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THE TRIASSIC NATHORSTITES FAUNA IN NORTHEASTERN BRITISH COLUMBIA

(REPORT, FIGURE, EIGHT FOSSIL PLATES, AND APPENDIX)

BY

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INTRODUCTION

The Nathorstites-bearing fauna plays an important part in the stratigraphy, correlation, and mapping of the Triassic formations in northeastern British Columbia. It has a wide distribution there, having been found along the foothills of the Rocky Mountains from Peace River to the Liard Valley.

Nathorstites was first collected on Liard River by McConnell, while making a hazardous descent of that river in 1887. Later it was discovered at several localities within the Arctic Circle, on Bear Island, on the island of Spitzbergen, and on Kotelny Island. Still later it was found at many places in northeastern British Columbia: in the Peace River Foothills, by the writer in 1917; on Aylard Summit and in the Hackney Hills, by Beach in 1943; in Sikanni Chief Valley, by Hage in 1943; and in Tetsa Valley, by M.Y. Williams in 1943. More recently it has been collected at several other localities by geologists of oil exploration companies. In 1943, E.D. Kindle reinvestigated some localities on Liard River, and in the following year the writer re-examined occurrences in the Halfway, Sikanni Chief, and Tetsa Valleys. In addition, collections have been made by Stuart Holland for the British Columbia Department of Mines; by M.Y. Williams and J.B. Bocock of the Pacific Great Eastern Railway Survey, and C.M. Sternberg of the Geological Survey. Special acknowledgment is made to Dr. John B. Reeside, Jr., of the United States Geological Survey for plaster casts of type specimens in the United States National Museum. Many field assistants have aided in making collections, including C.R. Stelck, R.A.C. Brown, and K.C. McTaggart.

STRATIGRAPHY

Formations

A comprehensive formational classification of the Triassic of all of northeastern British Columbia is not yet possible. A few formations have been established, but the naming of others is deferred until more information is acquired, and until more experience is gained in actual mapping. Present knowledge of the lithological and formational succession is summarized in Figure 1B. The succession and local correlations recorded in this figure must be regarded as tentative, and subject to confirmation or revision as stratigraphic investigation progresses in northeastern British Columbia.

In the Peace River Foothills all of the exposed Triassic strata have been included in the Schooler Creek formation. However, it is thought that they can be divided into at least three lithological subdivisions, which experience may demonstrate to be mappable units and to be worthy of recognition as formations, namely:

Pardonet beds (at top)

The 'Grey beds'

The 'Dark siltstones'

The Pardonet beds include dark shaly, calcareous siltstones, limestones etc., and carry several Upper Triassic faunas. The 'Grey beds' include massive, grey, calcareous, fine sandstones, siltstones, grey limestones, etc. with the Nathorstites fauna at the base and the Mahaffy Cliffs and Lima? poyana faunas above; further subdivision of this unit may not be impossible, but so far has not proved feasible. The 'Dark siltstones' include dark, shaly, calcareous siltstones, dark limestone, etc., and carry the Nathorstites fauna. The name is only a convenient, temporary, expedient, and it is only partly descriptive of the lithology of this unit, for dark siltstones also occur in the Pardonet beds and in the Toad formation. It is not known what directly underlies the 'Dark siltstones' in Peace River Valley. The future of the name "Schooler Creek" is also uncertain, if the above lithological units are recognized as formations; it may, however, survive as a group name.

In Halfway and Sikanni Chief Valleys it seems possible to recognize the above three units on the basis of both lithological and faunal evidence, although some difficulty may be experienced in drawing an exact boundary between the Pardonet and 'Grey beds'. In a former report the 'Dark siltstones' on Hage Creek were placed tentatively in the Anisian part of the Toad formation; they are now considered to be identical with the 'Dark siltstones' of Peace and Halfway Valleys. In Halfway and Sikanni Chief

Valleys the two following units are observed below the 'Dark' siltstones:

'Flagstones' (at top)

Toad formation

'Flagstones' is merely a convenient name for the higher of the above two units, and is only partly descriptive. It consists of flaggy, thin-bedded calcareous, grey siltstones; fine, calcareous, massive sandstones; and limestones. The massive sandstones and limestones of this unit are present in the Mount Wright section on Halfway River, but have not been observed in Hage Creek section in Sikanni Chief Valley; these massive beds recall a similar lithology in the 'Grey beds'. It is probable that the name "Toad" can be carried south at least as far as Halfway Valley, and applied to the dark siltstones and limestones that underly the 'Flagstones' and carry the Beyrichites-Gymnotoceras fauna. It is not known as yet what underlies the Toad formation in these valleys.

The Triassic section in Prophet River basin has not been studied by the writer, but fossil collections received from there suggest that it is much like that in Sikanni Chief and Halfway Valleys.

Farther north, in Tetsa and Liard River Valleys, the Pardonet beds and the upper part of the 'Grey beds' have disappeared; the decapitated 'Grey beds' are incorporated in the Liard formation; the 'Dark siltstones' and 'Flagstones' have not been recognized but equivalent beds may be included in the lower part of the Liard formation; and the Toad formation is present and underlain by the shales of the Grayling formation, definitely exposed on Liard River and possibly also on Tetsa River. The section is as follows:

Liard formation (at top)

Toad formation

Grayling formation

The Liard formation is made up of massive, grey, calcareous, fine sandstones and limestones, and carries the Nathorstites fauna; the Toad formation is composed of dark shales, shaly siltstones, and limestones and carries the Wasatchites and Beyrichites-Gymnotoceras faunas; and the Grayling formation consists of shale. The names Liard, Toad, and Grayling have all been introduced by E.D. Kindle for the Liard River section.

At all localities east of Mile-post 378 on the Alaska Highway, in Tetsa Valley and east of a line a few miles west of the mouth of the Toad River, on Liard River, the Liard formation disappears and the Triassic section is as follows:

Toad formation (at top)

Grayling formation

Important sections in which the Nathorstites-bearing strata are present are described in detail below. Complete faunal lists are included.

Peace River Foothills

The best section of the Nathorstites zone in the Peace River Foothills is that exposed on Beattie Hill, situated on the north side of Peace River between Adams and Aylard Creeks. It has been studied in detail by the writer (See McLearn, 1940) and, in addition, collections have been made by M.Y. Williams, J.B. Bocock, H.H. Beach, C.M. Sternberg, and others. It may be summarized as follows:

Top	Feet (approx.)
'Grey beds'	
Grey, light grey weathering, mostly thick-bedded, massive, calcareous, very fine sandstone, siltstone, and impure grey, shelly and silty limestone with Lingula	800
Similar beds with Lingula selwyni Whiteaves, Spiriferina onestae, 'Coenothyris' petriana, 'C.' silvana, Monotis? montini, Pecten tranquillianus Ostrea atsina n. sp., Pleuromya sp.	200
Similar beds with Spiriferina onestae, 'Coenothyris petriana, 'C.' silvana, Monotis ? montini, Daonella nitanae, Modiolus ahsisi, Lima cf. austriaca Bittner, Pecten tranquillianus, Pecten sp., Ostrea atsina n. sp., Enantiostreon sp., Placunopsis sp., Myophoria cf. urd Boehm, Myophoria sp., Myophoriopsis sp., Pinna sp., Myalina? sp., Hoernesia woyoniana, Gervillia sp., Pleuromya triasina, Pleuromya peacensis, Pleuromya sp., Homomya? sp., Myoconcha cauriniensis, Pleurophorus cf. kissoumi, Nathorstites mcconnelli var. lenticularis Whiteaves, Paratrachyceras caurinum n. sp.	200
'Dark siltstones'	
Dark grey and brownish grey, somewhat carbonaceous, calcareous, fissile, shaly or 'slabby' siltstone with some layers and lenses of dark, silty, partly carbonaceous limestone, carrying at about 100 to 130 feet above the base, Spiriferina onestae, 'Coenothyris' petriana, 'C.' silvana, Monotis? montini, Daonella nitanae, Posidonomya sp., Myophoria cf. urd Boehm, Modiolus ahsisi, Isculites schooleri, I. schooleri var.	

parvus, Lobites pacianus, Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves Sagenites gethingi, Nitanoceras selwyni, Nitanoceras leve. Proarcestes sp., Protrachyceras sikanianum, P. zauwae, Sirenites meginae and Silenticeras hatae -------- 430

Nathorstites thus ranges through approximately 530 feet of strata, through all of the 'Dark siltstones' and into the lower part of the 'Grey beds'. The brachiopods and a few pelecypods, contemporary with Nathorstites, range about 200 feet higher than this ammonoid and at this higher horizon the genus Lingula appears, that is, at an horizon above the range of Nathorstites.

The following were collected on the hill just east of Aylard Creek and directly north of the Beattie ranch buildings, in the grey, fine, calcareous sandstones and grey limestones of the lower part of the 'Grey beds': Monotis? montini, Daonella sp., Modiolus ahsisi, Hoernesia? woyoniana, Gervillia sp., Nathorstites mcconnelli var lenticularis Whiteaves and Protrachyceras sikanianum.

The following were collected by Beach 3 miles east of Aylard Creek and 1 mile north of Peace River and from the lower part of the 'Grey beds': Monotis? montini, Pecten sarsina n. sp., Ostrea atsina n. sp., Enantiostreon sp., and Placunopsis sp.

Nathorstites-bearing strata also occur in the bed of a small stream, Mahaffy Creek, on a low flat below Mahaffy Cliffs, about 1½ miles west of Schooler Creek on the north side of the valley. Grey, massive, fine, calcareous sandstones, limestone etc. of the 'Grey beds' contain: 'Coenothyris' sp., Monotis? montini, Daonella sp., Myophoria cf. urd Boehm, Placunopsis sp. and Nathorstites mcconnelli var. lenticularis Whiteaves. They are overlain by beds of similar lithology, with 'Coenothyris' sp., Spiriferina and Lingula. Much higher in the 'Grey beds' and in the Mahaffy Cliffs are grey sandstones and limestones with pelecypods of the 'Mahaffy Cliffs' fauna.

The Nathorstites-fauna occurs on the east spur of Brown Hill in massive grey, calcareous, fine sandstones and grey limestones of the 'Grey beds'. Here are Monotis? montini, Modiolus ahsisi, Pecten (Entolium) sp., Ostrea atsina n. sp., Myophoria cf. urd Boehm, Myalina? sp., Pleuromya triasina, Pleurophorus cf. kissoumi, Nathorstites mcconnelli Whiteaves, and

N. mcconnelli var. lenticularis Whiteaves. These massive, calcareous, fine sandstones of the 'Grey beds' are underlain, far up Folded Hill Creek, by dark shales and siltstones with Daonella (the 'Dark siltstones' ?).

On the south side of Peace River Valley, and on the strike of the strata of the east spur of Brown Hill, the Nathorstites-bearing beds are present on East Glacier Spur, just west of Glacier Creek. Here in massive, grey, calcareous, fine sandstones, siltstones and limestones of the 'Grey beds' are Monotis? montini, Daonella sp., Pecten tranquillianus, Myophoria cf urd Boehm, Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves, Lobites sp., Paratrachyceras sutherlandi n. sp., Asklepioceras laurenci, A. glaciense and A. mahaffii n. sp. The following are also from East Glacier Spur and from the Nathorstites zone: Ostrea atsina n. sp., Pecten? sarsina n. sp., Myalina? sp. and Protrachyceras? sp.

Aylard Summit and Hackney Hills

On Aylard Summit, about 10 miles north of Peace River and north of Aylard Creek, Beach collected the following from the 'Grey beds': Ostrea atsina n. sp., Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves and Paratrachyceras aylardi n. sp.?

On the east side of the Hackney Hills, about 1½ miles north of Graham River, Beach collected Spiriferina, 'Coenothyris' sp., Daonella sp., Myoconcha cauriniensis, Nathorstites mcconnelli var. lenticularis Whiteaves and Protrachyceras sp. from the 'Grey' beds.

Halfway Valley

Mount Wright, on the north side of Halfway River, about 35 to 40 miles west of the Alaska Highway, has been referred to in an earlier report (McLearn, 1946 A). It is a high hill with a steep front facing the river, and is furrowed by four principal gullies, named for the purpose of this report, from west to east, First, Second, Third, and Fourth Gullies. The Triassic beds lie nearly horizontally in Fourth Gully, and dip steeply to the west in the other gullies. The lowest beds are exposed in the lower part of Fourth Gully and the highest in First Gully.

The section in the Third and Fourth Gullies is as follows:

	Feet (Roughly)
'Grey Beds'	
Massive, grey, calcareous, fine sandstones, limestone	
'Dark siltstones'	
Dark, shaly siltstone, limestone, and shale with 'Coenothyris' sp., Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves, Paratrachyceras sutherlandi n. sp.	300
'Flagstones'	
Massive, grey, calcareous, fine sandstone and limestone with 'Coenothyris' sp.	180
Flaggy, calcareous siltstone and fine sandstones	200
Toad formation	
Dark, shaly siltstones with poor ammonoids	200

The ammonoids in what is probably the Toad formation are poorly preserved, but evidently are of the Middle Triassic Beyrichites-Gymnotoceras fauna. The 'Coenothyris' sp. in the higher massive beds of the 'flagstone' unit is similar to shells in the 'Dark siltstones' and 'Grey beds'. The Nathorstites fauna occurs in the 'Dark siltstones'. It was not found in the lower part of the 'Grey beds' where it usually occurs at other localities.

Nathorstites has also been collected from a locality west of Mount Wright and from what appears to be the 'Dark siltstones' by geologists of an oil exploration company.

Sikanni Chief Valley

Hage Creek has its origin on Mount Hage, and flows from the south into Sikanni Chief River east of Mount Withrop and just west of where the western trail from Halfway Valley, that is the Marion Lake trail, enters Sikanni Chief Valley.

In the lower part of Hage Creek, where it approaches the low valley flat bordering the river, are isolated exposures of calcareous, shaly siltstones and fine sandstones, probably of the 'Grey beds'. The following were collected: 'Coenothyris' sp., Daonella sp., Trigonodus? productus Whiteaves, 'Nautilus' sp., Isculites schooleri, Protrachyceras sp., and Arpadites? sp. Although Nathorstites is not present this collection includes diagnostic species of the Nathorstites fauna.

The best exposures of the Nathorstites-bearing beds are in the upper part of Hage Creek, above its junction with McTaggard Creek (See McLearn, 1936, Fig. 1A). Here the section is as follows:

Top	Feet (Very Approx.)
'Grey beds' Massive, calcareous, fine sandstone, grey limestone etc. with, 50 feet above base, Monotis? montini, Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves	50 ±
'Dark siltstones' Dark, calcareous siltstone and dark shale with Nathorstites sp., and 'Arcestes' sp., about 40 feet above base and the following near the top: Daonella nitanae, Nathorstites mcconnelli var. lenticularis Whiteaves, Lobites cf. pacianus?, 'Monophyllites' sp. Protrachyceras sikanianum, Paratrachyceras tetsa n. sp. Sirenites meginae ?, Silenticeras sp., Asklepioceras laurenci?	75
Concealed	30
'Flagstones' Thin-bedded flaggy and massive siltstones	235
Toad formation Dark shaly, calcareous siltstones etc., with Beyrichites-Gymnotoceras fauna	

The massive, calcareous sandstone, which in the section on Mount Wright in Halfway Valley occurs in the upper part of the 'Flagstones', appears to be absent in the Hage Creek section. The Nathorstites near the middle of the 'Dark siltstones' was misidentified in an earlier report (McLearn, 1946).

The following species were collected from the 'Grey beds' by Hage on Mount Withrow, on the north side of Sikanni Chief Valley west of Mount Hage: Daonella nitanae, Nathorstites mcconnelli var. lenticularis Whiteaves and Protrachyceras sikanianum.

West of Mount Withrow the geologists of an oil company have collected the following from what are apparently the 'Dark siltstones': Daonella elegans n. sp., Dawsonites? sp., and Asklepioceras delicatum n. sp.

Prophet River Basin and Kluachesi Lake

The Nathorstites fauna has been collected by geologists of oil companies from several localities in the Prophet River drainage basin and near Kluachesi Lake. At one locality Nathorstites mcconnelli Whiteaves was collected from a 'shale' zone, presumeably the 'Dark siltstones', and N. mcconnelli var. lenticularis Whiteaves from overlying, calcareous, fine sandstones, presumably the 'Grey beds'. At another locality the following were found: 'Coenothyris' sp., Nathorstites mcconnelli Whiteaves and N. mcconnelli var. lenticularis Whiteaves. The following came from a third locality: Daonella elegans n. sp., Nathorstites mcconnelli var. lenticularis Whiteaves, Paratrachyceras sutherlandi n. sp. and Asklepioceras cf. laurenci. The following also were found at a locality, partly in place and partly as talus from a 'shale' zone, presumably the 'Dark siltstones': 'Coenothyris sp. Nathorstites mcconnelli var. lenticularis Whiteaves, Dawsonites? n. sp.? and Lobites sp.

Tetsa Valley

It has already been recorded that along the Alaska Highway in the valley of Tetsa River, from Mile-post 375 to 378, the highest Triassic beds are of the Middle Triassic (Anisian) zone of the Toad formation, and that the Liard formation is absent. However, on a high and abandoned highway location near and west of Mile-post 378, and structurally on the west limb of the Cameron anticline, are the massive calcareous, grey, fine sandstones and grey limestones of the Liard formation, apparently coming in on top of the dark siltstones and limestones of the Toad formation. They contain a small fauna, including 'Coenothyris' sp., Pecten sp., Ostrea atsina n. sp. and Pinna sp.

The massive beds of the Liard increase in thickness to the west, and Nathorstites appears at several localities, first recorded by M.Y. Williams in 1944. Thus, on the top of 'Crooked' Mountain, north of Mile-post 384, Williams collected 'Coenothyris' sp. and Nathorstites mcconnelli var. lenticularis Whiteaves. A small collection was obtained a little west of Mile-post 386 on the highway, including 'Coenothyris' sp., Sphaera? sp. Daonella nitanae, 'Nautilus' sp., Nathorstites mcconnelli Whiteaves, N. mcconnelli var. lenticularis Whiteaves, 'Arcestes' sp., Sirenites meginae Paratrachyceras tetsa n. sp., and Paratrachyceras aylardi n. sp.

Liard River

(by E.D. Kindle)

Near the mouth of Toad River, on Liard River, the thin-bedded siltstones, platy shales and thin-bedded limestones of the Toad formation are about 800 feet thick and are immediately overlain by the basal shales of the

Garbutt formation of Jurassic or early Cretaceous age. Eight miles to the southwest, the Toad formation increases to an estimated, 1,800 feet in thickness, and is overlain by massive calcareous sandstones of the Triassic, Liard formation, estimated to have a minimum thickness of 600 feet. At Hell Gate, beds fairly high in the Liard formation are exposed; they consist of thick, calcareous, fine sandstones and limestones, and contain 'Coenothyris' sp., Daonella sp., Ostrea atsina McLearn, Nathorstites mcconnelli Whiteaves, and N. mcconnelli var. lenticularis Whiteaves. At the same locality McConnell (1891) collected the following: Terebratula liardensis Whiteaves and Dawsonites canadensis Whiteaves.

At the lower end of a canyon west of Hell Gate, McConnell reported Terebratula liardensis Whiteaves, Trigonodus ? productus Whiteaves, Margarita triassica Whiteaves and Nathorstites mcconnelli Whiteaves. Four or five miles west of this is the Rapids of the Drowned, where McConnell collected and Whiteaves identified Spiriferina borealis Whiteaves, Terebratula lairdensis Whiteaves, Monotis ovalis Whiteaves (from an earlier fauna?), 'Daonella lommeli Wissmann (= D. nitanae), Halobia occidentalis Whiteaves, 'Nautilus' lairdensis Whiteaves, Nathorstites mcconnelli Whiteaves and Dawsonites canadensis Whiteaves.

CORRELATION

The Problem

It has been possible to correlate, with at least some degree of accuracy, most of the Triassic faunas of northeastern British Columbia with those in other parts of the world, and so determine their age. This, unfortunately, is not true of the Nathorstites fauna, the age of which, in the opinion of the writer, has yet to be satisfactorily established. In this preliminary report nothing more is attempted than a brief statement of the problems involved and a brief review of the evidence.

Most European geologists have accepted the Karnian or early Upper Triassic age originally proposed by Boehm for the Nathorstites-bearing fauna of Bear Island. It is inferred that Spath (1934) questions the Karnian dating. It has seemed to the writer that the evidence furnished by the Nathorstites fauna in the Peace River Foothills favours a Ladinian or late Middle Triassic age. Indeed in recent publications of the Geological Survey and in papers in the Can dian Field-Naturalist more and more stress has been laid on the Ladinian dating. An endeavour has been made, however, not to take too definite a stand, and to keep the question open until undisputed evidence is available.

The difficulties seem to be largely geographical. Late Middle and Upper Triassic standard chronology is based mainly on the succession of faunas in temperate and tropical latitudes, on the site of ancient Tethys, in the Alps and Himalayas. Nathorstites, on the other hand, has a boreal distribution and does not extend far south, not even far into temperate latitudes (See Figure 1c).

Three possible correlations are worth considering: (1) the Nathorstites fauna is equal in age to the latest Ladinian or Protrachyceras archelaus fauna, and is merely a boreal phase of it; (2) the Nathorstites fauna is equal in age to the earliest Karnian or Trachyceras fauna, and is merely a boreal phase of it (this has been a widely accepted view. See Martin, 1926); and (3) the Nathorstites fauna differs in age from either the Protrachyceras archelaus or Trachyceras fauna and possibly is intermediate in age between them; this interpretation would involve adding a new faunal zone to the standard Triassic succession.

In this and earlier related reports by the writer, he wishes to point out, too, that comparison of species from British Columbia with those in foreign countries is not with actual specimens of these foreign species, but with illustrations or descriptions of them. The validity of correlations based on these comparisons, therefore, depends to a considerable degree on the excellence of these illustrations and the accuracy and detail of the descriptions.

Correlation with Europe and Asia

The latest Ladinian, or latest Middle Triassic, fauna is the Protrachyceras archelaus fauna. It has a wide distribution on the site of the ancient Tethys seaway, for example in the Wengen beds of the South Tyrol, in the Roten Kalke of Greece, in Bithynia, in the Dobrudscha area of Rumania, in the Daonella shale and, possibly also, Daonella limestone of Spiti, India.

and on the island of Timor. The earliest Karnian, or earliest Upper Triassic, fauna is the Trachyceras fauna. It, too, has a wide distribution on the site of ancient Tethys, for example in the Raibl beds and Feuerkogel of the Salzkammergut (Hallstadt area) of Upper Austria, in the St. Cassian beds of the South Tyrol, in the upper part of the Roten Kalke of Greece, in Dobrudscha and probably in the upper part of the Daonella limestone and part of the Grey shale of Spiti.

Isculites schooleri resembles Isculites ladinus Welter from the Ladinian Protrachyceras archelaus fauna of Timor. Sagenites gethingi is closest to the group of Sagenites inermis Hauer in the Alpine faunas. However, it is not identical with any Alpine species of that group. Protrachyceras sikanianum shows considerable resemblance to Protrachyceras longobardicum Mojsisovics from the late Ladinian zone of Protrachyceras archelaus in the Alps. Protrachyceras zauwae is closer to the late Ladinian spinose species Protrachyceras archelaus Laube than to the early Karnian spinose species Protrachyceras septemspinatum Mojsisovics. Paratrachyceras sutherlandi shows some resemblance to the specimen figured as Paratrachyceras regoledanum Mojsisovics by Arthaber from the late Ladinian of Bithynia. Paratrachyceras taylardi somewhat resembles the late Ladinian species Paratrachyceras richthofeni Mojsisovics. Not being a true Sirenites, the species Sirenites reginae affords no definite evidence of age. Dawsonites is not known beyond the boreal regions of northeastern British Columbia, and is of no value in correlating with other regions. Asklepioceras affords no satisfactory evidence of age; Asklepioceras laurenci has the same style of ornament as Asklepioceras segmentatum Mojsisovics of early Karnian age, and probably also as Asklepioceras redlichi Kittl of late Ladinian age.

Among the pelecypods no Halobia has yet been found in the Nathorstites fauna of northeastern British Columbia. However Daonella is represented by two species one of which, Daonella nitanae, resembles closely Ladinian species Daonella lommeli Wissmann. Daonella is common in the Middle Triassic and very rare in the Upper Triassic where it is mostly replaced by the closely related Halobia.

The absence of species of Halobia, Trachyceras and true Sirenites favour a late Ladinian rather than an early Karnian age.

Although the fossil evidence does not appear to afford decisive evidence for either a Ladinian or Karnian age, it does seem to favour the former. The possibility, however, of an age intermediate between Ladinian P. archelaus and Karnian Trachyceras time is not ruled out. It is evident that some of the uncertainty arises from the similarity of the P. archelaus and Trachyceras faunas, a similarity that has been noted by Spath (1934).

Evidence of Stratigraphic Position

The evidence for the stratigraphic position of the Nathorstites fauna with relation to other faunas can be examined. It has been recorded that the Nathorstites fauna occurs in the 'Dark siltstones' and in the lower part of the 'Grey beds'; that a Middle Triassic (Anisian) fauna is present in the upper part of the Toad formation; and that the 'Flagstones' are mostly barren but at one locality carry brachiopods not unlike these in the Nathorstites fauna. It follows that no great range of strata lies between the Nathorstites-bearing beds and the beds with an Anisian, early Middle Triassic fauna; at the most the range is that recorded by the 'Flagstones'.

On the other hand, beds of Karnian age are much higher in the section. Two faunas overlie the Nathorstites fauna in the upper part of the 'Grey beds'. The age of the Mahaffy Cliffs fauna is uncertain, but the age of the higher, the poyana, fauna is almost certainly Karnian, and by no means late Karnian, for the late Karnian Tropites fauna occurs in the overlying Pardonet beds.

Although the stratigraphic position of the Nathorstites fauna with relation to other faunas offers no final proof of its age, it does weight the evidence somewhat in favour of Ladinian time.

Alaska

Martin (1926) has reported the presence of Spiriferina borealis Whiteaves and Dawsonites canadensis Whiteaves from float on Hamilton Bay, Kupreanof Island, Alaska. This occurrence, however, is not referred to by Smith (1927).

From limestone, a mile above the mouth of the Nation River, Alaska, Smith (1927) lists Nathorstites alaskanus Smith, Trachyceras (Protrachyceras) cf. lecontei Smith and other species. The species of Protrachyceras indicates a late Karnian age, but the assignment of Nathorstites alaskanus Smith to the genus Nathorstites is open to question.

Spitzbergen

Nathorstites-bearing strata are present in the central and eastern parts of West Spitzbergen Island and on Barents and Edge Islands. They are underlain by the Daonella beds, and overlain by the Rhaetic plant-bearing beds. The Daonella beds have been dated Ladinian by Stolley (1911), and Spath (1921) has tentatively placed the 'Oozy Mound' beds with Daonella in the Ladinian. Frebold (1935) lists species of Daonella, Gymnotoceras, and Pr..apopanoceras from the Daonella beds, indicating an Anisian age. The ammonites are said to be mostly in the lower part, and in a table Frebold notes that perhaps the uppermost part of these beds is of Ladinian age. The evidence of relative stratigraphic position of the Nathorstites fauna to other faunas whose age is known is not, therefore, satisfactory; for the age of the immediately underlying beds is apparently as yet unknown and unless the Nathorstites beds are of late Norian time, which is improbable, a hiatus of considerable magnitude exists between them and the over-lying plant-bearing beds.

Nathorstites mcconnelli var. lenticularis Whiteaves is common to the Nathorstites faunas of Spitzbergen and northeastern British Columbia. Halobia is present in the Spitzbergen fauna, but absent from the fauna in northeastern British Columbia.

Bear Island

Bear Island is a small island in the Barents sea, south of Spitzbergen. On its east coast, grey sandstone and dark shale with clay-ironstone concretions carry the Nathorstites fauna. They are underlain by barren sandstone, and the overlying beds have been removed by erosion, the Nathorstites-bearing beds being the youngest exposed on the island. Evidently the relative stratigraphic position affords no evidence of age.

The presence in the Bear Island fauna (See Boehm, 1903) of Nathorstites mcconnelli var. lenticularis Whiteaves and Dawsonites canadensis Whiteaves suggests a correlation with the Nathorstites fauna of northeastern British Columbia. Halobia and Trachyceras reported in this fauna, however, are absent in the Nathorstites fauna of northeastern British Columbia. The Trachyceras, if valid, would decisively establish an early Karnian age; it may be, however, a Dawsonites. The Halobia may weight the evidence a little in favour of an early Karnian age.

Kotelny Island

Nathorstites has been recorded from Kotelny Island, one of the New Siberian Islands in the Arctic Sea north of Siberia. No other fossils have been found with it, so that no comparison can be made with Alpine and Himalayan faunas.

Conclusions

The preliminary study of the Nathorstites fauna has not reached a final and decisive verdict in the case of a Ladinian versus a Karnian age of the fauna. The evidence from a study of the fauna in northeastern British Columbia weights the case considerably in favour of a late Ladinian age, whereas that from the Bear Island fauna seems to favour, slightly, a Karnian age, but is based upon less diagnostic material than that from British Columbia.

The possibility of an age intermediate between Ladinian Protrachyceras archelaus and Karnian Trachyceras time is not yet eliminated.

NOTES ON FOSSILS

It is not intended in these preliminary reports on the Triassic of northeastern British Columbia, published in the Paper series of the Geological Survey, to attempt any detailed treatment of the palaeontology, based on an exhaustive study of the literature; nor is it intended to attempt any extended generic revision, although this is doubtless required in some ammonoid families. It is proposed, however, to discuss, in a general way, the relations and status of some genera and species groups, in order to understand the place of the Canadian species in the general scheme of classification.

Comparison of Canadian with foreign species, and the brief comments on the evolutionary history of foreign forms, are based on illustrations and descriptions in foreign publications and not on the examination of actual foreign specimens; it is possible that some illustrations, particularly those based on drawings, are not faithful reproductions, and so errors may enter into interpretations based on them. It is also possible that comparison of Canadian specimens with actual foreign specimens would result in the recognition of more foreign and fewer new species in the Canadian faunas. It is not known what percentage of species would be so effected, but it is expected that this percentage would be small.

In the following pages, early Ladinian refers to Protrachyceras reitzi time, late Ladinian to Protrachyceras archelaus time, early Karnian to Trachyceras time, and late Karnian to Tropites subbullatus time.

Genus Nathorstites Boehm

The specimens of this genus in northeastern British Columbia exhibit a wide range of variation. Whiteaves' inclusion of all the specimens available to him in the McConnell collection from Liard River in one species, namely Nathorstites mcconnelli, was fully justified. Inclusion in the same species of all the specimens recently collected from numerous localities in northeastern British Columbia appears to be equally justified. Whiteaves' separation of some specimens as var. lenticularis is recognized; indeed the specimens of this variety outnumber those of the typical species.

Nathorstites can be briefly described as follows: stout, wide, broadly fastigate, fairly involute inner whorls, with, in some specimens, short folds on the inner part of the sides of the whorl, pass gradually into a mature stage of more compressed, smooth, completely involute, sharp-ventered whorls; that is, in growth, the shell passes from sphaerocone to oxycone. The suture line is ceratitic and multisellate, with short, somewhat 'club-shaped' saddles.

In the typical species, Nathorstites mcconnelli Whiteaves, the inner whorls are wide and stout and the advance to oxycone is only partial. In the variety lenticularis Whiteaves the oxyconic shape is fully attained.

Some variation in the course of the growth lines is observed. In all specimens it is convex forward on the sides of the whorl. In the holotype and some other specimens it is projected forward as it approaches the venter; in others it curves a little backward (rursiradiate) at the venter.

Genus Nitanoceras McLearn

The shells of this genus resemble closely those of Megaphyllites Mojsisovics in form and suture line. The denticulations, however, do not run up so far on the sides of the saddles; that is, the suture line is simpler.

Genus Isculites Mojsisovics

This genus has been discussed in a previous paper (McLearn, 1937). The Peace River species Isculites schooleri from the Nathorstites fauna and, apparently also, Isculites ladinus Welter from the Ladinian of Timor differ chiefly from the species of the typical I. decrescens group in the lack of any Anatomites- or Juvavites-like ornament, and, from species like I. subdescrescens, in the simpler suture line. I. schooleri is much older than either I. decrescens or I. subdecrescens, which are of Norian age; is probably not very close to either of them, and, with I. ladinus, may require a new generic name.

Both Mojsisovics (1893) and Spath (1934) have included Isculites, in the strict sense, that is in the sense of Isculites decrescens Hauer, in the Haloritidae and near Anatomites.

Genus Protrachyceras Mojsisovics

Contemporary use of the genus Protrachyceras encompasses a wide range of form and ornament. No attempt is made to subdivide it into new genera and it is used in a broad sense. A brief history of the genus from Anisian to late Karnian is given, however, as a background against which to examine the species from northeastern British Columbia.

A considerable number of species from Anisian to late Ladinian time fall into the category of compressed shells with simple, unmodified tubercles. They vary a great deal but are mostly moderately involute, compressed, have mostly ribs of average strength, never fine, and the rows of lateral tubercles rarely exceed five or six. The tubercles do not become spinate, bullate or clavate. The suture line is ceratitic to moderately ammonitic. These species form what may be called the dunni group, and include the Anisian species Protrachyceras lahontanum Smith, P. americanum Smith, P. dunni Smith, P. springeri Smith, P. homfrayi Gabb from Nevada, the early Ladinian

P. margaritosum Mojsisovics and the late Ladinian P. anatolicum Toula, P. pseudoarchelaus Boeckh, P. steinmanni Mojsisovics, and the inner whorls of P. gredleri Mojsisovics. Of the above, P. lahontanum Smith and P. americanum in the Anisian of Nevada have stout, low, evolute whorls and coarse ribs like Nevadites, from which Protrachyceras is said to have originated or at least to which it was closely related in Anisian time. Protrachyceras ansoni Diener from the Tropites limestone of Byans, India, appears to have similar ornament, but is much more involute than any other species of Protrachyceras.

In some species of Anisian, Ladinian, and early Karnian time the tubercles of the ventral rows marginal to the ventral sulcus, one on either side, became modified to form clavi parallel with that sulcus. Clavate-like ventral tubercles first appeared in the Anisian species P. meeki, at maturity. From illustrations it is inferred that these ventral clavi appeared in the late Ladinian species Protrachyceras ladinum Mojsisovics and P. longobardicum Mojsisovics and in the early Karnian P. aeoli Mojsisovics. They also seem to have appeared in the early Karnian Protrachyceras attila Mojsisovics and related species, including P. medea Mojsisovics, P. thyrae Mojsisovics, P. arion Mojsisovics and P. baconicum Mojsisovics; this group has the additional distinctive character of an increase in number of ribs and number of rows of tubercles over and above those in the dunni group and above the other species with ventral clavi.

The simple ornament of the dunni group of species also became modified in another way in a few species. Small lateral bullae, with some reduction in strength of ribbing, appeared at maturity in the late Ladinian species Protrachyceras longobardicum Mojsisovics and in the early Karnian species Protrachyceras oedipus Mojsisovics and P. cassiopeia Mojsisovics. In P. longobardicum, as already noted, the ventral tubercles were modified to form clavi. In the other two species the ventral tubercles remained unmodified.

The ornament of the simply tuberculate species group of P. dunni became modified in yet another way. The tubercles became somewhat produced and assumed a spinate form. Spinate tubercles appeared in the late Ladinian Protrachyceras archelaus Laube and in the early Karnian Protrachyceras septemspinatum Mojsisovics. Spinose tubercles also appear in other groups of species and will be referred to later.

The early Karnian species, like Protrachyceras hadwigae Mojsisovics, P. rudolphi Mojsisovics, and P. subfurcatum Mojsisovics, shared a distinctive style of ornament with low, broad ribs, bearing clavi, an ornament similar to that in the genus Diplosirenites Mojsisovics.

The shell form of a species in the late Ladinian Daonella shale of Spiti, India, recalls the shell form of Anisian Nevadites, and is in contrast with the more compressed contemporary species. Protrachyceras spitiense Diener has fairly evolute, stout, whorls, about as high as thick, with coarse ribs and large spinate tubercles.

A distinctive style of ornament appears in the early Karnian species Protrachyceras atavum Mojsisovics, P. schloenbachi Mojsisovics, and P. servile Mojsisovics. A lateral ornament of mixed spines and tubercles is similar to that of the species group of Trachyceras hylactor, included of course in the genus Trachyceras.

From early Ladinian to Karnian time, several groups of species show fewer rows of tubercles than in the previously noted species. The reduction is frequently observed at maturity in specimens that have more rows on inner whorls. The reduction appears in what are probably quite independent groups of species, some probably representing independent offshoots from the dunni-l like species. Early Ladinian species like Protrachyceras reitzi Boeckh, P. chiesense Mojsisovics, P. cholnokyi Frech, and P. recubariense Mojsisovics, have only one or two rows of tubercles or spines at maturity. They have fairly coarse ribs, are fairly evolute, and have a ceratitic suture line. The late Ladinian, evolute species Protrachyceras julia Mojsisovics and P. doleriticum Mojsisovics show reduction in number of rows of tubercles. A reduced number of rows of tubercles at maturity is also observed in the early Karnian species Protrachyceras victoriae Mojsisovics and P. thous Dittmar. The late Karnian species Protrachyceras zenobii Diener also shows fewer rows of tubercles at maturity than on inner whorls, and has been compared with P. thous by Diener. Other examples of reduced tubercular ornament will be considered in describing the genus Paratrachyceras Arthaber.

A few species of Protrachyceras show reduction in, or modification of, the ribbing, including shortening of ribs, and the assumption of irregular, uneven ribbing. These species include P.? hispanicum Mojsisovics, P. ibericum Mojsisovics, P.? villanovie Verneuil, P.? laricum Mojsisovics and P.? rutoranum

Mojsisovics. The species Protrachyceras ladinum Mojsisovics and P. gredleri, already mentioned, grew to a large size, and at maturity lost most of their ornament. Possibly this mature stage was reached in some other species, but the adult shells have not been preserved.

Strigate ornament appears in a group of species of Protrachyceras in Shasta county, California, and in late Karnian time, when species referred to this genus made their last appearance. This distinct group includes Protrachyceras lecontei Hyatt and Smith, P. shastense Smith, P. madisonense Smith, P. lindgreni Smith, P. beckeri Smith and P. californicum Smith, all from the Hosselkus limestone. They have compressed to stout whorls, and bear a peculiar ornament, including a stage of rather coarse ribs, succeeded by a stage of more delicate ornament with very fine ribs, crossed by longitudinal ridges or lines, bearing very fine tubercles or very fine bullae. They are all fairly involute, and have deeply cut suture lines with deep saddles and long lobes. These species appear to have the most elaborate suture lines of those referred to Protrachyceras. The suture lines of Anisian and Ladinian species are mostly ceratitic, rarely subammonitic or weakly ammonitic. Very few suture lines of early Karnian species have been prepared; they are all ammonitic.

Protrachyceras sikanianum McLearn

(Plate I, Figures 2 to 5)

Of the many styles of shell ornament in Ladinian and Karnian time, described above, three are represented in the Nathorstites fauna of north-eastern British Columbia, two in the species Protrachyceras sikanianum and one in Protrachyceras zauwae.

It has been observed how in late Ladinian time, clavi marginal to, and parallel with, the ventral sulcus appeared in species like Protrachyceras pseudoarchelaus Boeckh and in the early Karnian species P. aeoli Mojsisovics. Varieties of P. sikanianum without lateral bullae are in this category. They differ from P. pseudoarchelaus in being a little more involute and in having one row less of tubercles and a simpler suture line. They differ from P. aeoli in having fewer rows of tubercles and in being somewhat more involute; unfortunately the suture line of P. aeoli is not known.

The appearance of lateral bullae at maturity, together with the marginal clavi parallel with the ventral sulcus in the late Ladinian species

Protrachyceras longobardicum Mojsisovics, have been described. The same features appear in the holotype and similar specimens of Protrachyceras sikanianum. Compared with P. longobardicum, the Canadian species has fewer rows of tubercles and a simpler suture line, and the lateral bullae appear at an earlier stage of growth.

Protrachyceras zauwae McLearn

(Plate I, figure 1)

Originally described as a variety of Protrachyceras sikanianum this is now recognized as a species.

Reference has already been made to the manner in which spinate tubercles appeared in the late Ladinian species Protrachyceras archelaus Laube and the early Karnian species P. septemspinatum Mojsisovics. The same ornament appears in the Canadian species Protrachyceras zauwae, which is smaller than P. archelaus, and in which the spinate tubercles appear at a later stage of growth and are probably coarser. Compared with Protrachyceras septemspinatum the ribs are farther apart at maturity, and the rows of tubercles are one less in number. P. zauwae is probably closer to P. archelaus than to P. septemspinatum.

Genus Paratrachyceras Arthaber

When describing the genus Paratrachyceras, Arthaber gave a long list of species to be included in it. Although they all show reduction in tubercles, most are too far removed from the genotype of Paratrachyceras, P. hofmanni Boeckh, to be included in this genus. Many have already been noted under Protrachyceras, and no doubt they will receive attention whenever the genus Protrachyceras is revised.

The following species seem close enough to the genotype to be included in Paratrachyceras, the late Ladinian species Paratrachyceras richthofeni Mojsisovics, P. regoledanum Mojsisovics, P. mundevillae Mojsisovics, and P. laczkoi Diener, and the early Karnian species P. hofmanni Boeckh, the genotype, and P. dichotomum Muenster. The early Karnian typical species are much more involute than the late Ladinian species, which are fairly evolute. The suture line of the early Karnian species is ammonitic and subammonitic, that of the late Ladinian species is not known. All have numerous, fine ribs finer on the average in the early Karnian than in the late Ladinian, fairly to strongly projected at their ventral ends and ending in tubercles or swellings. All are compressed and have a ventral sulcus of variable depth.

A peculiar departure from typical Paratrachyceras is shown by the specimen figured by Arthaber (1915) as P. regoledanum from the Late Ladinian of Bithynia. It has a very shallow sulcus and the ribs instead of ending in tubercles or swellings on the border of the ventral sulcus continue across it without interruption.

Paratrachyceras sutherlandi n. sp.

(Plate V, figure 9)

This species is briefly described in the printed appendix. It resembles the specimen from Bithynia figured by Arthaber (1915) under the name of Paratrachyceras regoledanum Mojsisovics; it has the same shallow ventral sulcus and the ribbing similarly crosses this sulcus, but the ribbing is coarser and the suture line simpler.

Paratrachyceras aylardi n. sp.

(Plate VIII, figures 1,2)

Two species Paratrachyceras caurinum n. sp. and P. aylardi n. sp. differ considerably from P. sutherlandi, having somewhat the appearance of an Arpadites but lacking the keels marginal to the ventral sulcus. They are not quite typical Paratrachyceras, as they lack the definite ventral tubercles or swellings of the ventral ends of the ribs. The ribs are attenuated on the ventral shoulder, and exhibit a slight tendency to enlarge a little at their ventral ends. Some species of Sirenites show this attenuation of ribs on the ventro-lateral shoulder. These species are closest to the more evolute late Ladinian species of Paratrachyceras, for example the late Ladinian species Paratrachyceras richthofeni Mojsisovics. The suture line is poorly preserved, but is known to be simple and apparently weakly ceratitic. They are tentatively included in Paratrachyceras.

Paratrachyceras aylardi n. sp. is briefly described in the printed appendix. It is fairly evolute [illegible]. The whorls are much higher than thick, have flattened sides, rounded [illegible] shoulders, ventral sulcus, no keels and well-rounded umbilical shoulder. The sides of the whorl are ornamented with fairly coarse ribs, strongly projected and also attenuated on the ventro-lateral shoulder; some ribs are single, some divide close to the umbilicus, others high up on the sides. The ventral ends of attenuated ribs tend to thicken slightly.

Paratrachyceras aylardi is smaller than Paratrachyceras richthofeni Mojsisovics, has coarser ribs, which are more strongly projected; thickening at the ends of ribs is rare and very slight, and the ventral attenuation of the ribs is not recorded for P. richthofeni.

Paratrachyceras caurinum n. sp.

(Plate VII, figure 13)

This species, briefly described in the printed appendix, is much like Paratrachyceras aylardi n. sp., and may be only a variety of it. The ribbing is much finer.

Paratrachyceras tetsa n. sp.

(Plate IV, figures 3,4; Plate VIII, figure 3)

This species is briefly described in the printed appendix. The ornament on the posterior part of the ultimate whorl, preserved, with its even ribbing ending in tubercles on the border of the ventral sulcus, is much as in P. dichotomum Muenster, but may be somewhat coarser. The irregular ornament at the anterior end of the ultimate whorl preserved is very different however, and unusual in Paratrachyceras.

Genus Sirenties Mojsisovics

A new style of ventral ornament in the family Trachyceratidae appeared in early Karnian, that is earliest Upper Triassic time, and continued on into the Norian. On or near the ventro-lateral shoulder the ribs divide into short, fine ribs, each of which ends in a tubercle; this means that the number of tubercles in the row marginal to the ventral sulcus is greater than the number of ribs on the sides of the whorls. All typical species have well-defined ribs and many lateral rows of tubercles.

In the long, Upper Triassic history of this genus many new kinds of ornament, or modifications of ornament, appear. The relative number of ventral tubercles increases; modification of the ventral tubercles is achieved by a braided ventral ornament; and, at maturity, lateral bullae appear in some species. The suture line becomes more complex. Reduced ornament at maturity is noted in some species; some varieties of Sirenites senticosus Dittmar, as figured by Mojsisovics, and the early Karnian species Sirenties loczyi Mojsisovics and Sirenites clavigo Mojsisovics are examples.

Sirenites meginae McLearn

(Plate V, figures 1 to 4)

This species has, at various times, been referred to the genera Steinmannites Mojsisovics, Meginoceras McLearn, Paratrachyceras Arthaber, and Sirenites Mojsisovics. It is certainly not a Steinmannites, a Norian genus, which has keels marginal to the ventral sulcus and a different suture line, a suture line more resembling Norian Clionites. Use of the name Meginoceras is deferred for the present, and Sirenites is used in the broad sense.

This species is not a Sirenites in the strict sense, but it shows some characters of both a Sirenites and a Paratrachyceras. In the number of ventral tubercles relative to the number of lateral ribs it is intermediate between Paratrachyceras and Sirenites. In Paratrachyceras the ribs do not divide near their ventral ends, so that there is no increase in number of the ventral tubercles.

Genus Dawsonites Boehm

It has been noted how a new style of ventral ornament appeared in the early Karnian in the shells included in the genus Sirenites Mojsisovics. At the same time another new style of ventral ornament appeared; it was a fission of each tubercle producing paired tubercles in each row bordering the ventral sulcus. This style of ornament, alone, without further complexity had a short range, did not survive the early Karnian, and is a diagnostic feature of the genus Trachyceras Laube, the genus indicative of the basal Karnian faunal zone. As in Sirenites the sides of the whorl are ornamented with curved ribs and rows of tubercles or spines. The suture line is typically ammonitic.

Boehm (1903) has given the name Dawsonites to ammonoids with the shell ornament of Trachyceras but with a much simpler and ceratitic suture line. This genus has been reliably recorded only from the Nathorstites fauna of northeastern British Columbia and Bear Island. Johnston has recorded Trachyceras with a comparatively simple suture line from New Pass, Nevada, but not so simple as that of Dawsonites.

Dawsonites canadensis Whiteaves

(Plate VIII, figure 6)

Only one of the specimens, the one illustrated by Whiteaves, is preserved. It is a fairly good specimen, although the surface is a little worn. The whorls have flattened sides, almost angular umbilical shoulder, somewhat flattened venter, rounded ventro-lateral shoulder, and a distinct ventral sulcus. The numerous, slender ribs are nearly straight on the sides and projected forward on the ventro-lateral shoulder; a few divide on this shoulder into two slender ribs. A few indistinct tubercles are on the umbilical shoulder. About 7 or 8 rows of tubercles are on the sides. The ribs end in swellings on the border of the ventral sulcus on the posterior part of the ultimate whorl, but the shell may have exfoliated here somewhat. They end in raised bullae, each bearing apparently two tubercles, much as in Trachyceras, on the anterior part of the ultimate whorl, No distinct keels are present. The suture line is very simple and ceratitic.

Genus Silenticeras McLearn

Silenticeras was originally described as a subgenus of the Norian Alpine genus Daphnites Mojsisovics, but it lacks the even ribbing of that genus. Silenticeras is related to the Trachyceratidae in the broad sense, representing a stock in which the ornament of ribbing and tubercles has been lost, or never acquired, and in which the growth lines have become strongly projected. It lacks the ventral keels of Arpadites Mojsisovics; and also the faint tubercles of Klipsteinia Mojsisovics, and has much stronger projection of growth lines.

Silenticeras hatae McLearn

(Plate V, figures 5 to 8)

This species resembles Arpadites schencki Johnston from New Pass, Nevada, but lacks the ventral keels.

Genus Asklepioceras Renz

The species in northeastern British Columbia differ very much among themselves, but all show some resemblance to species of Asklepioceras and can be referred to this genus if it is interpreted in a broad sense. All have the deep, strongly projected, radial furrows, and all have a ventral sulcus, but no keels. Three styles of ornament are present: (1) flat 'ribs' with tubercles: (2) broad flat 'ribs' with striae or fine costae; and (3) fine narrow 'ribs'. (The 'ribs' indicate the flat spaces between the radial furrows). Asklepioceras laurence has the second style of ornament only, but the innermost whorls are not preserved. A. glaciense and A. delicatum n. sp. have the first ornament only. A. mahaffii n. sp., has the second ornament succeeded by the third. The early Karnian species A. helenae Renz from Argolis has the first style of ornament, succeeded by the second; thus A. glaciense and A. delicatum have surface ornament similar to that of the inner whorls of A. helenae, and A. laurenci has surface ornament similar to that of the outer whorls of A. helenae. The early Karnian A. segmentatum Mojsisovics appears to have the second style of ornament only, the fine costae or striae on the flat 'ribs' showing clearly in Mojsisovics illustrations, but the deep furrows are more evenly spaced than in A. laurenci. The Ladinian A. redlichi Kittl from Dobrudscha also appears to have the second ornament only, but has more evenly spaced furrows and is more compressed than A. laurenci. The late Ladinian A. loczyi Diener from Bakony may have this second ornament only, but merely the core, not the surface of the shell is preserved; the furrows are closer and more regularly spaced than in A. laurenci. The early Karnian A. squammatum Arthaber from Bithynia may have the second ornament only, with the furrows at first widely spaced and at later stages of growth more narrowly spaced.

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APPENDIX. New species from the Triassic *Nathorstites* fauna, by F. H. McLearn.

Daonella elegans n. sp. Pl. IV, fig. 2. Longer than high; beak in advance middle hinge line. Costae, variable but always fine, wavy in places; change in direction costae on border umbones. Ornament somewhat like that of *Halobia subcomata* Kittl, but costae wavy in places, lacks *Halobia* anterior wing and relatively longer. G. S. C.: hol., 9537.

Ostrea atsina n. sp. Pl. VII, fig. 11. Thin, curved shell, low umbones, mostly higher than long. Mostly approximate, fine varices of growth, occasionally more prominent. Flatter shell with less prominent umbones than *Ostrea pictetiana* (Mortillet) Stoppani. G. S. C.: hol., 9538.

Pecten ? sarsiana n. sp. Pl. VII, figs. 3, 4. Higher than long to about as high as long; fairly convex; large, not well differentiated ears; numerous radial costae in two or three degrees of strength. More and finer costae than in *Pecten ? dishinni* McLearn. G. S. C.: hol., 9539; par., 9540.

Pleuromya peacensis n. sp. Pl. VII, fig. 12. Elongate, fairly convex; beaks about one quarter from anterior end shell; post-umbonal slope narrowly rounded; irregularly spaced varices of growth. Outline more narrowly rounded than in *Pleuromya musculoides* Schlotheim. G. S. C.: hol., 9541.

Pleuromya triasina n. sp. Pl. VII, figs. 8, 9. Somewhat subquadrate in outline, but narrowing anteriorly; abruptly rounded post-umbonal slope; faint varices of growth. Beaks more central than in *Pleuromya peacensis* n. sp. and outline not narrowed posteriorly. G. S. C.: hol., 9542; par., 9543.

Nitanoceras leve n. sp. Pl. III, fig. 6. Larger and smoother species than *Nitanoceras selwyni*; constrictions only at anterior end; growth lines straight or concave across venter. Suture line like *N. selwyni*, of which may be only variety. G. S. C.: hol., 9544.

Paratrachyceras tetsa n. sp. Pl. IV, figs. 3, 4; Pl. VIII, fig. 3. Moderately evolute, compressed, broad ventral sulcus. Ribs at first of even size and evenly spaced, then irregular and bundled. All ribs projected on ventro-lateral shoulder, ending in very small tubercles. More compressed, more evolute and with simpler suture line than *P. dichotomum* Munster and has stage irregular ribbing. G. S. C.: hol., 9545; par., 9546.

Paratrachyceras sutherlandi n. sp. Pl. V, fig. 9. Variably compressed, moderately evolute, with narrow venter, shallow ventral sulcus, angular ventro-lateral shoulder, abruptly rounded umbilical shoulder. Fine, rather flat, ventrally projected ribs crossing venter, but reduced there. Resembles *P. regoledanum* Mojsisovics as illustrated by Arthaber, but ribbing coarser and suture line simpler with fewer indentations. G. S. C.: hol., 9547.

Paratrachyceras caurinum n. sp. Pl. VII, fig. 13. Fairly evolute, compressed, rounded umbilical shoulder. Ribs partly single, partly branching, strongly projected and attenuated on ventro-lateral shoulder, slight tendency to thicken at ventral end. Ribs ventrally more strongly projected and more attenuated than in *Paratrachyceras richthofeni* Mojsisovics. G. S. C,: hol., 9548.

Paratrachyceras aylardi n. sp. Pl. VIII, figs. 1, 2. Fairly evolute, compressed, rounded ventro-lateral shoulder, ventral sulcus, no keels, well rounded umbilical shoulder. Coarse ribs attenuated and well projected on ventro-lateral shoulder. Smaller, with coarser ribs, more strongly projected and ventrally attenuated than in *Paratrachyceras richthofeni* Mojsisovics. G. S. C.: hol., 9549.

Asklepioceras delicatum n. sp. Pl. IV, figs. 6, 7. Moderately evolute, compressed, broad venter, rounded ventro-lateral shoulder, narrow, deep ventral sulcus, rounded umbilical shoulder. Numerous, narrow, almost flat, striated ribs separated by narrow furrows, which are wider and deeper on the core than on the surface. About ten rows lateral and ventro-lateral tubercles; two rows border ventral sulcus. More compressed, more numerous furrows, more deeply cut on core than *Asklepioceras glaciense* McLearn. G. S. C.: hol., 9550.

Asklepioceras mahaffii n. sp. Pl. VI, figs. 1 to 3. A small stout-whcrled moderately involute species, broadly rounded ventro-lateral shoulder, very shallow ventral sulcus. The small holotype shows stage of smooth to striate shell with distantly spaced furrows, succeeded by stage of slender ribs, projected on ventro-lateral shoulder and extending across the very shallow, ventral sulcus. No tubercles. Differs from *Asklepioceras laurenci* McLearn in presence of mature fine-rib stage. G. S. C.: hol., 9551; par., 9552.

Ottawa, Canada,
December, 1947.

NATHORSTITES FAUNA

'DARK SILTSTONES'

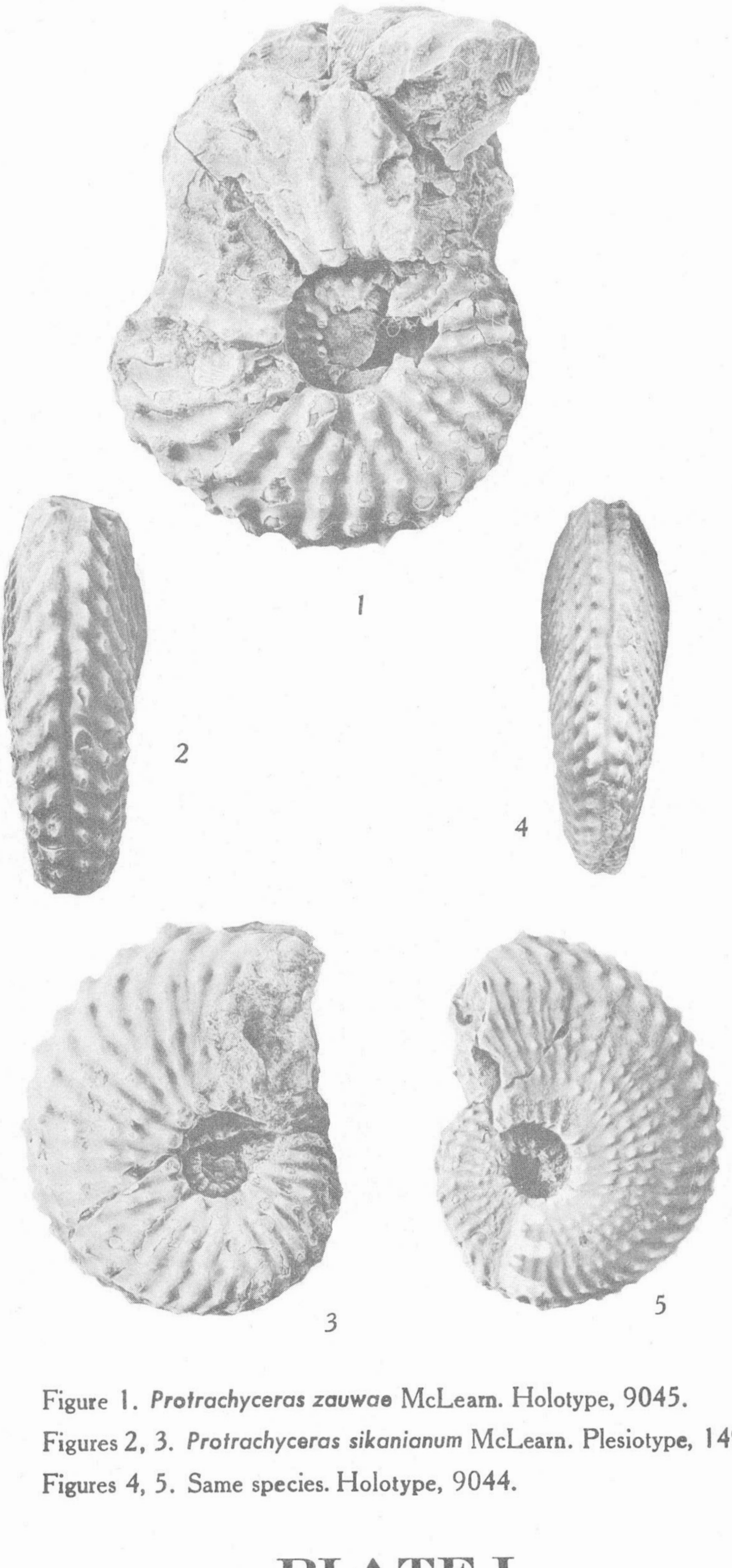


Figure 1. ***Protrachyceras zauwae*** McLearn. Holotype, 9045.

Figures 2, 3. ***Protrachyceras sikanianum*** McLearn. Plesiotype, 1494.

Figures 4, 5. Same species. Holotype, 9044.

PLATE I

NATHORSTITES FAUNA

'DARK SILTSTONES'

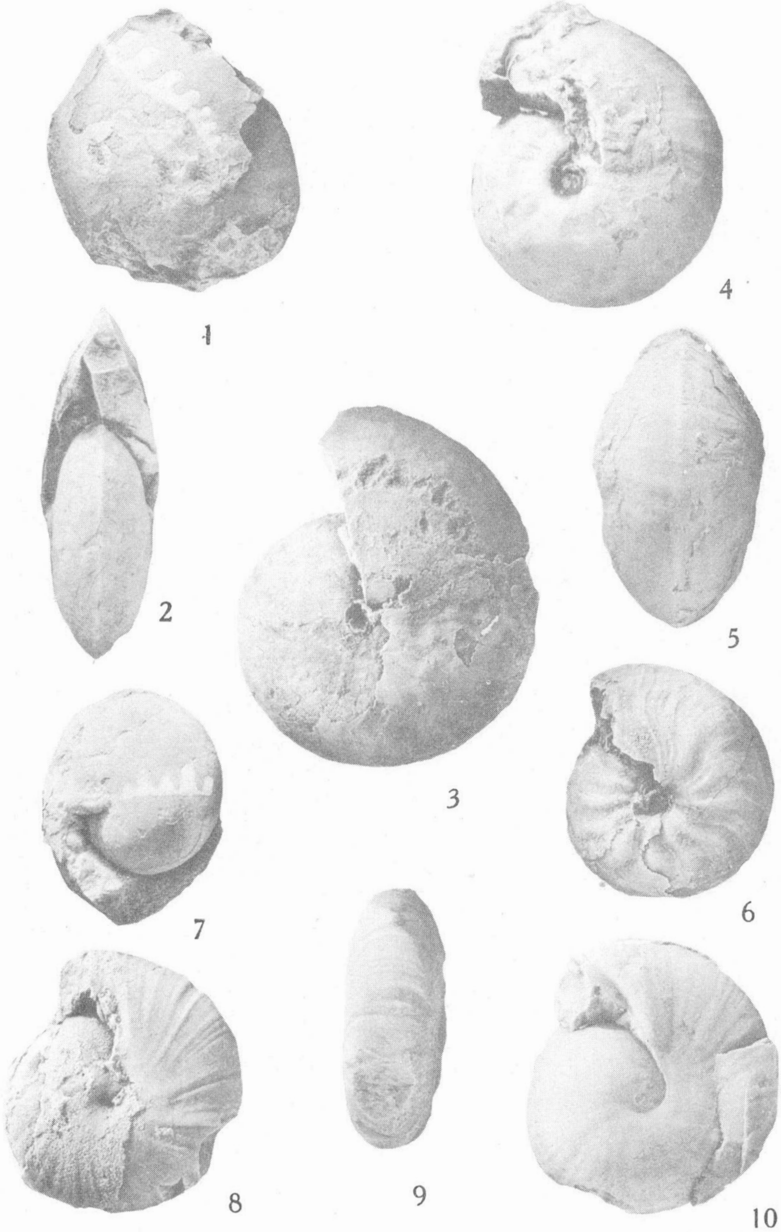


Figure 1. ***Nathorstites mcconnelli*** var. ***lenticularis*** Whiteaves. Plesiotype, 9520.

Figures 2, 3. Same variety. Plesiotype, 9521.

Figures 4, 5. ***Nathorstites mcconnelli*** Whiteaves. Plesiotype, 9522.

Figure 6. Same species. Plesiotype, 9523.

Figure 7. ***Lobites pacianus*** McLearn. Plesiotype, 9524.

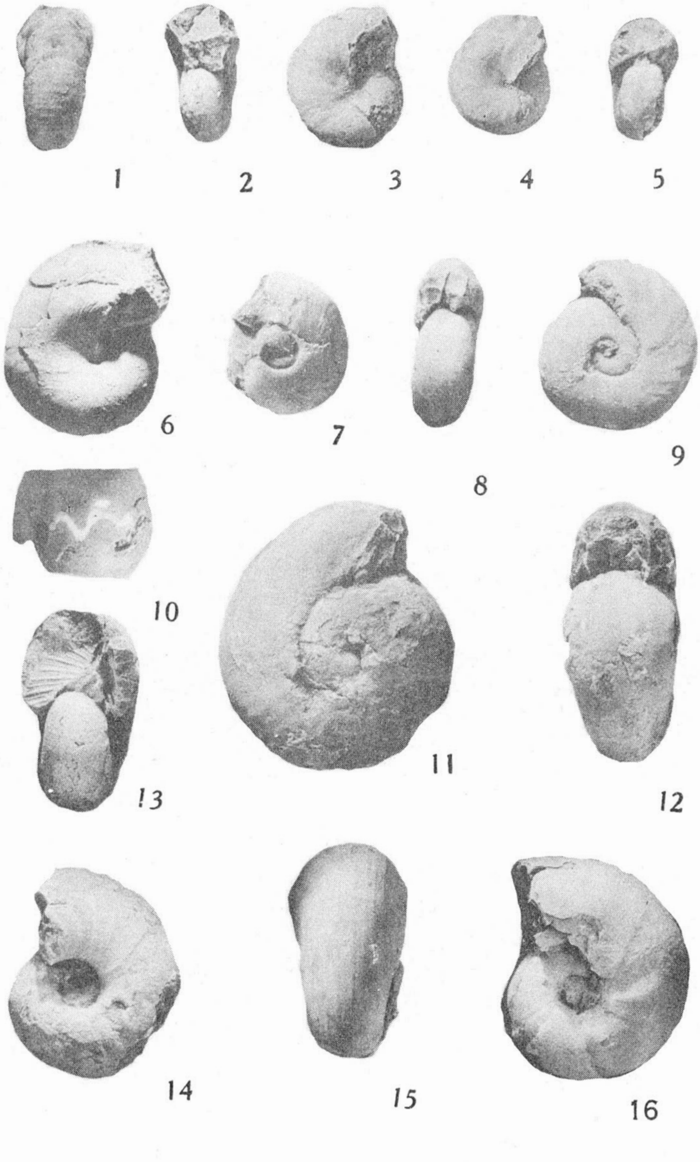
Figures 8, 9. Same species. Plesiotype, 9525.

Figure 10. Same species. Holotype, 8789.

PLATE II

NATHORSTITES FAUNA

'DARK SILTSTONES'



Figures 1, 2, 3. *Nitanoceras selwyni* McLearn. Holotype, 9047.
Figures 4, 5. Same species. Plesiotype, 9526.
Figure 6. *Nitanoceras leve* n. sp. Holotype, 9544.
Figure 7. *Isculites schooleri* var. *parvus* McLearn. Holotype, 8793.
Figures 8, 9. Same variety. Plesiotype, 9527.
Figure 10. *Isculites schooleri* McLearn. Plesiotype, 9528.
Figures 11, 12. Same species. Holotype, 9046.
Figures 13, 14. *Sagenites gethingi* McLearn. Plesiotype, 9529.
Figures 15, 16. Same species. Holotype, 8806.

PLATE III

NATHORSTITES FAUNA

'DARK SILTSTONES'

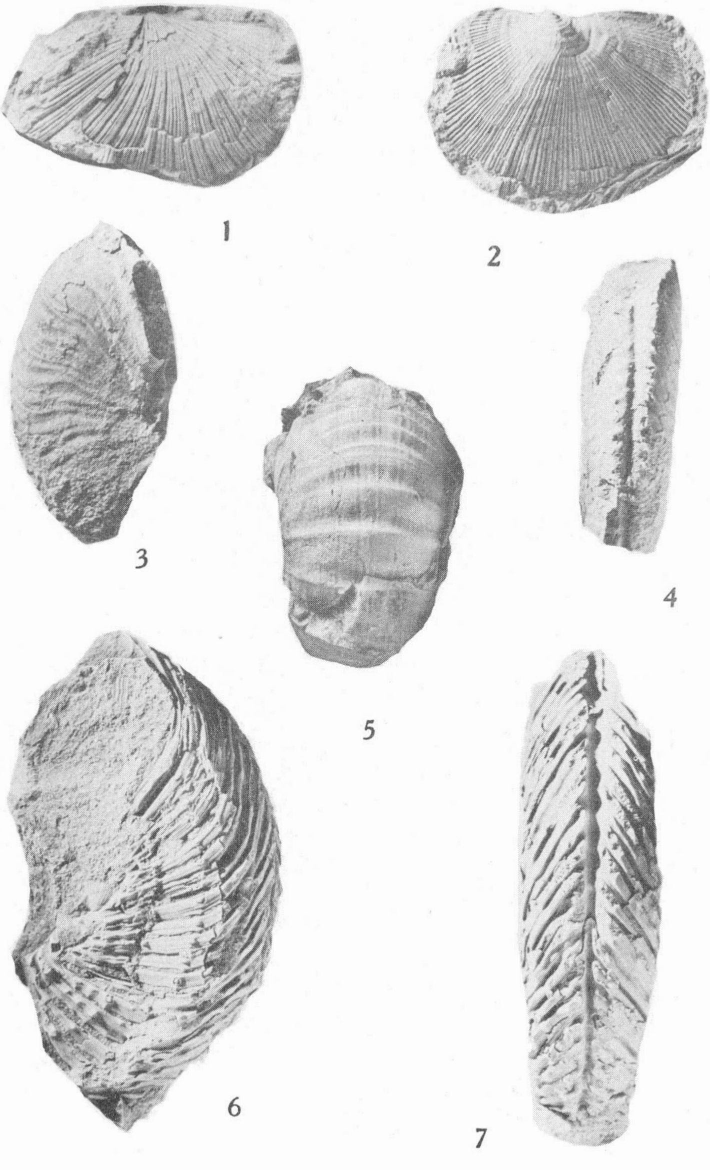
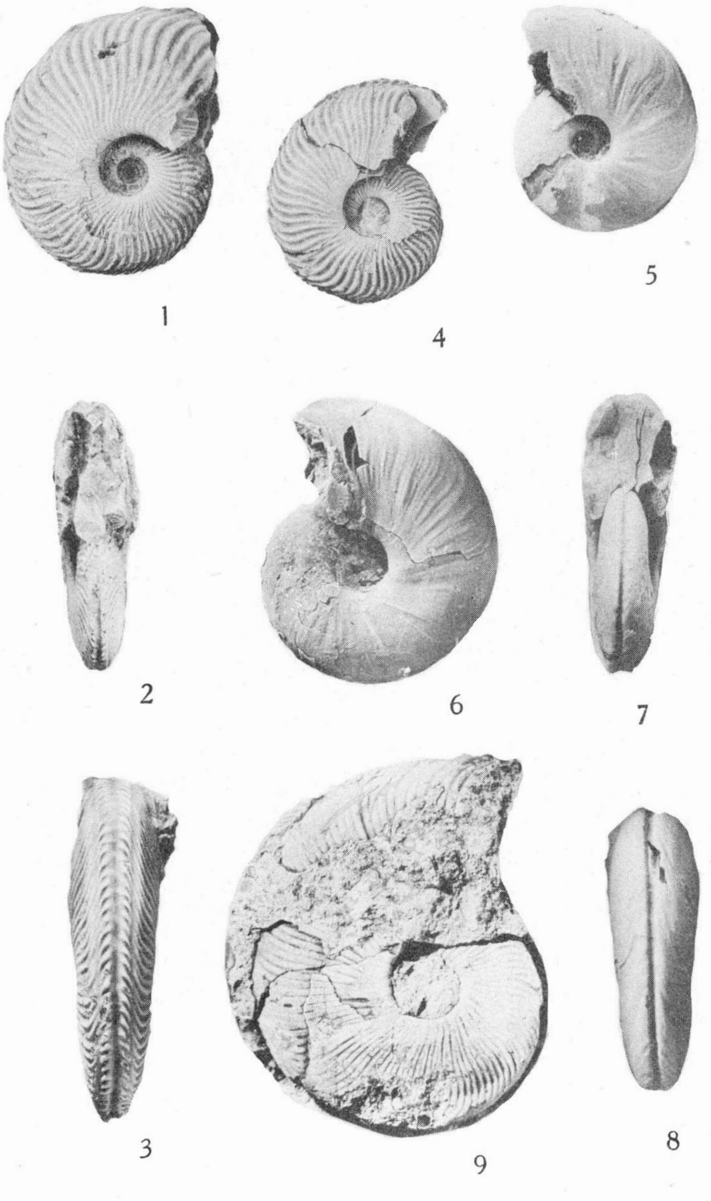


Figure 1. *Daonella nitanae* McLearn. Holotype, 8773.
Figure 2. *Daonella elegans* McLearn. Holotype, 9537.
Figures 3, 4. *Paratrachyceras tetsa* n. sp. Paratype, 9546.
Figure 5. *Sagenites gethingi* McLearn. Plesiotype, 9530.
Figures 6, 7. *Asklepioceras delicatum* n. sp. Holotype, 9550.

PLATE IV

NATHORSTITES FAUNA

'DARK SILTSTONES'



Figures 1, 2. *Sirenites meginae* McLearn. Holotype, 9042.
Figure 3. Same species. Plesiotype, 8811.
Figure 4. Same species. Plesiotype, 9531.
Figure 5. *Silenticeras hatae* McLearn. Plesiotype, 9532.
Figures 6, 7, 8. Same species. Holotype, 9043.
Figure 9. *Paratrachyceras sutherlandi* n. sp. Holotype, 9547.

PLATE V

NATHORSTITES FAUNA

'GREY BEDS'

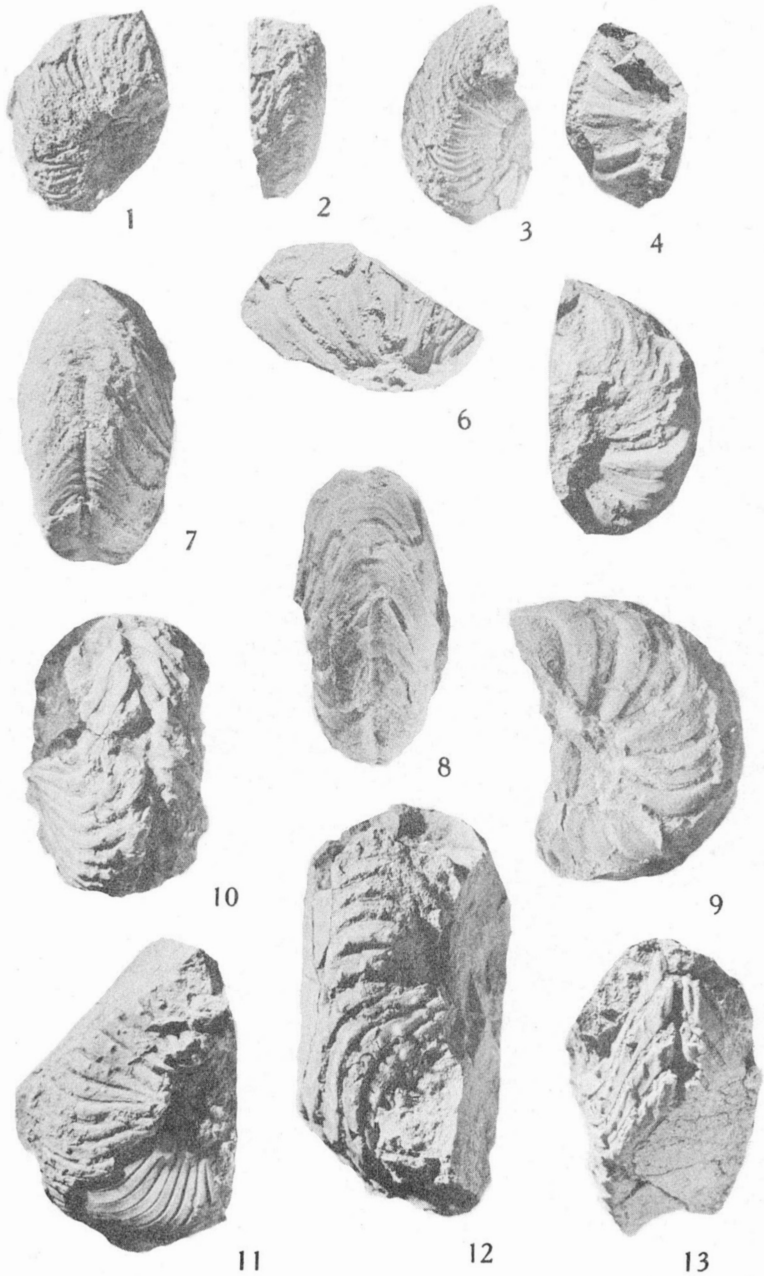


Figure 1. *Asklepioceras mahaffii* n. sp. Paratype, 9552.
Figures 2, 3. Same species. Holotype, 9551.
Figures 4, 5. *Asklepioceras laurenci* McLearn. Plesiotype, 9533.
Figure 6. Same species. Plesiotype, 9534.
Figure 7. Same species. Plesiotype, 9535.
Figures 8, 9. Same species. Holotype, 8805.
Figures 10. *Asklepioceras glaciense* McLearn. Holotype, 8808.
Figure 11, 12, 13. Same species. Plesiotype, 9536.

PLATE VI

NATHORSTITES FAUNA

'GREY BEDS'

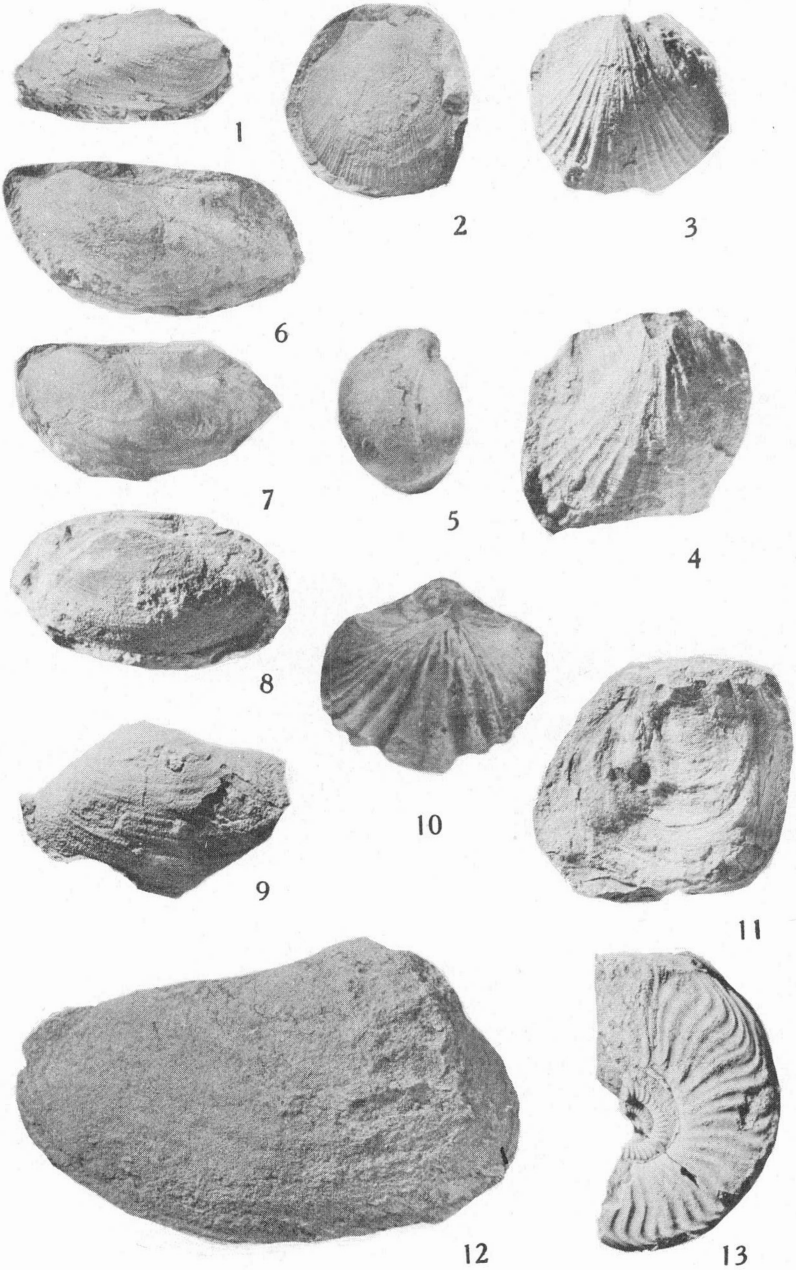
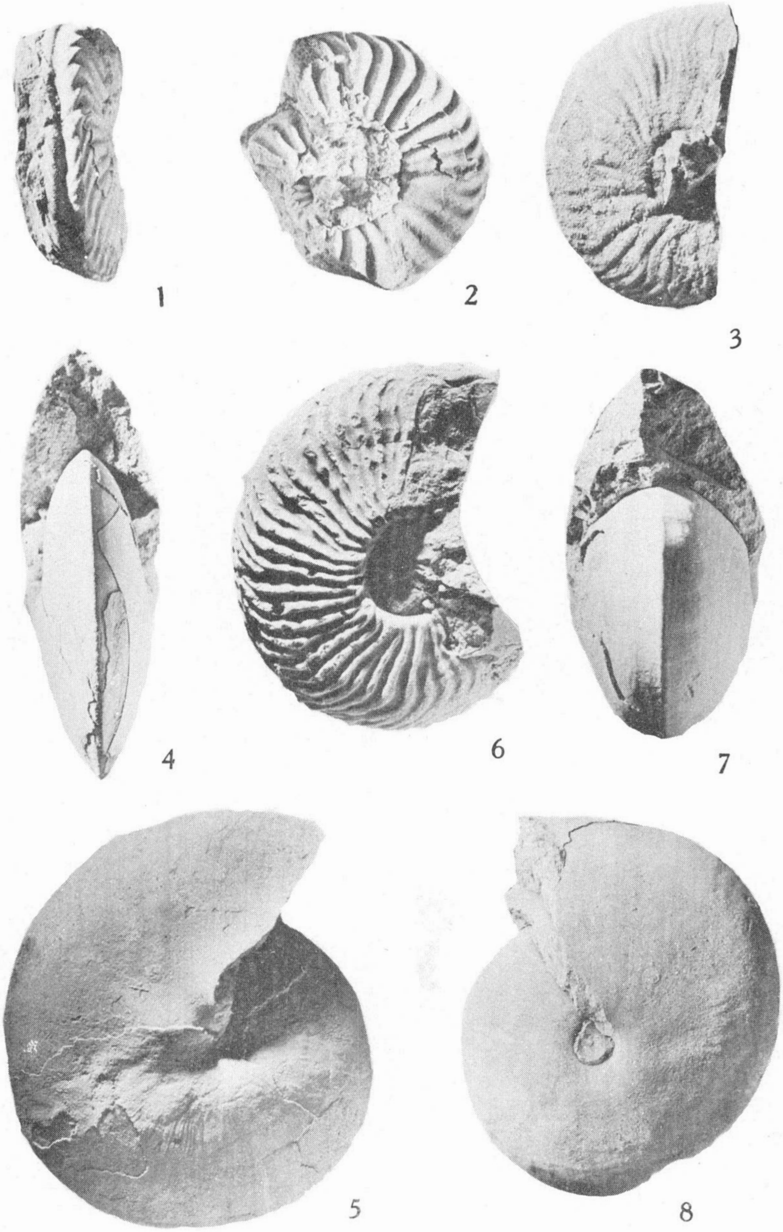


Figure 1. *Modiolus ahsisi* McLearn. Holotype, 8767. Figure 2. *Monotis ? montini* McLearn. Holotype, 8765. Figure 3. *Pecten ? sarsina* n. sp., X 2. Holotype, 9539. Figure 4. Same species, X 2. Paratype, 9540. Figure 5. *'Coenothyris' silvana* McLearn. Holotype, 9142. Figure 6. *Hoernesia woyoniana* McLearn. Holotype, 8768. Figure 7. Same species. Plesiotype, 9553. Figure 8. *Pleuromya triasina* n. sp. Holotype, 9542. Figure 9. Same species. Paratype, 9543. Figure 10. *Spirifer onestae* McLearn. Holotype, 9143. Figure 11. *Ostrea atsina* n. sp. Holotype, 9538. Figure 12. *Pleuromya peacensis* n. sp. Holotype, 9541. Figure 13. *Paratrachyceras caurinum* n. sp. Holotype, 9548.

PLATE VII

NATHORSTITES FAUNA

LIARD FORMATION



Figures 1, 2. *Paratrachyceras aylardi* n. sp. Holotype, 9549.
Figure 3. *Paratrachyceras tetsa* n. sp. Holotype, 9545.
Figure 4, 5. *Nathorstites mcconnelli* var. *lenticularis* Whiteaves. Holotype, 4721.
Figure 6. *Dawsonites canadensis* Whiteaves. Holotype, 4718.
Figure 7, 8. *Nathorstites mcconnelli* Whiteaves. Holotype, 4716.

PLATE VIII