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DEPARTMENT OF ENERGY, MINES AND RESOURCES

MACROFOSSIL ZONES OF THE MARINE CRETACEOUS OF THE WESTERN INTERIOR OF CANADA AND THEIR CORRELATION WITH THE ZONES AND STAGES OF EUROPE AND THE WESTERN INTERIOR OF THE UNITED STATES

(Report and 2 figures)

J. A. Jeletzky

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ABSTRACT

The marine Cretaceous macrofaunas of the Canadian western interior region are much more closely allied to those of Europe than is generally realized. Only a few species have, hitherto, been recognized as common to both regions (e.g. Inoceramus labiatus, Prionocyclus (Collignoniceras) woollgari, Inoceramus lobatus-cardissoides). A number of the zonal index species of the Canadian western interior region or of the North American continent are, however, considered to be conspecific with the well known European zonal indices (e.g. Buchia cascadensis = B. okensis, B. spasskensoides and B. acustriata = B. uncitoides, B. harrisonensis = B. juravskii, Inoceramus umbonatus = I. involutus, Inoceramus barabini and its allies are mostly = I. balticus-regularis, some forms of Scaphites quadrangularis = Scaphites elegans and Scaphites roemeri var. tuberculata). Furthermore, such European index fossils as Buchia terebratuloides, B. trigonoides, B. bulloides, B. crassa, B. crassicollis, Gastroplites cantianus (Scaphites hippocrepis, Scaphites roemeri f. typ. and Scaphites (Hoploscaphites) constrictus have been found in the western interior region of Canada. Conversely Scaphites (Hoploscaphites) nicolletii was recently found in northwest Germany. It is anticipated that further research will considerably increase the number of species common to both regions and further reduce the number of the zonal indices peculiar to the Canadian western interior region in particular and to the North American continent in general.

Already now it is possible to subdivide the Cretaceous rocks of the Canadian western interior region into European stages and substages. Consequently there is no need to introduce any local stages and substages for this region. Furthermore, it is mostly possible to recognize the zonal counterparts of the standard European macrofossil zones in the Canadian western interior region, a number of the fossil zones and the general succession of the Cretaceous fossil faunas being the same in both regions.

The above conclusions are also valid for the United States western interior region of North America, its faunas being mostly the same as those of the Canadian western interior region.

MACROFOSSIL ZONES OF THE MARINE CRETACEOUS OF THE WESTERN INTERIOR OF CANADA AND THEIR CORRELATION WITH THE ZONES AND STAGES OF EUROPE AND THE WESTERN INTERIOR OF THE UNITED STATES

INTRODUCTION AND ACKNOWLEDGMENTS

This report attempts to summarize and interpret the available data on the macrofossil zones of the marine Cretaceous of the western interior of Canada; to improve the existing correlation of the Canadian zones with those of the western interior of the United States; and to relate these zones more closely with the international standard stages based on the west European zones and type localities.

The attempt to realize these objectives has been based mainly on all available data on the established time ranges of those United States and European index fossils found in the western interior of Canada, supplemented by the information on ranges and occurrence of Canadian fossils outside of Canada.

Only by making the fullest use of all these data has it been possible to produce a detailed and usable zonal scheme. Furthermore, the practical usefulness and reliability of such a scheme is greatly enhanced by its dependence on index fossils that have already been well-figured and described.

The relationships between the zones used and at least some of the principal rock units of the western interior of Canada are indicated, but no detailed correlation is attempted.

The information now available on the subject is rather unevenly distributed and much of it is rather sketchy. An attempt was made to bring this information together and to generalize so as to present the problems involved as an integrated whole. As knowledge of the Cretaceous rocks and faunas of the region increases, some of these generalizations will undoubtedly need to be modified or abandoned, and every effort is made to distinguish between fact and inference and to indicate the probable reliability of each inference.

As this is a preliminary report, complete documentation of the views expressed is not attempted. The bibliography is, therefore, not complete but should rather be treated as a guide to the literature.

The western interior of Canada is here assumed to comprise the Rocky Mountains and the Foothills Belt, the Liard Plateau, the Mackenzie and Richardson Mountains, and the Interior Plains.

Manuscript first submitted: January 30, 1959.
Resubmitted with minor revisions: September 1967.

It is not possible to acknowledge individually the help of all who have contributed to this report by friendly discussions and criticisms, by written communications, and by making available specimens or replicas of pertinent fossils, all of which help is greatly appreciated. Special thanks must, however, be extended to the late Dr. F.H. McLearn (Geological Survey of Canada) who for the last few years has been continuously advising the writer and answering his numberless queries on the subject. Dr. W.A. Cobban and the late Dr. John B. Reeside, Jr. of the U.S. Geological Survey kindly provided the writer with most valuable published and unpublished information concerning the Cretaceous rocks and faunas of the western interior of the United States and with many plaster casts of their index fossils. This help has greatly facilitated some conclusions advanced in the following pages. Drs. P.S. Warren and C.R. Stelck have discussed several thorny problems concerning the Cretaceous rocks and faunas of Alberta and northeastern British Columbia, permitted the study of the pertinent collections and types preserved in the Geological Museum of the University of Alberta, and lent for study valuable collections of Buchia (=Aucella) and ammonites belonging to that museum.

Only rock (rock-stratigraphic) and rock-time (biochronological) units are used in this report (Jeletzky, 1956).

The following text was last revised by the writer in December 1958 and since then only a few minor corrections have been made and a couple of footnotes added.

Illustrations and brief descriptions of most of the Lower Cretaceous zonal index fossils utilized in the paper have been published in Paper 64-11 of the Geological Survey. That paper also contains a somewhat revised version of the Lower Cretaceous correlation chart (Fig. 1) of this paper.

Figures of a number of Upper Cretaceous zonal index fossils utilized in the following report will be published in the 5th edition of the Geology and Economic Minerals of Canada which is now being prepared.

BIOCHRONOLOGICALLY USEFUL FOSSILS

Only a few groups of macrofossils are biochronologically useful in the Cretaceous System of the western interior of Canada. As elsewhere, by far the most useful of these are ammonites; especially the scaphites and baculites of the Upper Cretaceous Series and the gastroplitids of the Albian Stage. These three groups were apparently endemic to the interior basin of North America and are, therefore, found in abundance and variety. They appear, furthermore, to form uninterrupted lineages, at least in part, which further increases their biochronological value.

Ammonites, other than scaphites and baculites, are rather rare in the mid to late Upper Cretaceous rocks of the western interior of Canada, although they are reasonably abundant in the Albian, Cenomanian, and Turonian rocks of the region. Ammonites are, furthermore, rare or absent in many parts of the marine Neocomian succession of the region.

Among pelecypods, only species of Inoceramus and Buchia (=Aucella), which occur in abundance and variety in many parts of the Cretaceous marine succession of the region, were found to be biochronologically valuable. Almost all other pelecypods appear to be far too long-ranging and facies-bound to be of any real use. Always excepting Inoceramus and Buchia, recent investigations tend to discredit rather than to confirm the biochronological value of even pelecypod genera (e.g. Aucellina) and species that have previously been considered to be diagnostic of certain zones and stages in the region.

Although valuable for external correlation, crinoids (e.g. Uintacrinus) and belemnites are mostly too rare to be of much value as regional zonal indices. Sponges, echinoderms, corals, brachiopods, gastropods, and the crustaceans are either too rare, or too little understood, or both, to be of much value in either regional or interregional correlation.

In view of the above considerations, the zonal table proposed herewith for the Cretaceous marine rocks of the western interior of Canada is based almost exclusively on ammonites, inocerami, and Buchia (=Aucella).

BOUNDARIES AND MAJOR DIVISIONS OF THE CRETACEOUS SYSTEM

The lower boundary of the Cretaceous System is drawn at the base of the Berriasian substage (Gignoux and Moret, 1946, pp. 63-64). In the boreal province, to which the rocks being considered belong, the equivalents of the Berriasian substage are known as the Infravalanginian substage, the latter name is considered to be a junior synonym and not used here. In European Russia the upper part of the Berriasian substage is known as the Ryasanian beds.

Following all modern Russian authors and Arkell (1946, p. 28) and contrary to Muller (1941, Table 1), Spath (1947, pp. 54-55, 66; 1952, pp. 22-23), and Arkell (1956, pp. 492-493), all the Ryasanian beds are here included in the Cretaceous System. The underlying zone of Craspedites (Craspedites) nodiger is recognized as the youngest zone of the boreal Jurassic System; it is assumed to correspond to the uppermost Tithonian Virgatosphinctes transitorius zone of the Tethys (see, Fig. 1).

The Berriasian age of the lower Ryasanian beds appears to be definitely established by Rengarten (1951, pp. 41-42), who, in Greater Caucasus, found that Berriasella (Riasanites) rjasanensis and other index ammonites of those beds are associated with Thurmannites cf. boissieri (Pictet), Spiticeras (Negreliceras) negreli (Matheron), Buchia volgensis (Lahusen) and other index fossils of the Berriasian substage. He correlated this fauna with the west European Thurmannites boissieri zone. This association suggests that the Berriasella (Riasanites) rjasanensis zone is somewhat younger than the basal Berriasian beds of west Europe and the lower part of the Buchia okensis zone of Canada (see below).

In the western interior of Canada equivalents of the combined Craspedites (Craspedites) zones of Russia can readily be identified by their Buchia fauna consisting of Buchia piochii (Gabb), Buchia fischeri (d'Orbigny), Buchia trigonoides (Lahusen), and Buchia subokensis (Pavlow). This fauna is followed by the Buchia okensis fauna corresponding to the Berriasella (Riasanites) rjasanensis zone, at least in part.

An Upper Tithonian (see Spath, 1950) ammonite Spiticeras (Notostephanus) cf. kurdistanensis Spath was recently found and identified by C.R. Stelck, in association with the Buchia piochii fauna in a loose boulder on Fischer Creek (Peace River Foothills). The same Buchia species occurs however, in the lower part of the Monteith Formation (shaly beds ?) of the marine Bullhead Group (McLearn and Kindle, 1950, pp. 68-72). The upper part of the Monteith Formation carries a lowermost Cretaceous (lower Berriasian) Buchia and ammonite fauna. In this area, therefore, the Jurassic-Cretaceous boundary lies within the Monteith Formation, although its exact position and character are unknown.

In northeastern Richardson Mountains the Jurassic-Cretaceous boundary lies between the Buchia fischeri and B. trigonoides zone below and the Buchia okensis zone above (Jeletzky, 1958a).

Outside of the above areas the Jurassic-Cretaceous boundary either lies within a major erosional interval embracing the uppermost Jurassic and Neocomian rocks or is situated within non-marine successions, which are beyond the scope of this report.

A two-fold subdivision of the Cretaceous System is favoured, following Muller and Schenck (1943), and Cobban and Reeside (1952, p. 1014). The boundary between the Lower and Upper Cretaceous is drawn between the Albian and Cenomanian Stages as defined by Muller and Schenck (1943).

The upper boundary of the Cretaceous System is drawn at the top of the boreal Eurasian Belemnella casimirovensis zone and its equivalents (Jeletzky, 1951b, 1958b), which form the top part of the Maestrichtian Stage. On a global scale this boundary is better characterized by the complete disappearance of ammonites, true belemnites (Belemnitellidae), inocerami, and rudistids. The disappearance of Scaphites (Hoploscaphites) constrictus (Sowerby) and Inoceramus tegulatus Hagenow at this systemic boundary is particularly significant.

The Danian Stage is excluded from the Cretaceous System and from the Mesozoic. The reasons for this action, and for the drawing of the Cretaceous-Tertiary boundary between Maestrichtian and Danian Stages were discussed elsewhere (Jeletzky, 1951b, pp. 4-12).

The youngest Cretaceous rocks so far known in the western interior of Canada represent the lower part of the lower Maestrichtian State (see below). Only non-marine facies of younger Maestrichtian rocks are known there. The problem of the upper boundary of the Cretaceous System in Canada is, therefore, beyond the scope of this report.

LOWER CRETACEOUS SERIES

NEOCOMIAN STAGE

The Neocomian Stage is here taken to include the Berriasian, Valanginian, Hauterivian, Barremian, and Aptian substages. This interpretation agrees with the original concept of this stage (d'Orbigny, 1840, pp. 620-621). It is widely used and is easy to apply in the western interior of Canada, where marine rocks of all the Neocomian substages are very local and sharply separated from the widespread Albian rocks. The restriction of the Neocomian Stage to the Valanginian and Hauterivian rocks as recently recommended by Gignoux and Moret (1946, p. 61), is considered impractical.

The distribution of the marine Neocomian rocks is very restricted in the western interior of Canada. Furthermore, some shoreward facies changes were observed towards the periphery of these Neocomian outliers, and non-marine Neocomian rocks occur in several adjacent areas. This suggests that the major hiatus representing Neocomian time over most of the region reflects lack of deposition rather than the subsequent removal of the Neocomian marine sediments.

One area of marine Neocomian rocks to be considered is in the Peace River Foothills. It seems likely, although as yet unproven, that this area includes the central Foothills south and north of the Athabasca River. This area of marine Neocomian beds obviously represents an ingression from the western belt of Cordilleran geosyncline. Only the Berriasian and Valanginian substages are known in the marine facies, the Hauterivian and Barremian substages appear to be represented only by non-marine rocks.

Another area of marine Neocomian rocks embraces the eastern flank of the Richardson Mountains between Stony Creek and Donna River (Jeletzky, 1958a). All probable or possible marine equivalents of the marine Neocomian rocks of northeastern Richardson Mountains found so far are restricted to the vicinity of this area.

The Neocomian sequence of northeastern Richardson Mountains is rather thick and includes marine rocks of all Neocomian substages. Coal-bearing, presumably non-marine, rocks are intercalated in the late Valanginian and early Hauterivian parts of the sequence only.

The Berriasian and Valanginian rocks of northeastern Richardson Mountains appear to represent southern extension of the widespread Arctic transgression. A short-lived regression and fluctuations of the sea during late Valanginian and early Hauterivian time was then followed by another major transgression in mid-Hauterivian time. This transgression, which lasted through the Barremian and well into Aptian time, was probably more limited in extent (Jeletzky, 1958a).

Berriasian Substage

Buchia okensis zone

The Buchia okensis zone is equivalent to the middle Russian Berriasella (Riasanites) rjasanensis and Craspedites (Subcraspedites) spasskensis zones, at least in part. In the Tethyan province of Europe the Buchia okensis zone probably corresponds only to the lower Berriasian (the Berriasella callistoides zone and, perhaps, the basal part of the Thurmannites boissieri zone; see Fig. 1). This is indicated by the occurrence of Spiticeras (Spiticeras) cf. scriptus (Strachey, 1865), Neocomites (s. lato) n. sp. indet., and Berriasella (Protacanthodiscus) n. sp. aff. B. (P.) micheicus (Bogoslovsky, 1897) on Vancouver Island well above the zone of Buchia okensis. On Vancouver Island these late Berriasian ammonites are associated with Buchia uncitoides (Pavlow) s. lato.

In the European Arctic the Buchia okensis zone appears to include at least some part of the Hectoroceras and Praetollia zones of Spath (1947, 1952, p. 33, Table 1). The specimens of Buchia figured by Spath (e.g. 1947, Pl. 3, fig. 5a-b; Pl. 5, figs. 1-2, and possibly Pl. 4, figs. 8-9; 1952, Pl. 3, fig. 6) belong, indeed, for the most part to Buchia okensis (Pavlow) and not to the true Buchia volgensis (Lahusen) s. str. It should be noted in this connection that B. okensis and B. volgensis s. str. are diagnostic of two successive Berriasian zones throughout Western Canada (Jeletzky, 1950a; 1958a). Their reported association in Ryasanian beds and elsewhere outside Canada is puzzling; it may be due to restricted distribution or because the corresponding stratigraphic columns are greatly condensed (especially in central Russia).

Rocks of the Buchia okensis zone are known only in the northeastern Richardson Mountains and in the Peace River Foothills. In the former area they are represented by 50 to 55 feet of shales with Buchia okensis et var. and Craspedites (Subcraspedites) aff. suprasubditus (Bogoslowsky). In the latter area the presence of the Buchia okensis zone is suggested by an ammonite found by Hans Frebold, presumably in the upper part of the Monteith Formation, on Hart Highway about 2 1/2 miles west of Fisher Creek. This ammonite was identified by the writer as Craspedites (Subcraspedites) ex aff. groenlandicus Spath.

Craspedites (Tollia) cf. payeri and Buchia volgensis zone

This zone is tentatively correlated with the greater, upper part of the Upper Berriasian Thurmannites boissieri zone of the Tethys and with the presumably contemporary Craspedites (Tollia) tolli and Craspedites (Tollia) stenomphalus zones of northern Eurasia. In Greenland, this Canadian zone may correspond with some part of the Hectoroceras and Praetollia zones, in addition to the local Craspedites (Tollia) payeri zone.

C. (T.) cf. payeri is now proposed as the zonal index instead of C. (T.) cf. tolli used previously by Jeletzky (1958a). C. (T.) cf. payeri is more common, better preserved, and the name is unquestionably valid.

Spath (1952, p. 20) considered the Greenland zone of Craspedites (Tollia) payeri to be equivalent to the Eurasian Craspedites (Tollia) tolli zone. This correlation seems to find some support in the association of C. (T.) cf. payeri with C. (T.) cf. tolli in the upper Berriasian rocks of Aklavik Range (Jeletzky, 1958a, p. 6) and is tentatively adopted in this report. The validity of this conclusion and of the late Berriasian age of the Craspedites (Tollia) tolli and Craspedites (Tollia) stenomphalus zones is, however, doubtful. Bodylevsky (1956, pp. 141-142) and Luppov (1956, p. 326) consider, indeed, that in Russia C. (T.) stenomphalus is restricted to the lowermost Valanginian beds with Pseudogarnieria, etc. This circumstance, and the fact that the zone of Craspedites (Tollia) tolli and Craspedites (Tollia) stenomphalus have never been observed in superposition, make it entirely possible that these Eurasian zones are younger than the Canadian Craspedites (Tollia) cf. payeri zone and are a faunal facies of the next younger Polyptychites (Euryptychites) n. sp. aff. Polyptychites latissimus zone.

Spath's (1952, p. 20) generic assignment of Craspedites (Tollia) stenomphalus and his placing of the zone containing it in the early Berriasian are considered improbable. The same applies to Spath's (1947, p. 23) interpretation of its close ally Craspedites (Tollia) mutabilis Stanton s. lato, which includes all the "Dichotomites species" of Anderson (1938) found at the type locality of the former species. C. (T.) mutabilis s. lato is definitely early Valanginian in age, being associated with Buchia crassa (Pavlow), Buchia tolmatschowi (Sokolow) var. americana (Sokolow), and allied forms. Furthermore, the closely related Craspedites (Tollia) mutabilis (Stanton) var. paucicostata (Donovan, 1953) occurs, in the writer's opinion, in the equivalents of the late lower Valanginian Polyptychites (Polyptychites) keyserlingi zone. Whatever the time ranges of its individual species may be, the subgenus Tollia ranges at least through both the upper Berriasian and lower Valanginian substages. It is, finally, possible that the better preserved and figured Russian specimen of Craspedites (Tollia) stenomphalus is specifically and subgenerically distinct from the English Spilsby sandstone specimen hitherto unreservedly identified with it by all workers[1].

The Craspedites (Tollia) cf. payeri zone is known in northeastern Richardson Mountains, where its index species is associated with Craspedites (Tollia) cf. tolli Pavlow, Buchia volgensis (Lahusen), and Buchia cf. keyserlingi (d'Orbigny) (Jeletzky, 1958a). In the Peace River Foothills its presence is suggested by the association of C. (T.) cf. tolli and B. cf. keyserlingi somewhere in the middle part of the marine Bullhead Group (either in the upper Monteith or in the lowermost Beattie Peaks).

Valanginian Substage

The sequence of the Valanginian zones proposed below is only tentative, because of our scanty knowledge of the boreal Valanginian key sections and their ammonite faunas, both in Canada and in northern Eurasia.

Polyptychites (Euryptychites) n. sp. aff. Polyptychites latissimus and Polyptychites anabarensis ? zone

This zone appears to be equivalent to some part of lowermost European Valanginian subzone with Platylenticeras gevrili and Polyptychites (Euryptychites) latissimus. At any rate it can hardly be younger than the lower part of the Polyptychites (Polyptychites) keyserlingi zone or older than

[1] After this paper went to the press the writer was able to study a plaster cast of the English figured specimen of "Olcostephanus" stenomphalus Pavlow, 1889 kindly provided by Dr. D. P. Naidin of the Geological Faculty of the Moscow State University. Although somewhat imperfect, this cast indicates that this specimen (see Pavlow, 1889, Pl. III, fig. 1) belongs to Subcraspedites Spath, 1923 and is subgenerically distinct from the figured Russian specimen of "Olcostephanus" stenomphalus (Pavlow, 1889, Pl. III, fig. 11) which is a Tollia closely allied to or specifically identical with Craspedites (Tollia) tolli Pavlow s. lato. This explains the above discussed controversy about the age of the "Olcostephanus" stenomphalus zone in England and Russia. The zone must, however, be used in the sense of Spath (1952, p. 20) and placed in the lower Berriasian as the English cotype of "Olcostephanus" stenomphalus Pavlow, 1889 has been selected as its lectotype by Spath (1947, p. 23). This selection invalidates the writer's interpretation of the species by its better preserved and figured Russian cotype (see above). The corresponding zonal graphs of Figure 1 of the paper should be corrected accordingly.

Craspedites (Tollia) stenomphalus zone. The Polyptychites (Euryptychites) n. sp. aff. Polyptychites latissimus and Polyptychites anabarensis? zone has so far been found only in the Aklavik Range, in the upper part of the buff sandstone member (Jeletzky, 1958a). There, a representative of Polyptychites (Tollia?), identical with or closely allied to P. anabarensis Pavlow, was found in association with Polyptychites (Euryptychites) n. sp. aff. Polyptychites latissimus and Buchia volgensis. This association indicates that Buchia volgensis ranges at least as high as the lowermost part of the Valanginian substage.

Polyptychites cf. keyserlingi and Buchia cf. keyserlingi zone

Polyptychites (Polyptychites) cf. keyserlingi Neumayr and Uhlig s. lato apparently closely related to or identical with P. (P.) keyserlingi var. lejanus (Bogoslowsky) or P. (P.) keyserlingi var. expansus (Bogoslowsky) was found recently at two localities 40 to 60 feet above the base of the Beattie Peaks Formation of the marine Bullhead Group of the Peace River Foothills by geologists of the Triad Oil Co. and of the British Columbia Department of Mines.

Less satisfactorily preserved representatives of the same species group and Neocomites (Odontodiscoceras?) sp. indet. were found elsewhere in the (? lower) Beatty Peaks Formation in association with Buchia cf. keyserlingi (Lahusen). In yet other localities the Beattie Peaks Formation has yielded only B. cf. keyserlingi.

As B. keyserlingi (Lahusen) was reported to have a wider time range than Polyptychites (Polyptychites) keyserlingi s. lato, all above occurrences are only tentatively considered to represent the same early Valanginian zone.

The Polyptychites (Polyptychites) cf. keyserlingi and Buchia cf. keyserlingi zone of the western interior of Canada appears to correspond to the late lower Valanginian zone of Polyptychites (Polyptychites) keyserlingi s. lato of western Europe.

Polyptychites (Euryptychites) barnstoni (Meek, 1859, p. 184, Figs. 1, 2), reported from an unknown locality in the Mackenzie River basin, may have been collected either from the rocks of the Polyptychites (Polyptychites) cf. keyserlingi and Buchia cf. keyserlingi zone or from those of Polyptychites (Euryptychites) n. sp. aff. Polyptychites latissimus and Polyptychites anabarensis? zone[1].

---

[1] The more recent study of the holotype of Ammonites barnstoni Meek has shown that it does not belong to Euryptychites but to the Callovian homoeomorph genus Cadoceras and is a senior synonym of Cadoceras crassum (Madsen, 1904). Polyptychitid ammonites of the Arctic Canada tentatively compared with A. barnstoni by the writer (e.g. Jeletzky, 1958a, p. 9) belong to Polyptychites (Euryptychites) ex gr. middendorfi Pavlow, 1914.

Buchia crassa zone

A Buchia fauna consisting of B. crassa (Pavlow), B. n. sp. aff. B. crassa (Pavlow), Buchia inflata (Toula), and Buchia cf. bulloides (Lahusen) occurs in the Beattie Peaks (? upper) and (?) Monach Formations of the marine Bullhead Group of the Peace River Foothills. A rather similar Buchia fauna was found in 1958 in the uppermost beds of the buff sandstone member and in the lowermost beds of the white sandstone member of the Aklavik Range (Jeletzky, 1958a, pp. 7-8).

The zonal sequence in the western Cordillera indicates that Buchia crassa fauna is older than the true Buchia crassicollis (Keyserling) fauna and roughly contemporary with the Craspedites (Tollia) mutabilis and B. crassa fauna of California. It is, therefore, tentatively correlated with the upper part of the European Polyptychites (Polyptychites) keyserlingi zone (see Fig. 1). Although the beds with B. crassa and others appear to overlie the Polyptychites (Polyptychites) cf. keyserlingi and Buchia cf. keyserlingi zone, they may be but a faunal facies of the latter.

Middle and upper Valanginian rocks

Marine rocks of middle and late Valanginian time are unknown in the western interior of Canada (see Fig. 1). In the Richardson Mountains they appear to be represented by the lower part of the presumably non-marine white sandstone member (Jeletzky, 1958a, pp. 7-9). Middle and upper Valanginian rocks may also be non-marine in the Peace River Foothills.

Hauterivian Substage

Marine rocks of Hauterivian time (in the sense of Muller and Schenck, 1943, non Spath, 1924) are so far known only in Aklavik Range, northeastern Richardson Mountains.

It is possible, although unlikely, that the Hauterivian stage is represented in the uppermost part of the marine Bullhead Group of the Peace River Foothills. It is assumed tentatively that all other parts of the western interior of Canada were above sea-level during the Hauterivian time.

Zone A

The upper, coal-bearing part of the white sandstone member of Aklavik Range (Jeletzky, 1958a, pp. 7-9) is now known to include marine Hauterivian beds, as Acroteuthis cf. conoides Swinnerton occurs in shales in the uppermost part of the member. A. conoides is a mid-Hauterivian fossil in England.

The replacement of the coal-bearing, presumably non-marine, rocks by the marine sandstones and shales in the uppermost beds of the white sandstone member marks the beginning of the widespread mid-Lower Cretaceous transgression on the eastern flank of Richardson Mountains, which can now be dated as of the mid-Hauterivian time.

Simbirskites (Simbirskites) cf. kleini zone

The basal 30 to 40 feet of the upper shale-siltstone division of Aklavik Range (Jeletzky, 1958a, pp. 10-11) have recently yielded large *Simbirskites* (*Simbirskites*) cf. *kleini* Neumayr and Uhlig, *Acroteuthis* cf. *conoides* Swinnerton, and *Oxyteuthis* sp. indet. and are, therefore, of late Hauterivian age; they are near the top of the west European *Subsaynella sayni* zone and probably correspond to its *Simbirskites* (*Simbirskites*) *progredicus* subzone (*see* Spath, 1924, p. 77, table opp. p. 80; this paper, Fig. 1).

Barremian Substage

Marine rocks of the Barremian substage are almost as strongly localized in the western interior of Canada as are those of the Hauterivian substage; they have so far only been found in northeastern Richardson Mountains, from lower Donna River to the Fort McPherson area. They probably occur, however, throughout the narrow belt of Arctic Canada surrounding this area (Jeletzky, 1958a) and overlap the older Lower Cretaceous rocks in all directions.

Zone B

In northeastern Richardson Mountains some 750 feet of the lower member of the upper shale-siltstone division, immediately overlying the upper Hauterivian basal beds, have only yielded poorly preserved belemnites and non-diagnostic pelecypods. The belemnites are comparable to *Oxyteuthis jasikowi* (Lahusen), *Oxyteuthis pugio* Stolley var. *rimata* Stolley, and *Acroteuthis subquadratus* (Roemer) emend. Swinnerton? This, and the direct superposition of these beds on the upper Hauterivian shales, indicates the early Barremian age of the former, which appear, therefore, to represent the lower part of the west European *Pseudothurmannia angulicostata* zone (*see* Fig. 1).

Crioceras (Hoplocrioceras) cf. remondi zone

This zone embraces the upper 750 to 790 feet of the upper shale-siltstone division of northeastern Richardson Mountains. Its fauna includes the following diagnostic fossils: *Crioceras* (*Hoplocrioceras*) cf. *remondi*

(Gabb), Crioceras (Hoplocrioceras) ex gr. remondi (Gabb), Grioceras (Hoplocrioceras) n. sp. aff. laeviusculum Koenen, Ancyloceras (Acrioceras) aff. starrkingi Anderson, Crioceras (Crioceras) cf. latum (Gabb), Crioceras (Shasticrioceras ?) sp. indet., large Ancyloceras (Ancyloceras) cf. durrelli Anderson, Aconeceras sp. indet., Acroteuthis pseudopanderi Sintsov, Acroteuthis ex aff. conoides Swinnerton, Aucellina caucasica (Abich) f. typ., A. caucasica (Abich) var. stuckenbergi Pavlow, and Aucellina sp. aff. A. aptiensis (d'Orbigny) Pompeckj).

Crioceras (Hoplocrioceras) n. sp. aff. laeviusculum Koenen, Ancyloceras (Acrioceras) aff. starrkingi Anderson, Ancyloceras (Ancyloceras) cf. durrelli Anderson, Aconeceras sp. indet., and all the Aucellina forms are restricted to the top 200 to 220 feet of the upper member of the upper shale-siltstone division.

Crioceras (Crioceras) cf. latum (Gabb) and Crioceras (Shasticrioceras ?) sp. indet. were, on the other hand, found only near the base of the upper member and in the upper part of the lower member. As Crioceras (Hoplocrioceras) cf. remondi (Gabb) and its allies range throughout and Crioceras (Crioceras) cf. latum (Gabb), the diagnostic fossil of the lower fauna, is exceedingly rare, it appears to be more practical for the time being to treat both faunas as subzones of the Crioceras (Hoplocrioceras) cf. remondi zone.

The occurrence of C. (C.) cf. latum in the lower part of C. (H.) cf. remondi zone suggests that this subzone begins with the Crioceras raricinctum subzone of the Pseudothurmannia angulicostata zone. This dating is also in keeping with the presence of Crioceras (Hoplocrioceras) cf. remondi and other hoplocrioceratids in Crioceras (Crioceras) cf. latum subzone, as well as in the overlying beds.

The upper subzone of Crioceras (Hoplocrioceras) cf. remondi zone is definitely of a general Barremian age. The dating previously suggested (Jeletzky, 1958a) was confirmed by later investigations, except that this subzone does not seem to include any beds of the latest Barremian (Costidiscus recticostatum zone) age. The upper subzone apparently corresponds with most or all of the Heteroceras astierianum zone (see Fig. 1). For more detailed discussion of its fauna and age see Jeletzky (1958a, pp. 12-14). The above comments show that the broad Crioceras (Hoplocrioceras) cf. remondi zone apparently spans most of the Barremian stage beginning with the upper part of Pseudothurmannia angulicostata zone and ending with the Heteroceras astierianum zone.

In spite of their unexpectedly great time range in Arctic Canada (see Jeletzky, 1958a, pp. 12-14), Aucellina ex gr. aptiensis-caucasica are nonetheless useful in being diagnostic of a broad zone spanning the upper half of the Barremian and all of the Aptian substages (see Fig. 1).

Zone C

The Crioceras (Hoplocrioceras) cf. remondi zone of northeastern Richardson Mountains is conformably and (?) gradationally overlain by about 120 to 130 feet of light coloured, quartzose sandstones that form the lower part of the upper sandstone division (Jeletzky, 1958a, pp. 10-11, 14-15). The fauna of these beds is now known to include Acroteuthis cf. pseudopanderi Sintsov, Acroteuthis resembling A. kernensis Anderson and A. mitchelli Anderson, Hibolithes n. sp. ?, non-diagnostic pelecypods listed in Jeletzky (1958a, p. 15), and a species of starfish. The belemnites favour a latest Barremian rather than a lower Aptian age for these beds, which appear therefore to be equivalent to the European Costidiscus recticostatum zone (see Fig. 1). The zone is left unnamed pending the discovery of better preserved zonal index fossils.

Aptian Substage

The presence of marine Aptian rocks in northeastern Richardson Mountains suggested by Jeletzky (1958a, p. 14, Fig. 2) was confirmed in 1958. The middle and upper parts of the upper sandstone division, which is estimated to be 800 to 900 feet thick in this area, were found to be of Aptian age.

It seems that Aptian marine rocks extend southward into the Vittrekwa and Road River basins, as well as eastward into the Darnley Bay area, overlapping the older mid-Lower Cretaceous marine rocks wherever these latter occur.

Zone D

Some 300 to 400 feet of light coloured, quartzose sandstone with considerable interbeds of dark grey sandy siltstone and shale gradationally overlie the sandstones of the unnamed zone C in northeastern Richardson Mountains. The light coloured sandstone has only yielded Aucellina caucasica (Abich) et var., A. aptiensis (d'Orbigny) Pompeckj, and other non-diagnostic pelecypods. This part of the upper sandstone division appears to represent the entire lower Aptian (Bedoulian), as it occurs between the beds assumed to be uppermost Barremian below and the early upper Aptian (Gargasian) beds above. It is not named because of lack of any suitable zonal indices.

Tropaeum australe zone

This zone embraces some 330 to 340 feet of beds in the upper part of the upper sandstone division. These beds consist of buff to rust coloured, quartzose sandstone and sand with major interbeds of siltstone and sandy shale. They are characterized by the occurrence of Tropaeum australe (Moore) emend. Whitehouse, 1926 and its varieties, and allied forms such as Tropaeum undatum Whitehouse, 1926. Other abundant but non-diagnostic fossils include: Aucellina caucasica (Abich) et var., A. aptiensis (d'Orbigny) Pompeckj, and other pelecypods and gastropods.

The Tropaeum australe zone is approximately equivalent to the early upper Aptian (lower Gargasian) Tropaeum subzones of Europe (see Whitehouse, 1926, pp. 196-197; Fig. 1).

It seems likely that the sandstones and shales outcropping on the shores of Darnley Bay (Jeletzky, 1958a, p. 14, Fig. 2) represent the Tropaeum australe zone of northeastern Richardson Mountains. The only ammonite fragment found there is, however, too poorly preserved to rule out Barremian and Hauterivian uncoiled forms, and zonal affinities of the associated pelecypods are uncertain.

The specific identity of the Canadian Tropaeum forms with those of the Southern Hemisphere but not with those of Europe and California is remarkable. It is, however, in keeping with the recurrence already noted (Whitehouse, 1926, p. 215; Frebold, 1934, pp. 100-101) of Australian and South American ammonite genera and species in the European Arctic.

Zone E?

In Stony Creek (Fort McPherson area) sections, the uppermost 30 to 40 feet of the upper sandstone division is represented by dull grey, sandy siltstone without diagnostic fossils. This siltstone gradationally overlies the uppermost sandstones of the Tropaeum australe zone and is transgressively overlapped by Albian rocks. It seems, therefore, probable that it is of late upper Aptian (late Gargasian) age, although it may be merely a facies of the top part of the Tropaeum australe zone, as known elsewhere in the northeastern Richardson Mountains.

ALBIAN STAGE

In contrast to the older Lower Cretaceous marine rocks, the marine rocks of the Albian Stage are widespread in the western interior of Canada from the extreme north to the extreme south. Marine rocks of this age extend, furthermore, for a considerable distance towards the east, under the Great Plains.

The marine Albian rocks correlative with the generalized Neogastroplites zone of the Fort St. John Group were found recently to extend as far south as northern Colorado and to underlie Wyoming and Montana (Cobban and Reeside, 1952, p. 1023).

Much of the pioneer work on the stratigraphy, biochronology, and palaeontology of the marine Albian rocks was done by McLearn (see list of references in McLearn and Kindle, 1950, pp. 198-199), who first recognized their late Lower Cretaceous age and succeeded in unravelling most of the principal features of their geological history. Further significant contributions to the knowledge of the Canadian Albian rocks were made by Warren (1937, 1947), Stelck [1949 and 1952 (unpublished), 1955, 1956 (in Mellon and Wall, p. 11), 1958]; Stelck et al. (1956), Henderson (1954), Workman et al. (1954), Wickenden (1949, 1951) and others.

Our knowledge of the succession of the Albian marine faunas of the western interior of the United States and of their correlation with the western interior of Canada is due to the recent studies of Cobban (1951) and Cobban and Reeside (1952; and unpublished).

Unlike the older Lower Cretaceous faunas of the region, the Albian faunas of the western interior of the continent are strongly provincial in their composition and relatively difficult to correlate with the Albian zones of Europe.

All the Canadian Albian faunas are probably endemic and appear to have evolved within this basin, out of the oldest known Canadian Lemuroceras s. lato and Cleoniceras faunas. The latter faunas are interregional (almost world-wide) in their distribution and have reached the western interior of Canada either from the Cordilleran geosyncline (Queen Charlotte Islands) or from the Arctic region, or both.

Fortunately, enough elements of the Canadian Albian marine faunas were found in the Arctic region and in Europe in association with the European index fossils to provide the basis for a rational zonal correlation of the corresponding rocks in both regions.

A series of generalized, regionally applicable Albian ammonite zones was introduced by McLearn (1945a) and was discussed in detail by McLearn and Kindle (1950, pp. 92-96); in ascending order they are:

(1) Lemuroceras or Beudanticeras affine zone;
(2) Gastroplites zone
(3) "Placenticeras" liardense zone; and
(4) Neogastroplites or Posidonia nahwisi zone.

McLearn stated that Lemuroceras occurs in the rocks of the Douvilleiceras mammillatum zone on Madagascar and that Gastroplites occurs in the uppermost middle Albian Dipoloceras cristatum subzone in England (Spath, 1937). These two zones, therefore, span all of the middle Albian time. An upper Albian age was suggested for the Neogastroplites zone because this genus is closely allied to the uppermost middle Albian genus

Gastroplites. McLearn, however, considered it possible that the *Neogastroplites* zone might be already early Cenomanian (earliest Upper Cretaceous) in age.

The presence of the "*Placenticeras*" *liardense* zone between *Gastroplites* and *Neogastroplites* zones was considered possible but far from proven (McLearn and Kindle, 1950, p. 93). Subsequently, however, the "*Placenticeras*" *liardense* zone was found in the same stratigraphic position by Henderson (1954, p. 2286). Its zonal index fossil is but little understood but is probably a representative of the genus *Gastroplites* McLearn.

The generalized ammonite zones listed above have been recently subdivided by workers in Alberta and the United States.

Lemuroceras or Beudanticeras affine zone

This generalized Albian zone is widespread in the northern part of the region but is not known to occur south of the Peace River Foothills and Plains or south of the lower Athabasca River area. It is assumed to be represented either by non-marine rocks or by a major erosional interval throughout the southern part of the western interior of Canada. For further details see McLearn and Kindle (1950, pp. 92-96).

The *Lemuroceras* or *Beudanticeras* *affine* zone is, according to Stelck (*in* Mellon and Wall, 1956, p. 11; Stelck et al., 1956, pp. 9-10) subdivisible into the following, in ascending order:

(1) *Lemuroceras* cf. *indicum* zone;
(2) *Lemuroceras* *irenense* zone; and
(3) *Lemuroceras* *mcconnelli* zone.

Stelck *et al.* (1956, pp. 9-10) have, furthermore, recognized the presence of the lower Albian *Sonneratia* cf. *kitchini* and *Cleoniceras* cf. *subbaylei* zones beneath the *Lemuroceras* zones in some areas. These older zones appear to be of the late lower Albian age in the sense of Spath (1923-1943, pp. 699-701) and equivalent to part or all of the west European *Leymeriella* *tardefurcata* and *Sonneratia* *trinitense* zones (*see* Fig. 1).

Stelck's *et al.* (1956, pp. 9-10) refined *Lemuroceras* zones are tentatively considered subdivisions of the generalized *Lemuroceras* or *Beudanticeras* *affine* zone; they appear to be of the early middle Albian age in the sense of Spath (1923-1943) and equivalent to part or all of the European *Douvilleiceras* *mammillatum* zone (*see* Muller and Schenck, 1943, pp. 272-273; this report, Fig. 1). The refined *Lemuroceras* zones may, however, be of the late lower Albian age, at least in part, as a peculiar *Puzosia*? sp. was described by Warren (1947, p. 122, Pl. 29, figs. 6-7) from the generalized Beudanticeras affine zone of the Mackenzie River basin. This Puzosia? sp. also occurs together with Lemuroceras belli McLearn and allied forms in the undivided Fort St. John shales of the Liard River basin and in the Clearwater Formation of the lower Athabasca River. The probably specifically identical "Puzosia" sigmoidalis was recently described by Donovan (1953, pp. 115-116, Pl. 24, figs. 3-6, text-fig. 11) from the Leymeriella tardefurcata zone of East Greenland. No representatives of Lemuroceras s. lato were, finally, found in the richly fossiliferous Douvilleiceras mammillatum zone of Queen Charlotte Islands.

It should also be mentioned in this connection that the regional validity of the refined Lemuroceras zones of Stelck et al. (1956, pp. 9-10) has not yet been sufficiently tested. Some anomalous associations of fossils have, furthermore, already come to light. So, for example, Cleoniceras cf. subbaylei Spath and allies have been observed together with Lemuroceras cf. belli McLearn and Beudanticeras affine in the Lower Peel River area and in Queen Elizabeth Archipelago.

Mellon and Wall (1956, p. 11) and Stelck et al. (1956, pp. 9-10) consider that the middle Albian transgression did not penetrate south of the Peace River area until the end of Lemuroceras irenense time. These workers did not find any faunal elements of Lemuroceras cf. indicum and Lemuroceras irenense zones in the Clearwater Formation of the Athabasca River area but only those of the next younger Lemuroceras mcconnelli zone. They assume, therefore, that both older zones are represented by the brackish water Astarte natosini fauna of McMurray Formation in the Lower Athabasca area.

The Survey's collections from the lower Athabasca area include Lemuroceras cf. irenense McLearn collected some 200 feet above the base of the Clearwater Formation by R. T. D. Wickenden. Lemuroceras irenense zone appears, therefore, also to be present in this area unless L. cf. irenense is a long-ranging form and was found there in Lemuroceras mcconnelli zone. If so, the Albian transgression reached the lower Athabasca area somewhat earlier than previously thought and only the Lemuroceras cf. indicum zone of the Liard River area is represented there by the brackish water Astarte natosini fauna of McMurray Formation. The close affinity of the microfauna found in the upper part of the McMurray Formation with that found in the basal part of the Clearwater Formation agrees with this assumption.

Zone F

A more or less thick shale interval without known index fossils occurs in the Fort St. John Group of northern Alberta and northeastern British Columbia between the generalized Lemuroceras or Beudanticeras affine zone on one hand and the Gastroplites zone on the other. It is assumed that these rocks represent part or all of the middle Albian time between its Douvilleiceras mammillatum and Dipoloceras cristatum subzones.

Gastroplites zone

This zone is widespread in the Peace River Foothills, northern Alberta, and adjacent areas of the Liard Plateau; it was also reported from the Mackenzie River basin (Hume, 1954).

Henderson (1954, p. 2286, Fig. 4) has subdivided the generalized Gastroplites zone into lower and upper Gastroplites horizons. The upper Gastroplites horizon was correlated with the Haplophragmoides gigas zone (Wickenden, 1949; Stelck, 1952) and stated to occur only 100 feet below "Placenticeras" liardense zone on the Liard River.

Stelck et al. (1956, pp. 9-10) have proposed an even more refined subdivision of the Gastroplites zone into the following, in ascending order:

(1) Lophidiaster cf. silentiensis zone;
(2) Gastroplites canadensis zone;
(3) Gastroplites cf. cantianus zone; and
(4) Inoceramus cf. comancheanus zone

The Geological Survey's collections from the generalized Gastroplites zone are insufficient to test conclusively the regional validity of any of Stelck's et al. (1956) subdivisions of this zone. It should be noted, however, that starfishes identical with or closely related to Lophidiaster silentiensis McLearn are often associated with Gastroplites canadensis. Also Gastroplites cf. cantianus Spath occurs together with G. canadensis and other Gastroplites forms in Peace River area (Charlie Lake map-area).

Regardless of whether or not G. cantianus is but a morphological variety of G. canadensis, its occurrence in the western interior of Canada and in the Dipoloceras cristatum subzone of England confirms the generally accepted correlation of part or all of the generalized Gastroplites zone with the top middle Albian of west Europe (see Fig. 1).

The occurrence of Inoceramus cf. comancheanus Cragin and Inoceramus belleviensis Reeside near the top of Joli Fou shale (Stelck, 1958, p. 3) is of an outstanding biochronological and palaeozoological interest. It suggests the contemporaneity of the upper part of the Gastroplites zone with the lower part of the Inoceramus comancheanus zone, and the contemporaneity of the lower part of the Gastroplites zone with the Oxytropidoceras sp. indet. zone (see Fig. 1). It also follows therefrom that the American and Canadian parts of the interior basin of the continent have been connected already during the late middle Albian time.

Zone G

The previously mentioned interval between the Gastroplites and "Placenticeras" liardense zones has not yielded any index fossils. This interval is assumed to be still of the uppermost middle Albian age in terms of the European standard and to be equivalent to the middle part of the Inoceramus comancheanus zone of the western interior of the United States.

"Placenticeras" liardense zone

This zone was already discussed. It has recently been placed into the basal upper Albian by Stelck et al. (1956, p. 9). These workers have definitely placed its index ammonite into the genus Gastroplites.

The occurrence of Dipoloceras cf. fredericksburgense Scott in the "Placenticeras" liardense zone (Stelck, 1958, p. 3) also permits of its latest middle Albian dating, but Stelck's et al. (1956, p. 9) dating is tentatively followed in this report.

"Placenticeras" liardense zone is correlated with the upper part of the Inoceramus comancheanus zone of the western interior of the United States because of its occurrence closely below Neogastroplites selwini zone (see Fig. 1).

Neogastroplites zone

This zone is the most widespread of the Albian zones in the southern part of the western interior of Canada. It was recently found in northwestern Alberta (Cadomin, Two Lakes, Adams Lookout, and Grande Cache map-areas) by C. R. Stelck and by the Geological Survey's mapping geologists. Although not found further south, Neogastroplites zone must have extended all the way to the International Boundary either along the Foothills Belt or under the southern Great Plains. Perhaps its rocks have been eroded away in these areas prior to the deposition of the basal Upper Cretaceous rocks.

The Neogastroplites zone, in contrast, has not been found either in the lower Athabasca area or in the Mackenzie basin (exclusive of the Liard River region). It is not known whether this due to its non-deposition or subsequent erosion in these areas.

Stelck et al. (1956, p. 9) have introduced the following new zones, in ascending order:

(1) "Ophiura" sp. zone;
(2) Posidonia moberliensis zone; and
(3) Posidonia goodrichensis zone

for the shale interval of the Fort St. John Group occurring between the "Placenticeras" liardense and the generalized Neogastroplites zones. The data available to the writer contradict the regional validity of all these zones.

Although it is possible that Posidonia moberliensis (McLearn) and Posidonia goodrichensis McLearn range below Posodonia nahwisi (McLearn) s.str., they both mostly occur in association with either Neogastroplites selwini or N. cornutus. The Goodrich and lower Sikanni sandstones, which are characterized by P. goodrichensis and P. moberliensis, are known to be of Neogastroplites age. As pointed out by McLearn (1945a, p. 11), the Posidonia nahwisi s. lato zone of the upper Fort St. John Group is but a faunal facies of his generalized Neogastroplites zone. No fossil zones are, for the time being, recognized between "Placenticeras" liardense and Neogastroplites zones (see Fig. 1).

In Canada, the generalized Neogastroplites zone was recently subdivided by Stelck et al. (1956, p. 9) into the following, in ascending order:

(1) Neogastroplites selwyni zone;
(2) Neogastroplites cornutus zone; and
(3) Neogastroplites wyomingensis zone.

Dr. John B. Reeside and Dr. W.A. Cobban have recently monographically studied the United States and Canadian collections of Neogastroplites. These workers propose the following subdivision of the generalized Neogastroplites zone applicable to both the United States and Canadian parts of the interior basin of the continent, in ascending order (written communication of Dr. John B. Reeside, Jr. of June 18th, 1956):

(1) Neogastroplites haasi Reeside and Cobban;
(2) Neogastroplites cornutus (Whiteaves);
(3) Neogastroplites muelleri Reeside and Cobban;
(4) Neogastroplites americanus (Reeside and Weimouth); and
(5) Neogastroplites mclearni Reeside and Cobban n. sp.

Judging by the plaster casts and figures of N. haasi provided by Dr. John B. Reeside, Jr., this species is but a junior synonym of N. selwyni McLearn. Also Neogastroplites cf. cornutus (Whiteaves) from the first Sikanni sandstone (McLearn, 1945a, Pl. XI, fig. 3) belongs to N. selwyni in the writer's opinion. The type locality of N. selwyni is the only other occurrence of Neogastroplites selwyni zone in Canada known to the writer.

Neogastroplites cornutus zone is widespread and the vast majority of the Neogastroplites records in the western interior of Canada (see McLearn, 1945a, McLearn and Kindle, 1950, pp. 92-96) refer to this zone.

Neogastroplites muelleri zone is unknown in Canada.

Neogastroplites americanus zone is known from the Adams Lookout area (written communication of Dr. John B. Reeside, Jr. of June 18th, 1956). Stelck et al. (1956, p. 9) have recently used the Neogastroplites wyomingensis zone for the beds corresponding to Neogastroplites americanus zone (Dr. C.R. Stelck, personal communication).

Neogastroplites mclearni zone has been found in the Grande Cache map-area (see Jeletzky; in Thorsteinsson, 1952, pp. 30-31) and probably at Cadomin. Gleddie's (1954, p. 492) record of Neogastroplites from the "fish-scale sand" probably also represents this zone.

It should be noted that the Neogastroplites mclearni zone is characterized by the presence of Engonoceras (Metengonoceras) sp. indet., which is unknown in the older Neogastroplites zones in Canada.

AGE OF NEOGASTROPLITES ZONES AND THE LOWER/ UPPER CRETACEOUS BOUNDARY

The base of the Dunvegan and Fort Nelson Formations was until recently accepted tentatively as the boundary line between the Lower and Upper Cretaceous series in the region extending from the Athabasca River valley to the Liard River valley north of Nelson Forks (McLearn, 1945b; McLearn and Kindle, 1950, Fig. 12, corr. table). All of the Fort St. John Group of these areas was placed in the late Lower Cretaceous. Outside of the Dunvegan-Nelson arenaceous wedge the Lower/Upper Cretaceous boundary was placed very low in shales of the Blackstone Formation or near the base of the undivided Alberta Group in the southern Foothills. On the Peace River plains it was placed in the upper part of the Shaftesbury Formation and on the lower Athabasca River very low in the Labiche shale.

Stelck (1949) was first to place the Lower/Upper Cretaceous boundary within the upper part of the Fort St. John Group and to use the top of the so called "fish-scale sand" as the boundary's marker over the most part of the Peace River-lower Athabasca River area. Stelck's (1949) placement of the Lower/Upper Cretaceous boundary was followed by Gleddie (1954, pp. 491-492), Henderson (1954, Fig. 4), Stelck et al. (1956, p. 9) and many other workers. Stelck et al. (1956, p. 9) list Neogastroplites wyomingensis (= N. americanus) as occurring underneath the "fish-scale sand" while Henderson (1954) has found Cenomanian Acanthoceras within the Sikanni Formation above the "fish-scale sand".

Warren and Stelck (1955, pp. 71-72) have described Acanthoceras athabascense closely allied to the Cenomanian Acanthoceras (Euomphaloceras) euomphalum Sharpe from a bed in the Labiche shale, which is "known to be within 40 feet of the "fish scale" beds".

In the Peace River Foothills the Cruiser shale is considered to be partly correlative with the upper Shaftesbury shales, which lie above the "fish-scale sand" and so are of the Cenomanian age in part (*see* Stelck, 1958, Fig. 1).

In the western interior of the United States all *Neogastroplites* species occur in beds underlying those with the typical Cenomanian ammonites, such as *Calycoceras* sp. indet. and *Acanthoceras*? *amphibolum* (Cobban and Reeside, 1952, p. 1017 and personal communication). Albian *Inoceramus anglicus* is, furthermore, associated with *Neogastroplites* in that region (Dr. John B. Reeside, Jr. personal communication).

The above palaeontological data are deemed to be sufficient to place all now known *Neogastroplites* zones into the upper Albian stage and to draw the Lower/Upper Cretaceous boundary in the western interior of Canada somewhere between the *Neogastroplites mclearni* and *Acanthoceras athabascense* zones. The Lower/Upper Cretaceous boundary is, therefore, mostly situated below the Dunvegan Formation and within the uppermost part of the Fort St. John Group in the Peace River-lower Athabasca River region. The "fish-scale sand" appears to be time-parallel within the Peace River-lower Athabasca River region and can be used as the Lower/Upper Cretaceous contact marker in this region. The lower boundary of the Dunvegan Formation appears, conversely, to be pronouncedly diachronic, at least in west-east direction (Stelck and Wall, 1955, pp. 17-19, Fig. 5) and the formation probably includes some uppermost Albian rocks in the upper Pine River area.

There is no valid reason to place the Lower/Upper Cretaceous boundary very low within the Blackstone Formation of the central and southern Foothills. In the southwestern part of the Foothills' belt the basal beds of the Blackstone Formation overlie disconformably either the Albian Blairmore Group or the Albian Crowsnest volcanics (Stelck, 1958, p. 3). These basal beds carry locally *Inoceramus labiatus* and *Watinoceras reesidei* (e.g. Castle River area, Stelck and Wall, 1954, p. 15; Blairmore area, Lyons Creek, Geological Survey of Canada collections) and so are of the early Turonian age. In other sections of the same area, however, *Dunveganoceras* was reported from the basal beds of the Blackstone Formation or from the beds occurring 50 to 100 feet above its base (Webb and Hertlein, 1934, p. 1409; Stelck and Wall, 1955, pp. 24-68). The base of the Blackstone Formation lies, therefore, well within the Upper Cretaceous Series in the extreme southwest of the Foothills' belt, although it appears to be noticeably time-transgressive already within this area.

The base of the Blackstone Formation remains time-transgressive farther northward along the Foothills' belt. As its barren member thickens in that direction, the occurrence of *Dunveganoceras* becomes restricted to the upper and middle beds of the member. The lower beds of the barren member become, therefore, older than the *Dunveganoceras* zone in the more northerly situated parts of southern and central Foothills; they appear to be equivalent with part or all of the Dunvegan Formation of the northern Foothills and Plains, at least in the northern part of the here discussed region.

The lowermost beds of the barren member finally become older than the Dunvegan Formation and equivalent to the uppermost beds of the Fort St. John Group of the northern Foothills and Plains a short distance south of the Athabasca River valley. The "fish-scale sand", which is here accepted as the approximate horizon marker of the Lower/Upper Cretaceous boundary within the Fort St. John Group farther north, appears indeed at the base of the Blackstone Formation at Nordegg according to Dr. C. R. Stelck (personal communication). This southernmost occurrence of the "fish-scale sand" within the Foothills' belt appears to mark the southern boundary of the latest Lower Cretaceous sea in this region. The basal beds of the Blackstone Formation are, therefore, believed to be of the early Upper Cretaceous age everywhere south of Nordegg area of the central Foothills.

The "fish-scale sand" has also been found 72 feet above the base of the Blackstone Formation at Cadomin by Dr. C. R. Stelck (personal communication). Neogastroplites has been collected by him in the "fish-scale beds" at this locality, which proves the value of these beds as the Lower/Upper Cretaceous boundary marker in the Nordegg-Cadomin area. The Cadomin Neogastroplites have been identified as Neogastroplites cf. mclearni by the writer. The Cadomin "fish-scale beds" appear, therefore, to be equivalent with the "fish-scale beds" containing N. mclearni in the Grand Cache area (see Jeletzky; in Thorsteinsson, 1952, pp. 30-31).

UPPER CRETACEOUS SERIES

The Upper Cretaceous marine rocks underlie the Canadian Great Plains from the Manitoba escarpment in the east to the Foothills' belt in the west. They are widespread in the southern and central parts of the Foothills' belt and also occur in some areas of the Rocky Mountains farther westward. Farther northward the Upper Cretaceous marine rocks underlie the Athabasca and Peace River Plains and are widespread in the northern Foothills and in the Peace River Foothills.

North of the Peace River Foothills the width of the area of the Upper Cretaceous rocks decreases sharply with their northernmost outcrops known on the Liard River in the vicinity of Nelson Forks.

Only isolated erosional bodies of the early Upper Cretaceous marine rocks are known to occur on the Liard Plateau, in the Mackenzie River valley, and on Arctic Red and Peel Rivers (Hume, 1954 and unpublished information).

In Arctic Canada sizable areas of marine Upper Cretaceous rocks were recently discovered in the basins of Eagle, Porcupine, and Bell Rivers, on the eastern slope of Richardson Mountains, and along the Arctic Coast between the Mackenzie River delta and Franklin Bay.

All areas of Upper Cretaceous rocks occurring in northern and Arctic Canada are obviously erosional remnants of a continuous body of sediments. The Upper Cretaceous sea that deposited these sediments must have extended all the way from the Canadian Arctic coast to the international boundary and therefrom across the western interior of the United States to the Gulf of Mexico.

CENOMANIAN STAGE

Zone H

The lower Cenomanian rocks are unknown in the western interior of Canada; they appear, however, to be represented by the zone of Calycoceras sp. indet. in the western interior of the United States (Cobban and Reeside, 1952, p. 1017). Part or all of the shale interval in the uppermost Fort St. John Group occurring between the Neogastroplites zones and the Acanthoceras athabascense zone is assumed to represent the early Cenomanian time; no index fossils are, however, known from this shale interval.

Acanthoceras athabascense zone

This zone is the oldest Upper Cretaceous zone so far known in the region. The closest ally of A. athabascense (A. euomphalum) occurs in the Holaster subglobosus zone of England. This zone occurs in the upper part of the Cenomanian Stage above the west European zones of Mantelliceras martimpreyi and Schloenbachia varians (see Fig. 2). This, and the occurrence of the Acanthoceras athabascense zone below the uppermost Cenomanian Dunveganoceras zone, suggests its early upper Cenomanian age.

Acanthoceras athabascense zone appears to be approximately contemporary with Acanthoceras? sp. A. zone of the western interior of the United States (Cobban and Reeside, 1952, p. 1017).

Acanthoceras athabascense zone may be a faunal facies of the restricted Inoceramus rutherfordi and Inoceramus dunveganensis zones, in part at least (see below).

Inoceramus dunveganensis zone

This zone includes principally marine to brackish water faunas of the Dunvegan Formation described by McLearn (1945b) and McLearn and

Kindle (1950). Elements of this fauna occur, however, in the lower part of Labiche shale of the lower Athabasca River area and in the unnamed shale formation of the eastern flank of Richardson Mountains. Inoceramus dunveganensis fauna appears to be a faunal facies of the non-marine Unio (Pleurobema) dowlingi and Unio (Elliptio) sulfuriensis fauna (McLearn, 1945b).

The external correlation of the Inoceramus dunveganensis zone is made difficult by the absence of ammonites and the facies-bound nature of almost all of its forms. As recognized by McLearn (1945b, p. 4), the fauna is Cenomanian in age. McLearn's (ibid.) main argument is the close affinity of I. dunveganensis with Inoceramus crippsi and its var. reachensis diagnostic of the Cenomanian rocks of Europe. Inoceramus aff. tenuis and I. aff. concentricus have also been reported from Inoceramus dunveganensis zone (McLearn, in Thorsteinsson, 1952, p. 35). The more recently established superposition of the uppermost Cenomanian zone of Dunveganoceras on Inoceramus dunveganensis zone confirms the earlier late Cenomanian age of the latter zone.

Stelck and Wall (1955, pp. 17-19, Fig. 5) have shown recently that Dunveganoceras and Inoceramus corpulentus do not descend into the Dunvegan sandstone proper in its type area and do not occur together with the Inoceramus dunveganensis fauna. The previous uncertainty on the subject was caused by the strongly diachronic nature of the upper boundary of the Dunvegan arenaceous wedge and its interfingering with the overlying Kaskapau shales.

Stelck and Wall (1955, p. 16) have proposed the following tentative upward zonal scheme for the rocks of the Dunvegan Formation here included into the broad Inoceramus dunveganensis zone:

(1) zone of Brachiodontes cf. tenuisculptus;
(2) zone of Brachiodontes cf. fulpensis;
(3) zone of Inoceramus rutherfordi and Ostrea dunveganensis; and
(4) zone of Inoceramus dunveganensis and Inoceramus athabaskensis.

Survey's collections indicate that I. athabaskensis also occurs in the zone of Acanthoceras athabascense low in the Labiche shale and in the generalized Dunveganoceras zone near the base of the Kaskapau and Blackstone Formations. It is, therefore, inappropriate as the zonal index of the restricted Inoceramus dunveganensis zone of Stelck and Wall (1955).

The validity of the separate and older zone of Inoceramus rutherfordi underneath the restricted Inoceramus dunveganensis zone is confirmed by all Survey's fossil collections studied by the writer.

Acanthoceras athabascense zone may be but a faunal facies of part or all of the broad Inoceramus dunveganensis zone. This is suggested by:

(1) the occurrence of *A. athabascense* closely below the generalized *Dunveganoceras* zone;

(2) the occurrence of *I. athabaskensis* in the *Acanthoceras athabascense* zone as well as in the *Inoceramus dunveganensis* zone;

(3) the fact that *Inoceramus dunveganensis* and *Acanthoceras athabascense* zones were never yet observed in superposition; and

(4) the occurrence of the broad *Inoceramus dunveganensis* zone closely below the generalized *Dunveganoceras* zone.

There is not enough good material available to test the regional validity of the two *Brachiodontes* zones proposed by Stelck and Wall (1955, p. 16).

Dunveganoceras zone

This important and widespread, generalized zone characterizes the basal beds of the Kaskapau and Blackstone (s.c. barren member) formations of the region. It was introduced by Warren and Stelck (1940) and is now known to occur in Alberta, northeastern British Columbia, and in the northern part of the western interior of the United States.

In the western interior of the United States, Cobban and Reeside (1952, p. 1017) have subdivided the *Dunveganoceras* zone into the following refined zones, in ascending order:

(1) zone of *Dunveganoceras pondi*; and
(2) zone of *Dunveganoceras* aff. *albertense*.

Stelck and Wall (1955, p. 16) propose an even more detailed tentative zonal subdivision for the western interior of Canada, in ascending order:

(1) zone of *Dunveganoceras* cf. *conditum* and *Inoceramus fragilis* var. *mesabiensis*;
(2) zone of *Dunveganoceras albertense* and *Inoceramus allani*;
(3) zone of *Dunveganoceras* cf. *parvum*; and
(4) zone of *Dunveganoceras hagei*.

They have also introduced the following zones, in ascending order, for the lowermost beds of the Kaskapau Formation occurring between the top of the Dunvegan Formation and the lowermost *Dunveganoceras* beds in the Pouce Coupe district:

(1) *Hillites* cf. *septarianus* and *Ostrea anomoides*; and
(2) *Ostrea aurea*.

Geological Survey's collections from the generalized Dunveganoceras zone and underlying Cenomanian beds are insufficient to test the regional validity of any of the above ammonite and pelecypod zones of Stelck and Wall (1955).

Warren and Stelck (1940, pp. 143-144) have been the first to propose the late Cenomanian age for the Dunveganoceras zone, which was still considered of the latest Cenomanian or earliest Turonian age by McLearn and Kindle (1950, p. 105). The occurrence of the Dunveganoceras zone underneath the zone of Inoceramus aff. Inoceramus fragilis and that of Inoceramus labiatus and Watinoceras leaves no doubt about its latest Cenomanian age, in the writer's opinion.

The occurrence of Inoceramus corpulentus McLearn in the Dunveganoceras beds of the Kaskapau Formation of the Pouce Coupe area (Stelck and Wall, 1955, p. 19) and in the Dunveganoceras-bearing middle and upper beds of the barren member of the Blackstone Formation (Warren and Rutherford, 1928, p. 132 and Geological Survey collections) deserves to be noted. I. corpulentus belongs to the widespread and biochronologically important group of Inoceramus lamarcki (Parkinson) Woods, which is generally speaking diagnostic of the upper Turonian rocks. The occurrence of a representative of this species group in the upper Cenomanian rocks of Canada is most unusual.

TURONIAN STAGE

Inoceramus aff. Inoceramus fragilis zone

This little known, but apparently valid zone was introduced by Stelck and Wall (1955, p. 16) for rocks of the Kaskapau Formation lying between the Dunveganoceras hagei zone and the Baculites (Sciponoceras) gracile and Prionocyclus (Collignoniceras) n. sp. subzone; it was placed in the uppermost Cenomanian by these workers but its lowermost Turonian age is preferred by the writer (see Fig. 2).

Watinoceras and Inoceramus labiatus zone

This important zone is widespread in the region from the Manitoba escarpment (Wickenden, 1945, pp. 28-32) to the northeastern Richardson Mountains (Jeletzky, unpublished). The beds of the lower Blackstone and Kaskapau Formations overlying their beds characterized by Dunveganoceras spp. and Inoceramus aff. I. fragilis Hall and Meek, belong to the Watinoceras and Inoceramus labiatus zone.

The validity of the Watinoceras and Inoceramus labiatus zone was repeatedly questioned (Webb and Hertlein, 1934, pp. 1406-1407 and others) ever since its introduction by Warren and Rutherford (1928, p. 132) and McLearn (1929, p. 93). Its regional validity was generally recognized more recently, however, after the disputed Prionocyclus (Collignoniceras) form rarely occurring in this part of the sequence in Canada was found to be specifically distinct from Prionocyclus (Collignoniceras) woollgari (Mantell) sensu Haas, 1946 (see Stelck and Wall, 1955, p. 16).

In the western interior of United States a zone of Baculites (Sciponoceras) gracile and Metoicoceras whitei is recognized immediately below beds characterized by Watinoceras reesidei and Inoceramus labiatus (Cobban, 1951, p. 2197; Cobban and Reeside, 1952, pp. 1017-1018). Watinoceras is, however, said to occur in the Baculites (Sciponoceras) gracile as well as in the restricted Inoceramus labiatus zone.

Stelck and Wall (1955, pp. 16-17) state that in Alberta Baculites (Sciponoceras) cf. gracile Shumard was found in beds assumed to lie more than 500 feet above the Dunveganoceras cf. albertense horizon. These beds are furthermore assumed to represent the horizon with Prionocyclus (Collignoniceras) n. sp. of the Watinoceras and Inoceramus labiatus zone and to lie some 200 feet above the so called "white chalcedonic bed" of the Kaskapau Formation.

For the time being it seems best to subdivide the Watinoceras and Inoceramus labiatus zone into:

(1) Baculites (Sciponoceras) cf. gracile and Prionocyclus (Collignoniceras) n. sp. subzone below; and

(2) Watinoceras reesidei and Inoceramus labiatus subzone above.

The Watinoceras and Inoceramus labiatus zone is one of the most important Cretaceous biochronological units of the western interior of Canada. I. labiatus is, indeed, a virtually world-wide index form, everywhere confined to the lower Turonian rocks. The Watinoceras and Inoceramus labiatus zone in Canada can, therefore, be confidently dated as of the early Turonian time and correlated with the European Inoceramus labiatus zone; it is equally well recognizable micropalaeontologically (Stelck and Wall, 1954).

Judging by its stratigraphic position and faunal affinities, Baculites (Sciponoceras) cf. gracile and Prionocyclus (Collignoniceras) n. sp. subzone of Watinoceras and Inoceramus labiatus zone may also include the upper part of the European Actinocamax plenus zone, provided that it really lacks Inoceramus labiatus.

Actinocamax plenus zone was placed in the lowermost Turonian by Spath (1926b) and correlated with Metoicoceras potieri and Metoicoceras whitei zones. The writer feels, however, that its index fossil straddles the Cenomanian-Turonian boundary and possibly ranges into the Inoceramus labiatus zone (see Fig. 2).

Prionocyclus and Inoceramus lamarcki zone

The rocks lying between Watinoceras and Inoceramus labiatus zone on one hand and Scaphites preventricosus and Inoceramus deformis zone on the other are traditionally placed into the generalized "Prionotropis" zone in the western interior of Canada. This zone was introduced by McLearn (1926, p. 117) and was subsequently redefined (McLearn, 1937) to embrace rocks occurring between Watinoceras and Inoceramus labiatus zone below and the broad Scaphites ventricosus zone above.

The name Prionotropis Meek, 1876 being taxonomically invalid, the name Prionocyclus Meek 1876 s. lato is used instead of it in this report on generic level.

The generalized Prionocyclus s. lato zone is still useful as ammonites of this genus are very often specifically and subgenerically indeterminable in the western interior of Canada. The generalized Prionocyclus zone is renamed here as Prionocyclus and Inoceramus lamarcki zone as it is also characterized by the abundance of Inoceramus lamarcki (Parkinson) Woods s. lato. which includes I. lamarcki var. websteri, I. lamarcki var. cuvieri, I. lamarcki var. apicalis, I. lamarcki var. septentrionalis Bodylevsky, 1958, I. corpulentus and other closely allied forms. I. lamarcki s. lato is not restricted to Prionocyclus and Inoceramus lamarcki zone in Canada but is mostly rare or absent above and below it.

Prionocyclus and Inoceramus lamarcki zone embraces the greater part of the upper Turonian Stage and corresponds approximately to the upper Turonian Inoceramus lamarcki zone of Germany and east European countries as well as to the greater, lower part of the broad west European Prionocyclus (Collignoniceras) woollgari zone (see Fig. 2).

The broad Prionocyclus and Inoceramus lamarcki zone of the western interior of Canada can be subdivided into:

(1) Prionocyclus (Collignoniceras) woollgari zone below; and

(2) Ostrea lugubris zone above.

Prionocyclus (Collignoniceras) woollgari zone

This refined zone is characterized by the common to abundant occurrence of Prionocyclus (Collignoniceras) woollgari (Mantell) sensu Haas,

1946. Neither the subgenus Collignoniceras nor the genus Prionocyclus s. lato are restricted to this zone as used here but Scaphites larvaeformis Meek and Hayden is its second important index fossil.

Prionocyclus (Collignoniceras) woollgari zone locally begins closely below the top of the labiatus member of the Blackstone Formation as used by Stott (1956). More often it begins at the base of the rusty member of the same formation. The Prionocyclus (Collignoniceras) woollgari zone commonly embraces all of the rusty member of the Blackstone Formation; it may, however, range upwards into its concretionary shale member. In some areas Prionocyclus (Collignoniceras) woollgari is known to ascend into the lower (and ? in the upper) part of the Cardium Formation. This indicates the markedly diachronic nature of the Cardium-Blackstone contact in southern and central Foothills.

Prionocyclus (Collignoniceras) woollgari zone also occurs low in the upper part of the Kaskapau Formation. It was not yet identified anywhere in the Manitoba and Saskatchewan, though its rocks are probably present there.

The refined Prionocyclus (Collignoniceras) woollgari zone is just as important for the purpose of interregional correlation as is the Watinoceras and Inoceramus labiatus zone. P. (C.) woollgari is a nearly world-wide index fossil of the early upper Turonian rocks and its Canadian zone corresponds approximately with the restricted European zone of Prionocyclus (Collignoniceras) woollgari (see Fig. 2).

Ostrea lugubris zone

A more or less thick interval in the Cardium Formation and (or) in the uppermost part of the Blackstone Formation is very poor in diagnostic fossils. According to its stratigraphic position, this interval corresponds to part or all of the following zones of the western interior of the United States (upward sequence):

(1) Prionocyclus (Collignoniceras) hyatti and Scaphites carlilensis;

(2) Prionocyclus (Collignoniceras) macombi and Scaphites warreni;

(3) Prionocyclus (Prionocyclus) wyomingensis and Scaphites ferronensis;

(4) Scaphites nigricollensis and Prionocyclus (Prionocyclus) reesidei; and

(5) Scaphites corvensis.

At present this interval can only be recognized by the common to mass occurrence of Ostrea lugubris Conrad, which is admittedly a second rate index fossil mostly confined to sandy and gritty phases of the Cardium Formation. O. lugubris was, however, never yet observed either above or below this rock interval in Canada. Also in the western interior of the United

States it is restricted to Prionocyclus (Collignoniceras) macombi and Scaphites warreni and Prionocyclus (Prionocyclus) wyomingensis and Scaphites ferronensis zones (Cobban and Reeside, 1952, pp. 1017-1018), which confirms its zonal value.

The use of the Cardium or Cardium pauperculum zone for the zonal interval discussed here is inappropriate in facilitating confusion of the Cardium Formation with the younger sandstone members of the Wapiabi Formation (e.g. Highwood and Solomon sandstones). Neither the genus Cardium nor the species Cardium pauperculum Meek are, indeed, restricted to Ostrea lugubris zone. In the western interior of the United States (Cobban and Reeside, 1952, pp. 1017, 1019) C. pauperculum appears already in the Cenomanian rocks and ranges into the upper Santonian zone of Desmoscaphites erdmanni. It has about the same known time range in the western interior of Canada, where it is characteristic of the sandstone facies throughout the Alberta Group, while rare or absent in its shale-siltstone facies.

No index fossils common in both shale and sandstone facies of Ostrea lugubris zone are known at the present time. Actinocamax manitobensis (Whiteaves) and its allies could, perhaps, prove to be such index fossils when better studied.

The insufficiently understood Actinocamax manitobensis fauna occurring in the Assiniboine Member of the Favel Formation of the eastern Great Plains is probably better placed in the Ostrea lugubris zone than in the restricted Prionocyclus (Collignoniceras) woollgari zone. Some belemnites of this fauna, for example Actinocamax aff. strehlensis Fritsch and Schloenbach, 1872, were, indeed, recently found in the Ostrea lugubris zone of the Cardium Formation of the central Foothills and in the Tuskoola Mountains sandstones of the upper Pine River area, thus providing a link between both facies of Ostrea lugubris zone.

There are some indications (Stelck, 1955, pp. 2-3) that the Ostrea lugubris zone is subdivisible either into the Cobban and Reeside's (1952) refined zones or in the more refined regional zones.

The Ostrea lugubris zone of the western interior of Canada should correspond with the greater, upper part of the broad west European Prionocyclus (Collignoniceras) woollgari zone, at least in part (see Fig. 2).

Scaphites preventricosus and Inoceramus deformis zone

This zone is widespread in the lowermost 50 to 80 feet of the Wapiabi Formation (lower part of its striped member; Stott, 1956, p. 8, Table 1) in the southern and central Foothills. Locally, however, this zone occurs in the uppermost beds of Cardium Formation, which indicates the diachronic nature of the Cardium-Wapiabi contact in this part of the Foothills belt.

In the Peace River Foothills and Plains (Stelck, 1955, pp. 3-4), Scaphites preventricosus and Inoceramus deformis zone occurs in the upper Kaskapau Formation below the Badheart sandstone. This zone is not known in the Athabasca River area nor in the Manitoba Escarpment area, but it was found recently in Aklavik Range of northeastern Richardson Mountains.

Typical Inoceramus deformis Meek occurs in Germany (Heinz, 1928a, Pl. III; 1928b, pp. 34-35, Pl. 2, fig. 1) in the zone of Inoceramus schloenbachi. Following Seitz (1956, p. 5), Inoceramus schloenbachi Boehm is considered to be but a morphological variety of Inoceramus deformis Meek. Also Inoceramus inconstans Woods is here considered to be but a morphological variety of I. deformis which occurs in Canada as well as in England and Europe in the same zone.

Inoceramus deformis var. schloenbachi zone is considered to be of the very late Turonian age in Germany and other mid-and east European countries (Heine, 1929, pp. 15-16; Seitz, 1956, p. 5). Some recent French authors dealing with the type area of the Turonian Stage also accept this placement of Inoceramus deformis var. schloenbachi zone (Sornay, 1950, p. 43). Therefore, and because of the apparent correspondence of the European Inoceramus koeneni zone with the basal beds of the Inoceramus involutus and Scaphites ventricosus zone of Canada, Webb's and Hertlein's (1934, p. 1412), Cobban's (1951, p. 2197), and Cobban's and Reeside's (1952, corr. table) correlation of Scaphites preventricosus and Inoceramus deformis zone with the lowermost Coniacian rocks of Europe is not followed here; the writer considers this zone to be equivalent to the uppermost Turonian rocks of Europe (see Fig. 2).

The subdivision of Scaphites preventricosus and Inoceramus deformis zone proposed by Cobban and Reeside (1952, p. 1021) for the western interior of United States is not yet possible in Canada due to the scarcity of stratigraphical and palaeontological data available.

CONIACIAN STAGE

Coniacian and lower Santonian rocks of the western interior of Canada have been included until recently in the broad Scaphites ventricosus zone of McLearn (1926, 1937). The corresponding part of the Colorado Group of the western interior of United States has been recently subdivided into a series of refined Scaphites zones by Cobban (1951, 1952). Most of Cobban's Scaphites zones have been found to be also applicable to the western interior of Canada. Being endemic faunal elements almost unknown outside of the interior basin of North America, these Scaphites species cannot be used for the purposes of intercontinental correlation. The Canadian Coniacian and Santonian inocerami species are, on the contrary, mostly identical with those of northern Eurasia and permit the correlation of the regional Canadian Scaphites zones with the European zones and international standard stages.

Inoceramus involutus and Scaphites ventricosus zone

This zone is widespread in the striped member of the Wapiabi Formation as defined by Stott (1956). Within the southern and central Foothills the stratigraphic position of the *Inoceramus involutus* and *Scaphites ventricosus* zone fluctuates between the basal beds of the Wapiabi Formation and the level some 250 feet above its base. Within this part of Foothills this zone is, furthermore, known to occur locally in the uppermost beds of the Cardium Formation. This stresses further the markedly diachronic nature of the Cardium-Wapiabi contact in southern and central Foothills.

Inoceramus involutus and *Scaphites ventricosus* zone occurs in the top beds of the Kaskapau Formation immediately below the base of the Badheart sandstone (McLearn, 1926, p. 120). Its extension into the Badheart sandstone itself and the association of *Scaphites ventricosus* with *Scaphites (Clioscaphites) montanensis* in the Badheart sandstone reported by Stelck (1955, p. 2) are contradicted by the Survey's collections.

Inoceramus involutus and *Scaphites ventricosus* zone is not known to occur in the Manitoba Escarpment area. Reports of this zone from the speckled shale of the Boine member of Vermillion River Formation in Manitoba (Wickenden, 1945, p. 42) refer to the broad *Scaphites ventricosus* zone of McLearn (1937). As it will be shown below, they refer to Santonian *Scaphites* zones.

Inoceramus involutus and *Scaphites ventricosus* zone is generally known in North America as *Inoceramus umbonatus* and *Scaphites ventricosus* zone. *I. umbonatus* Meek and Hayden is, however, synonymous with the European *I. involutus* Sowerby. *Inoceramus exogyroides* Meek and Hayden is, furthermore, but a morphological variety of *I. involutus*, and the same is probably true of *Inoceramus undabundus* Meek and Hayden. The presence of inocerami forms exactly corresponding with North American I. *umbonatus* and *I. exogyroides* in the middle Coniacian (or Emscherian) rocks of Germany and other European countries has been recognized already by Schlüter (1877); it was more recently confirmed by Heinz (1928a, pp. 76-77, Pl. III) and Heine (1929, pp. 94-105), who have also discovered *Inoceramus undabundus* Meek and Hayden in the same European beds. It is obvious, therefore, that even the range of subspecific variation of *I. involutus* Sowerby s. lato is the same on both sides of the Atlantic.

The outstanding value of *I. involutus* (= *I. umbonatus*) s. lato for the purpose of refined zonal correlation of the Upper Cretaceous rocks of the western interior of Canada with those of Europe, and for the exact fitting of the former rocks into the international standard stages, is obvious from the above discussion. *Inoceramus involutus* ranges through the middle Coniacian rocks on both sides of the Atlantic. The Canadian beds with *I. involutus* are therefore equivalent to the greater upper part of the broad west European Texanites (Barroisiceras) haberfellneri zone (see Muller and Schenck, 1943, pp. 271-272; this paper Fig. 2).

It should be stressed that the time-range of I. involutus s. lato in the western interior of Canada is shorter than that of S. ventricosus s. str. and that I. involutus s. lato characterizes its own subzone in the middle part of Inoceramus involutus and Scaphites ventricosus zone. S. ventricosus s. str. is, indeed, known to range lower than I. involutus and to mingle with Scaphites preventricosus Cobban and Inoceramus deformis Meek. The beds with this mixed fauna occur at the base of Inoceramus involutus and Scaphites ventricosus zone and can be conveniently designated as "overlap beds". These "overlap beds" are actually a subzone of the Inoceramus involutus and Scaphites ventricosus zone, which appears to be equivalent to the Inoceramus koeneni zone of Europe (see Fig. 2).

S. ventricosus s. str. is also known to range somewhat higher than I. involutus s. lato. In this top part of its vertical range it is sometimes associated with Inoceramus cf. subquadratus Schlüter and Scaphites aff. depressus Reeside. Also these beds form a subzone of the Inoceramus involutus and Scaphites ventricosus zone.

Only the Canadian Inoceramus involutus subzone of the Inoceramus involutus and Scaphites ventricosus zone is, therefore, truly equivalent to the European Inoceramus involutus zone and to the middle Coniacian of Europe. The zone as a whole embraces, on the contrary, all of the Coniacian Stage, including its Inoceramus subquadratus and Inoceramus fasciculatus beds (see Seitz, 1956, p. 5, Fig. 1; this paper, Fig. 2) above and the lower Coniacian Inoceramus koeneni zone below.

SANTONIAN STAGE

The delimitation of the Santonian Stage from the Coniacian and Campanian Stages and the zoning of the Santonian rocks present some difficulties in the western interior of Canada. This is mainly due to the complete absence or extreme rarity of most of the best North American or interregional index fossils of the Santonian Stage, such as Texanites texanus, Inoceramus undulatoplicatus, Marsupites, Uintacrinus, and Desmoscaphites, in this region.

The now generally used Baculites ovatus and Inoceramus lobatus-cardissoides (= I. lundbreckensis) zones have been introduced for the upper part of the Alberta Group and its equivalents, and for the overlying Allison, Lea Park, and equivalent formations, by Warren and Rutherford (1928, pp. 135-136) and by McLearn (1929b, pp. 106-107). These zones were considered Santonian in age; the time ranges of their both index fossils are, however, much longer than it is generally realized.

It must be stressed that Inoceramus of the I. lobatus-cardissoides stenstrupi species group are not diagnostic of the Santonian Stage in Europe. They are at best diagnostic of the Santonian Stage and the larger part of the lower Campanian substage combined (see Seitz, 1956, p. 5, Fig. 1; this paper, Fig. 2). Some of the representatives of this species group (e.g. Inoceramus subcardissoides Schlüter) appear already in the middle and upper Coniacian rocks. All previous European attempts to zone the Santonian-lower Campanian rocks with the aid of these inocerami are in need of a thorough revision, in the writer's opinion.

Inoceramus of the I. lobatus-cardissoides-stenstrupi species group abound in Canada and have about the same time range as in Europe. Almost all previously described European "species" of this group are represented in our region and no new species have been observed there.

It is possible that some Inoceramus of the I. lobatus-cardissoides-stenstrupi species group are restricted to the Santonian rocks of the western interior of Canada, just as they are stated to be in Europe (see Seitz, 1956, p. 5, Fig. 1). Specifically, Inoceramus lobatus Goldfuss s. str., Inoceramus cardissoides Goldfuss s. str., I. cardissoides var. pachti Arkhangelsky, and Inoceramus pinniformis Willet seem to be so restricted. Inoceramus patootensis de Loriol, Inoceramus stenstrupi de Loriol, Inoceramus tuberculatus Woods (possibly synonymous with the last species), and Inoceramus lingua Goldfuss may, on the other hand, be diagnostic of the lower Campanian Scaphites hippocrepis zone and equivalent rocks. The data now available are, however, insufficient to include the above inocerami forms among the proposed zonal indices. It is left to future work to prove or to disprove their zonal value.

Baculites ovatus Say and most of its varieties similarly range upwards throughout the lower Campanian rocks of the western interior of Canada and even cross the lower-upper Campanian boundary.

It should be noted in this connection that the Canadian usage of Baculites ovatus Say may well be wrong. As pointed out by Dr. John B. Reeside, Jr. (written communication of August 18th, 1956): "Baculites ovatus Say was described from the Mount Laurel-Navesink area of New Jersey and is a relatively late form. The type is lost and it is difficult to decide just what B. ovatus may be. We are, therefore, not using the name in the western interior, but are referring the older specimens to B. haresi and later ones to B. grandis."

The writer is in essential agreement with the above quoted views of the late Dr. Reeside. He feels, however, that it would be less confusing to continue the old and deeply rooted Canadian usage of B. ovatus Say until a fully documented and illustrated discussion of the Canadian or the western interior of the United States Baculites forms becomes available.

Inoceramus of the I. lobatus-cardissoides-stenstrupi species group and Baculites ovatus have, furthermore, been found to range downward into the upper part of the broad Scaphites ventricosus zone of McLearn (1937); they are now known even from the lowermost Santonian Scaphites depressus zone (see below).

The lack of realization of the actual time range of the Inoceramus of the I. lobatus-cardissoides-stenstrupi species group and of B. ovatus has resulted in the inclusion of a considerable part of the Canadian lower Campanian rocks in the Santonian Stage (e.g. Landes, 1940, p. 183). The inclusion of the Campanian Foremost, Oldman, Milk River, and Pakowki Formations of the southern Plains and Foothills in the Santonian Stage and the restriction of the Campanian Stage to the overlying Bearpaw Formation (Thompson and Axford, 1953, pp. 47-48, 53-55) is an extreme case of the incorrect upward extension of the Santonian stage in this country.

In this paper reliance is placed on Scaphites species for the refined zoning of the Santonian rocks and on the Scaphites and certain Inoceramus forms for the recognition and delimitation of this stage in the western interior of Canada.

Scaphites depressus zone

This zone appears to follow immediately the upper subzone of the Inoceramus involutus and Scaphites ventricosus zone in the western interior of Canada. At least there are no indications of any additional zones between the top beds of the latter zone, containing S. ventricosus s. str., S. aff. depressus, and Inoceramus cf. subquadratus but devoid of I. involutus and its varieties, and Scaphites depressus zone.

Scaphites depressus zone lies in the lower concretionary beds of the Wapiabi Shale in the southern and central Foothills. As far as known, its position there fluctuates from the (?) lowermost beds of Wapiabi Shale to 400 to 450 feet above its base. Scaphites depressus zone may even occur locally in the uppermost part of the Cardium Sandstone, provided that independent sandstone tongues within the Wapiabi Formation were not mapped erroneously as the Cardium Formation.

Scaphites depressus occurs in the Badheart Sandstone of the Peace River Foothills and Plains and probably is restricted to its lowermost beds. It is not known either from the lower Athabasca River area or from the Manitoba Escarpment, but its zone is probably present in both areas.

Scaphites saxitonianus McLearn, which may well be but an extreme morphological variety of S. depressus, occurs together with the latter species in the Badheart Sandstone and Wapiabi Formation throughout the Foothills belt. S. saxitonianus appears to occur in the same zone also in the undivided

Alberta Group of the Blairmore area, judging by its occurrence below the beds with Scaphites (Clioscaphites) vermiformis Meek and Hayden (McLearn, 1929b, p. 94). Scaphites depressus and S. saxitonianus are both known to range, however, at least into the lower part of the next younger Scaphites (Clioscaphites) vermiformis zone (see below).

Inoceramus cordiformis Sowerby s. lato is common in the Scaphites depressus zone and does not range below it. This Inoceramus species is, however, only diagnostic of the combined Scaphites depressus and Scaphites (Clioscaphites) vermiformis zones, as it is even more common in the latter zone.

Inoceramus pontoni McLearn, 1926, which was always considered a close ally of Inoceramus cordiformis Sowerby (see McLearn, 1943, p. 42), falls well within the known range of subspecific variation of I. cordiformis. The holotype of I. pontoni is, in the writer's opinion, identical with I. cordiformis var. haenleini Muller (1898, Pl. VI, fig. 1) and typical representatives of I. cordiformis Sowerby occur at many localities in the Scaphites depressus and Scaphites (Clioscaphites) vermiformis zones of the western interior of Canada. Also I. pontoni var. dolosonensis McLearn falls within the species I. cordiformis s. lato; its holotype is here considered to be closely allied to or identical with I. cordiformis var. böhmi Muller (1898, Text-Fig. 2a-b).

Among other closely allied Canadian inocerami of Scaphites depressus and Scaphites (Clioscaphites) vermiformis zones, Inoceramus selwyni McLearn and I. coulthardi McLearn are not known to range below Scaphites depressus zone of above Scaphites (Clioscaphites) vermiformis zone.

Unlike the Canadian part of the western interior of the continent, I. cordiformis Sowerby, its varieties, and closely allied forms were only reported from the Clioscaphites vermiformis zone in the western interior of the United States (see Cobban, 1951, p. 2195).

Inoceramus of the I. lobatus-cardissoides-stenstrupi species group first appear in the Scaphites depressus zone in the western interior of Canada. They only become common, however, in the next younger Scaphites (Clioscaphites) vermiformis zone in the region. This species group seems, therefore, to appear earlier, in the western interior of Canada than in the western interior of the United States, where its representatives were not yet found below the upper Santonian Desmoscaphites erdmanni zone (Cobban and Reeside, 1952, p. 1019).

As recognized by McLearn (McLearn and Kindle, 1950, pp. 105-106 and personal communication), Inoceramus lundbreckensis McLearn, 1926a is no more than a morphological variety of I. cardissoides Goldfuss s. lato, which species is richly represented in Santonian and (?) lower Campanian rocks of the western interior of Canada.

Baculites ovatus Say and some of its varieties first appear in the Canadian Scaphites depressus zone. They are, however, still rare in it and in the next younger Scaphites (Clioscaphites) vermiformis zone. Scaphites depressus zone appears, therefore, to represent the basal part of the broad Baculites ovatus and Inoceramus lundbreckensis zones. It should be noted that Baculites ovatus Say found in Scaphites depressus zone are not known to reach such a large size as the younger representatives of the species.

In the western interior of United States, the Scaphites depressus zone contains Texanites shoshonensis (Meek), which is closely related to the European Texanites bourgeoisi (d'Orbigny emend. Grossouvre) (Reeside, 1928, p. 10).

Scaphites depressus zone was previously correlated with the upper Coniacian of Europe (Cobban, 1951, p. 2197; Cobban and Reeside, 1952, corr. table; Stelck, 1955, p. 2, Table 1). It is, however, of early lower Santonian age because of the occurrence of I. cordiformis s. lato and Inoceramus of the Inoceramus lobatus-cardissoides-stenstrupi species group in it. I. cordiformis s. lato is not even known to range into the lowermost Santonian beds in northwestern Germany (Seitz, 1956, p. 5, Fig. 1) and Inoceramus of I. lobatus-cardissoides-stenstrupi species group are essentially diagnostic of the Santonian and lower Campanian rocks in Europe (see above).

The writer correlates the Scaphites depressus zone with the lower part of the European Texanites texanus zone because of its faunal affinities and of those of the next younger Scaphites (Clioscaphites) vermiformis zone (see Fig. 2).

Scaphites (Clioscaphites) vermiformis zone

This zone is widespread in the lower part of the Wapiabi Shale of southern and central Foothills. S. (C.) vermiformis usually occurs there in the upper part of the lower concretionary member of the Wapiabi Shale. It is also known, however, to occur in the lowermost beds of its next younger platy shale member as used by Stott (1956).

In the Blairmore area Scaphites (Clioscaphites) vermiformis zone occurs in the highest exposed beds of the undivided Alberta Group (McLearn, 1929b, p. 94).

Scaphites (Clioscaphites) vermiformis zone is typically represented in the Badheart Sandstone of the Peace River Foothills and Plains. Its index fossil was never yet reported from either the lower Athabasca area or the Manitoba Escarpment. The rocks of the Scaphites (Clioscaphites) vermiformis zone are, however, assumed to be present in both areas.

This is suggested specifically by the record of Scaphites ventricosus s. lato from the speckled shale of the Boine Member in Manitoba. This report of S. ventricosus s. lato must refer either to S. depressus or to S. (C.) vermiformis because of its reported association with Inoceramus pontoni and I. cf. lundbreckensis (Wickenden, 1945, p. 42).

It should be stressed that the Canadian zone of Scaphites (Clioscaphites) vermiformis does not seem to correspond with Clioscaphites vermiformis zone of the western interior of United States. Cobban (1951, p. 2197; 1952, pp. 5-7) reports, indeed, the association of S. (C.) vermiformis and S. (C.) montanensis in his Clioscaphites vermiformis zone. These two species have, however, never yet been seen together in the numerous collections studied by the writer from various areas of the Foothills belt. In these collections S. (C.) vermiformis was consistently observed to occur at the lower level within the Wapiabi Formation than S. (C.) montanensis; it was, furthermore, found in association with I. cordiformis s. lato. This latter species is known to range downward into the Scaphites depressus zone but was never yet seen in the younger beds than Scaphites (Clioscaphites) vermiformis zone in association with Scaphites (Clioscaphites) montanensis.

It is inferred from the above discussed relationships that the Canadian Scaphites (Clioscaphites) vermiformis zone only corresponds to the lower part of the United States Clioscaphites vermiformis zone and that the Cobban's (1951, p. 2197; 1952, pp. 5-7) mixed fauna of S. (C.) vermiformis and S. (C.) montanensis has been collected from the middle beds of the latter zone transitional between the Canadian zones of Scaphites (Clioscaphites) vermiformis and Scaphites (Clioscaphites) montanensis (see Fig. 2).

It seems likely that the previously discussed mixed fauna of S. (C.) vermiformis, S. saxitonianus, and S. depressus is restricted to the lower part of the Scaphites (Clioscaphites) vermiformis zone. S. depressus and S. saxitonianus do not occur, indeed, in association with S. (C.) vermiformis in the vast majority of the fossil collections studied.

Uintacrinus socialis Grinnell was only recorded once in the western interior of Canada (Warren and Crockford, 1948, p. 159). This specimen is here assumed to be from the Scaphites (Clioscaphites) vermiformis zone, as it is reportedly collected in the lower part of the Wapiabi Shale. As the genus Uintacrinus is not known to range below the upper Santonian, this specimen of U. socialis could hardly be from the restricted Inoceramus involutus and Scaphites ventricosus zone as suggested by above workers.

The common occurrence of I. cordiformis and its varieties in the Scaphites (Clioscaphites) vermiformis zone indicates its early Santonian age. This species is, indeed, diagnostic of the lower Santonian Texanites texanus and Placenticeras cf. guadalupae zones of Europe (see Fig. 2), which were named Inoceramus cordiformis beds in Germany.

Scaphites depressus zone being of the earliest Santonian age, Scaphites (Clioscaphites) vermiformis zone must be largely equivalent with the Placenticeras cf. guadalupae zone of western Europe. This correlation is supported to a certain extent by the occurrence of Placenticeras guadalupae Roemer in the Clioscaphites vermiformis zone of the western interior of the United States (Cobban and Reeside, 1952, p. 1019).

The occurrence of Texanites omeraensis and Inoceramus undulato-plicatus in the Clioscaphites vermiformis zone of the western interior of United States suggests that this zone may also embrace at least the upper part of the underlying European Texanites texanus zone. The same may be true also of the Canadian Scaphites (Clioscaphites) vermiformis zone (see Fig. 2).

It should be noted in this connection, that Inoceramus undulato-plicatus appears to have different time ranges in Europe and in North America. In northwestern Germany it was only recorded from the lowermost Santonian beds apparently corresponding to the lower part of the Texanites texanus zone of west Europe and to the Scaphites depressus zone of Canada (Seitz, 1956, p. 5, Fig. 1). In the western interior of the United States Inoceramus undulato-plicatus begins, on the contrary, in the later lower Santonian Clioscaphites vermiformis zone and ranges up to the top of the Santonian stage (Cobban and Reeside, 1952, p. 1019).

The oldest occurrence of Uintacrinus in the western interior of United States is in Clioscaphites vermiformis zone (Cobban and Reeside, 1952, p. 1019). This suggests that this United States zone also embraces upper Santonian beds. The same may well be the case with the Canadian zone of Scaphites (Clioscaphites) vermiformis (see above and Fig. 2).

Scaphites (Clioscaphites) montanensis zone

This zone is widespread in the middle part of the Wapiabi Shale in southern and central Foothills. In these areas S. (C.) montanensis ranges through most of the platy shale member of the Wapiabi Shale (as used by Stott, 1956), with the exception of its lowermost beds where it appears to be completly replaced by S. (C.) vermiformis.

In the Peace River Foothills and Plains S. (C.) montanensis is only known to the writer from beds overlying the Badheart Sandstone. Its range within the Wapiabi (= upper Smoky) Shale of Gleddie (1954) and Stelck (1955) is, however, still uncertain. Numerous Scaphites specimens available in the Geological Survey's collections from the Badheart Sandstone lend no support to Stelck's (1955, p. 2) identification of S. (C.) montanensis from this formation.

In the lower Athabasca area S. (C.) montanensis occurs within the upper part of the Labiche Shale. Its range within this formation is uncertain, but it does not range up into the Lea Park Shale of Wickenden (1949).

No fossils of Scaphites (Clioscaphites) montanensis zone were reported from the Manitoba Escarpment; it can be assumed, however, that it is also present there (see below).

The faunal affinities and stratigraphic position of the Canadian Scaphites (Clioscaphites) montanensis zone have already been discussed. It appears to be included in the upper part of the Clioscaphites vermiformis zone of the western interior of the United States (see Fig. 2).

Scaphites (Clioscaphites) montanensis zone appears to be of the early upper Santonian age and equivalent to the lower part of the west European Placenticeras surtale zone (= lower or middle part of the Uintacrinus beds).

Zone I

The Scaphites (Clioscaphites) choteauensis zone of the western interior of the United States is not definitely known to occur anywhere in the western interior of Canada. Its occurrence at the base of the upper concretionary member of the Wapiabi Formation of southern Foothills is, however, suggested by some fragmentary Scaphites in writer's possession. Scaphites (Clioscaphites) choteauensis zone may, therefore, be present throughout the Foothills' belt in the here discussed shale interval between Scaphites (Clioscaphites) montanensis and Scaphites (Desmoscaphites) zones, which is left unnamed in this report.

Scaphites (Desmoscaphites) zone

Throughout the Foothills' belt, and apparently elsewhere in the western interior of Canada as well, the beds with Scaphites (Clioscaphites) ex gr. montanensis-choteauensis are followed by beds completely devoid of these Scaphites forms. The fauna of these beds is older than and distinct from but closely allied to the fauna of the next younger Scaphites hippocrepis zone (= Eagle fauna).

The most diagnostic forms of this fauna are the very rare Scaphites lei Reeside and Scaphites (Desmoscaphites) cf. bassleri Reeside (Warren and Rutherford, 1928, pp. 138-139; Webb and Hertlein, 1934, p. 1406; Gleddie, 1954, p. 507). These rare Scaphites forms are unknown either in the younger or in the older rocks of the region and are the only immediately diagnostic elements of this fauna. This is, accordingly, designated herewith as Scaphites (Desmoscaphites) zone, following the suggestion of McLearn (1937, p. 118).

The Scaphites (Desmoscaphites) zone abounds in various Inoceramus of the I. lobatus-cardissoides-stenstrupi species group and in Baculites ovatus Say and its varieties. It is, therefore, approximately equivalent to the Baculites ovatus zone as used by Webb and Hertlein (1934, p. 1405) and Gleddie (1954, pp. 506-507), to the Inoceramus lundbreckensis zone of McLearn (1937), and to the zone of Inoceramus of the lobatus species group of McLearn and Kindle (1950, p. 105). B. ovatus and Inoceramus of the I. lobatus-cardissoides-stenstrupi species group are, however, inappropriate as index species of this zone (see above and Fig. 2).

Baculites haresi Reeside, Baculites aquilaensis Reeside var. separatus Reeside, and Placenticeras cf. planum Hyatt should be noted among other forms of Scaphites (Desmoscaphites) zone. These forms are unknown from the older beds, except possibly for B. haresi, which was noted in the basal beds of the upper concretionary member of the Wapiabi Shale together with Scaphites (Clioscaphites) resembling S. (C.) choteauensis. All above forms ascend, however, in the younger zones of Scaphites hippocrepis (=Eagle fauna) and Baculites obtusus and are, thus, inappropriate as zonal indices of Scaphites (Desmoscaphites) zone.

In southern and central Foothills Scaphites (Desmoscaphites) fauna occurs throughout the upper concretionary shale and the transition members of the Wapiabi Formation as used by Stott (1956); it may, however, be absent in the basal beds of the former member. The upper part of the undivided Wapiabi Formation appears to carry the Scaphites (Desmoscaphites) fauna also in the Peace River Foothills and Plains. Elements of this fauna also occur in the Solomon, Highwood, and Chinook sandstone tongues of the Wapiabi Formation throughout the Foothills belt.

The rarity of the diagnostic elements of Scaphites (Desmoscaphites) fauna and the complete absence of those of Scaphites hippocrepis zone throughout the Foothills belt makes it impossible to decide whether the former zone reaches the very top of the Wapiabi Formation. It is, therefore, uncertain whether in this region the Santonian-Lower Campanian boundary coincides with the top of the Wapiabi, is situated below the top of the Wapiabi, or runs higher within the Brazean, Wapiti, and Allison. The last mentioned alternative is, however, favoured by the writer.

Scaphites (Desmoscaphites) zone is unknown in the lower Athabasca River area. It should, however, be present in the uppermost beds of the Labiche shale (= Colorado shale of Wickenden, 1949) in view of the presence of Scaphites hippocrepis fauna near the base of the Lea Park Shale in this area.

Although unknown in the Manitoba Escarpment, Scaphites (Desmoscaphites) zone is probably present in this area as well.

Large erosional bodies of the marine Upper Cretaceous rocks occurring along the Arctic coast of Canada between Franklin Bay and Mackenzie River delta include Santonian to lower Campanian rocks. Inoceramus of the I. lobatus-cardissoides-stenstrupi species group have, indeed, been collected in 1955 in this area on Horton River near Narrowby Bay and in Smoky Mountains by Dr. J. Ross MacKay of the University of British Columbia. The abundance of Inoceramus of the I. lobatus-cardissoides-stenstrupi species group and the absence of any Scaphites in his collections favour their upper Santonian or lower Campanian rather than lower Santonian age. The writer, thus, places this fauna tentatively in the here discussed Scaphites (Desmoscaphites) zone. This discovery fully supports Jeletzky's (1950, pp. 22-23) conclusions about a direct and easy connection of the Canadian interior Santonian-early Campanian sea with that of Greenland, Novaya Zemlya, and Siberia.

The Scaphites (Desmoscaphites) zone of the western interior of Canada is correlated tentatively with the combined Desmoscaphites erdmanni and Desmoscaphites bassleri zones of the western interior of United States. The Scaphites (Desmoscaphites) bassleri zone is of the very late Santonian age in the western interior of United States because of the occurrence of Marsupites together with Uintacrinus in it (Cobban and Reeside, 1952, p. 1019). The writer considers, therefore, the Canadian Scaphites (Desmoscaphites) zone to be of the late upper Santonian age and proposes to draw the Santonian-lower Campanian boundary at its top. This placement of the Santonian-lower Campanian boundary in the western interior of Canada is confirmed by the recent discovery of the Scaphites hippocrepis-aquilaensis fauna in the basal Lea Park Formation (see below).

CAMPANIAN STAGE

Lower Campanian Substage

Scaphites hippocrepis zone

This zone is only known in the Lea Park Shale of Wickenden (1949), in the lower Athabasca River area and in the Lea Park equivalents of the Western Potash shaft at Vera, Saskatchewan. In the former area the Scaphites hippocrepis zone appears to be the same as "beds with B. cf. ovatus and small species of Scaphites" of McLearn (1937, p. 118).

The Scaphites cf. hippocrepis DeKay and S. cf. aquilaensis Reeside fauna occurs near the base of the Lea Park Shale in both above mentioned areas. In the lower Athabasca River area only the lower part of the Lea Park Shale is exposed near the mouth of Calling River where this fauna was collected (Wickenden, 1949). In the Western Potash shaft this fauna occurs within the "first speckled shale zone" and is associated with the widespread and biochronologically important foraminifera species Trochammina ribstonensis Wickenden, 1932 (R. T. D. Wickenden, personal communication in 1956).

According to Nauss (1945, p. 1619), the Trochammina ribstonensis zone is the lowermost zone of the Lea Park Shale of the Vermillion area confined to its lowermost 20 to 30 feet immediately above the level "where darker grey, flaky speckled shale first appears in the samples." It seems probable therefore that S. hippocrepis and T. ribstonensis have similar range and biochronological significance in the western interior of Canada. The stratigraphical position of both fossils in the sections indicates also that the so called "first speckled shale zone" lies close to or coincides with the Santonian-Campanian boundary in the east-central Alberta and west-central Saskatchewan.

In southern Alberta the equivalents of the Scaphites hippocrepis zone are represented by non-marine rocks of the Milk River Sandstone, which has been traced laterally into the Eagle Sandstone of Montana (Landes, 1940, p. 183).

The occurrence of Scaphites hippocrepis fauna in the basal beds of Lea Park Shale indicates the correlation of the next younger marine Pakowki Formation of the southern Alberta with the remaining upper part of the Lea Park Shale of the central Plains. This conclusion is supported by the occurrence of the elements of the younger Baculites obtusus fauna in the upper part of the Lea Park Shale (Landes, 1940, pp. 188-190).

Scaphites hippocrepis zone appears to be represented by non-marine rocks of the Belly River Group and its equivalents throughout the Foothills belt.

The rocks of the Scaphites hippocrepis zone appear to be present everywhere underneath the eastern Great Plains and to occur within the upper Boine Member of the Vermillion River Shale in the Manitoba Escarpment, in spite of the fact that its index fossils are unknown there. Erosional contacts are, indeed, unknown within the Vermillion River Shale of Manitoba and Saskatchewan and the top of the "first speckled shale zone" appears to coincide with the top of its Boine Member in this area (Wickenden, 1945, pp. 33-47). This, and the occurrence of Scaphites hippocrepis fauna in the "first speckled shale zone" in west-central Saskatchewan, suffice to invalidate the assumption of an erosional gap corresponding to the Scaphites hippocrepis zone in these areas made by Landes (1940, p. 183) and Cobban and Reeside (1952, corr. chart. column 116). The discovery of Scaphites hippocrepis fauna in Canada and the recent revision of the upper time limit of the Niobrara Formation of Kansas (Jeletzky, 1955, pp. 880-884) also invalidate the time-honoured assumption of a major erosional interval corresponding to the late Santonian and early Campanian Stages everywhere in the eastern part of the interior

Great Plains of North America. Drs. W.A. Cobban and John B. Reeside, Jr. have recently informed the writer that they have found additional faunal evidence supporting Jeletzky's (1955) conclusions on the subject.

Scaphites hippocrepis fauna is definitely of early Campanian age in Canada and elsewhere. S. hippocrepis and its allies, such as S. bindosus s. lato (including S. bartlingi and S. fischeri) and S. aquisgranensis, are indeed diagnostic of the lower Campanian rocks throughout Europe and in western Siberia. Also in the Atlantic, Gulf, and western interior regions of the United States this species and allied forms are diagnostic of the rocks of early Campanian age. Scaphites hippocrepis zone is, thus, yet another Upper Cretaceous zone with an almost circumboreal distribution; it is here considered tentatively to embrace all of the lower Campanian time (see Fig. 2).

Upper Campanian Substage

Baculites obtusus zone

This zone was proposed by Landes (1940, p. 184) for a distinctive fauna occurring throughout the Pakowki Formation and in the upper part of the Lea Park Shale. This fauna is best characterized by its baculitids including Baculites obtusus Meek, B. obtusus var. mclearni Landes (B. mclearni Landes is based on large representatives of B. obtusus Meek; Dr. W.A. Cobban, written communication of April 30, 1954), B. minerensis Landes, B. haresi Reeside, B. asperiformis Meek, and B. ovatus Say. Other diagnostic fossils include Inoceramus subdepressus Meek, Ostrea russelli Landes, and O. albertensis Landes. The absence of Inoceramus of the I. lobatus-cardissoides-stenstrupi species group and the appearance of the first representatives of "Acanthoscaphites" noted by Landes (1940) are other distinctive features of Baculites obtusus fauna.

As recognized by Landes (1940, pp. 184-185), Baculites obtusus fauna is younger than Scaphites hippocrepis fauna and older than any of the upper Campanian Scaphites nodosus faunas (= Baculites compressus zone) of the Bearpaw Formation and its equivalents. This conclusion is now fully confirmed by the discovery of the Scaphites hippocrepis fauna in the basal beds of the Lea Park Shale, which correspond to the Milk River Sandstone (see above).

Baculites obtusus zone is obviously replaced by non-marine beds of Belly River, Brazeau, and Wapiti Groups throughout the Foothills belt. Its presence in the Lea Park Shale of the lower Athabasca River area is assumed because of the presence of a thick marine succession above the basal Lea Park Shale carrying Scaphites hippocrepis fauna. The presence of Baculites obtusus zone in the Pembina Member of the Vermillion River Formation of the eastern Plains is also probable because of the lack of any known erosional intervals in this formation and its intergradation with the overlying Riding Mountain Formation carrying the Baculites compressus and Scaphites nodosus fauna.

In the western interior of United States Baculites obtusus zone should correspond approximately with the Baculites asperiformis zone of Cobban and Reeside (1952, p. 1020), which occurs in the Sharon Springs Member of the Pierre Shale and its equivalents including the Clagget Formation of Montana (see Fig. 2). The Baculites asperiformis fauna includes most of the diagnostic forms of the Canadian Baculites obtusus zone including "Acanthoscaphites".

As known now, the fauna of the Baculites obtusus zone is strongly provincial in its character and is difficult to place. The writer has placed it tentatively into the basal upper Campanian rather than in the uppermost lower Campanian substage. This was done because Baculites obtusus fauna appears to lack Inoceramus of the I. lobatus-cardissoides-stenstrupi group and the lower Campanian Scaphites of the S. hippocrepis-binodosus group. The first representatives of the so called Acanthoscaphites s. lato (that is Scaphites of the S. roemeri group; see Jeletzky; in Cobban and Reeside, 1952, pp. 1025-26) appear, furthermore, in this fauna in the Canadian and United States parts of the western interior region (see Cobban and Reeside, 1952, p. 1020; Landes, 1940, p. 189). This placement of Baculites obtusus zone may be subject to a revision in the future.

Zone J

The Baculites gregoriensis zone of the western interior of the United States is unknown in Canada (see Fig. 2). This zone should be equivalent to part or all of the non-marine Oldman and Foremost Formations of the southern Plains and to some parts of the non-marine Belly River, Brazeau, and Wapiti Groups of the Foothills' belt.

Baculites gregoriensis zone may, however, be represented in upper part of Lea Park Formation of the central and Athabasca-Peace River Plains above the zone of Baculites obtusus. Its presence in the uppermost part of the Vermillion River Formation or in the lowermost part of the Riding Mountain Formation of the eastern Plains is probable for the same reasons as the presence of the underlying Scaphites hippocrepis and Baculites obtusus zones.

Baculites compressus zone

This zone is regionally widespread and very important; it embraces most of the Bearpaw Formation of the southern Great Plains and Foothills, and is also known in the Bearpaw analoga all over the southern part of the central and eastern Great Plains. Baculites compressus zone has been introduced by Landes (1940, p. 185) and was later adopted for the western interior of the United States by Cobban and Reeside (1952, p. 1020).

According to Landes (1940, p. 185), Baculites compressus fauna is characterized by the absence of all diagnostic forms of the Baculites obtusus fauna and by the abundance of Baculites compressus Say s. lato and Inoceramus barabini Morton s. lato. As noted by McLearn (in Fraser et al., 1935, p. 21), Scaphites nodosus Owen s. lato is equally characteristic of this zone.

I. barabini Morton s. lato is not a reliable index fossil of the Baculites compressus zone. It commonly ranges down into the Baculites gregoriensis and Baculites asperiformis zones and up into the Baculites baculus and Inoceramus fibrosus zone in the western interior of the United States (Cobban and Reeside, 1952, pp. 1019-1020). The same appears to be true of the western interior of Canada.

A detailed comparison of I. barabini s. lato and allied North American species with the analogous European Inoceramus balticus-regularis species group cannot be attempted in this report. It is obvious, however, that a number of the European species and varieties of I. balticus-regularis group occur in the Baculites compressus zone of the western interior of Canada. It is a equally obvious that many of the Canadian representatives of the I. barabini species group are synonymous with the well known upper Campanian forms of the European I. balticus-regularis group.

Baculites compressus zone passes laterally into the non-marine rocks throughout central and northern Foothills and north of the Pembina River on the Plains (into the Edmonton Formation). In the east it embraces most of the Riding Mountain Formation (Wickenden, 1945, pp. 49-50) and is probably eroded away north of the North Saskatchewan and Saskatchewan Rivers in Saskatchewan. In eastern Saskatchewan and in Manitoba rocks of the Baculites compressus zone are not known to reach Red Deer River and Red Deer Lake in the north.

Zone K

The lower 300 to 350 feet of the broad Baculites compressus zone in the lower part of the Bearpaw Formation are characterized by the extreme rarity of Scaphites ex gr. nodosus Owen. This is in contrast with the higher beds of the zone. This lower part of the broad Baculites compressus zone is commonly rich in Arctica ovata Meek and Hayden; it is, therefore, often designated as the Arctica ovata zone in the recent Canadian literature. This part of the Baculites compressus zone may well form a separate refined zone but its fauna is very poorly known and Arctica ovata appears to be a facies-bound fossil inappropriate as a zonal index. This zone is, therefore, left unnamed in this report (see Fig. 2).

Scaphites nodosus and Rhaeboceras spp. zone

This refined zone embraces the middle part of the broad Baculites compressus zone. It includes most or all of the Manyberries Member of the Bearpaw Formation as defined by Loranger and Gleddie (1953, pp. 158-159) but is not known to extend any higher.

Transitional beds with mixed faunas may possibly occur between Scaphites nodosus and Rhaeboceras spp. zone on one hand and the next younger Scaphites quadrangularis and Scaphites brevis zone on the other. If present, these beds are restricted to the upper part of the Manyberries Member and (?) the Oxarart Member of the Bearpaw. Scaphites nodosus Owen s. str. and Rhaeboceras spp. are, indeed, not known to range either in the Belanger Member as defined by Furnival (1946, pp. 58-62) and Loranger and Gleddie (1953, p. 158, Fig. 4) or in its shale equivalents in southern Saskatchewan (McLearn and Warren: in Fraser et al., 1935, pp. 21-22, 123-125) characterized by Ponteixites robustus, P. gracilis, S. quadrangularis, S. brevis, and S. plenus.

In the eastern Saskatchewan and in Manitoba Scaphites nodosus and Rhaeboceras spp. zone is well represented in the Riding Mountain Formation.

Scaphites quadrangularis and Scaphites brevis zone

This zone is best known from the Belanger Sandstone Member of the Cypress Hills area and from equivalent shale beds of southern Saskatchewan. It may or may not include the underlying Oxarart Member of the Cypress Hills area. The Scaphites quadrangularis and Scaphites brevis zone does not include, however, either the Thelma and Medicine Lodge Members of the Bearpaw Formation in the Cypress Hills area or the equivalent and younger shale beds of the uppermost Bearpaw in southern Saskatchewan.

The zone of Scaphites quadrangularis and Scaphites brevis occurs in the Riding Mountain Formation of the eastern Plains. It is, however, only represented by scarce and poorly preserved fossil material in the collections studied from this formation. It is not known which part of the formation it embraces in its principal sections.

The upper boundary of the marine Bearpaw Formation becomes progressively younger in terms of biochronology from west to east across southern Alberta and southwestern Saskatchewan. Approximately 200 feet of the uppermost Bearpaw strata in southwestern Saskatchewan appear to be time equivalent to the post- Bearpaw non-marine sediments in southwestern Alberta according to Russell (1950, pp. 36-37, Fig. 2) and Loranger and Gleddie (1953, p. 168).

This age difference appears to be even greater than previously thought. Not only are the index fossils of the Scaphites quadrangularis and Scaphites brevis zone completely unknown from the Bearpaw Formation of southwestern Alberta but Rhaeboceras whiteavesi Landes has been found immediately below the top of Bearpaw in the Lethbridge section (Landes, 1940, pp. 175, 186). Even the highest beds of the Bearpaw Formation in this area are, therefore, part of the zone of Scaphites nodosus and Rhaeboceras spp. and are presumably older than the top of the Manyberries Member of the Cypress Hills area. Only the lower 600 feet of the Manyberries Member of the Cypress Hills' Bearpaw Formation appear, therefore, to be represented in the southwestern Alberta, all higher beds of the formation being laterally replaced by non-marine sediments of the Blood Reserve and St. Mary River Formations.

The unnamed zone K (= Arctica ovata zone) probably corresponds to the lowermost part of the Baculites compressus zone of the western interior of the United States. The refined Scaphites nodosus and Rhaeboceras spp. and Scaphites quadrangularis and Scaphites brevis zones may be correlated with the larger, upper part of the same United States zone (see Cobban and Reeside, 1952, p. 1020). The suggested subdivision of the United States Baculites compressus zone into five Baculites subzones (see Cobban and Reeside, 1952, pp. 1021-1022) cannot yet be applied to the western interior of Canada due to the scarcity of stratigraphically reliable Baculites material available to the writer. The relationships of these Baculites subzones with the Canadian subdivisions of the broad Baculites compressus zone shown in the Figure 2 are tentative.

The intercontinental correlation of the broad Baculites compressus zone and that of its Canadian subdivisions depend primarily on Scaphites nodosus and its allies. It depends, furthermore, on the placement of the Campanian-Maestrichtian boundary in the western interior of Canada discussed below.

The North American Scaphites nodosus species group is equivalent to the Scaphites roemeri species group of the northern Eurasia and Arctic regions. Some forms of the Scaphites nodosus group (e.g. Scaphites nodosus s. str., S. brevis, and S. plenus) are not known to occur in the northern Eurasia and in the Arctic region. Some other forms of this group are, however, definitely conspecific with certain well-known Eurasian forms of the S. roemeri group. Specifically, the finely ribbed and round-ventered Scaphites elegans Tate, 1865, which in the writer's opinion is but one of the extreme morphological varieties of Scaphites roemeri s. lato, occurs in the Belanger Member of the Bearpaw Formation in association with Scaphites quadrangularis Meek and Hayden, S. brevis Meek and Hayden, S. plenus Meek and Hayden, and Ponteixites spp. Representatives of Scaphites roemeri var. tuberculata Giebel figured by Michailev (1951, Pl. XVI, figs. 74-75) from Southern Russia are, furthermore, exceedingly close to S. elegans. They are, at the same time, indistinguishable from some varieties of Scaphites quadrangularis occurring in the Belanger Member and in the equivalent shales of southern Saskatchewan. The same applies to Scaphites roemeri figured by Moberg (1885, Pl. 3, fig. 9a-b).

In east Greenland Scaphites roemeri fauna was recently discovered by Donovan (1953, 1954). In the writer's opinion, Donovan's (1953, Pl. 24, figs. 9-10; 1954, Pl. 2, figs. 4-5) Scaphites groenlandicus is but a morphological variety of S. roemeri s. lato transitional between its typical form and var. tuberculata Giebel (as employed by Michailov, 1951, pp. 98-99). S. roemeri var. groenlandica Donovan matches perfectly some Canadian forms closely allied to S. elegans Tate and S. quadrangularis occurring in the Belanger Member and its shale equivalents. S. roemeri var. groenlandica is, furthermore, associated with fragmentary Scaphites apparently indistinguishable from some Canadian varieties of S. quadrangularis (see Donovan, 1953, Pl. 24, fig. 8).

The above discussed representatives of the S. roemeri species group are diagnostic of the late Upper Campanian zone of Bostrychoceras polyplocum and Belemnitella langei s. lato (including B. mucronata mut. minor). The zone of Scaphites quadrangularis and Scaphites brevis of the western interior of Canada is accordingly considered to be approximately equivalent with this European zone (see Pożaryski, 1938, 1948; Jeletzky, 1948b, 1951a-b) and is placed in the late Upper Campanian.

The immediately underlying Canadian zone of Scaphites nodosus s. str. must correspond, accordingly either with the lower part of the European zone of Bostrychoceras polyplocum and Belemnitella langei s. lato or with the upper part of the European early Upper Campanian zone of Hoplitoplacenticeras vari and Belemnitella mucronata mut. senior.

All of the Canadian Baculites compressus zone is, therefore, considered to be Upper Campanian in age.

MAESTRICHTIAN STAGE

The uncertainty with respect to the placement of the Campanian-Maestrichtian boundary in the western interior of North America in general and in its Canadian part in particular is essentially a reflection of the similar state of affairs in the western Europe where the type-localities of these stages are situated. The writer (Jeletzky, 1951a, b) has endeavoured to settle this uncertainty with regard to the western Europe. He proposed to place the lower boundary of the Maestrichtian Stage at the first appearance of such interregionally important fossils as Scaphites (Hoploscaphites) constrictus Sowerby s. lato and Inoceramus tegulatus Hagenow s. lato. This boundary appears to coincide with the first appearance of such biochronologically important provincial (boreal province of northern Eurasia) fossils as Scaphites

(Acanthoscaphites) tridens Kner and Belemnella lanceolata (Schloth.) f. typ. So defined, the Maestrichtian Stage corresponds with the known time ranges of Scaphites (Hoploscaphites) constrictus and Inoceramus tegulatus. This definition was since accepted by the majority of the European and non-European workers.

The writer feels that it is now possible to recognize at least the approximate position of the Campanian-Maestrichtian boundary, as above defined, in the western interior of Canada; he places it provisionally between the Scaphites quadrangularis and Scaphites brevis zone on one hand and Scaphites (Hoploscaphites) constrictus and Inoceramus fibrosus zone on the other (see Fig. 2).

Scaphites constrictus and Inoceramus fibrosus zone

This zone was introduced by Landes (1940, pp. 185-186, corr. table opp. p. 186) as Inoceramus fibrosus zone. Its diagnostic fauna was first found in the Medicine Lodge Coulée section in southeastern Alberta. Discoscaphites abyssinus described by Landes from his Inoceramus fibrosus zone actually belongs, however, to Scaphites (Hoploscaphites) constrictus s. lato; it is closely allied to or identical with S. (H.) constrictus Sowerby var. niedzwiedzkii (Uhlig).

The Medicine Lodge Coulée beds with I. fibrosus were originally correlated with the Eastend Formation by Russell (1940, 1943) and Landes (1940). Furnival (1941, 1946, pp. 74-77, Fig. 1) has shown, however, that these beds form part of the Bearpaw Formation and correlated them with its Belanger Member. Russell (1948, pp. 11-13, 19-21; 1950, pp. 28, 31-32, 36-37, Figs. 2-3) accepted Furnival's formational assignment of the Medicine Lodge Coulée beds; he has inferred, however, on lithology alone that these beds are older than the Belanger Member of the Bearpaw Formation.

Russell's (1948, 1950) correlation of the Medicine Lodge Coulée beds is not accepted here. Firstly, S. (H.) constrictus s. lato and I. fibrosus are unknown from the Belanger Sandstone and occur in the high Bearpaw of southern Saskatchewan separately from S. quadrangularis and S. brevis. Secondly, Landes' (1940, pp. 185-186, corr. table opp. p. 186) conclusion that his Inoceramus fibrosus fauna is younger than the Baculites compressus fauna was recently confirmed by Cobban and Reeside (1952, p. 1020), who found I. fibrosus in the Baculites baculus zone of the western interior of the United States.

The biochronological overlap of the Medicine Lodge Coulée beds with some (? upper) part of the Belanger Sandstone Member cannot be ruled out in view of the presence of Scaphites plenus and Scaphites (Hoploscaphites) pungens Binckhorst in some fossil collections from that member. However, this is probably only due to the presence of the mixed fauna of Scaphites quadrangularis and Scaphites brevis and Scaphites constrictus and Inoceramus fibrosus zones (transitional beds) in the upper part of the Belanger Member. It is also possible that more than one fauna occurs in the Belanger Member and that the so called Medicine Lodge Coulée fauna is equivalent to the younger Belanger fauna only.

Whichever interpretation is correct, the Medicine Lodge Coulée fauna is younger than the Scaphites quadrangularis and Scaphites brevis fauna of the Belanger Member.

It is most probable that the Medicine Lodge Coulée Sandstone is not correlative with the Belanger Sandstone, in spite of their possible biochronological overlap. It is rather correlative with the Thelma Member of Furnival (1946) and Loranger and Gleddie (1953, p. 164, Figs. 2, 4) or is an independent sandstone occurring in the uppermost part of the Bearpaw Formation of southeastern Alberta.

Scaphites constrictus and Inoceramus fibrosus zone is obviously replaced laterally by non-marine rocks west of the above discussed area of southeastern Alberta as already the next older Scaphites quadrangularis and Scaphites brevis zone is represented by non-marine rocks in southwestern Alberta (see above).

It is not known whether the Scaphites constrictus and Inoceramus fibrosus fauna ascends in the Medicine Lodge Shale Member of Loranger and Gleddie (1953, p. 164, Figs. 2, 4); it is, however, known to occur in the shales of the upper Bearpaw Formation of southwestern and southern Saskatchewan. In this area it is characterized by forms of Scaphites (Hoploscaphites) constrictus s. lato close to or identical with the nodate varieties of S. (H.) tenuistriatus Kner, S. (H.) pungens Binckhorst, and Ponteixites spp.

Scaphites constrictus and Inoceramus fibrosus fauna may also be present in the Odanah Member of the Riding Mountain Formation of the eastern Plains. The fragmentary fossil material available from this member is, however, insufficient for its definite dating.

The Canadian zone of Scaphites constrictus and Inoceramus fibrosus is, as already mentioned, approximately equivalent to the Baculites baculus zone of the western interior of United States (see Cobban and Reeside, 1952, p. 1020 and this paper Fig. 2).

The interregional correlation of the Canadian Scaphites constrictus and Inoceramus fibrosus zone depends on the presence of S. (H.) constrictus s. lato, S. (H.) pungens, and I. fibrosus in its rocks.

Both above mentioned ammonites are generally accepted as index fossils of the Maestrichtian Stage as here defined. They are not known to descend into the uppermost Campanian zone of Bostrychoceras polyplocum and Belemnitella langei, with the possible exception of the transitional beds between both stages.

I. fibrosus belongs to the species group of Inoceramus tegulatus Hagenow, 1842. This species group is diagnostic of the Maestrichtian Stage in Europe. I. fibrosus is, furthermore, very closely allied to and may be specifically identical with Inoceramus caucasicus Dobrov recently described from the lower Maestrichtian rocks of the Caucasus, Crimea, and Middle Russia (see Dobrov, 1951, pp. 167-170, Pl. II, figs. 2-10). This representative of the I. tegulatus species group was found to be diagnostic of a zone underlying that of I. tegulatus s. str. but occurring still within the time range of S. (H.) constrictus s. lato. The zone of Inoceramus caucasicus embraces, therefore, the lower part of the Maestrichtian Stage as used in this report.

The Canadian zone of Scaphites constrictus and Inoceramus fibrosus overlies, finally, the late upper Campanian zone of Scaphites quadrangularis and Scaphites brevis.

The above data strongly favour the lowermost Maestrichtian dating of the Canadian zone of Scaphites constrictus and Inoceramus fibrosus proposed in this report and its correlation with part or all of the boreal Eurasian zone of Belemnella lanceolata, as used by Jeletzky (1958b, pp. 57-64, corr. table opp. p. 112). The evidence now available is, however, not considered to be completely foolproof. Firstly, the time ranges of B. compressus and B. baculus in relation to other above mentioned index fossils of their zones are still uncertain in the western interior of Canada. Secondly, some index forms of the upper Campanian zone of Scaphites quadrangularis and Scaphites brevis appear to mingle with such forms of Scaphites constrictus and Inoceramus fibrosus zone as S. plenus and S. (H.) pungens (see above); they may even mingle with I. fibrosus itself (see Furnival, 1946, p. 62). Thirdly, it is possible, although still unproven, that S. (H.) constrictus s. lato and I. fibrosus first appear in beds immediately overlying these with S. (H.) pungens and S. plenus and corresponding only to the upper part of the Baculites baculus zone of the western interior of the United States.

As already pointed out, the above mentioned anomalous fossil associations are probably only due to the presence of transitional beds between upper Campanian and lower Maestrichtian Stages similar to the transitional beds with mixed fauna occurring at the Campanian-Maestrichtian boundary in Middle Poland (Pożaryski, 1938, pp. 18-19, 1948, pp. 58, 63-65) and in some other regions. It is possible, on the other hand, that the Scaphites constrictus and Inoceramus fibrosus zone is subdivisible into two more refined zones, the lower of which is still of latest Campanian age. If so, the Campanian-Maestrichtian boundary in the western interior of Canada would occur within the Scaphites constrictus and Inoceramus fibrosus zone and the first appearance of S. (H.) constrictus s. lato and I. fibrosus should be used as the corresponding time mark instead of the first appearance of S. (H.) pungens and S. plenus. The first appearance of the two last mentioned index fossils was, nevertheless, used as the time mark of the Campanian-Maestrichtian boundary in Canada in this report because the above discussed anomalous fossil associations are tentatively interpreted as mixed faunas occurring at this boundary. Some fragmentary or stratigraphically unreliable specimens in the writer's possession suggest, furthermore, that S. (H.) constrictus s. lato and I. fibrosus range downward into the beds of Belanger Member with the mixed fauna of S. (H.) pungens, S. plenus, S. quadrangularis, and Scaphites elegans. This, naturally, favours further the interpretation for these beds offered in this report.

Baculites grandis zone

This zone is the youngest marine Cretaceous zone known in the western interior of Canada. It was originally introduced for the western interior of the United States by Cobban and Reeside (1952, p. 1020). In Canada, Baculites grandis zone is so far known only from the southern and southwestern Saskatchewan where its name fossil was found at several localities in the upper part of the Bearpaw Shale (e.g. Fraser et al., 1935, pp. 125-126). Also a specimen of Scaphites (Discoscaphites) ex gr. roanensis Stephenson from an unknown locality in southern Saskatchewan was presumably collected from the rocks of Baculites grandis zone.

The tentative identification of Scaphites (Discoscaphites?) sp. from the siliceous shales of the Odanah Member of the Riding Mountain Formation (Wickenden, 1945, p. 49) suggests that this member may range as high as the Baculites grandis zone. It is also possible, although unproven, that the Medicine Lodge Shale Member of the Cypress Hills area (Loranger and Gleddie, 1953, p. 164, Figs. 2, 4) ranges into that zone. There is little doubt that the Baculites grandis zone passes laterally into non-marine beds westward of the Cypress Hills area.

The Maestrichtian age of the Canadian Baculites grandis zone is obvious because of its superposition on the Scaphites constrictus and Inoceramus fibrosus zone, which is of the lowermost Maestrichtian age in part at least (see above). The same applies to the Baculites grandis zone of the western interior of the United States where it overlies the Baculites baculus zone (Cobban and Reeside, 1952, p. 1020), which was already shown to be approximately equivalent to the Scaphites constrictus and Inoceramus fibrosus zone of the western interior of Canada.

Baculites grandis zone is equivalent either to the Belemnella lanceolata mut. junior zone or to the lower part of the Belemnella cimbrica zone of northern Europe as used by Jeletzky (1958b, pp. 57-64, Fig. 8). This dating is indicated by the recent discovery of a typical specimen of

Scaphites (Hoploscaphites) nicolletii indistinguishable from that figured by Meek (1876, Pl. 34, fig. 2) in the upper part of the lower Maestrichtian in northwestern Germany. This specimen was found in the Hemmoor chalk pit high in Belemnella cimbrica zone and in association with S. (H.) constrictus, S. (H.) tenuistriatus, and Belemnella cimbrica.

Although ranging downward into Baculites grandis zone, S. (H.) nicolletii and its varieties are principally diagnostic of the next younger Scaphites nicolletii zone of the western interior of United States (Cobban and Reeside, 1952, p. 1020 and a personal communication). This indicates that not only the Baculites grandis zone but also the next younger Scaphites nicolletii zone of the western interior of North America is still of the early Maestrichtian age in terms of the international standard stages (see Fig. 2).

Our knowledge of the uppermost Upper Cretaceous marine faunas of the western interior of Canada is very scanty. This makes it possible that marine rocks younger than the Baculites grandis zone are present locally in southern Saskatchewan or under eastern Great Plains where the sea has lingered longer than elsewhere in the western interior of Canada. There is, however, no palaeontological evidence supporting such an assumption. It appears more probable, therefore, that the marine Cretaceous history of the western interior of Canada has come to its close during the early Maestrichtian Baculites grandis zone.

PROVINCIAL CHARACTER OF FAUNAS, BROAD FAUNAL RELATIONS, AND THE BIOCHRONOLOGICAL NOMENCLATURE

The preceding account of the macrofossil zones and index fossils of the marine Cretaceous rocks of the western interior of Canada demonstrates conclusively that this region remained part of the so called boreal zoogeographical province throughout that time. This has resulted in the close affinity of the marine macrofaunas of the western interior of Canada with the contemporary marine faunas of the northern Eurasian region during most part of the Cretaceous time. This faunal affinity of the Cretaceous rocks of both regions is much greater than it was previously realized; it is reflected in a number of fossil zones and in the general succession of marine macrofaunas which is the same in northern Eurasia and in the western interior of Canada.

The marine Cretaceous rocks of northern Eurasia and the western interior of Canada have a great many index species in common. Many other index species of both regions are closely allied. The already known faunal affinity of marine Cretaceous rocks of northern Eurasia and the western interior of Canada is ample for an approximate to precise fitting of the vast majority of the macrofossil zones of the latter region into the international Cretaceous standard stages and substages based on the west European type-localities and areas. It is anticipated that further research, now in progress, will considerably increase the number of index species and zones common to both regions and further reduce the number of zonal indices and zones peculiar to the western interior of Canada in particular and to the western interior of North America in general.

Already there is no need to introduce any regional stages and substages for the marine Cretaceous of the western interior of Canada, or for that matter for the marine Cretaceous of the western interior of North America in general.

There is a tendency in Canada to use the Niobrara Formation or the Montana and Colorado Groups of the western interior of United States as broad stages of the late Lower and Upper Cretaceous Series. The Coloradoan, Niobraran, and Montanan Stages are, however, too broad for the purpose of refined regional and interregional correlation; they were, furthermore, but little used in this country. This makes them clearly inferior to the more refined and much better known international standard stages, which are equally easily recognizable in the western interior of Canada. The Coloradoan, Niobraran, and Montanan Stages are, therefore, not used in this report and their complete abandonment in favour of the international standard stages is recommended. The often observed tendency to use the Niobrara Formation or the Montana and Colorado Groups of the North American western interior region in the biochronological sense (as broad stages of the late Lower and Upper Cretaceous time) is not justified. The Coloradoan, Niobraran and Montanan Stages are superfluous, apart from being too embracing and general for the purpose of the practically useful regional correlation. The much more refined international standard stages and substages, which are sufficiently easily recognizable on this side of the Atlantic, are much more useful for this purpose in the Canadian, as well as in the United States part of the North American western interior region.

SELECTED REFERENCES

Anderson, F. M.

1938: Lower Cretaceous deposits in California and Oregon; Geol. Soc. Am., Spec. Paper 16, 339 pp., 83 Pls., 1 index map, 2 corr. tables, 3 figs.

Arkell, W. J.

1946: Standard of the European Jurassic; Bull. Geol. Soc. Am., vol. 57, No. 1, pp. 1-34.

1956: Jurassic geology of the World, Oliver and Boyd Ltd., Edinburgh and London; 806 pp., 30 Pls., 28 corr. charts, 102 figs.

Bodylevsky, V.I.
1956: O znachenii nekotorykh ammonitov dlya stratigrafii yurskich i nizhne-melovych otlozhenii Russkoi Platformy (The significance of some ammonites for the stratigraphy of Jurassic and Lower Cretaceous deposits of the Russian platform); Trudy Vsesoyuznogo Sovestchaniia po Razrabotke Unifitsirovannoi Skhemy Stratgrafii Mesozoiskich Otlozhenii Russkoi Platformy; Press GNTI, Leningrad, pp. 137-142.

Cobban, W.A.
1951: Colorado shale of central and northwestern Montana and equivalent rocks of Black Hills; Bull. Am. Assoc. Petrol. Geol., vol. 35, No. 10, pp. 2171-2193, 2 figs.

1952: Scaphitoid cephalopods of the Colorado Group; U.S. Geol. Surv., Prof. Paper 239, 42 pp., 21 Pls., 4 figs.

Cobban, W.A. and Reeside, J.B., Jr.
1952: Correlation of the Cretaceous formations of the western interior of the United States; Bull. Geol. Soc. Am., vol. 63, pp. 1011-1044, 2 figs, 1 corr. table.

Dobrov, S.A.
1951: Gruppa Inoceramus caucasicus sp. n. – Inoceramus tegulatus Hag. na Severnom Kavkase (The group of Inoceramus caucasicus sp. n. – Inoceramus tegulatus Hag. in Northern Caucasus); Symposium in memory of the Academician A.D. Arkhangelsky: Problems of lithology and stratigraphy of U.S.S.R.; publ. by Press Acad. Sci. U.S.S.R.; Moscow, pp. 163-172, 2 Pls. (Russian).

Donovan, D.T.
1953: The Jurassic and Cretaceous stratigraphy and palaeontology of Traill Ø, East Greenland; Medd. om Grønland, Bd. 111, No. 4, 150 pp., 25 Pls., 14 figs.

1954: Upper Cretaceous fossils from Trail and Geographical Society Øer, East Greenland; Medd. om Grønland, Bd. 72, 2nd Afdeling, No. 6, 33 pp., 3 Pls., 4 figs.

Fraser, F.J., McLearn, F.H., Russell, L.S., Warren, P.S., and Wickenden, R.T.D.
1935: Geology of southern Saskatchewan; Geol. Surv. Can., Mem. 176 137 pp., 5 Pls., 4 figs., map, geol. sections.

Frebold, H.
1930: Verbreitung und Ausbidldung des Mesozoicums in Spitzbergen; Skrifter om Svalbard og Ishavet, No. 31, 126 pp., 33 Pls., 8 figs.

Frebold, H. (cont'd)

1935: Marines Aptien von der Koldewey Insel (nördliches Ostgrönland); Medd. om Grønland, B. 95 (4), 112 pp., 8 Pls., 20 figs.

Furnival, G. M.

1941: The Belanger and Oxarart Members of the Bearpaw Formation, Cypress Hills area, Saskatchewan; Trans. Roy. Soc. Can., sec. IV, vol. 25, pp. 57-69, 1 table, 1 fig.

1946: Cypress Lake map-area, Saskatchewan; Geol. Surv. Can., Mem. 242, 161 pp., 4 Pls., 5 figs.

Gignoux, M., and Morét, L.

1946: Nomenclature stratigraphique du Crétacé inférieur dans le sud-est de la Françe; Travaux Lab. Géol. l'Univ. Grénoble, t. XXV, pp. 59-88.

Gleddie, J.

1954: Upper Cretaceous in western Peace River Plains, Alberta; Western Canadian sedimentary basin, a Symposium, publ. by Am. Assoc. Petrol. Geol. Press, Tulsa, Oklahoma, U.S.A., pp. 486-509, 2 tables, 9 figs.

Haas, O.

1946: Intraspecific variation in, and Ontogeny of, Prionotropis woollgari and Prionocyclus wyomingensis; Bull. Am. Mus. Nat. Hist., vol. 86, art. 4, 224 pp., Pls. 11-24, 108 figs.

Heine, F.

1929: Die Inoceramen des mittelwestfälischen Emschers und unteren Untersenons; Abh. Preuss. Geol. L.A., Heft 120, 124 pp., 20 Pls., 3 figs.

Heinz, R.

1928a: Das Inoceramen-Profil der Oberen Kreide Lüneburgs. Mit Anführung der neuen Formen und deren Kennzeichnung (Beitrage zur Kenntnis der oberkretazischen Inoceramen I); Jahresber. Niedersachs. Geol. Vereins zu Hannover, Bd. 21, pp. 63-81, Pl. 2, table III.

1928b: Über die bisher wenig beachtete Skulptur der Inoceramen-Shale und ihre stratigraphische Bedeutung (Beiträge zur Kenntnis der oberkretazischen Inoceramen IV); Mitt. Miner. - Geol. Staatsinstitut Hamburg; Heft 10, 39 pp., 3 Pls.

Henderson, W.R.S.
1954: Cretaceous and some Triassic beds of northeastern British Columbia, Canada; Bull. Am. Assoc. Petrol. Geol., vol. 38, No. 11, pp. 2269-2289, 6 figs.

Hume, G.S.
1953: The lower Mackenzie River area, Northwest Territories and Yukon; Geol. Surv. Can., Mem. 273, 118 pp., 3 Pls., 16 figs., 3 geol. maps.

Jeletzky, J.A.
1950a: Stratigraphy of the west coast of Vancouver Island between Kyuquot Sound and Esperanza Inlet, British Columbia; Geol. Surv. Can., Paper 50-37, 51 pp., 1 corr. table, 1 geol. map.

1950b: Actinocamax from the Upper Cretaceous of Manitoba; Geol. Surv. Can., Bull. 15, pp. 1-27, 3 Pls., 2 figs.

1951a: The place of the Trimingham and Norwich Chalk in the Campanian-Maestrichtian succession; Geol. Mag., vol. 88, No. 3, pp. 198-208, 1 corr. table.

1951b: Die Stratigraphie und Belemnitenfauna des Obercampan und Maastricht Westfalens, Nordwestdeutschlands and Dänemarks, sowie einige allgemeine Gliederungs-Probleme der jüngeren borealen Oberkreide Eurasians; Geol. Landesanst, Bundersrepublik Deutschland, Geol. Jahrb., Beih. 1, 142 pp., 7 Pls., 3 tables.

1955: Belemnitella praecursor Stolley, probably from the Niobrara of Kansas, and some stratigraphic implications; J. Palaeontol., vol. 29, No. 5, pp. 876-885, 1 fig.

1956: Palaeontology, basis of practical Geochronology; Bull. Am. Assoc. Petrol. Geol., vol. 40, No. 4, pp. 679-706.

1958a: Uppermost Jurassic and Cretaceous rocks of Aklavik Range, northeastern Richardson Mountains, Northwest Territories; Geol. Surv. Can., Paper 58-2, 84 pp., 1 map, 1 corr. chart.

1958b: Die jüngere Oberkreide (Oberconiac bis Maastricht) Südwestrusslands und ihr Vergleich mit der Nordwest- und Westeuropas. I. Dnjepr-Donez-Senke und Nordwestrand des Donezbeckens sowie einige Vergleichs- und Gliederungs-Probleme der russischen borealen Oberkreide; Geol. Landesanst., Bundeskepublik Deutschland; Beinefte zum Geol. Jahrb., Heft 33, Hannover, 157 pp. 11 figs., 1 corr. table.

Landes, R.W.
1940: Geology of the southern Alberta Plains, Pt. 2, Palaeontology of the marine formations of the Montana Group; Geol. Surv. Can., Mem. 221, pp. 129-217, 8 Pls., 1 corr. chart.

Leanza, A.F.
1945: Ammonites del Jurasico Superior y del Cretacico Inferior de la Sierra Asul, en la Parte Meridional de la Provincia de Mendoza; Ann. Museo de la Plata, N.S.; Paleontologia, 6, Moluscos, No. 1, 99 pp., 33 Pls., 13 figs., 1 corr. chart.

Loranger, D.M., and Gleddie, J.
1953: Some Bearpaw zones in southwestern Saskatchewan and southern Alberta; Third Annual Field Conference and Symposium, publ. by Alberta Soc. Petrol. Geol., pp. 158-175, 3 Pls., 4 figs.

Luppov, N.P.
1956: Discussion; Trudy Vsesoyuznogo Sovestchaniia po Rasrabotke Unifitsirovannoi Skhemy Stratigrafii Mesosoiskich Otlozhenii Russkoi Platformy; Press GNTI, Leningrad, pp. 325-327.

McLearn, F.H.
1926: New species from the Coloradoan of lower Smoky and lower Peace Rivers, Alberta; Nat. Museum Can., Bull. 42 (geol. series No. 45), pp. 117-126, Pls. 20-23.

1929a: Cretaceous Invertebrates; in Mesozoic Palaeontology of Blairmore region, Alberta; Nat. Museum Can., Bull. 58 (geol. series No. 50), pp. 73-79, Pls. 23-29.

1929b: Stratigraphic palaeontology; in Mesozoic Palaeontology of Blairmore region, Alberta; Nat. Museum Can., Bull. 58 (geol. series No. 50), pp. 80-107.

1937: The fossil zones of the Upper Cretaceous Alberta shale; Trans. Roy. Soc. Can., Ser. 3, sec. IV, vol. 21, pp. 111-120.

1943: Trends in some Canadian Cretaceous species of Inoceramus; The Can. Field Naturalist, vol. 57, Nos. 2-3, pp. 36-46, 1 fig.

1945a: Revision of the lower Cretaceous of the western interior of Canada; Geol. Surv. Can., Paper 44-17 (second edition), 14 pp., 12 Pls., 2 corr. charts.

1945b: The Upper Cretaceous Dunvegan Formation of northwestern Alberta and northeastern British Columbia; Geol. Surv. Can., Paper 45-27, 5 pp., 6 Pls.

McLearn, F.H., and Kindle, E.D.
1950: Geology of northeastern British Columbia; Geol. Surv. Can., Mem. 259, 236 pp., 8 Pls., 6 tables, geol. maps and corr. charts.

Meek, F.B.
1859: Remarks on the Cretaceous fossils collected by Professor Henry Y. Hind, on the Assiniboine and Saskatchewan Exploring Expedition, with Descriptions of some New Species; in Hind, M.A., Northwest Territory. Reports of Progress; together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition, made under instructions from the Provincial Secretary; J. Lovell's Press, Toronto, Canada, pp. 182-185, Pls. 1-2.

1876: A report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country; U.S. Dept. Interior, Report of the United States Geological Survey of the Territories, vol. IX, 629 pp., 45 Pls., 85 figs.

Mellon, G.B., and Wall, J.H.
1956: Geology of the McMurray Formation. Part 1. Foraminifera of the Upper McMurray and Basal Clearwater Formations; Res. Council, Alberta, Rept. No. 72, pp. 5-29, Pls. 1-2.

Michailov, N.P.
1951: Verkhnemelovye ammonity yuga Evropeiskoi chasti SSSR i ich znachenie dlya zonal'noi stratigrafii (Upper Cretaceous Ammonites of the south of the European Part of U.S.S.R. and their importance for the zonal stratigraphy); Trudy Instituta Geol. Nauk, Vyp. 129 (geol. series No. 50), 143 pp., 19 Pls., 32 tables, 35 figs. (Russian).

Moberg, J.Ch.
1885: Cephalopoderna i Sveriges Kritsystem (The Cephalopods of the Cretaceous System of Sweden) II. Artbeskrivning (description of species); Sver. Geol. Unders., ser. C, No. 73, 67 pp., 6 Pls. (Swedish).

Müller, G.
1898: Die Molluskenfauna des Untersenons von Braunschweig und Ilsede. I. Lamellibranchiaten und Glossophoren; Abhandl. Preuss. Geol. L.A., N.S., Heft 25.

Muller, S.Wm.
1941: Standard of the Jurassic system; Bull. Geol. Soc. Am., vol. 52, pp. 1427-1444, 2 tables.

Muller, S. Wm., and Schenck, H. G.
1943: Standard of the Cretaceous system; Bull. Am. Assoc. Petrol. Geol., vol. 27, pp. 262-278, 7 figs.

Nauss, A. W.
1945: Cretaceous stratigraphy of Vermilion area, Alberta, Canada; Bull. Am. Assoc. Petrol. Geol., vol. 29, No. 11, pp. 1605-1629, 5 figs.

Orbigny, A. de
1840-1842: Paléontologie française. Terrains crétacées, 1. Les Céphalopodes. 2. Les Animaux mollusques et rayonnes; Author's Press, Paris, France. 622 plus 465 pp., 256 Pls.

Pożaryski, W.
1938: Senonstratigraphie im Durchbruch der Weichsel zwischen Rachow und Pulawy in Mittelpolen; Bull. Inst. Géol. Pologne, No. 6, 94 pp., 1 Pl., 1 fig. (Polish with German Summary).

1948: Jurassic and Cretaceous between Radom, Zawichost, and Krasnik (Central Poland); Bull. Inst. Géol. Pologne, No. 46, 141 pp., 4 tables (geol. maps), 3 figs. (Polish with English summary).

Reeside, John B. Jr.
1928: Cephalopods from the lower part of the Cody shale of Oregon basin, Wyoming; U. S. Geol. Surv., Prof. Paper 150, pp. 1-19, Pls. 1-8.

Rengarten, V. P.
1951: Paleontologicheskoe obosnovanie stratigrafii nizhnego mela Bol'shogo Kavkaza (The palaeontological basis of the stratigraphy of the Lower Cretaceous of the Greater Caucasus); Symposium in memory of the Academician A. D. Arkhangelsky: Problems of lithology and stratigraphy of U. S. S. R., publ. by Press of Acad. Sci. U. S. S. R., Moscow, pp. 35-66, 1 fig.

Russell, L. S.
1940: Geology of the southern Alberta Plains, Part 1; Stratigraphy and Structure; Geol. Surv. Can., Mem. 221, pp. 1-128, 21 figs.

1943: Marine fauna of the Eastend Formation of Saskatchewan; J. Palaeontol., vol. 17, No. 3, pp. 281-288, Pls. 47-49, 3 figs.

Russell, L.S. (cont'd)
1949: Preliminary report; The geology of the southern part of the Cypress Hills, southwestern Saskatchewan; Dept. Nat. Resources Industrial Development, Petroleum Geol. Series, Rept. No. 1, 57 pp., 7 Pls., 1 geol. profile, 1 map.

1950: Correlation of the Cretaceous-Tertiary transition in Saskatchewan and Alberta; Bull. Geol. Soc. Am., vol. 61, No. 1, pp. 27-42, 4 figs.

Schlüter, Cl.
1877: Kreide-Bivalven. Zur Gattung Inoceramus; Palaeontographica, Bd. 24, pp. 251-288, Pls. 34-38.

Seitz, E.
1956: Über Ontogenie, Variabilität und Biostratigraphie einiger Inoceramen; Palaontol. Z., Bd.30, Sonderheft: Biostratigraphie der Oberkreide, pp. 3-6, 1 fig.

Sornay, J.
1950: Étude stratigraphique sur le Crétacé supérieur de la vallée du Rhone entre Valence et Avignon et des régions voisines; Travaux Lab. Géol. l'Univ. Grénoble, t. XXVII, pp. 35-278, 31 figs., 12 tables.

Spath, L.F.
1924: On the ammonites of the Speeton Clay and the subdivisions of the Neocomian; Geol. Mag., vol. 61, pp. 73-89, 1 corr. chart.

1926a: On new ammonites from the English Chalk; Geol. Mag., vol. 63, pp. 77-83, 1 corr. chart.

1926b: The zones of the Cenomanian and uppermost Albian; Proceed. Geol. Assoc., vol. 37, pp. 420-432, 1 corr. chart.

1923-1943: A monograph of the Ammonoidea of the Gault; Palaeontogr. Soc. London, vol. 1-2, Pts. 1-16, I-IXX, 778 pp., 64 Pls., 248 figs., 4 tables.

1937: The Canadian ammonite genus Gastroplites in the English Gault; The Annals and Mag. Nat. Hist., vol. XIX, 10th Ser. pp. 257-260, 1 fig.

1947: Additional observations on the invertebrates (chiefly ammonites) of the Jurassic and Cretaceous of East Greenland. 1. The Hectoroceras fauna of southwest Jameson Land; Medd. om Grønland, Bd. 132, No. 3, 69 pp., 5 Pls., 8 figs.

Spath, L.F. (cont'd)
1950: A new Tithonian ammonoid fauna from Kurdistan, Northern Iraq; Bull. Brit. Mus. (Nat. Hist.) Geol., vol. 1, No. 4, pp. 95-137, Pls. 6-10.

1952: Additional observations on the invertebrates (chiefly ammonites) of the Jurassic and Cretaceous of East Greenland. II, Some Infra-Valanginian ammonites from Lindemans Fjord, Wollaston Forland; with a note on the base of the Cretaceous; Medd. om Grønland, Bd. 133, No. 4, pp. 1-40, 4 Pls., 1 fig.

Stelck, C.R.
1949: Definition of the Lower Cretaceous-Upper Cretaceous boundary in Western Canada and associated Cenomanian-Albian foraminifera; an unpublished doctorate thesis, Stanford University.

1952: Table to illustrate the boundary problems of the Lower Cretaceous in Canada; privately circulated by the author.

1955: Cardium Formation of the Foothills of northeastern British Columbia; Bull. Can. Inst. Mining Met., vol. LVIII, pp. 132-139, 2 figs., 1 corr. table.

1958: Stratigraphic position of Viking Sand; J. Alberta Soc. Petrol. Geol., vol. 6 (7), pp. 2-7, 3 figs.

Stelck, C.R., and Wall, J.H.
1954: Kaskapau foraminifera from Peace River area of Canada; Res. Council Alberta, Rept. No. 68, 38 pp., 2 Pls., 5 figs.

1955: Foraminifera of the Cenomanian Dunveganoceras zone from Peace River area of Western Canada; Res. Council Alberta, Rept. No. 70, 62 pp., Pls. 1-3, 6 figs.

Stelck, C.R., Wall, J.H., Banan, W.G., and Martin, L.J.
1956: Middle Albian foraminifera from Athabasca and Peace River drainage areas of Western Canada; Res. Council Alberta, Rept. No. 75, 60 pp., 5 Pls., 2 figs.

Stott, D.F.
1956: The Alberta Group, Rocky Mountain Foothills, Alberta; Geol. Surv. Can., Paper 56-1, 71 pp., 2 tables, 1 fig.

Tate, R.
1865: Correlation of the Cretaceous formations of the northeast of Ireland; Quart. J. Geol. Soc. London, vol. 21, pp. 15-44, 3 Pls.

Thompson, R. L., and Axford, D. W.
1953: Notes on the Cretaceous of southwestern Alberta; Third Annual Field Conference and Symposium, publ. by Alberta Soc., Petrol. Geologists, pp. 32-59, 8 figs.

Thorsteinsson, R.
1952: Grand Cache map-area, Alberta; Geol. Surv. Can., Paper 52-26, 44 pp., 1 geol. map.

Warren, P. S.
1937: An Aptian horizon in the Cretaceous of the lower Mackenzie Valley; J. Palaeontol., vol. 11, No. 1, pp. 69-72, Figs. 1-3.

1947: Cretaceous fossil horizons in the Mackenzie River Valley; J. Paleontol., vol. 21, No. 2, pp. 118-123, Pls. 29-30.

Warren, P. S., and Crockford, M. B. B.
1948: The occurrence of the Crinoid Uintacrinus socialis in the Cretaceous of Alberta; The Canadian Field Naturalist, vol. 62, No. 5, p. 159, 1 Pl.

Warren, P. S., and Rutherford, R. L.
1928: Fossil zones of the Colorado shale, Alberta; Am. J. Sci., vol. XVI, pp. 129-136.

Warren, P. S., and Stelck, C. R.
1940: Cenomanian and Turonian faunas in the Pouce Coupe district, Alberta and British Columbia; Trans. Roy. Soc. Can., Ser. 3, sec. IV, vol. XXXIV, pp. 143-152, Pls. 1-4.

1955: New Cenomanian ammonites from Alberta; Res. Council Alberta, Rept. No. 70, pp. 63-81, Pls. 4-9.

Webb, J. B., and Hertlein, L. G.
1934: Zones in Alberta shale in Foothills of Alberta; Bull. Am. Assoc. Petrol. Geol., vol. 18, No. 11, pp. 1387-1416, 4 tables, 6 figs.

Whitehouse, F. W.
1926: The Cretaceous ammonoides of eastern Australia; Mem. Queensland Museum, vol. VIII, Pt. III, pp. 195-242, Pls. 24-36.

Wickenden, R. T. D.
1945: Mesozoic stratigraphy of the eastern Plains, Manitoba and Saskatchewan; Geol. Surv. Can., Mem. 239, 87 pp., 5 Pls., 1 fig.

Wickenden, R.T.D. (cont'd)
1949: Some Cretaceous sections along Athabaska River from the north of Calling River to below Grand Rapids, Alberta; Geol. Surv. Can., Paper 49-15, 31 pp., 1 fig.

1951: Some lower Cretaceous sections on Peace River below the mouth of Smoky River, Alberta; Geol. Surv. Can., Paper 51-16, 47 pp., 1 geol. map, 1 fig.

Workman, K.E. (Chairman) et al.
1954: Lower Cretaceous of the Peace River region; Western Canada Sedimentary Basin; a Symposium; publ. by Am. Assoc. Petrol. Geol. Press, Tulsa, Oklahoma, U.S.A., pp. 268-279, 1 fig.

Wright, G.W., and Wright, E.V.
1951: A survey of the fossil cephalopoda of the chalk of Great Britain; publ. by Palaeontogr. Soc. London, 40 pp.