenotropites caurus* or to *Longobardites larvalis* McLearn of the Varium Zone. Specimens of *Longobardites larvalis* obtained recently show that the adult whorl section is subtrigonal like that of *Lenotropites caurus* (McLearn). The suture line of *Longobardites larvalis,* however, has relatively numerous, narrow elements with at least three auxiliary lobes, unlike the short suture line of *Lenotropites.*

Among the Anisian ammonoids from Siberia described by Kiparisova (1937) and Popov (1961a), several suggest affinity with the fauna of the Caurus Zone; in fact most of the ammonoids from the *Beyrichites* Zone of Popov (1961a, p. 7) indicate affinity with either the Caurus Zone or the Varium Zone. Those that evidently relate to fauna of the Caurus Zone include *Grambergia taimyrensis* Popov, which resembles *Grambergia nahwisi*; also *Arctohungarites arcticus* (Kiparisova), which resembles *Arctohungarites bufonis* (McLearn). *Lenotropites* is also a member of the Anisian fauna of Siberia.

N. J. Silberling (pers. com.) has recently recognized equivalents of the Caurus Zone in the Prida Formation of Humboldt Range, Nevada.

In Timor, Welter (1915, pp. 102-103) has described a block in which beds with *Acrochordiceras anodosum* Welter, *Sturia,* etc., are adjacent to a bed with *Keyserlingites angustecostatus* Welter. *Acrochordiceras anodosum* resembles *Acrochordiceras americanum* and suggests a correlation with the Caurus Zone. This block apparently indicates the same relationship as is observed in Canada, namely superposition of the Caurus Zone (represented by *Acrochordiceras anodosum* in Timor) above the Subrobustus Zone (with *Keyserlingites angustecostatus* in Timor) (Tozer, 1965a, p. 12).

Middle Anisian Substage

Varium Zone

Index species: *Anagymnotoceras varium* (McLearn) (=*Gymnotoceras varium* McLearn, 1948, p. 33). (Pl. VII, figs. 2, 3)

Type locality: West limb of anticline west of Mile Post 375, Alaska Highway, northeast British Columbia (ann. 28).

Occurrence: Arctic islands — Blaa Mountain Formation, Lower Shale member, Ellesmere Island; Schei Point Formation, Ellesmere Island. Eastern Cordillera — Toad Formation, northeast British Columbia; Sulphur Mountain Formation, Black Shale member, Alberta.

This zone is characterized by the appearance of abundant Beyrichitidae, represented by *Anagymnotoceras* and *Hollandites.* According to McLearn's revision of the Anisian ammonoids of northeastern British Columbia (McLearn, 1966, and *in press*), the following species originally described as *Gymnotoceras* are now assigned to *Anagymnotoceras: Anagymnotoceras varium* (McLearn), *Anagymnotoceras moderatum* (McLearn), *Anagymnotoceras helle* (McLearn), *Anagymnotoceras wrighti* (McLearn), *Anagymnotoceras ino* (McLearn), *Anagymnotoceras columbianum* (McLearn). Recent work has established that all these species, with the exception of *Anagymnotoceras wrighti,* occur in the Varium Zone. *Anagymnotoceras wrighti* is probably also from the Varium Zone but this has not been definitely established.

Also characteristic of the Varium Zone are *Hollandites* n. sp. (described by McLearn, *in press*), *Hollandites spivaki* McLearn, *Longobardites larvalis* McLearn, *Czekanowskites hayesi* (McLearn), *Parapopanoceras selwyni* McLearn, *Ismidites* sp., and *Parapinacoceras hagei* (McLearn). *Hollandites humi* McLearn, *Ptychites wrighti* McLearn, and *Anagymnites* cf. *A. lamarcki* (Oppel) are probably also members of the fauna of the Varium Zone.

It is possible that this zone is capable of subdivision because there is an indication that there are two faunal assemblages in British Columbia, one characterized by *Longobardites larvalis* and *Parapinacoceras hagei,* the other by *Czekanowskites hayesi.*[1]

This zone probably has close correlatives in Siberia, as indicated by the occurrence of *Czekanowskites gastroplanus* (Popov) and *Czekanowskites wakeri* (Bayarunas) both of which closely resemble *Czekanowskites hayesi.* Equivalents may also be present in the *Hollandites*-bearing beds of the Himalayas and Japan and in the beds with *Ismidites* in Turkey.

N. J. Silberling recognizes a correlative of the Varium Zone in the Prida Formation of Humboldt Range, Nevada (Silberling and Tozer, *in press*).

Upper Anisian Substage

Deleeni Zone

Index species: *Gymnotoceras deleeni* (McLearn) (=*Beyrichites deleeni* McLearn, 1964a, p. 16), (Pl. VII, figs. 4, 5). McLearn (*in press*) assigns this species to *Gymnotoceras.*

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[1]Recent work has shown that *Czekanowskites hayesi* may characterize the upper part of the Varium Zone (*see* footnote, p. 72). *Epiczekanowskites* Popov is a junior synonym of *Czekanowskites* Diener (*see* Popov, Yu. N. *in* Krasnyi, L.E. (Ed.), Geological structure of the northwestern part of the Pacific Ocean Mobile Zone, U.S.S.R. Ministry of Geology, VSEGEI, 1966, pp. 151, 154). The type species of *Czekanowskites* is evidently from Middle Triassic beds, not Lower Triassic as formerly believed (M. V. Korchinskya, pers. com.).

Type locality: West limb of anticline west of Mile Post 375, Alaska Highway, northeast British Columbia (ann. 28).

Occurrence: Arctic islands — Schei Point Formation, Exmouth Island (?). Eastern Cordillera — Toad Formation, northeast British Columbia; Sulphur Mountain Formation, Silty Dolomite member, Alberta.

Besides the index species the following ammonoids are known in the Deleeni Zone of northeast British Columbia: *Gymnotoceras* aff. *G. rotelliformis* Smith, *Longobardites nevadanus* Hyatt and Smith, *Parapopanoceras tetsa* McLearn, *Anagymnites via-alaskae* McLearn, *Tropigymnites* cf. *T. planorbis* (Hauer), *Ptychites* sp. *Gymnotoceras beachi* McLearn and *Gymnotoceras liardense* McLearn are probably also from this zone.

The Deleeni Zone is also marked by the appearance of *Daonella*. Specimens actually associated with *Gymnotoceras deleeni* are referable to *Daonella americana* Smith, which according to Silberling (1962, p. 157, and pers. com.) is restricted to the lower part of the Upper Anisian in Nevada. The recognition of this zone in the Arctic islands is based solely on the occurrence of *Daonella* cf. *D. americana.*

Any discussion of the correlation of the Deleeni Zone must await the full description of the Upper Anisian zones of Nevada by N. J. Silberling.

Chischa Zone

Index species: *Gymnotoceras chischa* n. sp. (Pl. VII, figs. 6, 7)

Type locality: Chischa River, 8 miles above Muskwa River, northeast British Columbia (ann. 27).

Occurrence: Arctic islands — Blaa Mountain Formation, Lower Shale member, Ellesmere and Axel Heiberg Islands (?); Schei Point Formation, Exmouth Island. Eastern Cordillera — Toad Formation, northeast British Columbia; Sulphur Mountain Formation, Silty Dolomite member, Alberta (?).

The fauna of the Chischa Zone, at the type locality, comprises *Gymnotoceras chischa* n. sp., *Celtites* ? *polygyratus* Smith, *Parapopanoceras* sp. and *Daonella* cf. *D. moussoni* Merian. *Gymnotoceras chischa* has a well-defined ventral keel, unlike the *Gymnotoceras* species of the older zones. Keeled *Gymnotoceras* species, as yet unnamed, occur at other localities in British Columbia and they evidently indicate the occurrence of at least approximate correlatives of the Chischa Zone. The specimen of *Nevadites merriami* Smith, recorded from the Toad Formation by Westermann (1963), probably indicates the Chischa Zone or a slightly lower level. Unfortunately the exact locality and stratigraphic position of this *Nevadites* is unknown.

The presence of *Celtites* ? *polygyratus* and *Daonella* cf. *D. moussoni* in the Chischa Zone indicates a correlation with the upper part of the Upper Anisian of Nevada (Silberling, 1962, and pers. com.). Near or exact correlatives are present in Spitsbergen, as shown by the occurrence of *Gymnotoceras laqueatum* (Lindström), which closely resembles *Gymnotoceras chischa.*

The record of the Chischa Zone from the Arctic islands is based on the occurrence of *Gymnotoceras* cf. *G. laqueatum* (Lindström) and *Ptychites* cf. *P. trochlaeformis* (Lindström) (ann. 9).

Occurrences of *Daonella dubia* Gabb, as in the Sulphur Mountain Formation of Alberta, probably indicate the Chischa Zone, because Silberling (1962) has shown that this species is restricted to the uppermost Anisian of Nevada.

Ladinian Stage

The type section for the Ladinian Stage is in the Italian Tyrol. In this bulletin the Ladinian is interpreted as including only the Buchenstein and Wengen beds and their equivalents. The St. Cassian beds, containing the zone of *Trachyceras aon,* which overlie the Wengen strata, are regarded as Lower Karnian, following Mojsisovics (1895), Spath (1934), Leonardi (1956), and Jacobshagen (1961). Arthaber (1905), Pia (1930), and Rosenberg (1952, 1959) adopt a different convention and assign the St. Cassian beds to the uppermost Ladinian.

Lower Ladinian Substage

In Nevada, it has been shown by Silberling (1962, p. 653) that the appearance of *Protrachyceras* apparently defines the base of the Ladinian Stage.

Two ammonoid zones are recognized in the Lower Ladinian of Canada, the Subasperum Zone and the Poseidon Zone. These zones have not been observed in sequence.

The recognition of Lower Ladinian beds in the western and northern parts of the Cordillera is based solely on occurrences of *Daonella* cf. *D. degeeri* Boehm. No determinable ammonoids are known from these rocks.

Subasperum Zone

Index species: *Protrachyceras subasperum* (Meek); Smith, 1914, p. 137.

Type locality: Humboldt Range, Nevada (N. J. Silberling, pers. com.).

Synonym: *Protrachyceras* Zone (Silberling, 1962, p. 153).

Occurrence in Canada: Arctic islands — Blaa Mountain Formation, Ellesmere and Axel Heiberg Islands; Schei Point Formation, Ellesmere, Table, and Exmouth Islands. Eastern Cordillera — Toad Formation, northeast British Columbia.

In Nevada this zone is characterized by the occurrence, in the same beds, of *Protrachyceras subasperum, Protrachyceras meeki* (Mojsisovics), and a species of *Gymnotoceras* (N. J. Silberling, pers. com.). In the Toad Formation of British Columbia *Protrachyceras* cf. *P. meeki* is associated with *Gymnotoceras* spp., *Ptychites* sp., and *Daonella* cf. *D. moussoni* Merian, providing grounds for correlating with the Subasperum Zone of Nevada, despite the fact that the index species has not been found in Canada.

One specimen of *Protrachyceras,* with simple spines adjacent to the ventral furrow like *Protrachyceras meeki,* is known from the *Daonella frami* bed of the Schei Point Formation of Ellesmere Island. *Longobardites* sp., *Ptychites nanuk* Tozer, and *Daonella* cf. *D. degeeri* Boehm also occur with *Daonella frami*. This fauna probably indicates an approximate correlative of the Subasperum Zone.

The relationship between the Subasperum Zone and the adjacent Chischa and Poseidon Zones has not been demonstrated in a stratigraphic section in Canada. The Subasperum Zone is regarded as younger than the Chischa Zone on the basis of data provided by Silberling (1962, and pers. com.). In Canada the Subasperum Zone occurs in beds that undoubtedly represent the Toad Formation. The Poseidon Zone occurs in the basal beds of the Liard Formation. The faunas of the Subasperum and Poseidon Zones are markedly dissimilar. The available evidence suggests, but does not prove, that the Subasperum Zone is older than the Poseidon Zone.

Poseidon Zone

Index species: *Progonoceratites poseidon* n. sp. (Pl. VIII, figs. 3-5)

Type locality: Bluff north of Tuchodi River, 10 miles southeast of Mount Mary Henry, northeast British Columbia (ann. 25).

Occurrence: Eastern Cordillera — Liard Formation, northeast British Columbia.

This zone is characterized by *Progonoceratites poseidon* and by the appearance of the genus *Nathorstites.* The fauna also includes *Ptychites* n. sp., *Protrachyceras* cf. *P. sikanianum* McLearn, and a distinctive *Daonella* related to *Daonella longobardica* Kittl. Another distinctive species of *Daonella,* resembling *Daonella subarctica* Popov, associated with *Protrachyceras,* occurs above *Progonoceratites poseidon* and below the Meginae Zone (Upper Ladinian). The bed with *Daonella* cf. *D. subarctica* is arbitrarily regarded as Lower Ladinian. Until more ammonoids are known it is not possible to decide whether this bed represents a new zone or merely the upper part of the Poseidon Zone.

The Poseidon Zone underlies the Meginae Zone, so its position, with respect to the younger zones, is well established. As already mentioned, the Subasperum and Poseidon Zones have not yet been discovered in sequence.

Progonoceratites poseidon is probably closely related to *Progonoceratites atavus* (Phillipi), the index fossil of the lowest zone in the Upper Muschelkalk of Germany. This part of the Muschelkalk is generally considered to be correlative with the Lower Ladinian of the Alps (Spath, 1934, p. 35).

Upper Ladinian Substage

Three zones characterized by *Meginoceras meginae, Maclearnoceras maclearni,* and *Paratrachyceras sutherlandi* are assigned to the Upper Ladinian. These three zones correspond to the *Nathorstites* Zone of earlier reports (McLearn, 1937a, p. 95; 1947b; Tozer, 1961a). *Nathorstites* is abundant in all three zones but is not restricted to them; it is also present in the newly discovered Poseidon Zone of

Lower Ladinian age. *Nathorstites mcconnelli* (Whiteaves), in a restricted sense, is apparently confined to the Sutherlandi Zone. The *Nathorstites* from the Poseidon, Meginae, and Maclearni Zones differ from the types of *Nathorstites mcconnelli* in the details of growth lines, sculpture, and whorl section. They are probably at least subspecifically distinct from *Nathorstites mcconnelli,* but as yet they have not been named. *Daonella* occurs in all three Upper Ladinian zones. Most of the specimens from the Meginae and Maclearni Zones are assigned to *Daonella nitanae* McLearn, which closely resembles *Daonella lommeli* Wissmann, a guide fossil for the Alpine Wengen beds (Upper Ladinian). In the Sutherlandi Zone, *Daonella nitanae* is replaced by *Daonella elegans* McLearn. The occurrence of *Daonella nitanae* in the Meginae and Maclearni Zones seems to justify their assignment to the Upper Ladinian. The Sutherlandi Zone, as noted below, probably has no exact counterpart in the previously proposed zonal schemes for the Triassic. It evidently lies close to the Ladinian–Karnian boundary and is arbitrarily placed in the Ladinian.

The *Nathorstites* recorded from the Arctic islands resemble *Nathorstites mcconnelli* and are probably Upper rather than Lower Ladinian. *Neocladiscites* cf. *N. martini* (Smith) is the only other ammonoid known from the *Nathorstites* beds of the Arctic. On the basis of such a small fauna the beds cannot be more precisely dated.

Meginae Zone

Index species: *Meginoceras meginae* McLearn, 1930, p. 4. (Pl. VIII, figs. 6, 7)

Type locality: North side Liard River, Boiler Canyon, 1½ miles below the Rapids of the Drowned, northeast British Columbia (ann. 24).

Occurrence: Eastern Cordillera — Liard Formation, northeast British Columbia.

The characteristic ammonoids of this zone are *Meginoceras meginae* McLearn, *Silenticeras hatae* McLearn, *Thanamites schoolerensis* (McLearn), *"Sagenites" gethingi* McLearn, and a species of *Nathorstites* with simple, convex growth lines (McLearn, 1947b, Pl. II, fig. 6). *Protrachyceras sikanianum* McLearn has its type locality in beds of the Meginae Zone but this species, as already noted, probably ranges down into the Poseidon Zone. Species of *Megaphyllites* [=*Nitanoceras*] and *Lobites* also occur in the Meginae Zone; they are closely related to species that occur in the overlying Maclearni and Sutherlandi Zones. *Paratrachyceras tetsa* McLearn is about the same age as the typical members of the Meginae Zone but is probably somewhat older or younger and may eventually prove to be characteristic of an independent zone. *Arpadites* aff. *A. toldyi* Mojsisovics occurs in beds that are assigned to the Meginae Zone.[1]

Maclearni Zone

Index species: *Maclearnoceras maclearni* Tozer, 1963b, p. 35. (Pl. VIII, figs. 8a, b)

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[1]See footnote, page 67.

Type locality: North side Liard River, 2½ miles west of Hell Gate, northeast British Columbia (ann. 24).

Occurrence: Eastern Cordillera — Liard Formation, northeast British Columbia.

Maclearnoceras maclearni Tozer, *Liardites whiteavesi* Tozer, and *"Paratrachyceras" caurinum* McLearn are the only three ammonoids so far described from this zone. The undescribed fauna is large and includes *Hungarites* sp., *Protrachyceras* aff. *P. sikanianum* McLearn, *Anolcites* cf. *A. doleriticum* (Mojsisovics), *Maclearnoceras* n. spp., *Clionitites?* n. sp., *Asklepioceras* sp., *Nathorstites* sp., etc. The species of *Anolcites* closely resembles *Anolcites doleriticum* from the *Protrachyceras archelaus* Zone (Wengen beds) of Northern Italy.

Sutherlandi Zone

Index species: *Paratrachyceras sutherlandi* McLearn, 1947b, p. 22. (Pl. VIII, figs. 9-12)

Type locality: North side Liard River, Boiler Canyon, 3 miles below the Rapids of the Drowned, northeast British Columbia (ann. 24).

Occurrence: Eastern Cordillera — Liard Formation and basal Grey beds, northeast British Columbia.

The ammonoid fauna of the Sutherlandi Zone includes *Protrachyceras* sp. indet., *Protrachyceras* n. sp. aff. *Trachyceras brotheus* (Munster), *Daxatina* [=*Dawsonites*] *canadensis* (Whiteaves), *Paratrachyceras sutherlandi* McLearn, *Asklepioceras glaciense* McLearn, *A. laurenci* McLearn, *A. mahaffii* McLearn, *Hannaoceras* n. sp., Lobites cf. *L. ellipticus* (Hauer), *Joannites* sp., *Megaphyllites* sp., and *Nathorstites mcconnelli* (Whiteaves).

In some sections several species (e.g., *Daxatina canadensis, Protrachyceras* aff. *T. brotheus,* and *Joannites* sp.) range higher than *Paratrachyceras sutherlandi.* These occurrences suggest that two zones may eventually be discriminated within the Sutherlandi Zone. On the other hand, *Daxatina canadensis* and *Paratrachyceras sutherlandi,* and probably also *Protrachyceras* aff. *T. brotheus,* are also known to occur together and consequently only one zone is recognized.

At least the upper part of the Sutherlandi Zone is probably intermediate in age between the *Protrachyceras archelaus* Zone (Upper Ladinian) and the *Trachyceras aon* Zone (Lower Karnian). This suggestion is made because the Sutherlandi Zone overlies an equivalent of the Archelaus Zone (i.e., the Maclearni Zone), and underlies the Obesum Zone of Lower Karnian age. It is probable, however, that equivalents of the Sutherlandi Zone are present in other parts of the world, in beds that have generally been assigned to the Lower Karnian. The *Daxatina* beds of Bear Island (Boehm, 1903) are one example. Ammonoids identified as *Paratrachyceras regoledanum* (Mojsisovics) from Turkey (Arthaber, 1914) and Thailand (Kummel, 1960) are possibly conspecific with *P. sutherlandi,* and may indicate the occurrence of correlative beds.

Upper Triassic Series

Karnian Stage

The Karnian Stage is used here in the sense of Mojsisovics (1895), that is to say it includes equivalents of the Cordevolic, Julic, and Tuvalic Substages. As already mentioned, the St. Cassian beds, the stratotype for the Cordevolic Substage, are regarded as Ladinian by some authors. Spath (1934) recognized three divisions within the Karnian, from oldest to youngest the Trachyceratan, Carnitan, and Tropitan. The Trachyceratan includes the Cordevolic and Julic Substages; the Tropitan, the Tuvalic. Spath's Carnitan Division was proposed on hypothetical grounds and as noted by Arthaber (1935) the recognition of this division is apparently not justified. Lower Karnian, as used in this bulletin, is equivalent to the Trachyceratan and to a combination of the Cordevolic and Julic Substages. Upper Karnian is equivalent to the Tuvalic (=Tropitan). As noted below, it is possible that the Cordevolic and Julic Substages are partly contemporaneous.

Lower Karnian Substage

Obesum Zone

Index species: *Trachyceras obesum* n. sp. (p. 93, Pl. IX, figs. 1a, b)

Type locality: Ewe Mountain, 4½ miles ENE of Triangulation Station 6536, Toad River area, northeast British Columbia (ann. 23).

Occurrence: Arctic islands — Blaa Mountain Formation, Lower Shale member, Axel Heiberg Island (?). Eastern Cordillera — Grey beds and equivalents, northeast British Columbia. Western Cordillera — Lewes River Group, Yukon (?).

The Obesum Zone is named to include the beds that contain *Trachyceras* s.s. in Canada and their apparent correlatives. This zone is as yet imperfectly known, but there seems to be no doubt that there is a *Trachyceras*-bearing zone between the Sutherlandi and Nanseni Zones. At the type locality only the index species is known. From other places in northeast British Columbia the following Lower Karnian ammonoids probably indicate near or exact correlatives of the Obesum Zone: *Trachyceras* cf. *T. desatoyense* Johnston, *Clionitites reesidei* (Johnston), *Coroceras* cf. *C. nasutus* (Mojsisovics). *Halobia* sp. indet. occurs at the type locality and elsewhere.

Poorly preserved trachyceratids in the Lewes River Group of southern Yukon possibly indicate the Obesum Zone.

In northwest Axel Heiberg Island there are beds in the Lower Shale member of the Blaa Mountain Formation that contain *Discophyllites* cf. *D. taimyrensis* Popov and *Halobia* cf. *H. zitteli* Lindström. These beds are well below the Nanseni Zone and are probably approximately the same age as the Obesum Zone.

The presence of *Trachyceras* s.s. in the Obesum Zone suggests that correlatives occur in the *Trachyceras aon* Zone of the Italian Tyrol, or in the *Trachyceras aonoides* Zone of Austria, or, as an alternative, in both of these European zones.

Traditionally the Aon Zone is regarded as older than the Aonoides Zone, but they are not known in sequence. It seems possible that these two zones may include faunas of essentially the same age. The Aonoides Zone, as represented at the Feuerkogel, is said to contain an enormous fauna, including tropitids and juvavitids, as well as *Trachyceras* and *Sirenites*. This fauna includes genera that are restricted to one or other of four successive Karnian zones in Canada (Obesum, Nanseni, Dilleri, and Welleri) and also *Lobites* s.s., which is restricted to the Upper Ladinian. This suggests that the Aonoides Zones of the Feuerkogel represents a condensed deposit containing faunas of more than one age. The fauna listed from the Aonoides Zone at this locality even includes *Cyrtopleurites* and *Waldthausenites,* which in Canada are known only in the Norian. Norian ammonoid faunas, as well as the Aonoides and Subbullatus Zones of the Karnian are known from the Feuerkogel. In view of the anomalies introduced by the composition of the Aonoides Zone at this locality it is worth considering the possibility that the faunal list represents not only a condensed sequence, but also includes ammonoids derived from other zones. The fauna of the Aonoides Zone at Raschberg, unlike that of the Feuerkogel, may be relatively uncontaminated. The Raschberg fauna includes *Trachyceras, Sirenites, Coroceras,* etc., but there are no juvavitids or tropitids and none of the ammonoids that are restricted to the Norian in Canada.

Clionitites reesidei and *Trachyceras* cf. *T. desatoyense* suggest a correlation with the Lower Karnian fauna of New Pass Range, Nevada (Johnston, 1941; Silberling, 1956), but, as already noted, these two species are not known at the type locality of the Obesum Zone.

Nanseni Zone

Index species: *Sirenites nanseni* Tozer, 1961b, p. 77. (Pl. IX, figs. 2, 3)

Type locality: Ewe Mountain, 4½ miles ENE of Triangulation Station 6536, Toad River area, northeast British Columbia (ann. 23).

Occurrence: Arctic islands — Blaa Mountain Formation, Middle Shale member, Ellesmere and Axel Heiberg Islands; Schei Point Formation, Hat Island. Eastern Cordillera — Grey beds, northeast British Columbia. Western Cordillera — unnamed beds, Kluane area, Yukon (?).

The Nanseni Zone is characterized by abundant *Sirenites* and numerous *Halobia,* including *Halobia* cf. *H. zitteli* Lindström and *Halobia* cf. *H. rugosa* Gümbel. In British Columbia *Sirenites nanseni, S.* cf. *S. senticosus* (Dittmar) and *S.* cf. *S. striatofalcatus* (Hauer) occur at approximately the same level. In the Arctic islands *Sirenites nanseni* commonly occurs below *S. senticosus*. The former is in the Middle Shale member of the Blaa Mountain Formation; the latter is commonly in the Upper Calcareous member. *Sirenites senticosus* may have a long range in the Karnian for this species possibly occurs with *Jovites borealis* Tozer, which indicates the Welleri Zone (Tozer, 1961b, p. 37).

The questionable record of this zone from the Kluane Lake area, Yukon, is based on poorly preserved material.

Sirenites nanseni closely resembles a number of species in the *Trachyceras aonoides* Zone of Austria (Tozer, 1961b, p. 77).

Upper Karnian Substage

The classification used for the Upper Karnian is based on that of Silberling (1956; 1959, p. 22) who discriminated three divisions within this substage. Of the zones named by Silberling those characterized by *Tropites dilleri, Tropites welleri,* and *Klamathites macrolobatus* are recognized in Canada. Smith (1927) had previously recognized the Dilleri and Welleri Zones as the *Trachyceras* and *Juvavites* Subzones of the *Tropites subbullatus* Zone. As indicated by Smith, the faunas of the Dilleri and Welleri Zones have much in common with the Subbullatus Zone of Austria, which forms the basis for the Tuvalic Substage.

Dilleri Zone

Index species: *Tropites dilleri* Smith, 1904, p. 393. (Pl. IX, figs. 4, 5)

Type locality: Shasta County, California (Silberling, 1956, p. 1152).

Synonym: *Trachyceras* Subzone of *Tropites subbullatus* Zone (Smith, 1927, p. 4).

Occurrence: Eastern Cordillera — Grey beds, northeast British Columbia. Western Cordillera — Karmutsen Group and Quatsino Formation, Vancouver Island; Open Bay Formation, southwestern British Columbia; unnamed rocks, northwest British Columbia.

Well-preserved examples of *Tropites dilleri* are unknown in Canada, but several species characteristic of this zone in California occur in both the eastern and western parts of the Cordillera. The following are present in both regions: *Spirogmoceras shastense* (Smith), *Traskites* spp., *Paratropites sellai* Mojsisovics (of Smith), *Discotropites sandlingensis* (Hauer). The fauna from the Western Cordillera also includes *Paratropites* cf. *P. sulcatus* (Calcara of Gemmellaro), *Gymnotropites* cf. *G. americanus* Hyatt and Smith, *Bacchites* cf. *B. bacchus* Mojsisovics, *Leconteiceras* sp., *Trachysagenites herbichi* Mojsisovics. Present in the Eastern Cordillera, but unknown in the west, are *Thisbites* sp. and *Trachystenoceras* aff. *T. gabbi* (Hyatt and Smith). A fauna of this zone has recently been described from the Open Bay Formation of Quadra Island by Carlisle and Susuki (1965). This assemblage includes one small specimen compared with *Tropites welleri,* but the greater part of the fauna clearly indicates the Dilleri Zone, as recognized by Susuki.

A negative characteristic of the fauna of the Dilleri Zone, apparently applicable in California, Nevada, Vancouver Island, and in both northwest and northeast British Columbia, is the absence of juvavitids. They have been recorded from the Lower Karnian of Europe, but none has been found in the Dilleri Zone, or below, in Canada.

In Canada the halobiids that occur in the Dilleri Zone are poorly preserved. In northeast British Columbia *Halobia ornatissima* Smith is abundant in beds that lie between the Dilleri and Welleri Zones. Locally, *Halobia ornatissima* is associated with ammonoids that may, eventually, permit the recognition of a new zone, intermediate in age between the Dilleri and Welleri Zones. The *Discotropites sandlingensis* beds of Peace River (McLearn, 1960a, p. 6) probably fall within this interval.

Most of the ammonoids listed above occur in the Dilleri Zone of California. The *Paratropites* compared with *P. sulcatus* is apparently conspecific with specimens recorded under this name from the Dilleri Zone in the Natchez Pass Formation of Nevada (Silberling, 1961). In both British Columbia and Nevada this species of *Paratropites* is associated with a nautiloid resembling *Pleuronautilus alaskensis* Kummel.

Welleri Zone

Index species: *Tropites welleri* Smith, 1927, p. 33.

Type locality: Shasta County, California (Silberling, 1959, p. 21).

Synonym: *Juvavites* Subzone of *Tropites subbullatus* Zone (Smith, 1927, p. 4).

Occurrence: Arctic islands — Blaa Mountain Formation, Axel Heiberg Island; Schei Point Formation, Table Island. Eastern Cordillera — Pardonet Formation, northeast British Columbia. Western Cordillera — Quatsino Formation, Vancouver Island; Kunga Formation, Queen Charlotte Islands; unnamed rocks, northwest British Columbia. Northern Cordillera — unnamed rocks, Nash Creek area, Yukon.

Tropites welleri is not represented in Canada by well-preserved specimens but several ammonoid species characteristic of this zone occur in British Columbia. They include *Tropites johnsoni* Smith, *Tropites reticulatus* Smith, *Tropites* sp. aff. *T. welleri* Smith, *Discotropites theron* (Dittmar), *Discotropites mojsvarensis* Smith, *Hannaoceras major* (Smith), *Juvavites subintermittens* Hyatt and Smith, and *Homerites semiglobosus* (Hauer). Also present, associated with typical members of the Welleri Zone fauna, are *Hoplotropites* cf. *H. auctus* (Dittmar) and *Jovites* cf. *J. bosnensis* Mojsisovics. *Pamphagosirenites pamphagus* (Dittmar) occurs in beds that probably represent the Welleri Zone.

In Arctic Canada, the beds in the Schei Point Formation containing *Tropites* cf. *T. morani* Smith and *Jovites richardsi* Tozer probably represent the Welleri Zone. This is probably also true of the beds with *Arctosirenites canadensis* Tozer and *Jovites borealis* Tozer in the Blaa Mountain Formation. The age of *Arctosirenites canadensis* is apparently established by the occurrence, in a single talus block from northeastern British Columbia, of *Arctosirenites canadensis,* together with *Discotropites mojsvarensis* Smith, *Juvavites* cf. *J. hyatti* (Smith), and *Juvavites* cf. *J. brockensis* Smith.

The presence of this zone in the northern part of the Cordillera is indicated by the occurrence of *Juvavites* cf. *J. knowltoni* Smith.

Halobiids that resemble *Halobia superba* Mojsisovics are common in the Welleri Zone.

Macrolobatus Zone

Index species: *Klamathites macrolobatus* Silberling, 1959, p. 38.

Type locality: Union District, Shoshone Mountains, Nevada (Silberling, 1959, p. 22).

Occurrence: Eastern Cordillera — Pardonet Formation, northeast British Columbia.

Klamathites macrolobatus is unknown in Canada. The presence of the Macrolobatus Zone is recognized chiefly by the presence of *Anatropites* sp. (of Silberling, 1959, p. 51), which is a member of the fauna of this zone in Nevada. Also present in the Macrolobatus Zone of British Columbia are *Tropites* aff. *T. latiumbilicatus* Silberling, *Gonionotites gethingi* (McLearn), *Griesbachites* cf. *G. kastneri* (Mojsisovics), *Halobia* cf. *H. superba* Mojsisovics.

Norian Stage

This stage is divided into three substages, designated Lower, Middle, and Upper Norian (Tozer, 1965c; Silberling and Tozer, *in press*). Mojsisovics (1895) also recognized three divisions within the Juvavic (=Norian) Stage, from oldest to youngest, the Lacic, Alaunic, and Sevatic Substages. However, as pointed out by Diener (1926) it cannot be demonstrated that the Lacic and Alaunic Substages are in sequence. The evidence from British Columbia suggests that the Lacic faunas (*Sagenites giebeli* and *Cladiscites ruber* Zones) are younger, not older, than the Alaunic Zone of *Cyrtopleurites bicrenatus* (Tozer, 1965c). The Giebeli and Ruber Zones are probably about the same age as the *Pinacoceras metternichi* Zone of Sevatic age. The three divisions recognized in North America do not, therefore, correspond with those of Mojsisovics, although Upper Norian, as used in Canada, is essentially synonymous with Sevatic. The grouping of zones adopted to form the Lower and Middle Norian Substages is, of necessity, essentially arbitrary.

Lower Norian Substage

Kerri Zone

Index species: *Mojsisovicsites kerri* (McLearn), (=*Stikinoceras kerri* McLearn, 1930, p. 5). (Pl. X, figs. 1a, b)

Type locality: Brown Hill, Peace River, northeast British Columbia (ann. 20).

Synonyms: *Stikinoceras* Zone (McLearn, 1960, p. 21 etc.); *Guembelites* Zone (Silberling, 1959, p. 22).

Occurrence: Eastern Cordillera—Pardonet Formation, northeast British Columbia. Western Cordillera — Quatsino Limestone and Bonanza Group, Vancouver Island; unnamed beds, northwest British Columbia.

The Kerri Zone of northeastern British Columbia is characterized by a rich ammonoid fauna that includes *Sirenites nabeschi* McLearn, *Cyrtopleurites* sp., *Mojsisovicsites kerri* (McLearn), *Thisbites dawsoni* (McLearn), *Thisbites charybdis* (Gemmellaro), *Thisbites* cf. *T. pyrami* (Gemmellaro), *Thisbites custi*

(McLearn), *Styrites ireneanus* McLearn, *Tropiceltites columbianus* (McLearn), *Juvavites humi* McLearn, *Juvavites schoolerensis* McLearn, *Dimorphites pardonetiensis* (McLearn), *Gonionotites rarus* (McLearn), *Guembelites clavatus* (McLearn), *Guembelites jandianus* Mojsisovics.

In the Western Cordillera only the index species is known; there it is commonly associated with *Halobia alaskana* Smith.

The Kerri Zone of Canada has a close correlative in the Luning Formation of Nevada (Silberling, 1959). Farther afield no clear correlatives have been discriminated but they are probably present in Sicily (the type area for *Mojsisovicsites*) and also in Timor and the Himalayas (where *Guembelites jandianus* is found).

Dawsoni Zone

Index species: *Malayites dawsoni* McLearn, 1937b, p. 130. (Pl. X, figs. 2a, b)

Type locality: Brown Hill, Peace River, northeast British Columbia (ann. 20).

Occurrence: Eastern Cordillera—Pardonet Formation, northeast British Columbia.

The ammonoid fauna of this zone includes *Malayites dawsoni* and related species, *Gonionotites belli* McLearn, *Gonionotites* aff. *G. gethingi* McLearn, and *Waldthausenites* spp. *Waldthausenites* cf. *W. leophanis* Diener, described by McLearn (1960a, p. 106), is probably from the Dawsoni Zone. The halobiids of the Dawsoni Zone are mainly delicately ribbed species, like *Halobia fallax* Mojsisovics and *Halobia superbescens* Kittl. A new fauna, obtained 10 feet above a bed with *Malayites dawsoni* in Toad River area (ann. 20) includes *Metacarnites* sp., a distinctive new species of *Juvavites,* and *Waldthausenites* cf. *W. acutus* (Mojsisovics) (=*Discotropites* cf. *D. acutus* Mojsisovics of McLearn, 1960a, p. 74). *Waldthausenites* cf. *W. acutus* is said to occur with *Malayites dawsoni* on Peace River (McLearn, 1941a, p. 99) and this association suggests that the new fauna represents the Dawsoni Zone. Representatives of the Magnus Zone were obtained above the beds that provided this new fauna.

A correlative of the Dawsoni Zone is probably present in Austria, where *Malayites* is known only in the *Heinrichites paulckei* Zone of the Feuerkogel. The fauna of the Paulckei Zone also includes *Drepanites,* a genus restricted to the Middle Norian Rutherfordi Zone in Canada. This probably indicates that the Paulckei Zone, like the Aonoides and Bicrenatus Zones, includes ammonoids of more than one age. At least two other ammonoids from the Feuerkogel, namely, *Waldthausenites acutus* (Mojsisovics) and *Waldthausenites idunae* Diener, closely resemble species in the Dawsoni Zone. These ammonoids are said to be of Karnian age, but as noted on page 32 the evidence for this conclusion may be suspect.

Middle Norian Substage

The Magnus, Rutherfordi, and Columbianus Zones, which are classed as Middle Norian, all show affinity with the *Cyrtopleurites bicrenatus* Zone of Austria. This gives grounds for suggesting that the Bicrenatus Zone, like the Aonoides Zone (p. 32), is a condensed deposit.

Magnus Zone

Index species: *Juvavites magnus* McLearn, 1940, p. 48. (Pl. X, figs. 3a-c)

Type locality: Brown Hill, Peace River, northeast British Columbia (ann. 20).

Occurrence: Eastern Cordillera — Pardonet Formation, northeast British Columbia. Western Cordillera — Lewes River Group, southern Yukon; Bonanza Group, Vancouver Island; unnamed beds, central British Columbia (?).

The fauna of this zone includes *Cyrtopleurites magnificus* McLearn, *Pterotoceras caurinum* McLearn, *Juvavites biornatus* McLearn, and *Juvavites magnus* McLearn. In Nevada *Indojuvavites* cf. *I. angulatus* (Diener) occurs at approximately the same level as *Juvavites magnus* (N. J. Silberling, pers. com.). This suggests that *Indojuvavites* cf. *I. angulatus,* recorded by McLearn (1960a, p. 92) from an isolated locality in the Peace River Valley, is a member of the fauna of the Magnus Zone. McLearn (1960a, p. 90) records a single specimen of *Guembelites* from the beds now assigned to this zone. It should be noted, however, that the main level for *Guembelites* in British Columbia, as in Nevada, is the Kerri Zone (*see* p. 36).

The records of the Magnus Zone from the Western Cordillera are based on poorly preserved ammonoids that resemble *Indojuvavites angulatus.*

Rutherfordi Zone

Index subspecies: *Drepanites hyatti rutherfordi* McLearn, 1960a, p. 46 (= *Drepanites rutherfordi* McLearn, 1937a, p. 98) (Pl. X, figs. 4a, b). The writer agrees with McLearn (1960a, p. 46) that the index ammonoid of this zone is not specifically separable from *Drepanites hyatti* Mojsisovics. A binomial combination, using the subspecific name has been used for the zone (Table II) solely to provide uniform, concise terminology (Tozer, 1965c, p. 224).

Type locality: Brown Hill, Peace River, northeast British Columbia (ann. 20).

Occurrence: Eastern Cordillera—Pardonet Formation, northeast British Columbia.

The ammonoid fauna of the Rutherfordi Zone comprises *Drepanites hyatti rutherfordi* McLearn, *Cyrtopleurites* sp., *Acanthinites* cf. *A. eusebii* Diener, *Metacarnites* sp., and *Didymites* sp. The associated halobiids are mainly *Halobia* cf. *H. fallax* Mojsisovics. McLearn (1941b, p. 96) also records *Halobia symmetrica lata* McLearn, *Halobia* cf. *H. dilatata* Kittl and *Halobia pacalis* McLearn from this zone.

Columbianus Zone

Index species: *Himavatites columbianus* McLearn, 1939, p. 55. (Pl. X, figs. 5a, b)

Type locality: Brown Hill, Peace River, northeast British Columbia (ann. 20).

Synonym: *Himavatites* Zone (McLearn, 1960a, p. 26, etc.).

Occurrence: Arctic islands — Heiberg Formation, Axel Heiberg Island. Eastern Cordillera — Pardonet Formation, northeast British Columbia. Western Cordillera—Bonanza Group, Vancouver Island. Northern Cordillera—unnamed beds, Nash Creek area, Yukon.

The Columbianus Zone contains the richest ammonoid fauna known in Canada. Most of these ammonoids were first discovered in North America by the late F. H. McLearn, and descriptions will be found in his monograph (McLearn, 1960a). The following genera are now known from the Columbianus Zone of northeast British Columbia: *Pseudosirenites, Vredenburgites, "Sandlingites"* (group of *"S." idae*), *Alloclionites, *Steinmannites, *Himavatites, "Buchites"* (group of *"B." modestus*), *Helictites, Phormedites, Parathisbites, *Distichites, *Thetidites, *Parajuvavites, *Episculites, Hypisculites, Sagenites, *Placites, *Pinacoceras, *Rhacophyllites.*

The genera marked with an asterisk (*) also occur in the Columbianus Zone of Vancouver Island. The fauna from Vancouver Island contains as well at least two ammonoids unknown in northeastern British Columbia namely *"Dittmarites"* cf. *"D." hindei* Mojsisovics and *"Sandlingites"* cf. *"S." striatissimus* Diener.

In Arctic Canada only *Himavatites* is known, and the record of this zone from the Northern Cordillera is based on a single small specimen of *Steinmannites.*

In terms of bivalve faunas the Columbianus Zone marks the appearance of the genus *Monotis,* represented by subspecies of *Monotis scutiformis* (Teller), e.g., *Monotis scutiformis typica* (Kiparisova) and *Monotis scutiformis pinensis* Westermann. McLearn (1960a, p. 20) and the writer (Tozer, 1961a, p. 4) have identified the *Monotis* specimens from this level as *Monotis alaskana* Smith but Westermann (1962a, p. 759) has shown that this identification is incorrect. At Brown Hill, on Peace River, the lowest beds of the Columbianus Zone carry *Halobia* and the higher beds carry *Monotis* (McLearn, 1941b, pp. 95-96), but from other occurrences there is no doubt that the ranges of *Halobia* and *Monotis* overlap within the Columbianus Zone. It is possible that the ranges of the different subspecies of *Monotis scutiformis* will permit subdivision of the Columbianus Zone but additional work is necessary before this can be established.

Monotis scutiformis and related forms have been described from Siberia (Kiparisova, 1936, 1937) and Japan (Nakazawa, 1964). In the past these *Monotis* beds have been regarded as Karnian (Kiparisova, 1936, p. 120; Popov, 1960); more recently as Upper Karnian and early Norian (Vozin and Tikhomirova, 1964, p. 5), or early Norian (Ichikawa, 1956; Nakazawa, 1964), but no convincing evidence for the adoption of these age assignments has been provided. In terms of the nomenclature applied to the North American sequence it would appear that these *Monotis* beds are Middle Norian and probably correlative with the Columbianus Zone.

Upper Norian Substage

Suessi Zone

Index species: *Rhabdoceras suessi* Hauer, 1860, p. 125 (=*Rhabdoceras russelli* Hyatt, 1892, p. 398). (Pl. X, figs. 6, 7)

Type locality: Clan Alpine Range, Nevada (Silberling, *in* Silberling and Tozer, *in press*).

Occurrence: Arctic islands — Heiberg Formation, Ellesmere, Axel Heiberg, Cornwall, and Brock Islands. Eastern Cordillera — Pardonet Formation, northeast British Columbia. Western Cordillera — Tyaughton Group, Nicola Group, and unnamed rocks, southern British Columbia; Bonanza Group, Sutton Formation, Vancouver Island; Parson Bay Formation, Queen Charlotte Strait; Kunga Formation, Queen Charlotte Islands; Sinwa Formation and unnamed rocks, northwest British Columbia; equivalent of McCarthy Formation and Lewes River Group, southern Yukon. Northern Cordillera — Shublik Formation and related, unnamed formations, northern Yukon.

In terms of earlier nomenclature applied to rocks in Canada, the Suessi Zone is equivalent to the *Monotis subcircularis* Zone of McLearn (1960a, etc.) and Tozer (1965c), together with the beds in western British Columbia and southern Yukon that contain the "late Norian fauna" (Tozer, 1954; 1958, p. 19). *Rhabdoceras suessi* occurs in the *Monotis subcircularis* Zone and is also a member of the "late Norian fauna". Two divisions are recognized within the Suessi Zone: a Lower Suessi Zone, equivalent to the *Monotis subcircularis* Zone; and an Upper Suessi Zone, which includes the Norian beds that overlie *Monotis subcircularis*.

Westermann (1962a) has proposed an elaborate classification for the beds generally assigned to the *Monotis subcircularis* Zone, but for reasons given under annotation 19 his classification has been found unacceptable.

In most parts of Canada the Lower Suessi Zone is known only from pelagic faunas. The Upper Suessi Zone, on the other hand, contains a richly varied benthonic fauna. The differences between the faunas of the upper and lower parts of the Suessi Zone are largely due to environmental influences, and it is unlikely that the boundary between the two parts of the zone represents a constant time-stratigraphic plane. Nevertheless, a division of the Suessi Zone into two parts provides the most appropriate means of expressing the relationships observed in Canada.

The following ammonoids are known from the Lower Suessi Zone of the Cordillera ("E" indicates occurrence in the Eastern Cordillera; "W" in the Western Cordillera): *"Ceratites"* aff. *C. riezingeri* Mojsisovics (E), *Rhabdoceras suessi* Hauer (E, W), *Halorites* cf. *H. americanus* Hyatt (E, W), *Halorites*? n. sp. (=*Indoclionites*? sp., McLearn, 1960, p. 45) (E), *Sagenites* sp. (W), *"Arcestes"* sp. (E), *Placites* sp. (E), *Rhacophyllites* sp. (E, W).

The Upper Suessi Zone is known at only one locality in the Eastern Cordillera — Rapide-qui-ne-parle-pas on Peace River — where *Rhabdoceras suessi, Placites* sp., *Rhacophyllites* sp., and nautiloids occur in beds above *Monotis subcircularis*.

The Upper Suessi Zone of the Western Cordillera is known from numerous localities and has provided the following ammonoids: *Choristoceras suttonensis* Clapp and Shimer, *Rhabdoceras suessi* Hauer, *Paracochloceras suessi* (Hauer), *Cycloceltites* cf. *C. arduini* Mojsisovics, *Metasibirites* sp., *"Arcestes"* sp., *"Cladis-*

cites" sp., *Paracladiscites* sp., *Megaphyllites* cf. *M. insectus* (Mojsisovics), *Placites* sp., *Rhacophyllites* sp. The fauna of the Upper Suessi Zone also includes many benthonic bivalves, echinoids, brachiopods, and corals.

Recognition of the Suessi Zone in the Arctic islands is based solely on the occurrence of *Monotis ochotica* (Keyserling). *Monotis ochotica* is undoubtedly closely related to *M. subcircularis,* but whether or not they are exactly the same age is uncertain. The evidence from British Columbia (ann. 18) seems to indicate that whatever the exact relationship *M. ochotica* is certainly not older than *M. subcircularis.* Ammonoids are also unknown in the Suessi Zone of the Northern Cordillera, where the zone is recognized from the occurrence of *Monotis subcircularis* and *M. ochotica.*

The Suessi Zone may be correlated with the *Pinacoceras metternichi* Zone of Austria, as represented in the Hallstatt Limestone of the Steinbergkogel, and in the *Cochloceras*-bearing part of the Zlambach Beds, as exposed in the Stambachgraben (Arthaber, 1905, p. 380; Kittl, 1903, pp. 16, 58-59; Kuehn, 1962, p. 528). Nearly all the ammonoid genera listed from the *Cochloceras* beds are present in the Suessi Zone of Canada. *Monotis salinaria* Bronn, a close relative of *M. subcircularis,* is also a member of the fauna of the *Cochloceras* beds, according to Kittl. Mojsisovics (1893) described both *Rhabdoceras suessi* and *Paracochloceras suessi* from the Stambachgraben, and evidently regarded these species as representatives of the *Choristoceras haueri* Subzone, of the Metternichi Zone. However, it was later shown by Kittl that the Haueri Subzone includes two assemblages, one of Norian, the other of Rhaetian age. *Choristoceras haueri* is from the part that is now generally regarded as Rhaetian (Spath, 1934, p. 39; Kuehn, 1962, p. 87). Mojsisovics recorded *Rhabdoceras suessi* from the *Sagenites giebeli* and *Cladiscites ruber* Zones, as well as from the Metternichi Zone. He believed that the Giebeli and Ruber Zones were substantially older than the Metternichi Zone, but according to Diener (1926) the supposed age relationship between these three zones is not based on superposition. Mojsisovics' zonal sequence for the Norian is certainly incorrect, and the Metternichi, Giebeli, and Ruber Zones are probably more or less the same age (Tozer, 1965c, p. 225).

On the basis of occurrences of *Monotis* and *Rhabdoceras,* correlatives of the Suessi Zone can be recognized in the Tethyan, Circum-Pacific, and Circum-Arctic areas. The occurrences in northeast Asia are of particular interest because they apparently permit the recognition of both the lower and upper parts of the zone. Popov (1961c, d) has recently described Norian ammonoids from northeast Asia. He has described ammonoids from two levels: the lower being the beds with *Monotis ochotica* and the upper being the beds between those with *Monotis* and the Lower Jurassic. From the lower level he records ammonoids identified as follows: *Clionites* cf. *C. gandolphi* Mojsisovics, *Anatomites* cf. *A. subinterruptus* Mojsisovics, *Juvavites* cf. *J. senni* Mojsisovics, *Arcestes colonus* Mojsisovics. Afitsky (1965) has recently added *Rhabdoceras boreale* Afitsky to this list. From the beds above those with *Monotis ochotica,* on the Bolshoi-Anyuy River, Popov has described *Placites symmetricus* Mojsisovics, *Placites* cf. *P. platyphyllus* Mojsisovics, *Megaphyllites insectus* Mojsisovics, *Arcestes* cf. *A. biceps* Mojsisovics, *Cladiscites beyrichi* Welter, *Rhacophyllites debilis timorensis* Welter, *Rhacophyllites* cf. *R. debilis* Hauer. Popov and Afitsky regard the *Monotis ochotica* beds as "Lower Norian", i.e., older than Sevatic; the overlying beds they consider to be Upper Norian. From the evidence in Canada there seems to be no doubt that *Monotis ochotica* and *Monotis subcircularis* occur only in the Upper Norian, and this seems to justify the suggestion that the *Monotis ochotica* beds of Asia are correlative with the Lower Suessi Zone, and the overlying beds, with *Placites,* etc., with the Upper Suessi Zone. *Anatomites* and *Juvavites,* recorded by Popov from the *Monotis ochotica* beds, suggest an age older than Upper Norian, but the specimens illustrated are small and are possibly the inner whorls of Upper Norian *Halorites.*

Tuchkov (1962) regards the *Monotis ochotica* beds as Upper Norian and dates the immediately overlying strata, in both Asia and Canada, as Rhaetian. This age assignment cannot be upheld because on both continents characteristic Norian ammonoids occur above the *Monotis ochotica* and *Monotis subcircularis* beds. There is no justification for correlating any part of the Suessi Zone with the Rhaetian.

In New Zealand the Warepan Stage (with *Monotis richmondiana* Zittel) and the overlying Otapirian Stage (with *Arcestes* cf. *A. rhaeticus* Clark) are probably equivalent, respectively, to the Lower and Upper Suessi Zones although it is possible, as generally held, that the Otapirian includes beds of Rhaetian age (Marwick, 1953).

Rhaetian Stage

One ammonoid zone, that of *Choristoceras marshi,* is recognized in the Rhaetian Stage. This zone as developed in Canada correlates with the typical Rhaetian beds of the northern Alps in Austria and southern Germany. The correlation is based on the occurrence of *Choristoceras marshi* and also on the stratigraphic position of the Marshi Zone with respect to the underlying Suessi Zone, which, as already shown, clearly includes correlatives of the typical Upper Norian Metternichi Zone.

From the standpoint of ammonoid faunas the Rhaetian is not well endowed for world-wide recognition. Uncoiled representatives of the genus *Choristoceras* occur in the Suessi Zone. Not one ammonoid genus is restricted to the Rhaetian; all are survivors from the Norian. Spath (1934, p. 39) proposed two divisions (Rhaetitan, followed by Eopsiloceratan) for the Rhaetian. Spath's interpretation is not based on superposed faunas, and it appears that his conception of the Rhaetian as a long time interval is not supported by the available evidence. Popov (1961b, c) has drawn attention to the faunal break that occurs at the base of the Upper Norian and has proposed that the Rhaetian should be enlarged by embracing the *Pinacoceras metternichi* and *Sirenites argonautae* Zones. However, the Metternichi Zone is Upper Norian in terms of the original definition of the stage and the Argonautae Zone has a very doubtful status (Kittl, 1903, p. 15). From the standpoint of priority and general usage it is thus impossible to support this proposal, despite the fact, recognized by Popov, that the boundary beneath the Upper Norian is more readily recognized than that between the Upper Norian and the Rhaetian.

Traditionally the Alpine Rhaetian deposits have been correlated with strata that lie immediately beneath the *Psiloceras planorbis* Zone (lowest Jurassic) in northwest Europe. These beds beneath the Planorbis Zone are characterized by *Rhaetavicula contorta* (Portlock), a bivalve that is also recorded from the Alpine Rhaetian deposits. The wide distribution of this bivalve led to the introduction of the "Contorta Zone" as a synonym for the Rhaetian Stage. No ammonoids have been described from the Contorta Zone of northwest Europe. Slavin (1961, 1963) has recently questioned the generally accepted correlation of the Alpine Rhaetian with the Contorta Zone. He has suggested that the Contorta Zone of Schwabia, England, etc., is younger than the *Choristoceras*-bearing, typical Rhaetian strata. He proposes that the Contorta Zone of northwest Europe should be assigned to a new unit, the Bavarian Stage, which he regards as the basal stage of the Jurassic System. Because of the uncertainty of the correlation between the Alpine Rhaetian and the extra-Alpine Contorta Zone, Slavin's proposal has much to recommend it, although it has been criticized by Trümpy (1963), who accepts the classical correlation. Even if the Bavarian Stage is rejected, it seems undesirable to continue use of the term Rhaetian for the Contorta Zone of northwestern Europe. The Rhaetian Stage should accommodate only the beds that unquestionably correlate with the stratotype Rhaetian rocks of the Alps.

Marshi Zone

Index species: *Choristoceras marshi* Hauer, 1865, p. 655. (Pl. X, figs. 8, 9)

Type locality: Kendelbachgraben, St. Wolfgang, Austria. Reference locality for Canada: Tyaughton Creek, above Spruce Lake Creek, southwest British Columbia (ann. 32).

Choristoceras marshi is cited as the zonal index for the Rhaetian Stage by Kummel (1957, p. L124). European authors do not use an ammonoid as a zonal index for the Rhaetian, but *Choristoceras marshi,* originally described from the Kössen beds (the stratotype formation for the Rhaetian) seems as suitable a choice as any.

Occurrence: Western Cordillera — Tyaughton Group, southwest British Columbia.

The Marshi Zone is known at only one locality in Canada, Tyaughton Creek on the east side of the Coast Mountains. Two species of ammonoids occur: *Choristoceras marshi* Hauer, and *"Arcestes"* sp. The beds containing this small ammonoid fauna are correlated with the typical, Alpine, Rhaetian. Cephalopod-bearing Rhaetian deposits are relatively rare. They occur in the Kössen Beds of the Bavarian Alps, notably near Garmisch, and in the Osterhorn area near St. Wolfgang in Upper Austria (Mojsisovics, 1893). In Salzkammergut the *Choristoceras haueri*-bearing part of the Zlambach beds are generally regarded as Rhaetian (Kittl, 1903, p. 16; Arthaber, 1905, p. 380; Kuehn, 1962, p. 528) as are the Zlambach beds of Fischerwiese, with *Choristoceras* cf. *C. marshi* (Arthaber, 1905, p. 383).

Correlatives in the United States occur in the Upper Member of the Gabbs Formation of Nevada (Muller and Ferguson, 1939, p. 1606; Silberling, 1959, p. 27) and in the Modin Formation of California (Sanborn, 1960).

ANNOTATIONS

The annotations deal successively with the Arctic islands and the eastern, western and northern parts of the Cordillera. Localities are given with reference to the 1:250,000 maps of the National Topographic System. A full list of the map-areas referred to and an index map showing their position is provided by Figure 1.

Numbers of four or five digits in parentheses, without prefix, refer to the Geological Survey of Canada catalogue of invertebrate fossil localities. These numbers are placed on all specimens from one locality; they do not refer to individual specimens. In the palaeontological appendix and on the plate descriptions numbers prefixed "GSC No." refer to individual specimens housed in the type collection of the Geological Survey.

1. The Suessi Zone is recognized in the Arctic islands on the basis of occurrences of *Monotis ochotica* (Keyserling) in the Heiberg Formation of Cornwall Island (Cornwall Island area), Brock Island (Ballantyne Strait area), Raanes Peninsula, Ellesmere Island (Eureka Sound South area), and eastern Axel Heiberg Island (Eureka Sound North area) (Tozer, 1961b, p. 106; McLaren, 1963, p. 530; Souther, 1963, p. 433; Tozer and Thorsteinsson, 1964, p. 119). No ammonoids are known from the Suessi Zone in the Arctic islands.

2. The Columbianus Zone is represented in the Heiberg Formation 3 miles east of the head of Wolf Fiord in Glacier Fiord area, Axel Heiberg Island (Glenister, 1963, p. 477). Specimens of *Monotis* from this locality (26450) were tentatively assigned to *Monotis ochotica* (Keyserling) (Tozer, 1961b, p. 107, Pl. XXX, figs. 1-3), but, as indicated by Westermann (1962a, p. 773), these specimens should not be assigned to that species. They probably represent a new subspecies of *Monotis scutiformis* (Teller). A new collection was obtained from this locality in 1962. Associated with *Monotis* in the new collection (51643) are specimens of *Himavatites* cf. *H. canadensis* McLearn. The stratigraphic relationship between the beds with *Himavatites* and those with *Monotis ochotica* has not been positively demonstrated on Axel Heiberg Island. Their stratigraphic separation is probably small.

3. The *Meleagrinella antiqua* beds of Ellesmere and Axel Heiberg Islands (Eureka Sound North and South areas, Glacier Fiord area, Greely Fiord West area), which occur in the lower part of the Heiberg Formation (Glenister, 1963, p. 477; Souther, 1963, p. 433; Tozer, 1961b, p. 104), cannot be precisely dated but are younger than the Welleri Zone and older than the Columbianus Zone.

4. Upper Karnian strata, probably correlative with the Welleri Zone, occur at several localities in the Arctic islands. They include the beds with *Arctosirenites canadensis* Tozer, *Sirenites costatus* Tozer, and *Jovites borealis* Tozer in the upper part of the Blaa Mountain Formation of Axel Heiberg Island (Eureka Sound North area) (Tozer, 1961b, pp. 20, 37); the *Jovites borealis* bed of the Schei Point Formation of Table Island (Cornwall Island area); and the bed with *Tropites* cf. *T. morani* Smith and *Jovites richardsi* Tozer in the Schei Point Formation of Cameron Island (Domett Point area) (Tozer, 1961b, p. 37). In addition, one well-preserved *Juvavites* has been obtained from the upper part of the Blaa Mountain Forma-

tion of Strand Fiord area, western Axel Heiberg Island (51632) (Tozer, 1963c, p. 13). All these occurrences indicate at least an approximate correlation with the Welleri Zone, for the following reasons: *Tropites morani* is a member of the fauna of the Welleri Zone; *Arctosirenites canadensis* is now known to occur in a near or exact Welleri correlative in British Columbia (ann. 22); *Juvavites* is not known to occur below the Welleri Zone in Canada.

5. The *Sirenites* beds in the Blaa Mountain Formation of Ellesmere and Axel Heiberg Islands are very thick. As yet they have not been subdivided biostratigraphically, although as already noted, *Sirenites costatus* Tozer is probably a relatively young species, representing the Welleri Zone. In some sections *Sirenites senticosus* (Dittmar) occurs at a higher level than *Sirenites nanseni* Tozer, for example, at Blaa Mountain, Ellesmere Island (Greely Fiord West area), where *Sirenites senticosus* is in the Upper Calcareous member (55479) and *Sirenites nanseni* is in the lower part of the Middle Shale member (Tozer, 1961b, p. 79). In view of the association in British Columbia (ann. 23), this is regarded as insufficient evidence for the recognition of two *Sirenites* zones of useful application, and for the time being both the *Sirenites nanseni* and *Sirenites senticosus* beds are regarded as representative of the Nanseni Zone. In this sense the Nanseni Zone is known from the Schei Point Formation of Borden Island, Cornwall Island, Baumann Fiord, and Eureka Sound South areas, and from the Blaa Mountain Formation of Bukken Fiord, Greely Fiord West, and Strand Fiord areas.

"Protrachyceras" sverdrupi Kittl, described from material collected by Per Schei of the Second Norwegian Expedition in the "Fram" from Ammonite Mountain, Bjorne Peninsula, Ellesmere Island (Baumann Fiord area), is probably from the upper part of the Schei Point Formation and of Karnian age. The exact age and affinities of this species are not known.

6. The Triassic section NE of Griesbach Creek south of Bunde Fiord in NW Axel Heiberg Island (Bukken Fiord area) provides some data on the sequence of the Middle and Upper Triassic ammonoid faunas, as well as the best sequential data for the lowermost Triassic (ann. 17). *Sirenites nanseni* Tozer, indicating the Nanseni Zone, occurs near the base of the Middle Shale member of the Blaa Mountain Formation (64787). The underlying Lower Calcareous member is only 25 feet thick at this locality. The Lower Shale member, at the base of the formation, is 335 feet thick and provided fossils from three levels, as follows:

Upper bed, 9 feet below Lower Calcareous member, *Discophyllites* cf. *D. taimyrensis* Popov, *Halobia* cf. *H. zitteli* Lindström (64795 in place; 47565, 47535, 64727 in talus). Middle bed, 49 feet below Lower Calcareous member, *Neocladiscites* cf. *N. martini* (Smith) (64726). Lower bed, 55 feet below Lower Calcareous member, *Daonella frami* Kittl (64794).

The bed with *Daonella frami* is Lower Ladinian, probably Subasperum Zone. The *Neocladiscites* is identical with a species that occurs with *Nathorstites* on Ellesmere Island (Tozer, 1961b, p. 34) and is Upper Ladinian. The bed with *Discophyllites* and *Halobia* has no known exact counterpart in Canada. Because it lies between the Upper Ladinian and the Nanseni Zone it is presumably Lower Karnian and possibly represents an approximate correlative of the Obesum Zone.

7. The *Nathorstites* beds of the Schei Point and Blaa Mountain Formations, in Greely Fiord West, Eureka Sound South, Baumann Fiord, and Cornwall Island areas (Tozer, 1961b, p. 90) are dated as Upper Ladinian. Now that it is known that species of *Nathorstites* closely related to *Nathorstites mcconnelli* (Whiteaves) range throughout the whole of the Upper Ladinian, it is not possible to assign the Arctic beds to a zone. Further taxonomic study of the Upper Ladinian *Nathorstites* will possibly permit a more precise dating of these beds.

8. The *Daonella frami* beds of the Schei Point and Blaa Mountain Formations (Tozer, 1961b, p. 33) probably represent the Subasperum Zone. Ammonoids are rare in these beds, but on Bjorne Peninsula, Ellesmere Island (Baumann Fiord area), *Longobardites* sp., *Protrachyceras* sp., and *Ptychites nanuk* Tozer occur with *Daonella frami* Kittl. *Daonella frami*, occurring alone or associated with *Daonella degeeri* Boehm, is very widely distributed for it is known from Otto Fiord, Bukken Fiord, Greely Fiord West, Middle Fiord, Eureka Sound North and South, and Cornwall Island areas. Formerly these beds were simply dated as

Anisian or Ladinian, but now that Silberling (1962, p. 153) has shown that *Protrachyceras* is unknown below the Ladinian in Nevada it seems probable that the *Daonella frami* beds are post-Anisian. The *Protrachyceras* from Bjorne Peninsula (Tozer, 1961b, Pl. XXI, figs. 1a, b) has simple spinose, non-clavate ventral tubercles, like *Protrachyceras meeki* (Mojsisovics) which occurs in the Subasperum Zone of Nevada.

FIGURE 2. Spath and Diener Creeks, south of Otto Fiord, Ellesmere Island (Bukken Fiord area). Light coloured rocks are Pennsylvanian and Permian; darker rocks are Triassic. The arrow indicates the col, north of Spath Creek, where the Subrobustus and Caurus Zones are in sequence in the Lower Shale member of the Blaa Mountain Formation. For detail south of Diener Creek see Fig. 6. *RCAF T404L-216 (20,000 feet elevation)*

9. The best known sequence of Anisian faunas in the Arctic islands is in the Schei Point Formation of Exmouth Island, which lies in Cornwall Island area (Tozer, 1961b, p. 15). The Caurus Zone occurs near the base of the formation where it is represented by *Pearylandites* sp. (Tozer, 1961b, Pl. XXII, figs. 3a, b) associated with hungaritids now identified as *Lenotropites* cf. *L. caurus* (McLearn) (30339). Concretions above the Caurus Zone contain *Daonella* cf. *D. americana* Smith (30372) and are Upper Anisian, probably Deleeni Zone. Higher beds contain *Gymnotoceras* cf. *G. laqueatum* (Lindström) (= *Frechites* sp. of Tozer, 1961b, Pl. XXII, figs. 4a, b) and *Ptychites* cf. *P. trochlaeformis* (Lindström) (op. cit., Pl. XXII, figs. 1, 2) that indicate the Chischa Zone. *Ptychites* cf. *P. trochlaeformis* also occurs in the Lower Shale member of the Blaa Mountain Formation.

10. The Varium Zone is present in the Lower Shale member of the Blaa Mountain Formation at Smith Creek NW of Hare Fiord, Ellesmere Island, in Greely Fiord West area (Tozer, 1965a, p. 4) (*see* Fig. 4). *Posidonia aranea* Tozer, indicating the Subrobustus Zone, occurs at a lower level in the Blind Fiord Formation (47549, 47563). The Varium Zone is represented by *Anagymnotoceras* n. sp. (described by McLearn, *in press*), 553 feet above *Posidonia aranea* (51677). A lower bed, 540 feet above *Posidonia aranea,* contains *Sturia* sp. indet. and *Ussurites* cf. *U. yabei* Diener indicating either the Caurus Zone or the Varium Zone (51676). Occurrence of the Varium Zone in the lower part of the Schei Point Formation of Ellesmere Island is indicated by the presence of *Anagymnotoceras* cf. *A. helle* (McLearn) (Tozer, 1961b, p. 16) (28675).

11. The Subrobustus Zone (type locality) and the Caurus Zone are in sequence in the Lower Shale member of the Blaa Mountain Formation near Spath Creek, south of Otto Fiord, Ellesmere Island, in Bukken Fiord area (*see* Fig. 2).

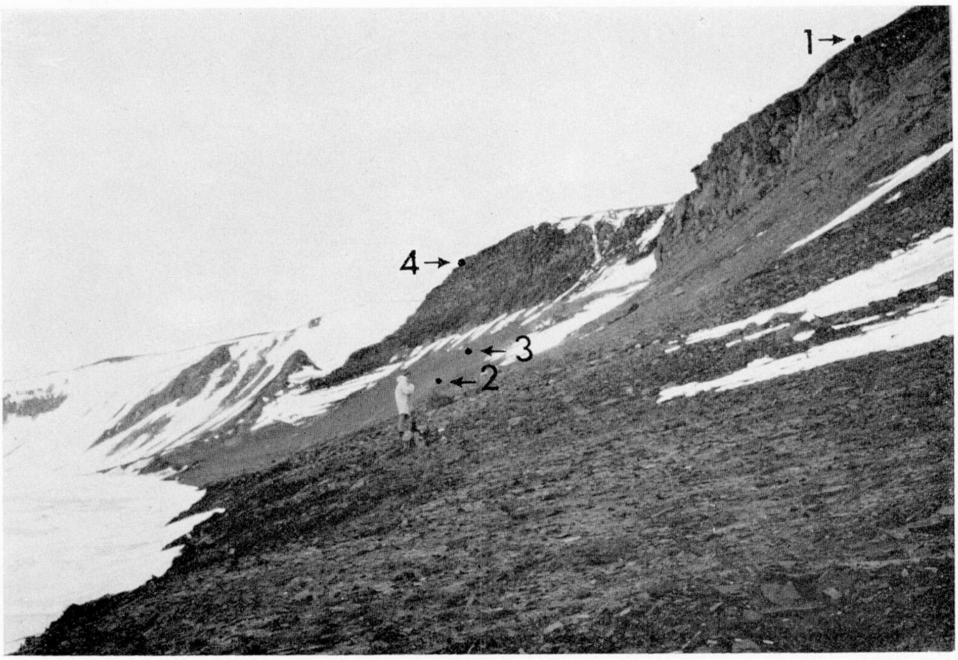

FIGURE 3. Cliffs 20 miles southeast of Cape Stallworthy, Axel Heiberg Island (Cape Stallworthy area). (1) indicates position of the Sverdrupi Zone; (2) Smithian beds with *Arctoceras;* (3) the Pilaticus Zone; (4) the Subrobustus Zone. A small fault breaks the section between (1) and (2). The *Arctoceras* beds are near the top of the Blind Fiord Formation; the overlying strata are assigned to the Lower Shale member of the Blaa Mountain Formation.

This is the type locality for the Spathian Stage (Tozer, 1965b, p. 4). The fauna of the Subrobustus Zone from this locality has been described (Tozer, 1965a, p. 3) and includes *Posidonia aranea* Tozer, *Popovites borealis* Tozer, *Zenoites arcticus* Tozer, *Olenikites canadensis* Tozer, *Svalbardiceras freboldi* Tozer, and *Keyserlingites subrobustus* (Mojsisovics). From higher beds in the section, two beds, 9 feet apart, indicate the Caurus Zone. The lower bed (47550), 170 feet above the Subrobustus Zone, contains *Grambergia* aff. *G. mctaggarti* (McLearn), *Gymnites* ? sp. indet., and *Leiophyllites* sp. The upper bed (47580), 179 feet above the Subrobustus Zone, has *Lenotropites* cf. *L. caurus* (McLearn) (= *Pearylandites* sp., Tozer, 1965a, p. 3).

12. The Pilaticus Zone (type locality) and the Subrobustus Zone are in sequence in the Lower Shale member of the Blaa Mountain Formation at the cliffs on the coast of Nansen Sound, on Axel Heiberg Island, 20 miles SE of Cape Stallworthy (Cape Stallworthy area) (Tozer, 1965b, fig. 1) (*see* Fig. 3). The Pilaticus Zone, represented by *Olenikites pilaticus* n. sp. and *Columbites* sp. (64719) occurs about 80 feet above the base of the Lower Shale member and 100 feet above Smithian beds with *Arctoceras blomstrandi* (Lindström) (64718). The Subrobustus Zone, about 150 feet above the Pilaticus Zone, contains fragile specimens of *Posidonia aranea,* which were not collected.

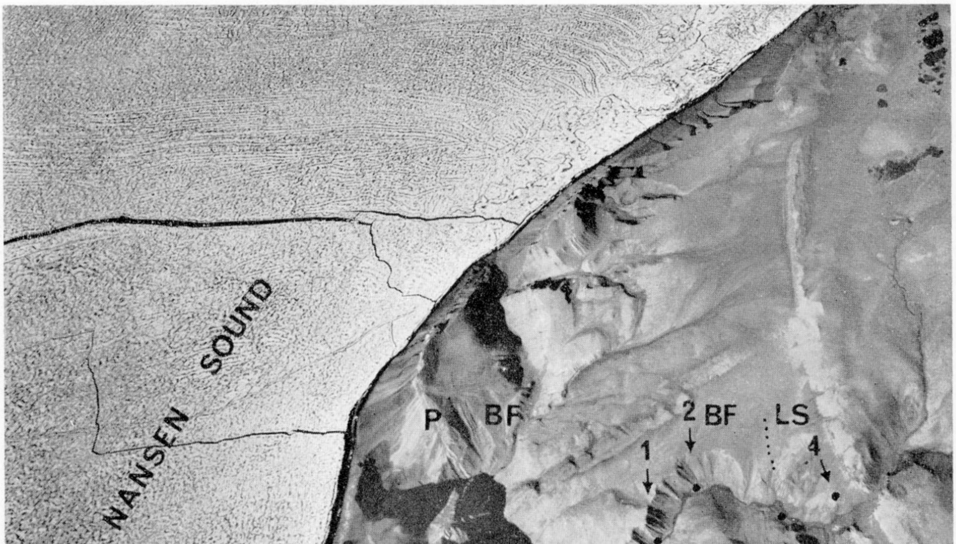

FIGURE 4. Smith Creek, flowing into Nansen Sound, near Hare Fiord, Ellesmere Island (Greely Fiord West area). (P) indicates Permian rocks; (BF), the Blind Fiord Formation; (LS) the Lower Shale member of the Blaa Mountain Formation. (1) indicates the position of the Romunderi Zone; (2) the Tardus Zone; (3), the Subrobustus Zone, and (4), the Varium Zone. The cliffs facing Nansen Sound have also been illustrated. (Tozer, 1961b, Pl. II.) *RCAF T408L-182 (20,000 feet elevation)*

13. The Romunderi, Tardus, and Subrobustus Zones are in sequence in the upper beds of the Blind Fiord Formation, exposed on the west coast of Ellesmere Island, 5 miles NW of the entrance to Hare Fiord (Greely Fiord West area) (*see* Fig. 4). They are also in sequence about a mile inland, in Smith Creek (Tozer, 1961b, pp. 12, 13; 1965a, p. 3) (*see* Fig. 4).

This is the type locality for the Smithian Stage. The stratigraphic intervals are as follows; each zone is about a foot thick.

Subrobustus Zone: *Posidonia aranea* Tozer, 2,825 feet above base of Blind Fiord Formation (47563).

Tardus Zone: *Wasatchites* cf. *W. tardus* (McLearn), *Xenoceltites* sp., *"Pseudomonotis" occidentalis* (Whiteaves), 2,015 feet above base of Blind Fiord Formation (47547).

Romunderi Zone (type locality): *Pseudosageceras multilobatum* Noetling, *Euflemingites romunderi* Tozer, *Flemingites?* sp., *Juvenites canadensis* Tozer, *Juvenites crassus* Tozer, *Prosphingites spathi* Frebold, *Anakashmirites borealis* Tozer, *Meekoceras gracilitatis* White, *Arctoceras blomstrandi* Lindström [=*Arctoceras oebergi* (Mojsisovics)], *Posidonia mimer* Oeberg, *"Pseudomonotis" boreas* Oeberg (Tozer, 1961b, p. 13), 1,795 feet above base of Blind Fiord Formation.

Twenty-two miles NW from the section described above, on the cliffs 6 miles SE of the entrance to Otto Fiord (Bukken Fiord area), the Tardus Zone is again exposed, with the following (51672): *Prosphingites* cf. *P. spathi* Frebold, *Arctoceras blomstrandi* (Lindström), *Wasatchites* cf. *W. tardus* (McLearn), and *"Pseudomonotis" occidentalis* (Whiteaves). This is the only place in Canada where *Arctoceras* is known to occur in the Tardus Zone. *Wasatchites* and *Arctoceras* are undoubtedly associated; they occur on the same slab of rock.

The Tardus Zone is also known from a section south of Bunde Fiord, Axel Heiberg Island, in the western part of the Bukken Fiord area (Tozer, 1961b, p. 31).

14. The relationship between the Sverdrupi and Romunderi Zones is shown in the Blind Fiord Formation on the bluffs west of Lindström Creek, on the north side of Otto Fiord, Ellesmere Island (Cape Stallworthy area) (Tozer, 1965b, pp. 1, 3) (*see* Fig. 5). This is the

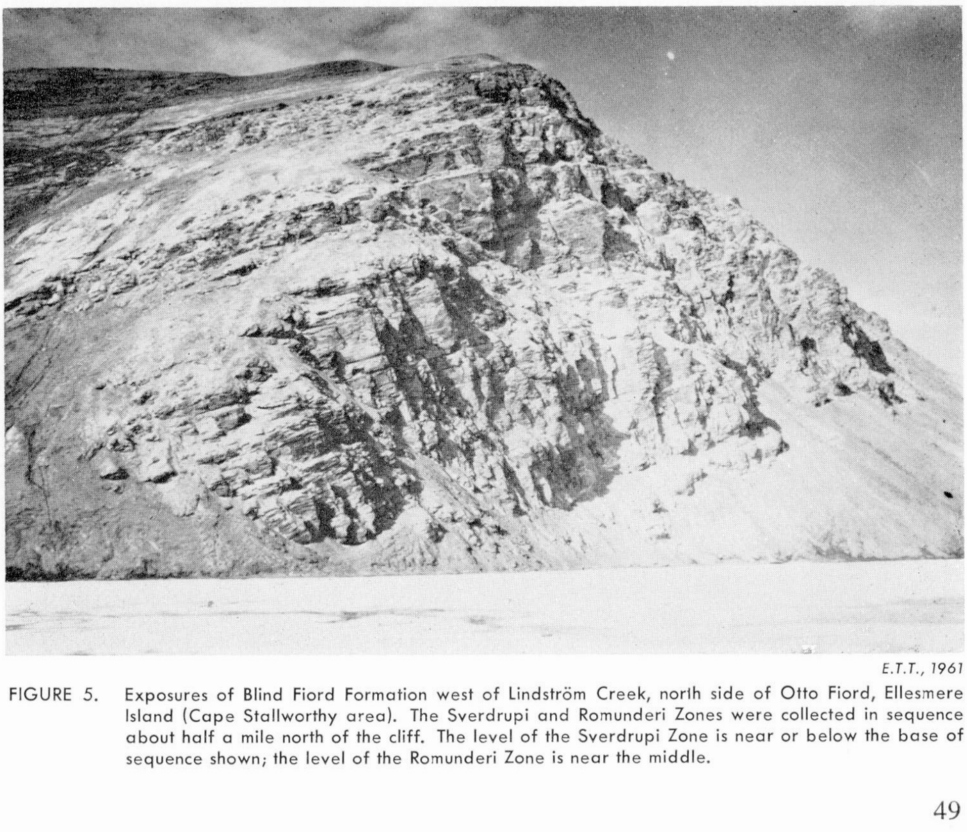

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FIGURE 5. Exposures of Blind Fiord Formation west of Lindström Creek, north side of Otto Fiord, Ellesmere Island (Cape Stallworthy area). The Sverdrupi and Romunderi Zones were collected in sequence about half a mile north of the cliff. The level of the Sverdrupi Zone is near or below the base of sequence shown; the level of the Romunderi Zone is near the middle.

type locality for *Paranorites sverdrupi* Tozer, and the type locality for the Sverdrupi Zone. At this place the Sverdrupi Zone, represented by the index species, is a foot thick and lies about 900 feet above the base of the Blind Fiord Formation. Four hundred feet higher (47801) the Romunderi Zone is represented by *Euflemingites romunderi* Tozer, *Juvenites crassus* Tozer, and *"Pseudomonotis" boreas* Oeberg. *Arctoceras* cf. *A. blomstrandi* (Lindström) occurs 253 feet above the Romunderi Zone (47623), and again 280 feet above the same datum (47534). The exact correlation of these *Arctoceras* beds is uncertain but they are undoubtedly Smithian.

A somewhat similar relationship is in evidence in the vicinity of Bunde Fiord, NW Axel Heiberg Island (Bukken Fiord area). In this area the beds assigned to the Romunderi Zone are characterized by *Euflemingites* cf. *E. cirratus* (White). The stratigraphic position of this fauna is shown by the section on the NE side of Griesbach Creek, south of Bunde Fiord (Tozer, 1965b, p. 2) where *Euflemingites* cf. *E. cirratus* (White) (64792) occurs 700 feet above the base of the Blind Fiord Formation and 250 feet above the Sverdrupi Zone, represented by the index species in situ (64723, 64725) and *Clypeoceras* n. sp. (47584) in talus. On the south side of the island between Bunde and Bukken Fiords the following are associated with *Euflemingites* cf. *E. cirratus* (47526): *"Paranorites"* cf. *"P." kolymensis costata* Popov (1961) (*not Clypeoceras costatus* (Popov) of Vavilov, 1965), *Arctoceras* cf. *A. blomstrandi* (Lindström).

15. At most localities in the Arctic islands the Sverdrupi Zone yields only the index species; however there are two places in northern Axel Heiberg Island where additional ammonoids are known. One is in Cape Stallworthy area on the cliffs 20 miles SE of Cape Stallworthy (*see* Fig. 3). The Sverdrupi Zone is in the Blind Fiord Formation. A small fault occurs between the beds with the Sverdrupi Zone and those with Smithian and Spathian ammonoids (ann. 12).

FIGURE 6. Bluffs south of Diener Creek, south of Otto Fiord, Ellesmere Island (Bukken Fiord area). (1) indicates the position of the contact between Permian rocks and the Blind Fiord Formation; *Otoceras* sp. occurs in the steep cutbank to the right. The Strigatus and Candidus Zones are in sequence on the slope indicated by (2). (3) shows the position of the Sverdrupi Zone.

The beds assigned to the Sverdrupi Zone are 25 feet thick and lie about 450 feet above the base of the Blind Fiord Formation. Fossils were obtained from three beds, as follows:

Upper bed (64716): *Paranorites heibergensis* Tozer (=*Prionolobus plicatus* Tozer, *not* Waagen), *Clypeoceras* n. sp. (as at 47584, ann. 14). Middle bed, 10 feet below Upper bed (64717): *Paranorites* cf. *P. kingianus* (Waagen). Lower bed, 25 feet below Upper bed (64715): *Paranorites sverdrupi* Tozer.

The second locality is in Bukken Fiord area, south of Bunde Fiord, 3 miles W of Camp Five Creek, where *Pseudosageceras multilobatum* Noetling and *Paranorites heibergensis* occur about 500 feet above the base of the Blind Fiord Formation, and 200 feet above the Candidus Zone (64731, 64764, 64856).

16. The Sverdrupi, Candidus, Strigatus, and Boreale Zones are in sequence in the Blind Fiord Formation south of Diener Creek, which drains into Otto Fiord on Ellesmere Island (Bukken Fiord area) (Tozer, 1965b, p. 3) (*see* Figs. 2, 6). This area (lat. 80°57′N, long. 88°50′W) provides the type section for the Dienerian Stage and for the Candidus Zone.

The sequence of zones is as follows:

Sverdrupi Zone: *Paranorites sverdrupi* Tozer (51695), in line of concretions, 955 feet above base of Blind Fiord Formation.

Candidus Zone (type locality): *Prionolobus* cf. *P. lilangense* (Krafft), *Proptychites candidus* Tozer (51691, 51692, 51694), 445-470 feet above base of Blind Fiord Formation.

Strigatus Zone: *Ophiceras* cf. *O. decipiens* (Spath), *Pachyproptychites strigatus* (Tozer), *Claraia stachei* Bittner (51689, 51690), 325-350 feet above base of Blind Fiord Formation.

Commune Zone: not recognized.

Boreale Zone: *Otoceras boreale* Spath (not collected), about 150 feet above base of Blind Fiord Formation.

A sequence from the Boreale Zone to the Sverdrupi Zone is also known in the belt of Triassic outcrops south of Bunde Fiord, Axel Heiberg Island (Bukken Fiord area). Fossils were first discovered in this area by R. Thorsteinsson in 1956 (Tozer, 1961b, p. 12). The area was visited by the writer in 1961 and again in 1964. The faunal sequence determined from Thorsteinsson's collections was confirmed, but some revision of the stratigraphic measurements was made. The Boreale, Strigatus, and Candidus Zones are represented by their index species. Four miles SW of the mouth of Camp Five Creek good collections were obtained from the Strigatus and Boreale Zones. The following collections were obtained in situ.

Strigatus Zone:

Ophiceras sp. indet. (64774), 55 feet above 64773.
Pachyproptychites strigatus (Tozer) (64768), 53 feet above 64773.
Ophiceras decipiens (Spath) (64769), 36 feet above 64773.
Pachyproptychites strigatus (Tozer) (64770), 35 feet above 64773.
Pachyproptychites strigatus (Tozer) (64771), 25 feet above 64773.

Commune Zone:

Ophiceras decipiens (Spath) (64772), 5 feet above 64773.
Ophiceras decipiens (Spath) (64773), about 250 feet above base of Blind Fiord Formation.

Boreale Zone:

Otoceras boreale Spath (64766), about 130 feet above base of Blind Fiord Formation.

The illustrated specimen of *Pachyproptychites strigatus* (Pl. III, figs. 2a, b) (64765) was obtained from talus derived from the Strigatus Zone at this locality.

The section given above illustrates the intimate relationship between the beds with *Pachyproptychites strigatus* and those with *Ophiceras decipiens*.

The Candidus Zone is also known from the sections south of Bunde Fiord. This zone occurs about 400 feet above the base of the Blind Fiord Formation, i.e., about 100 feet above the Strigatus Zone. It was formerly believed to occur at a lower level in the Blind Fiord Formation (Tozer, 1961b, p. 58). At or near the type locality of *Proptychites candidus* Tozer, which is 3 miles south of Bunde Fiord and 8 miles west of Camp Five Creek, *Discophiceras* cf. *D. columbianum* (Tozer) (47551) was collected in 1961. Formerly the specimens now identified as *Discophiceras* cf. *D. columbianum* were tentatively assigned to *Paranorites sverdrupi* Tozer, and the suggestion was made that the faunas with *Proptychites candidus* and *Paranorites sverdrupi* were about the same age (Tozer, 1963a, p. 7). Later work has shown that these ammonoids characterize separate zones. In the sections south of Bunde Fiord the Sverdrupi Zone is represented by *Paranorites heibergensis* Tozer, which occurs about 200 feet above the Candidus Zone (ann. 15).

An important locality for the Boreale, Commune, and Strigatus Zones is on the south side of the island between Bunde and Bukken Fiords (Bukken Fiord area). This locality was discovered by R. Thorsteinsson in 1957 (Tozer, 1961b, p. 13, etc.) and was revisited by Thorsteinsson and the writer in 1961. At this place a covered interval of about 100 feet separates the Permian beds from the Triassic. The sequence of fossil beds is given below. The Boreale Zone is in the basal shale unit of the Blind Fiord Formation; the Commune and Strigatus Zones are in the overlying beds of green siltstone. The highest Permian exposure is the stratigraphic datum used to express the position of the individual beds.

Strigatus Zone:

Pachyproptychites strigatus (Tozer) (47530), 320 feet above datum.
Pachyproptychites strigatus (Tozer) (47607), 296 feet above datum.
Ophiceras decipiens (Spath) (47609), 295 feet above datum.
Ophiceras decipiens (Spath) (47610), 292 feet above datum.
Pachyproptychites strigatus (Tozer) (47611), 289 feet above datum.
Ophiceras decipiens (Spath) (47612), 287 feet above datum.
Claraia stachei Bittner (47562), 266 feet above datum.
Ophiceras decipiens (Spath) (47615), 261 feet above datum.
Ophiceras decipiens (Spath) (47528), 259 feet above datum.
Pachyproptychites cf. *P. strigatus* (Tozer) (47570), 258 feet above datum.

Commune Zone:

"Glyptophiceras" extremum Spath (47571), 257 feet above datum.
Ophiceras decipiens (Spath) (47527), 256 feet above datum.
Ophiceras decipiens Spath (47529), 239 feet above datum.

Boreale Zone:

Otoceras boreale Spath (47613), 230 feet above datum.
Otoceras boreale Spath, *Metophiceras* cf. *M. subdemissum* (Spath) (47578, 47524), about 230 feet above datum.

Numerous specimens of *Ophiceras commune* and *Ophiceras decipiens* (47525) were collected from talus at this locality but no specimens of *Ophiceras commune* were found in place.

Higher beds in this section contain representatives of the Romunderi Zone (ann. 14).

The sequence from the Boreale Zone to the Strigatus Zone has also been observed on Raanes Peninsula, Ellesmere Island, 1½ miles W of the head of Blind Fiord (Eureka Sound South area). A covered interval of 180 feet separates the Permian and Triassic strata at this locality, which is near the type section of the Blind Fiord Formation. The sequence is as follows:

Strigatus Zone: *Ophiceras* sp. indet., *Pachyproptychites strigatus* (Tozer) (51593), about 600 feet above highest Permian exposure.

Commune Zone: *Ophiceras commune* Spath, *Discophiceras* sp. indet., *"Glyptophiceras" extremum* Spath, *Claraia stachei* Bittner (51591, 51592), 360-450 feet above highest Permian exposure.

Boreale Zone: *Otoceras boreale* Spath, *Metophiceras* cf. *M. subdemissum* Spath (51588, 51589), 265-285 feet above highest Permian exposure.

A loose block obtained near this locality (47548) contains specimens of *Otoceras boreale* associated with a species of *Ophiceras* that has an acute venter.

Fragmentary specimens of *Otoceras* were collected by R. Thorsteinsson from beds near the base of the Bjorne Formation, west of the head of Trold Fiord, Ellesmere Island (Eureka Sound South area) (Tozer, 1963c, p. 2). These specimens, formerly reported as lost, have now been found (68350), and they probably indicate the Boreale Zone.

E.T.T., 1961

FIGURE 7. View up valley of Griesbach Creek, Bukken Fiord area, northwest Axel Heiberg Island. Resistant rocks to the right are Permian chert, followed by a 36-foot covered interval, and the Concavum (1) and Boreale Zones (2) in the basal shaly beds of the Blind Fiord Formation. (3) indicates the position of Figure 8, where the Concavum to Strigatus Zones (inclusive) are exposed in sequence.

17. The Concavum, Boreale, Commune, and Strigatus Zones are in sequence in the lower beds of the Blind Fiord Formation on Griesbach Creek, south of Bunde Fiord, NW Axel Heiberg Island (Bukken Fiord area) (*see* Figs. 7, 8). This area is the type locality for the Griesbachian Stage and for the Concavum, Boreale, and Strigatus Zones. Griesbach Creek is in lat. 80°31′N, long. 94°40′W. It is a tributary, from the east, of Camp Five Creek, and the watercourse more or less follows the contact between the Blind Fiord Formation and the underlying Permian rocks. The Candidus Zone has not been recognized in this section, but higher parts of the section contain the Sverdrupi and Romunderi Zones and faunas of Middle and Upper Triassic age (ann. 6, 14).

The sequence of the lowest Triassic zones is as follows:

Strigatus Zone: *Pachyproptychites strigatus* (Tozer) (64763), 215 feet above base of Blind Fiord Formation.

E.T.T., 1964

FIGURE 8. Northeast side of Griesbach Creek, Bukken Fiord area, northwest Axel Heiberg Island. Arrow points to abrupt, exposed contact between Permian chert and silty shale of the Blind Fiord Formation. Man is standing at the level of the Concavum Zone. The Boreale, Commune, and Strigatus Zones are exposed to the right of the photograph.

Commune Zone: *Ophiceras decipiens* (Spath), *Claraia stachei* Bittner (64752, 64753, 64762, etc.), 190–214 feet above base of Blind Fiord Formation.

Ophiceras commune Spath, *Ophiceras decipiens* (Spath), *Discophiceras wordiei* Spath (64744, 64748, 64750, 64751, etc.), 175-190 feet above base of Blind Fiord Formation.

Boreale Zone: *Otoceras boreale* Spath (64783, 64782), 100-120 feet above base of Blind Fiord Formation.

Concavum Zone: *Otoceras concavum* n. sp. 64777, 64779, 64781, 47620, 47539 (talus), 64732 (talus), 40-56 feet above base of Blind Fiord Formation.

In the section described above the lowest 40 feet are unfossiliferous. Griesbach Creek is the only place where the Concavum Zone is known to occur. The Boreale Zone is known from many localities and commonly 100 feet or more of barren strata lie between the Boreale Zone and the highest Permian rocks (e.g., Tozer, 1961b, p. 12, sec. 3).

18. The relationship between the Columbianus and Suessi Zones is well displayed in the Pardonet Formation exposed on the west side of Mount Ludington 8 miles SW of Christina Falls, in Halfway River area, British Columbia (*see* Fig. 9). Collections were made from this mountain by W. W. Nassichuk for E. J. W. Irish in 1961, and the section was later described by Pelletier (1964, p. 83). Further collections were made by the writer and N. J. Silberling in 1965.

From the basal foot of the Suessi Zone the following were obtained (68300, 68304): *"Ceratites"* aff. "C." *riezingeri* Mojsisovics, *Rhabdoceras suessi* Hauer, *Halorites* cf. *H. americanus* Hyatt, *Halorites*? n. sp. (=*Indoclionites*? sp. of McLearn, 1960, p. 45),

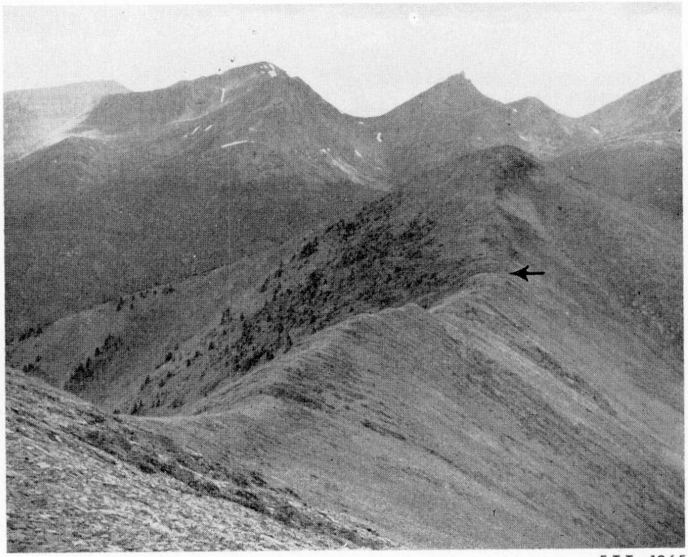


FIGURE 9.
Westward along spur on west side of Mount Ludington, 8 miles southwest of Christina Falls, Halfway River area, British Columbia. The arrow indicates the place where the Columbianus Zone, 5 feet thick (68301, etc.) is followed directly by the Suessi Zone (68300, etc.). Rocks in foreground are Grey beds. Pardonet Formation is exposed in saddle on spur. West summit of spur exposed beds of uncertain (Jurassic?) age. Front Range of Rocky Mountains forms the skyline.

E.T.T., 1965

Placites sp., *Rhacophyllites* sp., *Monotis* cf. *M. subcircularis* Gabb. Above this ammonoid bed is 55 feet of beds with *Monotis* cf. *M. ochotica* (Keyserling) (68299, 68300), which also represent the Suessi Zone. Above the Suessi Zone are siltstones and a grey limestone which Pelletier (loc. cit.) assigned to the Pardonet Formation. These beds are devoid of diagnostic fossils and cannot be dated.

Immediately below the Suessi Zone a five-foot bed contains the following representatives of the Columbianus Zone (46998, 51207, 68301, 68305): *Pseudosirenites* sp., *"Sandlingites"* cf. "*S.*" *archibaldi* Mojsisovics (= *Helictites* sp., Tozer, 1962, Pl. XI, figs. 4a, b), *"Sandlingites"* cf. *"S." idae* Mojsisovics, *"Sandlingites"* sp., *Alloclionites* cf. *A. woodwardi* (Mojsisovics) (op. cit., Pl. XI, figs. 5a-c), *Steinmannites* sp. (op. cit., Pl. XI, figs. 3a, b), *Himavatites* cf. *H. columbianus* McLearn, *Himavatites canadensis* McLearn, *Parajuvavites* sp., *Halobia* sp., *Monotis scutiformis typica* (Kiparisova).

Nine miles NW of the locality described above, on the saddle of the spur immediately NE of Triangulation Station 6740, E. J. W. Irish collected large phragmocones of *"Arcestes"* sp. associated with *Monotis* cf. *M. ochotica* (Keyserling) (46981). This occurrence also indicates the Suessi Zone.

The occurrences described above represent the lower part of the Suessi Zone. The relationship between the lower and upper parts of this zone is shown by the section at Rapide-qui-ne-parle-pas, on Peace River, in Halfway River area. This locality has been described by McLearn (1960a, p. 6) and Tozer (1965c, p. 222). At least 328 feet of beds referable to the Suessi Zone is present. No older zones are exposed. The Lower Suessi Zone is represented by 267 feet of beds with *Monotis* cf. *M. ochotica* (Keyserling) (64590, 64591, 64592, 64593). The Upper Suessi Zone, 61 feet thick, contains the following ammonoids:

1. 33 feet above the highest *Monotis* bed: *Rhabdoceras suessi* Hauer, *Rhacophyllites* sp. (64594).
2. 42 feet above the highest *Monotis* bed: *Placites* sp. (64595).
3. 60 feet above the highest *Monotis* bed: *Placites* sp. (64596).

McLearn (1960a, p. 6) described Jurassic outcrops above the Pardonet beds of this locality, but in 1964 none was found, possibly because of high water.

19. The *Monotis*-bearing beds of the Pardonet Formation in Pine Pass area, British Columbia, have been studied in detail by Westermann (1962a). According to Westermann, the sequence

of *Monotis* beds in this area is unlike the sequence established in other parts of British Columbia by McLearn (1941a, p. 95, etc.). In 1965 the writer, with N. J. Silberling, examined the *Monotis* beds of Pine Pass to compare the sequence with that of Peace River. It now appears that the sequence at Pine Pass closely resembles that of the localities to the north, and that it does not possess the unique characteristics attributed to it by Westermann. Well-preserved ammonoids are unknown from the *Monotis* beds of Pine Pass, but it is necessary to discuss this section in order to show the relationship between the successive *Monotis* beds discriminated by Westermann with the ammonoid zones recognized in this bulletin. According to the writer's interpretation, these *Monotis* beds represent part of the Columbianus Zone and the Lower Suessi Zone. The *Monotis* beds of Pine Pass do not include strata that are unrepresented in the sections on Peace River, as suggested by Westermann (1962a, p. 752, Table 1). This may be shown by comparing the interpretation made by Westermann with that made in 1965.

The section studied by Westermann is exposed in road and railway cuts on the north side of Pine River, three quarters of a mile west of Silver Sands Creek. He recognized five successive *Monotis* faunas, which he obtained from seven beds considered to form a stratigraphic sequence. According to his interpretation the sequence is as follows:

5. *Monotis ochotica posteroplana* Westermann .... (bed h) (youngest)
4. *Monotis subcircularis* Gabb, *M. pachypleura hemispherica* Trechmann, *M.* cf. *M. hoernesi* Kittl .... (beds f and g)
3. *Monotis callazonensis* Westermann, *M. jakutica* (Teller) .... (bed e)
2. *Monotis ochotica densestriata* (Teller) .... (bed d)
1. *Monotis scutiformis pinensis* Westermann, *M.* aff. *M. inaequivalvis* Bronn .... (beds b and c)

Monotis scutiformis pinensis, at the base of this sequence, is a widely distributed member of the fauna of the Columbianus Zone, so there appears to be no doubt about the age of beds "b" and "c". However, according to the writer's interpretation, the beds "d" to "h", inclusive, do not form a stratigraphic sequence. Specimens obtained by the writer at the west end of the railway bridge (i.e., from or near bed "d") are identified as *Monotis* cf. *M. subcircularis* (68307). Those obtained 70 feet west of the bridge (i.e., near, but probably below, bed "e") are *Monotis scutiformis pinensis* (68312). Twenty feet west of the bridge, between localities 68307 and 68312, there is a zone of sheared strata, evidently indicating the presence of a fault. According to this interpretation, the beds with *Monotis scutiformis pinensis* at locality 68312 are a repetition, through faulting, of Westermann's bed "b" or of bed "c". From this it follows that bed "e" is probably older, not younger, than bed "d". From the westernmost *Monotis* bed, which is the highest in the succession and is exposed about 350 feet west of the railway bridge, the writer obtained numerous specimens identified as *Monotis subcircularis* (68311). Locality 68311 is presumably at or near bed "h", the typical bed for *Monotis ochotica posteroplana,* but no specimens resembling this subspecies were found at 68311 or at any other level.

Expressing the conclusions in Westermann's terminology, it would appear that there is no good evidence for a zone of *Monotis callazonensis* between zones of *Monotis ochotica densestriata* and *Monotis subcircularis.* Furthermore, the presence of a zone characterized by *Monotis ochotica posteroplana* at the top of the sequence was not confirmed. In other words, at Pine Pass as on Peace River there are only two clearly defined *Monotis* zones, a lower zone with *Monotis scutiformis pinensis* (representing at least part of the zone of "*Monotis alaskana* Smith var." of McLearn) (*in* McLearn and Kindle, 1950, p. 55), and an upper zone, characterized by *Monotis subcircularis* (McLearn, 1960a, p. 26). Westermann may be correct in recognizing a zone of *Monotis callazonensis,* but if there is such a zone it evidently lies immediately above the zone of *Monotis scutiformis pinensis* and not above beds with *Monotis ochotica densestriata* (of Westermann).

In the proposed zonal terminology the beds with *Monotis scutiformis pinensis* are assigned to the Columbianus Zone, and those with *Monotis ochotica densestriata, Monotis subcircularis, Monotis ochotica posteroplana,* and possibly also those with *Monotis callazonensis* (all identifications according to Westermann), are assigned to the Lower Suessi Zone (= *Monotis subcircularis* Zone)

Above the *Monotis subcircularis* beds (68311) is about 40 feet of calcareous siltstone that is lithologically similar to the *Monotis* beds and contains pectenid bivalves and also *Gryphaea,* etc. (68310). Next in the section is about 25 feet of grey platy shales, interbedded with cherty or siliceous shale, containing one large calcareous concretion. These shales, on lithological grounds, are tentatively assigned to the Nordegg Formation of the Fernie Group. Where well developed, the Nordegg Formation carries a Sinemurian fauna (Frebold, 1957, p. 7). The exact age of the underlying *"Pecten* beds" (68310) is uncertain. They may be equivalent to the Upper Suessi Zone, or may be of Rhaetian or Lower Jurassic age, but whatever their age they apparently lie concordantly between the *Monotis* beds and the shales assigned to the Nordegg Formation. According to this interpretation, the Pardonet Formation is concordantly followed by Jurassic strata. West of the Nordegg shales there is an outcrop of 12 feet of fractured limestone, dipping to the west. This limestone is probably of Triassic age, in fault contact with the Nordegg Formation.

20. A succession of Lower and Middle Norian zones from the Kerri Zone to the Columbianus Zone occurs in the Pardonet Formation of Brown Hill, on the north side of Peace River, in Halfway River area, British Columbia (McLearn, 1941b, 1960a). The sequence of faunas established by McLearn, expressed in the proposed zonal terminology, is as follows. Full details for the individual beds will be found in McLearn's memoir (1960a, pp. 13-16). This section provides the type localities for the Kerri, Dawsoni, Magnus, Rutherfordi, and Columbianus Zones.

Columbianus Zone (=*Himavatites* Zone, McLearn, 1960a, p. 26): *Pseudosirenites pardoneti* McLearn, *Himavatites columbianus* McLearn, *Hypisculites stelcki* McLearn, *Placites* sp., *Halobia* sp., *Monotis scutiformis pinensis* Westermann, all in situ; *"Sandlingites"* cf. *"S." idae* Mojsisovics, *Alloclionites* sp., *Sagenites* sp. in talus.

Rutherfordi Zone (= *Drepanites* and *Cyrtopleurites* beds, McLearn, 1960a, pp. 25, 26): *Drepanites hyatti rutherfordi* McLearn, *Cyrtopleurites* sp., *Acanthinites* cf. *A. eusebii* Diener, *Metacarnites* sp., *Placites* sp., *Halobia* spp.

Magnus Zone (= *Pterotoceras–Cyrtopleurites magnificus* beds, McLearn, 1960a, p. 25): *Cyrtopleurites magnificus* McLearn, *Pterotoceras caurinum* McLearn, *Juvavites biornatus* McLearn, *Juvavites magnus* McLearn, *Juvavites* cf. *J. brocchii* Mojsisovics, *Guembelites* sp., *Halobia* spp.

Dawsoni Zone (= *Gonionotites belli* and *Malayites* beds, McLearn, 1960a, p. 24): *Gonionotites belli* McLearn, *Gonionotites rarus* McLearn, *Malayites* sp., in situ; *Gonionotites fuscus* McLearn, *Malayites dawsoni* McLearn, *Malayites butleri* McLearn, in talus.

Kerri Zone (= *Stikinoceras* Zone, and *Thisbites*-bearing beds, McLearn (McLearn, 1960a, Table I): *Mojsisovicsites kerri* (McLearn), *Thisbites dawsoni* McLearn, *Juvavites schoolerensis* McLearn, *Juvavites humi* McLearn, *Juvavites* cf. *J. edithae* Mojsisovics, *Dimorphites pardonetiensis* McLearn, *Gonionotites rarus* McLearn, *Gonionotites* cf. *G. rarus* McLearn, *Halobia* spp. In 1964 *Sirenites nabeschi* McLearn and *"Tibetites"* sp. (64664) were obtained 20 feet above the main bed of *Mojsisovicsites kerri* (64666).

McLearn also described the section at Pardonet Hill, on the south side of Peace River, 6 miles upstream from Brown Hill. It now appears that the Pardonet Hill section as described by McLearn is partly incorrect, because of repetitions due to faults that he did not recognize (Tozer, 1965c). On McLearn's map of Pardonet Hill (1960a, p. 7) there appears to be a small fault between localities III and V, and another, larger fault between localities V and VII. The beds and zones recognized by McLearn and the writer at Pardonet Hill are as follows:

E.T.T., 1964

FIGURE 10.

View across Peace River to the west side of Pardonet Hill. Exposures are of Pardonet Formation, dipping steeply towards the observer. (1) indicates the position of the Macrolobatus Zone (64616, etc.); (2), the Kerri Zone (64607); (3), a bed with *Juvavites*, etc., (64606) representing the Kerri Zone or the Dawsoni Zone; (4), the Dawsoni Zone (64605). The Columbianus Zone is present at (5) (64643) and at (6) (64645). Between (5) and (6) there are beds with *Monotis subcircularis* (64644), which indicates that there is repetition by faulting. *Monotis subcircularis* is also present at (7) and (8) (64648).

Columbianus Zone (= *Himavatites* Zone and *Parathisbites oineus* beds, McLearn, 1960a, p. 26): *Pseudosirenites pardoneti* (McLearn), *Pseudosirenites pressus* (McLearn), *Vredenburgites* sp., *Sandlingites?* sp., *Alloclionites* sp., *Steinmannites* sp., *Himavatites columbianus* McLearn, *Himavatites* cf. *H. watsoni* Diener, *Himavatites burlingi* McLearn, *Parathisbites oineus* McLearn, *Distichites* cf. *D. mesacanthus* Diener, *Thetidites exquisitus* McLearn, *Placites* sp., *Pinacoceras* sp. A collection from locality 13 of Tozer (1965c, fig. 1), near locality XXII of McLearn (1960a, Fig. 2), provided *Alloclionites* sp., *Himavatites* cf. *H. columbianus* McLearn, *Sagenites* sp., and *Monotis scutiformis pinensis* Westermann (64634).

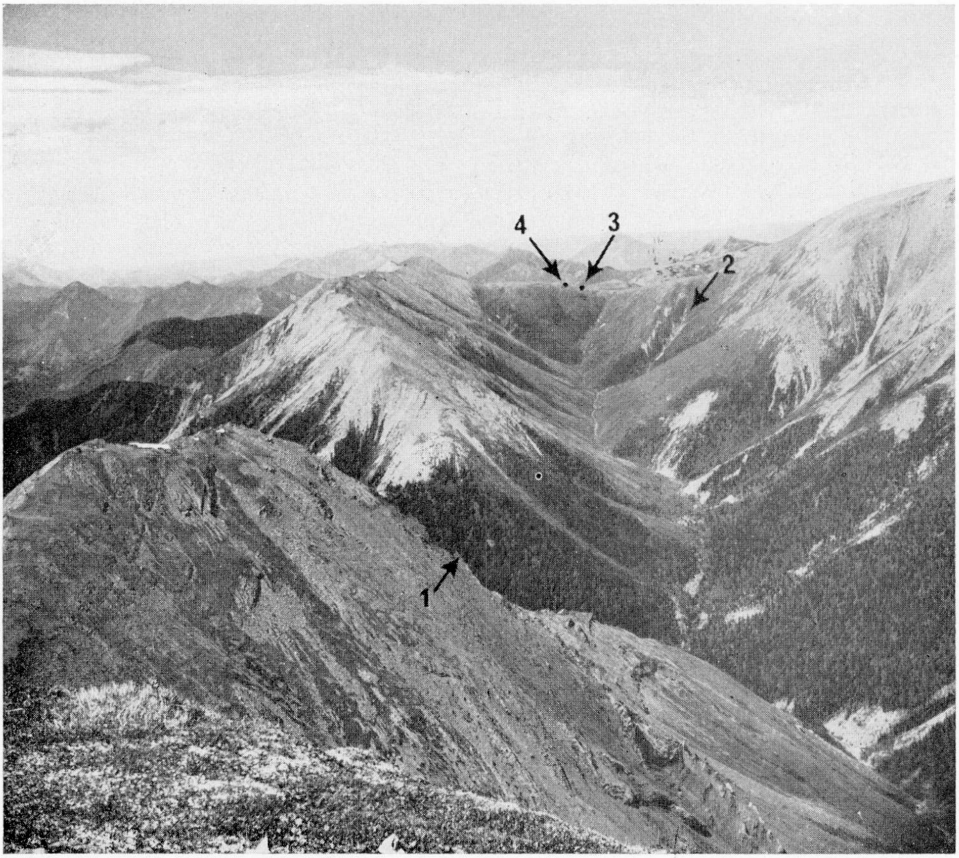
Rutherfordi and Magnus Zones: not recognized on Pardonet Hill.

Dawsoni Zone: Represented by *Malayites* cf. *M. dawsoni* near the head of Western Gully (64605; from locality 10 of Tozer, 1965c, fig. 1) (*see* Fig. 10) and by *Malayites dawsoni* on the east side of Pardonet Hill (64599, 64626, from locality 8, Tozer, 1965c, fig. 1; 64602, from locality 9, op. cit.). *Malayites butleri* McLearn, *Malayites* cf. *M. antipatris* Diener, *Malayites parcus* McLearn, and *Malayites custi* McLearn, all described from talus blocks on Pardonet Hill, are probably from the Dawsoni Zone.

Kerri Zone (= *Stikinoceras* Zone and part of *Styrites ireneanus* Zone, McLearn, 1960a, pp. 21-23): *Sirenites nabeschi* McLearn, *Cyrtopleurites* sp., *Mojsisovicsites kerri* (McLearn), *Thisbites dawsoni* (McLearn), *Thisbites charybdis* (Gemmellaro), *Thisbites* cf. *T. pyrami* (Gemmellaro), *Thisbites custi* (McLearn), *Styrites ireneanus* McLearn, *Tropiceltites columbianus* (McLearn), *Juvavites humi* McLearn, *Juvavites* cf. *J. edithae* Mojsisovics, *Dimorphites pardonetiensis* (McLearn), *Guembelites clavatus* (McLearn), *Gonionotites rarus* (McLearn), *Arcestes* sp., *Halobia* spp.

It is now known that the Macrolobatus Zone underlies the Kerri Zone on the west side of Pardonet Hill (Tozer, 1965c; this bulletin, ann. 21). *Gonionotites gethingi* (McLearn) and *Gonionotites* cf. *G. italicus* Gemmellaro, and possibly also *Juvavites selwyni* McLearn, all of which were described from the *Styrites ireneanus* Zone, are evidently from the Macrolobatus Zone.

McLearn described a rich fauna of the Columbianus Zone from "Black Bear Ridge", on the north side of Peace River. The rocks of "Black Bear Ridge" (in the sense of McLearn) are on strike with those of the west side of Pardonet Hill. McLearn's locality lies to the east of Black Bear Ridge as shown on the published topographical map of the Halfway River area. The Columbianus Zone is represented by the following at this locality: *Pseudosirenites pardoneti* (McLearn), *Pseudosirenites pressus* (McLearn), *Steinmannites* sp., *Himavatites* sp., *Helictites* cf. *H. subgeniculatus* Mojsisovics, *Helictites decorus* McLearn, *Distichites* cf. *D. celticus* Mojsisovics, *Distichites canadensis* (McLearn), *Distichites palliseri* McLearn, *Parajuvavites* sp., *Episculites browni* (McLearn), *Episculites ornatus* (McLearn), *Episculites teres* (McLearn), *Episculites corpulentus* (McLearn), *"Arcestes"* sp., *Placites* sp. A collection from this locality made in 1964 includes *Steinmannites* cf. *S. undulatostriatus* Mojsisovics, *Himavatites columbianus* McLearn, *Placites* sp., and *Monotis scutiformis pinensis* Westermann (64638).



E.T.T., 1965

FIGURE 11. View to the north of valley west of Mount McLearn, Toad River area, British Columbia. The stream in this valley flows into Sulphur Creek. The valley is essentially synclinal in structure; dark coloured, recessive beds are Pardonet Formation, and resistant light coloured rocks are Grey beds. (1) indicates the position of the small spur, with exposures of Pardonet Formation in which the Macrolobatus Zone (68202) is overlain by the Kerri Zone (68180); (2) shows the small gully where the Dawsoni Zone (68190) and Magnus Zone (68198, etc.) are in sequence. Higher beds contain the Columbianus and Suessi Zones, represented by *Monotis scutiformis pinensis* at (3) and *Monotis subcircularis* at (4).

At all the localities described above, namely Pardonet Hill, Brown Hill, and Black Bear Ridge, the Columbianus Zone is overlain by beds with *Monotis subcircularis,* representing the Lower Suessi Zone.

Nearly all the Lower and Middle Norian ammonoids known from northeastern British Columbia are described in McLearn's monograph (1960a). A few additions have been made in recent years by E. J. W. Irish, B. R. Pelletier, D. F. Stott, and the writer. They are as follows.

Columbianus Zone:

1. Ridge south of Nevis Creek, 57°20′N, 123°21′W, Trutch area collected by D. F. Stott, 1962: *"Buchites"* cf. *"B." modestus* (Buch) associated with *Monotis scutiformis pinensis* Westermann (52233).

2. Nevis Creek, north side, 3 miles along the strike from locality 52233 (*see above*), 57°23′N, 123°23′W, Trutch area, collected by D. F. Stott, 1964: *Phormedites* cf. *P. juvavicus* Mojsisovics, associated with *Distichites* spp., overlain by beds with *Monotis scutiformis pinensis* Westermann, all specimens catalogued 66027.

3. Mount Ludington, SW of Christina Falls, Halfway River area (*see* annotation 18).

Rutherfordi Zone: An important locality for the Rutherfordi Zone is a small tributary of Graham River, west of the Hackney Hills, in Halfway River area. Locally this stream is known as Short Creek, or White Creek, or Crying Girl Prairie Creek. Coordinates are 56°29′N, 122°53′30″W. Fossils were collected from this section by E. J. W. Irish in 1960 (42537) and by B. R. Pelletier in 1962. Pelletier's collections permit the discrimination of the Dawsoni, Rutherfordi, and Columbianus Zones (Pelletier, 1964, p. 88). The fauna of the Rutherfordi Zone includes *Drepanites hyatti rutherfordi* McLearn, *Metacarnites* sp., *Didymites* sp., *Halobia* cf. *H. fallax* Mojsisovics (42537, 46459). The *Metacarnites* and *Didymites* were collected by Irish and are attached to specimens of *Drepanites hyatti rutherfordi. Drepanites* and *Didymites* from this locality have been illustrated by Tozer (1962, Pl. X).

Magnus Zone: N. J. Silberling (pers. com.) has shown that *Indojuvavites* cf. *I. angulatus* Diener is a member of the fauna of the Magnus Zone in Nevada. It is therefore probable that *Indojuvavites* cf. *I. angulatus,* recorded by McLearn (1960, pp. 18, 92) from McLay Spur, on Peace River (Halfway River area) indicates an occurrence of the Magnus Zone.

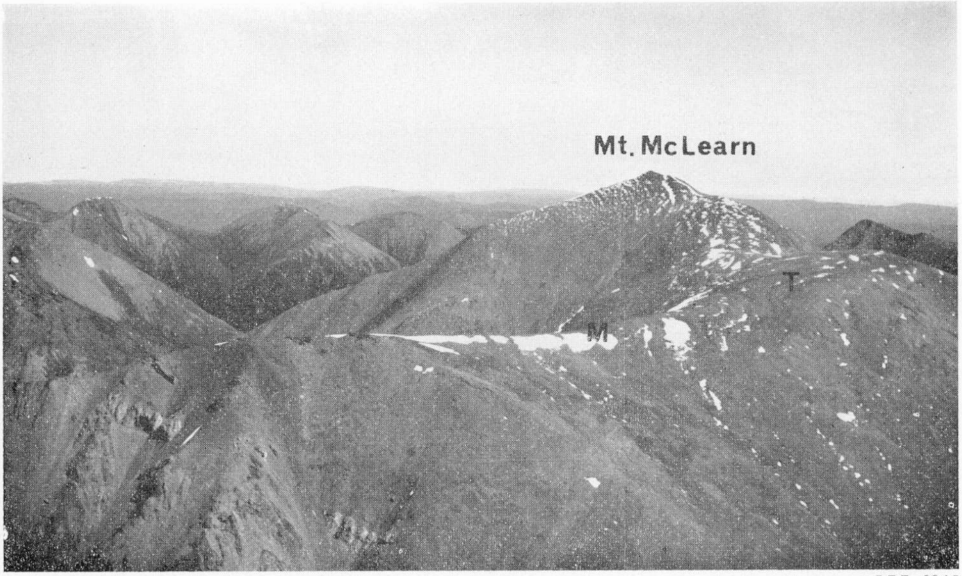
Dawsoni Zone: This zone is well represented in the synclinal area west of Mount McLearn, in Toad River area. One half mile SW of the summit of Mount McLearn the Dawsoni Zone carries *Malayites dawsoni* McLearn in situ (42327); and *Gonionotites* aff. *G. gethingi* (McLearn) and *Waldthausenites* cf. *W. leophanis* Diener from loose blocks derived from the Dawsoni Zone (42328, 42329) (*see* Fig. 12). 3¼ miles NNW of Triangulation Station 6536, in a small gully on the east limb of the synclinal structure, the Dawsoni Zone is represented by the index species (68190) and by a talus block containing *Waldthausenites* sp. together with *Malayites dawsoni* (68200) (*see* Fig. 11). Ten feet above the bed with *Malayites dawsoni* another bed contains *"Juvavites"* n. sp., *Waldthausenites* cf. *W. acutus* (Mojsisovics), and *Metacarnites* sp. (68193). Fifty feet higher in the section a third bed carries *Juvavites magnus* McLearn (68191, 68198). The fauna from locality 68193 probably represents the upper part of the Dawsoni Zone.

Kerri Zone: An important locality for this zone, which contributes several species to the fauna known in Canada, occurs ¾ mile SW of Mount McLearn in the Toad River area (*see* Fig. 11). From beds about 100 feet above the base of the Pardonet Formation at this locality the following were collected: *Sirenites nabeschi* McLearn, *Mojsisovicsites kerri* (McLearn), *Tropiceltites columbianus* (McLearn), *"Juvavites"* spp., *Dimorphites pardonetiensis* (McLearn), *Griesbachites* n. sp., *Guembelites jandianus* Mojsisovics, *Discophyllites* sp., *Halobia* cf. *H. superba* Mojsisovics (68180).

21. Superposition of the Kerri Zone above the Macrolobatus Zone can be demonstrated at two localities in NE British Columbia. Both are in the Pardonet Formation; one is at Pardonet Hill, in Halfway River area; the other is in Toad River area.

At the head of Western Gully on Pardonet Hill (loc. 2, Tozer, 1965c, fig. 1) (*see* Fig. 10) the basal Pardonet beds contain the following fossils indicative of the Macrolobatus Zone: *Tropites* sp. indet., *Anatropites* sp. (= *Anatropites* sp., Silberling, 1959, p. 51), *Gonionotites gethingi* (McLearn), *Griesbachites* cf. *G. kastneri* (Mojsisovics), *Halobia* cf. *H. superba* Mojsisovics (64616, 64627, 64628). About 50 feet higher in the section, at locality 6 (Tozer, 1965c, fig. 1) the Kerri Zone is represented by *Mojsisovicsites kerri* (McLearn), *Gonionotites rarus* (McLearn) (64607, 64629).

The locality in Toad River area is on the west limb of a synclinal structure, ¾ mile SW of Mount McLearn (*see* Fig. 11). There the Macrolobatus Zone occurs about 50 feet above the base of the Pardonet Formation and is represented by *Tropites* aff. *T. latiumbilicatus* Silberling, *Juvavites* sp., *Halobia* sp. (68202). About 50 feet higher in the section the Kerri Zone is represented by the fauna (68180) listed under ann. 20.



E.T.T., 1965

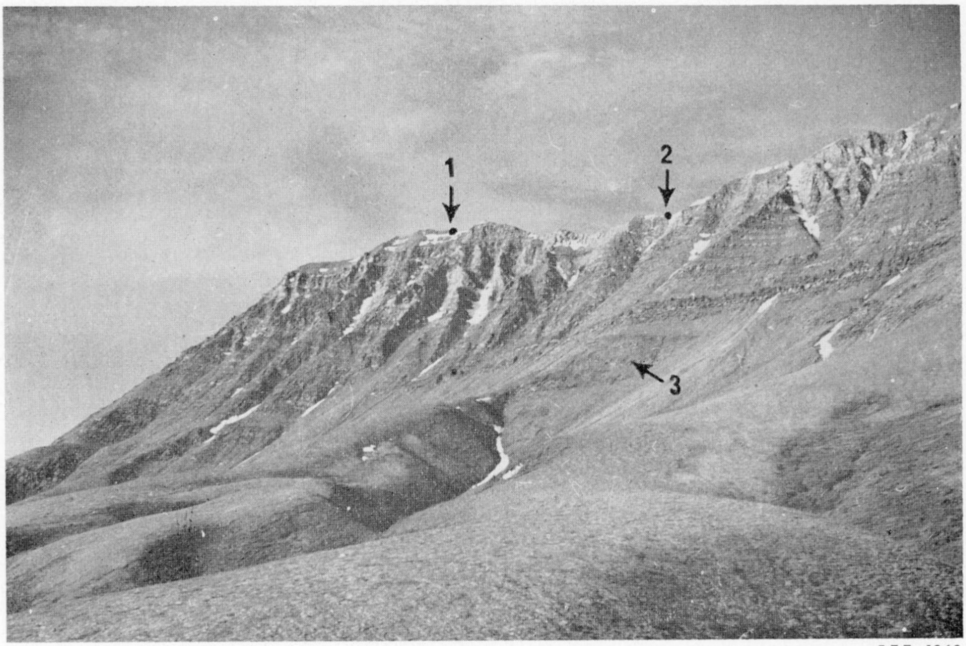
FIGURE 12. Southwest side of Mount McLearn, Toad River area, British Columbia, aerial view. (T) indicates the position of the boundary between the Grey beds and the Pardonet Formation, with the Welleri Zone (42320, etc.) in the basal Pardonet; (M), the position of the Dawsoni Zone (42327, etc.). The beds with the Welleri Zone are stratigraphically above those with the Dilleri Zone on the east face of Mount McLearn (Fig. 14).

22. Superposition of the Macrolobatus Zone above the Welleri Zone has not been demonstrated in a simple section but is nevertheless more or less established in the Pardonet Formation of Toad River area, British Columbia. The occurrence of the Macrolobatus Zone, about 50 feet above the base of the Pardonet Formation, has already been mentioned (ann. 21). The Macrolobatus Zone is on the west limb of a synclinal structure. On the east limb, a mile NNW of Triangulation Station 6536, SW of the summit of Mount McLearn (*see* Fig. 12), the following ammonoids of the Welleri Zone occur at the contact between the Pardonet Formation and the underlying Grey beds: *Tropites* spp., *Discotropites mojsvarensis* Smith, *Discotropites theron* (Dittmar), *Juvavites* cf. *J. hyatti* (Smith), *Jovites* sp. (42320, 42321, 42325, 42398, 68360). The relative position of these two zones with respect to the base of the Pardonet Formation leaves little doubt that the Macrolobatus Zone is higher than the Welleri Zone.

The best locality for the Welleri Zone in NE British Columbia is on the hill south of Mile Post 427 on the Alaska Highway, in Tuchodi Lakes area. The section there was studied by B. R. Pelletier and the writer in 1960 (Pelletier, 1961, p. 30; Tozer, 1961a, p. 11). The following fauna of the Welleri Zone was obtained from unit 10 of Pelletier's section: *Klamathites* sp. indet., *Hannaoceras major* (Smith), *Tropites* n. sp. aff. *T. welleri* Smith, *Discotropites mojsvarensis* Smith, *Discotropites theron* (Dittmar), *Hoplotropites* cf. *H. auctus* (Dittmar), *Juvavites subintermittens* Hyatt and Smith, *Juvavites hyatti* (Smith), *Homerites semiglobosus* (Hauer), *Jovites* cf. *J. bosnensis* Mojsisovics (42389, 42386, 42378, 42384). Some of the ammonoids from this locality have been illustrated (Tozer, 1962, Pls. VII, VIII). The *Klamathites* was formerly compared with *K. macrolobatus* Silberling, the index fossil of the Macrolobatus Zone. The specimens from Canada are small and are not specifically determinable; they could be *K. schucherti* Smith which occurs in the Welleri Zone of California.

One large talus block in the stream bed on the west side of the hill south of Mile Post 427 yielded well-preserved examples of the following: *Arctosirenites canadensis* Tozer, *Discotropites mojsvarensis* Smith, *Discotropites theron* (Dittmar), *Juvavites* cf. *J. hyatti* Smith, *Juvavites* cf. *J. brockensis* Smith (42306). Presumably this block is from the Welleri Zone. The specimens of *Arctosirenites* are the only ones known from British Columbia. Specimens from this block have been illustrated (Tozer, 1962, Pls. VII, VIII).

23. The sequence from the Sutherlandi Zone (Upper Ladinian), through the Karnian Obesum, Nanseni, Dilleri, and Welleri Zones has been established in the mountains that lie some 15 miles south of the Grand Canyon of Liard River. These mountains are in the SW part of Toad River area, British Columbia. The five zones do not occur in any one place, but three stratigraphic sections illustrate the zonal sequence. These sections are N and NE of the Triangulation Station (6536) east of the divide that separates Eight Mile Creek and Sulphur Creek. The Sutherlandi Zone occurs in beds assigned to the Liard Formation. The Obseum, Nanseni, and Dilleri Zones occur in a resistant, cliff-forming sequence of calcareous sandstone and siltstone that represent the Grey beds. The Welleri Zone, as already mentioned (ann. 22), is in the basal part of the Pardonet Formation, immediately above the Grey beds.



E.T.T., 1960

FIGURE 13. Exposures of Liard Formation and Grey beds, east face of Ewe Mountain, Toad River area, British Columbia: (1) indicates the position of the Nanseni Zone; (2), the Obesum Zone; (3), the approximate position of the Sutherlandi Zone. Sutherlandi Zone is in Liard Formation; Obesum and Nanseni Zones are in the Grey beds.

The Sutherlandi, Obesum, and Nanseni Zones are in sequence on Ewe Mountain whose summit lies 4½ miles ENE of Triangulation Station 6536 (*see* Fig. 13). The rock sequence there has been described by Pelletier (1961, pp. 13-15). The fossils have been listed, and some illustrated, by Tozer (1961a, p. 11; 1962, Pls. VII, VIII). On Ewe Mountain the stratigraphic interval between the beds with *Daxatina canadensis* (Whiteaves) in the Liard Formation (Sutherlandi Zone) and *Trachyceras obesum* n. sp. (Obesum Zone) in the overlying Grey beds is about 800 feet, and the fauna of the Nanseni Zone occurs about 300 feet above the Obesum Zone. The faunas of the Sutherlandi and Obesum Zones are meagre. The former (42316) includes only *Daxatina canadensis* and *Daonella* sp. indet. The Obesum Zone is represented by the index species, undetermined nautiloids and *Halobia* sp. (42308). The fauna of the Nanseni Zone includes *Sirenites nanseni* Tozer, *Sirenites* cf. *S. senticosus* (Dittmar), and *Halobia* cf. *H. zitteli* Lindström (42311). An oil company collection from Ewe Mountain includes *Sirenites* cf. *S. striatofalcatus* (Hauer) (68361). Ewe Mountain represents the type locality for the Obesum and Nanseni Zones.

The Nanseni and Obesum Zones are also exposed in the Grey beds on a ridge 3 miles west of Ewe Mountain. This ridge is 2¼ miles NNE of Triangulation Station 6536. The Nanseni Zone is represented by *Sirenites* cf. *S. nanseni* Tozer, *Sirenites* cf. *S. striatofalcatus* (Hauer) and *Halobia* cf. *H. rugosa* Gümbel on the summit of the ridge (68215). The Obesum Zone is on the east face of the ridge, about 400 feet lower in the section, with *Trachyceras* cf. *T. desatoyense* Johnston and *Halobia* sp. indet. (68217).

In a third section, about 4 miles west of Ewe Mountain, the sequence is carried up from the Nanseni Zone to the Dilleri and Welleri Zones. This section is on Mount McLearn,

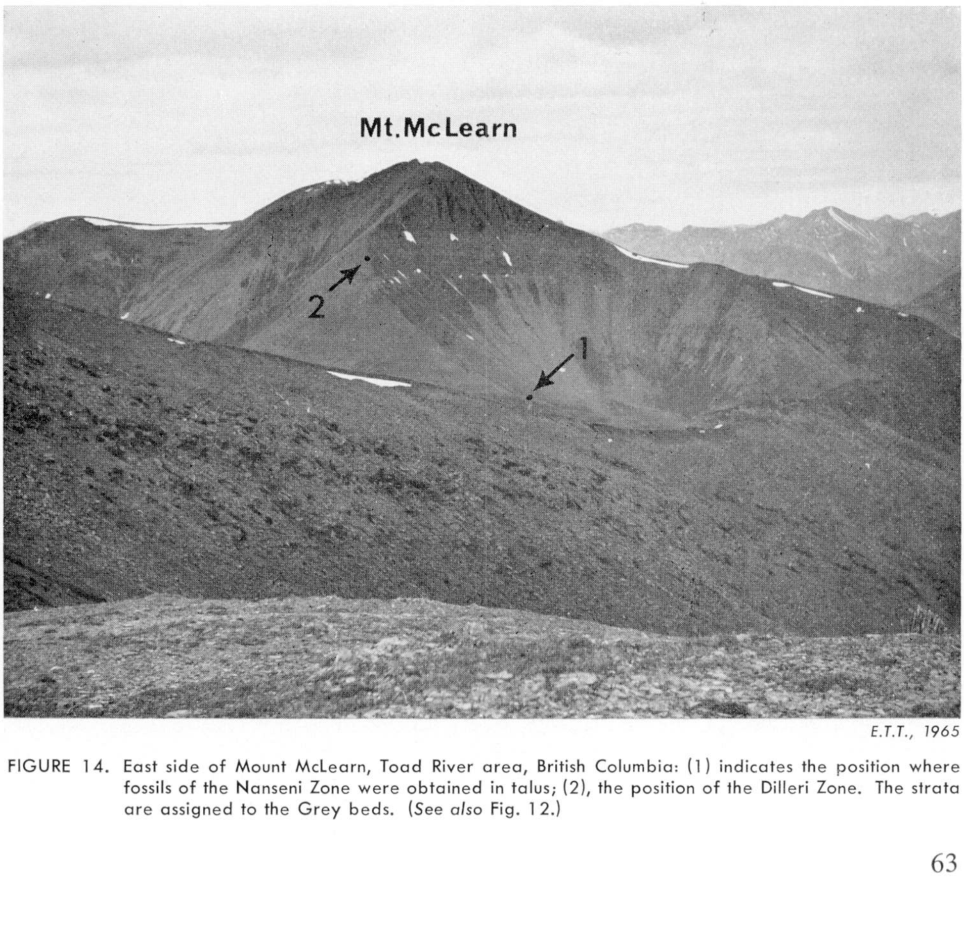


FIGURE 14. East side of Mount McLearn, Toad River area, British Columbia: (1) indicates the position where fossils of the Nanseni Zone were obtained in talus; (2), the position of the Dilleri Zone. The strata are assigned to the Grey beds. (*See also* Fig. 12.)

whose summit is 1¾ miles NNW of Triangulation Station 6536 (*see* Figs. 12, 14). The sequence there is as follows.

Welleri Zone: In basal part of Pardonet Formation, on saddle, SW of summit of Mount McLearn (42320, *see* ann. 22).

(Stratigraphic interval, about 750 feet).

Dilleri Zone: *Spirogmoceras shastense* (Smith), *Traskites* sp., *Trachystenoceras* aff. *T. gabbi* (Hyatt and Smith), *Thisbites* sp., *Tropites dilleri* Smith, *Discotropites sandlingensis* (Hauer), *Halobia* sp. (68208), in resistant sandstone unit, above brown calcareous siltstone, exposed on east face of Mount McLearn.

(Stratigraphic interval, about 700 feet.)

Nanseni Zone: *Sirenites* sp. (talus) (68209), in grey calcareous siltstone, on east side of Mount McLearn, near base.

Admittedly the record of *Sirenites* from this last locality is based on rather poor talus specimens, however, there is good lithostratigraphic evidence for correlating the *Sirenites* beds (Nanseni Zone) of locality 68215 with those of 68209. Above each occurrence of the Nanseni Zone there is a distinctive brown marker bed composed of recessive calcareous siltstone. Above locality 68215 this bed is 70 feet thick; above 68209 it is 300 feet thick.

Ammonoids that are certainly Lower Karnian and that probably indicate the Obesum Zone have been collected by geologists of Triad Oil Company from a ridge 2¼ miles NE of Clearwater Lake, in Pine Pass area. *Trachyceras?* sp., *Clionitites reesidei* (Johnston), and *Halobia* sp. (45751) were collected 1,835 feet above the base of the Triassic section. *Trachyceras*? sp., *Coroceras* cf. *C. nasutus* Mojsisovics, and *Halobia* sp. (45745) were obtained from a higher level, 2,115 feet above the base.

24. The Meginae, Maclearni, and Sutherlandi Zones of Upper Ladinian age are subdivisions of the *Nathorstites* Zone of earlier publications (McLearn, 1947b; Tozer, 1961b, p. 34). These three zones, each characterized by several distinctive ammonoids of restricted stratigraphic range, are readily recognized within the Upper Ladinian *Nathorstites* beds. Eventually it may be possible to distinguish as many as five zones within the Upper Ladinian.

In Toad River, Tuchodi Lakes, and Trutch areas the Meginae, Maclearni, and Sutherlandi Zones occur in the Liard Formation, as interpreted by Pelletier (1964). On Peace River (Halfway River area) the Meginae Zone and probably also the Maclearni Zone are in the "Dark Siltstones" (i.e., the Liard Formation), and the Sutherlandi Zone is in the lower part of the overlying Grey beds (McLearn, 1947b; McLearn and Kindle, 1950, p. 35).

Large collections from the Meginae, Maclearni, and Sutherlandi Zones are available at the Geological Survey, mostly made by geologists of several oil companies, E. J. W. Irish, B. R. Pelletier, and the writer. It is impossible to summarize all the information provided by this material. In order to give the critical data, a section is described on Liard River where the Meginae, Maclearni, and Sutherlandi Zones are exposed in sequence. Also included are descriptions of localities where other species, unknown in the described section, occur in these zones. The section on Liard River is not the only one in which all three zones occur in sequence. In addition to the Toad River area, where the Liard River section is located, all three zones are known in Tuchodi Lakes, Trutch, and Halfway River areas. The Meginae Zone is also known south of Peace River, in a section 20 miles NNW of Monkman Lake (Tozer, 1961a, p. 9) in Monkman Pass area.

The Meginae, Maclearni, and Sutherlandi Zones are displayed in sequence, with perfect exposures, on the canyon wall on the north side of Liard River at Boiler Canyon 1½ to 3 miles downstream from the Rapids of the Drowned, in Toad River area (*see* Fig. 15). On the river bank at the base of this section there is an abandoned pile of broken machinery, including a boiler: the wreckage of an abandoned river steamer. In this section the three zones range through 1,000 feet of northeasterly dipping beds that represent the Liard Formation, followed by about 300 feet of thick-bedded sandstone similar to the basal Grey beds of

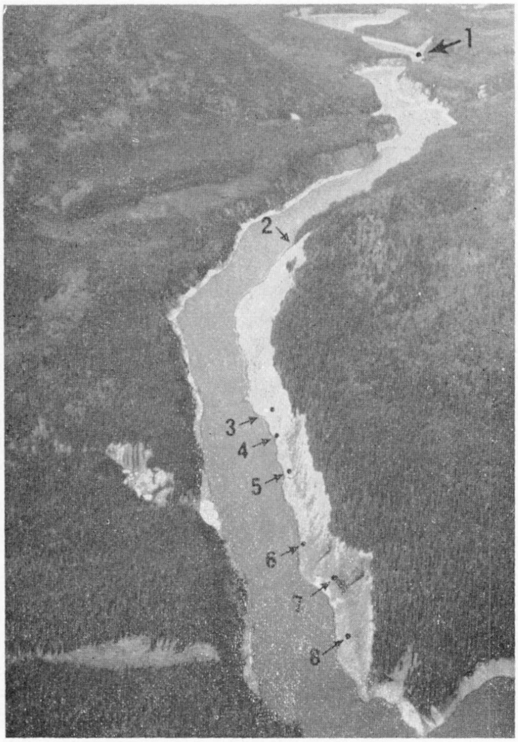


FIGURE 15. Aerial view upstream, from Boiler Canyon to the Rapids of the Drowned on Liard River, Toad River area, British Columbia. The Romunderi and Tardus Zones are in sequence in the Toad Formation at (1), immediately above the Rapids of the Drowned. Localities (2) to (8) are in the Liard Formation, in Boiler Canyon: (2) indicates the locality for the lower part of the Meginae Zone; (3), the Meginae Zone (68251); (4), Maclearni Zone (68242); (5), Maclearni Zone (68236, 68237); (6), Sutherlandi Zone (68234, 68254); (7), Sutherlandi Zone (68231); (8), Sutherlandi Zone (68229). *Canadian Pacific Airlines*, August 1935.

Pelletier (1964). The Grey beds are overlain disconformably by the Cretaceous Garbutt Formation. The position of the ammonoid zones with respect to the Triassic-Cretaceous contact is as follows.

Sutherlandi Zone (type locality): Obtained from five beds, between 340 and 590 feet below the Cretaceous contact.

1. 340 feet below contact: *Daxatina canadensis* (Whiteaves), *Nathorstites mcconnelli* (Whiteaves), *Lobites* cf. *L. ellipticus* (Hauer) (68229).

2. 460 feet below contact: *Daxatina canadensis* (Whiteaves), *Asklepioceras* cf. *A. laurenci* McLearn, *Nathorstites mcconnelli* (Whiteaves), *Daonella elegans* McLearn (68231).

3 and 4. 470 and 505 feet below contact: *Paratrachyceras sutherlandi* McLearn, *Nathorstites mcconnelli* (Whiteaves), *Daonella elegans* McLearn (68232, 68253).

5. 590 feet below the contact: *Paratrachyceras* aff. *P. sutherlandi* McLearn, *Megaphyllites* sp., *Daonella elegans* McLearn (68234).

Maclearni Zone: Obtained from three beds, between 860 and 1,090 feet below the Cretaceous contact.

1. The highest bed, 860 feet below the contact, contains a fauna that is largely undescribed: *Hungarites* sp., *Protrachyceras* aff. *P. sikanianum* McLearn, "*Protrachyceras*" n. sp. aff. "*P.*" *reitzi* (Boeckh), *Maclearnoceras* n. sp. aff. *M. maclearni* Tozer, *Maclearnoceras?* n. sp., *Asklepioceras* n. sp., *Lobites* cf. *L. ellipticus* (Hauer), *Megaphyllites* sp., *Nathorstites* aff. *N. mcconnelli* (Whiteaves), *Gymnites*? sp., *Monophyllites* sp. (68236).

2. The middle bed, 865 feet below the contact, provided *Protrachyceras* aff. *P. sikanianum* McLearn, *Anolcites* cf. *A doleriticum* (Mojsisovics), *Daonella nitanae* McLearn (68237).

3. The lowest bed, 1,090 feet below the contact provided *Paratrachyceras caurinum* McLearn, *Anolcites* cf. *A. doleriticum* (Mojsisovics), *Nathorstites* aff. *N. mcconnelli* (Whiteaves) (68242).

Meginae Zone (type locality): Obtained from two levels, between 1,220 and 1,330 feet below the Cretaceous contact.

1. 1,220 feet below the contact: *Meginoceras meginae* McLearn, *Nathorstites* aff. *N. mcconnelli* (Whiteaves), *Daonella nitanae* McLearn (68251).

2. Between 1,320 and 1,340 feet below the contact: *Protrachyceras sikanianum* McLearn, *Silenticeras hatae* McLearn, *Megaphyllites selwyni* (McLearn), *Lobites pacianus* McLearn, *Nathorstites* aff. *N. mcconnelli* (Whiteaves), *Daonella nitanae* McLearn (68248, 68249, 68243). Talus blocks from this level provided *Meginoceras meginae* McLearn and *Thanamites schoolerensis* (McLearn) (68244, 68351).

The section described above establishes the stratigraphic relationship between the Meginae, Maclearni, and Sutherlandi Zones. Additions to the faunas of each zone may be made by considering the assemblages known from other localities.

Additions to Sutherlandi Zone. Daxatina canadensis and *Paratrachyceras sutherlandi* are the most widely distributed members of the fauna of the Sutherlandi Zone. The section described above shows that *Daxatina canadensis,* at least locally, ranges above *Paratrachyceras sutherlandi.* A similar situation is found on the south side of Liard River, downstream from Boiler Gorge, 3½ miles west of Hell Gate and again in the section 10 miles SE of Mount Mary Henry in Tuchodi Lakes area. However, the ranges of *Daxatina canadensis* and *Paratrachyceras sutherlandi* definitely overlap in the section 3½ miles west of Hell Gate and for the time being only one zone is recognized for this interval. Ultimately it may prove desirable to recognize two subzones within the Sutherlandi Zone. The following species are associated with either *Daxatina canadensis* or *Paratrachyceras sutherlandi* at other localities in British Columbia and may be regarded as members of the fauna of the Sutherlandi Zone.

1. *Protrachyceras* n. sp. aff. *Trachyceras brotheus* (Münster), associated with *Daxatina canadensis* on south side of Liard River, 3½ miles west of Hell Gate, 170 feet below Triassic-Cretaceous contact (68272), and apparently with *Paratrachyceras sutherlandi,* on north side Liard River, 2¼ miles west of Hell Gate (42351), both localities in the Liard Formation of Toad River area.

2. *Asklepioceras glaciense* McLearn, *Asklepioceras laurenci* McLearn, *Asklepioceras mahaffii* McLearn, associated with *Paratrachyceras sutherlandi* in the lower part of the Grey beds, East Glacier Spur, south side Peace River opposite Brown Hill, Halfway River area (9797) (McLearn, 1941b, p. 98; 1947b, p. 6; McLearn and Kindle, 1950, p. 49).

3. *Asklepioceras delicatulum* McLearn, associated with *Paratrachyceras sutherlandi,* Liard Formation, 80 feet below Triassic-Cretaceous contact, north side of Liard River, 2¼ miles west of Hell Gate, Toad River area (42354).

4. *Hannaoceras* n. sp., associated with *Daxatina canadensis,* Liard Formation, 300 feet below Triassic-Cretaceous contact, south side Liard River, 3½ miles west of Hell Gate, Toad River area (42335).

5. *Joannites* sp., associated with *Daxatina canadensis,* Liard Formation, 10 miles SE of Mount Mary Henry, Tuchodi Lakes area (68280).

Additions to the Maclearni Zone. The type locality for the Maclearni Zone is in the Liard Formation on the north side of Liard River, 2½ miles west of Hell Gate, Toad River area (Pelletier, 1961, p. 25; Tozer, 1963b, p. 32). The fauna from the Maclearni Zone at this locality includes: *Protrachyceras* aff. *P. sikanianum* McLearn, *Anolcites* cf. *A. doleriticum* (Mojsisovics), *Maclearnoceras maclearni* Tozer, *Maclearnoceras* n. sp., *Liardites whiteavesi* Tozer, *Clionitites*? n. sp., *Nathorstites* aff. *N. mcconnelli* (Whiteaves) (42355).

Paratrachyceras caurinum McLearn is probably restricted to the Maclearni Zone. The type locality for this species is Beattie Ledge on Peace River, in Halfway River area. This species is represented by two specimens from Beattie Ledge; the holotype collected by H. H.

Beach and another specimen collected by C. M. Sternberg in 1930 (9276) and described on the label as "near the top of section of steep beds." This suggests that *Paratrachyceras caurinum* occurs above the Meginae Zone at Beattie Ledge, and in view of the position of this species in Boiler Gorge, indicates the presence of the Maclearni Zone in the highest part of the "Dark Siltstones" (Liard Formation).

Additions to the Meginae Zone. Most of the species now known to characterize the Meginae Zone were first described from the "Dark Siltstones" (Liard Formation) of Beattie Ledge, on Peace River, by F. H. McLearn (1930, 1937a, 1937b, 1940b, 1943, 1947b). The ammonoids described from this locality are *Protrachyceras sikanianum* McLearn, *Protrachyceras zauwae* McLearn, *Meginoceras meginae* McLearn, *Silenticeras hatae* McLearn, *"Sagenites" gethingi* McLearn, *Lobites pacianus* McLearn, *Proarcestes* sp., *Megaphyllites selwyni* (McLearn), *Megaphyllites leve* (McLearn), *Thanamites schoolerensis* (McLearn), *Thanamites schoolerensis parvus* (McLearn). The type locality for *Daonella nitanae* McLearn is in the Meginae Zone of Beattie Ledge. In Tuchodi Lakes area *Arpadites* aff. *A. toldyi* Mojsisovics is associated with *Daonella nitanae* in beds that are provisionally assigned to the Meginae Zone (*see* ann. 25).

The three zones described above indicate the stratigraphic position of nearly all the ammonoids known from the Upper Ladinian of British Columbia. There is, however, another faunal association known from the Liard Formation of at least two localities which cannot at present be placed in the sequence. This is the assemblage described from "Mount Hage", on the south side of Sikanni Chief River, in Trutch area. The name "Mount Hage" does not appear on the published map for this area; it represents the NE part of Mount Wooliever. The fauna from this locality, collected by McLearn (1947b, p. 8; McLearn and Kindle, 1950, p. 45) includes *Paratrachyceras tetsa* McLearn (paratype), a distinctive new species of *Silenticeras,* and *Nathorstites* sp. (10790). A closely comparable fauna was collected by E. J. W. Irish, south of Graham River, 20 miles SE of Christina Falls, in Halfway River area (42535). *Protrachyceras* cf. *P. sikanianum* McLearn and *Daonella nitanae* McLearn occur at both localities, which suggests that the assemblage characterized by *Paratrachyceras tetsa* is related to the fauna of the Meginae Zone, but there is probably a difference in age and eventually it may be possible to discriminate another zone or subzone. The holotype of *Paratrachyceras tetsa* is described as coming from the Liard Formation exposed on the Alaska Highway near Mile Post 386, in Tuchodi Lakes area. Exposures are poor and most of the fossils have been obtained from loose blocks; *Meginoceras meginae* is present in Dr. McLearn's collection from this locality (10781). No specimens of *Paratrachyceras tetsa* apart from the holotype are known in this collection, nor are they present in collections made by the writer (42299, 42412). The preservation of the holotype of *Paratrachyceras tetsa* is identical with that of the paratype from "Mount Hage", and it seems possible that a mistake was made in labelling the specimen.

25. The type locality for the Poseidon Zone is in the lower part of the Liard Formation, exposed on the prominent bluff facing the Rocky Mountains between Chischa and Tuchodi Rivers in Tuchodi Lakes area. This locality is 10 miles SE of Mount Mary Henry (*see* Fig. 16). Well-preserved ammonoids of this zone were obtained from two beds, 25 feet apart, and include *Progonoceratites poseidon* n. sp., *Protrachyceras* cf. *P. sikanianum* McLearn, *Proarcestes* sp., *Nathorstites* n. sp., and *Ptychites* n. sp. associated with *Daonella* cf. *D. longobardica* Kittl (68285, 68286, etc.). About 150 feet above the beds with *Progonoceratites poseidon,* between points 1 and 2 on Figure 16, *Daonella* cf. *D. subarctica* Popov together with *Protrachyceras* sp. was collected (68290). At an even higher level, about 300 feet above the beds with *Progonoceratites poseidon,* there is a prominent marker bed of dark recessive siltstone, about 75 feet thick, with *Arpadites* aff. *A. toldyi* Mojsisovics, *Silenticeras* sp., *Nathorstites* aff. *N. mcconnelli* (Whiteaves), and *Daonella nitanae* McLearn (68277); this fauna is regarded as Upper Ladinian and evidently indicates the Meginae Zone.[1]

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[1]In 1966 *Arpadites* aff. *A. toldyi* was collected about 100 feet below *Meginoceras meginae* on Mount Withrow in Trutch area.

E.T.T., 1965

FIGURE 16.

Bluff 10 miles southeast of Mount Mary Henry, Tuchodi Lakes area, British Columbia. Exposures are of the Liard Formation with the basal sandstone of the Grey beds forming the crest of the bluff. (1) indicates position of Poseidon Zone; (2), the Meginae Zone, with *Arpadites* aff. *A. toldyi;* and *Daonella nitanae;* (3), the Maclearni Zone; (4) and (5) indicate the Sutherlandi Zone.

Provisionally the bed with *Daonella* cf. *D. subarctica* is regarded as Lower Ladinian and representative of the upper part of the Poseidon Zone, but future work may show that this *Daonella* bed characterizes an additional zone between the Poseidon and Meginae Zones.

Specimens of *Daonella* cf. *D. longobardica,* identical with those at the type locality of the Poseidon Zone, occur on the north side of Liard River, three quarters of a mile below the Rapids of the Drowned in Toad River area (68240). *Progonoceratites* aff. *P. poseidon* is present in a collection made by J. E. Muller, 2½ miles NE of Mount Hunter, in Pine Pass area (42468). There seems to be no doubt that the Poseidon Zone, although relatively rare, is widely distributed in NE British Columbia.

26. The only occurrences of the Subasperum Zone known in Canada are north of Wapiti Lake in Monkman Pass area, NE British Columbia. The Subasperum Zone occurs in beds assigned to the Toad Formation by Pelletier (1963, p. 41). Twelve miles north of Wapiti Lake Pelletier collected the following representatives of the Subasperum Zone: *Gymnotoceras* spp., *Protrachyceras* cf. *P. meeki* (Mojsisovics), *Ptychites* sp., *Daonella* cf. *D. moussoni* Merian (46484). The Subasperum Zone is also represented in a collection recently submitted by Shell Oil Company, obtained from a section 10 miles NW of Wapiti Lake. In this collection *Protrachyceras* cf. *P. meeki* (Mojsisovics) occurs 920 feet above the base of the Triassic section and about 100 feet above a largely covered interval that provided abundant representatives of the Varium Zone.

The stratigraphic relationship between the Subasperum, Chischa, and Poseidon Zones has not yet been demonstrated in a continuous stratigraphic section.

27. The Chischa and Deleeni Zones occur in sequence in a section described by Pelletier (1960, p. 21) on Chischa River, 8 miles above Muskwa River, in the Fort Nelson area, British Columbia, at the boundary with the Tuchodi Lakes area. Discrimination of the Chischa

Zone is possible on the basis of collections obtained by Pelletier. Both zones are in the Toad Formation.

The Chischa Zone (type locality) occurs 13 feet below the top of unit 8 (Pelletier, 1960, p. 22) and contains *Gymnotoceras chischa* n. sp., *Celtites*? *polygyratus* Smith, *Parapopanoceras* sp. indet., *Daonella* cf. *D. moussoni* Merian (40088).

The Deleeni Zone occurs 45 feet lower in the section, represented by *Gymnotoceras deleeni* (McLearn), *Longobardites nevadanus* Hyatt and Smith, *Daonella americana* Smith (40089). A collection obtained from this bed in 1966 also includes *Gymnotoceras* aff. *G. rotelliformis* Smith and *Tropigymnites* cf. *T. planorbis* (Hauer) (74724).

A fossil bed more or less correlative with the Chischa Zone occurs on "Hage Creek". This creek drains the NE side of Mount Wooliever on the south side of Sikanni Chief River in Trutch area. F. H. McLearn discovered this bed (loc. 2, McLearn and Kindle, 1950, Fig. 6) and reported *Gymnotoceras* sp. and *Daonella* cf. *D. moussoni* Merian (10719). The species of *Gymnotoceras* from this locality, like *Gymnotoceras chischa,* has a well-defined keel and thus differs from the species of the Deleeni and older zones.

Daonella dubia Gabb, known from the Toad Formation and the Silty Dolomite member of the Sulphur Mountain Formation, probably indicates the Chischa Zone. Good specimens were obtained by D. W. Gibson from the Silty Dolomite member on the SE side of Monaghan Creek, 5 miles west of the junction with Sulphur River, in Mount Robson area (58386).

28. The Caurus, Varium, and Deleeni Zones are in sequence in the Toad Formation exposed on the north side of the Alaska Highway in Tetsa River Valley, west of Mile Post 375, in Tuchodi Lakes area. The geology of this area has been described by McLearn (1946a, b; McLearn and Kindle, 1950, pp. 38-40), and a geological map including the area has been prepared by Pelletier (1959). In 1965 the writer accompanied by N. J. Silberling examined the section, and discriminated the Caurus, Varium, and Deleeni Zones within the *"Beyrichites-Gymnotoceras"* Zone of McLearn (McLearn and Kindle, 1950, p. 35).

Two sections were examined, one on the east limb and the other on the west limb of the anticline immediately west of Mile Post 375. The Caurus, Varium, and Deleeni Zones were found on the east limb, and the Varium and Deleeni Zones on the west limb.

The sequence of fossiliferous beds on the east limb is given below (Section 1). The position of the individual beds is expressed in relation to the contact between the Triassic beds and the overlying Lower Cretaceous shales (Garbutt Formation). The contact is well exposed on the highway.

Section 1

Deleeni Zone: *Gymnotoceras deleeni* (McLearn), *Longobardites nevadanus* Hyatt and Smith, *Parapopanoceras* sp. indet., *Ussurites arthaberi cameroni* McLearn, *Daonella* cf. *D. americana* Smith, 500 feet below Cretaceous contact (68224).

Varium Zone: *Anagymnotoceras* cf. *A. varium* (McLearn), *Longobardites nevadanus* Hyatt and Smith, *Czekanowskites hayesi* (McLearn), *Parapopanoceras selwyni* McLearn, 590 feet below Cretaceous contact (68204).

Caurus Zone (type locality): Obtained from two beds, 660 and 675 feet below Cretaceous contact.

1. *Lenotropites caurus* (McLearn), *Groenlandites* cf. *G. nielseni* Kummel, *Grambergia* n. sp., *Ussurites muskwa* McLearn, *Leiophyllites kindlei* McLearn, 660 feet below Cretaceous contact (68203).
2. *Acrochordiceras americanum* McLearn, *Pearylandites* aff. *P. troelseni* Kummel, *Stenopopanoceras* sp., 675 feet below Cretaceous contact (68226).

On the west limb of the anticline the following sequence of four fossiliferous beds was found (Section 2; *see* Fig. 17). These beds are exposed between 175 and 300 feet west of the point where the anticlinal axis intersects the Alaska Highway.

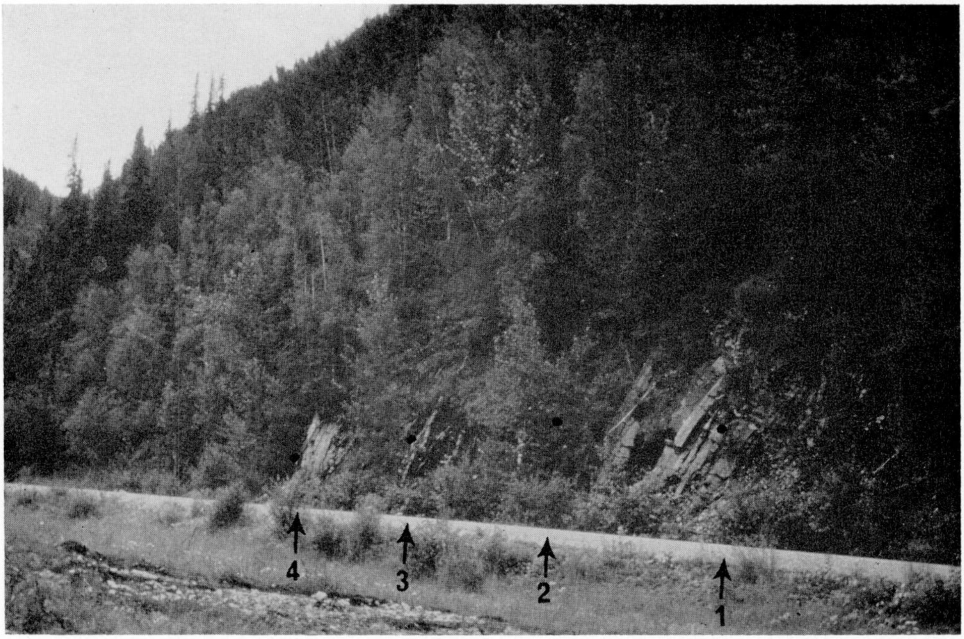

FIGURE 17. Exposures of Toad Formation, north side of Alaska Highway, west limb of anticline west of Mile Post 375, Alaska Highway (Tuchodi Lakes area, British Columbia). The beds are numbered as in the text; (1) and (2) represent the Varium Zone; (3) and (4) the Deleeni Zone.

Section 2

Deleeni Zone (type locality): Beds 3 and 4.

Bed 4. *Gymnotoceras deleeni* (McLearn), *Longobardites nevadanus* Hyatt and Smith, *Parapopanoceras* sp. indet., *Ussurites* sp. indet., *Daonella* sp. indet. (68297).

Bed 3 (25 feet below bed 4). *Gymnotoceras deleeni* (McLearn), *Longobardites* cf. *L. nevadanus* Hyatt and Smith, *Parapopanoceras tetsa* McLearn, *Daonella* sp. indet. (68228).

Varium Zone (type locality): Beds 1 and 2.

Bed 2 (32 feet below bed 3). *Hollandites spivaki* McLearn, *Gymnotoceras* sp., *Longobardites nevadanus* Hyatt and Smith, *Proarcestes* sp., *Parapopanoceras* cf. *P. selwyni* McLearn (68295).

Bed 1 (33 feet below bed 2). *Anagymnotoceras varium* (McLearn), *Anagymnotoceras moderatum* (McLearn), *Longobardites nevadanus* Hyatt and Smith, *Parapopanoceras selwyni* McLearn (68294).

Bed 1 is approximately, or exactly, locality 6 of McLearn (1946a, p. 4; McLearn and Kindle, 1950, p. 39) from which he obtained *Anagymnotoceras varium* (McLearn) (holotype), *Anagymnotoceras columbianum* (McLearn) (holotype), *Anagymnotoceras helle* (McLearn) (paratype), *Anagymnotoceras moderatum* (McLearn) (holotype), *Longobardites larvalis* (McLearn) (holotype) (10696).

The Caurus and Varium Zones occur in sequence in the Sulphur Mountain Formation of the Alberta Foothills. This is shown by collections made by D. W. Gibson. Gibson's best collections, obtained in 1963, are from Monaghan Creek approximately 5 miles west of the junction with Sulphur River in Mount Robson area. The collections are mainly from talus, but their position on the outcrop was accurately recorded and there seems to be no doubt that the sequence has been established. The Caurus Zone is represented by a talus collection "from the very base of the Black Shale member or absolute top of the Blocky Brown member" (Gibson, field label) by *Grambergia nahwisi* (McLearn) (58385A). Talus from the lower part of the Black Shale member yielded *Anagymnotoceras columbianum* (McLearn) and *Czekanowskites hayesi* (McLearn) indicating the Varium Zone (58385B).

The Caurus, Varium, and Deleeni Zones are also known from other localities in British Columbia and Alberta. The occurrences described below are of particular importance in that they add to the known faunas of the individual zones.

Caurus Zone. Among McLearn's collections the Caurus Zone is present at locality 2 on "Cameron Hill" near Mile Post 378 on the Alaska Highway. This locality, in the Tuchodi Lakes area, is a short distance west of the sections already described (McLearn, 1946a, p. 4; McLearn and Kindle, 1950, p. 39). The collection representing the Caurus Zone at the locality contains *Acrochordiceras americanum* McLearn (holotype), *Grambergia* n. sp. (described by McLearn, *in press*), *Parapopanoceras normale* McLearn (holotype), *Ussurites muskwa* McLearn (holotype) (10732).

Ammonoids of the Caurus Zone were also described by McLearn (1948) from Chischa River in Fort Nelson area, where W. I. Wright found these fossils in a section 6 miles upstream from the junction of Chischa and Muskwa Rivers. Wright collected *Lenotropites dawsoni* (McLearn) (holotype), *Grambergia mackenzii* (McLearn) (holotype), and *Parapopanoceras* sp. on the north bank of the river (10736). Along the strike, on the south side of Chischa River, Wright collected *Grambergia ovinus* (McLearn) (holotype) and *Ussurites muskwa* McLearn (paratype) (10733). McLearn (*in press*) places *Lenotropites dawsoni* in synonymy with *Lenotropites caurus*. *Ussurites muskwa,* as already mentioned, is in the Caurus Zone on the Alaska Highway. Thus there seems to be little doubt that these collections from Chischa River represent the Caurus Zone.[1]

The Caurus Zone is also present in the type section of the Toad Formation on the south side of Liard River about 2 miles downstream from the mouth of Toad River, in Toad River area (Kindle, 1944, p. 7; 1946, p. 21; McLearn and Kindle, 1950, p. 40). The collection made by Kindle at this locality includes *Acrochordiceras americanum* McLearn, *Longobardites nevadanus* Hyatt and Smith, *Grambergia mctaggarti* (McLearn) (holotype), *Grambergia nahwisi* (McLearn) (holotype), *Lenotropites caurus* (McLearn) (holotype), *Lenotropites boreas* (McLearn) (holotype), *Arctohungarites bufonis* (McLearn) (holotype), *Anagymnites hollandi* (McLearn) (holotype), *Sturia* sp., *Leiophyllites kindlei* McLearn (holotype) (10660). This locality was revisited in 1960 by B. R. Pelletier and the writer; most of the species listed above are represented in collections made at that time (42337, 42338, 42339, 42343). The Caurus Zone is about 20 feet thick at this locality.

Kindle also collected Anisian ammonoids from a locality on the north side of Liard River, 8 miles SW of the mouth of Toad River (Kindle, 1944, p. 8; 1946, p. 22; 1948, p. 38; McLearn and Kindle, 1950, p. 40). He records two fossiliferous beds at this locality: an upper 40-foot limestone, and a lower shale with fossiliferous concretions. The fossils obtained by Kindle have been given one catalogue number (10659). A large collection was made from the same place by the writer in 1960. Fossils are hard to extract from the outcropping limestone, but are easily obtained from talus blocks. In 1960 the collection from each talus block was catalogued separately. From the faunules in the individual blocks it appears that four faunal assemblages are present. Two evidently represent the Caurus Zone, and two mentioned later, the Varium Zone. Those that represent the Caurus Zone are as follows: one from a talus concretion presumably derived from the lower shale contains *Lenotropites caurus* (McLearn) and *Leiophyllites kindlei* McLearn (42349). The second Caurus Zone assemblage is in three blocks apparently from the upper bed with *Grambergia* n. sp. (as at locality 10732 on the Alaska Highway), *Ussurites* cf. *U. muskwa* McLearn and *Leiophyllites kindlei* (McLearn) (42401, 42403, 42404).

[1]This was confirmed when the writer visited Chischa River in 1966.

Ammonoids have been recorded from the Guardian Well, which was drilled in the Grande Prairie area, Alberta (Hunt and Ratcliffe, 1959, p. 569; Armitage, 1962, p. 39). C. R. Stelck identified specimens obtained at a depth of 5,737 feet as *Nathorstites* and *Parapopanoceras*. Professor Stelck kindly permitted the writer to examine these specimens, which are fragmentary and not well preserved. The best specimen is the outer part of a whorl showing a ceratitic suture line. What remains of this specimen suggests identification with *Grambergia ovinus* (McLearn) or *Grambergia nahwisi* (McLearn). This specimen evidently indicates an occurrence of the Caurus Zone in the Doig Formation.

Varium Zone. McLearn (1946a, p. 4; 1948, p. 5) lists representatives of the Varium Zone from locality 2 on Cameron Hill near Mile Post 378 on the Alaska Highway (*see* McLearn and Kindle, 1950, p. 39). Two collections evidently indicate this zone: one contains *Anagymnotoceras ino* (McLearn) (holotype) and *Czekanowskites hayesi* (McLearn) (10698); the other has *Czekanowskites hayesi* and *Parapopanoceras* sp. (10699). Although listed from the same geographic locality as *Acrochordiceras americanum*, etc. (10732), which represent the Caurus Zone, McLearn's field notes make it quite clear that the specimens from 10732, 10698, and 10699 were obtained from three separate outcrops, projecting as ledges from the hill side, more or less on strike with one another. There is no evidence to suggest that the faunas of the Caurus and Varium Zones occur in the same bed at locality 2. The holotype of *Anagymnotoceras wrighti* (McLearn), which was collected from talus near locality 2, is probably from the Varium Zone.

Among the collections made on Liard River 8 miles SW of the mouth of Toad River two of the four assemblages mentioned evidently indicate the Varium Zone. One is represented by three blocks containing *Anagymnotoceras* sp., *Longobardites larvalis* McLearn, *Parapopanoceras obesum* McLearn, *Parapinacoceras hagei* (McLearn), *Anagymnites* sp. (42400, 42406, 42409). The other assemblage is represented by two blocks with *Anagymnotoceras* sp., *Longobardites nevadanus* Hyatt and Smith, *Czekanowskites hayesi* (McLearn) (42410, 42411). *Czekanowskites hayesi* and *Longobardites larvalis* evidently do not occur together at this locality. The same is true on the Alaska Highway (*see above*), where *Longobardites larvalis* is recorded from the locality on the west limb of the anticline and *Czekanowskites hayesi* from the east limb. This introduces the possibility that two subzones may be distinguished within the Varium Zone, one characterized by *Longobardites larvalis* and *Parapinacoceras hagei;* the other by *Czekanowskites hayesi*.[1]

Well-preserved ammonoids of the Varium Zone have been collected by B. R. Pelletier from the Toad Formation on Chlotapecta Creek, 10 miles east of the Rocky Mountain front in Tuchodi Lakes area. The fauna from this locality includes two species unknown elsewhere — *Hollandites* n. sp. (described by McLearn, *in press*) and *Ismidites* sp. — associated with *Anagymnotoceras* cf. *A. columbianum* (McLearn) and *Parapopanoceras* sp. (40109).

Deleeni Zone. The holotype of *Anagymnites via-alaskae* McLearn is from talus collected on the Alaska Highway near Mile Post 375. The nature of the attached matrix leaves little doubt that this specimen came from the Deleeni Zone. This also applies to the type specimens of *Longobardites canadensis* McLearn and *Longobardites intornatus* McLearn. Both these species were later placed in synonymy with *Longobardites nevadanus* Hyatt and Smith (McLearn, 1951). McLearn also collected fragments of a large *Ptychites* in talus on the Highway (10694; this specimen, too, is almost certainly from the Deleeni Zone).

A richly fossiliferous locality for Anisian ammonoids occurs in the Silty Dolomite member of the Sulphur Mountain Formation east of Sulphur River in the Mount Robson area, Alberta (= loc. 28, Irish, 1965, p. 171). Collections by Irish (25118) and subsequently by geologists of an oil company (55007) include *Gymnotoceras* cf. *G. deleeni* McLearn and large *Ptychites* cf. *P. trochlaeformis* Lindström. These collections evidently indicate the Deleeni Zone.

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[1]In 1966 *Czekanowskites hayesi* was found 7 feet above a bed with *Parapinacoceras hagei* on Chischa River 6 miles above Muskwa River in Fort Nelson area. This suggests that *Czekanowskites hayesi* may characterize the upper part of the Varium Zone.

The foregoing account indicates the stratigraphic position of most of the Anisian ammonoids described from the Eastern Cordillera. A few species are still of uncertain position. They include *Ptychites wrighti* McLearn, described from McTaggart Creek (10731), on the west side of Mount Wooliever in Trutch area (McLearn and Kindle, 1950, p. 37, Fig. 6), possibly from the Varium Zone. *Hollandites humi* McLearn, described from a talus block in McTaggart Creek (10718), is also a possible representative of this zone. *Gymnotoceras liardense* McLearn and *Gymnotoceras beachi* McLearn are probably from the Deleeni Zone. *Gymnotoceras kindlei* (McLearn) is possibly from the Deleeni Zone, but this is by no means certain.

29. Three sections in the Halfway River area illustrate the relationship between the Candidus, Sverdrupi, Romunderi, and Subrobustus Zones. All four zones are in the Toad Formation, which rests directly on the Fantasque Formation of Permian age. Section 1 contains all four zones. Sections 2 and 3 are less complete, but they provide additional data on the composition of these zones.

Section 1 is on the prominent west-facing bluff 7 miles north of Mount Laurier.

Section 1

Subrobustus Zone: *Pseudosageceras bicarinatum* Tozer, *Preflorianites intermedius* Tozer, *Prosphingites* cf. *P. czekanowskii* Mojsisovics, *Isculitoides minor* Tozer, *Popovites occidentalis* Tozer, *Monacanthites monoceros* Tozer, *Keyserlingites subrobustus* (Mojsisovics), *Procarnites modestus* Tozer, *Posidonia aranea* Tozer, 406-420 feet above base of Toad Formation (full details in Tozer, 1965a, pp. 5, 6).

Romunderi Zone: *Posidonia mimer* Oeberg (56213, 56214), 150 and 210 feet above base of Toad Formation.

Sverdrupi Zone: *Paranorites sverdrupi* Tozer, *Paranorites* aff. *P. inflatus* Spath, *Hedenstroemia* or *Pseudosageceras* sp., *"Dinarites"* cf. *D. minutus* Waagen etc. (56209, 56222, 56223, 56225 etc.), 90-100 feet above base of Toad Formation.

Candidus Zone: *Prionolobus* cf. *P. lilangense* (Krafft), *Prionolobus* cf. *P. plicatus* (Waagen), *Proptychites* cf. *P. candidus* Tozer (56218, 56219, 56220, 56203 etc.), 50-80 feet above base of Toad Formation.

Section 2 is 2½ miles S7°W of the summit of Mount Laurier (Tozer, 1963a, p. 3; 1965a, p. 6).

Section 2

Subrobustus Zone: *Isculitoides minor* Tozer, *Popovites occidentalis* Tozer, *Monacanthites monoceros* Tozer, *Metadagnoceras pulcher* Tozer, *Keyserlingites subrobustus* (Mojsisovics), *Svalbardiceras chowadei* Tozer, *Procarnites modestus* Tozer, *Posidonia aranea* Tozer, 320-335 feet above base of Toad Formation (Tozer, 1965a, pp. 6, 7).

Romunderi Zone: *Posidonia mimer* Oeberg (56189, 56190), 110 and 123 feet above base of Toad Formation.

Sverdrupi Zone: not recognized.

Candidus Zone: *Prionolobus* cf. *P. lilangense* (Krafft), *Proptychites* cf. *P. candidus* Tozer (56180), 45 feet above base of Toad Formation. Talus blocks from this level contain *Prionolobus* cf. *P. indoaustralicus* (Wanner) (56182, 56183). Specimens of *Proptychites* cf. *P. candidus* Tozer from this locality have been illustrated (Tozer, 1963a, p. 22, Pl. III).

Section 3 is in the gorge of Needham Creek, 3 miles above the junction with Graham River. Collections were first made from this section by geologists of Shell Oil Company and B. R. Pelletier, and later (in 1963) by the writer. In the section given below the position of the fossil beds is expressed as the stratigraphic elevation above the highest exposure of the Fantasque Formation, which underlies the Toad Formation. The actual contact between the Permian and Triassic beds is not exposed. The measurements given are those made by the writer in 1963. Comparison with previous accounts (Pelletier, 1963, p. 26; Tozer, 1963a, p. 3) reveals slight discrepancies in the measurements, but whatever the exact figure may be the differences do not affect the conclusions regarding the faunal sequence. The discrepancies may be due to differing estimates of the covered interval between the Permian and Triassic rocks. Pelletier estimated the interval as 15 feet; the writer's figure is 45 feet.

Section 3

Subrobustus Zone: *Popovites* sp. indet., *Procarnites modestus* Tozer, *Posidonia aranea* Tozer, about 400-430 feet above Fantasque Formation.

Romunderi Zone: *Euflemingites* cf. *E. cirratus* (White), *Juvenites needhami* Tozer, *Juvenites* sp., *Meekoceras* cf. *M. gracilitatis* White, *Posidonia mimer* Oeberg (56166), in large concretion, 190 feet above Fantasque Formation.

Talus concretions, probably from exactly the same level, provided *Dieneroceras* sp., *Euflemingites* cf. *E. cirratus* (White), *Anakashmirites* sp., *Arctoceras* cf. *A. blomstrandi* (Lindström), new ammonoid genus (oxycone), *Posidonia mimer* Oeberg (56169, 56170, 56171, 56172, 56173, 56174, 56279).

Sverdrupi Zone: *Paranorites sverdrupi* Tozer, 85 feet below Romunderi Zone (Pelletier, 1963, p. 26; Tozer, 1963a, p. 15).

30. The principal locality for the Tardus Zone in British Columbia is in the Toad Formation on Liard River and on the Toad, near the confluence of the two rivers. This locality is in Toad River area. Originally discovered by E. D. Kindle (Kindle, 1944, pp. 7, 8; McLearn and Kindle, 1950, p. 40), it was revisited by B. R. Pelletier and the writer in 1960. Fossils from this locality have been described by McLearn (1945). The fossil beds on the Toad and Liard Rivers are on strike with one another and about 3 miles apart. The main Tardus bed is 4 to 6 inches thick and is a mass of ammonoids and bivalves. The relationships are best displayed on Toad River, 2 miles above its mouth. The section is as follows.

Tardus Zone (type locality): Upper Bed, *Xenoceltites subevolutus* Spath, *"Pseudomonotis" occidentalis* (Whiteaves) (42363).
(4-foot unfossiliferous interval).

Lower bed, 4 to 6 inches thick, *Xenoceltites robertsoni* McLearn, *Xenoceltites warreni* McLearn, *Wasatchites tardus* McLearn, *"Pseudomonotis" occidentalis* (Whiteaves), *Posidonia* aff. *P. mimer* Oeberg (42364).

Romunderi Zone (?): 60 feet of calcareous silty shale with bands of coquinoid rock composed of shells of *Posidonia mimer* Oeberg (42365, 42366, 42367).

At the locality on Liard River a talus fragment of rock with *Posidonia mimer* Oeberg also contains a fragment of *Euflemingites* (42362). This suggests that the *Posidonia mimer* beds, beneath the Tardus Zone, represent the Romunderi Zone.

The total ammonoid fauna of the main Tardus bed comprises *Pseudosageceras* n. sp., *Xenoceltites robertsoni* McLearn, *Xenoceltites warreni* McLearn, *Xenoceltites* cf. *X. hannai* Mathews, *Anasibirites* cf. *A. crickmayi* Mathews, *Prionites hollandi* McLearn, *Wasatchites* (= *Anawasatchites*) *tardus* (McLearn), *Wasatchites merrilli* (McLearn), *Wasatchites canadensis* McLearn, *Wasatchites meeki deleeni* McLearn, *Wasatchites procurvus* McLearn. *Wasatchites* is represented by several hundred specimens that exhibit extraordinary variability and it is possible that only one species is, in fact, represented. *Xenoceltites* is represented by several tens of specimens; *Anasibirites* by one specimen from Liard River (42340). *Pseudosageceras* is known from only one specimen obtained from a loose block (42369), clearly derived from the main Tardus bed.

In 1965 the Tardus Zone with *Wasatchites* cf. *W. tardus* (McLearn), and *"Pseudomonotis" occidentalis* Whiteaves (68184) was found on the north side of Liard River immediately above the Rapids of the Drowned (*see* Fig. 15). Large crushed *Euflemingites* (68183) were obtained from talus of beds that underlie the Tardus Zone. The relations observed on Toad and Liard Rivers leave little doubt that the Romunderi and Tardus Zones occur in sequence in British Columbia, as they do on Ellesmere Island (ann. 13).

The Romunderi Zone is represented by *Euflemingites* in the Sulphur Mountain Formation at several localities in the Alberta Foothills (Tozer, 1961a, p. 7). In Jasper National Park this zone lies within the Blocky Brown Siltstone member (Gibson, 1965, p. 6).

31. The relationship between the Candidus Zone and Griesbachian beds has been observed in the Grayling Formation exposed on Dunedin River 4½ miles north of Mile Post 384 on the Alaska Highway, in Tuchodi Lakes area, northeastern British Columbia (Pelletier, 1961, p. 27; Tozer, 1963a, p. 2). At this locality *Claraia stachei* Bittner of Griesbachian, probably Upper Griesbachian, age occurs 101 feet above the base of the Grayling Formation and the following ammonoids were obtained from a single concretion 117 feet above the base: *Xenodiscoides* cf. *X. radians* (Waagen), *Discophiceras columbianum* (Tozer) (= *Koninckites columbianus* Tozer), *Proptychites mulleri* Tozer, *Proptychites kummeli* Tozer, *Proptychites newelli* Tozer, *Dunedinites pinguis* Tozer. *Proptychites mulleri* closely resembles *Proptychites candidus* Tozer and this is taken to justify assignment of this ammonoid fauna to the Candidus Zone.

In addition to the locality described above, *Claraia stachei* is also known from the Grayling Formation of Liard River in Toad River area (McLearn, 1945; McLearn and Kindle, 1950, p. 36); the Shaly Siltstone member of the Sulphur Mountain Formation in Mount Robson area, Alberta (Gibson, 1965, p. 5), and in the Foothills and eastern ranges of the Rocky Mountains in Brazeau, Calgary, and Kananaskis Lakes areas (Malloch, 1911, p. 47; Warren, 1945, p. 486; Norris, 1958, p. 10; Tozer, 1961a, p. 3).

32. The relationship between the Marshi and Suessi Zones has been established in the vicinity of Tyaughton Creek in Taseko Lakes area, southern British Columbia. A variety of Triassic rocks and fossils have been known from this area for some time (Shimer, 1926; Cairnes, 1943; McLearn, 1942; 1953, p. 1216), but until recently little was known of the sequence. Recent study of this area by H. W. Tipper (1963b) and the writer has led to the identification of several distinct rock units within the Tyaughton Group of Cairnes (1943). The writer's work was confined to a small area south and west of Castle Peak, which lies north of Tyaughton Creek.

The four fossiliferous Triassic units in the Tyaughton Group of this area are, in ascending order, (1) limestone with corals and megalodont bivalves, including *Neomegalodus canadensis* (Shimer); (2) limestone and calcareous shale with *Monotis subcircularis* Gabb; (3) calcareous sandstone and siltstone, with *Rhabdoceras suessi* Hauer and other ammonoids, and characterized particularly by an abundance of *Cassianella lingulata* Gabb; (4) green conglomeratic sandstone with *Choristoceras marshi* Hauer. Unfossiliferous sandstones and conglomerates occur between units 2 and 3.

The *Monotis subcircularis* beds (2) represent the Lower Suessi Zone; the *Cassianella* beds (3) the Upper Suessi Zone; and the upper green conglomerate (4) contains the Marshi Zone. Lowermost Jurassic (Hettangian) ammonoids have been known from this area for some time (Frebold, 1951), and new collections have also been described by Frebold (1967). The exact relationship between the Marshi Zone and the Hettangian beds has not been demonstrated in a stratigraphic section, but according to Tipper (pers. com.) it is probable that ammonoids representing the Planorbis Zone (lowest Jurassic), identified by Frebold (1967), occur in the upper part of the conglomeratic unit that contains the Marshi Zone. In other words, the green conglomeratic sandstone probably bridges the Triassic–Jurassic boundary.

Two stratigraphic sections illustrate the relationships of the four fossiliferous Triassic units.

Section 1 illustrates the upper beds, showing the boundary between the Marshi and Suessi Zones. This section is exposed on the north side of Tyaughton Creek, 4,700 feet upstream from the mouth of Spruce Lake Creek (*see* Fig. 19). The beds are vertical and face eastwards.

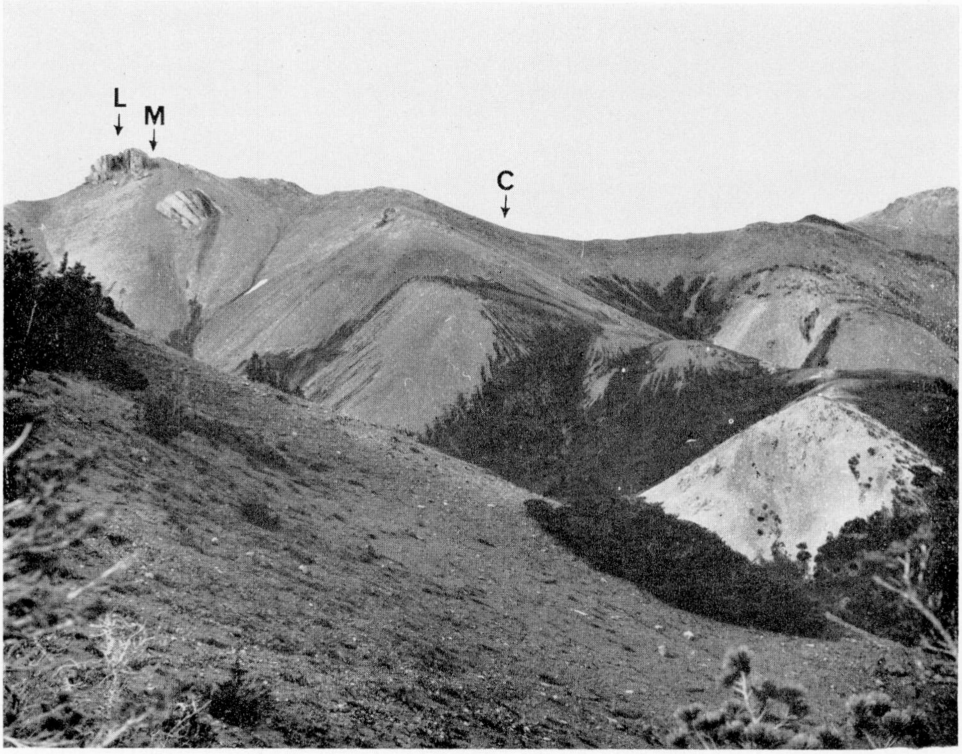

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FIGURE 18. View to the north of ridge west of Castle Peak, Taseko Lakes area, British Columbia (see ann. 32). (L) indicates the limestone with *Neomegalodus*, etc., (M), the *Monotis subcircularis* beds representing the Lower Suessi Zone, (C), the *Cassianella* beds of the Upper Suessi Zone.

Section 1
Top of Section

Unit No.		Thickness of Unit (feet)
	Marshi Zone (unit 3)	
3.	Green sandstone, with pebbles of volcanic rock up to 3 inches in diameter. Topmost bed has *Choristoceras marshi* Hauer, *Meleagrinella* sp. (56395); lower 3 feet have *Choristoceras* cf. *C. marshi, Modiola* cf. *M. strigillata* Goldfuss, "*Myophoria*" *suttonensis* Clapp and Shimer (56396, 56397)	30
2.	Covered interval	25
	Suessi Zone (unit 1)	
1.	"*Cassianella* beds", sandstone and siltstone, green, brown weathering, coquinoid beds contain *Modiola* cf. *M. strigillata* Goldfuss, *Cassianella lingulata* Gabb, *Myophoria cairnesi* McLearn (56398, 56400, 56401)	45

In 1939 C. H. Crickmay collected fossils from this locality and they include good specimens of *Choristoceras marshi* associated with small "*Arcestes*" sp. (10095).

Section 2, illustrating the lower beds in sequence is on the ridge NW of Castle Peak. The section was measured east of the prominent limestone summit 1½ miles NW of Castle Peak (*see* Fig. 18). The beds are more or less vertical throughout the section. Although vertical there is no doubt about the sequence, for a similar succession can be demonstrated on several adjacent fault blocks.

Section 2

Top of Section

Unit No.		Thickness of Unit (feet)
	Suessi Zone (units 2-9)	
9.	"*Cassianella* beds", green sandstone with hard reddish brown weathering coquinoid layers; *Cassianella lingulata* Gabb (56411)	150
8.	Mainly covered, some ribs of conglomeratic sandstone	65
7.	Sandstone and conglomerate; sandstone green, medium to coarse grained, in part reddish brown weathering; conglomerate composed of rounded pebbles of volcanic rock, commonly less than 3 inches in diameter	160
6.	Covered interval	60
5.	Sandstone, grey, with granules of quartz and seams of conglomerate	5
4.	Covered interval	40
3.	Conglomerate, composed almost entirely of unsorted limestone clasts up to 6 inches in diameter. Matrix is red quartzose sandstone and granule sandstone	70
2.	Limestone, grey, thin bedded, minor grey chert, calcareous shale partings; *Monotis subcircularis* Gabb 30 feet above base of unit (56407); *Halorites* cf. *H. americanus* Hyatt (crushed) 35 feet above base of unit (56410)	55
1.	Limestone, grey, weathers very light grey, thick bedded to massive, minor grey chert, *Neomegalodus canadensis* (Shimer) and corals (56406)	150
	Red sandstones and conglomerates, devoid of determinable fossils, underlie unit 1.	

Ammonoids were not found in the *Cassianella* beds of the measured sections but several are known from nearby exposures of this unit. *Rhabdoceras suessi* Hauer occurs with *Cassianella lingulata* (56415) 1½ miles NW of Castle Peak, on the fault block immediately west of the one on which the section described above was measured. *Paracochloceras suessi* Mojsisovics is with *Cassianella lingulata* (56405) 5,400 feet NW of Castle Peak on the fault block east of the measured section. Other ammonoids obtained from the *Cassianella* beds of the area around Castle Peak and Tyaughton Creek include *Placites* sp. (10141) collected from the mouth of Spruce Lake Creek by C. H. Crickmay; *Paracladiscites* sp. (10153) a mile SE of Castle Peak also collected by Crickmay; and large "*Arcestes*" sp. (62360, 62458) from the ridge west of Castle Peak, collected by H. W. Tipper.

There seems to be no doubt that the *Cassianella* beds, which are very distinctive both lithologically and faunally, form a marker unit throughout the Castle Peak–Tyaughton Creek area. Accepted as such, they serve to tie the succession from the Lower Suessi Zone (*Monotis subcircularis* beds), through to the Upper Suessi Zone (*Cassianella* beds), and finally, on Tyaughton Creek from the Upper Suessi Zone to the Marshi Zone. The *Cassianella* beds closely resemble the Middle Member of the Gabbs Formation of Nevada described by Muller and Ferguson (1939), which the writer had the opportunity to see in 1964, under the guidance of N. J. Silberling. The Middle Member of the Gabbs is evidently the source of the

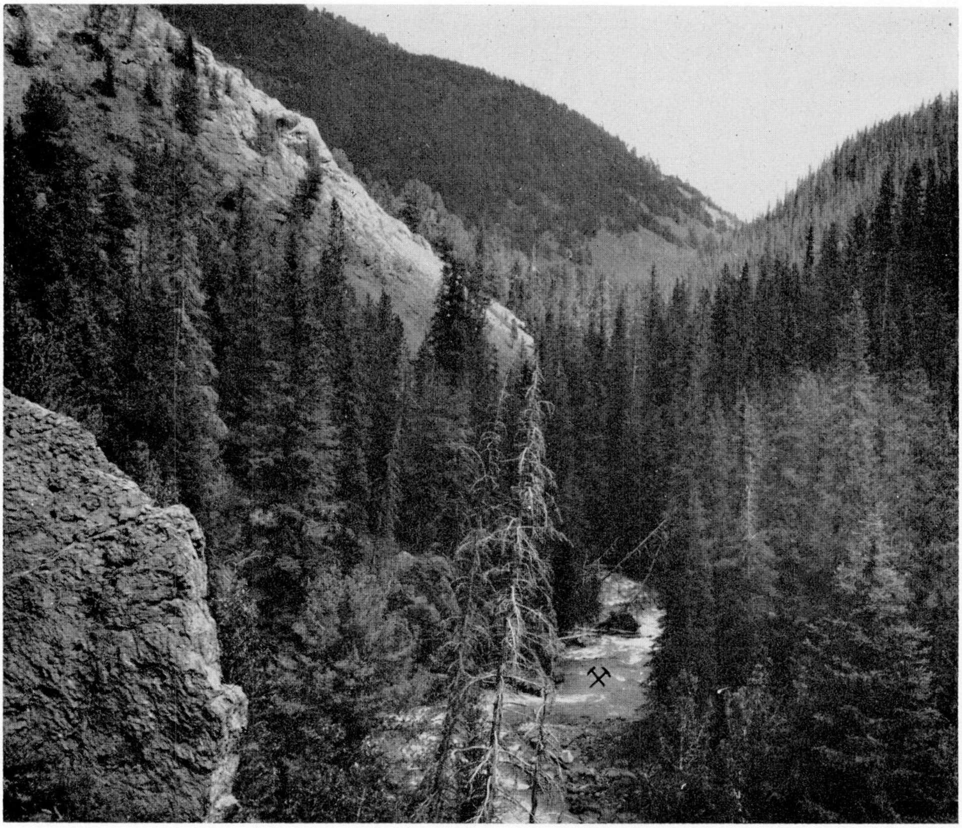

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FIGURE 19. View downstream on Tyaughton Creek, Taseko Lakes area, British Columbia. The rocks are broken by many faults. The crossed hammers are positioned immediately to the right of the place where the *Cassianella* beds (Upper Suessi Zone) are overlain by the Marshi Zone (page 76).

type specimen of *Cassianella lingulata* (S. W. Muller, pers. com.), and, like the beds in British Columbia, represents the Upper Suessi Zone (Silberling, *in* Silberling and Tozer, *in press*).

33. The Sutton Formation of Cowichan Lake, Vancouver Island (Cape Flattery area), contains an unusual fauna of the Suessi Zone, which includes the genus *Choristoceras* as well as *Rhabdoceras*. The locality at Cowichan Lake has been described by Clapp and Shimer (1911), Clapp (1912, p. 61), and Fyles (1955, p. 23). Clapp and Shimer originally dated the Sutton as Jurassic, but Martin (1916) and Smith (1927, p. 10) recognized that the fauna was Triassic. Smith assigned the Sutton fauna to the Lower Norian, the date he chose for all the Triassic coral beds of western North America. Coral beds are now known to occur at several levels in the Upper Triassic and Smith's assignment of the Sutton to the Lower Norian cannot be upheld.

At the type locality on Cowichan Lake the Sutton Formation forms a belt about 500 feet wide flanked on both sides by volcanic and pyroclastic rocks (Clapp and Shimer, 1911, p. 427). The limestone beds dip steeply to the northwest and are concordantly overlain by pyroclastic rocks (Clapp, 1912, p. 65; Fyles, 1955, p. 23). The relationships of the basal beds of the Sutton Formation are less clear. Fyles (op. cit.) considers that the Sutton beds overlie the Franklin Creek Volcanic Formation, but in the opinion of J. A. Jeletzky and the writer, who studied the section in 1953, the eastern contact is probably a fault.

Fossils are abundant in the Sutton Formation. Several corals, *Choristoceras suttonensis* Clapp and Shimer, *Terebratula suttonensis* Clapp and Shimer, and *"Myophoria" suttonensis* Clapp and Shimer, were described by Clapp and Shimer (1911). Clapp's collection, housed at the Geological Survey (13703), includes many undescribed fossils, mainly bivalves. Additional collections made by J. A. Jeletzky and the writer in 1953 reveal the occurrence of several ammonoids previously unknown.

The sequence of ammonoid-bearing beds in the Sutton Formation is as follows.

(Top of section)

Unit No.		Thickness of Unit (feet)
3.	Limestone, grey, mainly bioclastic; *Myophoria suttonensis* and corals in upper 40 feet; *Placites* sp. and *Megaphyllites* cf. *M. insectus* (Mojsisovics), 60 feet from top (23374); *Choristoceras suttonensis,* 70 feet from top (23380). Unit 3 forms the western limestone point on the lake shore (Clapp and Shimer, 1911, fig. 3)	95
2.	Covered interval (The marsh of Clapp and Shimer, op. cit., fig. 3)	about 150
1.	Limestone, grey, 4-foot coral bed 60 feet from top. *Rhabdoceras suessi* Hauer, *Choristoceras suttonensis* Clapp and Shimer, *Cycloceltites* cf. *C. arduini* Mojsisovics (Tozer, 1962, Pl. XII, figs. 16a, b), *Megaphyllites* sp. (23370, 23372) 73 feet from top of unit; *Choristoceras suttonensis,* cladiscitid indet. (23373) 100 feet from top of unit	200
	Unit 1 forms the eastern limestone point (Clapp and Shimer, 1911, fig. 3).	

Rhabdoceras suessi was found only in the lower beds (unit 1) where it is associated, in the same rock, with *Choristoceras*. The occurrence of *Placites* in the upper beds (unit 3) is taken to justify their assignment to the Suessi Zone, rather than to the Marshi Zone, despite the absence of *Rhabdoceras*. Possibly units 1 and 3 are the same bed, repeated by a fault in the covered interval. Exposures are not good enough to confirm or deny this possibility.

The benthonic fauna of the Sutton Formation suggests that the Upper, rather than the Lower Suessi Zone is represented.

34. The Suessi Zone is widely distributed in the Western Cordillera.

The Lower Suessi Zone (= *Monotis subcircularis* Zone) is known from the following localities in western British Columbia: (1) Bonanza Group of Vancouver Island (Alert Bay, Nootka Sound, and Alberni areas) (Gunning, 1932; Jeletzky, 1950; Hoadley, 1953; McLearn, 1953, p. 1210; Surdam, *et al.,* 1964); (2) Parson Bay Formation of Harbledown Island (Alert Bay area) (Crickmay, 1928); (3) Tyaughton Group of Taseko Lakes area (ann. 32); (4) Nicola Group of Ashcroft area (Cockfield, 1948, p. 14); (5) Antoine Creek, Quesnel Lake area (40031) (Campbell, 1961); (6) Bowron River, ½ mile W of 122 meridian, Prince George area (42501) (Tipper, 1961); (7) Takla Group of Fort Fraser area (Armstrong, 1949, p. 58); (8) Telegraph Creek area (Kerr, 1948, p. 83, and J. G. Souther, pers. com.); (9) Sinwa Formation of Tulsequah area (Souther, 1960); (10) Kunga Formation of the Queen Charlotte Islands, in Moresby Island and Graham Island areas (McLearn, 1953, pp. 1207-1209; A. Sutherland Brown, pers. com.).

In southern Yukon Territory the Lower Suessi Zone is represented by *Monotis subcircularis* in the St. Elias Mountains of Kluane Lake area (Muller, 1958), and in the Lewes River

Group of Whitehorse, Laberge and Glenlyon areas (Lees, 1934; Bostock and Lees, 1938; Wheeler, 1961, p. 34; Tozer, 1958; Campbell, 1960). The locality in Glenlyon area is at Eagles Nest Bluff on Yukon River (28504).

Ammonoids are rare in the Lower Suessi Zone of the Western Cordillera. *Rhabdoceras suessi* Hauer, *Halorites* cf. *H. americanus* Hyatt, and *Rhacophyllites* occur in the Lewes River Group of southern Yukon (Tozer, 1958, p. 15; 1962, Pl. XII, figs. 17, 18). *Halorites* cf. *H. americanus* also occur with *Monotis subcircularis* in the Tyaughton Group (ann. 32) in the Sinwa Formation of Tulsequah area (40429) and in an old collection (6897) made by V. Dolmage from the west coast of Vancouver Island. This last collection also contains crushed specimens ot *Sagenites* sp. associated with *Monotis subcircularis,* and specimens of *Rhabdoceras suessi*. The locality given for 6897 is "One Tree Island", which is now known as Clark Island, in Nootka Sound area. According to Jeletzky (1950), Clark Island is underlain entirely by Cretaceous rocks, but he obtained representatives of the Lower Suessi Zone at Mushroom Point, a mile east of Clark Island. Probably the specimens collected by Dolmage are incorrectly labelled. Although their exact locality may be uncertain, they nevertheless establish the occurrence of *Halorites, Sagenites,* and *Rhabdoceras,* with *Monotis subcircularis*.

The Upper Suessi Zone is also known from many localities in western British Columbia and southern Yukon. The Lower and Upper Suessi Zones occur in sequence at Tyaughton Creek (ann. 32) and also, as mentioned below, on Vancouver Island and in southern Yukon.

The Upper Suessi Zone is particularly well developed on Vancouver Island in Nootka Sound and Alert Bay areas, where it has been found by J. A. Jeletzky (1950, and unpubl. MS.) from the Arenaceous and Limestone members of the Bonanza Group. It has been shown by Jeletzky (1950, p. 7) that the Arenaceous and Limestone members overlie the *Monotis subcircularis* beds (Lower Suessi Zone). At one time it was thought that the section might be inverted (*see* McLearn, 1953, p. 1210), but later field work by Jeletzky has established beyond doubt that the sequence as originally described in 1950 is correctly interpreted (pers. com. from J. A. Jeletzky). The extensive collections obtained by Jeletzky include many bivalves (*Plicatula perimbricata* Gabb, *Cassianella lingulata* Gabb, *"Myophoria" cairnesi* McLearn, etc.). Also present, for example at Walters Cove, Kyuquot, are *Rhabdoceras suessi* Hauer and *Paracochloceras suessi* Mojsisovics (23072) (Tozer, 1962, Pl. XII, fig. 4).

The occurrence of the Upper Suessi Zone in the Sutton Formation of Cowichan Lake, Vancouver Island, is described above (ann. 33).

Mainland localities for the Upper Suessi Zone besides Tyaughton Creek (ann. 32) include Mount Snippaker in Iskut River area (28949) and the Klastline Plateau in Telegraph Creek area (32767) where collections have been made by J. G. Souther. Diagnostic ammonoids of the Suessi Zone are unknown from these localities, but characteristic bivalves, such as *Plicatula perimbricata* Gabb and *"Myophoria" cairnesi* McLearn, are present. *"Myophoria" adornata* McLearn, recorded from the Nicola Group, probably indicates the occurrence of the Upper Suessi Zone in the Hope area (Rice, 1947, p. 14; McLearn, 1942, p. 99).

In southern Yukon, the Upper Suessi Zone is in the upper part of the Lewes River Group in Whitehorse and Laberge areas (Lees, 1934; Tozer, 1958; Wheeler, 1961, p. 35). The most common fossils are *Spondylospira lewesensis* (Lees), *"Variamussium" yukonense* Lees, and *"Trigonia" textilis* Lees. Corals and brachiopods are also present. Ammonoids are very rare but are represented by one specimen of *Paracochloceras* (Tozer, 1958, p. 19), and by one small *Metasibirites* recently found in the collection from 14860 northeast of Fish Lake in Whitehorse area (Wheeler, 1961, p. 35).

35. The Columbianus Zone is well represented in collections made from the west coast of Vancouver Island by J. A. Jeletzky in Esperanza Inlet (Nootka Sound area) and on Union and Amos Islands (Alert Bay area). The zone occurs in the Thinly Bedded member of the Bonanza Group (Jeletzky, 1950, p. 7; 1954).

On the north shore of Esperanza Inlet east of Peculiar Point the zone is represented by *Himavatites* cf. *H. multiauritus* McLearn, *Thetidites?* n. sp., *Distichites* sp., *Episculites* sp., *Placites* sp., *Pinacoceras* sp., *Halobia* sp., *Monotis* cf. *M. scutiformis pinensis* Westermann (19678, 19709, 19275).

From the NW part of Union Island Jeletzky obtained *"Sandlingites"* cf. *"S." striatissimus* Diener and *Placites* sp. (20255) from beds 33 feet below the first occurrence of *Monotis subcircularis* (Lower Suessi Zone). This is the only known occurrence of this species of *"Sandlingites"* in Canada and it is tentatively regarded as representing the Columbianus Zone.

On Amos Island the following representatives of the Columbianus Zone were obtained by Jeletzky from several "nests" occurring in about 12 feet of strata: *Steinmannites* cf. *S. undulatostriatus* Mojsisovics, *Himavatites* sp., *Thetidites* cf. *T. brysonis* Diener, *Parajuvavites* cf. *P. buddhaicus* Mojsisovics (Tozer, 1962, Pl. XI, figs. 6a, b), *Placites* sp. (21431, 24352, 24351). About 15 feet lower in the section specimens of *"Dittmarites"* cf. *"D." hindei* Mojsisovics were collected (21430).

Surdam, *et al.* (1964) report *Monotis* cf. *M. scutiformis pinensis* Westermann from the section on Iron River in Alberni area, and this occurrence probably indicates the Columbianus Zone. Crickmay (1928, p. 59) recorded *Monotis alaskana* Smith from the Parson Bay Formation of Swanson Island at the SE end of Queen Charlotte Strait (Alert Bay area). Crickmay's *"Monotis alaskana"* apparently occurs below *Monotis subcircularis,* and as suggested by McLearn (1953, p. 1211; 1960a, p. 36) the lower *Monotis* bed is probably correlative with the Columbianus Zone.

Specimens that probably represent *Monotis scutiformis pinensis* (40028) occur in Gravel Creek 6 miles west of Horsefly in Quesnel Lake area (Campbell, 1961).

36. It is probable that the juvavitids that occur in Formation "D" of the Lewes River Group in Laberge area, Yukon, represent the Magnus Zone (Lees, 1934; Tozer, 1958, pp. 15, 16). All the ammonoids from this locality are crushed. At least three genera are present: a juvavitid, a tibetitid (?), and a third genus, evolute, with strong, unbranched ribs. The juvavitids have projected ribs that cross the venter; the identification of *Juvavites subinterruptus* Mojsisovics made by Lees (1934) and suggestive of a Karnian age cannot be upheld. It is more likely that they are related to *Indojuvavites angulatus* Diener, which is apparently a member of the fauna of the Magnus Zone (p. 37). Similar fossils, with comparable preservation, occur at localities 14859 and 24379 on the east side of Ibex River Valley in Whitehorse area (Wheeler, 1961, p. 34). A single specimen of *Indojuvavites*? sp. (40032) has been collected on the north shore of the easterly of the Prouton Lakes in Quesnel Lake area (Campbell, 1961). Possibly this occurrence indicates the Magnus Zone.

37. The Kerri Zone is known from the northern part of Vancouver Island (Alert Bay area), from collections made by H. C. Gunning and J. A. Jeletzky. At Rupert Inlet in Quatsino Sound Jeletzky obtained *Mojsisovicsites kerri* (McLearn) from the Quatsino Formation (23266). In the Nimpkish map-area Gunning obtained a collection from the Bonanza Group in which specimens of *Mojsisovicsites kerri* are associated with *Halobia alaskana* Smith (= *Halobia* cf. *H. arthaberi* Kittl of Tozer, 1961a, p. 15) (13712). Farther to the south on Union Island Jeletzky collected *Halobia alaskana* (20237) from the lower part of the Thinly Bedded member of the Bonanza Group (Jeletzky, 1950, p. 7; 1954).

Mojsisovicsites kerri is known from several localities in the Telegraph Creek area (Kerr, 1948, p. 82). Good specimens were collected from the hill 1½ miles north of Dutch Charlies Riffle on Stikine River (13248).

Halobia alaskana has been collected from the Kunga Formation of Graham Island (Graham Island area) in the Queen Charlotte Islands by A. Sutherland Brown (48606), and this species is also recorded from the Parson Bay Formation of Harbledown Island (Alert Bay area) (Crickmay, 1928, p. 59).

38. The following occurrences of the Welleri Zone are known in the Western Cordillera.

The Welleri Zone is well represented in a collection obtained by J. G. Souther, 3 miles west of Bob Quinn Lake in Iskut River area by: *Pamphagosirenites* cf. *P. pamphagus* (Dittmar), *Tropites johnsoni* Smith (Tozer, 1962, Pl. VIII, figs. 12a, b), *Tropites reticulatus* Smith, *Discotropites* sp., *Homerites semiglobosus* (Hauer) (28941).

Juvavites cf. *J. obsoletus* Smith and *Homerites semiglobosus* (69190) indicate the Welleri Zone in a collection made by A. Sutherland Brown from the Kunga Formation of Blue Jay Cove, Burnaby Island (Moresby Island area).

From Vancouver Island J. A. Jeletzky has collected representatives of the Welleri Zone from the Quatsino Formation of Ououkinsh and Malksope Inlets (Alert Bay area), and from Union Island, which lies in the Alert Bay and Nootka Sound areas.

The collections listed below will indicate the known associations and the total composition of the ammonoid fauna.

1. Island at mouth of Power River in Ououkinsh Inlet: *Discotropites* sp., *Homerites semiglobosus* (Hauer) (23161).

2. 500 yards SE of Izard Point, Ououkinsh Inlet: *Tropites* cf. *T. welleri* Smith, *Juvavites* cf. *J. brockensis* Smith, *Trachysagenites* cf. *T. herbichi* Mojsisovics (23066).

3. Islet immediately south of Amos Island, NW of Union Island: *Juvavites* sp. indet., *Tardeceras pygmaeus* (Smith), *Trachysagenites* sp. indet. (20236).

Jeletzky obtained good specimens of *Pamphagosirenites pamphagus* (Dittmar) (22270, Tozer, 1962, Pl. VII, figs. 5a-c) 950 yards SE of Izard Point, from severely faulted beds. This occurrence probably indicates the Welleri Zone.

R. B. Campbell has recently collected Upper Karnian ammonoids, probably of the Welleri Zone, from Quesnel Lake and Bonaparte Lake areas. The collection from the Quesnel Lake area is from Beaver Valley Road at lat. 52°25′10″ and includes *Discotropites* and *Juvavites* (68122), an association suggestive of the Welleri Zone. The collection from the Bonaparte Lake area is from south of Friendly Lake (51°34′, 120°28′), and contains *Tropites* sp. indet (68119); this collection could be as old as the Dilleri Zone.

39. The Dilleri Zone is known from several localities in western British Columbia.

From King Salmon Mountain in the Tulsequah area J. G. Souther collected the following representatives of the Dilleri Zone: *Spirogmoceras* cf. *S. shastense* (Smith), *Traskites* sp., *Discotropites* cf. *D. sandlingensis* (Hauer) (43695).

On the west coast of Vancouver Island J. A. Jeletzky obtained *Paratropites* cf. *P. sulcatus* (Calcara of Gemmellaro) and *Pleuronautilus* cf. *P. alaskensis* Kummel (24033) from sedimentary inclusions within the topmost part of the Karmutsen Volcanic Group, exposed on the NW shore of Union Island in Alert Bay area. A large collection from structurally isolated rocks believed by Jeletzky (pers. com.) to represent beds low in the Quatsino Formation, exposed on the largest of the Hisnit Islands in Ououkinsh Inlet (Alert Bay area), contains *Tropites* sp. indet., *Paratropites sellai* Mojsisovics (of Smith), *Paratropites* cf. *P. sulcatus* (Calcara of Gemmellaro), *Trachysagenites* cf. *T. herbichi* Mojsisovics, *Pleuronautilus* cf. *P. alaskensis* Kummel (23147, 23939). These assemblages evidently represent the Dilleri Zone.

Givens and Susuki (1964) report *Spirogmoceras shastense* (Smith), *Traskites* sp., *Paratropites* sp., and *Trachysagenites* sp. from "Interlava Sediments" in the Campbell River region, Alberni area. This fauna is presumably from an equivalent of the Karmutsen Group and, like the fauna from Union Island, clearly indicates the Dilleri Zone.

Carlisle and Susuki (1965) have described an Upper Karnian fauna from the Open Bay Formation of Quadra Island (Bute Inlet area). This fauna comprises *Spirogmoceras* sp., *Traskites* cf. *T. careyi* Smith, *Traskites* cf. *T. compressus* (Hyatt and Smith), *Traskites* cf. *T. rugosus* (Hyatt and Smith), *Hannaoceras* sp., *Tropites dilleri* Smith, *Tropites* cf. *T. welleri* Smith, *Tropites* spp., *Discotropites* cf. *D. sandlingensis* (Hauer), *Paratropites sellai* Mojsisovics (of Smith), *Gymnotropites* cf. *G. americanus* Hyatt and Smith, *Tornquistites*? sp., *Bacchites* cf. *B. bacchus* (Mojsisovics), *Leconteiceras* sp., *Trachysagenites herbichi* (Mojsisovics), *Arcestes* sp. Despite the presence of *Tropites* cf. *T. welleri* there seems to be little doubt that this fauna represents the Dilleri Zone as recognized by Carlisle and Susuki (1965, p. 458). These authors also state (op. cit., p. 473) that *Tropites dilleri* occurs at least 200 feet above the base of the Quatsino Formation in Iron River, Alberni area, in the section briefly described by Surdam, *et al.* (1964).

Tropitid and trachyceratid ammonoids, including *Paratropites spepsumensis* Crickmay associated with *Halobia,* have been recorded from the Ashcroft area (Crickmay, 1930; Duffell and McTaggart, 1952, p. 30). The trachyceratids recorded as *Protrachyceras* (Duffell and McTaggart, loc. cit.) (18607) are possibly *Spirogmoceras,* suggesting that this fauna represents the Dilleri Zone.

40. Upper Triassic halobiids are known from widely scattered areas in western British Columbia, for example in the McDame area (Gabrielse, 1963, p. 13); and in the Takla Group of Fort Grahame (Roots, 1954, p. 126), Whitesail Lake (Duffell 1959, p. 34), Nechako River (Tipper, 1963a, p. 23), and Manson River (Armstrong, 1949, p. 57) areas. Most, if not all, of these occurrences are probably of Upper Karnian age.

A peculiar Upper Triassic ammonoid of uncertain age is *Acrochordiceras carlottense* Whiteaves, described from Houston Stewart Channel, Moresby Island area. Smith (1927, p. 54) tentatively assigned this species to *Juvavites* and suggested that it might be of Norian age, presumably because G. M. Dawson who collected the type specimens also obtained *Monotis subcircularis* from Houston Stewart Channel. The lateral sculpture of *"Acrochordiceras" carlottense* consists of low ribs of the inner half of the flanks. Towards the venter these ribs break into low, long, rather erratically distributed bullae. The erratic sculpture is certainly suggestive of that found in some species of *Halorites,* so from the evidence provided by the type specimens alone it would seem reasonable to suggest that *Acrochordiceras carlottense* is an Upper Norian *Halorites.* On the other hand, McLearn (1947a, p. 4, and field notes) recorded a specimen of *Juvavites* cf. *J. carlottense* (Whiteaves) (9687) from talus on "Cascades Creek", on Pardonet Hill, in Halfway River area (Eastern Cordillera). The specimen from Pardonet Hill is probably Upper Karnian or Lower Norian. For the time being the age of these unusual ammonoids must be regarded as uncertain.

41. A possible occurrence of the Nanseni Zone is known from Kletsan Creek in the western part of Kluane Lake area, in Yukon Territory near the Alaska border. *Halobia* sp. indet. and *Sirenites* sp. indet. (31406) occur in shale at this locality, above volcanic rocks that are correlated with the Nikolai Greenstone (Muller, 1958, p. 4). This occurrence is not far from the type locality of *Sirenites hayesi* Smith, which is on the Middle Fork of White River, on the north front of the Wrangell Mountains, Alaska (Martin, 1926, p. 35; Smith, 1927, p. 82). *Sirenites hayesi* is closely related to *Sirenites senticosus* Dittmar, and probably indicates the Nanseni Zone.

42. Crushed ammonoids, possibly *Trachyceras* cf. *T. aonoides* Mojsisovics, have been recorded from the lower part (Formation "A") of the Lewes River Group of Laberge area, southern Yukon Territory (Tozer, 1958, p. 9). These ammonoids are probably Lower Karnian, Obesum Zone.

43. Middle Triassic Daonellas that resemble *Daonella degeeri* Boehm and are probably of Lower Ladinian age, are now known from three widely scattered areas in the Western Cordillera. They are (1) Kluane Lake area, Yukon, where *Daonella* (31403) occurs in beds that overlie Permian limestone and underlie the correlative of the Nikolai Greenstone (Muller, 1958, p. 4); (2) Near the head of Scud River (32768) in Telegraph Creek area, northwestern British Columbia, where the specimens were discovered by J. G. Souther; (3) from map-unit 9 (Little and Thorpe, 1965) near Phoenix in Penticton area, southern British Columbia (56910, 56905). A small undetermined ammonoid with a ceratitic suture line is in the collection from locality 56910.

44. *Monotis ochotica* (Keyserling) and *Monotis subcircularis* Gabb, indicating the Lower Suessi Zone, are now known from widely scattered localities in northern Yukon Territory. Specimens identified as *Monotis ochotica* are known from the following localities (Mountjoy, *in press*): (1) Loney Creek, tributary to Firth River, Herschel Island area (52795); (2) Babbage River, 10 miles south of Trout Lake (53302, 53326) and 18 miles south of Trout Lake (53322), Blow River area.

Specimens referable to either *Monotis ochotica* or *Monotis subcircularis* (47132) occur on the north side of Monster River at 64°58′N, 140°05′W (47132) and at 65°00′N, 138°38′W (47137) in the NW part of Dawson area (Green and Roddick, 1962), and also in the SE part of the Dawson area, 6 miles west of Tombstone Mountain (68900), where they were obtained by D. Tempelman-Kluit in 1965. In Nash Creek area Keele obtained Triassic fossils many years ago (McLearn, 1953, p. 1213), including *Monotis subcircularis*. Green and Roddick (1962) recently obtained new collections from this area, including *Monotis subcircularis,* collected on Rackla River, ¼ mile south of the creek draining the Kathleen Lakes (47141). *Monotis subcircularis* is also known on Tay River (42893), in Tay River area (Green and Roddick, 1961).

45. A single small specimen of *Steinmannites* (47134) was collected 3 miles SW of the largest of the Kathleen Lakes in Nash Creek area, central Yukon Territory (Green and Roddick, 1962). Undetermined species of *Monotis* occur at the same locality. The *Steinmannites* probably indicates occurrence of the Columbianus Zone.

46. Specimens of *Juvavites* cf. *J. knowltoni* Smith have been collected on Rackla River, ¼ mile south of the creek draining the Kathleen Lakes, in Nash Creek area (47135) (Green and Roddick, 1962). These specimens probably indicate the Welleri Zone. The Welleri Zone is probably also present on the north boundary of the Dawson area, north of Monster River (65°00′N, 139°38′W). At this locality (47133) halobiids similar to those in the Welleri Zone of NE British Columbia were obtained by Green and Roddick (1962).

47. Specimens of *Daonella* cf. *D. degeeri* Boehm have recently been collected by D. Tempelman-Kluit, 6 miles west of Tombstone Mountain in Dawson area (68899). These specimens are probably of Lower Ladinian age.

48. Abundant small specimens, apparently referable to *Posidonia mimer* Oeberg, have been collected by D. Tempelman-Kluit, 6 miles west of Tombstone Mountain in Dawson area (69117), stratigraphically below the Lower Ladinian fossils mentioned under annotation 47. This species occurs in great numbers in the Romunderi Zone of the Arctic islands and the Eastern Cordillera, and also on the north slope of Alaska (Silberling and Patton, 1964, p. A145). The occurrence in the Dawson area probably also indicates the Romunderi Zone.

APPENDIX

DESCRIPTION OF NEW SPECIES OF AMMONOIDEA

Family OTOCERATIDAE

Genus *Otoceras* Griesbach

Otoceras concavum n. sp.

Plate I, figures 1-3; Figure 20

Otoceras n. sp., Tozer, 1965b, p. 1.

Diagnosis. *Otoceras* with a phragmocone at least 95 mm in diameter. Flanks concave on inner whorls and flat on outer whorls; venter, on phragmocone, with three strong keels; suture line like that of *Otoceras boreale* Spath.

Types and dimensions[1].

Specimen	Locality	D	H	W	U
18881, paratype	64779	47	21 (0.45)	34 (0.72)	ca 10 (0.21)
18882, holotype	64777	64	31 (0.48)	36 (0.56)	ca 13 (0.20)
18883, paratype	47539	90	46 (0.51)	40 (0.44)	17 (0.19)
18884, paratype	64732	95	49 (0.52)	52 (0.55)	ca 17 (0.18)

[1]The measurements given in this appendix are in mm, in the conventional manner for diameter (D), whorl height (H), whorl width (W), and umbilical width (U). Figures in parentheses are the proportions of H,W, and U expressed as a decimal fraction of D.

Description. The small paratype (18881, Pl. I, figs. 3a, b) shows the characteristic concave flanks. The holotype (18882 Pl. I, figs. 1a, b) shows the transition from concave to more or less flat flanks. The largest known specimen (18884 Pl. I, figs. 2a, b) has nearly flat whorl sides and retains three strong keels to the end of the phragmocone. The last few septa of this specimen show slight approximation. Paratype 18883 (not illustrated on plate) closely resembles No. 18884. No. 18883 is the only specimen that reveals the suture line on the umbilical wall (Fig. 20).

Comparisons. *Otoceras concavum* differs from *Otoceras boreale* Spath, of which the original of Spath, 1935, Plate III, figures 1a, b, is now chosen as lectotype, in having concave flanks on the inner whorls; no well-defined spiral shelf adjacent to the umbilical margin; a more steeply inclined umbilical wall; and in the smaller size. The venters of the two species are also different. If they be compared with a gabled roof, the venter of *Otoceras concavum* has a lower pitch than that of *Otoceras boreale*. Furthermore, the outer whorl of *Otoceras boreale* loses the tri-

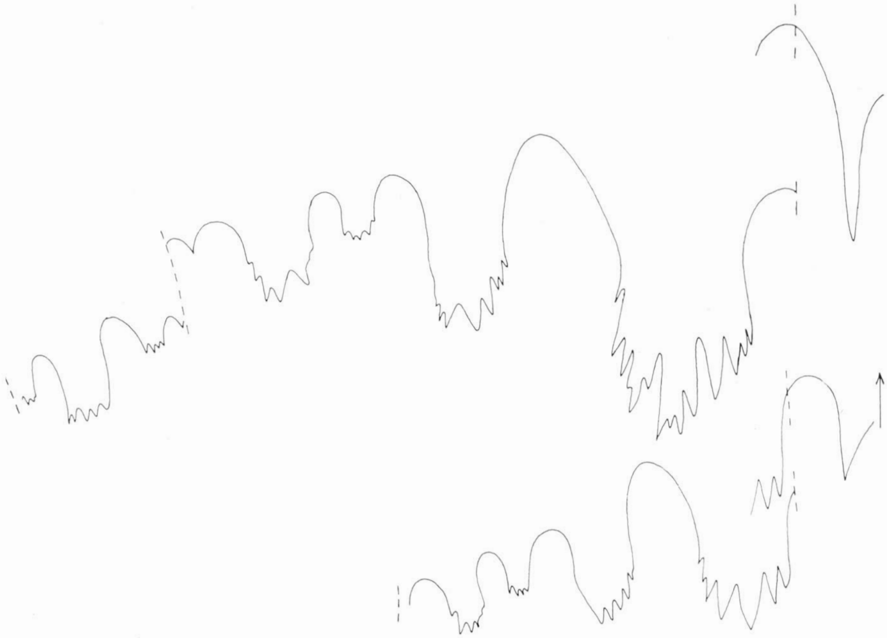

FIGURE 20. External suture lines of *Otoceras concavum* n. sp. (x2). Upper two figures of paratype, GSC No. 18883; lower two figures of holotype, GSC No. 18882.

carinate venter. In comparison the venter of *Otoceras concavum* retains the three keels at least to the end of the phragmocone, judging from No. 18884. Spath (1935, p. 10) described one specimen of *Otoceras boreale* as having concave inner whorl sides and a much wider ventral area than the other specimens. This particular specimen (No. 175) has been examined by the writer at the Mineralogisk Museum, Copenhagen. It is only 30 mm in diameter and lacks the prominent ventro-lateral keels of *Otoceras concavum*. Also the concavity of the flanks is much less marked. The umbilicus of *Otoceras concavum* is more like that of *Otoceras woodwardi* Griesbach than that of *Otoceras boreale*. However, the bifid second lateral saddle and concave inner whorls distinguish the new species from *Otoceras woodwardi*. The outer whorl of *Otoceras concavum* resembles that of *Otoceras indigirense* Popov from Siberia, but there is no evidence that the Siberian form has concave flanks on the inner whorls. It is assumed that the holotype of *Otoceras indigirense* is the original of Popov, 1961a, Pl. I, figs. 3a, b; not the specimen illustrated in 1958 (Popov, 1958, fig. 2). The specimens of *Otoceras boreale* and *Otoceras indigirense* that Popov figured in 1958 (figs. 1, 2) and in 1961 (Pl. I, figs. 3a, b; Pl. III, figs. 4a, b) are transposed. The specimen illustrated as *Otoceras boreale* in 1958 appeared as *Otoceras indigirense* in 1961, and *vice versa*. *Otoceras fissisellatum* Diener has a suture line like that of *Otoceras concavum*, but Diener's species lacks the characteristic concave flanks of the new species. The concave flanks of *Otoceras concavum* invite comparison with some of the Permian otoceratаceans from Dzhulfa in Armenia, particularly with *Araxoceras* *tectum* Ruzhencev. However, the suture line of *Otoceras concavum,* with two large well individualized auxiliary lobes and two smaller ones, immediately distinguishes the new species from the Permian forms.

Occurrence. Blind Fiord Formation, Griesbach Creek, east of Camp Five Creek, Axel Heiberg Island (80°31′N, 94°40′W) (Bukken Fiord area). GSC localities 64777, 44 feet above base of Blind Fiord Formation, E. T. Tozer, 1964; 64779, 50 feet above base, E. T. Tozer, 1964; 47539, from talus, R. Thorsteinsson and E. T. Tozer, 1961; 64732, from talus, E. T. Tozer, 1964.

Age. Lower Griesbachian, Concavum Zone.

Family DINARITIDAE

Genus *Olenikites* Hyatt

Olenikites pilaticus n. sp.

Plate VI, figures 1-5; Figure 21

Nordophiceras pilatum (Hyatt and Smith), Tozer, 1965b, pp. 2, 5, not *Meekoceras pilatum* Hyatt and Smith, 1905, p. 144.

Diagnosis. Olenikites attaining a diameter of at least 46 mm. Inner whorls coronate with strong bullae; later whorls with bullate ribs; outer whorls with distantly spaced bullate ribs which become progressively less prominent towards the aperture. Suture line with two ceratitic lateral lobes and an incised suspensive lobe.

Types and dimensions.

Specimen	Locality	D	H	W	U
18890, paratype	64719	11.5	4 (0.35)	ca 6 (0.52)	5 (0.43)
18891, paratype	64719	16			
18892, paratype	64719	25	8.5 (0.34)	8 (0.32)	8 (0.32)
18893, holotype	64719	40	17 (0.42)	ca 10 (0.25)	11 (0.27)
18894, paratype	64719	46	22 (0.48)	16 (0.35)	11 (0.24)

FIGURE 21. External suture lines of *Olenikites pilaticus* n.sp. (x3). Holotype, GSC No. 18893.

Description. The small paratype, No. 18890 (Pl. VI, figs. 1a, b) has an outer whorl that is wider than high. The whorl bears seven strong bullae that achieve their maximum elevation at the middle of the whorl side. At this stage the venter is wide and gently arched, the ventral shoulder is fairly well defined, and there is no distinct umbilical shoulder.

No. 18891 (Pl. VI, figs. 2a, b) shows the change from depressed to relatively elevated whorls. With the proportional increase in elevation, the bullae are replaced by bullate ribs.

No. 18892 (Pl. VI, figs. 3a, b) shows the mature whorl section. The umbilical wall is vertical, the umbilical shoulder rounded, the flanks are mildly convex, and the venter is rounded. This specimen has thirteen essentially radial bullate ribs which arise at the umbilical shoulder and fade on the outer third of the flank.

The holotype, No. 18893 (Pl. VI, figs. 4a, b) has ten ribs on the outer whorl. They are bullate near the umbilical shoulder, fade abruptly towards the venter and are barely discernible on the outer half of the whorl side.

No. 18894 (Pl. VI, figs. 5a-d), the largest known specimen, preserves a body chamber three quarters of a whorl long. The sculpture on the initial three quarters of the outer whorl is like that of the holotype. On the last quarter the bullate ribs are replaced by ribs that are little more than elevated growth lines. These lines show adapical curvature just below the umbilical shoulder and on the greater part of the flank and across the venter they follow an essentially radial course.

The holotype shows the suture line (Fig. 21).

Comparisons. Olenikites pilaticus is morphologically intermediate between representatives of *Arctoceras* and *Olenikites.* The sculpture resembles that of *Olenikites,* the suture line is like that of *Arctoceras. Olenikites pilaticus* is intermediate in age between *Arctoceras blomstrandi* (Lindström) and *Olenikites canadensis* Tozer, and the new species probably forms a phylogenetic link between the arctoceratids of the Smithian and the typical representatives of *Olenikites* in the Subrobustus Zone. *Olenikites pilaticus* may also be related to *Prohungarites tuberculatus* Welter, which differs only in having a fastigate venter on the outer whorl.

The most closely related species is *"Meekoceras" pilatum* Hyatt and Smith, with which the new species was formerly identified. Examination of the syntypes of *"Meekoceras" pilatum* has revealed the following distinctions: (1) *"Meekoceras" pilatum,* at a comparable diameter (35 mm) has ribs that persist, at even strength, over the whole of the flank; those of *Olenikites pilaticus* are restricted to the inner half of the flank; (2) the inner whorls of *"Meekoceras" pilatum* are not known to bear the strong bullae of *Olenikites pilaticus*; (3) *"Meekoceras" pilatum* attains a larger size than any known specimen of *Olenikites pilaticus*; (4) the suture of *Olenikites pilaticus* has wider saddles and more prominently incised lobes than that of *"Meekoceras" pilatum.*

"Xenodiscus" karpinskyi Mojsisovics, the type species of *Nordophiceras* Popov, lacks sculptured whorls, and the writer no longer believes that *"Meekoceras" pilatum* should be assigned to that genus.

Occurrence. Blaa Mountain Formation, Lower Shale member, about 80 feet above base; cliff on coast of Nansen Sound, 20 miles SE of Cape Stallworthy, northern Axel Heiberg Island (Cape Stallworthy area). GSC locality 64719; E. T. Tozer, 1964.

Age. Spathian, Pilaticus Zone.

Family Beyrichitidae

Genus *Gymnotoceras* Hyatt

Gymnotoceras chischa n. sp.

Plate VII, figures 6, 7; Figure 22

Diagnosis. *Gymnotoceras* with quadrangular whorl section. Inner whorls have bullae on the inner half of the flanks from which falcoid ribs and parabolae arise. Ribs have tuberculate endings at the ventral shoulder. Ventral keel well defined. Suture line with wrinkled saddles.

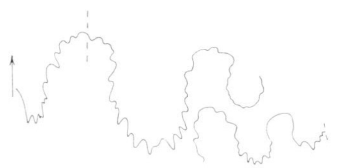

FIGURE 22. External suture line, below umbilical shoulder, of *Gymnotoceras chischa* n.sp. (x3). Holotype, GSC No. 18885.

Types and dimensions.

Specimen	Locality	D	H	W	U
18885, holotype	40088	29	13 (0.45)	12 (0.41)	9 (0.31)
18886, paratype	40088	ca 34	17 (0.50)	12 (0.35)	9 (0.27)

Description. The holotype (Pl. VII, figs. 7a, b) is entirely septate. There are nine bullate ribs on the inner half of the flank on the last half whorl, and about eighteen more or less tuberculate rib terminations at the ventral shoulder. To within a quarter of a whorl from the aperture parabolic sculpture (Arkell, *et al.*, 1957, p. L89, fig. 17) is clearly visible on the outer third of the whorl side. The paratype (Pl. VII, figs. 6a, b) preserves one third of a whorl of body chamber, most of which is in the form of internal mould. The initial part of the last whorl shows sculpture like that of the holotype: bullate ribs on the inner third of the whorl side, with a second rib implanted on the outer half. The bullae and ribs fade on the last quarter whorl but the ventrolateral tubercles are retained. The ventral keel is prominent on both the holotype and paratype, and is visible on both the test and the internal mould.

Comparisons. The *Gymnotoceras* species from Nevada do not show the parabolic sculpture that characterizes *Gymnotoceras chischa, Gymnotoceras deleeni* (McLearn), and *Gymnotoceras laqueatum* (Lindström). The angular, tuberculate ventral shoulders and strong ventral keel distinguish *Gymnotoceras chischa* from *Gymnotoceras deleeni*. *Gymnotoceras laqueatum* from Spitsbergen closely resembles *Gymnotoceras chischa* and apparently differs only in the character of the ventral shoulders, those of *Gymnotoceras chischa* being more angular at small diameter than those of *Gymnotoceras laqueatum*. Compared with the remaining species from Spitsbergen, some or all of which may be conspecific with *Gymnotoceras laqueatum, Gymnotoceras nathorsti* (Mojsisovics) is more inflated, with more prominent bullae; *Gymnotoceras geminatum* (Mojsisovics) has stronger bullae and a less prominent keel; and *Gymnotoceras falcatum* (Mojsisovics) has denser ribbing.

Occurrence. Toad Formation, 13 feet from top of unit 8 (Pelletier, 1960, section 6, p. 22), east entrance of canyon on Chischa River, 8 miles above Muskwa River, Fort Nelson area, northeastern British Columbia. GSC locality 40088, B. R. Pelletier, 1959.

Age. Upper Anisian, Chischa Zone.

Family CERATITIDAE

Genus *Progonoceratites* Schrammen

Progonoceratites poseidon n. sp.

Plate VIII, figures 3-5; Figure 23

Diagnosis. Progonoceratites attaining a diameter of about 75 mm. Sculptured whorls persist to a diameter of about 27 mm; thereafter the whorls bear falcoid growth lines only. The adult suture line has faintly wrinkled saddles and two well individualized auxiliary lobes.

Types and dimensions.

Specimen	Locality	D	H	W	U
18887, paratype	68286	17	8 (0.47)	4 (0.24)	4 (0.24)
18888, holotype	68286	28	15 (0.53)	8 (0.29)	5 (0.17)
18889, paratype	68286	42	23 (0.55)	12 (0.28)	5 (0.12)

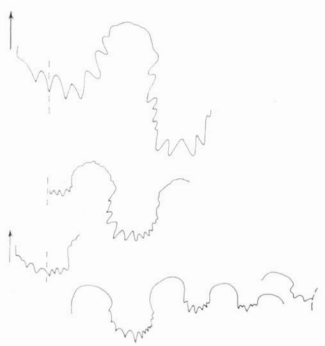

FIGURE 23. External suture lines, below umbilical shoulder, of *Progonoceratites poseidon* n.sp (x3). Upper figure is of paratype, GSC No. 18889. Lower three figures are of holotype, GSC No. 18888.

Description. The small paratype (Pl. VIII, figs. 3a, b) shows the inner, sculptured whorls. On the last whorl, this specimen has fifteen ribs at the inner half of the whorl side, the last eight of which are bullate. Each bullate rib branches to form two falcoid ribs that have strong terminations at the ventral shoulder. In addition, one or in places two falcoid ribs are implanted near the middle of the whorl side between the bullate ribs. As a result, for each bullate rib there are three or four tuberculate rib terminations at the ventral shoulder. The ribs cease abruptly at the ventral shoulder, and the venter is smooth and gently arched.

The holotype (Pl. VIII, figs. 4a-c) is wholly septate and shows the transition from sculptured to smooth whorls. The first quarter whorl shows faint, but clearly recognizable sculpture like that of the small paratype. This sculpture fades progressively and is absent entirely on the last half of the outer whorl. The suture line (Fig. 23) shows one well-defined auxiliary lobe and another at the umbilical shoulder. Initially the saddles appear to be entire, but near the aperture they are clearly wrinkled.

The large paratype (Pl. VIII, figs. 5a-c) is also entirely septate, but apparently shows the adult characters. The umbilical wall is vertical; the umbilical shoulder rounded; whorl sides convex, and widest at the inner third; ventral shoulders are rounded, but distinct; and the venter forms a low arch. The face of the last septum shows two well individualized auxiliary lobes below the umbilical shoulder.

The estimate of maximum size given in the diagnosis is based on fragmentary body chambers that occur in association with the type specimens.

Comparisons. Compared with *Progonoceratites atavus* (Philippi) and the other species described from the Muschelkalk of Germany, *Progonoceratites poseidon* loses its sculpture at an earlier stage. The suture line of *Progonoceratites atavus* is ceratitic, but according to Philippi (1901, p. 50) the incisions climb higher on the saddle walls than on the younger Muschelkalk ceratitids. There is some resemblance to species of *Paraceratites*, e.g., *Paraceratites binodosus* (Hauer), which as noted by Wenger (1957, p. 72) is not easily separated, morphologically, from *Progonoceratites atavus*. At present there is insufficient data to decide whether the resemblances between *Progonoceratites atavus* and *Paraceratites binodosus* indicate affinity or homeomorphy. There seems to be little doubt that *Progonoceratites atavus* is substantially younger than *Paraceratites binodosus*. In any event, *Progonoceratites poseidon* is morphologically distinct from both *Progonoceratites atavus* and *Paraceratites binodosus*. The new species is also quite distinct from the typical, trinodose, representatives of *Paraceratites*.

Occurrence. Liard Formation, bluff between Chischa and Tuchodi Rivers, 10 miles southeast of Mount Mary Henry, Tuchodi Lakes area, northeast British Columbia, GSC locality 68286; N. J. Silberling and E. T. Tozer, 1965.

Age. Lower Ladinian, Poseidon Zone.

Family TRACHYCERATIDAE

Genus *Trachyceras* Laube

Trachyceras obesum n. sp.

Plate IX, figures 1a, 1b

Trachyceras sp., Tozer, 1962, pl. VII, figures la,lb.

Diagnosis. Large, thick-whorled *Trachyceras* with eleven rows of spirally arranged tubercles: one on the umbilical shoulder, eight on the flanks, and two adjacent to the shallow ventral furrow. There is a band of almost smooth shell between the two ventral rows and those of the flanks.

Material. Holotype, GSC No. 14311, from GSC locality 42308.

Description. This species is known only from the holotype and a few associated fragments. The holotype is a whorl fragment with no sign of septa. At a height of about 50 mm the whorl is about 40 mm wide. The whorl section is U-shaped. The umbilical wall is visible at one place (Pl. IX, fig. 1a); it is about 10 mm high, vertical, and it shows one tubercle on the umbilical shoulder. Just below the place where the umbilical wall is preserved the shell is slightly distorted, but the greater part of the specimen is apparently undistorted. The inner and middle parts of the whorl side bear six evenly spaced rows of tubercles. They are followed by two more rows that are closer together. Adjacent to these rows there is an almost smooth band, traversed only by faint ribs. The smooth band is bordered by the two rows, characteristics of *Trachyceras,* adjacent to the ventral furrow. The ribs are of irregular strength but are never prominent; most, if not all, can be traced from the umbilical shoulder to the venter without branching.

Comparisons. There is considerable resemblance to *Trachyceras austriacum* Mojsisovics, which differs in having more rows of tubercles on the whorl side. *Trachyceras desatoyense* Johnston has the same number of rows but is more compressed, is not known to attain the large size of *Trachyceras obesum,* and lacks the well-defined smooth band adjacent to the rows of ventral tubercles.

Occurrence. Grey beds, summit ridge of Ewe Mountain, between north and south summits, 4½ miles ENE of Triangulation Station 6536, Toad River area, northeast British Columbia (59°05′N, 125°20′W), GSC locality 42308; B. R. Pelletier and E. T. Tozer, 1960.

Age. Lower Karnian, Obesum Zone.

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PLATES I to X

Figures are natural size unless otherwise stated

X marks the position of the last septum

Plate I

LOWER TRIASSIC AMMONOIDS

Griesbachian Stage

Lower Griesbachian — Concavum Zone

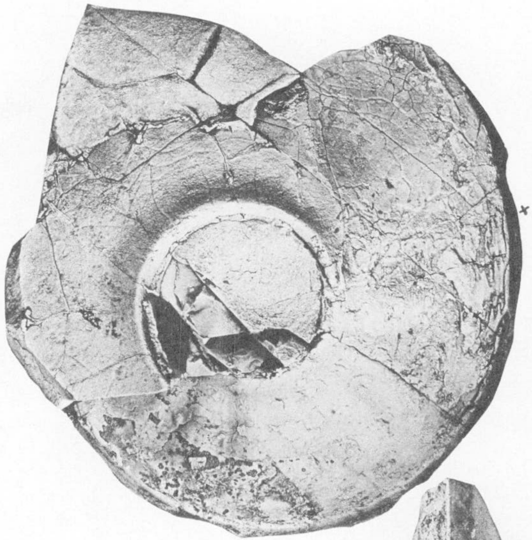
Otoceras concavum n. sp. (Page 86)

Figures 1a, b. Venter (1a) and side (1b) of holotype, GSC No. 18882, Blind Fiord Formation, Griesbach Creek, Axel Heiberg Island (GSC loc. 64777).

Figures 2a, b. Venter (2a) and side (2b) of paratype, GSC No. 18884, talus from Blind Fiord Formation, Griesbach Creek, Axel Heiberg Island (GSC loc. 64779).

Figures 3a, b. Venter (3a) and side (3b) of paratype, GSC No. 18881, Blind Fiord Formation, Griesbach Creek, Axel Heiberg Island (GSC loc. 64779).

1a



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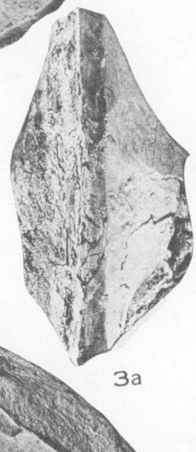
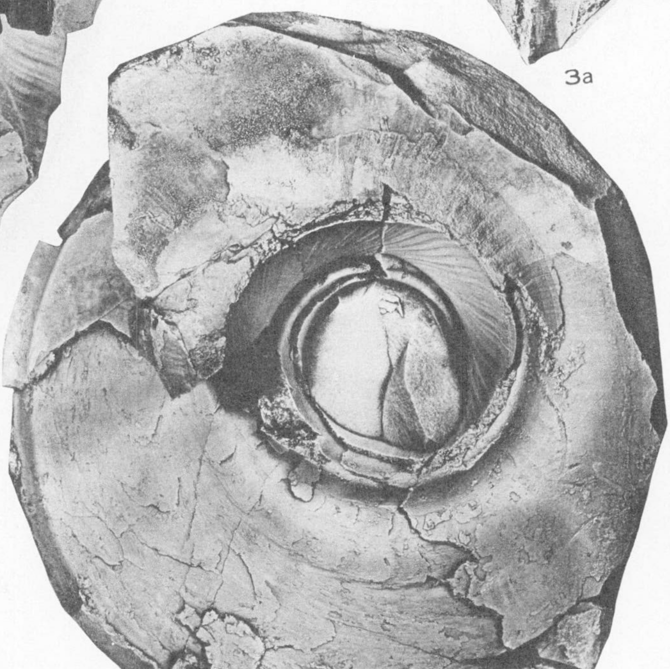


3a

2a



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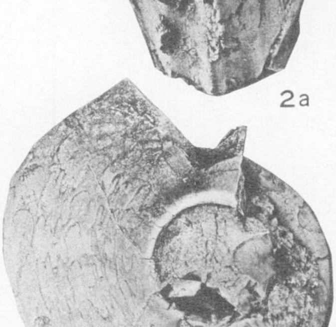

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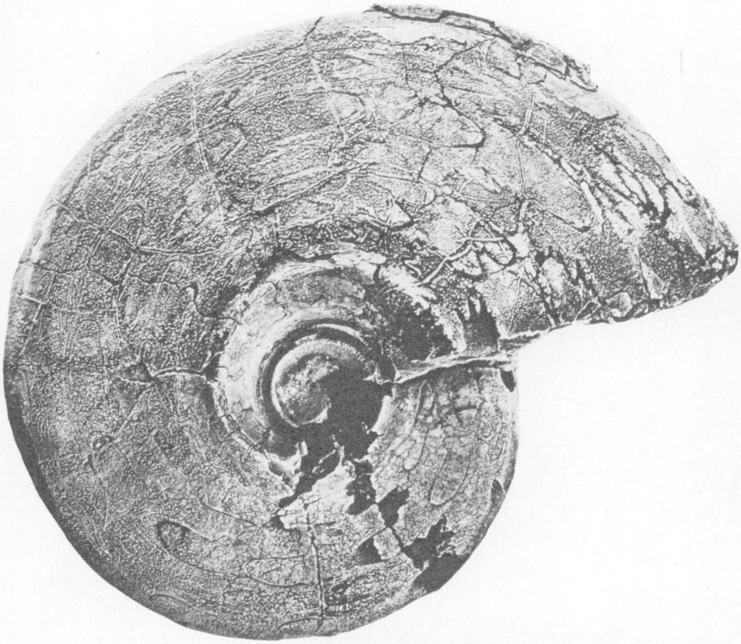
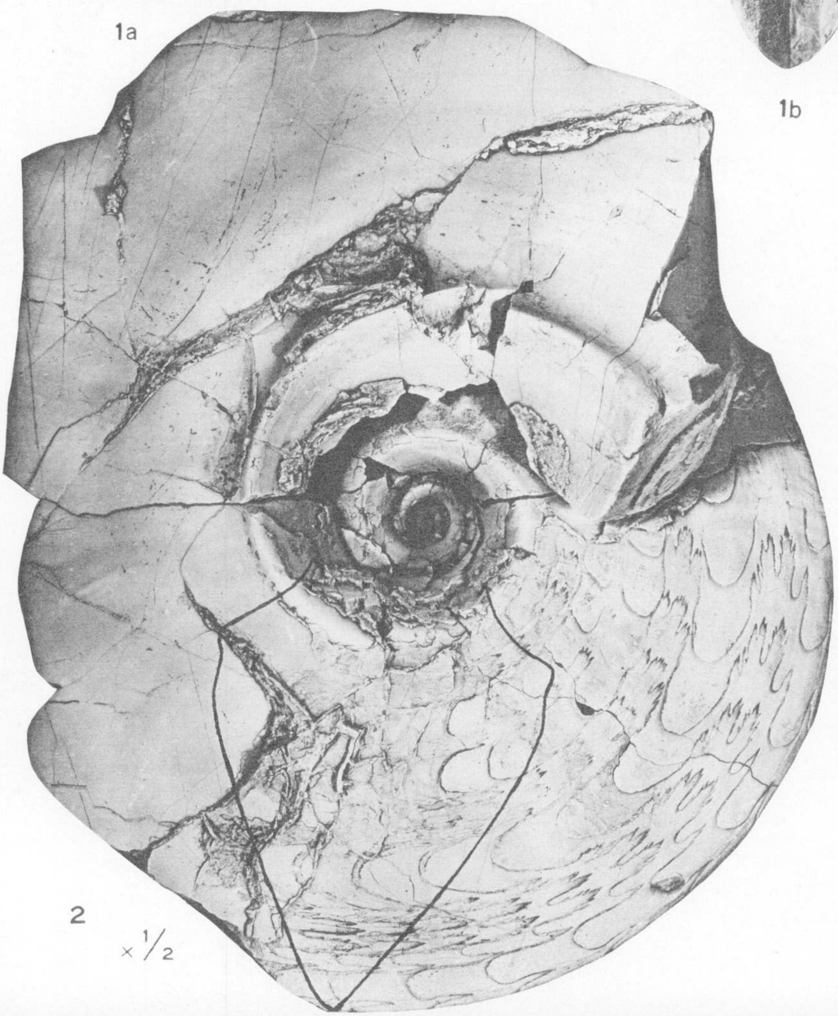


1a

1b



2

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PLATE II

LOWER TRIASSIC AMMONOIDS

GRIESBACHIAN STAGE

Lower Griesbachian — Boreale Zone

Otoceras boreale Spath

Figures 1a, b. Side (1a) and front (1b) of GSC No. 14026, Blind Fiord Formation, 3 miles south of Bunde Fiord, 8 miles west of Camp Five Creek, Axel Heiberg Island (GSC loc. 32215).

Figure 2. Side of GSC No. 18895, ½ natural size, Blind Fiord Formation, south shore of island between Bunde and Bukken Fiords, Axel Heiberg Island (GSC loc. 47524). The outline shows the whorl section at the end of the phragmocone. The inner whorls of this specimen can be seen and are like No. 14026 (figs. 1a, b). Phragmocone diameter is 236 mm.

PLATE III

LOWER TRIASSIC AMMONOIDS

GRIESBACHIAN STAGE

Upper Griesbachian — Commune Zone

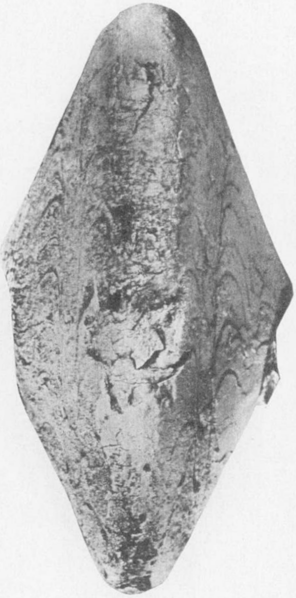
Ophiceras commune Spath

Figures 1a, b. Venter (1a) and side (1b) of GSC No. 18897, Blind Fiord Formation, south shore of island between Bunde and Bukken Fiords, Axel Heiberg Island (GSC loc. 47525).

Upper Griesbachian — Strigatus Zone

Pachyproptychites strigatus (Tozer)

Figures 2a, b. Venter (2a) and side (2b) of GSC No. 18896, Blind Fiord Formation, 4 miles SW of mouth of Camp Five Creek, Axel Heiberg Island (GSC loc. 64765).



2a

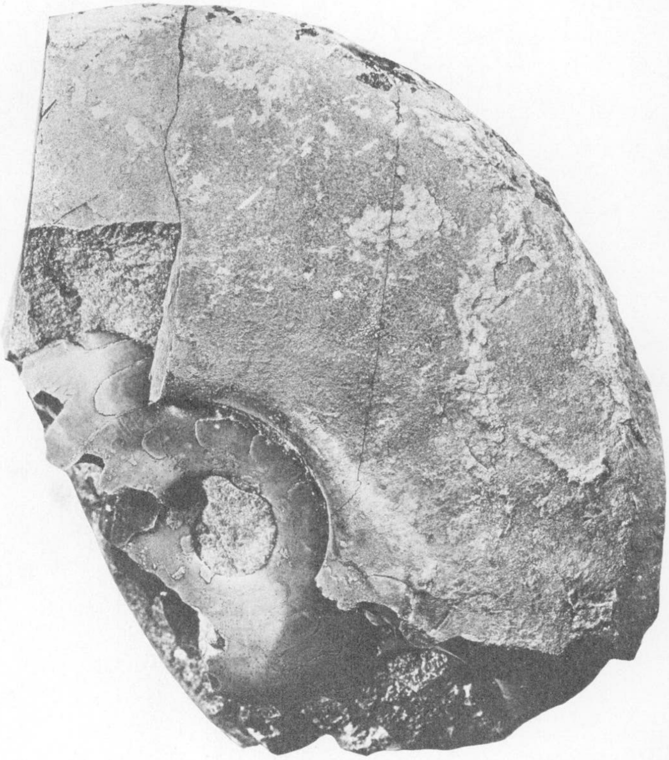
2b

1a

×

1b

1a



1b

2a

2b

PLATE IV

LOWER TRIASSIC AMMONOIDS

DIENERIAN STAGE

Candidus Zone

Proptychites candidus Tozer

Figures 1a, b. Venter (1a) and side (1b) of holotype, GSC No. 14044, Blind Fiord Formation, 3 miles south of Bunde Fiord, 8 miles west of Camp Five Creek, Axel Heiberg Island (GSC loc. 32368).

Sverdrupi Zone

Paranorites sverdrupi Tozer

Figures 2a, b. Side (2a) and venter (2b) of GSC No. 18898, Blind Fiord Formation, cliff facing Nansen Sound, 20 miles SE of Cape Stallworthy, Axel Heiberg Island (GSC loc. 64715).

PLATE V

LOWER TRIASSIC AMMONOIDS

SMITHIAN STAGE

Romunderi Zone

Euflemingites romunderi Tozer

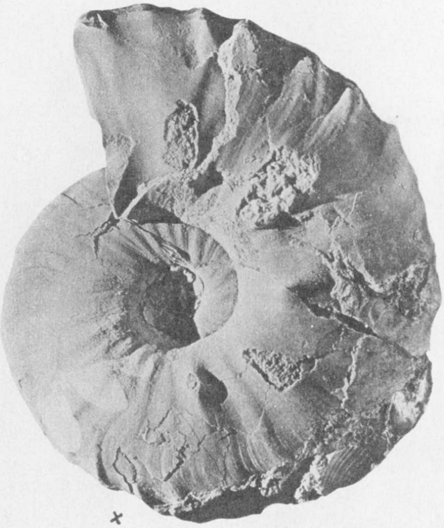
Figures 1a, b. Side (1a) and venter (1b) of holotype, GSC No. 14051, ½ natural size, Blind Fiord Formation, west coast Ellesmere Island, 5 miles NW of entrance to Hare Fiord (GSC loc. 28680).

Figures 2a, b. Side (2a) and venter (2b) of paratype, GSC No. 14191 (listed in error as No. 14052, Tozer, 1961b, p. 52), Blind Fiord Formation, west coast Ellesmere Island, 5 miles NW of entrance to Hare Fiord (GSC loc. 28681).

Tardus Zone

Wasatchites tardus (McLearn)

Figures 3a-c. Side (3a), venter (3b), and front (3c) of holotype, GSC No. 9470, Toad Formation, north side Liard River, 2 miles below Toad River, NE British Columbia (GSC loc. 10657).

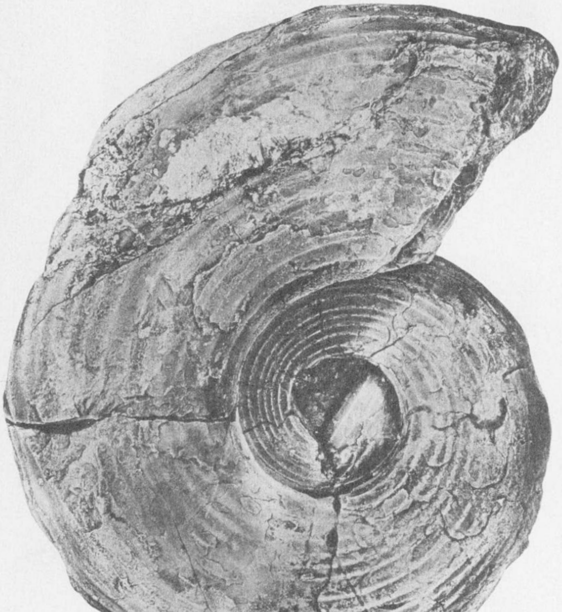


x

3a

3b

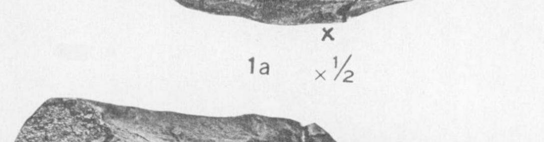
3c



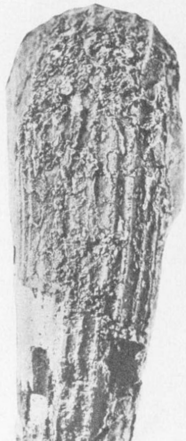
x

1a ×1/2

2a



1b ×1/2



2b

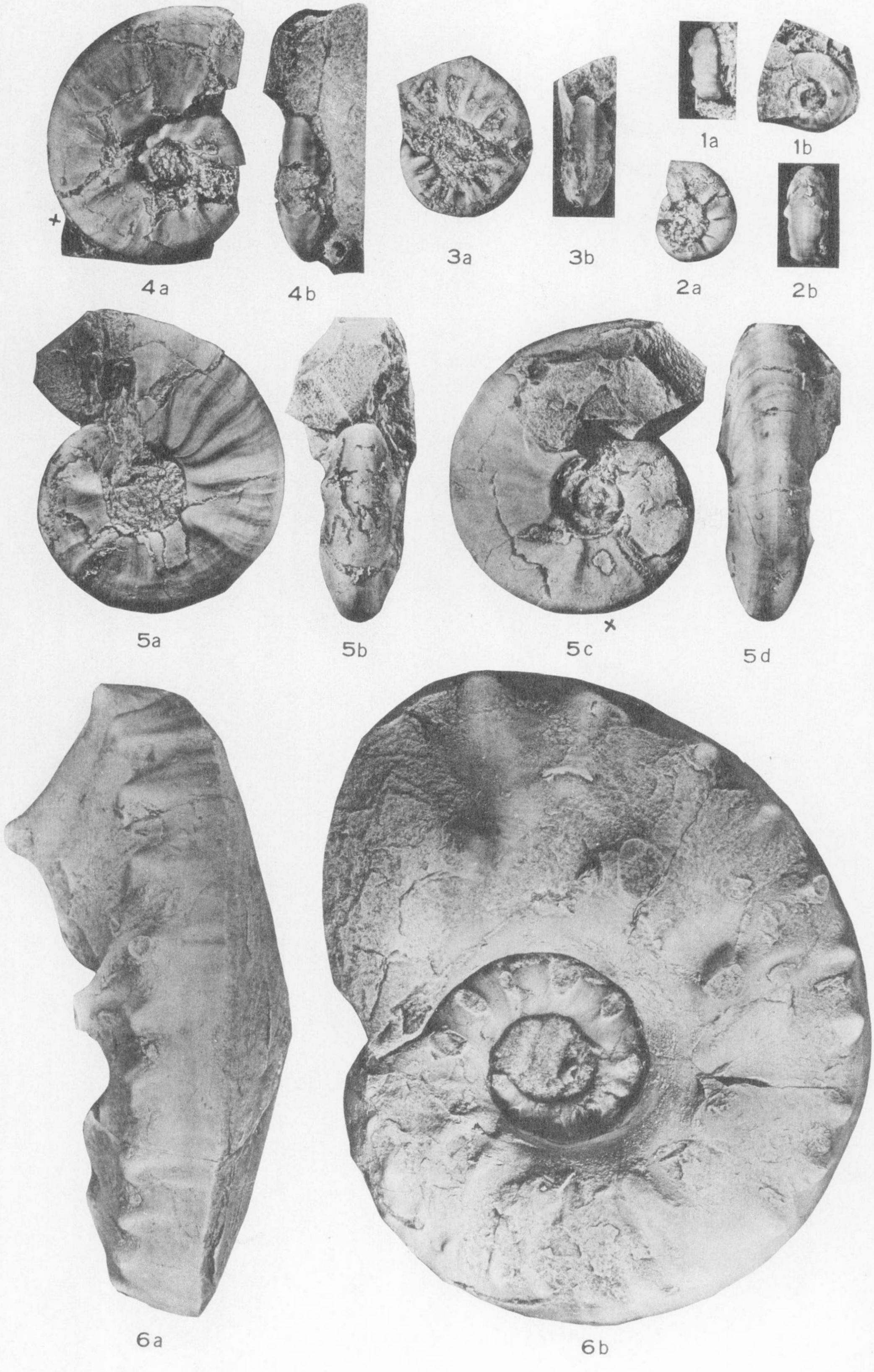

1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
5c
5d
6a
6b

PLATE VI

LOWER TRIASSIC AMMONOIDS

SPATHIAN STAGE

Pilaticus Zone

Olenikites pilaticus n. sp. (Page 88)

Figures 1a, b. Venter (1a) and side (1b) of paratype, GSC No. 18890, Lower Shale member, Blaa Mountain Formation, cliff facing Nansen Sound, 20 miles SE of Cape Stallworthy, Axel Heiberg Island (GSC loc. 64719).

Figures 2a, b. Side (2a) and venter (2b) of paratype, GSC No. 18891, locality as fig. 1.

Figures 3a, b. Side (3a) and front (3b) of paratype, GSC No. 18892, locality as fig. 1.

Figures 4a, b. Side (4a) and front (4b) of holotype, GSC No. 18893, locality as fig. 1.

Figures 5a-d. Both sides (5a, c), front (5b) and venter (5d) of paratype. GSC No. 18894, locality as fig. 1.

Subrobustus Zone

Keyserlingites subrobustus (Mojsisovics)

Figures 6a, b. Venter (6a) and side (6b) of GSC No. 18845, Lower Shale member, Blaa Mountain Formation, Spath Creek south of Otto Fiord, Ellesmere Island (GSC loc. 47545).

Plate VII

MIDDLE TRIASSIC AMMONOIDS

Anisian Stage

Lower Anisian — Caurus Zone

Lenotropites caurus (McLearn)

Figures 1a, b. Venter (1a) and side (1b) of holotype, GSC No. 9585, Toad Formation, south side Liard River, 2 miles below Toad River, NE British Columbia (GSC loc. 10660).

Middle Anisian — Varium Zone

Anagymnotoceras varium (McLearn)

Figures 2a-c. Side (2a), front (2b), and venter (2c) of topotype, GSC No. 18899, Toad Formation, west of Mile Post 375, Alaska Highway, NE British Columbia (GSC loc. 68294).

Figures 3a, b. Both sides of holotype, GSC No. 9595, locality as fig. 2 (GSC loc. 10696).

Upper Anisian — Deleeni Zone

Gymnotoceras deleeni (McLearn)

Figures 4a, b. Venter (4a) and side (4b) of holotype, GSC No. 6479, Toad Formation, talus near Mile Post 376, Alaska Highway, NE British Columbia (GSC loc. 10694).

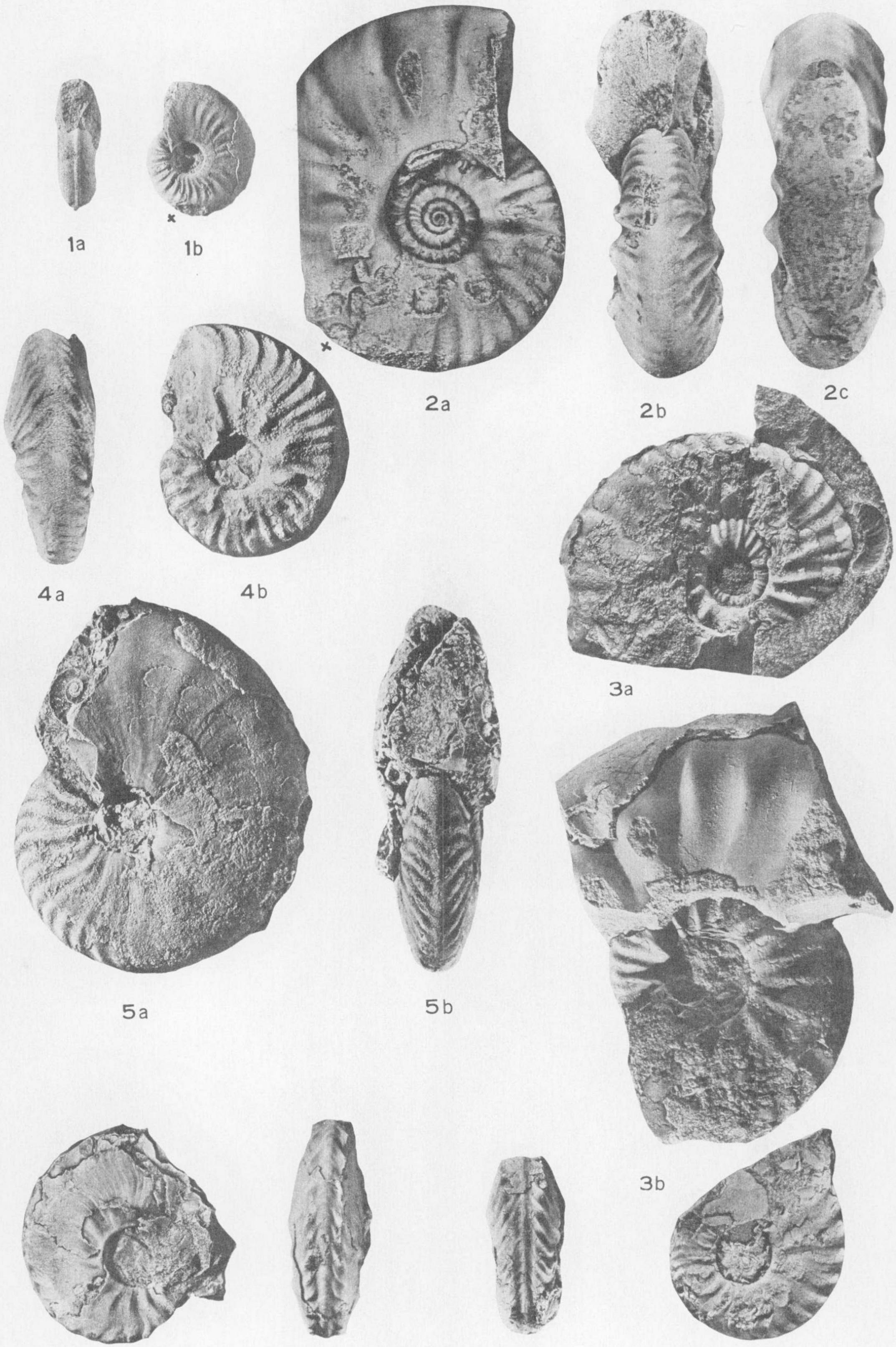
Figures 5a, b. Side (5a) and venter (5b) of paratype, GSC No. 6480, locality as fig. 4.

Upper Anisian — Chischa Zone

Gymnotoceras chischa n. sp. (Page 90)

Figures 6a, b. Side (6a) and venter (6b) of paratype, GSC No. 18886, Toad Formation, Chischa River, 8 miles above Muskwa River, NE British Columbia (GSC loc. 40088).

Figures 7a, b. Venter (7a) and side (7b) of holotype, GSC No. 18885, Toad Formation, locality as fig. 6.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2c
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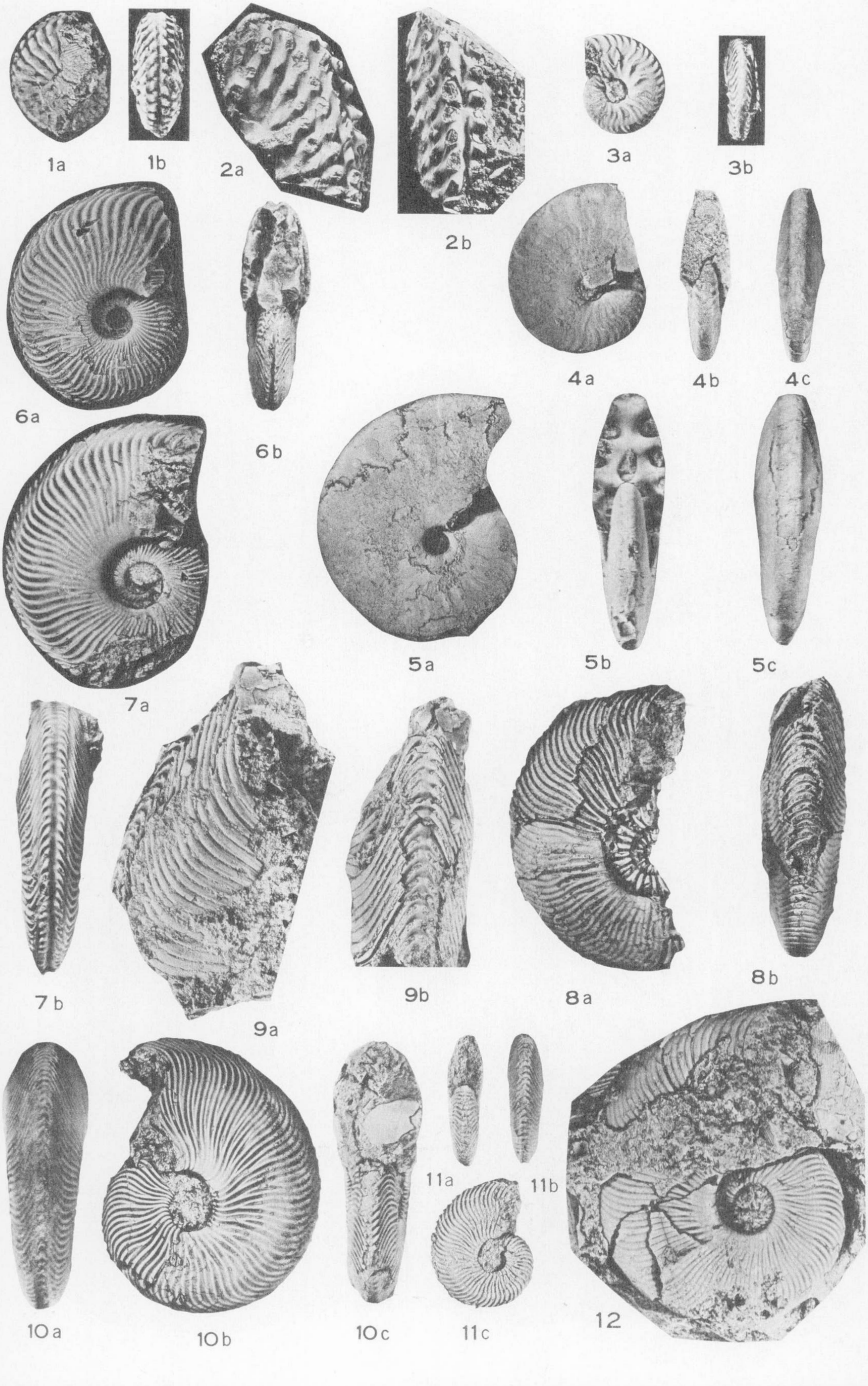
6b
7a
7b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5a
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5c
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7b
9a
9b
8a
8b
10a
10b
10c
11a
11b
11c
12

Plate VIII

MIDDLE TRIASSIC AMMONOIDS

Ladinian Stage

Lower Ladinian — Subasperum Zone

Protrachyceras cf. *P. meeki* (Mojsisovics)

Figures 1a, b. Side (1a) and venter (1b) of GSC No. 18900, Toad Formation, 12 miles north of Wapiti Lake, NE British Columbia (GSC loc. 46484).

Figures 2a, b. Side (2a) and venter (2b) of GSC No. 18901, Toad Formation, locality as fig. 1.

Lower Ladinian — Poseidon Zone

Progonoceratites poseidon n. sp. (Page 91)

Figures 3a, b. Side (3a) and venter (3b) of paratype, GSC No. 18887, Liard Formation, 10 miles SE of Mount Mary Henry, NE British Columbia (GSC loc. 68286).

Figures 4a-c. Side (4a), front (4b), and venter (4c) of holotype, GSC No. 18888, locality as fig. 3.

Figures 5a-c. Side (5a), front (5b), and venter (5c) of paratype, GSC No. 18889, locality as fig. 3.

Upper Ladinian — Meginae Zone

Meginoceras meginae McLearn

Figures 6a, b. Side (6a) and front (6b) of holotype, GSC No. 9042, "Dark Siltstones", Beattie Ledge, Peace River, NE British Columbia (GSC loc. No. erased).

Figures 7a, b. Side (7a) and venter (7b) of topotype, GSC No. 8811, "Dark Siltstones", Beattie Ledge, Peace River, NE British Columbia (GSC loc. 9163).

Upper Ladinian — Maclearni Zone

Maclearnoceras maclearni Tozer

Figures 8a, b. Side (8a) and venter (8b) of paratype, GSC No. 14299, Liard Formation, Liard River, 2½ miles above Hell Gate, NE British Columbia (GSC loc. 42355).

Upper Ladinian — Sutherlandi Zone

Paratrachyceras sutherlandi McLearn

Figures 9a, b. Oblique view (9a) and venter (9b) of GSC No. 18902, Liard Formation, south fork, Tetsa River, NE British Columbia (GSC loc. 36484).

Figures 10a-c. Venter (10a), side (10b), and front (10c) of GSC No. 18903, Liard Formation, Liard River, 2¼ miles above Hell Gate, NE British Columbia (GSC loc. 42351).

Figures 11a-c. Front (11a), venter (11b), and side (11c) of GSC No. 18904, Liard Formation, locality as fig. 10.

Figure 12. Side of holotype, GSC No. 9547, Liard Formation, Prophet River, NE British Columbia (GSC loc. No. erased).

PLATE IX

UPPER TRIASSIC AMMONOIDS

KARNIAN STAGE

Lower Karnian — Obesum Zone

Trachyceras obesum n. sp. (Page 93)

Figures 1a, b. Side (1a) and venter (1b) of holotype, GSC No. 14311, Grey beds, Toad River area, NE British Columbia (GSC loc. 42308). The arrows indicate the position of the spiral rows of spines adjacent to the ventral furrow.

Lower Karnian — Nanseni Zone

Sirenites nanseni Tozer

Figures 2a, b. Side (2a) and venter (2b) of topotype, GSC No. 18905, Middle Shale member, Blaa Mountain Formation, west coast Ellesmere Island, 15 miles NW of entrance to Hare Fiord (GSC loc. 28439).

Figures 3a, b. Side (3a) and venter (3b) of GSC No. 18906, Middle Shale member, Blaa Mountain Formation, west coast Ellesmere Island, 7 miles NW of entrance to Hare Fiord (GSC loc. 28427).

Upper Karnian — Dilleri Zone

Tropites dilleri Smith

Figure 4. Imperfectly exposed specimen showing umbilical shoulder and spines, GSC No. 18907, Grey beds, Toad River area, NE British Columbia (GSC loc. 68208).

Figure 5. Venter (GSC No. 18908) and flank, showing spiral striae (GSC No. 18909), Grey beds, locality as fig. 4.

Upper Karnian — Welleri Zone

Tropites sp. aff. *T. welleri* Smith

Figures 6a, b. Venter (5a) and side (5b) of GSC No. 18910, Pardonet Formation, hill south of Mile Post 427, Alaska Highway, NE British Columbia (GSC loc. 42389).

Upper Karnian — Macrolobatus Zone

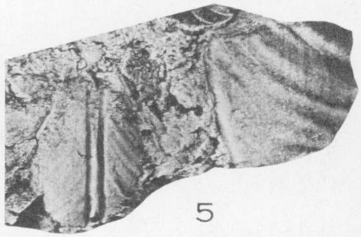
Anatropites sp.

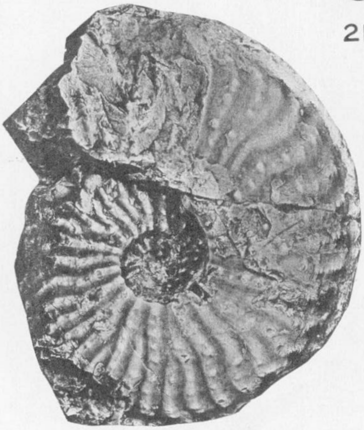
Figures 7a, b. Venter (6a) and side (6b) of GSC No. 18911, Pardonet Formation, head of Western Gully, Pardonet Hill, Peace River, NE British Columbia (GSC loc. 64627).


2a


2b


4


5

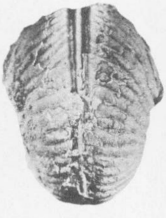

3a


3b

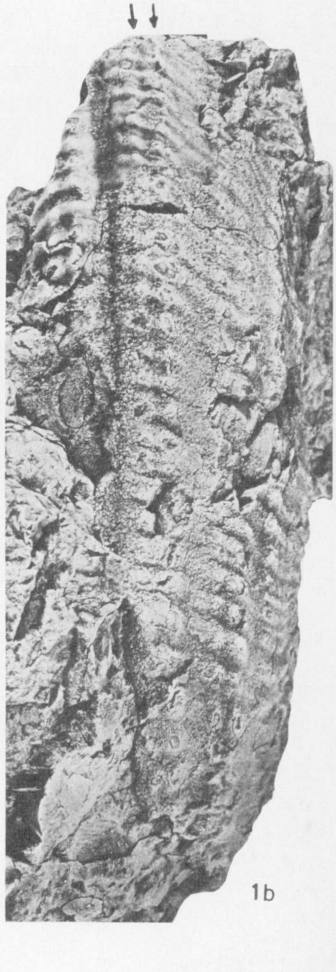

7a


7b


1a


6a


6b


1b

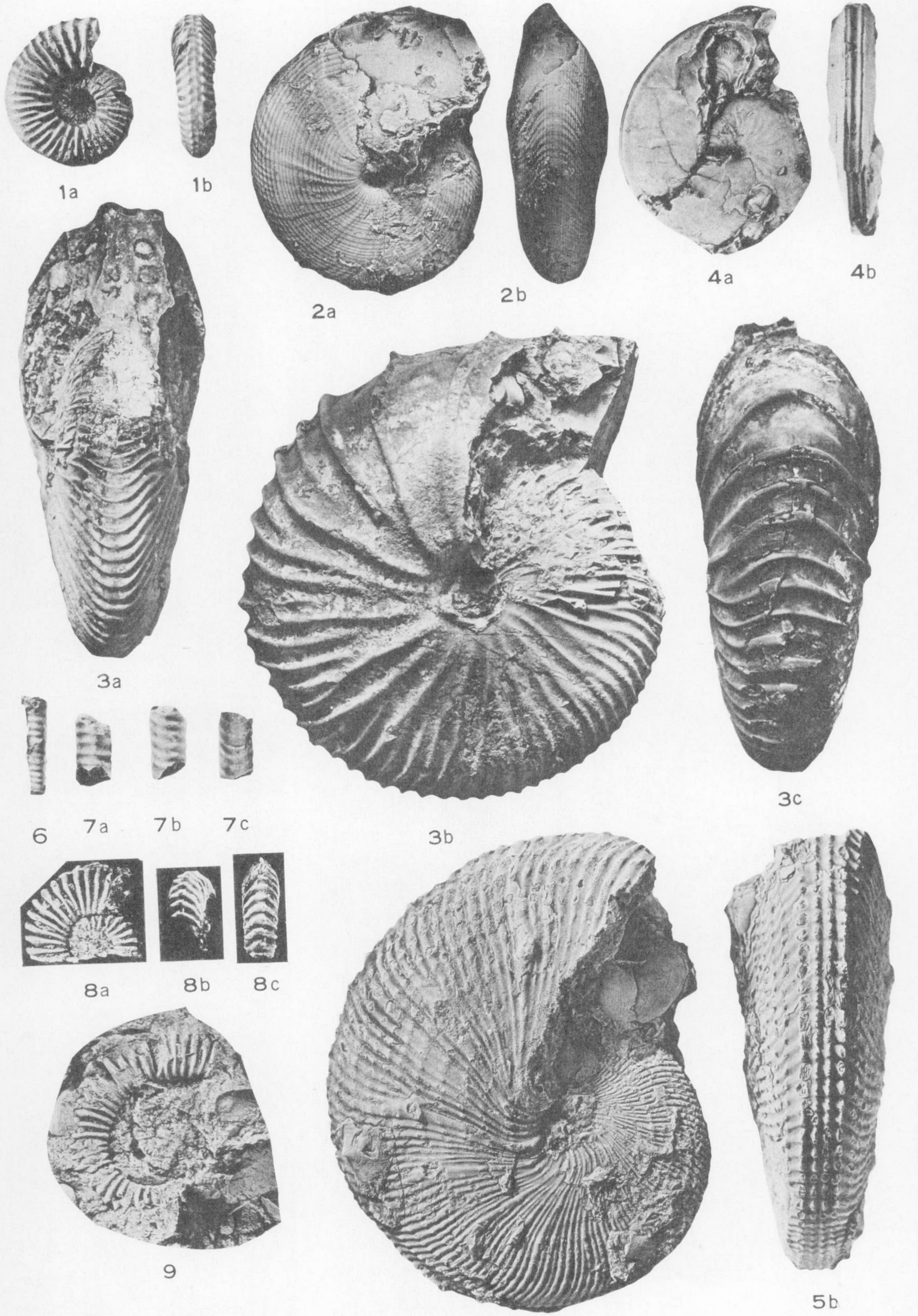

1a
1b
2a
2b
4a
4b
3a
3b
3c
6
7a
7b
7c
8a
8b
8c
9
5a
5b

Plate X

UPPER TRIASSIC AMMONOIDS

Norian Stage

Lower Norian — Kerri Zone

Mojsisovicsites kerri (McLearn)

Figures 1a, b. Side (1a) and venter (1b) of topotype, GSC No. 22736, Pardonet Formation, Brown Hill, Peace River, NE British Columbia (GSC loc. 9157).

Lower Norian — Dawsoni Zone

Malayites dawsoni McLearn

Figures 2a, b. Side (2a) and venter (2b) of holotype, GSC No. 8836, Pardonet Formation, north side Peace River, near Jewitt Fault, NE British Columbia (GSC loc. 9556).

Middle Norian — Magnus Zone

Juvavites magnus McLearn

Figures 3a-c. Front (3a), side (3b), and venter (3c) of holotype, GSC No. 8837, Pardonet Formation, Brown Hill, Peace River, NE British Columbia (GSC loc. 9836).

Middle Norian — Rutherfordi Zone

Drepanites hyatti rutherfordi McLearn

Figures 4a, b. Side (4a) and venter (4b) of GSC No. 14248, Pardonet Formation, near Graham River, Halfway River area, NE British Columbia (GSC loc. 42537).

Middle Norian — Columbianus Zone

Himavatites columbianus McLearn

Figures 5a, b. Side (5a) and venter (5b) of GSC No. 9625, Pardonet Formation, Sikanni Chief River, below mouth of Chicken Creek, NE British Columbia (GSC loc. 10739).

Upper Norian — Suessi Zone

Rhabdoceras suessi Hauer

Figure 6. Side of GSC No. 14265, Lewes River Group, Formation "D", near Summit of Povoas Mountain, Laberge area, Yukon Territory (GSC loc. 23457).

Figures 7a-c. Dorsal (7a), side (7b), and ventral (7b) views of GSC No. 14264, locality as fig. 6.

Rhaetian Stage

Marshi Zone

Choristoceras marshi Hauer

Figures 8a-c. Side (8a), oblique (8b), and ventral (8c) views of GSC No. 18912, Tyaughton Group, Tyaughton Creek above Spruce Lake Creek, SW British Columbia (GSC loc. 56395).

Figure 9. Side of specimen with uncoiled outer whorl, GSC No. 18913, Tyaughton Group, Tyaughton Creek, below Spruce Lake Creek, SW British Columbia (GSC loc. 62392).

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Numbers in **BOLD**-face type indicate pages where stratigraphic units are defined

BULLETINS

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