

## DEVONIAN GONIATITES AND STRATIGRAPHICAL CORRELATIONS IN WESTERN CANADA

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**ABSTRACT.** A systematic account of available Devonian ammonoids from western Canada is given and the evidence they provide concerning correlations within the Canadian Devonian is reviewed. Most of the material described has been provided by oil companies which have been exploring along the Mackenzie River and adjacent areas, but an attempt has been made in addition to study all goniatite material from this region previously mentioned in the literature.

Goniatites probably representing Emsian faunas occur in beds below the Hume Formation on the Ogilvie River and Eifelian goniatites occur in the Funeral Formation of the Northwest Territories. Givetian goniatites occur above the Hume Formation on Francis Creek and the *terebratum* Zone is represented in the Fort Creek Shale of the Ogilvie and Anderson River areas; it is also present in dark shale immediately overlying the Hume Formation in the Norman Wells area. The basal Frasnian *lumlicosta* Zone is represented in the Maligne Formation of Alberta and in dark shales overlying the Beavertail Formation at Carcajou Ridge; it is also probably represented in the upper part of the Fort Creek Shale in the Ogilvie and Thunder River areas. Middle and late Frasnian goniatites have been examined from the Perdrix, Mount Hawk, Escarpment, Redknife, and Carcajou Mountain Formations but have not enabled the precise recognition of zones.

Famennian faunas are rare, but a fauna of the upper *Cheiloceras* major Zone is recognized in the lower D5 beds, and the *Platyclymenia* major Zone may be recognized in the upper D5 beds of the Northwest Territories. A specimen probably referable to *Platyclymenia* is recorded from the Palliser Formation. No evidence of upper Famennian ammonoids has been found.

The following genera are recorded for the first time from Canada: *Gyroceratites* (*Lamelloceras*), *Teicherticeras*, *Anarcestes* (*Latanarcestes*), *Cabrierocheras*, *Maeniocheras*, *Ponticeras*, *Lobotornoceras*, *Cheiloceras*, and *Sporadoceras*. A new genus, *Sellagoniatites*, is erected with *S. discoides* Waldschmidt as type species. Two new species are described, *Sellagoniatites jacksoni* and *Teicherticeras lenzi*. Amongst other revisions it is shown that *Manticoceras septentrionale* should be regarded as a synonym of *M. cordiforme* and *Timanites occidentalis* a synonym of *T. keyserlingi*.

DEVONIAN goniatites have been known in western Canada since 1887, when McConnell discovered a specimen now known to be *Manticoceras* on Hay River. Many more Frasnian goniatites have been found subsequently, but it is only in recent years that Middle Devonian and Famennian ammonoids have been found in the Northwest Territories and the Yukon. The recent discoveries have largely been due to the impetus to exploration provided by the discovery of oil in western Canada. This account is based mainly on material collected by The California Standard Company, the Geological Survey of Canada, Pan American Petroleum Corporation, Shell Oil Co. of Canada Ltd., and Triad Oil Co. Ltd. We are particularly indebted to these organizations for making their specimens available to us. In addition we have attempted to re-examine all Devonian ammonoids previously recorded in western Canada.

The new ammonoid evidence is interesting and important for two reasons. Firstly, a nearly complete ammonoid sequence has been identified from equivalents of the Emsian to the lower Famennian, which shows considerable affinity with the well-known European faunas. Secondly, the correlations to which the ammonoid evidence contributes help in the elucidation of the complex facies changes known within the Devonian of western Canada.

This account is given in two parts; the first, by A. E. H. P., is a synthesis of the [Palaentology, Vol. 6, Part 3, 1963, pp. 491-539, pls. 70-77.]

Devonian stratigraphy in western Canada in the light of the new evidence; the second part is by M. R. H. and is a systematic description of the ammonoids at present known.

### STRATIGRAPHY

by A. E. H. Pedder

As would be expected from a mere consideration of the huge areal extent and considerable thickness of the Devonian in western Canada, the relationships of its various facies are complex. This has naturally led to the erection of a large body of stratigraphic nomenclature, which is constantly being expanded and modified with the acquisition of new information.

Text-fig. 2 is a simplified correlation chart of the ammonoid-bearing Devonian stratigraphic sequences in western Canada. In preparing it an attempt was made to reconcile all the available palaeontological evidence. The main part of this section is an alphabetically arranged discussion of the nomenclature and fossil content of rock units appearing in the chart.

Many of the standard world ammonoid zones are now known to be present in western Canada. Their correlation with the accepted local brachiopod zones is indicated in Table 1. The Canadian Famennian brachiopods are at present under study by P. Sartenaer and it is expected that McLaren's (1954) Famennian zones will be modified at least in name. No attempt is made here to anticipate Sartenaer's work in any way and therefore McLaren's early generic assignments are retained in parenthesis.

STAGES	EUROPEAN AMMONOID ZONES	CANADIAN BRACHIOPOD ZONES
Famennian (pars)	<i>Platyclymenia</i>	' <i>Nudirostra</i> ' <i>utahensis ventricosa</i>
	?	' <i>Nudirostra</i> ' <i>gibbosa seversoni</i>
	<i>Cheiloceras</i>	' <i>Nudirostra</i> ' <i>gibbosa walcottii</i>
Frasnian	<i>Crickites holzapfeli</i>	<i>Theodossia scopulorum</i>
	?	<i>Calvinaria albertensis</i>
	<i>Manticoceras cordatum</i>	<i>Calvinaria insculpta</i>
	<i>Pharciceras humlicosta</i>	<i>Calvinaria athabascensis</i>
	?	<i>Ladlogioides kakwaensis</i>
Givetian	<i>Maenioceras terebratum</i>	<i>Leiorhynchus eastmea</i>
	<i>Maenioceras molarium</i>	?
	<i>Cabrierooceras rouvillei</i>	<i>Schuchertella adoceta</i>

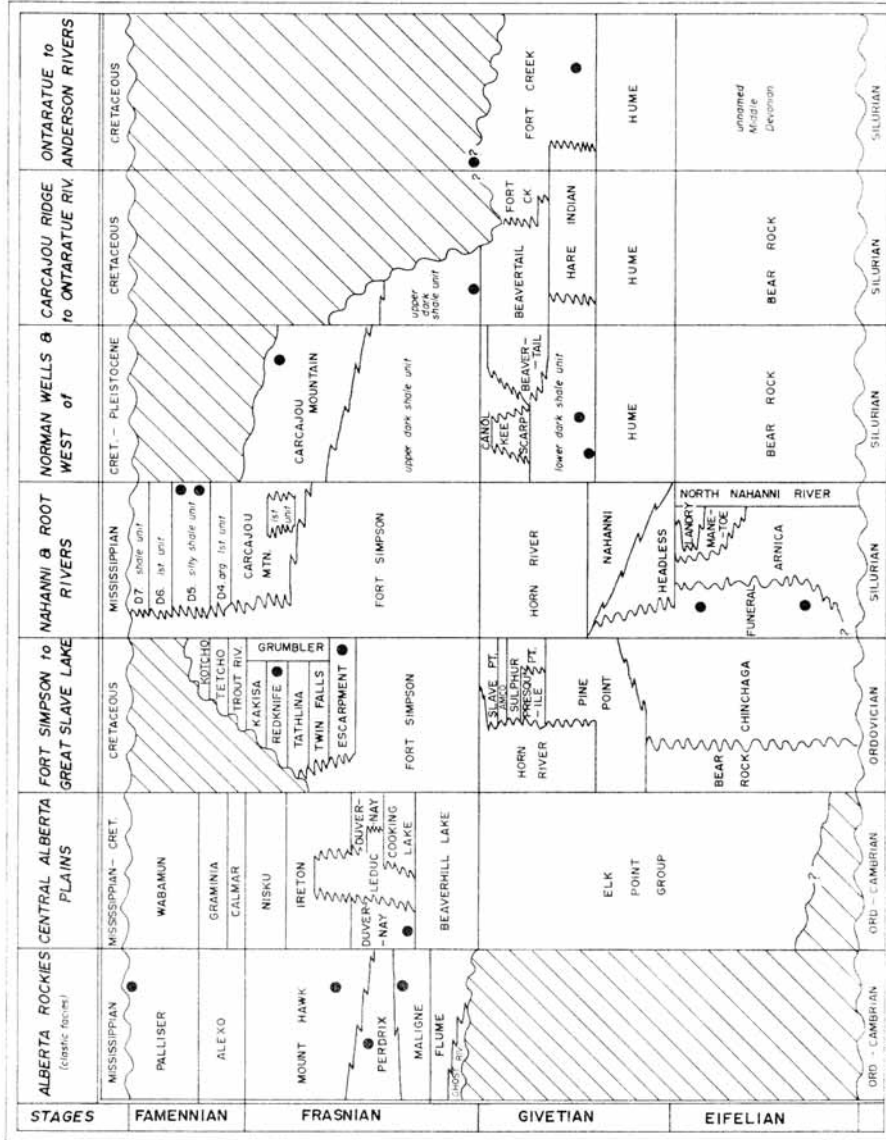
TABLE 1. A comparison of the western Canadian brachiopod zones with the standard European ammonoid zones.

#### *Beavertail Formation*

The limestone forming the Ramparts of the Mackenzie River was considered by Bosworth (1921a, p. 287) and by Kindle and Bosworth (1921, pp. 45-47) as being distinct and older than the limestones upstream at Beavertail Point and Carcajou Rock. The belief



TEXT-FIG. 1. Map of western Canada showing the position of the main localities referred to in the text.



TEXT-FIG. 2. Correlation chart of the Devonian rock units in western Canada. Ammonoid occurrences indicated by solid circles.

led them to erect two names, Rampart(s) and Beavertail, for them, but subsequently it was recognized that these are approximately synonymous and the latter was suppressed (Hume and Link 1945, p. 21). Unfortunately Rampart had been pre-empted by Spurr (1898, pp. 155–69) for a Mississippian formation in Alaska and in view of this Bassett (1961, pp. 492–4) applied the name Kee Scarp to the Beavertail and Ramparts Limestones. However, the relationship of the type Kee Scarp lentil to other limestones with diagnostic Givetian fossils is so controversial, that at present it is considered wiser to confine the name Kee Scarp to the type locality and provisionally to reinstate the name Beavertail for the definitely Givetian limestones in the Norman Wells and Ramparts regions. At Beavertail Mountain and the Ramparts only about 200 and 250 feet respectively of the formation are preserved, but according to Bassett (1961, p. 493) a maximum thickness of 800 feet has been measured about 55 miles south of the Ramparts.

Warren and Stelck's (1949, pp. 142, 143; 1950, p. 73; 1956, pl. 8, 9) '*Cyrtina panda*' fauna, said to have come from the Beavertail Formation at Carcajou Ridge and Rock, may have been collected from both above and below the upper limit of the formation. There is also very good evidence, which was personally demonstrated to the writer by D. J. McLaren, that there is at least some mixing of the published localities of these specimens. The presumed younger species of the fauna, such as *Allanaria sp.* and *Spinocyrtia euruteines* (Owen), may have come from thin limestones at the base of the overlying dark shale unit, which, on the basis of its ammonoids, is very early Frasnian in age. Other species such as *Leiorhynchus hippocastanea* (Crickmay), *Hadorrhynchia sandersoni* (Warren), *Warrenella timetea* Crickmay, and *Stringocephalus aleskanus* Crickmay are normal elements of the Beavertail fauna. They are also typical Givetian forms and together with the overlying Frasnian goniatites, allow the Givetian–Frasnian boundary to be fixed, in the Carcajou Ridge area, with unusual precision.

#### *Canol Formation*

The shales immediately above the Beavertail, and possibly also the Kee Scarp Formation in the Norman Wells area, are particularly bituminous. The geologists of the Canol Project referred to them informally as the bituminous shale member of the Fort Creek Formation (Stewart 1945; Hume and Link 1945); later Bassett (1961, pp. 494, 495) formalized their status by erecting the Canol Formation for them. The type section is nearly 55 miles due west of Norman Wells and is 75 feet thick, but the Canol Formation's thickness in the Norman Wells area is generally greater and varies between 100 and 400 feet. Since it is thickest where the underlying Beavertail Limestone is thinnest, and vice versa, these formations are possibly at least partly correlatives, although it is equally possible that depositional draping over an uneven sea-floor was responsible for this.

Bassett recognizes the formation over a very wide area; however, it is clear that to the north and south of the Norman Wells region, he includes in it beds which are here referred to the upper shale unit and Horn River Formation. Furthermore the reported goniatite impressions from the 'Canol' exposures at Carcajou Ridge (Bassett 1961, p. 495) may have come from the same horizon as those shown here to belong to the *lumulicosta* Zone.

#### *Carcajou Mountain Formation*

Kindle and Bosworth first recognized this unit and proposed (1921, p. 48) the name

Bosworth Sandstone and Shale for it. Independently, however, Bosworth (1921*a*, p. 287; 1921*b*, p. 282) in papers published in London named it the Camp Creek Series. The first of these papers predates their joint publication by a few days, but this is irrelevant, since both names were preoccupied, Bosworth by a Cambrian formation in British Columbia (Walcott 1908, pp. 2, 3) and Camp Creek by a member of a Pennsylvanian formation in Texas (Drake 1893, pp. 402, 416, 417). Consequently Kindle (1936, pp. 14, 15) erected Carcajou Mountain Beds as a replacement. Hume and Link (1945, pp. 34, 35) rejected the new name on the grounds that its type section is incomplete and attempted to replace it by a new formation, which they called Imperial. Not only was this unnecessary, but their choice of name was unfortunate, as Imperial had been used by Hanna (1926, pp. 434–5) for a Miocene formation in California. In this paper, therefore, a return to the name Carcajou Mountain Formation is advocated.

The formation is composed of dark shales interbedded with greenish-grey, partly calcareous and argillaceous, micaceous siltstones and sandstones. In the Root and Dahadinni River regions it includes prominent biostromal limestones. The thickness of the formation is extremely variable due to its diachronous lower contact and subsequent erosion in many areas, as well as to differences in depositional thickness. Incomplete sections about 60 miles west-north-west of Norman Wells are about 2,000 feet thick, whereas a complete section in the Root River area is only 1,360 feet thick. Incomplete sections at Carcajou Ridge and Norman Wells are much thinner. The unit can be traced as far south as the lower reaches of Liard River, where it passes laterally into silty limestones of the Grumbler Group.

The uppermost beds in the Root River region contain early Famennian brachiopods of the *Cyrtiopsis portae* and *C. prepta* species group, but the main part of the formation contains middle and late Frasnian corals and brachiopods. Miller (1938) described *Manticoceras cordiforme* and *M. septentrionale* as new species from near the top of the formation at Norman Wells. Their types have been re-examined and are considered to be specimens of the same species, for which the name *M. cordiforme* is retained. Another species reported from the formation (Hume and Link 1945, p. 39; Hume 1954, p. 46) is *M. intumescens* (Beyrich). The specimen on which this record is based also came from near the top of the preserved formation at Norman Wells and is now deposited in the Walker Museum, Chicago. Through the kindness of M. H. Nitecki it has been loaned to the writers and proves to be another example of *M. cordiforme*. The species is considered to be indicative of either the upper *cordatum* or the *holzapfeli* Zone.

#### *Chinchaga Formation*

Cameron (1918, p. 25) proposed the name Fitzgerald Formation for various, partly Devonian, carbonate and gypsum beds occurring below the Pine Point Formation in the southern Great Slave Lake area. Because its definition is in doubt, Douglas (1959, p. 9) recommended that Cameron's formational name be allowed to lapse. Subsequently, officers of the Geological Survey of Canada have referred the Devonian part of the original Fitzgerald Formation to the Chinchaga Formation. This practice is followed here. The Chinchaga Formation was proposed by Law (1955, pp. 1963–4) for a sub-surface evaporitic unit in northern Alberta; its type section is in California Standard's Steen River 2-22-117-5W.6M well and is 205 feet thick.

*D4 to D7 units*

Throughout most of the Northwest Territories Famennian beds are either poorly exposed, or have been removed by erosion. Good exposures are presently confined to the Yohin syncline, just north of the lower reaches of the North Nahanni River. Hume (1922, pp. 71–73) first described the Famennian succession in that area and recognized four units above what are now termed the Fort Simpson Shales. In ascending order, he designated these units D4 to D7. Except for D4 they are here retained without modification. The exception is necessary not only because Hume failed to recognize the Carcajou Mountain Formation as a separate entity, but also because he failed to assign its beds consistently to the same unit. For instance, on Root River, beds which include a biostrome and are now assigned to the Carcajou Mountain Formation were included in the D4 unit, whereas on North Nahanni River they were excluded from it.

In this paper the D4 unit is used in the way Hume used it on North Nahanni River. Thus defined it consists there of 830 feet of soft light-grey argillaceous microgranular limestone containing abundant specimens of *Basilicorhynchus basilicum* (Crickmay). The exceptional abundance of this brachiopod, which does not occur in the underlying Carcajou Mountain Formation, prompted Hume to designate the unit the '*Leiorhynchus* Zone'.

The D5 unit is an olive and maroon weathered shale interbedded, especially in the upper part, with thin calcareous siltstones. Hume also called it 'Shale Zone No. 2'. In Yohin syncline it is 1,178 feet thick. Except for a few beds crowded with brachiopods, the unit is sparsely fossiliferous, but the lower part has yielded a particularly interesting suite of goniatites, including *Lobotornoceras* aff. *bilobatum* (Wedekind), *Cheiloceras* (*C.*) *sacculum* (G. and F. Sandberger), *Sporadoceras* cf. *primaevum* Schindewolf, and *Imitoceras* sp. These are indicative of the upper *Cheiloceras* major Zone. Higher in the unit, the presence of a *Tornoceras* comparable with *T. crebrisepium* (Raymond) of the Three Forks Formation of Montana, probably indicates that the upper part of the unit is to be assigned to the *Platyclymenia* major Zone.

The D6 unit, or '*Athyris angelica* Zone', is a thick-bedded, light grey, buff-weathered, microgranular, and partly silty limestone. It is about 90 feet thick and contains a rich Famennian brachiopod fauna, but to date has not yielded ammonoids.

The D7 unit, or 'Shale Zone No. 3', consists of dark grey, non-calcareous shale, of which only the lower 325 feet are preserved in the Yohin syncline. It is barren of macrofossils and may be Devonian, or Mississippian, or both.

*Dark shale units*

Since the days of Canol Project drilling, dark, variably bituminous shales with minor siltstone and limestone interbeds have been known to lie above and below the oil-producing limestone of the Norman Wells area. These have most frequently been called the Upper and Lower Fort Creek Shales (Hume and Link 1945, p. 29; Stewart 1945, pp. 5, 6; Warren and Stelck 1949, p. 143; 1950, fig. 1; Hume 1954, p. 35; Storey 1961, p. 499), but Bassett (1961, pp. 490–2), who followed Crickmay (1957, p. 11) in disagreeing with earlier correlations, applied the name Hare Indian to the lower unit and included the upper unit in the Canol Formation and lower part of the Imperial Formation. In this paper the shales are provisionally and informally referred to as the upper and lower

dark shale units. Drilling results in the Norman Wells region (Hume and Link 1945, pp. 79, 82; Hume 1954, p. 35) indicate that the thickness of the lower unit varies between 385 and 780 feet and that of the upper between 660 and 840 feet. The upper may be an exaggerated tongue of the Fort Creek Formation extending southwards over Givetian limestones, but at the present time this possibility is difficult either to prove or disprove, because erosion has worked deep in critical areas.

On Bosworth and Francis Creeks, near Norman Wells, the lower beds of the lower dark shale unit have yielded: *Agoniatites* cf. *fulguralis* (Whidborne), *A.* cf. *vanuxemi* (Hall), *Cabrieroceras karpinskyi* (Holzapfel), *C.* sp., *Tornoceras* (*T.*) cf. *westfalicum* (Holzapfel), *Leiorhynchus castanea* (Meek), *Warrenella* sp., *Emanuella* sp. and various coniconchines. This is a Givetian fauna and enables the lower dark shale unit to be correlated with the lower part at least of the Fort Creek Shale to the north and the Horn River Shale to the south. It also demonstrates a Givetian age for the *castanea* brachiopod Zone.

An important goniatite assemblage, consisting of *Ponticeras* cf. *tchernyschewi* (Holzapfel), *P.* sp., *Proboloceras* sp. and *anapychi*, has been collected by A. C. Lenz 10 to 40 feet above the base of the upper dark shale unit at Carcajou Ridge. The fauna strikingly resembles that from the earliest Frasnian of Timan and is indicative of the *humlicosta* Zone.

#### Duvernay Formation

The unit was proposed (Geological staff, Imperial Oil Limited 1950, pp. 1817-19) for 175 feet of partly bituminous and calcareous brown and black shales in the Anglo-Canadian Beaverhill Lake 11-11-50-17W.4M well. This locality is east of the Rimbey-Meadowbrook Leduc reef chain of the Edmonton area (Belyea 1956, fig. 1), where Duvernay lithology is developed below argillaceous limestones of the Ireton Formation and above clastic limestones of the Cooking Lake Formation.

Although *Manticoceras* cf. *simulator* is said (Alberta Soc. Petrol. Geol. 1960, p. 107) to be one of the distinctive fossils of this formation, we have seen no ammonoids from it east of the reef chain. However, *Calvinaria insculpta* (McLaren), *Leiorhynchus carya* Crickmay, and *Warrenella nevadensis* (Walcott) have been obtained from Duvernay cores in this region, indicating that the formation, in the vicinity of its type locality, is a correlative of the Perdrix Formation of the mountains.

The statement that *Manticoceras* occurs in the formation is probably based on Crickmay's (1950, p. 223) report that *M.* cf. *simulator* Hall was found in black shale between 7,720 and 7,980 feet in the Imperial Paddle River 5-17-56-8W.5M well. He has more recently stated (personal communication, 17 April 1962) that 'some queer objects from 7,730 feet in that hole were at first thought by me to be *Manticoceras* opercula, but later proved to be an arthropod—' and that the only true ammonoids were obtained from 7,913-7,932 feet. These have been re-examined and identified as *Proboloceras*. They are poorly preserved juveniles and it is not possible to assign them specifically, but they are thought to indicate the *humlicosta* Zone. Further specimens from between 9,990 and 9,995 feet in the Imperial Amerada Willesden Green 3-16-43-5W.5M well are possibly the same. Both of these occurrences are west of the Rimbey-Meadowbrook reef chain, where the Duvernay Shale is thicker and extends down to the top of the Beaverhill Lake Formation and is therefore, in part, older than on the



eastern side of the reef chain. Both occurrences are less than 62 feet above the top of the Beaverhill Lake Formation, the upper part of which, on the western side of the reef chain, has yielded *Allanaria minutilla* Crickmay, *Calvinaria athabascensis* (Kindle), and other fossils indicative of the Maligne Formation of the mountains. The Duvernay-Beaverhill Lake formational boundary, therefore, west of the reef chain, falls within the *lumlicosta* Zone and correlates with a horizon within the Maligne Formation of the mountains.

That the older dark shales to the west of the Rimbey-Meadowbrook reef chain are equivalent to the limestones of the Cooking Lake Formation to the east has long been known, and they are now widely referred to as the Majeau Lake Member of the Cooking Lake Formation (Alberta Soc. Petrol. Geol. 1960, p. 213, and Alberta Oil and Gas Conservation Board 1960). At the time of writing, however, this unit has not been formally proposed and the older practice of applying the name Duvernay to the entire dark shale unit immediately west of the reef chain is followed on the correlation chart.

#### *Escarpment Formation*

Cameron (1918, pp. 25, 26) established the name Hay River for the entire Upper Devonian section exposed on Hay River and recognized in it an upper limestone and a lower shale division. Warren and Stelck (1950, fig. 1) expanded the term to embrace Hume's D4 to D6 units in the Root River region, but Crickmay (1953, p. 11) restricted it almost to Cameron's lower division by taking its upper limit at the base of Alexandra Falls on Hay River. This is stratigraphically about 50 feet higher than the upper limit of Cameron's Hay River Shale, which was drawn at the base of Louise Falls on the same river (Belyea and McLaren 1962, p. 2). Douglas (1959) remapped the type area without applying the name to any of his map units. Belyea and McLaren (1962, pp. 2, 3) redefined the formation yet again, by assigning to it all the beds below the base of Alexandra Falls and above the Slave Point Formation in the type area. They also introduced the term Escarpment Member for the upper 364 feet of the formation, which are more calcareous and biostromal and contain a rich brachiopod and coral fauna. In this paper the name Hay River is abandoned, the Escarpment Member is elevated to formational status, and the underlying beds down to the Slave Point Formation are assigned to the Fort Simpson Formation.

The main components of the fauna of the Escarpment Formation are: *Endothyra gallowayi* Thomas, *Phillipsastrea nevadensis* Stumm, *Macgeea proteus* Smith, *Tabulophyllum mcconnelli* (Whiteaves), *Nervostrophia maclareni* Pedder, *N. vestita* Crickmay, *Calvinaria variabilis* (Whiteaves), *Cyrtospirifer occidentalis* (Whiteaves), *C. thalattodoxa* Crickmay, *Warrenella labrecquei* Crickmay, and *Manticoceras* sp. It is of interest to note that one of the two known specimens of *Manticoceras* sp. is the first indubitable Devonian ammonoid to have been found in western Canada. It was collected by McConnell in 1887 and has been figured by both Whiteaves (1891) and Miller (1938). Although the specimens of *Manticoceras* are not identified specifically, they are consistent with the assignment of the Escarpment Formation to the lower *cordatum* Zone.

#### *Exshaw Formation*

At its type locality on Jura Creek, near Banff the formation consists of 31 feet of black shale, with a basal parting of sandstone, overlain by 37 feet of silty argillaceous

limestone. In spite of its thinness, the formation is widely distributed and can be traced throughout the Alberta Rocky Mountains and in wells eastwards to the pre-Cretaceous erosion surface. Warren (1937, p. 456) created the name but the shale was discovered as long ago as 1886 by McConnell (1887, p. 18).

A species of *Imitoceras* occurs in the upper silty limestone on Jura Creek. Crickmay (1952, p. 590) identified it as *Aganides* sp. close to *A. discoidalis* Smith; previous identifications include *Clymenia* (McConnell 1887, p. 18), *Phylloceras* (Raymond in Warren 1956, p. 141), and *Tornoceras* sp. cf. *T. uniangulare* (Conrad) (Miller 1938, p. 166; Warren 1937, p. 455; Warren and Stelek 1950, p. 63; 1956, pl. 29, figs. 1-3). At Crowsnest Pass, about 100 miles south-east of the type locality, Copeland (1960) described a Mississippian ostracod and conodont fauna from the same part of the formation. The lower black shale is normally without macrofossils, but a dwarfed and pyritized fauna, including *Imitoceras* aff. *discoidale* (Smith), *I. spp.*, *Protocanites* cf. *gurleyi* (Smith), and *Prodromites?* sp., is known from near Mount Arête, Alberta (Pamenter 1956; Schindewolf 1959).

Although originally considered Devonian, the faunal evidence now indicates that this formation is very early Mississippian and that the *Clymenia* and *Wocklumeria* major Zones are absent in the Canadian Rocky Mountains, since the Exshaw Formation rests disconformably on the *Platyclymenia* fauna of the Palliser Formation.

#### *Flume Formation*

The excessive thicknesses quoted in the proposal of the formation (Raymond 1930, pp. 294, 295, 297) suggest that Cambrian as well as Devonian beds were included in it. Subsequently de Wit and McLaren (1950, p. 4) restricted the formation to Devonian carbonates below the Perdrix Shale and divided it into two members. The upper is a dark to black slightly argillaceous limestone, whereas the lower is a coarser and lighter cherty dolomite and limestone unit. At the type locality on Roche Miette, near Jasper, these members are 50 and 101 feet thick respectively (McLaren 1956, p. 26). The name was further restricted by Taylor (1957, p. 187), who confined it to the lower of de Wit and McLaren's members and established a new formation, named the Maligne, for the upper. The revision is generally accepted and is incorporated in the correlation chart.

On comparing the succession of faunas in the McMurray region with that in the Rocky Mountains, it is evident that the Flume Formation of the northern Alberta Rockies is older than that of the central and southern Alberta Rockies. This is probably due partly to onlap and partly to change from Ghost River to Flume facies. The older northern Flume Formation contains the *Ladogioides kakwaensis* fauna, but so far has not yielded ammonoids.

#### *Fort Creek Formation*

This is a dark bituminous shale with minor fine sandstones and limestones. In a reconnaissance study, Kindle and Bosworth assigned all Devonian beds of this lithologic type in the central and lower Mackenzie region to a single formation, which they named the Fort Creek Shale (Bosworth 1921a, p. 287; Kindle and Bosworth 1921, pp. 47, 48). Because shale of this type overlies Givetian limestone at Carcajou Ridge, it was regarded as being of Upper Devonian age everywhere. Other geologists (Warren 1944, p. 107;

Hume and Link 1945, p. 6; Stewart 1945, p. 3; Warren and Stelck 1949, p. 139; 1956, p. 11; Hume 1954, p. 34; and Storey 1961, p. 499) accepted the opinion.

The type locality of the formation is at the mouth of Thunder (previously Fort Creek) River, where only about 175 feet and neither contact is exposed. Fortunately an *Agoniatites* has been found there, indicating that the type Fort Creek Shale is at least partly Middle Devonian. Richer Middle Devonian faunas occur in the formation at several places in the Anderson drainage region. The lowest beds contain *Leiorhynchus castanea* (Meek), *Cassidirostrum pedderi* McLaren, *Warrenella* cf. *kirki* (Merriam), and other forms, while what are believed to be higher beds have yielded *Sellagoniatites jacksoni* sp. nov., *Wedekindella brilonense* (Kayser), *W.* aff. *brilonense* (Kayser), *W.* sp. (unconstricted form), *Maenicoceras* cf. *terebratum* (G. and F. Sandberger), and *M.* sp. The goniatites are late Givetian and indicative of the *terebratum* Zone, although two of them had been previously misidentified as Upper Devonian forms (Warren and Stelck 1949, p. 142; 1950, p. 73; see House 1962, p. 255). Farther west the Fort Creek Formation has yielded *Agoniatites* cf. *fulgurialis* (Whidborne) from a locality on Ogilvie River and *Agoniatites* sp. from Hungry Lake. These are also Givetian forms.

In addition to this overwhelming evidence that much of the Fort Creek Shale in the Ogilvie, lower Mackenzie, and Anderson River regions is Middle Devonian, there are also indications that it is partly early Frasnian. On Ogilvie River the formation has yielded a single fragment of a goniatite body chamber with retracted growth-lines, which appears to be a species of *Ponticeras*. Furthermore, from the type section of the Fort Creek Shale, there are two anaptychi with outlines also suggesting a species of *Ponticeras*. Their preservation is similar to the anaptychi occurring in the upper dark shale at Carcajou Ridge, which is definitely of early Frasnian age.

#### *Fort Simpson Formation*

In the upper Mackenzie region, much of the Frasnian (and particularly the early part) is represented by meagrely exposed soft, grey, and partly calcareous shales. Cameron (1918, pp. 25, 26) introduced the name Simpson for limited exposures of these in the vicinity of Fort Simpson. The results of many wells drilled since Cameron's work show that shales in the Fort Simpson region are part of the same lithological unit as the shales outcropping on Hay River below the Escarpment Formation. Cameron believed that the shales at Fort Simpson were older than those on Hay River. However, the opposite is true, since the fossils of the former (Kindle 1919) are now recognized as elements of the *Calvinaria albertensis* fauna. Douglas and Norris (1961, pp. 20, 21) proposed a slight modification of Cameron's name to Fort Simpson, because Simpson is preoccupied by an Ordovician formation in Oklahoma (Taff 1902, p. 3). Belyea and McLaren (1962, p. 9) designated the section in Briggs Turkey Lake No. 1 well (61° 07' 30" N.; 120° 22' 30" W.), where the formation is 1,940 feet thick, as the type.

#### *Funeral Formation*

West of the Nahanni and Camsell Ranges dolomites of the Arnica Formation are mostly replaced by grey argillaceous limestones and calcareous shales, for which Douglas and Norris (1961, pp. 17, 18) proposed the name Funeral Formation. The beds characteristically weather light rusty grey and are fissile, but also include, particularly in the northern part of their development, some purer and more massive weathering

limestones. In the southern Funeral Range, the Headless and Nahanni Formations similarly grade laterally into beds of this formation. In the regions of its greatest development the formation is nearly 2,000 feet thick. Kingston (1951, p. 2411) described a 'Devonian black fissile shale' in the area in which it occurs, but his unit is a misidentified Silurian shale.

Apart from abundant coniconchines the Funeral Formation is sparsely fossiliferous, although *Gyroceratites* (*Lamelloceras*) *sp.* and *Agoniatites* *sp.* have been found low in the formation and *Anarcestes* (*Latanarcestes*) *cf. praecursor* Frech is recorded 469 feet below the top. Both probably indicate Eifelian correlations.

#### *Grumbler Group*

Crickmay (1953, p. 11) divided the Frasnian limestones of the upper Mackenzie region into the Alexandra and overlying Grumbler Formations. These were new names for what was virtually the Hay River Limestone of previous workers (Cameron 1918, pp. 25, 26; Warren and Stelek 1950, fig. 1). Following more detailed surface and subsurface stratigraphical studies, Belyea and McLaren (1962, pp. 4-8) raised the Grumbler Formation to group status, recognized four formations in it, and since the Alexandra Limestone appears to be only a very local facies, demoted it to member status at the base of the group. In ascending order their formations are the Twin Falls (mostly limestone with minor shales), the Tathlina (a mixture of calcareous siltstones and silty limestones), the Redknife (argillaceous and silty limestones in the lower part becoming more argillaceous in the upper part), and the Kakisa (characterized by biostromal and biohermal reefs). At their type localities these formations are 521, 440, 231, and 187 feet thick respectively. About 50 miles west of Great Slave Lake, the Twin Falls and Tathlina Formations pass laterally into the Fort Simpson Formation and west of the lower Liard River the Redknife and Kakisa Formations pass laterally into the Carcajou Mountain Formation.

Many beds in the group have yielded prolific coral and brachiopod faunas, but ammonoids are not common. There are several specimens from the Redknife Formation on Liard River and Warren and Stelek (1956, pl. 24, figs. 2, 4) have figured another from the same formation on Trout River. All are specimens of *Manticoceras*, but at the present time it is not possible to assign them to species.

#### *Hare Indian Formation*

Kindle and Bosworth (1921, p. 45) erected the name Hare Indian River Shale for soft, greenish-grey, argillaceous limestones and calcareous shales, which are weathered fawn, and lie below the purer and more massive limestones of the Ramparts Formation in the Fort Good Hope area. The type section, on Mackenzie River a few miles above the mouth of Hare Indian River, exposes only about the top 100 feet of the formation. Probably a much thicker part lies concealed below, since at Imperial anticline, 60 miles south-south-west, the formation is 750 feet thick. Geologists of the Canol Project (Hume and Link 1945, pp. 19, 20; Hume 1954, pp. 23-25) discarded the name on the grounds that the formation is not sufficiently distinct to be mapped in the Norman Wells area. This was not justified; their correlations were at least partly inaccurate and at Norman Wells, 80 miles south-east of the type section, the Hare Indian is replaced by a dark shale facies. Warren and Stelek (1950, fig. 1; 1956, pl. 3) applied the name to

older beds on Anderson River, which are now included in the Hume Formation. Bassett (1961, pp. 490-2) broadened the formation in another way by including in it the distinct, but equivalent, lower dark shales of the Norman Wells area. North of the mouth of Ontaratue River there is a similar change in facies to the Fort Creek Formation.

#### *Headless and Hume Formations*

The beds discussed under this heading are very fossiliferous brown and grey, partly argillaceous limestones. On Anderson River their measured thickness is 197 feet, but southwards they thicken to between 400 and 600 feet in the central Mackenzie area, and still farther south, on Ram Plateau, about 80 miles west-south-west of Fort Simpson, to as much as 829 feet. The Hume Formation has long been known and referred to under several names, such as Ramparts (Warren 1944, pp. 120-2) or Hare Indian (Warren and Stelck 1950, fig. 1; 1956, pl. 3) in the Anderson River area, and Lower Ramparts Limestone Member (Hume and Link 1945, p. 19; Hume 1954, pp. 23, 24), or 'Ramparts' (Warren and Stelck 1950, fig. 1), or Lower Hare Indian Shale (Warren and Stelck 1956, pl. 1), or basal Devonian limestone (Crickmay 1960a, p. 1) in the central Mackenzie region. Such names could only be provisional and Crickmay (1960b, p. 877) introduced the Norman Wells Formation for the unit, with the 2,010 to 2,570 feet section in the Discovery No. 3 well of the Norman Wells oilfield as type section. Bassett (1961, pp. 486-90), in a publication which crossed Crickmay's in press, introduced the Hume Formation for the same unit, based on a surface section exposed on Hume River. Although Crickmay's name has about nine months' priority, article 11b of the Code of Stratigraphic Nomenclature is invoked to retain the name Hume Formation.

The Hume Formation can be traced southwards into the Nahanni Formation, from which it is distinguished only by its greater argillaceous content and softer and browner weathering characteristics. The Headless Formation was proposed by Douglas and Norris (1961, pp. 19, 20) for a more argillaceous facies equivalent of the Nahanni Formation, most obviously developed north and west of Nahanni Butte. Although the name is provisionally retained, it is most likely that the Hume and Headless Formations will be considered synonymous, in which case the name Hume should be retained since it has about four months' priority over Headless.

The Hume and Headless Formations have yielded extraordinarily prolific early Givetian faunas with particularly abundant corals and brachiopods, but surprisingly ammonoids have not been found.

#### *Horn River Formation*

The higher Givetian carbonates of the Great Slave Lake area change facies north-westwards and are replaced by dark, partly bituminous shales and minor limestones in the Horn Plateau region. Whittaker (1922, p. 52) studied limited exposures of the latter on Horn River and named them after that river. The West Territories Westrol No. 7A well (61° 39' 13" N.; 120° 43' 34" W.) encountered dark bituminous shales between 1,441 and 1,597 feet, for which Hunt (1954, pp. 2300, 2301) proposed the name Spence River Formation, but since they are part of the same unit as the Horn River Shales, Hunt's name is suppressed as a synonym.

Limestones in the formation on Horn and Willowlake Rivers contain *Leiorhynchus castanea* (Meek). Thus a Givetian age is established for at least part of the formation

and at the present time the Middle–Upper Devonian boundary, over a wide area around Fort Simpson, is placed at the Horn River–Fort Simpson formational contact.

#### *Kee Scarp Formation*

For reasons given previously (Pedder 1963) this name is at present used only in a most restricted sense for the type Kee Scarp lentil.

#### *Maligne Formation*

The history of the study of these beds is outlined in the section on the Flume Formation. The Maligne Formation includes the type horizon of *Timanites occidentalis*, which is now regarded as being synonymous with *T. keyserlingi* Miller. The importance of this occurrence lies in that it firmly correlates the *Calvinaria athabascensis* brachiopod fauna with the upper part at least of the *lumlicosta* Zone. *Manticoceras* has been reported from the Maligne Formation on several occasions, but it is unlikely that the genus *sensu stricto* occurs in beds as old as these. The reports by Allan *et al.* (1932, p. 236) and Fox (1951, pp. 827, 828) of *M. cf. oxy* are based on the holotype of *Timanites occidentalis*. Taylor's (1957, p. 190) report of *Manticoceras* is based on material which neither he nor Shell Oil Co. are now able to locate, and McLaren's material (1954, p. 169; Belyea and McLaren 1956, p. 89) was not among that loaned to the writers by the Geological Survey of Canada.

#### *Mount Hawk Formation*

This formation was proposed by de Wit and McLaren (1950, p. 5) for fossiliferous, argillaceous limestones and dolomites occurring in the clastic facies of the Alberta Rocky Mountains. Its thickness is variable, but is typically about 550 feet. Since its inception the limits of the type section have been modified (McLaren 1956, pp. 15, 16), at the base by the addition of the upper 156 feet of the Perdrix Formation of the earlier classification, and at the top by the removal of 82 feet to the Alexo Formation. It has also been refined by division into members, but for the sake of clarity these are omitted in the correlation chart.

There were several earlier classifications of the beds now assigned to this formation. The first of these was Raymond's (1930, pp. 294–6, 300), which included the beds in the lower part of the Fiddle and Boule Formations. Apart from interests of refinement, Fox (1951, pp. 823, 825) has given good reasons why much of Raymond's nomenclature is unsatisfactory. Other classifications included this formation in the upper part of the Blackface Formation (Kelly 1939, p. 2000) and in the lower part of the Cheviot Formation (Fox 1951, pp. 830–4). As a result of considerable subsequent work, these terms have lost most of their earlier usefulness and are now obsolete.

The first goniatites to have been recorded from this formation are said to be in the Cornell University collection. Merriam (1940, p. 73) referred to them as 'goniatites which appear to be of the *Manticoceras* type' and stated they came 'from beds immediately above the Miette black shale' (i.e. in the Mount Hawk Formation). Unfortunately, in spite of Professor Wells's efforts to find these specimens, they remain lost, but copies of the plates in Bissell's unpublished thesis (1930, pl. 8) clearly show that *Manticoceras* is present. Warren's (1949, p. 569) report of *Manticoceras* in his *jasperensis* Zone (i.e. in the Maligne to Mount Hawk Formations of present usage) is worded to suggest that

it is based on Merriam's report and therefore on the same specimens. However, the specimens of *Manticoceras* reported from the Mount Hawk Formation by McLaren (1956, pp. 25, 30; Belyea and McLaren 1956, p. 89) have, through his kindness, been restudied and are identified as *M. cf. sinuosum* (Hall). Several other specimens, also referred to *M. cf. sinuosum*, have been collected from the *Calvinaria albertensis* beds of the lower part of the formation. These occurrences clearly establish a correlation between part of the *cordatum* ammonoid Zone and the *albertensis* brachiopod Zone.

#### *Nahanni Formation*

Hage (1945, pp. 5, 6) established the Nahanni Formation for dark and fine-grained elastic limestones, that commonly form massive light grey cliffs. At the type locality it caps a prominent feature known as Nahanni Butte and is about 450 feet thick. Sections to the north and west, however, are thicker. Douglas and Norris (1960, pp. 14, 15) redefined the formation by removing the lower 130 feet of the original type section to what they later (1961, pp. 19, 20) called the Headless Formation.

The limestones of the type section were first mentioned by McConnell (1891, pp. 56, 57), who in spite of noting that the only coral in them had the external appearance of a Carboniferous genus, seems to have considered them Devonian. Cameron and Warren (1938, p. 17), who also described these limestones, assigned them more definitely to the Devonian. Farther north, the upper 130 feet of Kindle and Bosworth's (1921, p. 44) Lone Mountain section is the lower part of the Nahanni Formation and was correctly assigned to the Devonian.

No ammonoids have yet been found in the Nahanni Formation, but Givetian corals and brachiopods are common in some beds.

#### *North Nahanni River Group*

The first classification of the carbonates forming this group was made when McConnell (1891, pp. 14, 56) referred to the banded dolomites at Nahanni Butte as 'undoubtedly' belonging to the Castle Mountain Group. Subsequently dolomites of the same unit, exposed on Lone Mountain near the mouth of North Nahanni River, were named the Lone Mountain Dolomite (Kindle and Bosworth 1921, pp. 44, 45), but since this name was preoccupied by a Silurian formation in Nevada (Hague 1883, pp. 253, 262, 267), Kindle (1936, pp. 14, 15) replaced it by the term North Nahanni River Dolomite. The type area was remapped by Douglas and Norris (1961, pp. 14-19), who deliberately ignored previous nomenclature and proposed three formations for the old Lone Mountain Formation. In descending order these are the Landry (grey cryptocrystalline limestone), Manetoe (coarse, vuggy and brecciated dolomites), and Arnica (dark, banded, fine-grained, and dense dolomites). Following these proposals the old North Nahanni River Formation is raised to group status to embrace the new formations. Along its most eastern outcrop the group is between 2,000 and 3,000 feet thick, but about 45 miles to the west (that is, in those places where the group is not replaced by the Funeral Formation), thicknesses of more than 5,000 feet have been measured.

The group yields so few determinable fossils that Bosworth (1921a, p. 287) once named it the Barren Series. However, Givetian corals have now been found in the group and also it can be shown in the field to pass laterally into the Funeral Formation, which

contains Eifelian ammonoids. Thus its age is Middle Devonian and earlier suggestions that it is Cambrian or Silurian are erroneous.

#### *Palliser Formation*

Beach (1943, pp. 15–17) established this name for massive very fine-grained grey limestones and partly mottled dolomites, which constitute one of the great mountain building units of the Rockies and commonly exceed 1,000 feet in thickness, especially in the western ranges. De Wit and McLaren (1950, p. 6) refined it by proposing a lower Morro and much thinner upper Costigan Member. Most of Walcott's (1924, p. 51) Pipestone Formation is identical with the Palliser, but the name never gained popular usage and in any case is preoccupied by a Pre-Cambrian quartzite in Minnesota (Winchell 1888, p. xxii).

A clymenid, tentatively identified as *Platyclymenia*, has been found in the Costigan Member. It occurs with *Leioproductus* sp. cf. *L. coloradensis* (Kindle), '*Nudirostra*' *ventricosa* (Haynes), '*Camarotoechia*' *nordeggi* Kindle, and *Cyrtiopsis* sp. Thus the local *ventricosa* brachiopod Zone can now be tentatively directly correlated with the *Platyclymenia* major Zone. Previously both Warren (1927, p. 20) and Taylor (1958, p. 15) hinted that clymenids are present in the Palliser Formation by listing ?*Platyclymenia americana* Raymond and cf. *Platyclymenia* respectively, from it. Unfortunately the specimens in both cases are now lost.

#### *Perdrix Formation*

The Perdrix Formation consists of dark to black, partly calcareous shales, or, especially towards the carbonate facies, of dark nodular argillaceous limestones. The fullest sections are between 500 and 600 feet thick, but the formation thins and becomes less distinct towards the carbonate facies. The unit was first named Miette by Kindle (1929, pp. 180, 184). This name, however, had already been pre-empted by Walcott (1913, pp. 335, 340) for Pre-Cambrian sandstones in British Columbia and Alberta. At about the same time the unit was also recognized by Raymond (1930, pp. 295, 296) and Kelly (*in* Allan *et al.* 1932, pp. 234, 235; Kelly 1939, p. 2000). A misunderstanding of the structure on Roche Miette led Raymond to confer two names on the formation, the Perdrix and the now discarded Kiln. Kelly termed the unit the Blackface, or Blackface Mountain Formation, but seems to have included in it beds now referred to the Mount Hawk Formation. In any case the name was never formally proposed and has passed out of use.

The fauna described by Burgess (1931) is typical of the Perdrix Formation in the Jasper area. The more calcareous facies, however, contains *Leiorhynchus carya* Crickmay, *Calvinaria insculpta* (McLaren), and *Warrenella nevadensis* (Walcott). The Perdrix goniatites mentioned by Raymond (1930, p. 296) and identified by Burgess (1931, p. 2000) as *Tornoceras bicostatum* Hall, which is an *Aulatornoceras*, have been restudied and are now referred to *Tornoceras* (*T.*) sp. indet. The other specimens mentioned by Raymond (1930, p. 298) as *Manticoceras* sp. indet. and *Gephuroceras* sp. indet. have not been seen, but two specimens of *Manticoceras* cf. *sinuosum* (Hall) kindly loaned to the writers by the Geological Survey of Canada are from this formation. Although far from spectacular, these occurrences indicate that the *insculpta* brachiopod Zone may be equated with part of the *cordatum* goniatite Zone.



*Slave Point, Amco, and Sulphur Point Formations*

Cameron (1918, p. 26) proposed the name Slave Point for limestones lying between the Simpson and Presqu'île Formations in the Great Slave Lake area. It is now appreciated that the facies relationships in that area are more complex than envisaged by Cameron and that modifications of his classification are required. Law's (1955, pp. 1943-9) suggestion that the Slave Point be restricted to beds above a thin shale interval named the Amco by Campbell (1950, p. 90) is followed here. The limestones between the Amco Shale and the Presqu'île Dolomite are being named the Sulphur Point Formation (Norris, in press); this is also incorporated in the correlation chart. The Slave Point, Amco and Sulphur Point Formations on the southern side of Great Slave Lake are reported by Campbell (1950, pp. 90, 91) to be 170, 11, and 130-190 feet thick respectively.

Precise correlations of these formations is not possible, mainly because of the lack of palaeontological control. However, Norris has found *Stringocephalus* in the Sulphur Point, Presqu'île, and underlying Pine Point Formations, and *Ladogioides* has been found above the Slave Point Formation in the vicinity of Sulphur Bay (D. J. McLaren, personal communication). These occurrences confirm that the Slave Point and Sulphur Point Formations are Givetian. As pointed out by Law (1955, p. 1951), the Amco and at least some part of the Sulphur Point Formation are equivalent to the Watt Mountain Formation of north-western Alberta.

## SYSTEMATIC DESCRIPTIONS

by M. R. House

Family MIMOCERATIDAE Steinmann 1890

Genus GYRO CERATITES von Meyer 1831

*Type species by the subsequent designation of Schindewolf 1933: Gyroceratites gracilis* Bronn 1835.

*Gyroceratites (Lamelloceras) sp.*

Plate 74, fig. 1

*Material.* One specimen preserved crushed and distorted in silty fissile shale.

*Remarks.* The critical features of this specimen may be seen on the illustration. Crushed and displaced along the venter are shown paired ridges which appear to have extended as spiral sheets. This unusual feature is only known, among early tightly coiled goniatites, in certain species of *Gyroceratites* for which Erben (1960, p. 78) has proposed the sub-generic name *Lamelloceras*, with *G. dorsolamellatus* Erben (1953, p. 185, pl. 17, figs. 7, 9, text-fig. 3; 1960 pl. 4, fig. 7, text-fig. 18b) as type species. The ornament in the Canadian specimen is close to that known in the Eifelian *G. (G.) gracilis*, but may well be shown on species of *Lamelloceras* larger than those so far described. *Lamelloceras* ranges in Europe from the upper Emsian to the middle Eifelian.

*Horizons and locality.* GSC 16921 (TOC G5058), collected by A. E. H. Pedder from 1,466-1,476 feet below the top of the Funeral Formation and 2,484-2,494 feet below the top of the Nahanni Formation (both measurements slightly excessive due to minor faulting in the section) in the northern Arnica Range, Northwest Territories, about 61° 55' N., 125° 13' W.

## Genus TEICHERTICERAS Erben 1960

Type species by original designation: *Gyroceratites desideratus* Teichert 1948.

*Teicherticeras lenzi* sp. nov.

Plate 75, figs. 1-3, 10, 11; text-fig. 3

*Material.* One exquisitely preserved specimen in a black, styliolinid mudstone. The specimen is a testate phragmocone partly preserved in crystalline calcite.

*Dimensions (in mm.)*

	D	WW	WH	UW
GSC 16929	51.0	13.0	19.2	21.8
..	32.0	8.5	11.8	13.5
..	11.1	3.2	4.1	4.4



TEXT-FIG. 3. *Teicherticeras lenzi* sp. nov. Cross-section at 52 mm. diameter based on GSC 16929 from 296 feet below the apparent Hume Formation on the Ogilvie River, Northwest Territories. Natural size.

*Description.* Shell form laterally compressed, evolute, whorls advolute at least above 4.5 mm. diameter. Whorl section with flat dorsum and rounded umbilical shoulders: maximum width on the lower flanks, the flanks then converging towards a flat tabular venter. At the sharp ventro-lateral shoulders there appear to have been continuous raised flares. Along the course of the tabular venter are periodic indentations (Pl. 75, fig. 2) which are related to grooves between slight ribs on the flanks.

Growth-lines form a salient on the dorsal mid-line and another slight salient on the umbilical shoulder. Over the flanks growth lines are gently rursiradiate with a shallow sinus on the outer-mid-flanks and a salient on the outer flanks. The growth-lines pass back to a deep linguiform sinus on the venter. Before about 15 mm. diameter, the shell is ornamented by periodic strong rursiradiate ribs with a sharp crest commonly developed (Pl. 75, fig. 11).

A septum seen at 50 mm. diameter shows a broad lateral sinus passing to a saddle centred on the dorsal mid-line which may have a slight lobe at its crest. Ventrally there is probably a small lobe, but this was not seen.

*Remarks.* There is no evidence at any stage that there is an impressed area. This factor, and the paired ventral flares, would suggest that generic reference should be to *Gyroceratites* (*Lamelloceras*). But the growth-line pattern is utterly different from any known in *Gyroceratites* and is distinctly primitive. Similar patterns are shown in the early whorls of *Teicherticeras lardeuxi* Erben (1960, p. 68, pl. 5, figs. 5-7). The poor evidence of ornament in *T. desideratum* (Teichert 1948, p. 65, pl. 16, fig. 1) at larger diameters is similar to that of the Canadian specimen. The whorls of an undescribed species from Nevada are significantly more serpenticonic and are distinctly ribbed and have no marked lateral sinus. The new species is referred to *Teicherticeras*, but, as has been remarked elsewhere (House 1962, p. 252), the *Teicherticeras* group is a variable group which is still only imperfectly known. The horizon of the specimen is probably Emsian rather than Eifelian.

*Horizon and locality.* GSC 16929 (CSC W6-58) from 296 feet below the base of the Hume equivalent on the Ogilvie River, Yukon, 65° 23' N., 138° 31' W.

Family AGONIATITIDAE Haug 1898  
Genus AGONIATITES Meek 1877

*Type species by the subsequent designation of Foord and Crick 1897: Goniatites expansus Vanuxem 1842.*

*Agoniatites cf. vanuxemi* (Hall)

Plate 72, figs. 3, 4

*Material.* Two specimens preserved partly in a tentaculitid-rich limestone and partly as internal moulds of crystalline calcite.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>Wh</i>	<i>UW</i>
GSC 16922	47.5	20.0	c. 20.0	c. 17.5	18.3
"	30.0	15.8	—	—	10.0
GSC 16923	—	—	23.8	19.0	—

*Description.* Shell form compressed, sub-evolute, with whorl section of early volutions depressed, reaching WW = WH at about 47 mm. diameter and becoming slightly compressed thereafter. Whorl section with maximum width close to the steep umbilical wall and rounded shoulder. Flanks converge convexly towards a ventro-lateral furrow which is weakly double both on the shell and internal mould. The venter is almost flat but slightly convex.

Suture shows a small V-shaped ventral lobe, and an immediately adjacent ventro-lateral saddle. The broadly rounded lateral lobe extends from the ventro-lateral saddle to an umbilical saddle which centres on the umbilical seam. Dorsal suture not seen.

*Remarks.* Agoniatitids are notoriously variable, but the best of these specimens (GSC 16922) is almost identical with comparable inner whorls of type material of *A. vanuxemi* from the Cherry Valley Limestone of New York (compare with Miller 1938, pl. 10, fig. 3). but since no outer whorls are available the Francis Creek specimens cannot with certainty be assigned to that species.

*Horizon and locality.* Both specimens, GSC 16922-3 (TOC H6053), were collected by E. W. Best and D. Barss from an unnamed dark shale unit (the Lower Fort Creek and Hare Indian of authors) 10-20 feet above the top of the Hume Formation in Francis Creek, Northwest Territories, about 65° 14' 20" N., 126° 23' 40" W.

*Agoniatites aff. fulgurialis* (Whidborne)

Plate 70, fig. 1; Plate 73, fig. 5

1962 *Agoniatites sp.* House, p. 255.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WH</i>	<i>UW</i>
GSC 16925	75.0	c. 39.0	c. 12.0
GSC 16924	45.0	c. 23.5	c. 5.0

*Description.* Shell form probably compressed, involute with small open umbilicus. Ornament weak, consisting of growth-lines which form a prominent projecting ventro-lateral salient, a shallow sinus on the outer flanks and a weak salient on the lower

flanks. In the smaller specimen growth lines are marked by raised striae about 1.2 mm. apart on the mid flanks at about 33 mm. diameter. These appear to become weaker and closer set at larger diameters. Suture not seen.

*Remarks.* Agoniatitids with subdued ornament and small umbilicus at diameters comparable with these specimens are not numerous. Described species of the group include: *A. fulgurialis phillipsi* Wedekind (1917, p. 112, pl. 16, fig. 1), *A. roemeri* (Holzapfel 1882, p. 234, pl. (45) 2, figs. 1, 1a), *A. vernorhenanus* (Maurer 1876, p. 821, pl. 1, figs. a-c), *A. kayseri* Wedekind (1917, p. 110, pl. 15, fig. 10), *A. clariondi* Petter (1959, p. 77, pl. 1, figs. 9, 9a), and *A. occultus* (Barrande 1865, p. 36, pl. 9, figs. 14-17). The presence of a prominent ventro-lateral furrow in the Canadian specimens is shown in *A. vernorhenanus*, *A. occultus*, and *A. fulgurialis fulgurialis* (Whidborne). Of these, comparison with the last is preferable, but the specimens show less sinuous growth-lines and a narrower umbilicus than the types of Whidborne (1890, p. 59, pl. 5, figs. 4, 4a).

*Horizon and localities.* One specimen collected by A. E. H. Pedder, GSC 16924 (TOC D139) from an unnamed dark shale (Lower Fort Creek and Hare Indian of authors) about 20 feet above the top of the Hume Formation on Bosworth Creek, Northwest Territories, about 65° 20' N., 126° 51' W. The other specimen, GSC 16925 is from the Fort Creek Shale at an unknown horizon on the Ogilvie River, Yukon, at about 65° 20' N., 138° 44' W.

*Agoniatites* cf. *holzapfeli* Wedekind

Plate 70, fig. 8

*Material.* A single, incomplete, partly crushed specimen preserved in tough fissile dark-grey shale.

*Remarks.* The specimen is a distinctively evolute agoniatitid. Although poorly preserved, the large protoconch shows clearly. This specimen is comparable to *A. holzapfeli* Wedekind (1917, p. 113, pl. 15, figs. 13, 14, text-fig. 21i) rather than *A. costulatus* (d'Archiac and de Verneuil 1842, p. 341, pl. 26, figs. 3, 3a, 3b), for the lateral growth-line sinus is low on the flanks and the ribbing becomes quite subdued by 22 mm. diameter.

*Horizon and locality.* The specimen, GSC 16926 (CSC MC21-59), is from the Fort Creek Formation on the Ogilvie River, Yukon, about 65° 20' N., 138° 44' W.

EXPLANATION OF PLATE 70

- Fig. 1. *Agoniatites* aff. *fulgurialis* (Whidborne) from the Fort Creek Formation on the Ogilvie River, Yukon. GSC 16925,  $\times 1$ .  
 Figs. 2, 3, 7. *Maenioceras* sp. from the Fort Creek Formation on the Carnwarth River. Respectively GSC 16941-2,  $\times 2$ ; GSC 16948,  $\times 1$ .  
 Fig. 4. *Agoniatites* sp. from the Fort Creek Formation at Hungry Lake, Yukon. GSC 16927,  $\times 2$ .  
 Figs. 6, 10. *Ponticeras* sp. from an unnamed shale unit 10-40 feet above the top of the Beavertail Formation on Carcajou Ridge, Northwest Territories. 6, GSC 16947,  $\times 2$ . 10, GSC 16945, showing sutures weathered out.  
 Figs. 5, 9. *Ponticeras* cf. *tchernyschewi* (Holzapfel) from the same horizon and locality. GSC 16943 and GSC 16944 respectively, both  $\times 1$ .  
 Fig. 8. *Agoniatites* cf. *holzapfeli* Wedekind from the Fort Creek Formation on the Ogilvie River, Yukon. GSC 16926,  $\times 2$ .

*Agoniatites* sp.

Plate 70, fig. 4

*Material.* A single, incomplete specimen preserved in dark-grey shale.

*Remarks.* The marked ribbing shown on the illustration of this specimen is due to crushing of the camerae of the phragmocone. The interest of the specimen lies in the unusually weak projection of the ventro-lateral salient and the apparent absence of a ventro-lateral furrow. This may represent a new species.

*Horizon and locality.* The specimen, GSC 16927 (CSC WH23H-58), is from an unknown horizon in the Fort Creek Formation at Hungry Lake, Yukon, 65° 36' 30" N., 136° 24' W.

## Genus SELLAGONIATITES nov.

*Type species.* *Goniatites discoides* Waldschmidt 1885 (the holotype is refigured here: Pl. 73, figs. 6, 7).

*Diagnosis.* Involute, umbilicate, laterally compressed agoniatitids with a suture similar to *Agoniatites* but with a mid-dorsal lobe and a shallow lobe on the ventral face of the ventral lobe. Growth-lines biconvex.

*Distribution.* The type species occurs in the upper Givetian *discoides* Kalk in Germany (Schmidt 1958, p. 325) and is known in the upper Givetian of North Africa (Petter 1959, p. 87). The genus may well be represented in New York State by *S. unilobatus* (Hall) and is represented in the Northwest Territories by *S. jacksoni* sp. nov.

*Sellagoniatites jacksoni* sp. nov.

Plate 71, figs. 1-4; text-fig. 4A, B

*Material.* One specimen only, the holotype, preserved as an incomplete internal mould in a grey calcareous mudstone.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>UW</i>
GSC 16928	156	c. 50	78	30.5

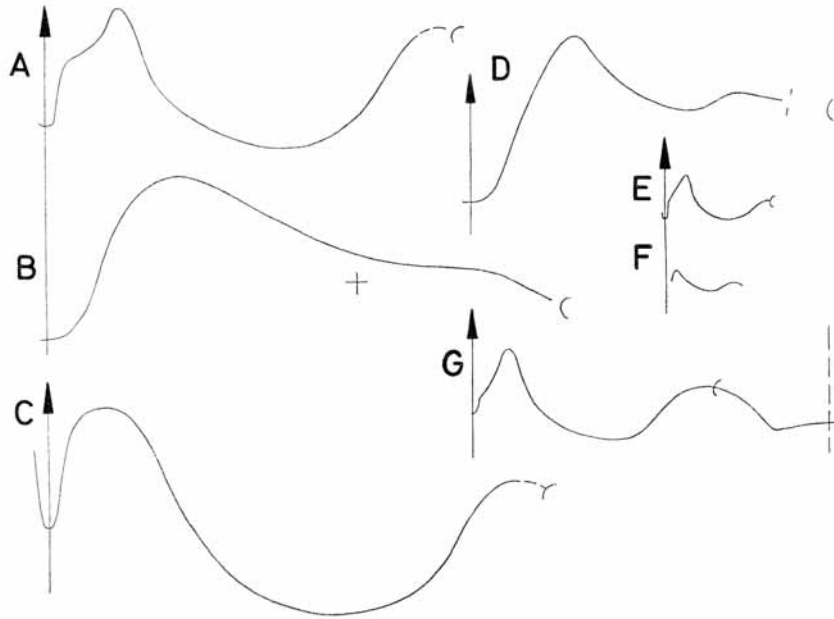
*Description.* Shell form involute, laterally compressed. Whorl section compressed, with maximum width two-fifths across the flanks from the umbilicus at the maximum diameter. The outer flanks slope flatly towards a well-rounded venter; the inner flanks slope convexly towards the umbilicus. Along the line of maximum whorl width are periodic nodes, and there are five of these, with weak traces of a sixth, in the last half whorl. The nodes become more prominent on the body chamber.

Sutures (text-fig. 4A) show a V-shaped ventral lobe with sigmoidal sides, the lobe being extended apically along the course of the siphuncle. The ventro-lateral saddle is acutely rounded and the lateral lobe is very broad and semicircular. The dorsal suture has not been observed.

Growth-lines (text-fig. 4B) show a deep linguiform sinus on the venter passing to a broad salient on the outer flanks. Laterally the growth-lines are concavely prosiradiate with a weak salient on the inner flanks. At the extreme apertural end of the body chamber is a very shallow constriction parallel with the course of the growth-lines.

*Remarks.* This species is larger than the two other members of *Sellagoniatites* so far

recognized, *S. unilobatus* (Hall 1879, pl. 71, figs. 15, 16; pl. 74, fig. 5) and the type species *S. discoides*. Illustrations of the latter are given here (Pl. 73, figs. 4, 6–8): one is the holotype and the other is a topotype in the Göttingen Museum, and a dorsal view of the impressed area (Pl. 73, fig. 8) shows the mid-dorsal saddle which is the critical



TEXT-FIG. 4. A, B, *Sellagoniatites jacksoni* gen. et sp. nov. A, Suture at c. 120 mm. diameter. B, Growth-line at 145 mm. diameter: the cross marks the position of a node. Both based on the holotype, GSC 16928, from the Fort Creek Formation on the Carnwarth River, Northwest Territories. C, D, *Agoniatites vanuxemi* (Hall). C, Suture at 127 mm. diameter based on AMNH 4416/1; i (figured Hall 1879, pl. 67, fig. 1). D, Growth-line at c. 91 mm. diameter based on AMNH 4416/1; iii (figured Hall 1879, pl. 66, figs. 1, 2). Both from the Cherry Valley Limestone at Manlius, N.Y. E, F, *Sellagoniatites unilobatus* (Hall). E, Suture at 33 mm. diameter. F, Growth-line at 27 mm. diameter. Both based on the holotype, NYSM 3547, labelled 'Hamilton Beds, Norton's Landing, Cayuga Lake, N.Y.'. G, *Sellagoniatites discoides* (Waldschmidt). Suture at a whorl height of 31 mm. of a topotype in the GP1G from the *discoides* Schichten at Ense near Wildungen, Germany. All natural size.

feature of the new genus. *S. jacksoni* differs from the type species in that the venter is flatly rounded rather than sub-acute. At comparable diameters, *S. discoides* appears to be more compressed. *S. unilobatus*, known only from the holotype from the top of the Hamilton Formation at Norton's Landing, Cayuga Lake, New York, is too small for adequate comparison with either species since the maximum diameter of the holotype is only 36 mm. However, an examination of that specimen (NYSM 3547) suggests that the growth-lines have a deeper lateral sinus and more prominent salient on the inner

flanks than are shown by *S. jacksoni* at much greater diameters (text-fig. 4B, F). All species included within the new genus show a characteristic concavity at the sides of the ventral lobe (text-fig. 4A, E, G).

*Horizon and locality.* The holotype, GSC 16928 (PAPC GS-4-59B), is from talus at the foot of an outcrop of the lower part of the Fort Creek Formation on the Carnwarth River, Northwest Territories, 7½ miles downstream (direct) from the confluence with the Iroquois River, 68° 11' 30" N., 129° 20' 24" W.

Family ANARCESTIDAE Steinmann 1890  
Genus ANARCESTES Mojsisovics 1882

*Type species by the subsequent designation of Foord and Crick 1897: Goniatites plebeius* Barrande 1865.

*Anarcestes (Latanarcestes) cf. praecursor* Frech

Plate 74, fig. 3

- 1865 *Goniatites plebeius* (pars) Barrande, p. 37, pl. 7, figs. 3-9.  
1897 *Anarcestes praecursor* Frech, p. 169.  
1913 *Anarcestes praecursor* Frech, p. 14.  
1959 *Anarcestes praecursor* Chlupáč, p. 482, 492, 505.

*Material.* One crushed specimen preserved in grey calcareous mudstone.

*Description.* Shell form apparently sub-globular, involute with small open umbilicus. Growth-lines weakly shown, with a salient on the lower flanks and a slight sinus on the mid flanks which passes towards a ventro-lateral salient. Suture with a broad and very shallow lateral lobe and a saddle approximately centred on the seam. Suture not seen on the ventral and dorsal sides.

*Remarks.* The weak growth-lines and subglobular form preclude this specimen from *Agoniatites* and indicate an anarcestid, and the shallow and wide lateral lobe shows that it should be referred to *Anarcestes (Latanarcestes)*, among the described species of which only *A. (L.) praecursor* has so narrow an umbilicus. Indeed, the Canadian specimen has a smaller umbilicus than that shown on any of Barrande's figures, but this is in part at least emphasized by crushing.

Chlupáč has shown that this species occurs in the Trebotov Limestone of Czechoslovakia, and in the Suchomasty Marble associated with a lower Eifelian fauna. He has also demonstrated that Prantl's statement (1954) that the species is Siegenian is false.

*Horizon and locality.* The specimen, GSC 16930 (TOC G5170), was collected by A. E. H. Pedder from a horizon 469 feet below the top of the Funeral Formation and 1,525 feet below the top of the Nahanni Formation in the northern Funeral Range, Northwest Territories, about 61° 41' 30" N., 125° 05' W.

Genus CABRIEROCERAS Bogoslovski 1958

*Type species by original designation: Goniatites rouvillei* von Koenen 1886.

*Cabrieroceras karpinskyi* (Holzapfel)

Plate 72, figs. 1, 2, 7, 9-12; text-fig. 5

- 1895 *Anarcestes karpinskyi* Holzapfel, p. 77, pl. 3, figs. 15-20.  
1917 *Anarcestes Rouvillei* (pars) Wedekind, p. 109.

1933 *Werneroceras rouvillei* (pars) Schindewolf, p. 98.

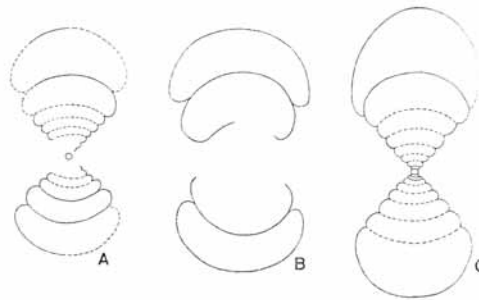
1958 *Werneroceras karpinskyi* Bogoslovski, p. 74.

1959 *Werneroceras* (?) *karpinskyi* Petter, p. 105.

*Material* Eight specimens preserved as internal moulds in crystalline calcite.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>UW</i>
GSC 16931	48.2	c. 22.3	15.9	20.3
GSC 16932	37.4	c. 19.0	c. 10.5	18.2
..	24.2	15.1	6.8	11.8
GSC 16933	24.3	15.7	8.4	11.5
GSC 16934	27.5	17.0	c. 9.5	c. 11.0

*Description.* Protoconch 1.4 mm. wide. Shell form rotund in the inner whorls with an open, expanding umbilicus; becoming compressed in the outer whorls. Whorl section



TEXT-FIG. 5. *Cabrieroceras karpinskyi* (Holzapfel). A, Cross-section based on GSC 16932. B, Tangential cross-section of GSC 16935. C, Cross-section based on GSC 16931. All from 0-10 feet above the top of the Hume Formation on Francis Creek, Northwest Territories. All natural size.

extremely depressed up to about 20 mm. diameter with the whorl height about one-third of the whorl width; the venter is thus extremely broad and flat and the flanks limited and well rounded. Above 20 mm. diameter the section gradually becomes more reniform, and the relative whorl height increases; thus the umbilical angle, which in early whorls is about  $86^\circ$ , becomes less in the outer whorls (text-fig. 5). The diameter at which this change takes place is rather variable as the figures given above show, but the quality of the material is not sufficient to analyse the variation critically. The suture has not been seen.

Growth-lines are well shown and on the inner whorls occur as finely spaced striae backwardly directed from the umbilical seam. At 20 mm. diameter growth-lines on the broad venter form a shallow sinus distally and a rounded salient before passing back into a U-shaped sinus, about as broad as deep, on the mid-ventral line.

#### EXPLANATION OF PLATE 71

Figs. 1-4. *Sellagoniatites jacksoni* gen. et sp. nov. Holotype, GSC 16928, from talus at the foot of an outcrop of the lower part of the Fort Creek Formation on the Carnwarth River, Northwest Territories. 1, 2, 4,  $\times 0.94$ ; 3,  $\times 2$ .



*Remarks.* The only other species of *Cabrieroceras* known from North America is *C. plebeiforme* (Hall) from the *Werneroceras* Bed below the Cherry Valley Limestone in eastern New York State (Rickard 1952, House 1962), unless *Werneroceras staufferi* Sweet and Miller (1956) belongs here. Both *C. plebeiforme* and its probable European equivalent, *C. crispiforme*, show a regular increase in the width of the umbilicus and an almost constant whorl form throughout ontogeny without such prominent modifications in the outer whorls as Holzapfel described in the type material of *C. karpinskyi*. These modifications were apparently overlooked by Wedekind and Schindewolf (1933, p. 94), who have regarded *C. crispiforme* (= *C. rouvillei*) and *C. karpinskyi* as synonyms. Stratigraphically *C. crispiforme* is characteristic of the lowest Givetian whilst *C. karpinskyi* occurs in the middle and upper Givetian. Illustrations of one of Holzapfel's original types are given here for comparison with the Canadian specimens (Pl. 72, figs. 5, 6, 8).

*Horizon and locality.* Eight specimens collected by E. O'Bertos, GSC 16931-8 (TOC H6054), from an unnamed dark shale unit (Lower Fort Creek and Hare Indian of authors) 0-10 feet above the top of the Hume Formation. Specimens of *Cabrieroceras* sp. also occur slightly higher in the succession. The locality is on Francis Creek, Northwest Territories, 65° 14' 20" N., 126° 23' 46" W.

Family MAENIOCERATIDAE Ruzhencev 1958  
Genus MAENIOCERAS Schindewolf 1933

*Type species by original designation:* *Goniatites terebratus* G. and F. Sandberger 1850.

*Maenioceras* sp.

Plate 70, figs. 2, 3; Plate 72, fig. 16

*Material.* Two poorly preserved specimens in tough calcareous shale.

*Remarks.* The specimens are too poorly preserved to warrant detailed description. The involute form, evidence of ventro-lateral furrows, angular lateral lobes (Pl. 70A, fig. 3), and distinctive wrinkle layer (Pl. 72, fig. 16; see House 1962, p. 269), all show that reference should be to the *Maenioceras terebratum* group. The occurrence with these of specimens determinable as *Wedekindella* aff. *brilonense* (Kayser), and *Agoniatites* sp. confirms that the horizon is upper Givetian.

*Horizon and locality.* Both specimens are from an unknown horizon in the Fort Creek Shale along the Carnwarth River, Northwest Territories, about 67° 40' N, 128° 22' W. The specimens are GSC 16941-2 (CSC RAS62-59).

Family PINACITIDAE Schindewolf 1933  
Genus WEDEKINDELLA Schindewolf 1933

*Type species by original designation:* *Goniatites retrorsus* var. *brilonense* Kayser 1872 (the holotype is figured here: Pl. 73, fig. 2).

Several specimens of this genus are now known from several localities in the Northwest Territories. A description has already been given of two specimens of *W. brilonense* from along the Carnwarth River (House 1962). New material includes a specimen of *Wedekindella* sp. (GSC 16959) from the Fort Creek Shale on the Anderson River (Pl. 73, fig. 1) which appears to represent a non-constricted form. From the Fort Creek Shale is a specimen referred to *W.* aff. *brilonense* (Pl. 73, fig. 3) which differs from *W. brilonense*

in showing evidence of a weak but continuous ventro-lateral furrow. None of the specimens referred to *Wedekindella* so far show the form of the suture.

*Horizons and localities.* GSC 16939 (CSC RAS83-59) from an unknown horizon in the Fort Creek Formation, 45 miles NNE of the Thunder River Mouth, Northwest Territories, about 68° 00' N., 130° 10' W. GSC 16940 (CSC RAS62-59), from an unknown horizon in the Fort Creek Formation on the Carnwarth River, Northwest Territories, about 67° 41' N., 128° 22' W. AU 45447, from 130 feet above the base of the Fort Creek Formation on the Carnwarth River, Northwest Territories.

Family GEPHURCERATIDAE Frech 1902  
Genus PONTICERAS Matern 1929

*Type species by original designation: Ammonites aequabilis* Beyrich 1837.

*Ponticeras* cf. *tschernyschewi* (Holzapfel)

Plate 70, figs. 5, 9, 10

*Material.* Seven specimens collected by A. C. Lenz and preserved crushed in grey fissile siltstone.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WH</i>	<i>UW</i>
GSC 16944	62.5	20.4	26.4
..	44.0	17.8	14.0

*Description.* Shell form evolute, apparently laterally compressed, with wide open umbilicus. Whorl section not discernible, but fractures suggest maximum whorl width was on the lower flanks and there was a ventro-lateral furrow with a slightly raised ridge on the umbilical side. Several specimens show a slight contraction of the whorl height in the outer part of the body chamber.

Sutures show evidence of a trifid ventral lobe, a large lateral saddle with a crest on the mid-flanks and a rounded sub-umbilical lobe. Weathered sutures (Pl. 70, fig. 10) falsely resemble those of *Protornoceras*. Growth-lines not seen.

*Remarks.* Evolute ponticeratids of this type occur in the Lower Frasnian in many parts of the world. The specimens resemble *P. perlatum* (Hall) from the Genesee Shale and Sherburne Sandstone of New York State, but the whorls of that species appear to expand more rapidly and show irregularities along the growth-lines simulating ribs (House 1962, pl. 45, fig. 10). Other closely related species are: *P. tschernyschewi* (Holzapfel 1899, p. 30, pl. 4, figs. 1-6; pl. 6, fig. 8), *P. sandbergeri* (Wedekind 1913), *P. sahlgrundensis* Matern 1931, *P. pernai* (Wedekind 1917). All these are Lower Frasnian forms apart from *P. sandbergeri*, which Wedekind records in the Middle Frasnian. Other known species of *Ponticeras* have too rotund a whorl section to be comparable. In the anticipation that solid specimens will eventually appear from Canada some dimensions (in mm.) of the types of these European species will be given, based on new measurements, to facilitate future comparisons.

	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>UW</i>
<i>P. tschernyschewi</i> (probable syntypes in Göttingen Museum)	45.0	17.0	7.8	15.5
..	-	19.5	9.9	-
<i>P. sandbergeri</i> , lectotype	c. 17.0	4.7	5.5	c. 8.0
.. syntype	13.0	3.5	4.5	5.5
<i>P. sahlgrundense</i> , syntype	25.3	7.8	10.4	7.1
<i>P. pernai</i> , holotype	38.0	c. 12.0	14.6	11.5
..	c. 22.0	8.2	9.5	7.2

Of these species only *P. tschernyschewi* has been recorded at diameters comparable with the Canadian specimens, and agreement is close in other factors; for example, some of Holzapfel's figures (e.g. pl. 4, figs. 5, 6) show the same contraction of the adult whorl height, and others (e.g. pl. 4, fig. 3) show the same ventro-lateral groove and ridge on the internal mould.

*Horizon and locality.* GSC 16943-6 (CSC L-8) collected by A. C. Lenz from an unnamed dark shale 10-40 feet above the top of the Beavertail Formation (Upper Fort Creek of authors) on Carcajou Ridge, Northwest Territories, about 65° 36' N., 128° 30' W.

#### Genus PROBELOCERAS Clarke 1898

*Type species by monotypy:* *Goniatites lutheri* Clarke 1885.

The genus *Probeloceras* forms a very distinct group of lower Frasnian goniatites. In addition to the type species, the following species belong here: *P. forcipiferum* (G. and F. Sandberger), *P. genundewa* (Clarke), *P. planorbis* (G. and F. Sandberger 1851, pl. 9, fig. 3a here designated lectotype), *P. (?) orientale* Bogoslovski and *P. applanata* (Wedekind). The group has tabular or grooved venters; commonly the grooved form is seen only in testate specimens whilst internal moulds often show no ventral groove. Very closely related to this group, and probably derived from it, are those species generally included in *Manticoceras* which have a similar shell form. These include *M. neapolitanum* (Clarke), *M. holzapfeli* (Clarke), and *M. alveolatum* (Glenister). The only distinction between the two groups is that the latter group have an umbilical lobe in addition to the lateral lobe. If a generic name is ever required for this group, then the somewhat inappropriate name *Acanthoclymenia* is available, the type species of which is *M. neapolitanum* (see House 1961).

#### *Probeloceras* sp.

Plate 76, figs. 1-4, 7; text-fig. 6 A-C

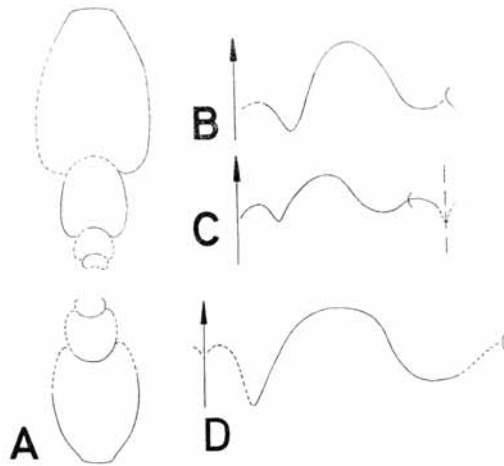
*Material.* Three small pyritized specimens, and three specimens crushed flat in black shale which may belong here.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>UW</i>
IOC 258a	17.2	-	c. 5.0	c. 4.9
IOC 258b	8.8	2.2	3.3	3.3
..	5.9	1.6	2.3	2.0
GSC 16972	4.5	1.3	1.75	1.4

*Description.* Shell form laterally compressed, evolute in innermost whorls, sub-evolute in outer whorls. Whorl section with slight impressed area from earliest whorls, with well-rounded flanks, weak ventro-lateral furrows, and sub-tabular venter by 6 mm. diameter becoming sharply tabular in outer whorls. Shell development shown in text-fig. 6A. At no stage seen is the internal mould grooved. Sutures are illustrated in text-fig. 6B. Growth-lines are not well seen, but are apparently biconvex.

*Remarks.* The two species of *Probeloceras* from the *cordatum* Zone, or its equivalents, *P. lutheri* and *P. genundewa*, both have more pronounced mid-ventral saddles at comparable diameters. Of those from the *lumlicosta* Zone, the holotype of *P. forcipiferum*, which reaches 18 mm. diameter, has a higher mid-ventral saddle and narrower lateral

saddle than the Canadian specimens at 10 mm. diameter, and the flanks of both *P. forcipiferum* and *P. planorbis* are considerably flatter. *P. applanata* and *P. (?) orientale* are apparently more involute and rotund, but there is a *Proboloceras* among specimens figured by Hall (1879, pl. 70, fig. 8) which has a suture at *c.* 24 mm. diameter (text-fig. 6D) with a relatively broader lateral saddle, but the flanks are moderately rounded.



TEXT-FIG. 6. *Proboloceras* sp. from Canada and New York State. A, B, Whorl section at 8.8 mm. diameter and suture at 7 mm. diameter based on IOC 258b from the Imperial Paddle River Borehole between 7,913 and 7,932 feet. Both  $\times 6$ . C, Suture at 9.5 mm. diameter based on IOC 258a from the same locality and horizon.  $\times 6$ . D, Suture at 2.24 mm. diameter based on AMNH 5833/1:2 (figured Hall 1879, pl. 70, fig. 8) from the Genesee Shale near Genesee, N.Y. Reversed for comparison.  $\times 5$ .

It is unfortunate that these various species are not better described. As a result the Canadian specimens cannot be critically compared with them at similar diameters. The specimens seem closest to those species from the *lumulicosta* Zone rather than the *cordatum* Zone.

#### EXPLANATION OF PLATE 72

- Figs. 1, 2, 5-12. *Cabrieroceras karpinskyi* (Holzapfel). 1, 2, GSC 16931,  $\times 1$ . 7, 9-12, GSC 16933; 9-12,  $\times 1.5$ ; 7,  $\times 4$ . Both specimens from an unnamed shale unit 0-10 feet above the top of the Hume Formation on Francis Creek, Northwest Territories. 5, 6, 8, A cotype figured by Holzapfel (1895, pl. 3, fig. 18) in the Göttingen Museum from the Oderhauser Kalk at Ense, Germany. 5, 6,  $\times 2$ ; 8,  $\times 4$ .
- Figs. 3, 4. *Agoniatites* cf. *vanuxemi* (Hall) from the same locality, 10-20 feet above the top of the Hume Formation. GSC 16922,  $\times 1$ .
- Fig. 13, 14. *Agoniatites* sp. from the Fort Creek Shale along the Carnwarth River, Northwest Territories. 13, GSC 16970,  $\times 4$ . 14, GSC 16969,  $\times 1$ .
- Fig. 15. *Tornoceras* (*T.*) cf. *westfalicum* Holzapfel, from an unnamed shale unit 10-40 feet above the top of the Beavertail Formation on Carcajou Ridge, Northwest Territories. GSC 16949,  $\times 1$ .
- Fig. 16. *Maenioceras* sp. Close-up photograph showing the wrinkle layer of a specimen figured on Pl. 70, fig. 3. GSC 16942,  $\times 10$ .

*Horizon and localities.* IOC 25*a, b* from Imperial Paddle River 5-17-56-8W.5M well, core 85, at depths between 7,913 and 7,932 feet. GSC 16972 (loc. 16545) from the same borehole and core at 7,922 feet depth. Also placed here, but with little assurance, are three crushed specimens, GSC loc. 26784 from Imperial Amerada Willesden Green 3-16-43-5W.5M well, Alberta, between 9,990 and 9,995 feet. The horizon is the lower part of the Duvernay Formation (*sensu lato*).

#### Genus MANTIOCERAS Hyatt 1884

*Type species by original designation:* *Goniatites simulator* Hall 1874.

Determination of specimens of *Manticoceras* presents particular difficulty at present. Over sixty species and subspecies are referred to the genus, and almost all the types of these have never adequately been described, particularly with regard to the ontogeny of shell and suture form. Further, many represent large, usually limestone, specimens whilst others are based on small or minute pyritic specimens. Until a detailed study of the group has been accomplished and revision of the type material made, a large number of the available specific names are virtually useless, and the determination of material very difficult.

*Manticoceras* occurs not uncommonly in the Frasnian rocks of western Canada, but most specimens are too poorly preserved either to warrant detailed description or to enable refined determinations to be made. *M. oxy* has been reported on the basis of specimens whose oxyconic form results purely from crushing. Only *M. cordiforme* and *M. septentrionale* (here shown to be synonyms) can be critically described. Other specimens shed little light on correlation with the successions known in Europe or New York. But most specimens appear to belong to the *cordatum* Zone assemblages, rather than to other Frasnian levels.

#### *Manticoceras cordiforme* Miller

Plate 76, figs. 5, 6, 8-11; text-figs. 7A-D, 9F, H

- 1938 *Manticoceras cordiforme* Miller, p. 82, pl. 21, figs. 2-4.  
 1938 *Manticoceras septentrionale* Miller, p. 102, pl. 23, figs. 1, 2, text-fig. 19.  
 1945 *Manticoceras intumescens* Hume and Link, p. 39.  
 1954 *Manticoceras intumescens* Hume, p. 46.

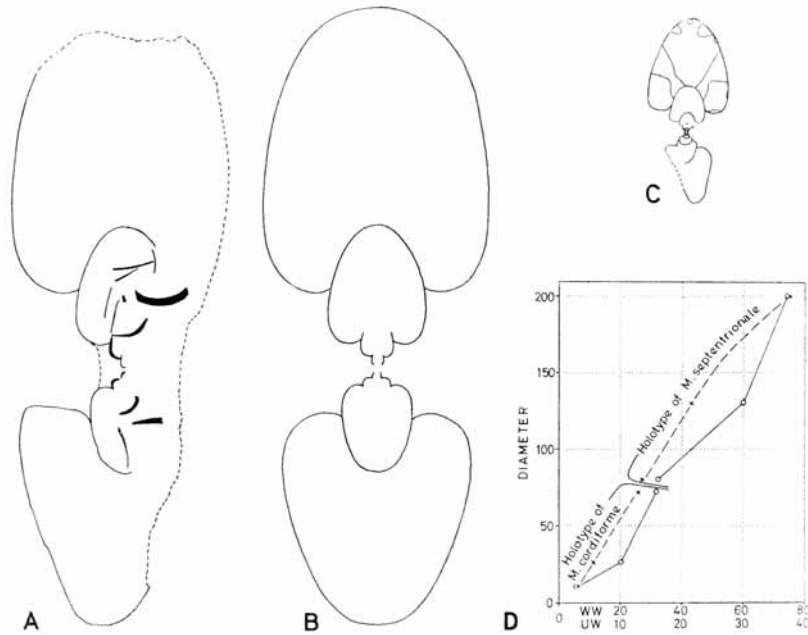
Examination and sectioning of the holotypes of *M. cordiforme* and *M. septentrionale* has led to the conclusion that they are conspecific. The name *M. cordiforme* is therefore used as it has page priority, but the name is somewhat inappropriate as the cordate section is emphasized by crushing of the holotype.

*Material.* The holotypes of both species and six other specimens, some indifferently preserved, which are thought to be probably conspecific.

The detailed description below is based on the holotypes of *M. cordiforme* and *M. septentrionale* alone.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WH</i>	<i>WW</i>	<i>Wh</i>	<i>UW</i>
GSC 5139	c. 200	c. 93	c. 74	c. 70	37.5
..	c. 130	c. 72	c. 60	c. 50	21.4
..	c. 80	c. 40	c. 32	-	13.2
GSC 2393	72.0	31.5	26.2	-	12.6
..	26.5	11.5	11.0	8.6	5.5
..	10.5	4.9	5.1	3.6	2.9

*Description.* Shell form in the earliest whorls, before 5 mm. diameter, evolute and serpenticonic, and at subsequent diameters evolute, so that at 200 mm. diameter the form is sub-involute with  $UW/D = 19$  per cent. Whorl section in the early stages is depressed with a very slight impressed area but by 15 mm. diameter  $WH = WW$  and the



TEXT-FIG. 7. *Manticoceras cordiforme* Miller from the Carcajou Mountain Sandstone at Norman Wells, 45 miles north-west of Fort Norman, Northwest Territories. A, Actual cross-section of the holotype of *M. septentrionale* at 200 mm. diameter. B, Reconstructed cross-section. Both based on GSC 5139. Both  $\times 0.5$ . C, Actual cross-section of the holotype of *M. cordiforme* at 60 mm. diameter based on GSC 2393.  $\times 0.5$ . D, Graph showing the relation between diameter and whorl width (full line) and umbilical width (pecked line) of the holotypes of *M. cordiforme* and *M. septentrionale*.

EXPLANATION OF PLATE 73

- Fig. 1. *Wedekindella* sp. from the Fort Creek Formation, 45 miles NNE of the Thunder River Mouth, Northwest Territories. GSC 16939,  $\times 2$ .  
 Fig. 2. *Wedekindella brilonense* (Kayser). Holotype of the species from the upper Givetian at Brilon, Germany, in the GPIG.  $\times 2$ .  
 Fig. 3. *Wedekindella* aff. *brilonense* (Kayser) from the Fort Creek Formation on the Carnwarth River, Northwest Territories. GSC 16940,  $\times 2$ .  
 Figs. 4, 6, 7, 8. *Sellagoniatites discoides* (Waldschmidt). 6, 7, Holotype from the *discoides* Schichten at Ense, Germany,  $\times 1$ . 4, 8, A toptype in the GPIG. 4,  $\times 1$ ; 8,  $\times 2.5$ .  
 Fig. 5. *Agoniatites* aff. *fulgurialis* (Whidborne) from an unnamed shale unit about 20 feet above the top of the Hume Formation on Bosworth Creek, Northwest Territories. GSC 16924,  $\times 1$ .

impressed depth has increased considerably. Above 15 mm. diameter or thereabouts the whorl form becomes progressively compressed. From about 5 mm. diameter to about 70 mm. diameter the whorl section shows a robust form with the flanks converging convexly towards the venter, but at the maximum diameter seen (text-fig. 7B) the flanks become more parallel sided.

Suture first seen at 38 mm. diameter, where the subumbilical lobe is sub-acute; subsequently this lobe becomes sharply acute. At 57 mm. diameter all the sutural elements are seen and the mid-ventral saddle, 11 mm. high, shows only a slight lobe above the siphuncle. The broadly rounded lateral saddle is slightly asymmetric (text-fig. 9F, H) but the relative proportions of this and other elements appear to change little at subsequent diameters.

Growth-lines at 58 mm. diameter (Pl. 76, fig. 6) are almost convex but show a very slight sinus on the mid flanks. This form is also seen at 220 mm. diameter (Pl. 76, fig. 10) where the growth-lines have a slightly rursiradiate course across the flanks as a whole.

*Remarks.* The most distinctive feature of *M. cordiforme* is the growth-line pattern, which is intermediate between that of typical *Manticoceras* and *Crickites*. Several species with this type of growth-line have been recorded. *M. sinuosum* (Hall, lectotype selected by House 1962, p. 259 as Hall 1843, p. 243, fig. 106:8) shows this feature as does one of the syntypes of *Goniatites patersoni* Hall (1879, pl. 72, fig. 4 = AMNH 6242/1) from the 'Chemung group, Pine Valley, town of Catherine, Schuylers county, N.Y.' These two species have been regarded as synonyms by Clarke (1898) and Miller (1938). But *M. cordiforme* differs from specimens referred to *M. sinuosum* by Miller in showing a rather more robust whorl section. Among European species, *C. expectatum* Wedekind, *C. sahlgrundensis* Matern, and *C. scheldensis* Matern show growth-lines which are nearly rectilinear across the flanks, but the holotype of *C. scheldensis* (SMF 328c) shows a weak lateral sinus which is lost by 25 mm. diameter. If a generic name for manticoceratids similar to *M. cordiforme* is ever required, then *Gephuroceras* (Hyatt 1884, p. 316) is available.

With the present absence of detailed work on *Manticoceras* and its allies it is difficult to interpret the stratigraphic significance of the Canadian specimens. Wedekind (1917, p. 130), who did more work on this group than any of those who have since criticized him, noted that *Crickites* is rare in the upper *cordatum* Zone (of present usage) and common in the *holzapfeli* Zone. The New York species comparable, in growth-line form, to *M. cordiforme* occur in the Cashaqua Shale, which, on other grounds, is thought to represent the upper *cordatum* Zone (House 1962, p. 259). Thus the evidence suggests that the Carcajou Mountains Sandstone and its equivalents are upper Frasnian, but whether upper *cordatum* Zone or *holzapfeli* Zone age cannot at present be determined.

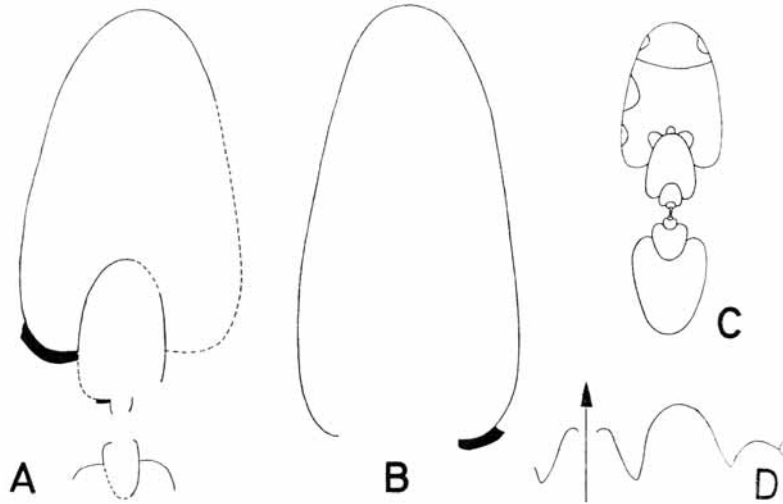
*Horizon and locality.* GSC 5139 (the holotype), GSC 2393, and WM 51873, all from the Carcajou Mountain Sandstone at Norman Wells (Oil Creek), 45 miles north-west of Fort Norman, Northwest Territories.

*Manticoceras* cf. *sinuosum* (Hall)

Plate 74, figs. 6, 7; text-fig. 8A-D

*Material.* Specimens from the Perdrix Formation and Mount Hawk Formation, mostly rather poorly preserved in dark-grey argillaceous limestone.

Dimensions (in mm.)	D	WW	WH	UW
<i>Perdrix Formation</i>				
GSC 16973	33	c. 11	c. 17	5.5
GSC 16974	c. 32.5	c. 12.5	c. 16.5	c. 4.6
<i>Mount Hawk Formation</i>				
GSC 16976	-	36.5	72	-
SOC T6207	51.5	16.6	24	11.5



TEXT-FIG. 8. *Manticoceras* cf. *sinuosum* (Hall) from the Mount Hawk Formation. A, Cross-section based on GSC 16975 from Deception Creek. B, Cross-section based on GSC 16976 from the North Saskatchewan River Gap. C, D, Cross-section and suture at 52 mm. diameter based on SOC T6207 from Crescent Creek, Nelson Range. All natural size.

*Remarks.* The specimens from the Perdrix Formation are all poorly preserved, particularly specimens above 33 mm. diameter, but all show an acute lateral lobe and are similar in shell form to the Mount Hawk specimens except in showing a rather smaller umbilicus and an associated more rapid expansion in whorl height. The Mount Hawk specimens are illustrated in text-fig. 8. Noticeable is the development of a slender, compressed whorl section at larger diameters which is not wholly accountable by crushing. In this feature they are reminiscent of *M. rhynchostoma* Clarke (see Miller 1938, p. 100, text-fig. 18H), but the inner whorls of the New York species are more depressed; no other species is comparable at such large diameters. There is one Perdrix specimen (GSC 16977) which reaches a whorl height of 65 mm. and appears to show an oxyconic form, but this is probably due to crushing. The missing specimens of Bissell (1930, pl. 8, figs. 1-3) from the Mount Hawk Formation may well be *M. cf. sinuosum*.

*Horizons and localities.* From the Perdrix Formation is GSC 16973,4 (GSC loc. 36946) labelled 'Head Sulphur Creek, Miette area', collected by E. J. Mountjoy. From the Mount Hawk Formation are GSC 16975 (GSC loc. 24560) collected by D. J. McLaren from unit 11 on Deception Creek, GSC



16976 (GSC loc. 18101) collected by D. J. McLaren from the north side of a gap on the North Saskatchewan River, GSC 16978 (TOC RC4252) collected by A. E. H. Pedder from the Saskatchewan Gap in the Brazeau Range about 52° 25' N., 115° 50' W., 280 to 290 feet below the top of the formation, and SOC T6207 from Crescent Creek, Nelson Range, Alberta, about 53° 35' 30" N., 118° 30' W.

*Manticoceras* spp.

Plate 74, figs. 8, 9; text-fig. 9A, B, D, E

- 1938 *Manticoceras* aff. *M. sinuosum* Miller, p. 116, pl. 27, figs. 6, 7.  
 1956 *Manticoceras* sp. Warren and Stelck, pl. 22, fig. 17.  
 1956 *Manticoceras oxy* Warren and Stelck, pl. 24, figs. 1, 3.  
 1962 *Manticoceras* sp. House, p. 261, text-fig. 4A.

*Escarpment Formation.* Two specimens are available from this horizon. The first, GSC 4294, was collected by McConnell in 1887 from opposite mile 23 on the original Mackenzie highway (*sic*): it was described with full synonymy by Miller (*loc. cit.*). A second specimen, GSC 16979 (GSC loc. 31261) collected by P. Harker, comes from 150 feet below a sandstone marker near the junction of Mills Lake Road and the Hay River: this specimen is figured here (text-fig. 9B, E; the section is very slightly widened by the section being cut just obliquely).

*Grumbler Group.* Several specimens from the Liard Rapids, Northwest Territories, about 61° 26' N., 121° 38' W., belong here, probably from the Redknife Formation. All are somewhat distorted and preserved in siltstone. One, GSC 16964 (TOC NF9, Pl. 74, figs. 8, 9), which externally appeared oxyconic, gave evidence on cross-sectioning (text-fig. 9A) of crushing with rounded venters and moderately compressed inner whorls. The specimen figured by Warren and Stelck (*loc. cit.*) as *M. oxy* is also from this locality and the specific assignment is probably similarly explained and incorrect. The suture of GSC 16964 is similar to others from this locality (House 1962, p. 261, text-fig. 4A) in showing a gentle rise from the acute lateral lobe in the umbilical seam, a distinctive feature shown also by *M. cordiforme*. Another specimen, GSC 16980 (GSC loc. 32966) collected by B. R. Pelletier from near the base of a 100-foot section of sandy argillaceous limestone on the left bank at Liard Rapids, also shows this feature.

Genus TIMANITES Mojsisovics 1882

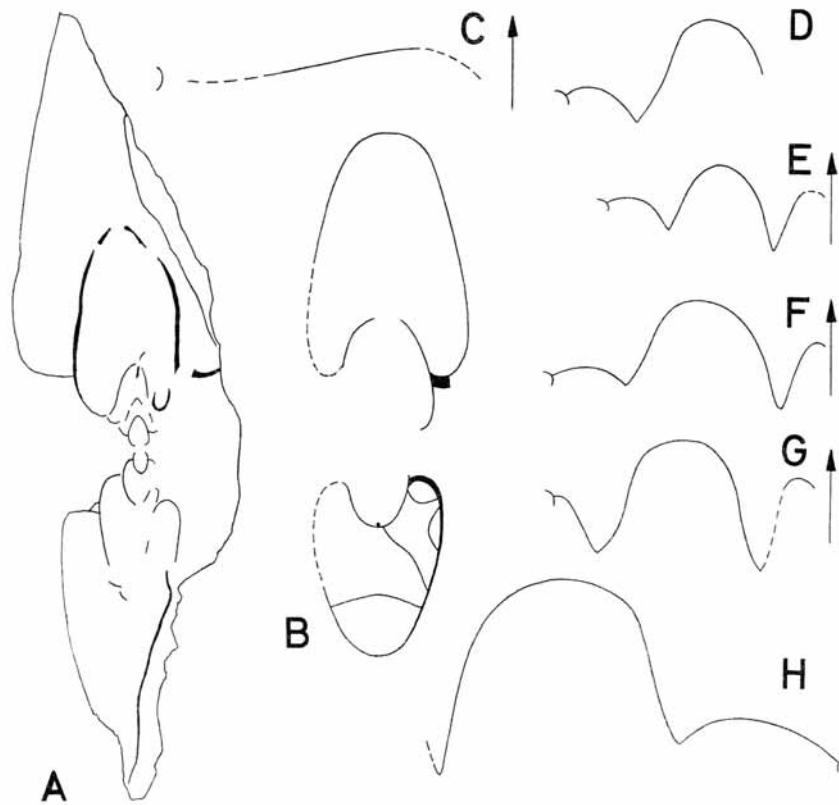
*Type species by original designation: Goniatites acutus* Keyserling 1846 (pl. 12, fig. 6) = *Timanites keyserlingi* Miller.

Since Keyserling was incorrect in supposing his specimens belonged to *Goniatites acutus* Münster, no valid name had been applied to these forms until Miller (1936, p. 634) proposed the name *T. keyserlingi*. Hence it is not possible to agree with Petter's resurrection of Münster's specific name. A new specimen from Canada shows that *T. occidentalis* should be regarded as a synonym of *T. keyserlingi*. The synonymy includes references to the types and Canadian specimens only.

*Timanites keyserlingi* Miller

Plate 75, figs. 6-9; text-fig. 10

- 1844 *Goniatites acutus* (*non* Münster) Keyserling, p. 232, pl. 1, fig. 6.  
 1846 *Goniatites acutus* (*non* Münster) Keyserling, p. 280, pl. 12, figs. 6a, b.



TEXT-FIG. 9. *Manticoceras* spp. from western Canada and New York State.

A, D. *Manticoceras* sp., cross section and suture at 85 mm. diameter based on GSC 16964 from the Grumbler Group at the Liard Rapids.

B, E. *Manticoceras* sp., cross-section and suture at 54 mm. diameter based on GSC 16979 from the Escarpment Formation near the junction of Mills Lake Road and the Hay River.

C. *Manticoceras sinuosum* (Hall), growth-line of the lectotype at a whorl height of 48.7 mm. based on AMNH 5887/1 from the Cashaqua Shale, New York State.

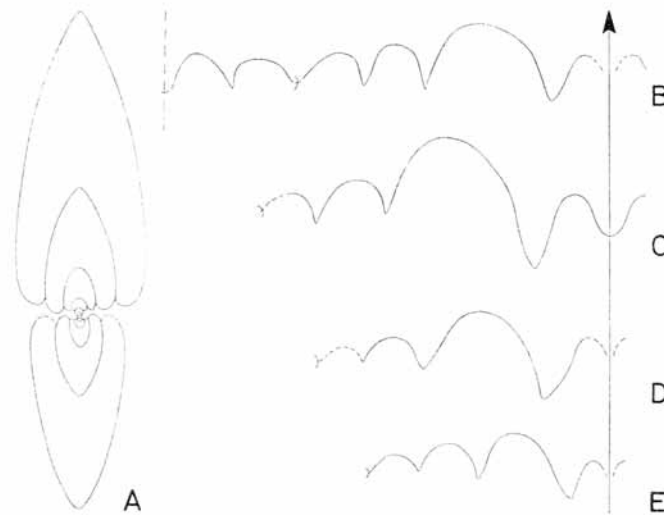
F, H. *Manticoceras cordiforme* Miller. F. Suture of the holotype at 63 mm. diameter based on GSC 2393; H. Suture at c. 105 mm. diameter based on the holotype of *M. 'septentrionale'*; both from the Carcajou Mountain Sandstone at Norman Wells, 45 miles north-west of Fort Norman, Northwest Territories.

All natural size.

- 1882 *Timanites acutus* Mojsisovics, p. 183.  
 1932 *Manticoceras* cf. *M. oxy* Allan *et al.*, p. 236.  
 1936 *Timanites occidentalis* Miller in Miller and Warren, p. 632, figs. 1-3.  
 1936 *Timanites occidentalis* Miller and Warren, p. 634, text-figs. 4, 5.  
 1938 *Timanites occidentalis* Miller, p. 131, pl. 29, figs. 4, 5.  
 1951 *Manticoceras* cf. *M. oxy* Fox, pp. 827, 828.  
 1954 *Manticoceras* cf. *M. oxy* Fox, p. 115.  
 1956 *Timanites occidentalis* Warren and Stelck, pl. 14, figs. 26, 27.  
 1959 *Timanites acutus* Petter, p. 161.

*Material.* Only two Canadian specimens are known, the holotype of *T. occidentalis* and a very fine specimen recently found by C. R. Stelck. Both are from the same horizon and approximately the same locality.

Dimensions (in mm.)	D	WW	WH	UW
AU Dv684 (from Miller)	105	20	47	0
AU 38975	95	24.5	58	2.5
...	32	11.0	18.5	0
...	20.4	7.6	13.4	0



TEXT-FIG. 10. *Timanites keyserlingi* Miller from western Canada and Russia.

A, B, D. Cross-section and sutures at 78 mm. and 20 mm. diameter based on AU 38975 from the Maligne Formation in Jasper Park, Alberta. A, B,  $\times 1$ ; D,  $\times 5$ . C, Suture diagram from Miller (1938, p. 132, text-fig. 27A) of the holotype of *T. occidentalis* from the same horizon and locality, based on AU Dv684,  $\times 1$ . E, Suture diagram from Holzapfel (1899, p. 44, text-fig. 13) of a specimen from the lower Frasnian of the Timan Mountains, U.S.S.R.

*Description.* Shell form compressed and discoidal, with umbilicus probably closed (by the shell) and venter acute in the adult. Early stages (text-fig. 10A) show a well-rounded whorl section but by about 15 mm. diameter the adult type acute venter is developed. Growth-lines, seen on the outer whorls only (Pl. 75, fig. 8), show a slight salient on the

lower flanks and weak sinus on the midflanks, and the growth-lines pass forward, and become emphasized at the ventro-lateral salient. Over the venter the growth-lines form an acute, V-shaped, sinus. The wrinkle layer is seen as a dorsal structure on top of the previous whorl at 30–35 mm. diameter (Pl. 75, fig. 5; the same area is seen on fig. 6). The wrinkle layer striae pass slightly backwards from the umbilicus and continue in an irregular rectilinear course towards the venter, frequently bifurcating.

By 20 mm. diameter (text-fig. 10D) the adult sutural elements have formed and the dorsal suture has a mid-dorsal lobe and a sub-umbilical lobe. The adult suture is illustrated on an accompanying diagram (text-fig. 10B, C).

*Remarks.* The new specimen, from the same formation as the holotype of *T. occidentalis*, shows even closer similarity to Russian specimens from the Timan Mountains. The slight differences in the umbilical portions of the suture of Miller's specimen seem to be due, as he supposed, to distortion during fossilization. There seems no reason to keep a separate name for the Canadian species. Details of the wrinkle layer, and the inner whorls, now appear the same in the Russian and Canadian specimens.

This genus appears to be restricted to the *lumulicosta* Zone. In addition to the type species, Petter (1959) has described two species from the Sahara from the *lumulicosta* Zone as *T. meridionalis* and *T. complanatum*. Certainly the former and probably the latter should be assigned to the genus *Komioceras* Bogoslovski (1958, p. 115).

*Horizon and localities.* AU Dv684 from the Maligne Formation on the north-east shoulder of Roche Miette in Jasper Park, Alberta. AU 38975 is from the Maligne Formation at Sulphur Spring just east of a bridge over the Athabaska River in Jasper Park, Alberta.

#### Family TORNOCERATIDAE Arthaber 1911

#### Genus TORNOCERAS Hyatt 1884

*Type species by original designation: Goniatites uniaugularis* Conrad 1842.

#### *Tornoceras (Tornoceras) cf. westfalicum* Holzapfel

Plate 72, fig. 15; text-fig. 11

*Material.* Five specimens preserved as solid limestone internal moulds of the body chambers and crystalline calcite internal moulds of the phragmocones. Some specimens are testate.

#### EXPLANATION OF PLATE 74

- Fig. 1. *Gyroceratites (Lamelloceras) sp.* from the Funeral Formation in the northern Arnica Range, Northwest Territories. GSC 16921,  $\times 1.44$ .
- Fig. 2. ?*Platyclymenia sp.* from the Costigan Member of the Palliser Formation on the south-east slope of Mt. Lorette, Alberta. GSC 16963,  $\times 1$ .
- Fig. 3. *Anarcestes (Latanarcestes) cf. praecursor* Frech from the Funeral Formation in the Northern Funeral Range, Northwest Territories. GSC 16930,  $\times 1.2$ .
- Figs. 4, 5. *Tornoceras (Tornoceras) cf. crebriseptum* Raymond from Hume's D5 unit, 6 miles south of the eastern tip of Carlson's Lake. GSC 16954,  $\times 1.67$ .
- Figs. 6, 7. *Manticoceras cf. sinuosum* (Hall) from the Mount Hawk Formation on Crescent Creek, Nelson Range, Alberta. SOC T6207,  $\times 1$ .
- Figs. 8, 9. *Manticoceras sp.* from the Redknife Formation at the Liard Rapids, Northwest Territories. GSC 16964,  $\times 1.35$ .
- Figs. 10, 11. *Imitoceras sp.* from Hume's D5 unit on the North Nahanni River, Northwest Territories. GSC 16960,  $\times 2$ .

Dimensions (in mm.)	D	WW	WH	Wh	UW
GSC 16949	47.2	18.2	27.8	12.5	0
GSC 16950	37.2	15.5	c. 20.2	—	0
GSC 16951	c. 34.0	13.7	—	—	0
GSC 16952	20.0	8.5	c. 11.5	—	c. 1.0

*Description.* Shell form laterally compressed, involute with closed umbilicus, subtrochoidal. Whorl section with maximum width close to the umbilicus and flanks sloping flatly to a broad well-rounded venter (text-fig. 11).

Suture with V-shaped ventral lobe, a broad asymmetric lateral lobe and a short latero-umbilical saddle with a steep ventral face which flexures sharply over to the saddle crest. Suture similar at all stages seen.

Growth-lines, typically for genus, form a weak salient on the lower flanks, a weak sinus on the middle flanks and then pass forward to a prominent ventro-lateral salient and back to a deep mid-ventral linguiform sinus. On one specimen (GSC 16950) there are several small rounded notches on the body chamber mould, presumably marking damage in life. The wrinkle layer is well seen on one specimen (GSC 16950) as fine posteriorly directed striae laid down on top of the preceding whorl in the dorsal part of the body chamber.

*Remarks.* These specimens are interesting in showing a subtrochoidal shell form rather than the more typical subtegoidal form found commonly in *Tornoceras*. Also the umbilico-lateral saddle is unusually short. These are features shown especially by *T. westfalicum* Holzapfel (1895, p. 104, pl. 4, figs. 11, 12) from the German Givetian, but the holographs of that species show a slightly open umbilicus with a shell ridge surrounding it. Unfortunately none of the larger species are testate in the umbilical region so that it cannot be demonstrated whether this feature also occurs.

Unpublished work by the writer on the evolution of *Tornoceras* in the American Devonian suggests that species with such a sharp flexure between the ventral slope and crest of the umbilico-lateral saddle predominate in the United States at levels above the Centerfield Limestone, and *T. westfalicum* occurs in Germany in levels which probably represent the upper Givetian.

*Horizon and locality.* GSC 16949–53 (TOC H6053) collected by E. W. Best and D. Barss from an unnamed dark shale unit (the Lower Fort Creek and Hare Indian of authors) 10–20 feet above the top of the Hume Formation on Francis Creek, Northwest Territories, about 65° 14' 20" N., 126° 23' 40" W.

*Tornoceras (Tornoceras) cf. crebrisseptum* Raymond

Plate 74, figs. 4, 5

*Material.* Two specimens preserved as poor internal moulds of crystalline calcite and limestone.

Dimensions (in mm.)	D	WW	WH	UW
GSC 16954	17.4	8.0	9.8	1
GSC 16971	18.0	c. 8.0	—	c. 0



TEXT-FIG. 11. *Tornoceras (Tornoceras) cf. westfalicum* (Holzapfel). Cross-section based on GSC 16949 from 10–20 feet above the top of the Hume Formation on Francis Creek, Northwest Territories. Natural size.

*Description.* Shell form very compressed, involute with closed umbilicus or nearly so. Maximum whorl width on the lower flanks, and the sides then converge convexly towards a well-rounded venter. Body chamber seen for half a whorl. Growth-lines and ornament not seen.

Suture-lines not well preserved but showing a very small V-shaped ventral lobe, a ventro-lateral saddle close to the mid-ventral line passing almost rectilinearly back to a shallow lateral lobe. The ventral face of the umbilico-lateral saddle is moderately steep and the slope from the saddle crest to the umbilicus is gentle and even.

*Remarks.* Unfortunately the suture is in neither case well preserved, but clearly it is not deeply undulating as in the Lower Famennian species *T. acutum* Frech, *T. guestfalicum* Frech and others. The affinities clearly lie rather with the *T. crebrisepium* group (see Miller 1938, p. 149), in which the sutural elements are relatively subdued.

*Locality and horizon.* GSC 16954, 16971 (TOC G8353) collected by A. E. H. Pedder from Hume's D5 unit, 564 to 574 feet below the top, and 614 to 604 feet above the base of the unit, from 6 miles south of the eastern tip of Carlson's Lake, Northwest Territories, about 62° 21' N., 123° 43' W.

*Tornoceras (Tornoceras) sp.*

1931 *Tornoceras bicostatum* Burgess, p. 200.

1938 (?) *Tornoceras bicostatum* Miller, pp. 168, 170.

*Material.* The two plesiotypes of Burgess preserved in black mudstone.

*Remarks.* Neither of these specimens show a ventro-lateral furrow so that they cannot belong to *Aulatornoceras bicostatum*. The larger specimen reaches 28 mm. diameter and shows biconvex growth-lines, with faint, sub-radial ribs on the lower flanks. The smaller specimen reaches 12.5 mm. diameter and shows a typical *Tornoceras* suture, with asymmetrical lateral lobe, but no evidence of growth lines. In both the umbilicus is closed and the shell form laterally compressed but well rounded.

*Horizon and locality.* Both specimens are numbered MCZ 3473 and come from the Perdrix Formation (= Kiln Formation) from 3 miles south of Pochahontas on the east side of the Athabaska River, Alberta, and were found 'in concretions scattered through a black fissile shale'.

Genus LOBOTORNOCERAS Schindewolf 1936

*Type species by original designation: Goniatites ausavense* Steininger 1853.

EXPLANATION OF PLATE 75

Fig. 1, 2, 10, 11. *Teicherticeras lenzi* sp. nov. Holotype from 296 feet below the base of the Hume Formation equivalent on the Ogilvie River, Yukon, GSC 16929,  $\times 1$ . 10, 11, The inner whorls of the same specimen,  $\times 2$ .

Fig. 4. *Manticoceras* sp. from the Mount Hawk Formation at the Saskatchewan River Gap, Alberta, AU Dv1707,  $\times 1$ .

Figs. 5-9. *Timanites keyserlingi* Miller from the Maligne Formation at Sulphur Spring just east of a bridge over the Athabaska River, Jasper Park, Alberta, AU 38975. 5, The wrinkle layer,  $\times 4$ . 6, 7, The inner whorls showing the dorsal septal line of the subsequent whorl,  $\times 1$ . 8, 9, The outer whorls,  $\times 1$ .

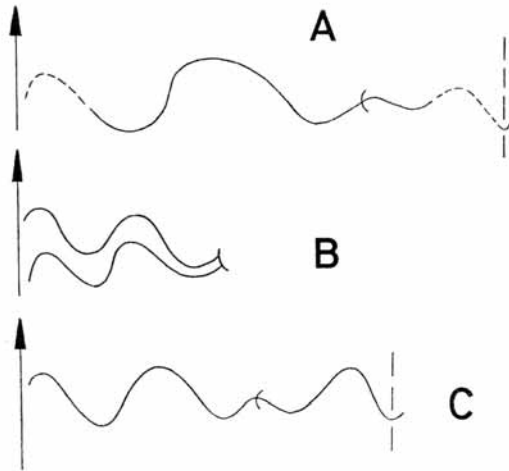
*Lobotornoceras* aff. *bilobatum* (Wedekind)

Plate 77, figs. 1, 2; text-fig. 12A

*Material.* One specimen collected by A. E. H. Pedder preserved as an internal mould of the phragmocone in limestone. Form slightly crushed.

Dimensions (in mm.)	<i>D</i>	<i>WW</i>	<i>WH</i>	<i>UW</i>
GSC 16955	31.5	c. 13.8	18.0	c. 0

*Description.* Shell form laterally compressed, involute with closed umbilicus. Maximum whorl width close to the umbilicus and the flanks coverge sharply towards an apparently

TEXT-FIG. 12. *Lobotornoceras* sp. from Germany and western Canada.

- A. *L.* aff. *bilobatum* (Wedekind). Suture at 34 mm. diameter based on GSC 16955 from Hume's D5 unit near Carlson's Lake, Northwest Territories.  
 B. *L. bilobatum* (Wedekind). The original illustration of the sutures on the holotype (Wedekind 1908, pl. 39, fig. 35) from the *Cheiloceras* Stufe at Engeberg, Germany.  
 C. *L. ausavense* (Steininger). Suture diagram from Schindewolf (1936, p. 690, text-fig. 1) of a specimen from the *Mantioceras* Stufe at Büdesheim, Germany.  
 All twice natural or stated size.

well-rounded venter giving the whorl section a subtriangular form. Growth-lines and ornament not preserved. The suture is illustrated in text-fig. 12A. A small saddle can be seen on the specimen centred slightly dorsal of the umbilical seam.

*Remarks.* The specimen clearly belongs to the Fammenian *L. bilobatum*-*L. escoti* group rather than the Frasnian group represented by the type species (text-fig. 12C). It seems probable these groups are phylogenetically unrelated, although both descended indubitably from *Tornoceras* s.s. Since the lateral lobe of the specimen from Canada is rounded, rather than pointed as in *L. escoti* (Frech 1902, p. 48, pl. 3(2), fig. 19), the affinities are with *L. bilobatum* (Wedekind 1908, p. 579, pl. 39, fig. 35; pl. 40, fig. 8) from the *Cheiloceras* Stufe at Engeberg, but the specimen differs from *L. bilobatum* in showing a wider

umbilico-lateral saddle (text-fig. 12B). Also, if the descriptions of Schindewolf (1923, p. 307) apply to this species, the whorl section is more flat-sided than *L. bilobatum*. Schindewolf (1923, p. 492) records the species in the lower *Cheiloceras* Stufe at Hof, and it occurs elsewhere in the Rheinische Gebirge both in the lower and upper parts of the *Cheiloceras* Stufe.

*Horizon and locality.* GSC 16955 (TOC G854F), from talus about 150 feet above the base of Hume's D5 unit, 6 miles south of the eastern tip of Carlson's Lake, Northwest Territories, about 62° 21' N., 123° 43' W.

Family CHEILO CERATIDAE Frech 1897

Genus CHEILO CERAS Frech 1897

*Type species by the subsequent designation of Wedekind (1917): Goniatites subpartitum* Münster 1839.

*Cheiloceras (Cheiloceras) sacculum* (G. and F. Sandberger)

Plate 77, figs. 3, 4; text-fig. 13A, B

1851 *Goniatites retrorsus* var. *sacculus* G. and F. Sandberger, p. 109; pl. 10, fig. 22; pl. 10b, figs. 7, 20, 22.

1908 *Cheiloceras sacculum* Wedekind, p. 584, pl. 39, fig. 2.

1917 *Cheiloceras sacculum* Wedekind, p. 146, pl. 18, fig. 11; text-fig. 46n.

1923 *Cheiloceras sacculum* Schindewolf, p. 320.

1959 *Cheiloceras sacculum* Petter, p. 233, pl. 17, figs. 17, 17a, 18, 18a.

*Material.* Two specimens preserved as phragmocones in solid limestone, mostly as internal moulds.

Dimensions (in mm.)	D	WW	WH	UW
GSC 16956	29	18	16	0

*Description.* Shell form rotund, laterally compressed, involute with closed umbilicus. Whorl section with maximum width close to the umbilicus and flanks sloping convexly towards a well-rounded venter. Shell form at early diameters is similar and is shown in text-fig. 13A.

Growth-lines have not been seen, but the wrinkle layer is shown as backwardly directed fine striae, spiral near the umbilicus, of the *Tornoceras* type.

The suture (text-fig. 13B) shows a small, narrowly V-shaped ventral lobe and a broad flat ventro-lateral saddle: in the larger specimen (GSC 16956) the septal line, but not the suture, shows a weak concavity along this 'saddle'. The lateral lobe is small and rounded and the ventral face of the latero-umbilical saddle rises steeply from it to form a wide, well-rounded saddle. Dorsal suture not seen. The smaller specimen (GSC 16957) shows, at a diameter of 19 mm., considerable approximation of the septa, for there are eight in the last quarter whorl, whereas the larger specimen has only eight in the last half whorl.

EXPLANATION OF PLATE 76

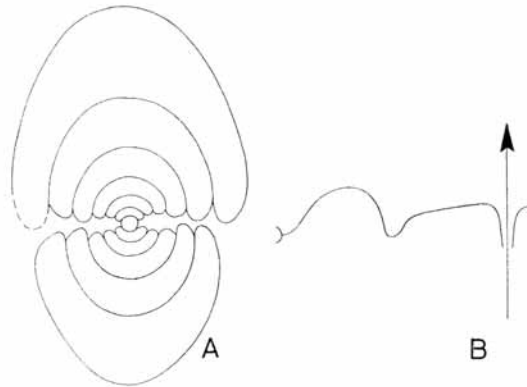
Figs. 1-4, 7. *Probeloceras* sp. from the Imperial Paddle River 5-17-56-8W.5M well between 7,913 and 7,932 feet depth. 1, 2, GSC 16972,  $\times 2$ . 3, 4, IOC 258a,  $\times 2.5$ . 7, A latex mould from IOC 258b,  $\times 2.5$ .

Figs. 5, 6, 8-11. *Manticoceras cordiforme* Miller from the Carcajou Mountain Sandstone at Norman Wells, 45 miles north-west of Fort Norman, Northwest Territories. 5, 6, Holotype, GSC 2393,  $\times 1$ . 8, 9, WM 51873,  $\times 1$ . 10, 11, Holotype of *M. 'septentrionale'*, GSC 5139,  $\times 0.5$ .



*Remarks.* Of all the described species of *Cheiloceras* only *C. sacculum* shows such a rotund form and distinctive suture. *C. amblylobum* (G. and F. Sandberger), which is the only other species of *Cheiloceras* to be described from North America (House 1962), does not show the small rounded lateral lobe. *C. sacculum* is typical of the upper *Cheiloceras* Stufe, that is the *pompeckji* Zone, in Germany, but Schindewolf (1923, p. 321) has noted that the species also occurs in the underlying *curvispina* Zone.

*Horizon and locality.* Both specimens collected by A. E. H. Pedder: GSC 16956-7 (TOC G8342) come from scree below Hume's D5 beds, from about 150 feet above the base, 6 miles south of the eastern tip of Carlson Lake, Northwest Territories, about 62° 21' N, 123° 43' W.



TEXT-FIG. 13. *Cheiloceras (Cheiloceras) sacculum* (G. and F. Sandberger). A, Cross-section. B, Suture. Both based on GSC 16956 at 29 mm. diameter, from Hume's D5 unit near Carlson's Lake, Northwest Territories. Both  $\times 2$ .

*Cheiloceras (C.) cf. sacculum* (G. and F. Sandberger)

A single specimen, GSC 16958 (TOC G5487), poorly preserved, from Hume's D5 beds collected by I. Zemmels may be compared with *C. sacculum*. It comes from an isolated outcrop 5 miles SSW of the confluence of Battlement Creek and the North Nahanni River, about 62° 7' 35" N., 123° 38' W.

Genus SPORADOCERAS Hyatt 1884

*Type species by original designation: Goniatites bidens* G. and F. Sandberger 1851.

*Sporadoceras cf. primaevum* Schindewolf

Plate 77 figs. 6-7; text-fig. 14A-C

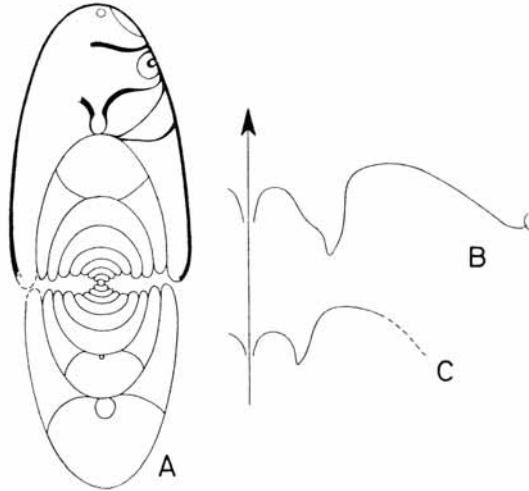
1923 *Sporadoceras primaevum* Schindewolf, p. 340, text-fig. 5a.

*Material.* One specimen collected by A. E. H. Pedder preserved as a phragmocone in solid limestone mostly as an internal mould.

Dimensions (in mm.)	D	WW	WH	UW
GSC 16959	81.0	30.0	48.0	0
..	60.0	25.5	c. 32.0	1.5

*Description.* Shell form compressed, involute with closed umbilicus and subtegoidal in the adult, where the maximum whorl width lies close to the umbilicus and the flanks slope with increasing convexity to the well-rounded venter. The shell form at earlier diameters is illustrated by a cross-section which shows that the early whorls are globular with an open umbilicus (text-fig. 14A).

Suture when first seen at about 45 mm. diameter shows a narrow ventral lobe, a broad subsemicircular ventro-lateral saddle with a slight flattening on the dorsal side, and a



TEXT-FIG. 14. *Sporadoceras* cf. *primaevum* Schindewolf. A, Cross-section. B, Suture at 73 mm. diameter. C, Suture at c. 45 mm. diameter. All based on GSC 16959 from Hume's D5 unit near Carlson's Lake, Northwest Territories. All natural size.

subacute lateral lobe tilted ventrally at the apex (text-fig. 14C). At greater diameters the flattening on the dorsal face of the ventro-lateral saddle becomes more concave (text-fig. 14B). Dorsal suture not seen.

Growth-lines are poorly seen but appear to be convex.

*Remarks.* Some might argue that the  $A_2$  lobe is insufficiently developed to warrant calling this species *Sporadoceras* rather than *Cheiloceras*. Indeed, there is some justification for claiming that such a lobe is incipient until a radial line from the umbilicus would

#### EXPLANATION OF PLATE 77

Figs. 1, 2. *Lobotornoceras* aff. *bilobatum* (Wedekind) from talus below Hume's D5 unit 6 miles south of the eastern tip of Carlson's Lake, Northwest Territories. GSC 16955,  $\times 2$ .

Figs. 3, 4. *Cheiloceras* (*Cheiloceras*) *sacculum* (G. and F. Sandberger) from the same locality and horizon. GSC 16956,  $\times 1.25$ .

Fig. 5. ?*Imitoceras* sp. from the same locality and horizon. GSC 16961,  $\times 1$ .

Figs. 6-8. *Sporadoceras* cf. *primaevum* Schindewolf from the same locality and horizon. GSC 16959,  $\times 1.12$ .

cut both sides of the flexure. But it will avoid confusion to follow the usage of Schindewolf. The relations of this species have been discussed by Schindewolf (loc. cit.) and he has noted that the holotype was found in, and the range restricted to, the lowest beds of Zone II $\beta$  at Gattendorf, that is, the lower part of the *pompeckji* Zone. Correlation with this level is supported by the evidence of *C. sacculum*, which is associated with *S. cf. primaevum* in Hume's D5 beds.

If Schindewolf's illustration of the suture is natural size, and this is not stated, then the Canadian specimen shows a much later development of the A<sub>2</sub> lobe than the holotype. This suggests that it may be slightly younger than the true *S. primaevum*.

*Horizon and locality.* GSC 16959 (TOC 8342), collected from talus about 150 feet above the base of Hume's D5 unit, 6 miles south of the eastern tip of Carlson's Lake, Northwest Territories, about 62° 21' N., 123° 43' W.

Family IMITOCERATIDAE Ruzhencev 1950  
Genus IMITOCERAS Schindewolf 1923

*Type species by original designation:* *Ammonites rotatorius* de Konink.

*Imitoceras* sp.

Plate 74, figs. 10, 11

*Material.* One specimen collected by Dr. Paul Sartenaer preserved as an internal mould of the phragmone in limestone.

<i>Dimensions (in mm.)</i>	<i>D</i>	<i>WW</i>	<i>UW</i>
GSC 16960	22.5	15.3	0

*Description.* Shell form subglobular, slightly compressed, involute with closed umbilicus. Maximum whorl width close to the umbilicus; well-rounded venter. Growth-lines not seen. No trace of constrictions. Suture shows typical elements of the genus (Pl. 74, figs. 10, 11).

*Remarks.* The specimen is too poorly preserved to be adequately compared with the many Devonian described species. In shell proportions it approaches *I. lineare* (Münster) amongst others. *Imitoceras* first appears in Europe in the *Cheiloceras* Stufe, and this is the level of the Canadian specimen, showing that the genus was widely distributed even at its first appearance.

*Horizon and locality.* GSC 16960 (loc. 38701) collected from the lower 355 feet of the outcrop of Hume's D5 beds on the North Nahanni River, 62° 21' N., 123° 42' W.

?*Imitoceras* sp.

Plate 77, fig. 5

A large specimen, GSC 16961 (TOC G8342), collected by R. de Wit from scree below the type section of Hume's D5 beds, shows a typical *Imitoceras*-type lateral lobe but evidence at the umbilicus of a shallow saddle centred on the seam. Unfortunately the specimen is badly crushed. The same curious feature is shown on another poorly preserved specimen (GSC 16962) collected by A. E. H. Pedder. This may be caused by crushing or by a dorsal displacement of the umbilical seam. Both specimens belonged

to the Triad Oil Co. collections and came from talus about 150 feet above the base of Hume's D5 beds, 6 miles south of the eastern tip of Carlson's Lake, about 62° 21' N., 123° 43' W.

Family CLYMENIIDAE Edwards 1849

Genus PLATYCLYMENIA Hyatt 1884

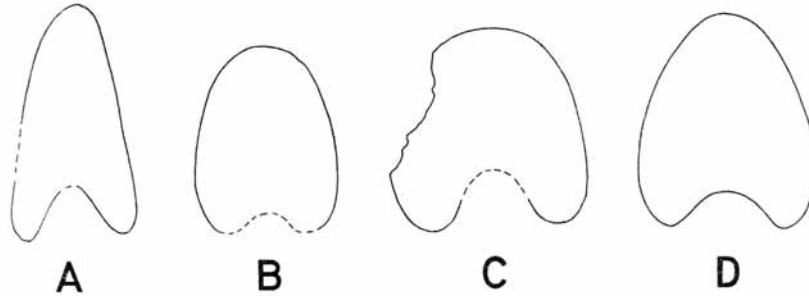
*Type species by subsequent designation: Goniatites annulatus* Münster 1832.

? *Platyclymenia* sp.

Plate 74, fig. 2

*Remarks.* This poorly preserved and weathered specimen shows no trace of ornament. It is crushed but gives the impression of having been laterally compressed in shell form, and evolute. These characters and the simple form of the suture (Pl. 74, fig. 2: the siphuncle has not been seen) suggest reference to *Platyclymenia* rather than to any other Upper Devonian ammonoid genus.

*Horizon and locality.* GSC 16963, collected by A. E. H. Pedder from 0–16 feet below the top of the Costigan Member of the Palliser Formation on the south-east slope of Mt. Lorette, Fisher Range, Alberta, about 50° 59' 30" N., 115° 08' W.



TEXT-FIG. 15. Anaptychi from Carcajou Ridge and Thunder River. A, GSC 16965 (CSC L-17), C, GSC 16967 (CSC L-17). Both from the Fort Creek Shale at Thunder River. B, GSC 16966 (CSC L-8), D, GSC 16968 (CSC L-8). Both from an unnamed shale 10–40 feet above the Beavertail Formation on Carcajou Ridge. All natural size.

#### Anaptychi

Associated with *Ponticeras* cf. *tshernyschewi* in an unnamed shale 10–40 feet above the top of the Beavertail Formation on Carcajou Ridge, Northwest Territories, are several anaptychi collected by A. Lenz. These are poorly preserved as shiny films on bedding surfaces of the black shale. Outlines of two are illustrated here (text-fig. 15B, D). The rounded form, with shallow impressed region, is reminiscent of the whorl section of species of *Ponticeras* not uncommon in the German *lumlicosta* Zone but for which there is no other evidence at Carcajou Ridge.

From the type section of the Fort Creek Shale at Thunder River come two types of anaptychi. The first is long and narrow (text-fig. 15A) with a slight axial concavity which becomes more prominent towards the crest of the impressed depth. This form is not

dissimilar to the whorl section of *P. tschernyschewi* itself (Holzapfel 1899, pl. 4, figs. 3a, 6a) and may represent the operculum of the comparable *Ponticeras* common at Carcajou Ridge. However, it is curious that this form has not been found at Carcajou Ridge and that Holzapfel recorded no anaptychi of this type from the Russian beds with *P. tschernyschewi*.

The second type of anaptychus from the Fort Creek Shale is more nearly rounded (text-fig. 15c), but with a deeper impressed depth than that of the commonest forms at Carcajou Ridge. Again the whorl section is reminiscent of some lower Frasnian species of *Ponticeras*. A poorly preserved specimen from the same horizon as the anaptychi may be a *Ponticeras*, but in any case the evidence seems to suggest that in the type area of the Fort Creek Shale both Givetian and lowest Frasnian faunas occur in the formation.

*Abbreviations.* For simplicity the following abbreviations are used throughout the text.

Measurements are given in millimetres and apply to the stated diameter unless otherwise indicated. D = diameter. UW = umbilical width. WH = whorl height. Wh = distance from the ventral crest of the whorl to the ventral crest of the preceding whorl. WW = whorl width.

*Museum Collections:*

- AMNH = The American Museum of Natural History, New York.
- AU = Geology Department, University of Alberta, Edmonton.
- CSC = The California Standard Company.
- GPIG = Geologisch-Paläontologisches Institut, Göttingen.
- GSC = Geological Survey of Canada, Ottawa.
- GSC loc. = Geological Survey of Canada locality number.
- IOC = Imperial Oil Ltd.
- MCZ = Museum of Comparative Zoology, Cambridge, Massachusetts.
- NYSM = New York State Museum, Albany.
- PAPC = Pan American Petroleum Corporation.
- SMF = Geologisches Abteilung Natur-Museum Senckenberg, Frankfurt am Main.
- SOC = Shell Oil Co. of Canada Ltd.
- TOC = Triad Oil Co. Ltd.
- WM = Walker Museum, University of Chicago, Illinois.

*Location of specimens.* Through the generosity of the managements of the oil companies concerned it has been possible to present most of the mentioned material to the Geological Survey of Canada. In the text both the Survey collection numbers and the relevant oil company specimen numbers are given, the latter in parenthesis. Plaster casts of most figured specimens are deposited in the collections of the Geology Department, University of Durham.

*Acknowledgements.* For providing specimens or information, or both, we are indebted to: E. W. Best of Triad Oil Co. Ltd., G. A. Cooper of the U.S. National Museum, C. H. Crickmay of Imperial Oil Ltd., D. E. Jackson of Pan American Petroleum Corporation, A. C. Lenz of the California Standard Company, D. J. McLaren of the Geological Survey of Canada, M. H. Nitecki of the Walker Museum, Chicago, G. O. Raasch of Shell Oil Co. of Canada Ltd., C. R. Stelek of the University of Alberta, J. W. Wells of Cornell University and H. B. Whittington of Harvard University. One of us (M. R. H.) is indebted to the Commonwealth Fund of New York for the award of a fellowship which enabled the study of comparative material in the United States, and to Durham University for similar aid in Europe. We are also indebted to G. Dresser of Durham University and a grant from the D.S.I.R. for preparation of all the photographs used on the plates, and to T. Glarum, of Triad Oil Co. Ltd., and B. Whan of New England University for preparing text-figs. 1 and 2.

Finally we owe our thanks to the managements of the oil companies concerned who have so generously allowed us to study and publish on their material.

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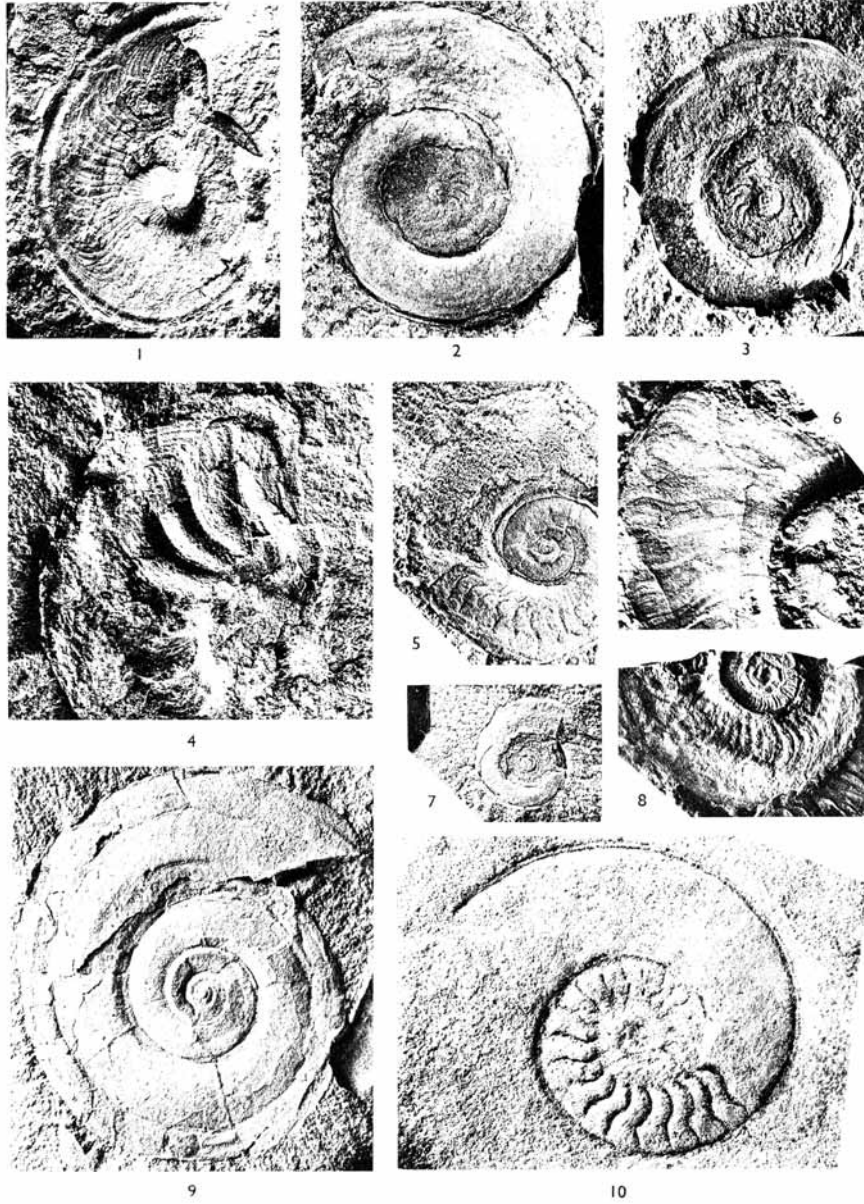
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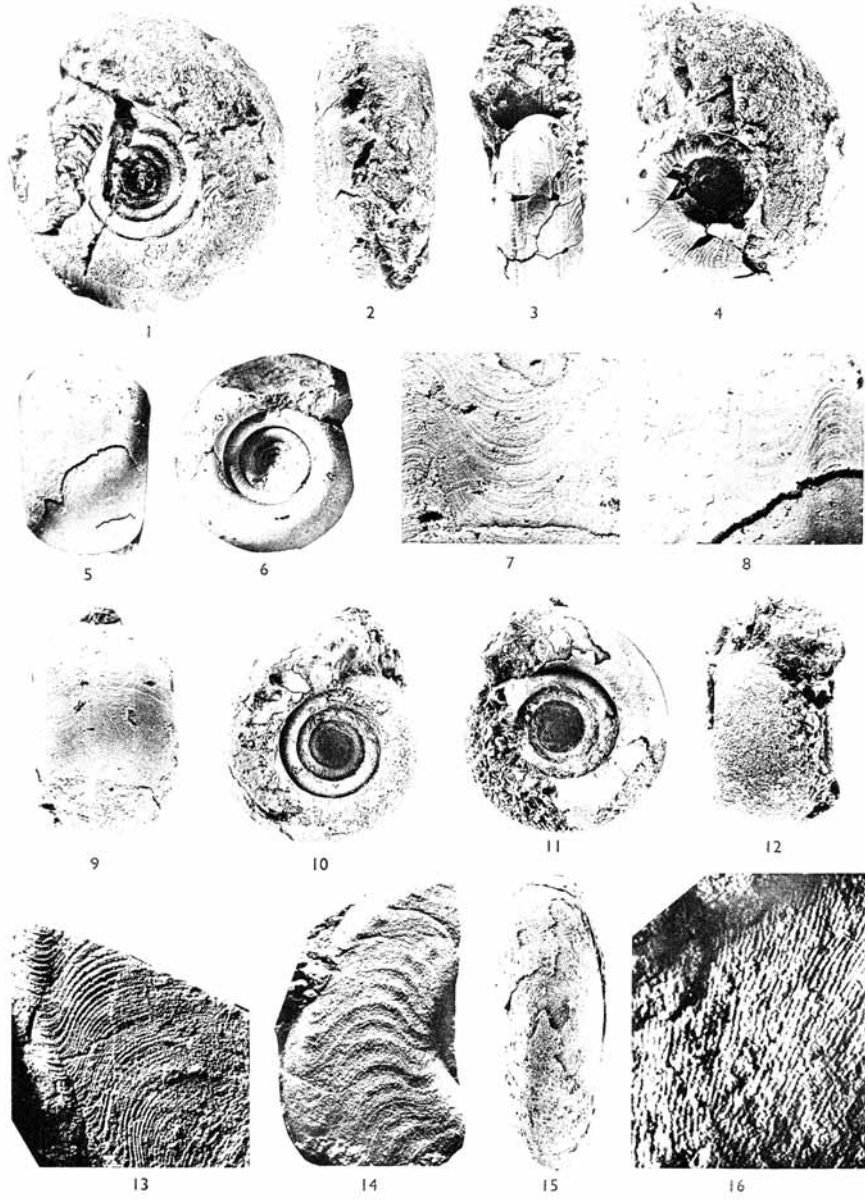
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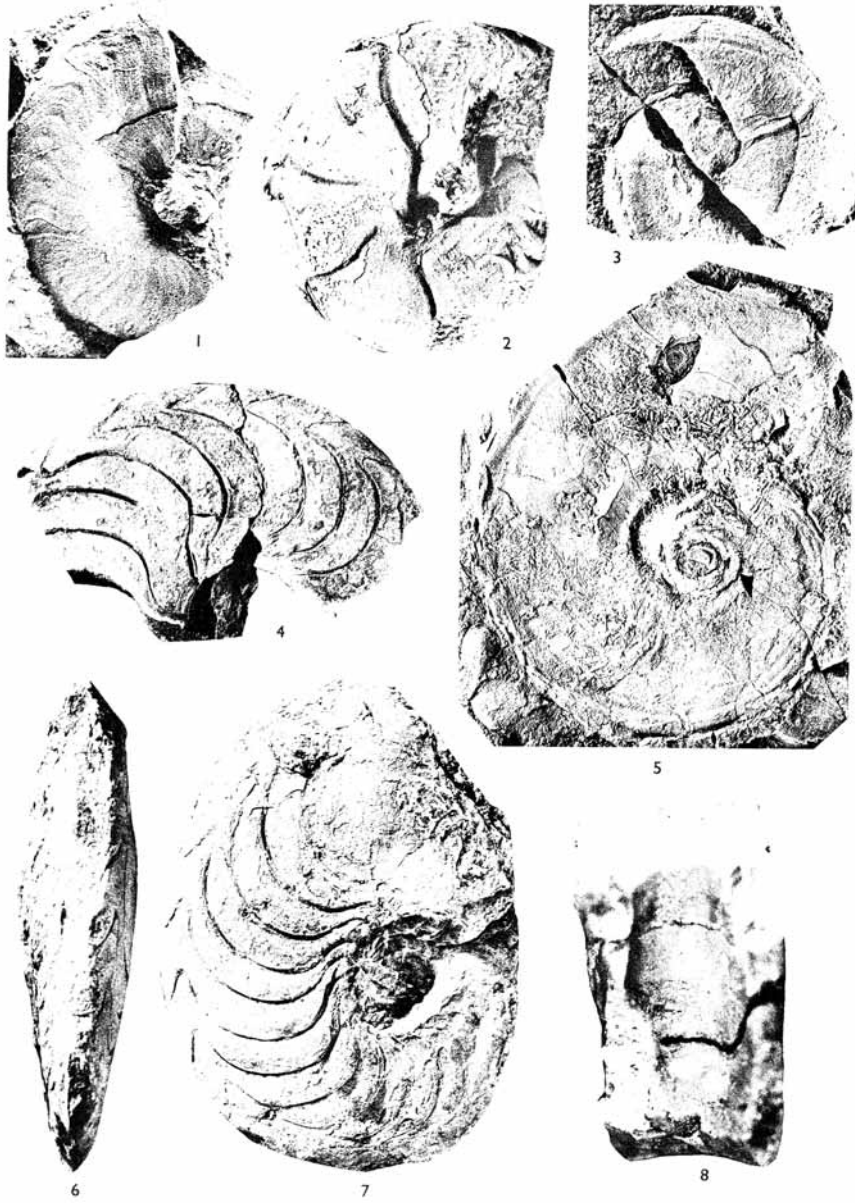
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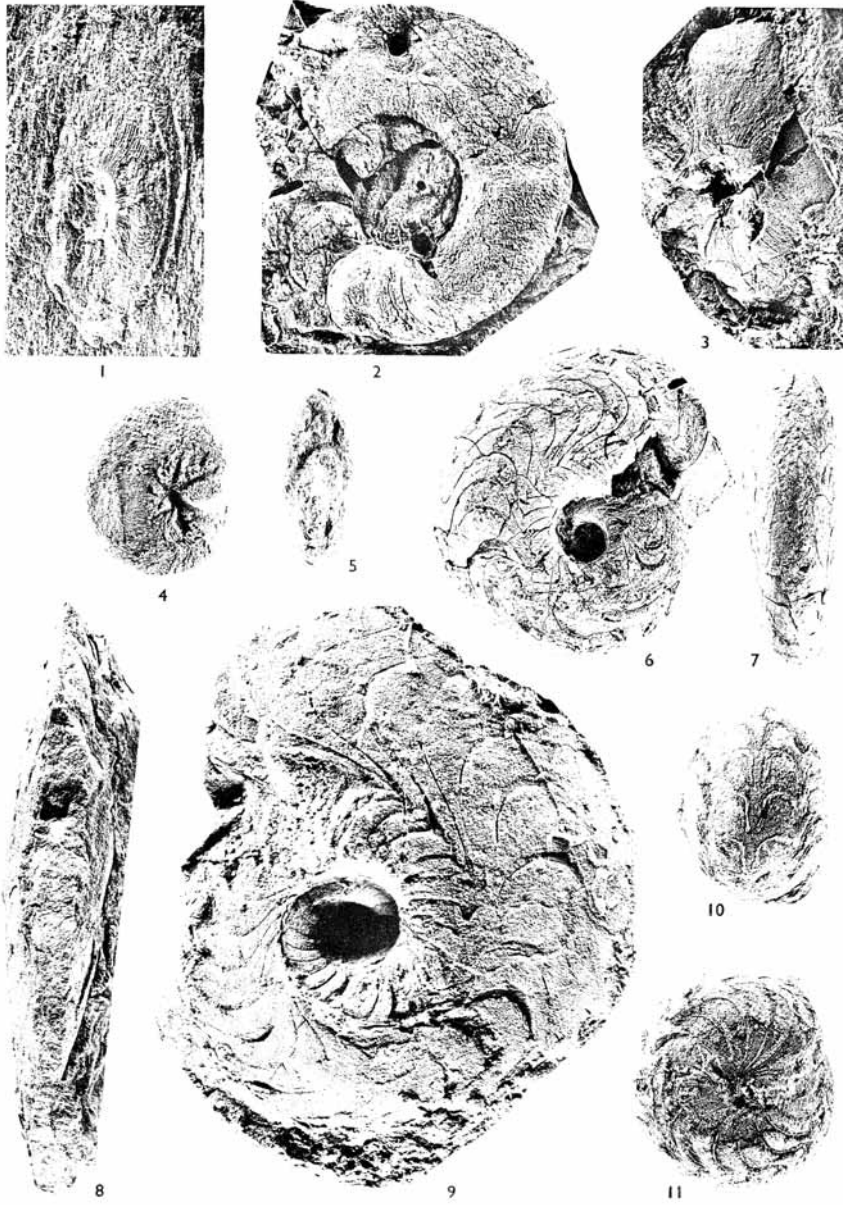


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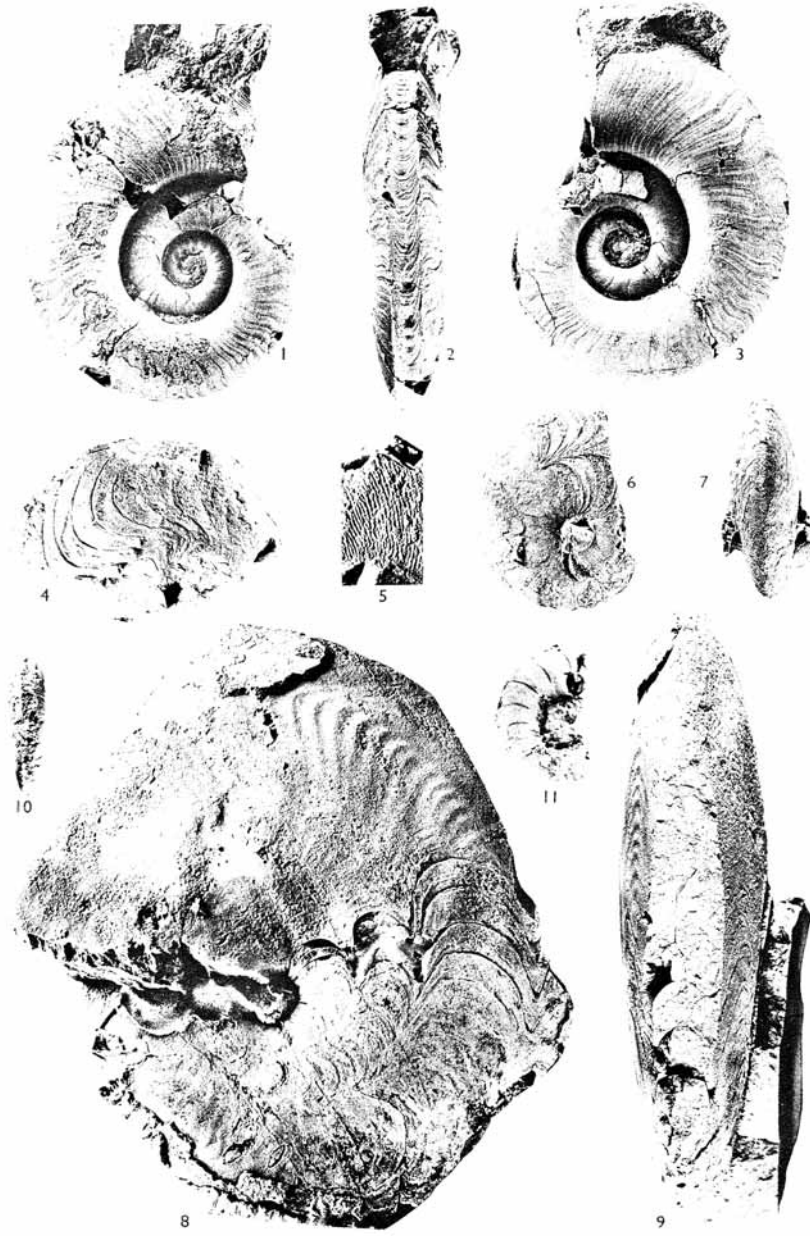


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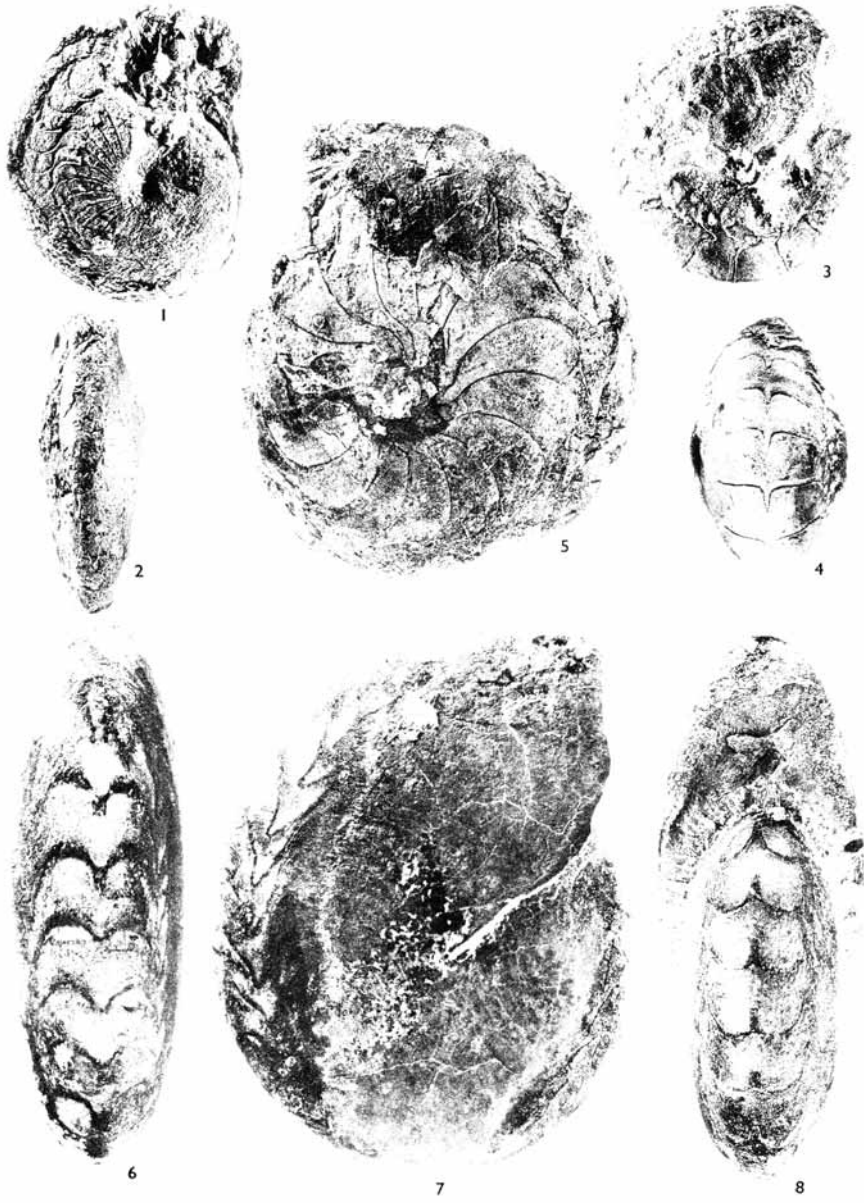


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