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THE SEQUENCE OF MARINE TRIASSIC FAUNAS IN WESTERN CANADA

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E. T. Tozer

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E.T. Tozer

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INTRODUCTION

Our knowledge of the sequence of marine Triassic faunas in Western Canada is mainly due to the research of F.H. McLearn. The results of McLearn's work have been published in many papers and were summarized in 1953 (McLearn, 1953)[1]. During the past 7 years many new collections have been obtained, both by members of the Geological Survey—R.B. Campbell, L.H. Green, P. Harker, E.J.W. Irish, J.A. Jeletzky, E.W. Mountjoy, J.E. Muller, D.K. Norris, B.R. Pelletier, J.G. Souther, H.W. Tipper, and the writer—and by geologists of oil companies; officials of Shell Oil Company, Triad Oil Company, and Imperial Oil Limited have kindly made collections available for examination. Some additions to our knowledge of the Triassic faunal sequence have resulted from the study of these collections, and it is the principal object of this paper to record these discoveries in a preliminary fashion. In order to place the new discoveries in perspective, the whole sequence of marine Triassic faunas in Western Canada will be reviewed. The emphasis is on the faunas of the eastern Cordillera, but some faunas from western British Columbia and Yukon are also discussed.

Much taxonomic work on Canadian Triassic faunas remains, and this is being pursued at the Geological Survey by McLearn and the writer. McLearn's (1960) monograph on the ammonoid fauna of the Pardonet formation (Upper Triassic) is now available and he is engaged in monographic study of the Anisian ammonoids of British Columbia and Alberta. McLearn and the writer are studying the Nathorstites fauna. The remaining undescribed ammonoid faunas mentioned here, most of which are of Karnian age, will be described by the writer in future reports.

This paper is not particularly concerned with the Triassic rock succession. Considerable detail on the rocks of the eastern Cordillera is available in recent works by Best (1958), Hunt and Ratcliffe (1959), Manko (1960), and Pelletier (1960, 1961).

In the course of field work in 1960 the writer was capably assisted by C.G. Andrews of Fort St. John, British Columbia.

FAUNAL FACIES

Two distinct faunal facies occur in the Triassic of Western Canada. First, there is a facies in which the dominant

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[1] Names and dates in parentheses refer to publications listed in the References.

fossils are cephalopods (mainly ammonites) and thin-shelled pelecypods. The exact environment in which these cephalopods and pelecypods lived is uncertain but it seems unlikely that they represent a normal shallow-water benthonic assemblage. It seems more probable that these animals did not live on the sea floor. Consequently, the term 'pelagic facies' is tentatively applied to this type of faunal assemblage. This facies is well developed in the Toad, 'Dark Siltstones', and Pardonet formations. It is also well developed in an unnamed formation exposed on 'Mount Kindle', near mile-post 428 of the Alaska Highway in the northwestern part of Tuchodi Lakes area (see Pelletier, 1961, sec. 8). In this section, dark siltstones and some limestone were apparently deposited more or less continuously from late Scythian to Karnian time. An imperfectly exposed section near the head of Sulphur Creek, 25 miles to the northwest and on strike with Mount Kindle, includes Norian beds with Monotis in the same facies. Probably most of the Triassic (i.e. Upper Scythian, Anisian, Ladinian, Karnian, and Norian) is represented by this facies in the Mount Kindle - Sulphur Creek area. This interesting unnamed formation seems to represent a coalescence of the Toad, 'Dark Siltstones', and Pardonet formations, without any intervening sandstone of Liard or 'Grey beds' type.

The second main faunal facies is clearly benthonic. In the eastern Cordillera the fossils that represent this facies are mainly pelecypods and brachiopods. The rocks in which they occur are mainly grey calcareous quartzose sandstone with some limestone. Typical representatives are the Liard formation and the 'Grey beds'. These formations evidently represent wedges of sandstone that disappear to the west. Study of current structures by Pelletier (1959, 1960) suggests a northeastern and perhaps also eastern source for these beds, which were presumably shallow-water deposits laid down on the eastern margin of the Western Canada Triassic sea. The fact that these sandstones are actually wedges that disappear to the west is shown by the sections adjacent to Sentinel Range, at Mount Kindle, and Sulphur Creek, where the sandstone facies had disappeared completely.

Benthonic faunas are widely distributed in the western Cordillera. There the faunas include corals, sponges, and echinoderms as well as pelecypods and brachiopods. The benthonic pelecypods, throughout Western Canada, include trigoniids, ostreids, limids, pernids, pectinids etc. in rich variety, compared with the monotonous suite of Pectinacea (Claraia, Posidonia, Daonella, Halobia, and Monotis) that characterizes the pelagic facies. Some ammonoids occur in the benthonic assemblages. Some were probably merely allochthonous strays. However, in the Norian, ammonites are fairly common in the benthonic facies and they include loosely coiled (Choristoceras), straight (Rhabdoceras), and helicoid (Paracochloceras) forms. Perhaps these ammonites were bottom dwellers. The distribution of the ammonoid Nathorstites is somewhat anomalous. This genus is fairly common in sandstone in the Liard formation and the 'Grey beds', where it is commonly found with brachiopods and Ostrea.

Probably a more refined classification of faunal facies than the twofold division here suggested could be made, particularly with the benthos. It nevertheless seems desirable to make some distinctions in faunal facies in order to appreciate to what extent faunal differences reflect facies variations as opposed to differences in age. For example, it is implied, in this paper, that the upper 'Grey beds' are probably more or less the same age as the Tropites beds of Mount Kindle, but owing to the difference in facies there is no faunal evidence to support this correlation. This paper is mainly concerned with the succession of pelagic faunas, and the benthonic assemblages will not be treated in detail. Table I shows that several distinct benthonic faunas have been distinguished, and future work will probably reveal the presence of others.

SEQUENCE OF FAUNAS

The main Triassic faunas recognized, and their sequence, are shown in Table I. The composition, distribution, and correlation of the successive pelagic faunas will now be considered.

Lower Triassic (Scythian)

In Western Canada, Lower Triassic faunas are known only in the eastern Cordillera—in the Foothills, and in the eastern ranges of the Rocky Mountains of Alberta and British Columbia. Three successive faunas are distinguished. They are of lower Scythian, early upper Scythian, and late upper Scythian age.

Lower Scythian (Claraia) Fauna

The Claraia fauna, which includes Claraia stachei Bittner and related species, is of lower Scythian age (Spath, 1930, 1935; Newell and Kummel, 1942).

This fauna was first recorded from the Sulphur Mountain beds of Alberta by Warren (1945). From collections at the Geological Survey this fauna is known from the Sulphur Mountain formation at the following localities:

1. Approximately 250 feet above the base; south side of Beehive Creek 3 miles west of the continental divide, Fording River area (east half), British Columbia (Norris, 1958, p. 10).

2. 200-250 feet above the base; Goat Range, south of Banff (BP Exploration, Canada, Ltd.)

3. Brazeau River (see Malloch, 1911, p. 47). The specimens from this locality were identified by Charles Schuchert as "Monotis circularis Gabb". However, they include good specimens of Claraia aurita (Hauer) (Tozer, in press).

The next occurrence to the northwest of Claraia, known to the writer, is in Ganoid Range near Wapiti Lake, British Columbia, where collections have been made by Triad Oil Company.

		PELAGIC FAUNAS		BENTHONIC FAUNAS
		AMMONOIDS	PELECYPODS	
UPPER TRIASSIC	NORIAN			*Spondylospira lewesensis, Myophoria cairnesi, M. textilis, M. suttonensis, "Variamussium" yukonensis, Plicatula perimbricata, Cassianella lingulata, Paracochloceras* etc.
UPPER TRIASSIC	NORIAN	*Halorites* cf. *americanus, Rhabdoceras suessi*	*Monotis subcircularis*	
UPPER TRIASSIC	NORIAN	*Himavatites* fauna with *Distichites, Pseudosirenites, Episculites, Parajuvavites, Alloclionites, Steinmannites* etc.	*Monotis alaskana*	
UPPER TRIASSIC	NORIAN	*Drepanites*		
UPPER TRIASSIC	KARNIAN	*Gonionotites-Malayites* fauna with *Mojsisovicsites (Stikinoceras), Guembelites clavatus, Dimorphites pardonetiensis, Sirenites nabeschi* etc.	Established range of *Halobia*	
UPPER TRIASSIC	KARNIAN	Main tropitid fauna with *Tropites, Discotropites, Hoplotropites, Jovites, Homerites semiglobosus, Klamathites* etc.		*Lima poyana* fauna
UPPER TRIASSIC	KARNIAN	*Trachyceras*		Mahaffy Cliffs and Red Rock Spur faunas
MIDDLE TRIASSIC	LADINIAN	*Nathorstites* fauna with *Protrachyceras, Paratrachyceras, Silenticeras, Arpadites, Lobites, Daxatina* etc.	*Daonella nitanae, Daonella elegans*	*Spiriferina borealis, Terebratula liardensis* etc.
MIDDLE TRIASSIC	ANISIAN	*Gymnotoceras* fauna with *Longobardites, Parapopanoceras, "Ceratites" hayesi, "Hungarites"* etc.	*Daonella* spp.	
LOWER TRIASSIC	UPPER SCYTHIAN	(*Olenikites* occurs with *Posidonia aranea* on Ellesmere Island)	*Posidonia aranea*	
LOWER TRIASSIC	UPPER SCYTHIAN	*Wasatchites, Xenoceltites, Euflemingites*	*Pseudomonotis occidentalis, Posidonia mimer*	
LOWER TRIASSIC	LOWER SCYTHIAN		*Claraia stachei*	GSC

Table 1. Principal Marine Triassic Faunas of Western Canada

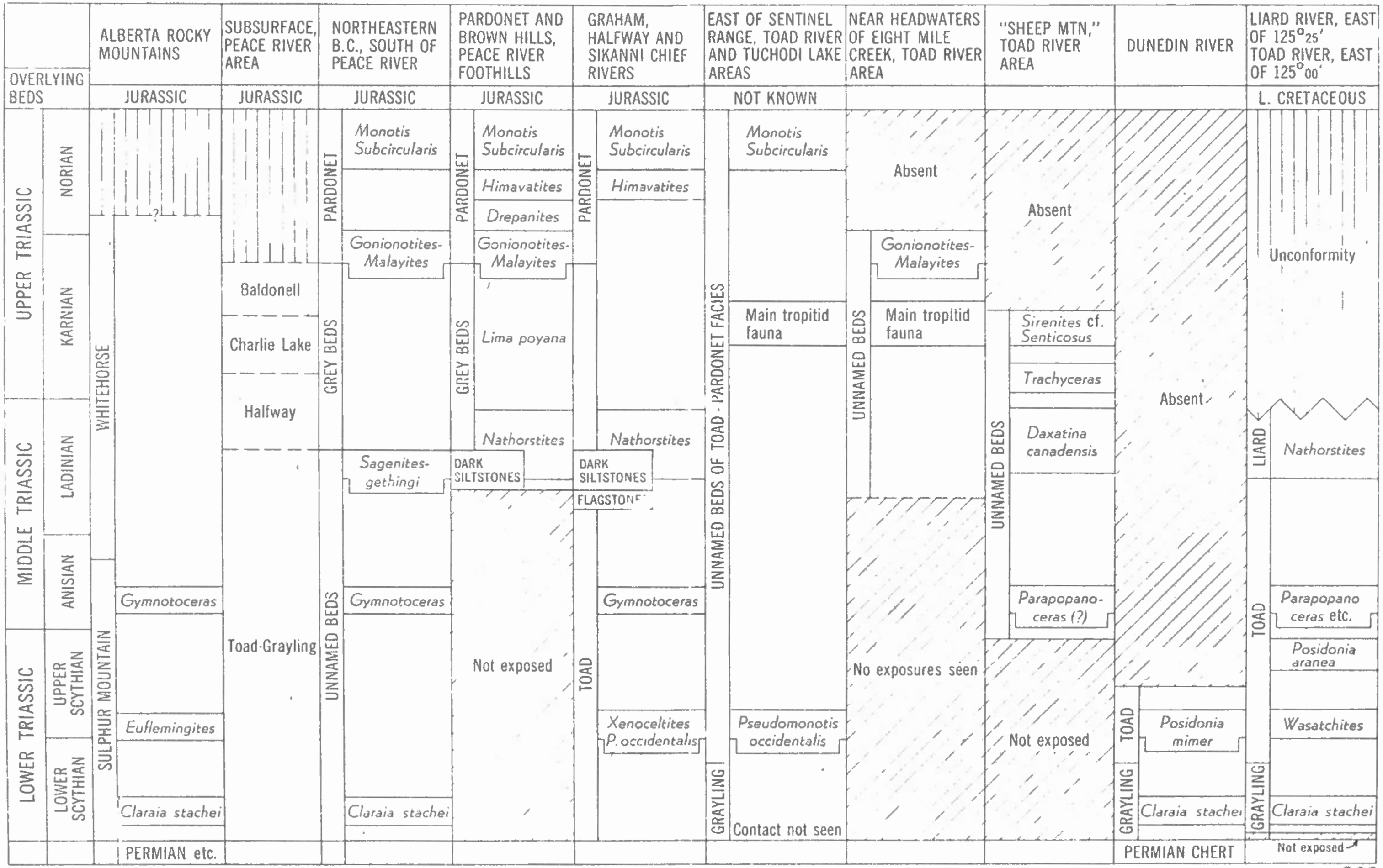

Figure 1. Correlation chart, Triassic formations of the Eastern Cordillera, Alberta and British Columbia

The only other occurrences of this fauna that can be established from collections at the Geological Survey are from the Grayling formation of Liard and Dunedin Rivers, northeastern British Columbia. On Liard River, Kindle collected fossils from the Grayling formation that McLearn (1945) identified as Claraia cf. stachei. The base of the Grayling formation is not exposed in Liard River, consequently the position of this fauna in relation to the base of the formation cannot be determined from the outcrops. A completely exposed section of the Grayling formation on Dunedin River, 4 miles north of mile-post 380, Alaska Highway, was studied by Pelletier and the writer in 1960 (see Pelletier, 1961, sec. 7). In this section Claraia stachei occurs 90 feet above the base of the Grayling formation. A few ammonoids were collected 16 feet above the bed with Claraia stachei on Dunedin River. They appear to be new and do not, at present, materially contribute to the dating of these beds. However, they are probably lower Scythian.

Early Upper Scythian Faunas

In 1944, Kindle collected well-preserved ammonoids from the lower part of the Toad formation on Liard and Toad Rivers. These fossils have been described by McLearn (1945). The fauna includes Wasatchites and Xenoceltites and is dated as early upper Scythian by McLearn. This locality was visited by the writer in 1960. Pelecypods associated with Wasatchites include "Pseudomonotis" occidentalis Whiteaves (=Pseudomonotis ovalis Whiteaves, a preoccupied name) and Posidonia mimer Oeberg. In addition, crushed specimens of ammonoid Euflemingites were collected in talus from a horizon close to that of Wasatchites.

New occurrences of the pelecypods associated with Wasatchites have now been found and they permit a tentative early upper Scythian dating for beds at the following localities.

Pseudomonotis occidentalis occurs in the Toad formation on the south side of Tetsa River, 1/2 mile above the junction with north Tetsa River. This species also occurs in beds of Toad facies in a gully on the west side of Mount Kindle, near mile-post 428, Alaska Highway (see Pelletier, 1961, sec. 8). Posidonia mimer occurs 32 feet above the base of the Toad formation, and 913 feet above the base of the Triassic sequence on Dunedin River, 4 miles north of mile-post 380, Alaska Highway (see Pelletier, 1961, sec. 7).

Irish has recently discovered upper Scythian fossils in the Halfway River area, on Graham River, just below the junction of Graham River and Horn Creek. This faunule includes Xenoceltites cf. subevolutus Spath and Pseudomonotis occidentalis (Whiteaves), and is of early upper Scythian age.

Crushed ammonites are common in the Sulphur Mountain beds of Alberta. Evolute forms with pronounced strigate sculpture are the most common. They have been identified as Flemingites by Warren (1945) and the writer (in Irish, 1954, p. 18).

These ammonites, although poorly preserved, should probably be placed in Euflemingites rather than Flemingites. In Idaho and on Ellesmere Island, Euflemingites occurs in the Meekoceras zone, of early upper Scythian age. The crushed Euflemingites from the Sulphur Mountain formation are probably of this age, and approximately the same age as the Wasatchites of the Toad formation. The talus occurrence of Euflemingites from the Toad formation, mentioned above, seems to support this correlation.

Euflemingites is known from the Sulphur Mountain formation at the following localities in Alberta:

1. 483 feet above the base; Evans Thomas Creek, Ribbon Creek area (Crockford, 1949, p. 21).

2. 600 feet above the base; near Banff (Warren, 1945).

3. From talus of beds about 225 feet above the base; Fiddle River, below the mouth of Morris Creek, Miette area.

4. Talus, Mystery Lake, Miette area; collected by Mountjoy. This occurrence is based on a single piece of talus which has impressions of Euflemingites together with the external mould of a large ammonite, probably the body chamber of Arctoceras oebergi (Mojsisovics). This occurrence supports the assignment of Euflemingites to the early upper Scythian, for Arctoceras oebergi occurs with Meekoceras, Euflemingites etc. on Ellesmere Island (Tozer, in press).

5. Within the lower 200 feet; Llama Mountain, Kvass Flats area (Irish, 1954, p. 17).

Late Upper Scythian Fauna

Ammonite faunas of latest Scythian age have not been recognized in northeastern British Columbia. On Liard River, below the mouth of Toad River, flattened ammonites occur in the interval between the Wasatchites and Gymnotoceras zones. Unfortunately they are too poorly preserved for identification. On Toad River, at lat. 59°06'N, long. 124°40'W, geologists of Shell Oil Company have collected Posidonia aranea (Tozer, in press), from a bed 250 feet below the Gymnotoceras zone. On Ellesmere Island this distinctive Posidonia occurs with Olenikites—a late upper Scythian ammonoid. It therefore seems reasonable to date the Toad River occurrence of Posidonia aranea as late upper Scythian.

Middle Triassic (Anisian and Ladinian)

Middle Triassic faunas of both Anisian and Ladinian age occur in northeastern British Columbia. Souther has recently collected well-preserved specimens of Daonella in the Coast Range of British Columbia, in Chutine map-area. This occurrence of

Daonella provides the only available evidence for the occurrence of Middle Triassic rocks in the western Cordillera. Although the Daonella specimens are almost certainly of Middle Triassic age it is not possible to date this collection with precision.

Anisian

A Middle Triassic (Anisian) ammonoid fauna has been described from the Toad formation by McLearn (1946b), and Warren (1945) has recorded Anisian ammonites from Alberta. This fauna is currently being monographed by McLearn, and the present writer proposes only to record some new occurrences. So far it has not been possible to distinguish more than one zone within the Anisian of Western Canada. For the time being it will be assumed that all the Anisian faunas are essentially the same age.

The Anisian fauna, characterized particularly by species of Gymnotoceras, Parapopanoceras, Longobardites and "Ceratites" hayesi McLearn, is now known more or less throughout the eastern Cordillera, from Liard River to Athabasca River. On the Liard, Toad, Tetsa, Muskwa, Sikanni Chief, and Halfway Rivers, this fauna occurs in the Toad formation (McLearn and Kindle, 1950, pp. 36-40). The fauna is not exposed in the Peace River valley where the stratigraphically lowest beds are the 'Dark Siltstones' with the Nathorstites fauna. The Anisian fauna has been collected by geologists of oil companies at several places in northeastern British Columbia, south of Peace River. It has been obtained by Imperial Oil Limited at Wapiti Lake and by Triad Oil Company 760 feet above the base of the Triassic sequence, 20 miles north-northwest of Monkman Lake, and about 700 feet above the base, near the headwaters of the north branch of Burnt River.

In Alberta, at Mount Pierce and at Blue Creek, collections by the Triad company and by Harker reveal the presence of this fauna in beds about 700 feet above the base of the Triassic sequence. The Anisian fauna has also been collected by Irish (1954, 1955) in Kvass Flats and Adams Lookout areas. In the past it has generally been assumed that the beds yielding the Anisian fauna in Alberta should be assigned to the Whitehorse formation. Manko (1960) assigns the beds in question to the upper part of the Sulphur Mountain formation.

Ladinian

Under this heading the Nathorstites fauna will be discussed. Much of this fauna has been described and discussed by McLearn (1947a), who dated it as late Ladinian or early Karnian. Besides Nathorstites, McLearn has recorded species of Protrachyceras, Paratrachyceras, Daxatina (= Dawsonites), Asklepioceras, Silenticeras, Lobites, Thanamites, Nitanoceras and Sagenites from this zone. New collections, mainly from the Liard, Toad and Testa Valleys, permit the addition of Arpadites sp. (group of A. cinensis Mojsisovics), Hannaoceras, Anolcites ?, a new genus of Trachyceratidae, and another new genus—possibly a member of the Buchitidae. Nautiloids (Sibyllonautilus, Styrionautilus and Germanonautilus) and Daonella spp. also occur.

In recent years the Nathorstites fauna has been discovered in Siberia (Popow, 1946) and in the Queen Elizabeth Islands (Tozer, in press). All the recent evidence, and also new evidence from British Columbia, support the Ladinian dating first suggested by McLearn. The writer has discussed this problem, incorporating the data from the Queen Elizabeth Islands (Tozer, in press). The new evidence from British Columbia is derived from 'Sheep Mountain' in the Toad River area, 12 miles south of Rapids of the Drowned on Liard River. On this mountain, Pelletier and the writer (see Pelletier, 1961, sec. 3) collected a single specimen of Trachyceras from a bed about 650 feet above strata with Daxatina canadensis (Whiteaves). Daxatina canadensis is a member of the Nathorstites fauna. The overlying Trachyceras is probably of Lower Karnian age. Thus the relative stratigraphic positions of Daxatina and Trachyceras support the assignment of the Nathorstites fauna to the Ladinian.

The Nathorstites fauna is now known throughout much of northeastern British Columbia. The northern occurrences—in Toad River and Tuchodi Lakes areas—are in the Liard formation (McLearn and Kindle, 1950; Pelletier, 1960). Farther south—on Sikanni Chief, Halfway and Peace Rivers—the Nathorstites fauna occurs in the 'Dark Siltstones' and the 'Grey beds'. The southernmost occurrence known to the writer is based on collections made by Triad Oil Company, from a section 20 miles north-northwest of Monkman Lake, where Paratrachyceras sp. and Sagenites gethingi McLearn occur 490 feet above the Anisian fauna and 1,250 feet above the base of the Triassic sequence.

The Nathorstites zone is thick in some sections. At Peace River, McLearn (1947a, p. 5) records the range of Nathorstites through approximately 530 feet of strata. On Liard River, Pelletier and the writer have collected Nathorstites all through about 400 feet of beds. It is probable that zones or subzones may be distinguished on Liard River, but more taxonomic work must be done to establish them.

Hunt and Ratcliffe (1959, p. 570) record Nathorstites (identified by C.R. Stelck) about 150 feet above the base of the Halfway formation in the Guardian Well, ls. 7, sec. 7, tp. 80, rge. 12, W6th mer., Alberta. Parapopanoceras (a member of the Anisian fauna) is listed from the same level. It is unlikely that both identifications are correct and consequently this record of the Nathorstites fauna is not entirely satisfactory. The Nathorstites fauna has never, so far as the writer is aware, been collected from outcrops in Alberta. Possibly some beds of the Whitehorse formation are Ladinian but the facies of this formation is apparently inimical to the preservation of ammonoids.

Upper Triassic (Karnian and Norian)

Upper Triassic faunas are widely distributed in Western Canada, far more so than those of Lower and Middle Triassic age. Upper Triassic faunas occur not only in the eastern Cordillera, but at scattered localities throughout the western Cordillera in British Columbia and south and southwest Yukon. New occurrences have recently been found by geologists of oil companies in northern Yukon, and by Green in Tay River area, east-central Yukon.

The best known sequence of Upper Triassic faunas in Western Canada is that of the Pardonet formation of Peace River. This sequence has been studied by McLearn, and a monographic treatment of the ammonoid faunas is now available (McLearn, 1960). Faunas of upper Karnian and Norian age occur in the sections studied by McLearn. Recent field work has shown that Karnian faunas, older than those of the Pardonet formation, occur in Toad River and Tuchodi Lakes areas, near the northeastern corner of British Columbia. These discoveries not only add to our knowledge of the Triassic of these areas but they assist in the interpretation of the Karnian fauna of the Pardonet formation itself. The new faunal occurrences are briefly recorded here and a review is given of the sequence of Karnian and Norian faunas in Western Canada.

Karnian

A relatively good sequence of Karnian ammonoid faunas has now been established in the Toad River and Tuchodi Lakes map-areas. Three faunas are distinguished, and the lower two appear to be older than the Karnian fauna of the Pardonet formation as exposed on Pardonet and Brown Hills on Peace River, some 250 miles south-east of Toad River. In order to explain the relationship and sequence it is necessary to describe briefly the Triassic stratigraphy of the Toad River and Tuchodi Lakes areas. A tabular summary, showing the faunal sequence at each locality, is provided by the correlation chart (Fig. 1).

The Triassic rocks of the eastern part of these map-areas have been described by Kindle (1944), McLearn (1946b, 1947a), McLearn and Kindle (1950), and Pelletier (1959, 1960). In these eastern areas the youngest Triassic rocks are of Ladinian age (Liard formation) and they are overlain unconformably by Lower Cretaceous strata. These rocks do not concern us here.

Field work by Pelletier and the writer in 1960 has shown that Upper Triassic rocks are preserved in the western part of the Toad River and Tuchodi Lakes areas. In these western areas, unlike in the eastern areas, Upper Triassic rocks have survived the pre-Lower Cretaceous erosion that affected so much of the northwestern part of the Western Interior.

Pelletier and the writer found sections revealing Karnian ammonoid faunas at three localities, namely: (1) 'Sheep

Mountain', 12 miles south of Rapids of the Drowned on Liard River; (2) an unnamed ridge east of the lakes on the divide between Eight Mile Creek and Sulphur Creek, 10 miles southwest of Rapids of the Drowned, and (3) 'Mount Kindle', on the south side of the Alaska Highway near mile-post 427. These sections have been described by Pelletier (1961). In the discussion that follows these localities are referred to by the numbers given above.

At locality 1 a single specimen of Trachyceras was found (in bed 34 of Pelletier's section 3), about 650 feet above a bed (28 of section 3) with Daxatina canadensis (Ladinian, Nathorstites zone). The Trachyceras bed is probably of lower Karnian age. Occurring in bed 38 of the same section, about 540 feet above the Trachyceras bed, are Sirenites cf. senticosus (Dittmar) and Halobia sp. The Sirenites bed is also Karnian, either lower or upper Karnian.

An upper Karnian fauna occurs at locality 2, with Tropites, Discotropites cf. mojsvarensis Smith, Discotropites sp., Juvavites (Anatomites) sp., Proarcestes sp., and Halobia sp. A single small specimen of Sirenites cf. senticosus was also collected at this locality. About 150 feet higher in the section at this locality, a bed yielded Malayites dawsoni McLearn and Gonionotites cf. gethingi McLearn in situ, and Waldthausenites cf. leophanis Diener in talus. This Malayites-bearing bed clearly correlates with the Gonionotites-Malayites zone, which occurs near the base of the Pardonet formation of Pardonet and Brown Hills (McLearn, 1960).

At locality 3, a relatively rich upper Karnian fauna was obtained. This fauna includes Klamathites cf. macrolobatus Silberling, Arctosirenites canadensis Tozer, Hannaoceras cf. major Smith, Homerites semiglobosus Hauer, Jovites sp., Juvavites (Anatomites) sp., Hoplotropites cf. auctus (Dittmar) (?= Margarites senilis Mojsisovics, of Smith, 1927), Tropites n. sp. aff. T. morani Smith, Discotropites cf. mojsvarensis Smith, Discotropites sp. (=? D. empedoclis Gemmellaro, of Smith, 1927), Proarcestes sp., Proclydonautilus cf. triadicus Mojsisovics, and Halobia sp.

The species of Juvavites, Discotropites, and Tropites at locality 3 appear to be identical to those from locality 2, some 16 miles to the north-northwest. Correlation of the Tropites faunas at localities 2 and 3 seems justified. The relatively rich fauna from locality 3 is clearly related to upper Karnian faunas of Shasta county, California (Smith, 1927). These faunas are generally considered to be the North American manifestation of the upper Karnian zone of Tropites subbullatus, of the Halstatt limestone, Austria. Smith (1927) recognized two subzones in the Tropites zone of California—the "Trachyceras subzone" below, and the "Juvavites subzone" above. For various good reasons that do not concern us here, Silberling (1956, 1959) has recently renamed the "Trachyceras subzone" as the Tropites dilleri zone; the overlying "Juvavites subzone" he has named the Tropites welleri zone. In the Union district of Nevada, Silberling has also described a new Tropites fauna, apparently younger than the fauna of the Tropites welleri zone. To the beds characterized by this new, younger, Tropites fauna, Silberling applies the name Klamathites macrolobatus zone. The Tropites fauna of locality 3 seems to be related to either the fauna of the Tropites welleri zone, or to that of the Klamathites macrolobatus zone. Klamathites cf. macrolobatus occurs at locality 3, but other forms from this locality (Homerites semiglobosus, and the species of Hoplotropites and Discotropites) occur in the Tropites welleri zone of California.

As already noted, the section at locality 2 shows that the Tropites fauna of the Toad River area is older than the Gonionotites-Malayites zone of the Pardonet formation. It follows that the Tropites welleri and Klamathites macrolobatus zones, of California and Nevada respectively, are probably also older than the Gonionotites-Malayites zone.

The new data on the sequence of the Tropites and Gonionotites-Malayites zones agrees closely with the sequence described in Nevada by Silberling (1959). In the Nevada section the Guembelites zone overlies the Klamathites macrolobatus zone. The Nevada Guembelites zone contains Guembelites clavatus (McLearn) and Mojsisovicsites (=Stikinoceras) kerri (McLearn). Both these species occur in the Gonionotites-Malayites zone of the Pardonet formation. Thus in both British Columbia and Nevada an assemblage with Guembelites clavatus and Mojsisovicsites kerri occurs at a higher stratigraphic level than the beds with the main upper Karnian tropitid fauna.

However, McLearn (1947b, 1960) has collected a species of Tropites from a bed within the Gonionotites-Malayites zone of Pardonet Hill. This led him to suppose that the Gonionotites-Malayites zone might be a local manifestation of the main upper Karnian Tropites fauna. The species of Tropites from Pardonet Hill is definitely not the same as the species from localities 2 and 3. The occurrence of Tropites within the Gonionotites-Malayites zone of Pardonet Hill is not considered to conflict with the conclusion that the Tropites beds of localities 2 and 3 are older than the Gonionotites-Malayites zone. Most of the diagnostic genera of the Gonionotites-Malayites zone (e.g. Guembelites, Mojsisovicsites, Malayites, Thisbites and Styrites) do not occur in the Tropites dilleri, Tropites welleri, and Klamathites macrolobatus zones. Furthermore, they do not occur in the Tropites fauna of localities 2 and 3. It is therefore suggested that the Gonionotites-Malayites zone is younger than the Tropites zones of the Toad River area, California, and Nevada.

Silberling (1959) dates the Guembelites zone as early Norian, whereas McLearn (1960) dates the apparently contemporary Gonionotites-Malayites zone as Karnian. The writer favours McLearn's age-determination, but this decision is essentially an arbitary one because the Karnian-Norian boundary in Austria and the Himalayas is very poorly defined. Beyond North America many of the genera of the Guembelites and Gonionotites-Malayites zones occur in areas of confused stratigraphy and collecting, such as the Feuerkogel "Mischfauna" of Austria and the extraordinary "Tropites limestone of Byans" in the Himalayas; the latter, despite the fact that it is only a few feet thick, is said to contain many genera that are widely separated stratigraphically in North America. Many are in the exotic blocks of Timor where the stratigraphic sequence cannot be determined.

The available evidence suggests that the sequence of Karnian faunas in northeastern British Columbia is as follows:

(Youngest)

3. Gonionotites-Malayites fauna, with Sirenites nabeschi McLearn, Mojsisovicsites kerri (McLearn), Thisbites spp., Tropites sp., Styrites ireneanus McLearn, Tropiceltites columbianus (McLearn), Guembelites clavatus (McLearn), Malayites (=Heinrichites) spp., Dimorphites pardonetiensis McLearn, etc.

2. Tropites fauna of localities 2 and 3, with Klamathites, Arctosirenites, Hannaoceras, Homerites, Jovites, Juvavites (Anatomites), Hoplotropites, Tropites, Discotropites spp. etc. For convenience this assemblage may be called the 'main tropitid fauna'.

1. Trachyceras fauna of locality 1, a meagre fauna consisting only of Trachyceras and nautiloids.

Halobia is common in the Tropites and Gonionotites-Malayites faunas. The halobiids from the Trachyceras fauna are too poorly preserved for generic identification.

This scheme does not account for the Sirenites cf. senticosus fauna of locality 1. Sirenites senticosus is typically a lower Karnian species in Austria, and this species has also been recorded from the Queen Elizabeth Islands (Tozer, in press). The occurrence in the Queen Elizabeth Islands was tentatively dated as lower Karnian by the writer. However, as already noted, a single specimen of Sirenites—apparently S. cf. senticosus—occurs in the Tropites fauna of locality 2. It follows that the Sirenites beds of locality 1 may be about the same age as the Tropites beds of locality 2, but this relationship is not yet clear.

The occurrence of Arctosirenites in the Tropites fauna of locality 3 suggests that the typical Arctosirenites of Axel Heiberg and Ellesmere Islands (Tozer, in press) may be of upper Karnian age.

Another fauna which is difficult to place is the Pterotoceras-Cyrtopleurites magnificus fauna of Brown Hill in the Peace River valley (McLearn, 1941, p. 96; 1953, p. 1221; 1960). This fauna is placed in the Norian by McLearn. However, it includes a single specimen of Guembelites, distinct from G. clavatus, and close to G. philostriati Diener which occurs in the Guembelites zone of Nevada. Possibly the Pterotoceras-Cyrtopleurites magnificus fauna should be placed in the uppermost Karnian and regarded as a phase of the Gonionotites-Malayites zone.

The distribution of these three Karnian faunas in other parts of Western Canada is as follows:

The oldest assemblage, with Trachyceras, and of lower Karnian age, is not known elsewhere in British Columbia. Trachyceras has been tentatively identified from the basal part of the Lewes River group of Laberge area, central Yukon, but the specimens are not well preserved (Tozer, 1958, p. 10). Sirenites-bearing beds in the Queen Elizabeth Islands (Blaa Mountain and Schei Point formations) have been tentatively dated as lower Karnian by the writer (Tozer, in press). However, in view of the above remarks concerning the occurrence of Sirenites cf. senticosus, it seems unwise to accept unreservedly a precise lower Karnian age for these Arctic beds. The only really satisfactory record of the Trachyceras fauna in North America is the assemblage described from New Pass, Nevada, by Johnston (1941).

Faunas related to the middle assemblage, characterized by numerous tropitids, are widely distributed in western British Columbia. Jeletzky has obtained this fauna from the Quatsino limestone of Union Island, Malksope Inlet, and Ououkinsh Inlet, all on the west coast of Vancouver Island (see Jeletzky, 1954). This fauna also occurs on Quadra Island, between Vancouver Island and the mainland (Mathews, 1947; McLearn, 1953, p. 1212). A small collection containing well-preserved representatives of this fauna (including Tropites boehmi Smith and Homerites semiglobosus Hauer) has been obtained by Souther in the Iskut River area, western British Columbia. Souther has also collected representatives of this fauna near Taku River, in the Tulsequah area.

As already mentioned, the main tropitid fauna is not represented in the well-known sections of the Pardonet formation (Pardonet and Brown Hills) studied by McLearn. In view of the above conclusions this fauna might be expected to occur in the upper part of the 'Grey beds', which underlie the Pardonet formation. Most of the fossils from the upper 'Grey beds' are pelecypods and brachiopods. Apparently the upper 'Grey beds' represent a facies hostile to the preservation of ammonoids. However, it must be remembered that McLearn (1960) has recorded Discotropites sandlingensis Hauer from beds on Peace River above Point Creek, west of Pardonet Hill. This occurrence may indicate the presence of the main tropitid fauna. If so, these Discotropites-bearing beds are presumably older than the basal Pardonet beds of Pardonet and Brown Hills, which contain the fauna of the Gonionotites-Malayites zone. If correct, this interpretation implies that the 'Grey beds' facies is partly replaced by strata of the Pardonet facies in the western part of the Peace River foothills — a slender piece of evidence suggesting that the 'Grey beds' may gradually disappear towards the west, to be replaced by Pardonet-type beds. This suggested change in facies is analogous to the westward disappearance of the Liard formation at the latitude of Toad River, some 250 miles to the north.

The youngest Karnian fauna, characterized by Mojsisovicsites, Malayites, Guembelites and Gonionotites, is, like the underlying tropitid assemblage, represented in the western

Cordillera. "Stikinoceras cf. kerri" (i.e. Mojsisovicsites) has been identified by McLearn from collections made by Kerr near Stikine River about 6 miles northeast of Chutine Landing (see Kerr, 1948). Mojsisovicsites cf. kerri is also present in collections made some years ago by H.C. Gunning on Vancouver Island. This occurrence is in the Bonanza group of the south fork of Asulkan River, Nimpkish area. Jeletzky has obtained similar fossils from beds classed as Quatsino limestone at Rupert Inlet, near the head of Quatsino Sound. In the Nimpkish area and at Rupert Inlet, Mojsisovicsites is associated with a distinctive Halobia, like Halobia arthaberi Kittl. On Union Island, Jeletzky has collected Halobia cf. arthaberi from the lower part of the Bonanza group, above the Tropites-bearing beds of the Quatsino limestone. Although Mojsisovicsites has not been found above the tropitid fauna on Vancouver Island the stratigraphic relations on Union Island suggest that Mojsisovicsites does lie in this position. The evidence from Union Island seems perfectly compatible with the conclusions drawn from locality 2 of the Toad River area—namely that the Gonionotites-Malayites fauna (which at Peace River includes Mojsisovicsites) is younger than the main tropitid fauna.

Norian

The best known sequence of Norian pelagic faunas in Canada is that from the Pardonet formation of the Peace River foothills (McLearn, 1953, 1960). The sequence established by McLearn in this area is as follows:

Top

3. Monotis subcircularis fauna.

2. Himavatites fauna (with many other ammonoids, Monotis alaskana and the last appearance of Halobia).

1. Drepanites fauna.

At Ne-parle-pas Rapids on Peace River, McLearn has described Triassic beds above the Monotis subcircularis zone, and these beds contain Rhacophyllites and Placites. As both these ammonoids also occur in the Monotis subcircularis zone, the beds above Monotis probably do not constitute a distinct faunal zone of more than local importance.

The Drepanites fauna is known only in the Peace River area and the writer can add nothing to the description or correlation of this zone.

The overlying Himavatites fauna is known in various parts of northeastern British Columbia (McLearn, 1946a, 1960) and it has also been obtained by Jeletzky from the Bonanza group of Esperanza Inlet, on the west coast of Vancouver Island.

The Monotis subcircularis fauna[1], long known to be very widespread in Western Canada (see McLearn, 1953, for occurrences), has recently been collected from several new localities. Pelletier and the writer have found Monotis near the head of Sulphur Creek in the Toad River area, northeastern British Columbia. Tipper has collected Monotis subcircularis on Bowron River immediately west of the Rocky Mountain Trench in Prince George map-area; this new occurrence is of considerable palaeogeographic interest.

Several new occurrences of the Monotis fauna are now known from Yukon Territory. Triassic faunas, including Monotis, have long been known in southern Yukon—in Laberge, Glenlyon, Whitehorse, and Kluane map-areas. A single collection with Monotis subcircularis was made by Keele (1906) at the forks of Rackla River in east-central Yukon. This occurrence gave rise to suspicions that Triassic rocks might turn up at other localities in eastern and northern Yukon. These suspicions were justified, for Monotis subcircularis has now been collected at the following localities:

1. On Tay River, lat. 62°43'N, long. 133°22'W; by Green.

2. In the Ogilvie Mountains, about lat. 64°58'N, long. 139°52'W; by geologists of an oil-exploration company.

3. At several localities in the Barn Mountains, west of Aklavik; by geologists of Triad Oil Company.

In connection with these new occurrences, it should be mentioned that Martin (1926, p. 102) has recorded Upper Triassic faunas, including Halobia and Monotis, from the Firth River area, a few miles west of the International Boundary. The presence of Halobia so close to the International Boundary suggests that Upper Triassic strata older than the Monotis beds may be present in northern Yukon. However, so far as the writer knows there is no evidence at all to suggest that Lower and Middle Triassic rocks are present in northern Yukon.

The Monotis subcircularis fauna is dated as late Norian from its stratigraphic position with respect to the Himavatites fauna. Ammonoids are rare with Monotis in Canada but the few that do occur confirm this dating. Indoclionites ?, Rhacophyllites and Placites occur at Peace River (McLearn, 1960). Souther (1960) has collected Halorites cf. americanus Hyatt and Smith with Monotis subcircularis in the Sinwa limestone of Tulsequah area. Halorites, Rhabdoceras suessi (Hauer), and Rhacophyllites occur in the Monotis subcircularis zone of Laberge area, southern Yukon (Tozer, 1958, p. 15). Muller and Ferguson (1939) have suggested that the fauna of large arcestids ("Galeati fauna") and Pinacoceras metternichi that occurs in the Gabbs formation of Nevada may be the same age as Monotis

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[1] G.E.G. Westermann informed the writer that he has distinguished several zones within the Monotis beds of British Columbia. The results of this research are not yet available.

subcircularis. This arcestid fauna has never been found in Canada. An interesting Norian benthonic fauna occurs above Monotis beds in southern Yukon and in various parts of western British Columbia (Tozer, 1958, p. 11). This fauna has never been found in the eastern Cordillera.

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