LOWER BAJOCIAN (JURASSIC) CEPHALOPOD FAUNAS FROM WESTERN CANADA

and

PROPOSED ASSEMBLAGE ZONES FOR THE LOWER BAJOCIAN OF NORTH AMERICA

By

RUSSELL L. HALL AND GERD F. G. WESTERMANN

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ABSTRACT

The Stephanoceratidae and Sphaeroceratidae of the northeastern Pacific margin, particularly the Queen Charlotte Islands, have been reinvestigated. The Lower Yakoun Formation along Skidegate Inlet contains three distinct late Early Bajocian ammonite faunules, probably in the following succession (from top): Stephanoceras itinsae - Chondroceras oblatum faunule on South Balch Island; Stephanoceras skidegatense - Chondroceras defontii faunule at Richardson Bay; and Zemistephanus richardsoni faunule at Mackenzie Bay.

Taxonomic and stratigraphic comparisons indicate close affinities to southern Alaska, mainland British Columbia, western Alberta and eastern Oregon, and lesser ones to the western interior of the United States. The following dimorphic species are recognised: Stephanoceras itinsae (McLearn) & Stephanoceras yakounense McLearn, S. skidegatense (Whiteaves) & [microconch new], Zemistephanus richardsoni (Whiteaves) & [microconch new], Chondroceras oblatum (Whiteaves) & [microconch new] and Chondroceras defontii (McLearn) & [microconch new]. The microconchiate Itinsaites McLearn, 1927 becomes, therefore, synonymous with Stephanoceras Waagen, 1869: Kanastephanus McLearn, 1927 becomes synonymous with Zemistephanus McLearn, 1927. The new species Zemistephanus alaskensis is described.

The following Bajocian assemblage zones and subzones are formally distinguished for parts or all of western North America (from top):

**Megasphaeroceras rotundum Zone.** — Lepitosphinctes, Sphaeroceras, Lissoceras and late Stephanoceratinae. Early Late Bajocian, c. Subfurcatum Chronzone.

**Chondroceras oblatum Zone.** — Stephanoceras itinsae, abundant S. (Stemmatoceras) and some Teloceras. Late Early Bajocian, late Humphriesianum Chronzone.

**Stephanoceras kirschneri Zone.** — Late Early Bajocian.


(Unnamed Subzone). — S. (Skirroccras) juhlei, Asthcnoceras and early Dorsctetia. Late Sauzei Chronzone.

**Parabigotites crassicostatus Zone.** — Emileia, Sonninia (Papilliceras), Stephanoceras and Arkellocceras. Middle Early Bajocian, early Sauzei Chronzone.

**Docidoceras widebayense Zone.** — earliest Bajocian.

**Witchella sutneroides Subzone.** — c. Ovalis Chronzone.

**Docidoceras camachoi Subzone.** — D. (Pseudocidoceras) and Sonninia (Euhoplloeceratinae) c. Discites Chronzone.

INTRODUCTION

Early failures to separate Jurassic and Cretaceous faunas from the Queen Charlotte Islands were the result of mixing of collections thought to have come from the same strata exposed on several islands in Skidegate Inlet (Whiteaves, 1876, p. 6). MacKenzie (1916) recognised that this confusion had arisen because of failure to separate sandstones of the Cretaceous Haida Formation from the underlying Middle Jurassic Yakoun Formation.

The presence of two distinct ammonite faunas within the Yakoun Formation was shown by McLearn's careful collecting from several measured stratigraphic sections (McLearn, 1927, 1949). Ammonites from three localities within the lower volcaniclastic parts of the Yakoun Formation (Richardson Bay, MacKenzie Bay and South Balch Island; see Text-fig. 1) were presumed to represent a single ammonite faunule belonging to the Stephanoceras humphriesianum Zone (McLearn, 1949; Imlay, 1964, p. B19). Arkell (1956, p. 542), however, suggested that the fauna from MacKenzie Bay was older and possibly represented the Otoites sauzei Zone; this was based on the misidentification of Zemistephanus carlottensis (Whiteaves) with Pseudotoites.
One of us [Hall] made new collections from the Queen Charlotte Islands and parts of western Alberta during the summer of 1971 to (1) clarify the faunal associations at each of the three localities in the lower parts of the Yakoun Formation where the supposed “Lower Yakoun or Stephanoceras fauna” was present; (2) determine the stratigraphic sequence and ages of these ammonite faunas and attempt to correlate them with similar faunas from Alaska, mainland western Canada and United States, Chile and Argentina; and (3) obtain sufficient material for biometric analysis in an attempt to demonstrate infraspecific morphological identity of the juvenile stages of several sexual dimorphs and to allow pairing at the species level.

The lower Yakoun Formation is exposed along the shores of Skidegate Inlet, Queen Charlotte Islands and on several small islands in the Inlet (Text-fig. 1). Lower Bajocian ammonites have been recorded and described from three localities: Maude Island, at Richardson Bay on the southeast shore and MacKenzie Bay on the northwest shore, and on South Balch Island. These localities are easily accessible by small boat from Queen Charlotte City on the north shore of Skidegate Inlet. Detailed measurement of each section, and in situ collecting of fossils, were attempts to establish the stratigraphic and geographic distributions of ammonites. Special attention was given to forms believed to represent dimorphic pairs.

Stratigraphic measurement, correlation and fossil collecting were hampered by some physical features of these islands. The average tidal range of approximately 7.5 m commonly restricts work along the shore to short periods each day. Much of the exposed platform is covered by seaweed and other marine life, which makes collecting difficult. Many of the fossils, covered by water much of the time, are badly weathered and difficult to remove or transport. Although exposure on the wide, wave-cut platforms is good, sections are often interrupted by Recent beach deposits, ranging from sand and pebbles to large boulders. Thick forests of pine, cedar and hemlock with a thick undercover of mosses, ferns and fallen trees cover the islands to within a few meters of the high tide level, so that tracing beds across even the smallest islands is impossible. Streams exposing rock outcrops occur only on the largest islands. Many small faults that break up the sections cannot be traced laterally for any distance.

Access to isolated outcrops of the Yakoun Formation in the interior of the two largest islands (Graham and Moresby) is by private forestry roads. Outcrops yielding specimens of Lower Bajocian age are not easily located and are of no biostratigraphic value for the lower part of the Yakoun Formation.

Collections were made by both of us from the Rock Creek Member of the Fernie Group in Ribbon Creek, southern Alberta. This outcrop is well exposed and easily accessible from the Kananaskis-Coleman road.

Our material was supplemented by collections of A. Sutherland Brown made between 1958 and 1965, and by some undescribed specimens collected several decades ago by F. H. McLearn; this material was made available on loan from the collections of the Geological Survey of Canada in Ottawa. Two specimens of Stephanoceras itinsae (McLearn) (known to have come from Skidegate Inlet (the lithology of the matrix is identical with that on specimens collected by Hall from South Balch Island) were loaned by the Geology Department museum at the University of British Columbia. Comparative material from southern Alaska was obtained on loan from the U.S. National Muse-
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

um in Washington, D.C. Specimens from the Rock Creek Member collected from several scattered localities in northern Alberta and kept in the collections of the Geology Department, University of Alberta, were examined, but most lacked information on locality, associated fauna and precise stratigraphy.

The holotypes and other figured specimens of species based on material from the Queen Charlotte Islands, western Alberta and southern Alaska were re-examined; when such material was not easily accessible, plaster molds were obtained.

The Lower Bajocian includes the European Standard Zones of *Hyperlioceras discites* to *Stephanoceras humphriesianum*. Our scheme follows that most recently developed by Mouterde and others (1971, pp. 9-13) for France, by Parsons (1974, table 1, p. 154) and Morton (1975, table 1, p. 43) for Great Britain and by Sturani (1967) for Central and Western Europe.

ACKNOWLEDGEMENTS

Access to type collections was kindly provided by Dr. M. K. Howarth (British Museum of Natural History), Dr. I. Cooke (British Geological Survey Museum) and Dr. T. Bolton (Geological Survey of Canada). Dr. C. Stelck (University of Alberta), Dr. R. Imlay (United States Geological Survey), and Dr. A. Sutherland Brown (Geological Survey of British Columbia) made available collections from western Alberta, southern Alaska and British Columbia, respectively. Drs. Bolton and Stelck also provided photographs of type specimens. Helpful discussions with Dr. J. Callomon and Mr. C. Parsons, England, and Prof. J. Wiedmann, C. F. R., are also acknowledged. Mr. J. Whorwood and Mr. R. Larush assisted with the photography.

Financial assistance for this project was provided by the National Research Council of Canada and McMaster University, Hamilton, Ontario, Canada. Funds to defray some costs of publication were provided by the University of Calgary.

REPOSITORIES

Material described or figured here is kept in one of six repository institutions. Catalogue numbers of these institutions are cited in the text by means of the following abbreviations:

McM — Department of Geology paleontology collections, McMaster University, Hamilton, Ontario.

GSC — Geological Survey of Canada collections, Ottawa; includes material collected by Richardson, McLearn, Sutherland Brown and Frebold.

UBC — University of British Columbia, Geology Department museum.

USNM — U.S. National Museum, Washington, D.C.; from southern Alaska. Unfigured material from southern Alaska is identified by the U.S. Geological Survey Mesozoic locality numbers with decimal digits added by us for identification of individual specimens from each locality.

UA — University of Alberta, Edmonton; Geology Department.

STRATIGRAPHY

Queen Charlotte Islands

Previous Work

Early geological exploration of the Mesozoic formations of Skidegate Inlet (Pl. 16, fig. 1) was prompted by commercial interest in the coal-bearing rocks of the area. J. Richardson first examined the broad synclinal structure along the Inlet and nearby islands in 1873 and divided the rocks into three horizons (Table 1). Believing the shales on several islands to represent the same geological horizon he did not think it necessary to maintain separate fossil collections (Whiteaves, 1876, p. 6). In describing these fossils Billings (1873) inferred that more than one fauna was present. Whiteaves (1876, pp. 87, 88) also noted "an apparent mixture of Oolitic and Cretaceous types". He recognised that *Ammonites Richardsoni, A. Carlottensis, A. Skidegatensis* and *A. Loganianus* 'forms A and B' resembled "Oolitic" forms from England (Middle - Upper Jurassic), but added (p. 91) that this similarity "is often of a very general character and can scarcely in any case be shown to amount to actual specific identity." Among Richardson's specimens were several species known to be Cretaceous and so Whiteaves (p. 9) concluded that only one fauna was present and that it represented "a blending of the life of the Cretaceous period with that of the Jurassic".

Richardson's failure to separate Cretaceous rocks (now Haida Formation) from Jurassic rocks (now Yakoun Formation) and the continued insistence by Whiteaves (1876, 1884, 1900) that only one fauna was present confused later workers.

More extensive work by Dawson (1880) resulted in division of the "Cretaceous" sequence into five units (Table 1). Whiteaves (1884) described the fossils collected by Dawson and again noted four ammonites from the "lower
Table 1. — History of the use of lithostratigraphic units for the Jurassic - Cretaceous rocks of the Skidegate Inlet area, Queen Charlotte Islands. Heavy line represents position of the Jurassic - Cretaceous boundary.

<table>
<thead>
<tr>
<th>RICHARDSON 1873</th>
<th>DAWSON 1880 1889</th>
<th>ELLS 1906</th>
<th>CLAPP 1914</th>
<th>MACKENZIE 1916</th>
<th>SUTHERLAND BROWN 1968</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper shale and sandstone</td>
<td>upper shales and sandstone 1500</td>
<td>Skidegate member</td>
<td>Skidegate Formation 2000</td>
<td>Skidegate Group</td>
<td></td>
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<tr>
<td>coarse conglomerate 2000 B</td>
<td></td>
<td>Hanna member</td>
<td>Hanna Formation 1300' - 1400'</td>
<td>Turonian</td>
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<tr>
<td>lower shale with coal and iron ore</td>
<td>lower shales and sandstones with coal 5000' C</td>
<td>Haida member</td>
<td>Haida Formation 3800'</td>
<td>? Cenomanian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queen Charlotte Formation</td>
<td></td>
<td></td>
<td></td>
<td>Cenomanian</td>
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<td></td>
<td>Albian</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>early Cenomanian</td>
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<td>Yako Formation 3000' - 6000'</td>
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<td></td>
<td></td>
<td>early Bajocian</td>
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<tr>
<td>Maude Formation 600'</td>
<td></td>
<td></td>
<td></td>
<td>Toarcian</td>
<td></td>
<td></td>
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<tr>
<td>Vancouver Group</td>
<td></td>
<td></td>
<td></td>
<td>Pliensbachian</td>
<td></td>
<td></td>
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<tr>
<td>early Sinemurian</td>
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</tbody>
</table>

shales" (Unit C of Dawson) that he stated would be regarded as Jurassic in Europe: *Ammonites Richardsoni*, *Stephanoceras oblatum* [= *Ammonites Loganianus* form A], *S. cepoides* [= *Ammonites Loganianus* form B] and *Perisphinctes Skidegatensis*. However, the association in the collection of these and known Cretaceous forms again led Whiteaves (1884) to suggest a lower Middle Cretaceous age. Stanton and Martin (1905) noted the resemblance of early Middle Jurassic fossils from southern Alaska to certain forms in the "lower shales" of the Queen Charlotte Islands; they believed the latter to have no connection with the Cretaceous faunas supposed to occur in the same formation. In 1889 Dawson distinguished his Units C, D and E as the Queen Charlotte Islands Formation, believing them to represent a continuous sequence which rested unconformably on older (probably Triassic) rocks. Unit D was separated
from the overlying coal-bearing beds by Ells (1906) and given a pre-Cretaceous age. However, Clapp (1914) extended the Queen Charlotte Series to include Unit D, believing it to be a basal conglomerate of local development, conformable with the overlying units, but resting unconformably on “metamorphic volcanic rocks which seem to belong to the Vancouver Group” (p. 12). Argillites and sandstones, shown by field relations to lie unconformably below the Queen Charlotte Series, were presumed to be of Jurassic or Triassic age. Clapp formally named the Skidegate, Honna and Haida Members for Dawson’s subdivisions A, B and C.

The Jurassic of Skidegate Inlet was finally divided into two formations by MacKenzie (1916): the lower Maude Formation (Dawson’s Unit E) and the overlying Yakoun Formation (Dawson’s Unit D and those parts of Unit C which contained Jurassic fossils). MacKenzie recognised that the strong lithological similarities between the Cretaceous Haida Formation and parts of the Jurassic Yakoun Formation had been responsible for Dawson’s failure to separate them and the faunas they contained. He stressed the importance of the unconformity between these two formations.

Detailed mapping and careful collecting with attention to stratigraphy by McLearn in 1921 led to the recognition of several faunal horizons within the Jurassic formations of Skidegate Inlet. His descriptions of the stratigraphy and ammonite faunas of the Yakoun Formation (McLearn, 1927, 1929, 1932a, 1949) led to the distinction of two faunas: the Lower Yakoun or Stephanoceras fauna of early Bajocian age and the Upper Yakoun or “Seymourites” fauna of early Callovian age, separated by a thick sequence of unfossiliferous volcanic agglomerates and tuffs. A section along the southern shore of Maude Island from Richardson Bay to Robber Point was recorded in detail; it has recently been remeasured and designated the type section of the Yakoun Formation by Sutherland Brown (1968, pp. 68, 72, 73).

Yakoun Formation

The Yakoun Formation is comprised of rocks ranging from massive volcanic agglomerates and tuffs to volcanic sandstones, shales and siltstones. The type section on the southeastern shore of Maude Island is about 915 m thick and has been subdivided into five members (Sutherland Brown, 1968):

<table>
<thead>
<tr>
<th>Member</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>E member</td>
<td>140 m, interbedded massive greenish volcanic sandstone with pebbly beds and grey shales and siltstones. — Callovian</td>
</tr>
<tr>
<td>D member</td>
<td>240 m, dominantly finely crystalline lithic tuffs with</td>
</tr>
<tr>
<td></td>
<td>minor volcanic sandstone.</td>
</tr>
<tr>
<td>B member</td>
<td>30 m, interbedded shales and tuffaceous sandstones. — Bajocian</td>
</tr>
<tr>
<td>C member</td>
<td>290 m, coarse, porphyritic andesite and conglomerate. — Callovian</td>
</tr>
</tbody>
</table>

The rocks present in any one section of the Yakoun Formation vary considerably. Sutherland Brown (1968) has delineated a “facies front” which marks the zone of transition from dominantly volcanic agglomerate in the east to tuffs, volcanic sandstones and shales in the west. The type section is in this zone of transition so that all lithologies are present in abundance. Clastic rocks in the sequence are composed predominantly of fragments derived from porphyritic andesite. The agglomerates, tuffs and lapilli tuffs contain mainly blocks and fragments of porphyritic andesite, about 20 percent crystal fragments and 20 percent fine matrix that commonly is considerably altered. Related conglomerates are also composed almost entirely of rounded volcanic rock fragments. The volcanic sandstones are made up of subangular fragments of porphyritic andesite and angular crystal fragments in a chloritic matrix. Sutherland Brown envisaged the agglomerates and tuffs originating from a series of vents along a line on the eastern edge of the islands. Pulses of volcanic activity were separated by periods of marine sedimentation with redistribution of volcanic detritus in a shallow, neighbouring sea. The abundance of leaves, fruit and wood fragments in some of these marine strata suggests the proximity of a vegetation-covered land surface. A period of non-marine accumulation resulted in the formation of coal beds within the volcanic sandstones of the Yakoun River valley.

MacKenzie Bay (Pl. 16, fig. 2). — Both the upper and lower boundaries of the B member are covered by Recent beach deposits. The basal part of the exposed section consists of just over 7 m of fine, dark shales, highly fragmented and with many small (2 to 6 cm), hard, rounded or elongated calcareous concretions. Several thin bands of grey-green sandstone show graded bedding. From one horizon (a in Text-fig. 2) near the base (exposed only at low tide) come large, rounded calcareous concretions (10 to 15 cm), about half of which contain Zemistephanus richardsoni (Whitewaves) 9 & Z. crickmaysi (McLearn) 8. Chondroceras sp., a few bivalves and belemnites were collected from the associated shales. Abruptly overlying the shales is a thin but very prominent bed (60 cm thick) of buff-coloured volcanic sandstone with some minor bands of angular lithic fragments. Scour-and-fill structures are abundant, and there is some cross-bedding. Load structures occur along the base of the unit.
Text-figure 2.—Measured sections and fossil occurrences in the lower Yakoun Formation of Skidegate Inlet, Queen Charlotte Islands; see Table 2 for listing of fossil assemblages.
The succeeding 15 m of grey shale with sandy interbeds (b in Text-fig. 2) are sparsely fossiliferous, having yielded single specimens of *Chondroceras* sp., *Zemistephanus* sp., together with *Stephanoceras*? (Stemmatoceras?) ex gr. *S. acuticostatum* (Weisert) ["Teloceras itinsae" McLearn], a few belemnites, bivalves and brachiopods. This unit is well bedded with conspicuous bands of elongated calcareous concretions. Cutting unconformably across the top of these beds is a massive, wedge-shaped unit, 5 m thick, of green volcanic sandstone and agglomerate.

In the overlying 35 m of poorly-bedded grey, silty shale a few fossils were found at two horizons. From just 2 m above the agglomerate (c in Text-fig. 2) come several *Zemistephanus alaskensis* n. sp. and 15 m higher (d in Text-fig. 2) additional *Z. richardsoni* (Whiteaves) and some worm borings. Some grey-black argillite bands give the only evidence of bedding.

### Table 2. — Ammonite species found in the stratigraphic sections of Skidegate Inlet, Queen Charlotte Islands (Text-fig. 2). Dimorph is indicated, and number of specimens appears in ()

<table>
<thead>
<tr>
<th>Locality</th>
<th>Bed</th>
<th>Ammonite species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richardson Bay</td>
<td>d</td>
<td><em>Stephanoceras skidegatense</em> (Whiteaves) δ (7) &amp; θ (7)</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td><em>Stephanoceras</em> sp. aff. <em>S. skidegatense</em> δ (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Chondroceras defontii</em> (McLearn) δ (1)</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td><em>Stephanoceras skidegatense</em> (Whiteaves) δ (1) &amp; θ (3)</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td><em>Chondroceras defontii</em> (McLearn) δ (1) &amp; θ (7)</td>
</tr>
<tr>
<td>South Balch Island</td>
<td>d</td>
<td><em>Stephanoceras itinsae</em> (McLearn) δ (3) &amp; θ (15)</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td><em>Chondroceras oblatum</em> (Whiteaves) δ (1) &amp; θ (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Cenoceras</em> sp. (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Calliphylloceras</em> sp. (1)</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td><em>Stephanoceras itinsae</em> (McLearn) δ (4) &amp; θ (9)</td>
</tr>
<tr>
<td>MacKenzie Bay</td>
<td>d</td>
<td><em>Zemistephanus richardsoni</em> (Whiteaves) δ (1) &amp; θ (3)</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td><em>Zemistephanus alaskensis</em> n. sp. θ (2)</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td><em>Zemistephanus</em> sp. indet. θ (1) &amp; θ (1)</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td><em>Zemistephanus richardsoni</em> (Whiteaves) δ (4) &amp; θ (15)</td>
</tr>
</tbody>
</table>

Richardson Bay (Pl. 16, fig. 3). — The base of the section is covered by Recent beach deposits. The lower 9 m consist of massive, poorly-bedded shales with some white feldspar grains. From several broad and poorly-defined horizons (a-c) come specimens of *Stephanoceras skidegatense* (Whiteaves) θ & δ and abundant *Chondroceras defontii* (McLearn) θ & δ. Above these are 7.5 m of grey, highly-fractured sandy shale with occasional thin bands of pebbly tuff and some lightly contorted bands of finer, yellowish-green tuff.

From the succeeding 3.5 m of dark, grey brown shale (d) additional specimens of *S. skidegatense* (Whiteaves) θ & δ and *C. defontii* (McLearn) δ, some bivalves, gastropods and belemnites were collected. This unit also contains abundant hard, calcareous concretions of varying size and fragments of carbonized logs and branches.

Above a covered beach interval of 4 m is a thin succession of bands of alternating brown-grey sandy shales, blue-grey cherty argillite and agglomerates which are highly contorted and broken apart. These are faulted against massive brown, volcanic agglomerate containing several large blocks of the underlying contorted sediments. This fault represents the base of the thick, massive agglomerate designated the C member by Sutherland Brown (1968, p. 73).

South Balch Island (Pl. 16, fig. 4). — The western shore of this small island has an apparently continuous exposure of about 51 m through the B member. Beginning on the southern shore is a sequence of 6 m of fine, grey shales with three prominent beds of grey-green sandstone all showing minor fault displacements. Fossils in this sequence (a-c) include abundant *Stephanoceras itinsae* (McLearn) θ & δ, some *Chondroceras oblatum* (Whiteaves) θ & δ, bivalves, a few brachiopods and fossil fruit.

Next comes a barren, monotonous sequence of grey shales 25.5 m thick extending along the western shoreline and largely covered by loose boulders. It has yielded several bivalves and gastropods and some fossil fruit. Towards the top of the sequence massive volcanic agglomerate and sandstone become the dominant lithologies with a few interbeds of sandy shales, one of which (d) yielded the *S. itinsae - C. oblatum* fauna, along with single specimens of *Eutrephoceras* sp., *Cenoceras* sp. and *Calliphylloceras* sp. and rare bivalves.

The eastern side of the island is a large fault block cut by several smaller faults. It is composed mostly of massive, coarse volcanic sandstones, grey-green and brown in colour. There are minor dark grey shales. In addition to scattered specimens of *S. itinsae* (McLearn) θ & δ, *C. oblatum* (Whiteaves) θ & δ and a single *Calliphylloceras* sp., these
1. MacKenzie Bay
   *Zemistephanus richardsoni* (Whiteaves)  
   *Z. junteri* McLearn
   *Z. carlottensis* (Whiteaves)  
   *Z. vancouverei* McLearn  
   *Normannites* (*Kanastephanus*) *crickmayi* (McLearn)  
   *N. (K.) canadensis* (McLearn)  
   *N. (K.) altus* (McLearn)  
   *N. (K.) mackenzii* (McLearn)  
   *Teloceras itinsae* McLearn

2. Richardson Bay
   *Stephanoceras skidegatense* (Whiteaves)  
   *S. skidegatense* var. *laperousii* McLearn  
   *Chondroceras* (*Defonticeras*) *defontii* (McLearn)  
   *C. (D.) colnetti* (McLearn)  
   *C. (D.) ellsi* (McLearn)  
   *C. (D.) marchandi* (McLearn)  
   *C. (D.) maudense* (McLearn)

3. South Balch Island
   *Stephanoceras yakoutiense* McLearn  
   *Normannites* (*Itinsaites*) *itinsae* (McLearn)  
   *Stephanoceras caamanoi* McLearn  
   *Chondroceras* (*Defonticeras*) *oblatum* (Whiteaves)

Table 3. — List of previously recognized, revised and new taxa from the lower part of the Yakoun Formation (** = forms described here for the first time).

<table>
<thead>
<tr>
<th>PREVIOUSLY IDENTIFIED TAXA</th>
<th>REVISED AND NEW TAXA</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Zemistephanus richardsoni</em> (Whiteaves)</td>
<td><em>Z. richardsoni</em> (Whiteaves)</td>
</tr>
<tr>
<td><em>Z. carlottensis</em> (Whiteaves)</td>
<td><em>Z. alaskensis</em> n. sp.</td>
</tr>
<tr>
<td><em>Z. vancouverei</em> McLearn</td>
<td><em>Z. crickmayi</em> (McLearn)</td>
</tr>
<tr>
<td><em>Normannites</em> (<em>Kanastephanus</em>) <em>crickmayi</em> (McLearn)</td>
<td><em>Stephanoceras</em> ex gr. <em>acuticostatum</em> Weisert</td>
</tr>
<tr>
<td><em>N. (K.) canadensis</em> (McLearn)</td>
<td><em>Chondroceras n. sp. indet.</em></td>
</tr>
<tr>
<td><em>N. (K.) altus</em> (McLearn)</td>
<td><em>C. defontii</em> (McLearn)</td>
</tr>
<tr>
<td><em>N. (K.) mackenzii</em> (McLearn)</td>
<td><em>C. maudense</em> (McLearn)</td>
</tr>
<tr>
<td><em>Teloceras itinsae</em> McLearn</td>
<td><em>S. itinsae</em> (McLearn)</td>
</tr>
<tr>
<td><em>S. skidegatense</em> (Whiteaves)</td>
<td><em>S. caamanoi</em> McLearn</td>
</tr>
<tr>
<td><em>S. skidegatense</em> var. <em>laperousii</em> McLearn</td>
<td><em>C. caamanoi</em> McLearn</td>
</tr>
<tr>
<td><em>Chondroceras</em> (<em>Defonticeras</em>) <em>oblatum</em> (Whiteaves)</td>
<td><em>C. oblatum</em> (Whiteaves)</td>
</tr>
</tbody>
</table>
The Zemistephanus fauna from this locality corresponds closely in composition to that from the Fitz Creek Siltstone in southern Alaska (see discussion under South Alaska). Species in common are Z. richardsoni (Whiteaves) ♀ & ♂, Z. carlottensis (Whiteaves) ♀, Z. crickmayi (McLearn) ♂ ["Normannites (Kanastephanus) spp."] and Z. alaskensis ♀. Species of Chondroceras are also present in both faunas.

Because of discontinuity of outcrop the lithostratigraphic position of these beds relative to those at Richardson Bay and on South Balch Island cannot be established. The only clue to the relative ages of the contained faunas is a small ammonite nucleus (GSC 13636; Pl. 9, fig. 5) that, according to McLearn's handwritten label, was collected by him between MacKenzie and Maude Bays on the north shore of Maude Island. This locality description corresponds to the uppermost part of the section shown for MacKenzie Bay in Text-figure 2, i.e. stratigraphically above the Zemistephanus horizons. No other material has been recovered from this part of the section. This nucleus bears a very strong resemblance to Stephanoceras skidegatense (Whiteaves) (McM J1802f; Pl. 9, fig. 4) collected about 20 m above the exposed base of the section at Richardson Bay. A detailed analysis of similar faunas within the Fitz Creek Siltstone and Cynthia Falls Sandstone of southern Alaska (see discussion under that heading) also suggests that the Zemistephanus fauna is older than those from Richardson Bay and South Balch Island which contain abundant Stephanoceras but no Zemistephanus.

Richardson Bay. — The fauna is characterized by abundant Chondroceras defontii (McLearn) ♀ & ♂ and Stephanoceras skidegatense (Whiteaves) ♀ & ♂, while Zemistephanus is unknown. In southern Alaska C. defontii ♀ ranges through most of the Fitz Creek Siltstone where it is associated with Zemistephanus and persists into the overlying Cynthia Falls Sandstone where Z. richardsoni is absent and C. oblatum ♀ first appears. We suggest that the S. skidegatense faunule is probably younger than the Z. richardsoni faunule.

South Balch Island. — The Stephanoceras (Stephanoceras) itinsae (McLearn) ♀ from this locality is very similar to European species group of S. umbilicum and S. mutabile; these forms in western Europe first appear and reach maximum numbers in the middle parts of the S. humphriesianum Zone (Schmidtill and Krumbeck, 1938; Mouterde et al., 1971). S. itinsae ♀, which is so abundant in the Bajocian faunas of the Queen Charlotte Islands and Alberta, is not known from the thick sequences of southern Alaska where the Zemistephanus faunule is dominant. Stephano-

ceras obesium Imlay from the Tuxedni Formation in the Talkeetna Mountains of southern Alaska (Imlay, 1964, pp. B45, 46; pl. 18, figs. 5-11) is a similar but apparently older form (see discussion under subgenus Stephanoceras Waagen, 1869). In the Cynthia Falls Sandstone of southern Alaska, however, Chondroceras oblatum (Whiteaves) occurs with an undescribed species of Stephanoceras (Imlay, 1964, table 7). Chondroceras cf. oblatum (Whiteaves) and C. defontii (McLearn) are listed from the Cynthia Falls Sandstone (table 7), but do not occur at the same locality, a feature also noted in the lower Yakoun Formation. Whether such faunal segregation is due to some ecological factor or difference in age is not clear.

Conclusions. — It is tentatively concluded that the S. itinsae - C. oblatum faunule from South Balch Island is younger than the Zemistephanus fauna at MacKenzie Bay and that they correlate respectively, to the middle to upper and lower S. humphriesianum Standard Zone of Europe (Table 4).

Mainland British Columbia

Stephanoceratid and sphaeroceratid ammonites have been recorded from the thick volcanoclastic sequences comprising the Laberge Group in northern British Columbia and the Hazelton Group in central and central-western British Columbia. Knowledge of the systematics and stratigraphic occurrence of these forms is, however, minimal because of poor preservation and widely scattered localities; much work remains to be done on the Middle Jurassic ammonites of this region.

In southwestern British Columbia, S. (Skirroceras) cf. kirschneri Imlay occurs in the Taseko Lakes area, but cannot be dated independently since the associated "Witchellia sp." cannot be identified at the generic level (Frebold et al., 1969, pl. 4, fig. 7). That fragment could, among others be a Sonninia (Papulliceras) of the European O. sauzei Zone or a Dorsetensia of the upper O. sauzei to S. humphriesianum Zones. Better evidence for the age of Zemistephanus was furnished by the Lookout Section in Manning Park, 180 km due east of Vancouver (Frebold et al., 1969, p. 18). The isolated occurrence of Chondroceras "marshallii" (McLearn) [= C. oblatum] in the same area indicated the S. humphriesianum Zone.

Lookout Section. — Frebold et al. (1969, p. 19) described a thick sequence of deep-water turbidites which yielded, from the base (1) "Otoitidae", (2) a faunule with "Graphoceras crickmayi" n. sp., and Zemistephanus richardsoni, (3) Chondroceras spp. indet. and unidentified ammonites, and (4) an upper faunule with Chondroceras aff.
ellis (McLearn) and Stephanoceras cf. S. caamanoi (McLearn). While the large figured specimen of Z. richardsoni was correctly identified, the associated alleged new species of the late Aalenian Graphoceras was based on 3 fragmentary specimens with unknown whorl section, i.e., two one-sided impressions (including the holotype) and one crushed specimen.

Imlay (1973, p. 75) had already noted the close similarity of “Graphoceras crickmayi” Frebold et al. (1969) to Poccilomorphus “varius” Imlay (1973), stating that they differ only in the slightly concave flanks of the former. However, this feature may well be the result of partial crushing, and the species erected by Frebold and Imlay cannot be discriminated on objective grounds. However, the type-material of “P. varius” Imlay is very poor and both “species” are a close match to, and may well be conspecific with, P. cycloides (d’Orbigny). An excellent series of this variable species, a subzonal index in the basal S. humphriesianum Zone from the Alps to England, was figured by Sturani (1964, pl. 8). Whether “Graphoceras crickmayi” is conspecific or closely affiliated with P. cycloides makes little difference for the time-correlation, since the entire genus Poccilomorphus (sensu Sturani) is restricted to that subzone. This therefore strongly indicates the age of the occurrence of Z. richardsoni as P. cycloides subzone [= D. romani Subzone], i.e., approximating the age of Zemistephanus in eastern Oregon, as discussed below.

**Alberta**

Jurassic rocks ranging in age from Sinemurian to Upper Portlandian comprise the Fernie Group which has been mapped from southernmost Alberta over 1,000 km to the north in the Peace River area (Frebold, 1957, pp. 1, 2; Frebold and Tipper, 1970, pp. 9, 10). The section is incomplete, with many hiatuses indicated by the absence of index fossils.

Warren (1934) proposed the name Rock Creek Member for a calcareous sandstone bed, 1.5 to 9 m thick and 15 to 45 m above the base of the Fernie Shale in southern Alberta. No identifiable ammonites have been found in this unit at its type locality at Rock Creek, but interbedded shales and calcareous sandstones in many other parts of western Alberta with Stephanoceras, S. (Stemmatoceras), Teloceras and Chondroceras spp. and belemnites of the “Teloceras fauna” (Warren, 1934) [S. humphriesianum Chronzone] are considered correlative (Frebold, 1976). This rock sequence continues downward, containing earlier ammonite assemblages in some places. Frebold (1976, p. 4) has recently proposed extending the Rock Creek Member to include all strata between the “Toarcian paper shale” and Callovian “grey beds”; ammonites representing both the “S. sowertyi” and S. humphriesianum Chronzones are known from this interval. This extension of the Rock Creek Member from a single sandstone bed, as originally defined by Warren (1934), to include a sequence of calcareous sandstones, shales and limestones is not desirable.

While the “Teloceras fauna” has been recorded from numerous localities throughout western Alberta (Warren, 1947; McLearn, 1927, 1928, 1930, 1932b; Frebold, 1957), the European O. sauzei Chronzone is rarely indicated, as it is at the Snake Indian River locality (below).

**Ribbon Creek.**—New collections of the “Teloceras fauna” were made separately by both of us at the Ribbon Creek locality of the Rock Creek Member proper; details of this section were given by Frebold (1957, pp. 81, 28).

The best preserved and most abundant forms at this locality are Chondroceras allani (McLearn) ? and C. oblatum (Whiteaves) ? (“C. marshalli (McLearn)” ?). “Zemistephanus” crickmayi Frebold (1957, pp. 52, 53; pl. XXV; pl. XXVI; pl. XXVII) is here referred to Teloceras [Teloceras crickmayi (Frebold, 1957) ? (q.v.)]; we have found other larger, fragmentary specimens of this species which may be the only North American true Teloceras. The holotype of “Teloceras” [S. (Stemmatoceras)] dowlingi McLearn is also assumed by Frebold (1957, p. 52) to have come from this locality. “Stemmatoceras albertaine” McLearn of Frebold (1957, p. 50) is probably another Stephanoceras itinsae (McLearn) ? [Stephanoceras (Stephanoceras) itinsae (McLearn, 1927) ? & (q.v.)]; other fragmentary material from this locality is also identified with this species (Pl. 8, fig. 1). The corresponding microconch, “Itinsaiites itinsae” McLearn, has also been collected from this locality (McM J1838; Pl. 8, fig. 7), along with numerous possibly conspecific stephanoceratid nuclei.

The association of Stephanoceras itinsae ? & with Chondroceras oblatum ? indicates that the Rock Creek Member exposed at Ribbon Creek is correlative with the lower Yakoun Formation of South Balch Island (see discussion under Queen Charlotte Islands). The presence of Teloceras, together with several S. (Stemmatoceras), and the absence of Zemistephanus, suggest correlation with the upper parts of the S. humphriesianum Standard Zone of western Europe. Similar S. (Stemmatoceras) with rather narrow coronate inner whorls, are reported from just below the T. blagdeni Subzone in France (Mouterde et al., 1971, pp. 11, 12) and in England (Parsons, pers. comm.).
Teloceras crickmayi (Frebold) closely resembles typical Teloceras of the T. blagdeni Subzone.

Snake Indian River. — Two faunules from two horizons 18 m apart are present in the fine section of the Rock Creek Member (s.l.) exposed in Snake Indian River valley (Frebold, 1957, pl. 7A). The “Stephanoceras ex. gr. skidegatense” described by Frebold (1957, p. 49; pl. 22, fig. 2; pl. 25, fig. 2) is probably a S. itinsae (McLeam) [Stephanoceras (Stephanoceras) itinsae (McLeam, 1927) \& \delta (q.v.)]. Unfortunately, its exact stratigraphic horizon is not recorded. “Stephanoceras” occur at several levels in this section.

The upper parts of the Red Glacier Formation were correlated with the upper O. sauzei Zone because “Normannites” and Chondroceras are not known from below this level (Imlay, 1964, p. B12). The specimens of Chondroceras cf. defontii (McLeam) listed as occurring in the Red Glacier Formation, however, were ex situ and the reported species “Normannites” are now referred to other genera. “N. kialagvikensis” Imlay is the microconch of Parabigotites crassicostatus Imlay (cf. Imlay, 1973, pp. 32, 85, 95); both dimorphs are restricted to the Red Glacier Formation where they commonly occur together. “N. (Itinsaites) crickmayi” (McLeam) is a microconch form of Zemistephanus \& [Zemistephanus crickmayi (McLeam, 1927) \& (q.v.)]. Both macroconch and microconch samples of Chondroceras have been reported recently from the supposed W. laeviuscula Zone of southern England (Parsons, 1974, p. 167) and the genus occurs at a similar level in Argentina (Westermann and Riccardi, unpublished information). This removes the constraints which led Imlay to suggest correlation of this fauna with the upper part of the O. sauzei Zone.

In the highest parts of the Red Glacier Formation, Stephanoceras (Skirroceras?) kirschneri Imlay \& is the dominant species; it is not associated at any of the listed localities with P. crassicostatus Imlay \& and \delta. S. kirschneri is intermediate in coiling between typical Skirroceras, mainly of the O. sauzei Zone, and the slightly more involute Stephanoceras s.s. of the early S. humphriesianum Zone; the inner whorls resemble S. pyritosum (Quenstedt) known from Europe and from similar levels in the Andes (Westermann, unpublished information). This would suggest that the S. kirschneri range zone belongs in the late O. sauzei — early S. humphriesianum Chronozones, i.e., intermediate between the ranges assumed by Imlay (1964, 1973).

The overlying Galena Sandstone, of which only the basal part is fossiliferous, contains Emilia constricta Imlay (a close relative of E. polyschides, Waagen), Bradfordia caribouensis Imlay, ”Witchellia” sp., and Sonnia (Papilliceras) cf. arenata (Quenstedt). This fauna was originally correctly correlated with the O. sauzei Zone (Imlay, 1964). S. (Papilliceras) ranges from the upper “Sowerbyi Zone” through the O. sauzei Zone in western Europe (Mouterde et al., 1971, p. 11; Parsons, 1974), Chile and Argentina (Westermann and Riccardi, 1972, pp. 73-77). E. polyschides has a similar range in Europe (Parsons, 1976), while the other taxa are of dubious affinity and age.
Due to the supposed presence of "Normannites" and Teloceras, the fauna of the Fitz Creek Siltstone was correlated with the S. humphriesianum Zone (Imlay, 1964, p. B12). But none of the figured "Normannites (Itinsaites) crickmayi" (McLearn) and "N. (I.) itinsae" (McLearn) from this unit is a true "Normannites" or "Itinsaites", i.e., Stephanoceras microconch; "Kanastephanus" crickmayi and its allied forms are microconch Zemistephanus, as is the "N. (I.) itinsae". They show neither the rounded whorl section nor the persistence of dense secondary ribbing (three to each primary) right to the aperture, two features which characterize Stephanoceras itinsae δ. Furthermore, the material identified with the poorly known "Teloceras itinsae" McLearn (Imlay, 1964, p. B50) belongs to Zemistephanus alaskensis n. sp. The dominant ammonite species in the Fitz Creek Siltstone is Zemistephanus richardsoni (Whiteaves). It is restricted to this unit and here proposed as an appropriate guide fossil to replace Imlay's "Teloceras itinsae". Stephanoceras (Skirroceras) kirschneri Imlay appears to range to the top of the Z. richardsoni range zone (Imlay, 1964, p. B47, Table 8, USGS Meso. locs. 26599, 21274).

Chondroceras defontii (McLearn), which forms a strong association with Zemistephanus throughout the Fitz Creek Siltstone, does not usually occur with C. allani (McLearn); they are reported together only at one locality (USGS Meso. loc. 21276) which covers a stratigraphic interval of 10.7 m (Imlay, 1964, table 6). C. allani does occur together with C. cf. oblatum (Whiteaves) which first appears at the base of the overlying Cynthia Falls Sandstone (Imlay, 1964, table 8) and also with C. "marshalli" [= C. oblatum] in the Tuxedni Formation (Imlay, 1964, table 12). C. allani and C. oblatum are found associated with undescribed Stephanoceras s.s. and S. (Stemmatoceras), subgenera with which they commonly occur in the Queen Charlotte Islands and in the "Teloceras fauna" of western Alberta (see discussion under Alberta). The evidence indicates that the C. allani - C. oblatum - Stephanoceras faunule represents a higher horizon than the Z. richardsoni - C. defontii faunule and is equivalent to middle and upper parts of the S. humphriesianum Zone.

OREGON

Bajocian rocks in east-central Oregon (Imlay, 1973, pp. 8-9, fig. 1) consist of sequences of marine clastics ranging from coarse conglomerates to siltstones and mudstones. Clasts are of volcanic origin and locally there are andesitic lavas and volcanic breccias. These rocks vary greatly in thickness so that lithic units cannot be traced laterally for any great distance. Dickinson and Vigras (1965) therefore extended the Snowshoe Formation (Lupher, 1941) to include a number of previously named "Formations". In the Suplee area, it is divided, from below, into the Weberg, Warm Springs and Basey Members. Ammonite faunas and lateral continuity of some beds allow correlation of these units with the Snowshoe Formation in the Izee area where it is much thicker and includes strata both older and younger than in the Suplee area.

A westward onlapping sequence of hard, sandy limestone and calcareous sandstone, 15 to 75 m thick, comprises the Weberg Member in the Suplee area (Imlay, 1973, pp. 20-22). The association of Tmetoceras scissum (Benecke), Praestrigites and Eudmetoceras near the base indicates correlation with the European G. concavum Zone and the Alaskan E. howelli Zone; the middle and upper parts of the Member yield Sonninia (Euhoploceras) adica modesta Buckman, Docidoceras lupheri Imlay and the evolute Witchellia (Laiwitchellia) spp. indicating the H. discites and S. ovalis Zones (Imlay, 1973, pp. 20-22).

The overlying Warm Springs Member consists of soft, calcareous, thinly laminated claystones and mudstones, 30 to 90 m thick, and on the basis of faunal similarity may be correlated with the upper parts of the unnamed "Lower Member" in the Izee area. The Lower Member there consists of 150 to 230 m of black and dark grey siltstone, clay­stone and mudstone with local developments of concretions and thin limestone beds (Imlay, 1973, p. 14). The correlation of the faunas with the middle and upper parts of the "S. Sowerbyi" Zone [S. ovalis and W. laeviuscula Standard Zones] and the O. sauzei Standard Zone is based on . . . the presence of Witchellia throughout the member, the end of occurrences of Witchellia and Papilliceras at its top, the presence of Emilia and Dorsetensia in its upper two thirds, the presence of Normannites near its top, and the presence of Fontannesia near its base (Imlay, 1973, p. 22).

In the upper parts of the Warm Springs Member is an assemblage including the diagnostic ammonites Parabigotites crassicostatus Imlay, Stephanoceras (Skirroceras) juhlei Imlay, Witchellia connata (Buckman), "Otoites contractus" (Sowerby) and Emilia buddinghageni Imlay, all of which occur together at a single locality (Imlay, 1973, table 6, loc. 78). This fauna correlates with the Parabigotites faunule found in the upper parts of the Red Glacier Formation in southern Alaska and has been correctly placed in the O. sauzei Chronozone (Imlay, 1964, 1973); it could, however, begin in the W. laeviuscula Chronozone. Significantly, E. buddinghageni is closely affiliated to E. giebeli submicro-
stoma (Gottsche) from the W. laeviuscula to lower O. sauzei Chronozones of the Andes (Westermann and Ricardi, 1979).

The overlying Basey Member in the Suplee area consists of massive units of volcanic fragmental rocks and interbedded andesitic lavas. It is 760 m thick but thins rapidly to the east, grading into finer clastic rocks that are placed in the Middle Member of the Snowshoe Formation in the Ize area. Here this unit is 305 m thick and consists of thinly bedded, dark grey and black calcareous siltstone and claystone with alternating grey and green sandy siltstones and fine sandstones of volcanic origin. Further east these beds intertongue with conglomeratic volcanic rocks of the Silvies Member (Imlay, 1973, p. 14). According to Imlay the lower fauna resembles that of the underlying Warm Springs Member, i.e., (? ) Dorsetensia cf. subpecta Buckman, Pelekodites (? ) silviesensis Imlay, S. (Skirroceras) juhlei Imlay and Astenoceras delicatum Imlay, together with the first S. (Skirroceras) kirschneri Imlay and Dorsetensia (? ) orogenensis Imlay. The middle part of the unit has yielded few ammonites but in the upper part Poecilomorphus cf. "varius" Imlay [= P. cycloides?], Chondroceras allani (McLearn), "Normannites" orbignyi Buckman, "N. (Itinsaites) crickmayi" (McLearn), [= Zemistephanus δ ] and "Stephanoceras cf. nodosum" (Quenstedt)" are said to make their first appearance. The lower fauna was correlated with the O. sauzei Zone [here, lower S. kirschneri Zone] and the upper fauna with the S. humphriesianum Zone (Imlay, 1973, p. 24) [here, Z. richardsoni Subzone of S. kirschneri Zone]. Although the critical septal sutures of the Dorsetensia have not been described, at least some of the specimens appear to be true Dorsetensia, indicating an age not older than O. sauzei Chronozones (Westermann and Ricardi, 1972; Morton 1972, pers. comm.). The occurrence of late S. kirschneri together with Zemistephanus near the top of the Basey Member suggests correlation with the upper Red Glacier Formation or lowermost Fitz Creek Siltstone in southern Alaska (Imlay, 1964, pp. B28-30). The associated Poecilomorphus ex gr. P. cycloides (d’Orbigny) is of time-stratigraphic significance because the entire genus (s.s.) is restricted in western Europe to the lower part of the S. humphriesianum Zone, marking the "P. cycloides Subzone" of Sturani (1971) [= Dorsetensia romani Subzone]. Imlay omitted the comparison of his alleged new species to P. cycloides, with which Sturani (1971, p. 100) united the "species" of Buckman mentioned by Imlay as well as all other Buckman "species". This upper fauna containing Zemistephanus thus is correlated with the lower, rather than with the upper, S. humphriesianum Standard Zone as was suggested by Imlay (1973, p. 24).

At a number of localities in the unnamed “Middle Member” of the Snowshoe Formation in the Seneca and Emigrant Creek areas, ammonite faunas occur which are very similar in generic and even specific composition to those from the Fitz Creek Siltstone in southern Alaska (Imlay, 1973, table 9). Stephanoceras (s.s.), S. (Stephanoceras) and Teloceras which are so abundant in British Columbia and in the “Teloceras fauna” of Alberta are absent from the associations of Stephanoceras kirschneri - S. juhlei and of “Normannites crickmayi" [= Zemistephanus δ ] - Zemistephanus richardsoni - “Teloceras itinsae" [= Zemistephanus Θ ] - Chondroceras. This again suggests that these associations are older than the British Columbia and Alberta faunas mentioned.

Specimens identified with the poorly known “Teloceras itinsae” McLearn by Imlay (1973, p. 90; pl. 46, figs. 10, 11, 13) are too poorly preserved and fragmentary to allow confident placement in Teloceras; indeed, the nature of the primary ribbing and nodes is very similar to that seen on the phragmocone whorls of Zemistephanus. Microconchs described under “Normannites (Itinsaites) crickmayi” (McLearn) "Teloceras cf. nodatipingius" (Quenstedt)" which comprise the rest of the fauna at this locality, suggest correlation with the upper O. sauzei or lower S. humphriesianum Standard Zones. In British Columbia and Alberta, the true Stephanoceras itinsae is associated with S. (Stephanoceras), Teloceras and C. oblatum (Whiteaves) and is placed in the middle to late S. humphriesianum Chronzone.

The virtual absence in Oregon of the usually rich “Teloceras fauna” of Alberta and of similar associations of British Columbia, is noteworthy. The “Stephanoceras aff. S.
"Albertense" McLearn' of Imlay (1973, pp. 89, 90; pl. 46, figs. 1-9) is very similar to Stephanoceras itinsae (McLearn) in whorl shape, ornamentation and suture pattern but has more closely spaced primary ribs. Imlay compared this material with a specimen from Ribbon Creek, Alberta, described by Frebold (1957; pl. 21, fig. 2a, b; pl. 23, figs. 1b, c) as "Stemmatoxerus albertense" and herein referred to S. itinsae \( \varphi \) [see discussion under Stephanoceras (Stephanoceras) itinsae (McLearn, 1927) \( \varphi \) & \( \delta \)]. The Oregon specimens, however, all come from a conglomeratic whorl shape, ornamentation and suture pattern but has of significance. Fragments representing four unnamed species derived from underlying parts of the Snowshoe Formation (Imlay, 1973, pp. 29, 30) and so have little biostratigraphic significance. Fragments representing four unnamed species of Stephanoceras are known from localities within the undifferentiated Snowshoe Formation of the Seneca area. Of these, "Stephanoceras sp. C" and "Stephanoceras sp. D" are associated with Spirobax, suggesting Upper Bajocian, and appear to be macroconchs of Luperites Imlay; the similar "Stephanoceras sp. B", however, is said to come from a fauna (Lupher's loc. 57) indicative of the O. sauzei Chronozone.

Wyoming, Idaho and Utah

Thick sequences of grey, shaly limestones with minor sandstone, red beds and massive limestone found along the Wyoming-Idaho border and in north-central Utah have been designated the Twin Creek Limestone. The original definition and subsequent use of this stratigraphic unit have been reviewed by Imlay (1967, p. 2; table 1) who distinguished seven members and described their ammonite and bivalve faunas.

The lowest unit, the Gypsum Spring Member, varies greatly in thickness and consists mainly of soft, brownish red to yellow siltstones and claystones which are poorly exposed, with interbedded brecciated and chert-bearing limestones (Imlay, 1967, p. 17). Thick masses of gypsum also occur in some areas. An early Bajocian age (S. humphriesianum Zone) was suggested for this poorly fossiliferous member because the superposed Sliderock Member contains earliest Late Bajocian ammonites.

The basal oolitic limestone of the Sliderock Member varies similarly in thickness. Most of its upper parts consist of dark, fossiliferous, bedded limestones, that have yielded an interesting ammonite assemblage at numerous localities. Stephanoceratids known from the S. humphriesianum Chronozone of western Canada are said to be associated with Megasphaeroceras rotundum Imlay and Eocephalites primus Imlay (Imlay, 1967, table 3). M. rotundum is well known from the early Late Bajocian of southern Alaska where it is associated with "Dettermanites" [= "Normannites" = Stephanoceras \( \delta \)] vigorousus (Imlay), Leptospinctes cliffensis Imlay, and L. (Prorsisphinctes) delicatus (Imlay, 1961, 1962, 1964). A single specimen described as Stephanoceras cf. skidegatense (Whiteaves) from 33 m below the top of the Sliderock Member (Imlay, 1967, p. 89; pl. 6, fig. 10) differs markedly from that species in the Queen Charlotte Islands in both strength and density of the body chamber ornamentation and is here identified with S. itinsae (McLearn) \( \varphi \). This occurrence is presumably lower than that of the numerous fragments of "Stemmatoxerus" aff. S. albertense McLearn" found with "Stemmatoxerus" [Stephanoceras s.s.] aricostum Imlay and the Megasphaeroceras faunule in the upper 15 m of the Sliderock Member. Also associated with this fauna are four corroded fragments of "Normannites? cf. N. crickmayi (McLearn)" (Imlay, 1967; pl. 12, figs. 1-4). These specimens have, however, much coarser secondary ribbing than Zemistephanus crickmayi \( \delta \) or related species. The uppermost Sliderock Member belongs in the Megasphaeroceras rotundum Zone (defined below) of the basal Upper Bajocian which, in the S. subfurcatum Standard Zone of Europe, yields a similar mixed fauna with surviving Stephanoceratinae (cf. Mouterde et al., 1971).

Assemblage Zones

Table 4 shows the scheme of assemblage zones for the Lower Bajocian of western North America here proposed, and their suggested correlation with European Standard Zones. Correlation in the lowermost Bajocian is uncertain because of the recent fine subdivision of the former European "Sonninia sowerbyi Zone" into three Standard Zones, i.e., those of Hyperlioceras discites (oldest), Sonninia ovalis, and Witchellia laeviuscula.

The definition and characteristic fauna, occurrence and correlation of these zones follows, beginning with the oldest:

1. — Assemblage Zone of Docidoceras widebayense

Definition. — The assemblage is characterized by abundant Docidoceras (Pseudocidoceras) widebayense Westermann and other species, together with late Pseudolioceras, early Witchellia and the Sonninia subgenera Eukhoploceras and Alaskinia; associates are Pseudotoites, Asthenoceras and Eudmetoeceras. Two assemblage subzones can be recognized within this Zone:

a. — The Docidoceras camachoi Subzone in the lower
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

<table>
<thead>
<tr>
<th>BAJOCIAN</th>
<th>EUROPE</th>
<th>SOUTH ALASKA</th>
<th>BRITISH COLUMBIA</th>
<th>SW. ALBERTA</th>
<th>OREGON &amp; W. INTERIOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>SUBFURCATUM</td>
<td>Megasphaeroceras rotundum</td>
<td>?</td>
<td>?</td>
<td>Megasphaeroceras rotundum</td>
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<tr>
<td></td>
<td></td>
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<td>Chondroceras oblatum</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Stephanoceras kirschneri</td>
<td>Zemistephanus richardsom</td>
<td>?</td>
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<td></td>
<td></td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Lower</td>
<td>HUMPHRIES - IANUM</td>
<td>?</td>
<td>Chondroceras obtusum</td>
<td>Chondroceras mixtum</td>
<td>Chondroceras obtusum</td>
</tr>
<tr>
<td></td>
<td>ROMANI</td>
<td>Stepbanoceras kirschneri</td>
<td>Zemistephanus richardsom</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>HEBRIDICA</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>SAUZEI</td>
<td>Parabigotites crassicostatus</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>LAEVUSCULA</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>OVALIS</td>
<td>Docidoceras widebayense</td>
<td>Witchellia sutneroides</td>
<td>with Soninia gracilis &amp; Euhoploceras</td>
<td>with Soninia gracilis &amp; Euhoploceras</td>
</tr>
<tr>
<td></td>
<td>DISCITES</td>
<td>Docidoceras camachoi</td>
<td>with Soninia gracilis &amp; Euhoploceras</td>
<td>with Soninia gracilis &amp; Euhoploceras</td>
<td>with Soninia gracilis &amp; Euhoploceras</td>
</tr>
<tr>
<td></td>
<td>CONCAVUM</td>
<td>Eudmetoceras amplexus</td>
<td>with Euhoploceras</td>
<td>with Euhoploceras</td>
<td>with Euhoploceras</td>
</tr>
</tbody>
</table>

Table 4.—Proposed Bajocian assemblage zones for western North America and their correlation with the European standard zones.

part, containing D. (Pseudocidoceras) camachoi Westermann, D. (P.) widebayense Westermann and Soninia (Euhoploceras) bifurcata Westermann; approximately H. discites Chronozone.

b.—The superjacent Witchellia sutneroides Subzone, with W. sutneroides Westermann and D. (P.) widebayense; approximately S. ovalis Chronozone.

Occurrence.—The best known assemblage and faunal sequence of this zone is at Wide Bay, Alaska Peninsula (Westermann, 1969b), here designated the type area. The southeastern Alaskan faunas include part of this assemblage but may differ in age (Imlay, 1964; Westermann, 1969b). A similar, related assemblage occurs in the middle and upper parts of the Weberg Member, Snowshoe Formation in Eastern Oregon; abundant Soninia (Euhoploceras), Docidoceras and Astenoceras with Witchellia (Latewitchellia) and Fontannesia indicate time-equivalence to this zone (Imlay, 1973).

Correlation.—This zone is approximately equivalent to the H. discites and S. ovalis Chronozones.

2. — Assemblage Zone of Parabigotites crassicostatus

Definition.—This zone utilizes one of Imlay's (1964) suggested “guide fossils” for southern Alaska. The characteristic fauna there consists of Parabigotites crassicostatus Imlay, ? and ?; Soninia tuxedniensis Imlay, Witchellia adnata Imlay [= Dorsetensis], Stephanoceras cf. triptolemus (Morris and Lycett), Emileia constricta Imlay, ? and ? and Soninia (Papilliceras) cf. arenata (Quenstedt) recorded at USGS Mesoz. locs. 21296, 21261, 21263 and 3009. In eastern Oregon the following fauna (at USGS Mesoz. loc. 29241, 29395 and Loc. no. 69) from the middle and upper parts of the Warm Springs Member, Snowshoe Formation also represents this Zone (Imlay, 1973): Parabigotites crassicostatus Imlay, “Otoites contractus” (Sowerby) [= Emileia constricta Imlay, ?], Emileia buddenhageni Imlay, Witchellia connata (Buckman), Soninia (Papilliceras) stantoni (Crickmay), Stephanoceras mowichense Im-
lay, “Normannites cf. crickmayi” (McLearn), Dorsetensia cf. pulchra Buckman and Stephanoceras (Skirroceras) juhlei Imlay. Arkellocceras Frebold also appears to belong to this Zone (see discussion under Alberta).

Occurrence. — As well as the type locality in the middle parts of the Red Glacier Formation, Cook Inlet, southern Alaska (Imlay, 1964) and the middle and upper parts of the Warm Springs Member, Snowshoe Formation, eastern Oregon (Imlay, 1973) occurrences of this fauna have been recorded from the upper parts of the Kialagvik Formation at Wide Bay, Alaska Peninsula (Westermann, 1969b) and from the Rock Creek Member, Fernie Group in the Snake Indian River valley, western Alberta (by the presence of Arkellocceras; Imlay, 1964; Westermann, 1964b).

Correlation. — The P. crassicostatus Zone is placed in the early O. sauzei Chronozone (? and latest W. laeviuscula Chronozone).

3. — Assemblage Zone of Stephanoceras kirschneri

Definition. — In southern Alaska Stephanoceras (Skirroceras) kirschneri Imlay first appears in the upper parts of the Red Glacier Formation (USGS Mesoz. loc. 21267), associated with Holcophylloceras costisparsum Imlay and Sonninia? sp. jv. (Imlay, 1964); it occurs alone at Mesoz. locs. 21264 and 2013. The species ranges almost to the top of the overlying Fitz Creek Siltstone (Mesoz. locs. 26599 and 21274) where it is associated with species representing the subzone of Zemistephanus richardsoni (discussion below).

In eastern Oregon S. kirschneri occurs near the base of the Basey Member, Snowshoe Formation, associated with Dorsetensia oregonensis Imlay, D. cf. subtexta Buckman, D. cf. eduardiana (d’Orbigny), Asthenoceras delicatum Imlay, Pelekodites silviesensis Imlay and S. (Skirroceras) juhlei Imlay.

The Subzone of Zemistephanus richardsoni represents the upper part of the S. kirschneri Zone; Z. richardsoni (Whiteaves) replaces “Teloceras itinsae” of Imlay (= Zemistephanus alaskensis n. sp.) as the “guide fossil” previously suggested for this fauna by Imlay (1964). In southern Alaska Z. richardsoni appears at the base of the Fitz Creek Siltstone and occurs throughout this unit with the following fauna: Z. carlottenensis (Whiteaves), Z. alaskensis n. sp., Chondroceras defontii (McLearn), Stephanoceras (Skirroceras) kirschneri Imlay and S. (Stemmatoceras?) cf. palliseri (McLearn). The upper parts of the Basey Member, Snowshoe Formation, eastern Oregon have yielded a fauna which includes Pocilomorphus ‘varius’ Imlay, Chondroceras allani, McLearn, Stephanoceras cf. nodosum (Quenstedt). ‘Normannites’ orbignyi Buckman, “N. crickmayi (McLearn), S. (Skirroceras) kirschneri Imlay, Dorsetensia oregonensis Imlay, Pelekodites do bsonensis Imlay and Sphaeroceras sp.

The Upper Red Glacier Formation and the Fitz Creek Siltstone at Cook Inlet, southern Alaska are designated the type area for both the S. kirschneri Zone and its Z. richardsoni Subzone.

Occurrence. — Outside the type area, the S. kirschneri Zone is represented in the Taseko Lakes area of British Columbia where S. (Skirroceras) cf. kirschneri has been recorded (Frebold et al., 1969). Faunas representing the Z. richardsoni Subzone are more widely known, occurring at MacKenzie Bay, Queen Charlotte Islands (with Z. richardsoni ? & §, Z. alaskensis and Chondroceras sp.), in Manning Park, southern British Columbia (Z. richardsoni with “Graphoceras crickmayi” Frebold = Pocilomorphus; Frebold et al., 1969) and in the unnamed Middle Member of the Snowshoe Formation in the Emissary Creek area, eastern Oregon (Z. cf. richardsoni with S. kirschneri and “Teloceras itinsae” McLearn = Zemistephanus alaskensis n. sp.; Imlay, 1973).

Correlation. — The entire S. kirschneri Zone is placed in the late O. sauzei Chronozone, Dorsetensia hebridica Subzone (Morton, 1975, 1976), and in the early S. humphriesianum Chronozone, D. romani Subzone. The association of Pocilomorphus with the faunas of the Z. richardsoni Subzone indicates the D. romani Chrono-Subzone [= “P. cycloides subzone”].

4. — Assemblage Zone of Chondroceras oblatum

Definition. — The fauna characterizing this zone is best known from the Fernie Group at Ribbon Creek, southern Alberta where C. oblatum (Whiteaves) occurs with C. allani (McLearn), Stephanoceras itinsae (McLearn) ? and § (= “Itinsaites itinsae” (McLearn)]. S. (Stemmatoceras) doeblingi (McLearn), and Teloceras crickmayi (Frebold). This is designated the type area.

Occurrence. — The so-called “Teloceras fauna” is known from numerous other localities within the Fernie Group of western Alberta (Frebold, 1957), in the lower part of the Yakoun Formation on South Balch Island, Queen Charlotte Islands (S. itinsae ? and § with C. oblatum ? and §) and at the base of the Cynthia Falls Sandstone at Tuxedni Bay, southern Alaska where C. oblatum first appears and is associated with C. allani and Stephanoceras sp.

Correlation. — Due to the presence of Teloceras together with typical Stephanoceras, this zone is dated as middle and late S. humphriesianum Chronozone, approximately “S. humphriesianum” and T. blagdeni Subzones.
5. — Assemblage Zone of *Megasphaeroceras rotundum*

**Definition.** — From the Twist Creek Siltstone, Cook Inlet, southern Alaska comes an ammonite fauna consisting of *M. rotundum* associated with *Macrophyllloceras* cf. *grosicostatum*, *Calliphylloceras* sp., *Lytoceras* sp., *Spiroceras* sp., *Lissoceras bakeri*, *Oppelia* (*Liroxytes*) *kellumi*, *Sphaero­ceras* talkeetnanum, ‘Dettermannites’ *vigorosus*, *Lepto­sphinctes clifensis* and *L. (Prorsisphinctes) delicatus*, all Imlay spp. (1962, 1964). This is designated the type area.

**Occurrence.** — Outside southern Alaska faunas belonging to the *M. rotundum* Zone have been recognized in the Sliderock Member of the Twin Creek Limestone, Western Interior of the United States [where *M. rotundum* occurs with *Stephanoceras cf. itinsea* (McLearn), *S. (Stemmato­ceras) arcicostum* Imlay, *S. (Stemmato­ceras) cf. albertense* (McLearn), “Normannites cf. crickmayi” (McLearn) and *Eocephalites primus* Imlay (Imlay, 1967)] and in an undifferentiated part of the Snowshoe Formation at Emigrant Creek, eastern Oregon. However, the latter clearly represents a mixed fauna collected from 65 to 75 m of section (Imlay, 1973, p. 51). The zone may also be represented in the Hazelton Group of British Columbia where Frebold and Tipper (1973) have tentatively identified deformed specimens as *Megasphaeroceras* aff. *M. rotundum*. During fieldwork in 1978 in south-western Alberta, one of us [Hall] located in the Fernie Group a fauna comprising *Spiroceras* sp., *Megasphaeroceras* ? sp. and various stephanoceratids, which is the first recorded occurrence of this zone in Fernie strata. The geographic distribution of this zone is currently being extended to the Andes of northern and central Chile and, possibly, to Mendoza province, Argentina (Westermann and Riccardi, unpublished information; their field work in September 1978 suggests, however, that *Megasphaeroceras* is congeneric with *Eurycephalites* and that the species *rotundum* may have a much extended vertical range.

**Correlation.** — The association of *Leptosphinctes* with late stephanoceratids in this zone parallels faunas described from the base of the European *S. subjurcatum* Standard Zone (Pavia and Sturani, 1968; Pavia, 1969). The upper boundary of this Zone in North America is unknown.

**THE SUPPOSED PACIFIC FAUNAL REALM**

Increasing knowledge of Jurassic ammonoid faunas has necessitated constant revision of the concept of faunal realms first discussed by Neumayr (1883) and further developed by Uhlig (1911). As pointed out by Arkell (1956) these early schemes attempted to deal with the whole of Jurassic time, leading to many discrepancies as new faunas became known. Such comprehensive treatment was impossible because, as is now clear, the differentiation of Jurassic ammonoid faunas was both spasmodic and progressive, reaching a maximum in the Upper Jurassic (Gordon, 1976). Arkell still believed that the Lower Jurassic ammonoid faunas were universal in their distribution (Arkell, 1956, p. 609) but more recent work has shown the existence of provinciality throughout most of the Lower Jurassic (Dean et al., 1961; Hallam, 1971; Sapunov, 1971; Howarth, 1973).

Arkell (1956) recognised three Jurassic ammonoid Faunal Realms, the Boreal, Tethyan and Pacific, distinguished mainly on the basis of restricted occurrences of certain ammonite families. The Boreal and Tethyan Realms are clearly discerned on this basis for most of the Jurassic, though the boundary between them frequently fluctuated north and south. The causes of initiation, maintenance and periodic expansions of these two Realms have been the subject of much recent discussion (Imlay, 1965; Stevens, 1971; Stevens and Clayton, 1971; Hallam, 1969, 1971).

Development of the Pacific Realm, beginning in the Lower Bajocian with the appearance of the “peculiar Pacific genera *Pseudotoites* and *Zemistephanus*” was proposed by Arkell (1956, p. 609). These genera were supposedly restricted to Western Australia, Indonesia and the western seas of North and South America. Records of *Zemistephanus* from Western Australia are now believed to be misidentifications (see discussion under *Zemistephanus* McLearn, 1927) and it seems this genus was endemic to the North American Cordilleran geosyncline. It is definitely known only from the Queen Charlotte Islands and southern Alaska, where it occurs in beds of the uppermost *O. sauzei* or lower *S. humphriesianum* Chronozones. *Pseudotoites* is well known from the “S. sowerbyi Zone” of southern Alaska (Westermann, 1969b), and Chile and west-central Argentina (Westermann and Riccardi, 1972). The transfer of *Zemistephanus carlot­tensis* (Whiteaves) to *Pseudotoites* by Arkell (1954) has been shown to be unwarranted (Imlay, 1964; Westermann, 1964a). *Pseudotoites* is also known from Western Australia (Arkell, 1954) and some islands of the Indonesian Archipelago (Westermann and Getty, 1970). On the other hand, the distribution of the overwhelming number of Lower Bajocian genera is cosmopolitan: *Emileia* (including *Oitoites*), *Sonninia* and *Stephanoceras* (*Skirroceras*) in the *O. sauzei* Chronzone; *Stephanoceras* s.s. (including *Normannites*), *Teloceras* and *Chondroceras* in the *S. humphriesianum* Chronzone. Other genera do seem to be endemic to the western Cordilleran seas of North America, e.g., *Para­bigotites* and *Zemistephanus*. The restricted occurrence of
these few genera in faunas otherwise composed of predominantly cosmopolitan families indicates some endemism but does not justify separate Realm status.

Also, *Pseudotoites* and *Zemistephanus* are of different age, further diminishing the number of supposedly “unique” forms defining the Pacific Realm at any one time. Different parts of the supposed Pacific Realm were inhabited at various times by ammonite genera that migrated from the Boreal, eastern Tethyan and western Tethyan Realms. While it is clear that some genera were able to migrate across the Pacific basin (Westermann and Riccardi, 1976) others retained a restricted distribution (Westermann, 1969b; Khudoley, 1974).

Of greater significance may be the geographic distribution of *Arkelloccras* which is known in relative abundance from strata of uncertain age in the North West Territory and Arctic Canada (Frebold, 1961; Frebold et al., 1967), as a specimen from the O. sauzei Chronozone of northern Alaska (Imlay, 1976), and also from southern Alaska (Imlay, 1964) and western Alberta (Westermann, 1964b). The dominance of this genus in the Arctic may represent the initiation of the more strongly defined Boreal faunas with *Cranocephalites* in the Upper Bajocian and Lower Bathonian (Frebold, 1961, p. 36).

**SYSTEMATIC PALEONTOLOGY**

**Measurements**

All measurements of specimens are given in mm. Where possible whorl dimensions were measured on cut and polished cross-sections or on broken specimens obtained during dissection. Most measurements were made on internal molds. The following abbreviations are used throughout the text and in text-figures:

- **D** = shell diameter.
- **W** = maximum whorl width measured between ribs or tubercles.
- **H** = height of the whorl measured from the umbilical seam to the venter.
- **U** = diameter of the umbilicus measured between the umbilical seams.
- **P** = Number of primary ribs per half-whorl, apicad from the stated shell (umbilical) diameter.
- **S** = Number of secondary ribs per half-whorl, counted as for primary ribs.
- **Pl** = length of the primary ribs measured from the umbilical seam to the centre of the tubercle or point of furcation.

The graphs represent “mass curves”, usually with more than one measurement taken from each specimen; points measured on phragmocone whorls are represented by open symbols, those from the body chamber are solid. Macroconchs (♀), microconchs (♂) and specimens from different localities are indicated by the use of symbols that are explained on each graph. Points joined by thin, continuous lines represent measurements made from various growth stages on the same specimen (“individual growth curves”); heavier continuous lines joining numbered points represent measurements from holotypes; other dashed lines joining numbered points represent measurements on “species” considered synonymous with the named species. Approximate “growth lines” for each dimorph appear in small insets.

On graphs showing rib counts, individual points from different growth stages of each specimen are joined to produce a “growth curve” emphasising individual ontogenetic variation. The use of umbilical diameter allows data to be incorporated from the inner whorls of undissected specimens and figured specimens, at least for primary ribbing exposed on the lower flanks or umbilical walls.

The diameter at which individual sutures were drawn is indicated to the right of each figured suture. Shell diameters at which cross-sections were drawn are indicated on each diagram. Sections through body chamber whorls are shaded; black areas represent ribs and tubercles.

For the septal suture, the conventional symbols of the (mostly European) recent literature are used. These are, from venter to dorsum: E, external lobe; L, lateral lobe; U₁, U₂ etc., umbilical lobes in order of appearance; U₃, secondary internal lateral lobe; and I, internal lobe.

**Dimorphism and Nomenclature**

Each of the three Lower Bajocian faunas described from the Yakoun Formation on the Queen Charlotte Islands is of very low diversity, usually with only one stephanoceratid and one sphaeroceratid dimorphic species at each locality (Table 2). Thus difficulties due to possible overlap of morphological features between closely related species are minimized, especially among the less variable microconchs, allowing dimorphs to be paired at the species level. Corresponding dimorphs are regarded as the sexes of a single ammonite species and given the same name; the probable sex of each dimorph is indicated by the use of the appro-
propriate biological symbols, though this is recognised as being a convention (Palframan, 1969, p. 148). In this usage we follow the procedures already proposed by Palframan (1969), Westermann (1969a), Makowski (1962) and Guex (1967), among others. Where one partner of a dimorphic pair has not been previously named, no new name is given if the two dimorphs are regarded as being conspecific. In those cases where both dimorphs have previously been described and named, rules of priority must be followed when choosing a single name for the species.

Full morphological descriptions and synonymies of both dimorphs are given separately, then comparison of their juvenile morphologies is made. The holotype of a dimorphic pair has not been previously named, no new name is given if the two dimorphs are regarded as being conspecific. In those cases where both dimorphs have previously been described and named, rules of priority must be followed when choosing a single name for the species.

There is a need for further study of data selection in attempts to demonstrate identical growth gradients for supposed dimorphs by means of formal statistical tests, i.e. whether one should use regression statistics based on (a) ‘mass’ curves in which numerous measurements are obtained from each individual at different growth stages; (b) ‘mass’ curves in which only one measurement is obtained from each specimen; or (c) individual growth curves using many measurements taken throughout the ontogeny of a single specimen representing each dimorph.

The biological meaning of the intercept (‘b’ in the allometric equation $Y = bX^a$) is uncertain (White and Gould, 1965). The inequality of ‘b’ found in most growth patterns for dimorphs tested here may represent some real difference in shape of the embryonic growth stages of males and females; on the other hand, dimensions and growth patterns on the first (nepionic) whorl of ammonites are known to diverge significantly from those found throughout the remainder of the phragmocone and so differences in ‘b’ may have no biological significance.

Order AMMONOIDEA Hyatt, 1889
Suborder AMMONITINA Hyatt, 1889
Superfamily STEPHANOCERATAE Neumayr, 1875
Family STEPHANOCERATIDAE Neumayr, 1875
Subfamily STEPHANOCERATINAE Neumayr, 1875
Genus ZEMISTEPHANUS McLearn, 1927

Type species. — Ammonites richardsoni Whiteaves, 1876 (by original designation).
Discussion. — The type-species, originally described by Whiteaves (1876, pp. 32, 33; pl. 5, figs. 1, 2), was based on a single specimen from the collection of fossils made by J. Richardson in 1872 from the shores of Skidegate Inlet, Queen Charlotte Islands. No further information on its precise locality was given. McLearn (1929, pp. 18-21) described an additional specimen as Zemistephanus richardsoni (Whiteaves) and two other specimens (designated Z. vancouerii McLearn, 1929 and Z. funteri McLearn, 1929) from the lower part of the Yakoun Formation on the shore of MacKenzie Bay, Maude Island, Skidegate Inlet (Text-fig. 1). More recent collections by Sutherland Brown (1968) and one of us [Hall] have produced a number of macroconchs only from this locality, so it seems certain that the holotype of Z. richardsoni came from here. Zemistephanus appears to be endemic to western North America (with the possible exception of “Coeloceras” indicum Kruizinga from the Sula Islands, Indonesia) and is of restricted stratigraphic range and diversity; yet the identity and affinities of the genus have been subject to widely varying treatment by other authors.

Another specimen from Skidegate Inlet recently recognized as belonging to this genus (Imlay, 1964) was described by Whiteaves (1876, pp. 38, 39) as Ammonites carlottensis. However, this species was not included by McLearn (1927, 1929) in his original discussion of the genus Zemistephanus and has been variously placed in Perisphinctes, Stephano­ceras and Pseudo­toites. Arkell (1954) believed there was a strong resemblance between A. carlottensis and the Western Australian Pseudotoites leicharti (Neumayr) and so transferred the poorly known Canadian species to that genus. Later work on material from southern Alaska, in which details of the suture were recognized for the first time, resulted in establishment of A. carlottensis Whiteaves as a Zemistephanus (Imlay, 1964). This was based on the strong similarities of the body chamber, ornamentation and suture with the type-species. Similar characters are used here in transferring the Alaskan material described by Imlay (1964, pp. B50, 51) as ‘Teloceras iiinsae McLearn’ to Zemistephanus, as Z. alaskensis n. sp. The aplanulate structure of the septum indicates that Zemistephanus should be affiliated with the family Stephanoceratae rather than the Otoitidae which exhibit an abullate septum (Westermann, 1964a): E/L and I/U are much larger than the adjacent saddle elements in the suture.

The two additional species erected by McLearn, Z. vancouerii and Z. funteri, were based on single, incomplete and poorly preserved specimens. The holotype of Z. funteri is badly weathered and one side is missing; it is here regarded as a slightly smaller form of Z. richardsoni. As previously
suggested by Imlay (1964, p. B53), the incomplete holotype of Z. vancouveri appears to be identical with the Alaskan specimens of Z. carlottensis (Whiteaves).

Two alleged Australian species described by Arkell (1954), 'Z.' corona and 'Z.' armatus, have been shown to be correlative developments of Pseudotoites (Westermann, 1964a, p. 62). From mainland western Canada several specimens have previously been placed in Zemistephanus. 'Z. crickmayi' Frebold (1957, pp. 52, 53) from the Rock Creek Member of the Fernie Group at Ribbon Creek in southern Alberta is a Teloceras [see discussion under Teloceras crick­mayi (Frebold, 1957) 8]. 'Zemistephanus sp.' of Frebold and Tipper (1973, p. 1123), from Tenas Creek in north­central British Columbia, represented by a poorly preserved outer whorl with unknown coiling and cross-section, is of uncertain generic affinity.

A single impression of a stephanoceratid ammonite from the Lookout Section in Manning Park, southern British Columbia, was identified as Z. richardsoni (Whiteaves) by Frebold (in Frebold et al., 1969, pp. 25, 26; pl. II, fig. 1; pl. IV, fig. 1). The specimen appears to be complete and not significantly larger than other described specimens from Alaska and the Queen Charlotte Islands. However, the occurrence of fine riblets or striae in place of relatively coarse secondary ribs on all visible parts of the flanks and venter and the loss of the large, conical nodes on the body chamber are not characteristic of Z. richardsoni (Whiteaves). Even the generic identity remains uncertain because of the unknown whorl shape.

'Teloceras' warreni McLearn is a large species of Zemistephanus, characterized by a narrow umbilicus, steep umbilical wall and large nodes situated low on the flanks.

Whiteaves (1876, p. 33) commented on the close relationship of Ammonites richardsoni to A. [Erymno­ceras] coronatus Bruguier (1789) and A. [Teloceras] Blagdeni Sowerby (1818). Since then several authors (Warren, 1947, p. 72; Frebold, 1957, p. 53, Arkell, 1954, p. 579; Westermann, 1964a, pp. 62, 68) have questioned the genus-level distinction of Zemistephanus and Teloceras, though McLearn (1929) in his original description of the type species of Zemistephanus had already noted two important distinctions: the more dorsal position of the tubercles and the change on the body chamber to more serpenticone coiling. Imlay (1964, p. B52) distinguished the two genera by characters of the body chamber:

Zemistephanus is characterized by rather marked uncoiling of the body chamber, the low position of the tubercles on the flanks of the body chamber, a tendency for the tubercles to weaken near the aperture of the large, adult specimens.

Teloceras has a coronate adult body chamber, its tubercles occur higher on the flanks and remain strong on the body chamber, and the adult whorl contracts little or none at all from the preceding whorl.

Several specimens of Teloceras cf. blagdeni (Sower­by) from Goslar in northwest Germany have been compared with the inner whorls of Z. richardsoni from the Queen Charlotte Islands and southern Alaska. Clear differences are already apparent at 25 mm diameter. In Zemistephanus, the whorls are broader and more strongly arched than in Teloceras; the inner flanks are more strongly convex and grade into the almost vertical umbilical slope, forming a deep, crater-like umbilicus, and the nodes are more blunt and much lower on the flanks (Text-fig. 3). On the inner whorls,

Text-figure 3.—Cross-sections of phragmocone whorls of Zemistephanus and Teloceras. a-b, Z. richardsoni ♀ (McM J1797a at D = 70 mm and USNM 3008.1 at D = 62 mm), with whorl overlap of 40% and 33%, respectively; c, T. cf. blagdeni ♀ (McM J1875a from Goslar, Germany, at D = 63 mm), with whorl overlap of 25% X 0.9.

the primary ribs in T. cf. blagdeni are more prominent than the low and more distant ribs on Zemistephanus. The nodes are not as large and conical as in Zemistephanus but instead are sharp terminations of the primaries. On later growth stages of typical Teloceras the primary ribs remain broader and prominent, the nodes become large and rounded and secondary ribs are thick and relatively sharp; the coronate cross-section becomes more pronounced, with a broad, flat venter. The end of the adult Zemistephanus phragmocone, in contrast, has weaker ornamentation, the primary ribs becoming broad undulations and the nodes blunt and rounded.

Species of Stephanoceras (Stemmatoceras), that more closely resemble Zemistephanus in adult whorl section and coiling than does Teloceras, are all distinguished from Zemistephanus by the elliptical rather than ovate inner whorls.
and the more prominent primary ribs (at least on the juvenile whorls).

Some species exhibit an exceptionally close homoeomorphy to Australian and South American representatives of *Pseudotoites* Spath, in particular the relatively evolute and coarsely ribbed *Z. carlottensis* (Whiteaves) (*cf.* Arkell, 1954, pls. 35, 36, 39, 40; Imlay, 1964, pls. 25, 27). Besides its earlier age (*S. ovalis* vs. *S. humphriesianum* Zone), *Pseudotoites* differs in the denser, thinner ribbing of the juvenile whorls and, particularly, in the bullate, not planulate, se­

juvenile whorls).

*Zemistephanus richardsoni* of *dotoites

*Zemistephanus alaskensis* with 3-6 secondary ribs to each primary arching forward on tum (subequal first and second, internal and external lateral saddles in the suture). The two genera belong indeed to separate families (Westermann, 1964a).

**Zemistephanus** ♀ (macroconch)

*Diagnosis.* — Inner whorls cadiconic with broadly arched venter, well-defined lateral shoulder with large, conical nodes and steep, convex flanks forming a deep, narrow umbilicus. Primary ribs broad, faint on lower flanks, with 3-6 secondary ribs to each primary arching forward on the venter. Body chamber egresses strongly with marked decrease in whorl width and rounding of the whorl section, usually three-quarters to one whorl in length. Aperture simple with flared collar.

The following species are here included:

*Zemistephanus richardsoni* (Whiteaves, 1876) ♀ (Pl. 3, figs. 2a, b), lower part of the Yakoun Formation, Queen Charlotte Islands and Fitz Creek Siltstone, southern Alaska.

*Zemistephanus carlottensis* (Whiteaves, 1876) ♀ (Pl. 3, figs. 1a, b), lower part of the Yakoun Formation, Queen Charlotte Islands; Fitz Creek Siltstone and Cynthia Falls Sandstone, southern Alaska.

*Zemistephanus alaskensis* n. sp. ♀, lower part of the Yakoun Formation, Queen Charlotte Islands and Fitz Creek Siltstone, southern Alaska.

*Zemistephanus warreni* (McLearn, 1930) ♀, Fernie Group, Porcupine Creek, Kananaskis Valley, southern Alberta. (??) *Zemistephanus urinum* (Imlay, 1964), Fitz Creek Siltstone, southern Alaska.

**Zemistephanus** ♂ (microconch) (*Kanastephanus*)

The microconch dimorph of the type species *Z. richardsoni* (from MacKenzie Bay) is described here for the first time. In all essential features it closely resembles those specimens from the same locality described by McLearn (1927) under *Kanastephanus*. Arkell (1957) placed *Kanastephanus* in synonymy with *Normannites* Munier-Chalmas, but *Kana-

*stephanus* differs from that genus in having a deeper and narrower umbilicus, more coronate whorl section, large conical tubercles and a higher ratio of secondary to primary ribs on the phragmocone. Westermann (1964a, p. 68) placed *Kanastephanus* in synonymy with *Itinsaites* McLearn, 1927; however, *I. itinsae* is here shown to be the microconch of *Stephanoceras yakounense* McLearn (see discussion under *Stephanoceras* (*Stephanoceras*) *itinsae* (McLearn, 1927) ♀ & ♂). The "microconch genus" *Kanastephanus* McLearn, 1927 is here placed in synonymy with the corresponding "macroconch genus" *Zemistephanus* McLearn, 1927.

*Diagnosis.* — Phragmocone cadiconic, whorl section strongly depressed with broadly arched venter, lateral shoulder and steep, convex flanks forming a deep, narrow umbilicus. Primary ribs broad, faint on lower flanks, with large, conical nodes along the lateral shoulder and three to six secondary ribs to each primary. Body chamber egresses and contracts, aperture with ventro-lateral lappets. Orna­

mentation strong to aperture but nodes lost and primary ribs bifurcate.

The following species are included:

*Zemistephanus richardsoni* (Whiteaves, 1876) ♂, lower part of the Yakoun Formation, Queen Charlotte Islands and Fitz Creek Siltstone (possibly Cynthia Falls Sandstone also), south Alaska.

*Zemistephanus crickmayi* (McLearn, 1927) ♀, lower part of the Yakoun Formation, Queen Charlotte Islands; Fitz Creek Siltstone and Cynthia Falls Sandstone, south Alaska.

*Zemistephanus richardsoni* (Whiteaves, 1876) ♀ & ♂

Plate 1; Plate 2, figures 1-4; Plate 3, figure 2a b; Text-figures 4-7

*Zemistephanus richardsoni* ♀ (macroconch)

1876. *Ammonites richardsoni* Whiteaves, pp. 32, 33; pl. 5, figs. 1, 2.
1927. *Zemistephanus richardsoni* (Whiteaves); McLearn, p. 63.
1929. *Zemistephanus richardsoni* (Whiteaves); McLearn, p. 19; pl. 9, figs. 1, 2; pl. 10, fig. 2.
1929. *Zemistephanus funteri* McLearn, p. 20; pl. 10, fig. 1.
1964. *Zemistephanus richardsoni* (Whiteaves); Imlay, p. B51; pl. 25, figs. 6, 7; pl. 26, figs. 1-7.
1969. *Zemistephanus richardsoni* (Whiteaves); Frebold et al., pp. 25, 26; pl. 2, fig. 1; pl. 4, fig. 1.

*Holotype.* — GSC 5013, collected by J. Richardson in 1872, presumably from the lower part of the Yakoun Formation at MacKenzie Bay on the north shore of Maude Island, Skidegate Inlet, Queen Charlotte Islands (Text-fig. 1).

*Material.* — Two complete specimens (McM 1977a, b), five reasonably complete specimens (McM 1977c-g) from Yakoun Formation, lower 5 m of the section exposed at MacKenzie Bay; one specimen (McM 1977j) from shales 45 m above base of exposed section at MacKenzie Bay.
Seven specimens from the Fitz Creek Siltstone, southern Alaska (USGS Mesozoic locs. 2999, 3000, 10515, 26599). The holotype (GSC 5013), McLearn’s “plesiotype” (GSC 9006) and another specimen from this locality (GSC 13639) were reexamined.

Description. — Protoconchs were obtained from one Alaskan specimen (USGS Mesozoic loc. 2999) and two juvenile specimens from MacKenzie Bay (McM J1797h, i). The protoconch is smooth and transversely elongate with a width of about 0.5 mm and a height of 0.35 mm. The first whorl is smooth with a broad, flattened venter that curves abruptly near the umbilical seam to form a short, convex flank. One whorl after the prosuture, at a diameter of 0.8 mm, there is a broad, faint constriction on the venter which fades approaching the umbilical seam. The siphuncle at this stage has a relatively large diameter and is central (Text-fig. 4).

Immediately following the constriction a distinct lateral shoulder forms with steep, convex flanks falling to the umbilical seam. A change in shell dimensions occurs at the end of the first whorl with positive allometry for whorl height; growth ratios remain constant from this point to the end of the phragmocone. At a diameter of 1.5 mm small, elongated tubercles appear along the lateral shoulder and extend onto the upper flanks; these are strongly prosiradiate. At a diameter of 4 mm faint secondary ribs appear; they are broad and rounded, usually two to each primary. At this stage the tubercles are prominent and conical and the primary ribs are broad, curved undulations of the flanks that do not reach the umbilical seam. Whorl cross-section is depressed and coronate with H/W = 0.50 to 0.60. The venter is broad and only slightly arched while the flanks become very steep and almost vertical near the umbilical seam. Secondary ribs soon become sharper than the primaries and more densely spaced with increasing diameter, as many as five per primary. Primary ribs become rectiradiate but are still massive and rounded with large, conical nodes: their spacing during ontogeny at first decreases from 8-12 per half-whorl to a minimum of six to eight between umbilical diameters of 5 and 15 mm and then increases again to eight to ten on the final whorl (Text-fig. 5). Fine striae, which may entirely mask the secondary ribbing, appear on the outer shell surface of some specimens at diameters between 50 and 75 mm.

Marked changes in growth occur on the body chamber, which is about one whorl long. The umbilical seam egresses suddenly from the line of nodes on the previous whorl, the flanks become less steep and the relative (and sometimes absolute) whorl width decreases sharply, resulting in strong contraction of the whorl (Text-figs. 5, 7). H/W ratios increase to as much as 0.75 with rounding of the cross-section. Both primary and secondary ribs become faint and may disappear entirely. Nodes are blunt and rounded but persist to the aperture, situated low on the whorl. The aperture is marked by a slight constriction followed by an expanded collar and complete lip.

Remarks. — The specimens from southern Alaska and MacKenzie Bay agree closely in whorl shape, coiling and ornamentation (Text-figs. 5, 7). Most Alaskan representatives of the species attain larger sizes and have broader body.
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

Text-figure 5. — Bivariate plots of whorl width (W), whorl height (H), umbilical diameter (U), shell diameter (D) and number of primary (P) and secondary (S) ribs per half-whorl, for Zemistephanus richardsoni ♀ and ♂ from Alaska and Queen Charlotte Islands. Based on 16 macroconchs and five microconchs, with some individual “growth lines” indicated. Insets are same graphs showing approximate positions of best-fit mass curves. See Measurements for additional explanations.

chambers and coarser secondary ribs. The character of the nodes on the body chamber also varies, some becoming blunt and rounded while others remain high and fairly sharp.

This species differs from Z. carlottensis (Whiteaves) in having more coronate whorls, losing strong secondary ribbing on the body chamber but retaining the large, conical nodes. Z. alaskensis n. sp. ♂ has similar phragmocone whorls but a higher body chamber whorl (H/W = 0.80 - 0.95) retaining strong secondary ribs with the nodes higher on the flanks.
Text-figure 6.— Sutural ontogenies for *Zemistephanus richardsoni* \( \delta \), left (a-c, USGS Mesozoic loc. 2999.3, d-h, USGS Mesozoic loc. 26599.1) and \( \delta \), right (McM J1796d). The position of the umbilical seam is marked by (. See Measurements for additional explanations.

**Zemistephanus richardsoni** \( \delta \) (microconch)

(This dimorph has not been described previously.)

**Allotype.**— McM J1796a, complete with lappets, from Yakoun Formation, lower 5 m exposed at MacKenzie Bay, Queen Charlotte Islands.

**Material.**— Four specimens (McM J1796a-d), three complete with aperture, from lower 5 m of Yakoun Formation exposed at MacKenzie Bay, Queen Charlotte Islands; GSC 48593 from the same locality; two crushed specimens from the Fitz Creek Siltstone in southern Alaska, USGS Mesozoic locs. 2999, 26599.
Description. — The nature of the protoconch and earliest whorls is unknown. At a diameter of 3 - 4 mm small, sharp tubercles appear along the lateral shoulder, and extend onto the upper flanks as small ridges. The venter is smooth, broad and only slightly arched while the flanks are steep, falling straight to the umbilical seam. As diameter increases the tubercles become sharper and conical and the primary ribs extend further towards the umbilical seam; there are nine to ten per half-whorl. Broad, faint secondary ribs appear at a diameter of about 10 mm, two to each primary. At this stage the primary ribs take on characteristics that are retained throughout the phragmocone: they are broad, rounded undulations of the flanks, fading near the umbilical seam, rectiradiate and terminating in high and sharp conical nodes on the lateral shoulder. Their number decreases to six to eight per half-whorl between umbilical diameters of 5 and 15 mm, but later increases to 10 to 12 near the end of the phragmocone. Secondary ribs become strong, curving forward from the nodes, then crossing straight over the venter. Density of secondaries increases to three per primary (Text-fig. 5).

Whorl cross-section throughout the phragmocone is coronate with steep, convex flanks forming a deep, crater-like umbilicus. Nodes are situated at the point of maximum whorl width on the abrupt lateral shoulder which is at 40 to 50 percent of the total whorl height. H/W ratios throughout the phragmocone are 0.50 - 0.60.

The body chamber occupies about three-quarters of a whorl with egression from the line of nodes on the previous whorl commencing just after the last septum. While remaining broad and depressed in section, relative height increases on the body chamber, H/W ratios increasing to 0.62 - 0.64. Ribbing remains strong to the aperture with only two secondaries to each primary and the loss of the high, conical nodes. Most primary ribs bifurcate simply at the point of maximum whorl width. Flanks are less steep than on the phragmocone whorls. Lappets are ventro-lateral, short and spatulate with prominent growth lines (Pl. 2, figs. 1a, 2a); there is no strong constriction preceding the aperture and only weak flaring of the flanks.

Remarks. — Z. richardsoni is distinguished from the four “species” of ‘Kanastephanus’ described from this locality (McLearn, 1929) by having a broader living chamber (H/W = 0.62 - 0.64 vs. 0.68 - 0.74) and less arched venter. It also has more prominent conical nodes, broad rectiradiate primary ribs and steep, convex flanks; it resembles ‘Kanastephanus’ spp. in the loss of nodes on the body chamber and decline of secondary rib density to two per primary.

Dimorphism. — Comparison of whorl dimensions and ribbing pattern on the phragmocone whorls shows these specimens to be identical with the inner whorls of Z. richardsoni (Text-figs. 5, 7; compare Pl. 1, figs. 3c, 4 with Pl. 2, fig. 3; Appendix 1) which occurs in the same beds both at MacKenzie Bay and in southern Alaska. Both show...
steep flanks with massive primary ribs and large, conical nodes, broad venter and similar changes in ribbing density at the same growth stages during ontogeny. Ornamentation of the body chamber, however, is quite different: while the microconch retains strong, bifurcating ribs but loses the sharp, conical nodes (Pl. 2, figs. 1a, 2a, 4) the macroconch has an almost smooth body chamber except for the large, rounded nodes low on the flanks (Pl. 1, figs. 1, 2). Adult macroconchs are about twice the size of microconchs and in the MacKenzie Bay strata outnumber them approximately four to one.

_Zemistephanus crickmayi_ (McLearn, 1927) δ

[? microconch to _Z. carlottensis_ (Whiteaves, 1876) ?]

Plate 2, figures 5-8; Plate 5, figure 2; Text-figures 8-10, 11a-c

1927. _Kanastephanus crickmayi_ McLearn, p. 73; pl. I, figs. 5, 6.
1929. _Kanastephanus crickmayi_ McLearn; McLearn, pp. 23, 24; pl. XVI, figs. 7, 8.
1929. _Kanastephanus canadensis_ McLearn, p. 25; pl. XV, figs. 4, 5.
1929. _Kanastephanus mackenzii_ McLearn, p. 23; pl. XVI, figs. 1-3.
1949. _Normannites (Kanastephanus) crickmayi_ McLearn; McLearn, pp. 13, 16.
1954. _Itinsaites crickmayi_ (McLearn); Westermann, pp. 290-292; figs. 122, 123; pl. 27, fig. 3.
1964. _Normannites (Itinsaites) crickmayi_ (McLearn); Imlay, pp. B43, 44; pl. 14, figs. 3-8, 13.
1964. _Normannites (Itinsaites) itinsae_ (McLearn); Imlay, p. B44; pl. 14, figs. 1, 2.

_Holotype._ — _GSC 9016, from the lower part of the Yakoun Formation on the north side of Maude Island, Queen Charlotte Islands, 10-22 ft. (3–7 m) above the base of the section exposed there (McLearn, 1929, p. 23)._ Material. — The holotypes of McLearn's four "species" of _Kanastephanus_ (GSC 9016, 9017, 9018, 9019) have been reexamined; one additional complete specimen (McM J1798a) and a number of fragments (McM J1798b-h) were collected from the type locality at MacKenzie Bay. Six specimens from the Fitz Creek Siltstone in southern Alaska (USGS Mesozoic locs. 2999, 3000, 19997, 21276).

_Description._ — The protoconch is smooth and elongated transverse to the plane of coiling; its width is about twice the diameter (Text-fig. 8). Though the nepionic constriction was not observed, after approximately one whorl (at _D_ = 0.85 mm) there is a sudden decrease in relative whorl width and an increase in umbilical diameter. After this point growth ratios remain constant throughout the phragmocone (Text-fig. 9). On the first whorl the shell is smooth and globose with broadly arched venter and strongly convex flanks falling steeply towards the umbilical seam. The siphuncle is central. At _D_ = 3.0 mm small, elongated tubercles appear along the sharp lateral shoulder which is situated at about 30 to 40 percent of the whorl height. These elongated tubercles are directed adapicad onto the upper flanks. They also extend slightly onto the venter as faint, broad undulations when the diameter reaches 4.5 mm. There are 10 per half-whorl. The whorl cross-section is broad and depressed (H/W = 0.50 - 0.60) with a gently arched venter, sharp lateral shoulder and steep, convex flanks. Secondary ribs extend across the venter becoming much stronger than the primary ribs and outnumbering them two to one. Throughout the phragmocone the whorls remain broad and depressed with H/W ratios of 0.55 - 0.65.

The number of primary ribs per half-whorl decreases from 10-13 on the earliest whorls to a minimum of six to eight at umbilical diameters between 5 and 15 mm, then increases again to eight to 12 at the end of the phragmocone (Text-fig. 9). At the same time the number of secondaries per half-whorl increases to a maximum, then declines on the body chamber. The ratio of secondary to primary ribs increases from two on the earliest whorls to three or four, and later decreases on the body chamber to two. Similar variations in ribbing density during ontogeny were also noted on _Z. richardsoni_ δ. Primary ribs are broad and massive, but a little sharper and more curved than on _Z. richardsoni_ δ; the nodes on _Z. richardsoni_ δ are more massive and conical.

The body chamber is about one whorl in length and is marked by egression of the umbilical seam from the line of nodes on the previous whorl, changes in the shape of the
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

Text-figure 9.—Bivariate plots of whorl width (W), whorl height (H), umbilical diameter (U), shell diameter (D) and number of primary (P) and secondary (S) ribs per half-whorl, for *Zemistephanus crickmayi* (with synonyms) from Queen Charlotte Islands and southern Alaska. Based on 13 microconchs, with some individual “growth lines” indicated. See Measurements for additional explanations.

cross-section, and ornamentation. The flanks become less steep and the lateral shoulder more rounded with contraction of the whorl (Text-figs. 9, 11); H/W increases to 0.65 - 0.75. Primary and secondary ribbing remain strong to the aperture but the nodes disappear; primary ribs simply bifurcate. There is no constriction or flaring at the aperture, which terminates with lateral lappets.

Remarks.—The narrow body chamber clearly separates *Z. crickmayi* from *Z. richardsoni*, which occurs in the same beds at MacKenzie Bay. There is only a slight increase in the H/W ratios on the body chamber of that species from 0.50 - 0.60 to 0.62 - 0.64 while the values for the same stages on *Z. crickmayi* are 0.55 - 0.65 and 0.65 - 0.75 respectively. The venter on the body chamber of *Z. crickmayi* is more highly arched, having a radius of curvature of 80-100 mm at a diameter of 30 mm compared with a radius of curvature of 140 mm for *Z. richardsoni* at the same size. In addition, the nodes on the phragmocone whorls of *Z. richardsoni* are more massive and the primary ribs broader and rectiradiate. In the material described by Imlay
Text-figure 10. — a, sutural ontogeny for *Zemistephanus crickmayi* ♂ (USGS Mesozoic loc. 2999.4); b, adult septal suture of *Z. alaskensis* ♀ (USGS Mesozoic loc. 2999.2), both from southern Alaska. The position of the umbilical seam is marked by . See *Measurements* for additional explanations.

(1964) as *N. (I.) crickmayi* (McLearn) from southern Alaska he notes a considerable variation in whorl width; this suggests that specimens of both *Z. richardsoni* ♂ and *Z. crickmayi* ♀ are present, but because of crushing are not easily distinguished.

McLearn (1929) distinguished four “species” in his genus *Kanastephanus* based on minor differences in coiling and ornamentation. *K. altus* supposedly has a higher whorl section and wider umbilicus but growth curves (text-fig. 9) show these differences to be very small and intermediate between values from other specimens. *K. mackensii* was separated from the type species because it had more primary ribs but the number per half-whorl is the same as on *K. altus* and some of the Alaskan material. *K. canadensis* has slightly broader whorls than the other “species” but is identical in this character with McM J1798a from MacKenzie Bay as well as some of the Alaskan material. Each of McLearn’s four “species” was based on a single specimen, and the minor variations used to distinguish them are here shown to lie within the range of variation of all the available material representing *Z. crickmayi* (McLearn) ♂ (Text-fig. 9).

This species could be the microconch of *Z. carlottensis* (Whiteaves) ♀, the holotype of which (Pl. 3, fig. 1a, b) probably came from the MacKenzie Bay locality. Both forms are characterized by coronate early whorls that contract strongly on the body chamber, losing the steep flanks. At the same time relative whorl height increases with stronger arching of the venter. Broad ribbing persists to the aperture on both forms with a decline in the density of the secondaries to two per primary and loss of the prominent nodes. However, the only other macroconchs described are from southern Alaska (Imlay, 1964) and the few entirely septate specimens are too crushed to allow significant comparisons of whorl dimensions to be made.

**Zemistephanus alaskensis** n. sp. ♀
Plate 5, figure 1; Text-figure 12

1964. *Teloceras itinsae* McLearn; Imlay, p. B50; pl. 23, figs. 9, 10 (holotype); pl. 24, figs. 5, 7. (? 1, 2).
1964. *Zemistephanus richardsoni* (Whiteaves); Imlay, p. B51; pl. 25, fig. 6; non pl. 25, fig. 7 and pl. 26, figs. 1-7.

Holotype. — USNM 131434, described and figured by Imlay (1964; pl. 23, fig. 10) as a “plesiotype” of *Teloceras*
Text-figure 11. — a-c. Cross-sections of Zemistephanus crickmayi δ, body chamber shaded, × 1.3. a,c, from southern Alaska (USGS Mesozoic loc. 21270.1); b, from Queen Charlotte Islands (McM J1798a); d, cross-section of Z. warreni (McLearn) 9, fully septate holotype from southern Alberta, × 1. See Measurements for additional explanations.

*itinsae* McLearn, from USGS Mesozoic loc. 21270 in the Fitz Creek Siltstone of the Tuxedni Group, Tuxedni Bay, southern Alaska.

**Material.** — Three other specimens from the Fitz Creek Siltstone in southern Alaska (USGS Mesozoic locs. 2999, 21270; McM J1245); two specimens (McM J1858a, J1858b) from shales 30 m above the base of the Yakoun Formation exposed at MacKenzie Bay and another (McM J1859) from 20 m above the base of the section.

**Description.** — The large macroconch reaches a maximum diameter of at least 155 mm and has a simple, slightly flared aperture. The phragmocone whorls are depressed (H/W = 0.55 - 0.65) with steep flanks, producing a deep umbilicus. The venter is broad and gently arched, curving sharply onto the flanks along the line of nodes to form an abrupt lateral shoulder (Text-fig. 12). The primary ribs are broad, rounded undulations, rectiradiate or slightly curved forward on the inner whorls, eight to 10 per half-whorl, and end in prominent, conical nodes. The secondaries are prominent and broad, curving forward from the nodes and then crossing straight over the venter, usually with 3 to 3.5 to each primary.

The body chamber is a single whorl long and is marked by changes in growth ratios similar to those in other species of the genus. Egression of the umbilical seam from the line of nodes on the previous whorl begins just after the last septum; it is accompanied by strong contraction of the whorl with a marked decrease in the absolute whorl width and increase of whorl height so that H/W ratios change from 0.60 - 0.65 at the end of the phragmocone to 0.80 - 0.95 near the aperture. The flanks become less steep and are nearly flat near the aperture while the undulations forming the primary ribs almost disappear. The conical nodes remain prominent to the aperture but occur successively higher on the flanks: at 36 percent of the whorl height on the phragmocone, 40 to 45 percent on the early body chamber and 55 to 60 percent near the aperture. Strong, coarse secondary ribs persist to the end, usually 3 to 3.5 to each node. On two specimens (USNM 131437 and another from USGS Mesozoic loc. 21270) secondary ribbing is obscured by fine striae (shell) on the early parts of the body chamber.

**Remarks.** — Coronate inner whorls with steep flanks, low and distant primary ribs on the juvenile whorls becoming...
shortened on the intermediate and obsolete on the outer whorls, large conical nodes set low on the whorl, and a gently arched venter are all features of the other known species of *Zemistephanus*. The marked egression of the body chamber with decrease in whorl width and flattening of the flanks, and the persistence of the large, rounded nodes to the aperture are also diagnostic of the genus. This species differs from *Z. richardsoni* (Whiteaves) in the persistence of broad secondary ribs to the aperture, the higher position of the nodes on the flanks and the more rounded section of the body chamber. The density of secondary ribbing on the phragmocone is lower and the ribs are much coarser than on *Z. richardsoni*. *Z. carlottensis* (Whiteaves) differs in the steeper umbilical slope, the lower position of the lateral shoulder (at 30 to 35 percent of the whorl height), and in lacking the large, conical nodes on the last part of the body chamber. The similar *Stephanoceras* (*Stemmatoceras*) ex. gr. *acuticostatum* (Weisert) ["Teloceras itinsae" McLearn] differs in the prominent primary ribs on all but the ultimate one or two whorls.

The corresponding microconch is unknown.

**Zemistephanus warreni** (McLearn, 1930) ♀

Plate 4; Text-figure 11d

1930. *Teloceras warreni* McLearn, p. 3, pl. 1, fig. 4.
1932b. *Teloceras warreni* McLearn; McLearn, p. 113, pl. 3, fig. 4.
Yakoun Formation of the Queen Charlotte Islands. The transfer of this species to that genus.

VII, fig. 1). The close affinity to Stephanoceras closely allied to Sowerby, 1825 (by subsequent designation of Buckman, 1898). Type specimen refigured by Buckman (1908; pl. VII, fig. 1).

Discussion. — The taxonomy of the group of ammonites closely allied to Stephanoceras Waagen has long been the subject of disputed and varied treatments, especially in Europe; our treatment for North American forms is summarised in Table 5. Early nomenclatural difficulties arose because of doubt concerning the availability of the name Stephanoceras; this was settled by Spath (1944) who pointed out that the similar spelling of the older name Stephanoceras (Rotatoria) did not invalidate the younger name Stephanoceras. He also emphasized that the type species was Stephanoceras humphriesianum (J. de C. Sowerby, 1825) by a subsequent designation of Buckman (1898, p. 454).

Because he believed the name was pre-occupied, Buckman had emended Stephanoceras to Stepheoceras; while rejecting the need for this alteration Mascke (1907), however, retained both names, separating forms with a very wide umbilicus, weaker sculpture and a strongly enlarged aperture as Stepheoceras Buckman (group of Amm. Humphriesianus Sow.). Those species with heavy sculpture, a deeper umbilicus and only slightly enlarged aperture (group of Amm. Humphriesianus mutabilis Quenstedt) were described as Stephanoceras (Waagen) em. Mascke. In addition he proposed three new groups of closely related stephanoceratids: Stemmatoceras, Skirroceras and Teloceras.

**Stemmatoceras** (type species: Amm. Humphriesianus coronatus Quenstedt, 1886-1887 [= S. frechi Renz, 1913] included forms with a wide umbilicus, depressed whorls and medium-strong sculpture that declines on the body chamber, particularly in the density of secondary ribbing. Skirocceras (type species: Amm. Humphriesianus macer Quenstedt, 1886-1887) was separated from Stemmatoceras because of its more strongly incised sutures and wider, shallower umbilicus. The whorls expand only slowly and are rounded in section with less inflated flanks on the body chamber. Teloceras (type species: Amm. Blagdeni J. Sowerby, 1818) was characterized by great whorl thickness with large nodes on a sharp lateral edge that persisted onto the body chamber, with a decline in the strength of ornament (and rounding) only near the aperture.

In his extensive review of the group Weisert (1932) recognized only three subgenera: Stephanoceras Waagen, 1869; Stemmatoceras Mascke, 1907; and Teloceras Mascke, 1907. He included Mascke’s Skirroceras and Stepheoceras, along with many of Buckman’s vast array of stephanoceratid “genera” (Kallistephanus, Skolekostephanus, Rhytostephanus, Oecostephanus, Stegoostephanus, Mollistephanus, Kumatoostephanus) in Stephanoceras Waagen. In addition he gave a detailed discussion of the characters distinguishing each genus throughout ontogeny. Included under Stephanoceras Waagen were forms with a rounded whorl section, narrow to broad umbilicus, ribbing of variable strength and low, fine nodes; the suture was said to be strongly differentiated, with a greatly subdivided “1st lateral” saddle (? L/U). Stemmatoceras on the other hand was defined as having a poorly-differentiated suture (of which the “1st lateral” saddle was only weakly subdivided), strong, high and pointed nodes with a decrease in the strength of the sculpture on the body chamber. The whorls are not as rounded as in Stephanoceras and the venter is not as highly arched.

While following Weisert’s treatment of these closely related forms, Schmidtill and Krumbeck (1938) again made clear reference to the existence of two groups within Stephanoceras Waagen as defined by Weisert. They emphasized the contrast between the group [containing S. umbilicum (Quenstedt), S. auberbachense Schmidtill and Krumbeck and S. mutabile (Quenstedt)] having a deep umbilicus of medium width with broader whorls and the group [including S. humphriesianum (Sowerby), S. zieteni Quenstedt and S. scalar Mascke] that all have a fairly wide, shallow umbilicus, discoidal form and higher whorl section (p. 324). These two groups would correspond to “Stephanoceras Waagen emend. Mascke” and “Stepheoceras Buckman” respectively. Schmidtill and Krumbeck did not add further
to the discussion of the genus Skirroceras Mascke, but unlike Weisert (1932) accepted as reasonable its separation from Stephanoceras.

The lectotype of S. humphriesianum (BM 43908a) is an entirely septate specimen cut along the sagittal plane; thus nothing is known of its adult size or body chamber characteristics. It does, however, have a rounded whorl section lacking a lateral shoulder, and a broad, shallow umbilicus with uncoiling commencing at least one complete whorl (at U = 20-25 mm) before the end of the specimen. Clearly this specimen is closer to the more serpenticone forms of Skirroceras than to the S. mutabile group and its designation as type species is unfortunate. Also, those forms with broader whorl section, less arched venter, stronger and sharper ornamentation and later uncoiling (often at U = 40 mm and corresponding to the beginning of the body chamber) bear close resemblance to Stemmatoceras. Indeed, Schmidtill and Krumbeck (1938, p. 325) noted that forms of S. mutabile “show a remarkable approach” to Stemmatoceras. Other members of this group would include S. brodiae (J. Sowerby), S. umbilicum (Quenstedt), S. itinas (McLear) and S. skidegatense (Whiteaves). However, it must be emphasized that whatever character or combination of characters is used, there are transitional forms that are difficult to place confidently in one subgenus. There seems to be a morphological trend within the group for prolongation of the juvenile morphology into successively mature stages of the conch (Mouterde et al., 1971, p. 12). Thus in the early Skirroceras only the innermost whors are comparatively involute cadicones; in Stephanoceras and Stemmatoceras these characters are present in successively later stages until in Teloceras most of them persist to the aperture. However, at any stratigraphic level a variety of morphologies is commonly present, and only the proportions change with time (Callomon, pers. comm.).

Although Teloceras, with its broad, coronate whors persisting to the body chamber, is clearly distinguishable in the adult stage, a number of specimens of this genus from western Europe and South America examined by us (including T. cf. blagdeni from Goslar, Germany) have juvenile whors that are difficult to distinguish from those of the relatively broadwhorled Stephanoceras spp. And, on the other hand, stephanoceratids with typically coronate juvenile and even intermediate stages may have rounded and planulate adult whors (i.e., Stemmatoceras). This again emphasizes the necessity of basing systematic distinctions on mature specimens with known body chamber characteristics; many European species have been erected for small, incomplete phragmocones; e.g., the small nucleus that is the type specimen of S. umbilicum Quenstedt makes proper interpretation of that species impossible. Similar situations have led to blurring of the distinctions between Teloceras, Zemistephanus, Stephanoceras s.s. and S. (Stemmatoceras) in North America.

In the Treatise on Invertebrate Paleontology, Arkell (1957, p. 1289) treated Skirroceras as a subgenus of Stephanoceras s.s., but retained Stemmatoceras and Teloceras as separate genera. The great variety of Stephanoceras s.s. and the morphological resemblance of some species to Stemmatoceras require that Stemmatoceras also be classified as a subgenus of Stephanoceras Waagen. Indeed, many specimens from North America that have been identified with Stemmatoceras are here shown to be closely allied with the Stephanoceras itinas group and thus also to the broader-whorled European forms such as Stephanoceras mutabile (Quenstedt). Stemmatoceras is here treated as a subgenus of Stephanoceras because of the gradation in characters previously used to distinguish the two “genera”.

Teloceras is also linked to S. (Stemmatoceras) by a series of morphologically intermediate species that characterize by relatively narrow but, nevertheless, coronate immature whors bearing distant primaries with prominent nodes; the rounded adult ultimate whorl (including body chamber) clearly distinguishes complete specimens from typical Teloceras, but it is commonly crushed or missing. This is the species group of ‘T.’ acuticostatum Weisert, including the poorly known European species ‘T.’ subblagdeni Schmidill and Krumbeck and ‘Cadomites’ blagdeniformis Roché, which seems to be diagnostic of the lower T. blagdeni subzone in western Europe (Schmidill and Krumbeck, 1938; Mouterde et al., 1971) and continues to be classified in Teloceras. Following this precedent, Westermann (1964a, p. 68) originally classified Stemmatoceras tentatively as a subgenus of Teloceras, but later (Westermann and Getty, 1970, p. 248) because of the abundance of the intermediate forms (‘T.’ acuticostatum group) in the circum-Pacific area, united all in the single genus Stephanoceras. Most if not all of the North American species originally described under Teloceras belong to the ‘T.’ acuticostatum group (see below), and this entire group is here transferred to Stephanoceras (Stemmatoceras). Because of the great morphologic distance of the typical European Teloceras (the T. blagdeni group) from the typical Stephanoceras (s.s.), because of its well-established chronologic significance, and after consulting a number of colleagues, we decided to distinguish Teloceras at the genus level. Teloceras is thus redefined to include (in the macroconchs) only the extremely and completely coronate, large Stephanoceratinae.
Taxonomic treatment of microconch Stephanoceratidae has been varied. Westermann (1954) originally retained Itinsaites as a genus, making the Canadian species of Kanastephanus synonymous with it, but later (1964a) considered it tentatively as a subgenus of Teloceras. Arkell (1957, p. L289) placed Normannites, including Itinsaites, Kanastephanus, and others, in the family Otoitidae. McLearn (1949) and Imlay (1964) both regarded Itinsaites as a subgenus of Normannites; Imlay also transferred the four Canadian species of Kanastephanus to Itinsaites, rightly suggesting that they probably represented a single species. However, all Kanastephanus spp. differ from Itinsaites and are in fact the corresponding microconchs to Zemistephanus McLearn.

The pairing of macroconch-microconch genera in the family Stephanoceratidae was attempted by Westermann (1964a); microconch equivalents for Stephanoceras, Stemmatoceras, Teloceras, Zemistephanus, Kumastephanus and Cadomites were sought in the several subgenera or related genera of Normannites Munier-Chalmas. Itinsaites McLearn is here shown to be the microconch equivalent to Stephanoceras s.s. (part). Comparison of the inner whorls of Itinsaites itinsae McLearn and Stephanoceras yakounense McLearn from South Balch Island in the Queen Charlotte Islands indicates they are corresponding dimorphs (see discussion under Stephanoceras itinsae). Itinsaites McLearn thus becomes a junior subjective synonym of Stephanoceras Waagen.

Table 5.—Genus-group classification of North American Stephanoceras and Teloceras (excluding Mexico).

<table>
<thead>
<tr>
<th>Subgenus STEPHANO CERAS Waagen, 1869</th>
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<tbody>
<tr>
<td>Stephanoceras (Stephanoceras) itinsae (McLearn, 1927) ♀ + ♂</td>
</tr>
<tr>
<td>Plates 6-8; Plate 11, figure 1; Plate 13, figure 2; Text-figures 13-17</td>
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*S. itinsae* ♀ (macroconch) ['S. yakounense']

1930. *Stephanoceras yakounense* McLearn, p. 5; pl. 1, fig. 1 (holotype).
1932a. *Stephanoceras yakounense*; McLearn, p. 56; pl. 2, fig. 1 (holotype); pl. 3, figs. 2 and 6 (holotype); pl. 5, fig. 10.
1947. *Stemmatoceras meclareni* Warren, p. 68; pl. 1, fig. 1; pl. 4, fig. 1.
1947. *Stemmatoceras carri* Warren, p. 69; pl. IV, fig. 2; pl. VI, fig. 3.
1957. *Stemmatoceras ex. gr. skidegatensis* (Whiteaves); Frebold, p. 49; pl. XXI, fig. 1; pl. XXII, fig. 2; pl. XXV, fig. 2.
1957. *Stemmatoceras albortense* McLearn; Frebold, p. 59; pl. XXI, figs. 2a, b; pl. XXIII, figs. 1a-c.
1967. *Stephanoceras cf. skidegatensis* (Whiteaves); Imlay, p. 89; pl. 6, fig. 10.

Allotype.—GSC 9057, almost complete internal mold from lower part of the Yakoun Formation, South Balch Island, Skidegate Inlet, Queen Charlotte Islands [originally the holotype of Stephanoceras yakounense].

Material.—Ten relatively complete specimens (McM J1807-J1811) and many other phragmocone and body chamber fragments were collected from the type locality; also from this locality four specimens, three almost complete, were collected by Sutherland Brown (GSC locs. 48601, 44711) and two were collected by McLearn (GSC loc. 13634). One complete specimen and another with part of the body chamber were collected by Sutherland Brown from Reef Island, Queen Charlotte Islands (GSC loc. 40985). Two specimens, one almost complete, were obtained on loan from University of British Columbia Museum, labelled “Skidegate Channel”. The holotype and McLearn’s “plios type” were also reexamined.

Description.—Maximum diameters of adult macroconchs range from 148-196 mm. One body chamber fragment is 66 mm wide at the position of the last septum and must have attained a greater diameter than any of the complete specimens examined; most adults reach a maximum width of only 60-65 mm at the aperture.

On the phragmocone the umbilical seam lies along the outer edge of the line of tubercles on the previous whorl. The whorls are much wider than high, with H/W = 0.55 - 0.60 at diameters up to 30 mm; throughout ontogeny the whorls gradually become higher with H/W = 0.65 - 0.70 between diameters of 30 and 100 mm (Text-fig. 15). The flanks are strongly convex with strong primary ribs that are prorsiradiate and curved forwards, ending in prominent conical tubercles situated at about 50-65 percent of the whorl height and just above the point of maximum whorl width.
The flanks curve strongly onto the broadly arched venter forming a lateral shoulder, particularly on the phragmocone whorls. The number of primary ribs per half-whorl increases slowly throughout ontogeny from nine at diameters up to 30 mm to 11 at 30-60 mm and 14 at 60-100 mm. The number of secondary ribs also increases from three per primary on the inner whorls to a maximum of four to five at diameters between 40 and 50 mm and declines again to three on the...
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Text-figure 15. — Cross-sections of *Stephanoceras itinsae* 9, body chamber shaded; a, (McM J1808g) × 2; b, (UBC collections) × 1. See *Measurements* for additional explanations.

Body chamber. Secondary ribs curve slightly forward from the tubercles, then cross straight over the venter.

At diameters between 95 and 130 mm uncoiling begins (this corresponds to U = 35 - 55 mm), the umbilical seam moving gradually away from the line of tubercles, coiling thus becoming more serpenticone. The point at which uncoiling begins also corresponds closely to the beginning of the adult body chamber, which is usually three-quarters of a whorl in length. On the body chamber there is a decrease in relative whorl height and width (Text-fig. 13) while the

Text-figure 14. — Sutural ontogeny of *Stephanoceras itinsae* 9, incomplete for early stage (a-b, McM J1810b; c-d, J1808g; e, J1809a). The position of the umbilical seam is marked by (. See *Measurements* for additional explanations.)
H/W ratio increases to about 0.75 and may be as high as 0.90. In cross-section the body chamber is oval with the venter more strongly arched than on the phragmocone, is almost as high as wide, and has lost the strong lateral shoulder seen on the phragmocone. There are 16-26 (average 19) primary ribs on the final half-whorl and commonly three secondaries to each primary rib. However, the secondary ribs are much fainter than the primary ribs while the tubercles become blunt and rounded and sometimes obsolescent near the aperture. The primary ribs are shorter near the aperture, extending to less than 50 percent of the whorl height. The aperture is marked by a broad, shallow constriction and a slightly expanded, complete lip.

The suture is moderately deeply incised (Text-fig. 14). E is deep and narrow, L fairly broad, straight and trifid, almost as deep as E. Umbilical lobes are strongly retracted; \( U_0 \) is deep, narrow, trifid and oblique; I is much deeper and narrow. E/L is broad and high; L/U\(_2\) is very broad and not nearly as high as E/L. The tubercle is situated on L/U\(_2\).

Remarks. — \( S. \) itinsae \( ? \) strongly resembles the European species group of \( S. \) umbilicum (Quenstedt), including \( S. \) mutabile (Quenstedt) and \( S. \) brodai (Sowerby), all of which are characterized by a relatively deep umbilicus with late uncoiling and broad whorls. \( S. \) umbilicum at similar diameters has a considerably smaller umbilicus (33 percent of diameter vs. 40-50 percent on \( S. \) itinsae), and relatively wider whorls (H/W of 0.58 vs. 0.68). \( S. \) mutabile has a less depressed whorl section than \( S. \) itinsae (H/W of 0.75 vs. 0.65 - 0.70 on \( S. \) itinsae at similar diameters). \( S. \) itinsae most closely resembles \( S. \) brodai differing only slightly in ornamentation: the holotype of \( S. \) brodai has fewer primary ribs (13 per half-whorl vs. 15-24 on \( S. \) itinsae at D = 105 mm). However, other specimens in the British Museum (Natural History) regarded as conspecific with \( S. \) brodai have ribbing densities closer to those on \( S. \) itinsae \( ? \). The tubercles on \( S. \) brodai are larger and more rounded than the sharp, pointed tubercles characteristic of \( S. \) itinsae \( ? \).

The single specimen from the Rock Creek Member in Ribbon Creek, southern Alberta, described by Frebold (1957, pp. 50, 51) as Stemmatoceras albertense McLearn, is very similar to \( S. \) itinsae \( ? \) in whorl dimensions, coiling and the style and density of ribbing but differs from the poorly preserved holotype in the narrower and probably more rounded whorls. The inner whorls are subcoronate, wider than high (H/W = 0.60 - 0.70 at D = 60 mm) with a broadly arched venter, distinct lateral shoulder and steep, convex flanks curving continuously to the umbilical seam that runs along the line of tubercles on the previous whorl. Primary ribs are strong and fairly sharp on the inner whorls, curving forward slightly with small, rounded tubercles at about 50 percent of the whorl height. The secondary ribs are also strong and sharp, passing almost straight over the venter from the tubercles. On the outermost preserved whorl (of which three-quarters is body chamber according to Frebold's description) the primary ribs become broader and less sharp but remain curved, the tubercles decline in strength and the secondary ribs are less sharp but still spaced 3 to each primary. The increase in the density of secondary ribbing from three to four per primary at diameters between 40 and 50 mm with the subsequent decline to three on the body chamber matches similar ontogenetic variation in \( S. \) itinsae \( ? \).

Two other specimens described and figured by Frebold (1957, pp. 49, 50; pl. 21, fig. 1; pl. 22, fig. 2; pl. 25, fig. 2) as Stephanoceras ex. gr. skidegatense (Whiteaves) are more probably identical with \( S. \) itinsae \( ? \), having three secondary ribs to each primary on the adult whorls; these secondary ribs are broad, rounded and faint, not sharp as on \( S. \) skidegatense \( ? \).

'Stemmatoceras' carri Warren (Pl. 13, fig. 2) was based on three syntypes characterized by depressed elliptical whorls with rounded lateral shoulders and strong rounding of the outer whorl(s). The long, curved primary ribs were said to be less robust and more closely spaced than those of 'Stemmatoceras' melearnii; the inner flanks of \( S. \) carri are steeper and more inflated, at least on the early whorls (Warren, 1947, p. 69). The syntype from the headwaters of Sheep Creek near Burns Mine (UA Jr 485) is an incomplete phragmocone (\( D = 80 \) mm) with whorl dimensions similar to those of the inner whorls of \( S. \) itinsae \( ? \) and with similar ornamentation: long, curved primary ribs (16 per half-whorl at \( D = 80 \) mm) terminating in small, sharp tubercles and with three to four fine secondary ribs per primary. 'Stemmatoceras' carri is therefore a junior subjective synonym of \( S. \) itinsae.

The holotype of 'Stemmatoceras' melearnii Warren (UA Jr 192) from Cadomin, Alberta, is very similar to \( S. \) itinsae \( ? \) in coiling and ribbing. The almost entirely septate holotype egresses near the end. The umbilicus is broad and shallow with slightly inflated flanks rounding gently onto the venter. On the internal mold the ribs are only of moderate relief, long and curved with small, round tubercles. On the greater part of the ultimate whorl the venter has been badly crushed and corroded but the secondary ribs are of moderate relief, and curve slightly forward from the tubercles, with about three to each primary at the beginning of the body chamber. Umbilical lobes of the suture are strongly retracted. This species bears a close resemblance to Stephano-
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Stephanoceras obsenum Imlay, from the lower part of the Tuxedni Formation in the Talkeetna Mountains of southern Alaska (Imlay, 1964, p. B45), has almost the same whorl dimensions as S. itinsae on the phragmocone whorls (H/W = 0.70), though the body chamber of the Alaskan material is unknown. Both have closely similar rib densities and style of ornamentation, although the secondaries on S. obsenum are slightly finer and sharper.

Stephanoceras itinsae \( \delta \) (microconch) ['Itinsaites']

1927. Itinsaites itinsae McLearn, p. 73; pl. I, fig. 7 (holotype).
1929. Itinsaites itinsae; McLearn, pp. 25, 27; pl. XV, figs. 2, 3 (holotype).
1933. Otoitites reesidei Crickmay, p. 912; pl. 27, figs. 9-11.
1949. Normannites (Itinsaites) itinsae (McLearn); McLearn, pp. 15, 16.
1954. Itinsaites itinsae McLearn; Westermann, pp. 251-254; pl. 26, figs. 5a, b (holotype refigured); pl. 27, figs. 1a, b; text-figs. 101-107.

Holotype. — GSC 9020, from the lower part of the Yakoun Formation, South Balch Island, Skidegate Inlet, Queen Charlotte Islands.

Material. — The holotype was reexamined and compared with three other complete specimens in the GSC collections, Ottawa, that came from the type locality (GSC locs. 13634, 48601). Four complete specimens (McM J1799a-c, J1800) and numerous fragments and incomplete phragmocones (McM J1799d, J1801a, b and J1810b) were collected by Hall from the type locality.

Description. — The protoconch is cigar-shaped, elongated transverse to the plane of coiling, and is more than twice as wide as high (D/W = 0.43) with a diameter in the plane of coiling of 0.43 mm (Text-fig. 16). At a diameter of 0.8 mm the nepionic constriction, seen clearly on the venter, marks the end of the first whorl.

The shell is smooth up to a diameter of 2.5 mm. The first ornamentation consists of broad secondary ribs and small tubercles along the lateral shoulder; primary ribs are faint. By D = 6 mm strong, curved primary ribs extend from the umbilical seam to the lateral shoulder where they terminate in large, conical tubercles; two secondary ribs arise from each tubercle and at this stage in growth are stronger and sharper than the primary ribs. Whorls are much wider than high (H/W = 0.50-0.60) with a broad, slightly arched venter, pronounced lateral shoulder and gently convex flanks curving gradually to the umbilical seam that runs just on the ventral side of the row of tubercles on the previous whorl.

Throughout the phragmocone the whorls are coronate in cross-section, wider than high with a broadly arched venter (Text-fig. 16); the line of tubercles and the position of the pronounced lateral shoulder are a little higher on the flanks than the position of maximum whorl width (as measured between the primary ribs). Secondary ribs remain sharp, stronger than the primary ribs, and increase in density from two per primary to three and even four. Primary ribs are strongly curved forward reaching their maximum strength in the centre of the flanks and becoming weaker towards the umbilical seam and also towards the tubercles; the latter are large, conical and sharp. The number of primary ribs per half-whorl increases gradually from eight at diameters below 30 mm to 10 at diameters between 30 and 40 mm.

The body chamber is half a whorl or a little more in length, but conspicuous uncoiling occurs only in the last
Text-figure 17.—Sutural ontogeny for *Stephanoceras itinsae* ♂ from Queen Charlotte Islands (McM J1800). The position of the umbilical seam is marked by (See *Measurements* for additional explanations.

quarter-whorl before the aperture where the umbilical seam moves away from the line of tubercles on the previous whorl. This is accompanied by a decrease in relative whorl height and width, with a marked change in the cross-section which becomes rounded with loss of the marked lateral shoulder. There is an increase in the H/W ratio from 0.60 at the end of the phragmocone to 0.70-0.80 just behind the aperture. Ornamentation on the body chamber remains strong, the sharp, curved primary ribs now stronger than the secondaries. There are 10 to 12 primary ribs on the last half-whorl with 2.5 to 3.0 secondary ribs to each primary; tubercles become a little less sharp but are still prominent. The aperture is marked by a narrow constriction with a flared lip extending into long, lateral lappets. Maximum diameters of about 50 mm are attained.

On the single protoconch obtained there are two closely spaced protosepta showing the large, rounded ventral saddle with adjacent narrow lobes on the external suture (Text-fig. 16). $U_n$ appears high on the outer flank of $I/U_1$ at a diameter of 2 mm. The mature suture is not deeply dissected; E is deep and narrow, L short, broad and trifid and the umbilical lobes strongly oblique. E/L is high and broad and not deeply dissected (Text-fig. 17). The tubercle lies on the ventral edge of $L/U_2$.

Remarks.—McLearn (1929, pp. 26, 27) separated this species from the other lappet-bearing stephanoceratids on the Queen Charlotte Islands (i.e., *Kanastephanus* spp.) on the basis of the greater density of secondary ribbing. *I. itinsae* maintains a 3:1 ratio of secondary to primary ribs on the body chamber but on *Kanastephanus* this ratio declines to 2:1. All other material known from South Balch Island has a density of 3:1. The number of primary ribs per half-whorl increases gradually during ontogeny from eight to 12 whereas on *Kanastephanus* this number shows an initial decrease from 10 to 13 to six to eight with an increase to eight to 12 again on later parts of the phragmocone. In addition, the primary ribs on the phragmocone of *I. itinsae* are sharper and more strongly curved than those of *Kanastephanus* and the tubercles are smaller and sharper, persisting onto the body chamber while on *Kanastephanus* the tubercles are lost on the body chamber where the ribs bifurcate simply.

Two partially preserved specimens from the Rock Creek Member of the Fernie Group (UA Jr 491, 494) were tentatively placed in *Itinsaites* by Warren (1947, p. 73). In-
spéculation of the figures (pl. VI, fig. 2; pl. VII, fig. 2) indicates ribbing densities similar to those of 'Itinsaites' but the growth stage is unknown. One complete specimen (Pl. 8, fig. 7) from the Rock Creek Member at Ribbon Creek, southern Alberta, shows the body chamber with three secondary ribs to each primary. The body chamber is a little wider than on the specimens from the Queen Charlotte Islands. Other incomplete small specimens from the Ribbon Creek locality probably also belong to this species.

The single specimen figured by Imlay (1964; pl. 14, figs. 1, 2) as N. (I.) itinsae (McLearn) from the Fitz Creek Siltstone, southern Alaska is almost fully septate with only a small part of the body chamber. On the last half-whorl preceding the body chamber the density of the secondary ribs has already declined to 2.4 per primary, which is characteristic of Zemistephanus δ.

'Otoites' reesidei Crickmay from the Mormon Formation, Mt. Jura, California is very close to S. itinsae δ in most features, except that in the former the density of secondary ribs on the preserved part of the body chamber declines to 2.5 per primary whereas on specimens of S. itinsae δ the density usually remains at 3.0.

**Dimorphism.** — Dimensions and growth patterns throughout the phragmocone whorls of the macroconch and microconch agree closely (Text-fig. 13; Appendices 1, 2; compare Pl. 6, figs. 1c-d with Pl. 8, figs. 3-4); shape of the whorl cross-section is also similar (compare Text-figs. 15, 16d-e). The pattern and density of primary and secondary ribbing correspond closely (Text-fig. 13), both dimorphs showing a gradual increase in the density of secondary ribs from two to four per primary with a decrease to three in later growth stages. This 3:1 ratio is maintained on the body chamber of the microconch (Pl. 8, figs. 2-7) though on the macroconch, ornamentation declines in sharpness and the tubercles almost completely disappear near the aperture (Pl. 7, figs. 2-4). In both dimorphs the body chamber uncoils slowly, becoming relatively higher and rounder in cross-section with loss of the lateral shoulder.

These dimorphs occur together on South Balch Island (Table 2; Text-fig. 1), the macroconch being approximately three to four times the size of the microconch and almost four times as abundant. Specimens of both dimorphs also occur together in the Rock Creek Member of the Fernie Group at Ribbon Creek in southern Alberta. The specific epithet 'itinsae' (1927) has precedence over 'yakounense' (1930); the species is renamed Stephanoceras itinsae (McLearn, 1927).

**Stephanoceras (Stephanoceras) skidegatense** (Whiteaves, 1876) ♀ & ♂

Pl. 9; Plate 10, figure 1; Text-figures 18-21

**Stephanoceras skidegatense** ♀ (macroconch)

1876. *Ammonites Skidegatensis* Whiteaves, p. 34; fig. 4; pl. 7.
1932a. *Stephanoceras skidegatense* (Whiteaves); McLearn, p. 54; pl. 1, fig. 2; pl. 2, fig. 3; pl. 3, figs. 8, 9.
1932a. *Stephanoceras skidegatense var. inperousii* McLearn; pp. 54, 55; pl. 1, fig. 1; pl. 3, fig. 3.

**Holotype.** — GSC 5011, collected by J. Richardson at Skidegate Inlet in 1872. The precise locality is unknown. However, the only other specimens from the Queen Charlotte Islands referable to this species have all been collected from the lower parts of the Yakoun Formation at Richardson Bay on the south shore on Maude Island (Text-fig. 1).

**Material.** — Two large body chamber fragments and a number of incomplete phragmocones have been collected by Hall and by Sutherland Brown from the Richardson Bay locality.

**Description.** — The inner whorls are coronate in cross-section, being much wider than high (H/W ratios average 0.65 up to diameters of 60 mm) with a broadly arched venter curving sharply onto flanks that are at first flat and steep. During ontogeny the flanks become more inflated with gradual rounding onto the more highly arched venter (Text-fig. 19).

Ribbing is very sharp and strongly developed throughout. At diameters less than 30 mm there are nine to 12 primary ribs per half-whorl. These are strongly prorsiradiate with prominent, conical tubercles. There are 2.5 secondaries to each primary. During growth the number of primary ribs increases slowly to 15 per half-whorl and the density of secondaries increases to 2.5-3.5 per primary.

The length of the body chamber is unknown, because complete specimens with aperture have not been found; but is in excess of three-quarters of a whorl. Uncoiling to the serpenticone condition begins at about 100 mm diameter but the umbilical seam moves only slowly away from the line of tubercles on the previous whorl. The body chamber is relatively higher and rounder than the phragmocone whorls and becomes ovate in cross-section (H/W = 0.75). Ribbing remains strong and sharp to the aperture but the tubercles are reduced to low, laterally elongate swellings on the flanks. Secondary ribs remain as strong as the primaries but decrease in density until there are only 2-2.5 per primary. There is also a loss of bifurcation, most secondaries arising
Text-figure 18. — Bivariate plots of whorl width (W), whorl height (H), umbilical diameter (U), shell diameter (D) and number of primary (P) and secondary (S) ribs per half-whorl, for Stephanoceras shidegatense ♀ and ♂ from Queen Charlotte Islands. Based on 12 macroconchs and three microconchs, with several individual “growth lines.” Insets are same graphs showing approximate positions of best-fit mass curves. See Measurements for additional explanations.

by intercalation and lacking any connection with the tubercles; it is not uncommon for simple ribs to continue over the venter.

One body chamber fragment collected by Hall shows a small part of the apertural margin, which consists of a simple, flared lip preceded on the flank only by a broad and very shallow depression.

Remarks. — In whorl dimensions and ribbing this macroconch is closely allied with S. itinsae ♀ from the South Balch Island locality. However, the decline in the density of secondary ribbing and tubercle strength and the persistence of strong, sharp secondary ribs on the body
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

Text-figure 19. — Cross-sections of *Stephanoceras skidegatense* ♀, with body chamber shaded, from Queen Charlotte Islands. X 0.7, a, “var.” laperousii (holotype, GSC 6482); b, holotype (GSC 5011); c, McM J1878. See *Measurements* for additional explanations.

The well-preserved specimen with 3/4 whorl body chamber (GSC 56694) was bought by Dawson from the Indians of Queen Charlotte Islands (Whiteaves, 1884, p. 210).

*Description.* — This is the largest microconch stephanoceratid from any of the Queen Charlotte Islands localities, attaining maximum diameters of 60-65 mm with robust ornamentation and only minor uncoiling on the last quarter-whorl.

At a diameter of 4 mm the whorl cross-section is coronate with a smooth shell, broadly arched venter, sharp lateral shoulder and slightly convex, moderately steep flanks. The only ornamentation at this stage consists of small, rounded tubercles on the lateral shoulder and extending adapicad as faint undulations about halfway down the flanks (incipient primary ribs). By a diameter of 6 mm faint secondary ribs appear, two to each primary, curving forward over the broad venter. Primary ribs are still seen only as faint extensions of the tubercles onto the upper parts of the flanks. Earliest whors are much wider than high with H/W ratios of 0.55-0.65.

Primary ribs become strong by D = 10 mm, extending to the umbilical seam and curving forward with prominent, sharp tubercles on the lateral shoulder. Secondary ribs are broad and strong, curving forward from the tubercles and then crossing straight over the venter. Throughout the remainder of the phragmocone the primary ribs are stronger than the secondaries, conspicuously curved, reaching maximum height in the middle of the flanks and terminating in prominent tubercles at 43 to 53 percent of the whorl height. The number of primary ribs increases gradually from nine to 11 per half-whorl while the ratio of secondary to primary ribs increases from 2.5 to 3 by the end of the phragmocone. Whorl cross-section remains coronate with H/W ratios of 0.60-0.65, a broad venter and convex flanks (Text-figs. 18, 21). There is no distinct umbilical wall.

The body chamber is just over one-half whorl in length, marked only by slight uncoiling of the last quarter-whorl. The whorl cross-section is oval and relatively higher than on the phragmocone whors (H/W = 0.75-0.85). Both primary and secondary ribbing remain strong to the aperture with 14 to 15 primaries on the last half-whorl but only 2-2.5 secondaries to each primary. The decline of secondary rib density is particularly noticeable on the last quarter-whorl where each primary rib bifurcates and intercalated ribs are absent. Tubercles become smaller, sharper and laterally elongate.

The aperture, not preceded by any constriction, is marked by a slightly flared lip; the beginning of the lateral lappets is visible on the four nearly complete specimens.
The mature suture is only moderately incised (Text-fig. 20). L is trifid and not as deep as E while U₂ is very short. U₃ is long, narrow and strongly oblique. E/L is higher than L/U₂; the tubercle is situated on the ventral side of the L/U₂ saddle.

Remarks. — The decline to strong, bifurcating ribbing on the body chamber is similar to the body chamber ornamentation of Zemistephanus ♂. However, S. skidegatense ♂ reaches larger diameters, has less steep flanks, sharper ribbing, tubercles on the body chamber, more primary ribs on the last half-whorl (14-15 compared with 9-12 for Zemistephanus ♂) and a relatively higher whorl cross-section (H/W = 0.75-0.85 vs. 0.60-0.70).

S. itinsae (McLearn) ♂ differs strongly in having a higher density of secondary ribs on the body chamber (3 per primary) but fewer primary ribs per half-whorl (8-10 vs. 14-15).

S. skidegatense (Whiteaves) ♂ resembles 'Normannites' orbignyi Buckman in coiling, whorl proportions and ornamentation. The holotype of 'N.' orbignyi differs in rib density, having only 12 primaries on the last half-whorl; however, other specimens from Dorset [in the collections of the Geological Survey, London and the British Museum (Natural History)] show denser ribbing on the body chamber. The strong, curved primaries, sharp tubercles that decline on the body chamber and the strong, bifurcating secondary ribs all agree closely with the material here described as S. skidegatense (Whiteaves) ♂.
Dimorphism. — The specimens described here for the first time as S. skidegatense ♂ are morphologically identical throughout the phragmocone whorls with the previously known macroconch specimens from Richardson Bay (Text-fig. 18). Whorl shape and dimensions, density and form of ribbing and changes in ornamentation during ontogeny are closely similar in both dimorphs. Body chamber modifications are also similar in both (excluding apertural modifications), which is unusual for the stephanoceratids described here.

Slight egression of the last part of the body chamber is accompanied by rounding of the whorl section, decrease in the density of secondary ribs (2-2.5 per primary) and changes in the nature of the tubercles. The persistence of strong secondary ribbing right to the aperture enables separation of this species from the closely-related S. itinsae.

Adult macroconch specimens are about 3 times the size of the largest microconchs (60-65 mm); in all collections so far made from the Richardson Bay locality they occur in approximately equal numbers.

Stephanoceras sp. ♂ aff. S. skidegatense (Whiteaves, 1876) ♂

Pl. 10, figures 2-3; Text-figure 22

Material. — Two partially preserved specimens from the lower part of the Yakoun Formation at Richardson Bay, Maude Island, Queen Charlotte Islands: McM J1804, half of one body chamber whorl with one half-whorl of the preceding phragmocone attached, from 9 m above the base of the exposed section; and McM J1806, a smaller phragmocone found 20 m above the base of the section.

Description. — The phragmocone whorls are depressed (H/W = 0.63-0.72) with a strongly arched venter that rounds evenly onto the inflated flanks, there being no lateral shoulder (Text-fig. 22). The flanks slope gradually to the umbilical seam. Primary ribs are relatively short, reaching only 36 to 42 percent of the whorl height. The primary ribs are strong, rounded and curved forward; there are nine to 12 per half-whorl. Secondary ribs are also strong, curving slightly forward from the point of bifurcation and then crossing straight over the venter; there are 26 per half-whorl (i.e., 2.4 to each primary).

The half-whorl of body chamber preserved shows gradual egression but the whorl section and ornamentation show little change. There are 14 primary ribs on the last half-whorl with 28 secondaries, all of which remain strong and rounded.

Remarks. — This species is distinguished from S. skide-

gatense (Whiteaves) ♂ by its stronger, more widely spaced secondary ribbing on the phragmocone whorls (compare Pl. 10, figs. 2-3 with Pl. 10, figs. 1b,c), more rounded whorl cross-section with highly arched venter, but lacks a lateral shoulder and has shorter, thicker primary ribs without sharp tubercles.

S. itinsae (McLearn) ♂ differs in the higher density of secondary ribbing that persists almost to the aperture, and the more coronate whorl section with a clearly defined lateral shoulder and broad venter on the phragmocone whorls.

Stephanoceras (Stephanoceras) pyritosum (Quenstedt, 1886-1887) ♀

1886-1887. Ammonites Humphriesianus pyritosus Quenstedt, p. 536; pl. 66, fig. 4.

Stephanoceras (Stephanoceras) pyritosum caamanoi McLearn, 1930 ♀

Pl. 10, figures 4a, b

1930. Stephanoceras caamanoi McLearn, p. 55; pl. 3, fig. 7; pl. 4, fig. 8.

1969. Stephanoceras cf. S. caamanoi; Frebold et al., p. 26, pl. 4, fig. 3.

The holotype came from South Balch Island in Skidegate Inlet, Queen Charlotte Islands, i.e., the type locality of Stephanoceras ‘yakounense’ McLearn [= S. itinsae ♀]. The type is a large phragmocone (D = 110 mm) with typically
planulate, subcircular and evolute whorls, bearing sharp and dense, not prominent ribbing; small tubercles occur slightly below the middle of the whorls, at the end of the somewhat curved and projected primaries.

This specimen closely resembles the holotype of *S. pyritosum* (of which we possess a plaster cast) and is considered conspecific with the widely distributed European and Andean species (cf. Morton, 1971; Westermann and Riccardi, 1979). The only difference seems to be the longer primaries of *S. p. caamanoi*. Both resemble *S. humphriesianum* (Sowerby), the type-species, which differs in the coarser and stiffer ornament. This species clearly indicates the lower to middle *S. humphriesianum* Chronozone.

**Subgenus STEMMATOCERAS** Mascke, 1907

*Type species.* — *Am. Humphriesianus coronatus* Quenstedt, 1886-1887 [= *S. frechi* Renz, 1913; = "Cadomites quenstedtii" Roché, 1938, obj. syn.]

Discussion. — Most North American species placed originally in *Stemmatoceras* are here transferred to the nominate subgenus *Stephanoceras*, i.e. 'Stemmatoceras' *mcLearni* Warren, 'S.' *carri* Warren and (?) 'S.' *aricostum* Imlay, while 'S.' *albertense* McLearn and 'S.' *palliseri* McLearn are tentatively retained in *S. (Stemmatoceras)*; and 'S.' *ursinum* Imlay is more tentatively transferred to *Zemi-stephanus*. Most of these species belong to the species group of *Stephanoceras umbilicum* (Quenstedt), characterized by broad subelliptical whorls with rounded lateral shoulders, and bear the coarse primary ribs of *S. brodiaei* (Sowerby).

Typical *S. (Stemmatoceras)* from North America were previously placed in *Teloceras*, i.e. 'T.' *dowlingi* McLearn, 'T' *allani* Warren and probably "T. *itinsae"* McLearn [not "*Itinsites* *itinsae* McLearn].

**Stephanoceras (Stemmatoceras) dowlingi** (McLearn, 1930)

Plate 11, figures 2a, b; Text-figure 23a

1932b. *Teloceras dowlingi*; McLearn, p. 112, pl. 1; pl. 5, figs. 2, 3.

Remarks. — This species was based on an incomplete specimen, probably from Ribbon Creek in Alberta, that is wholly septate except for about one quarter-whorl of body chamber. In the first full description, McLearn (1932b, pp. 111-113) noted the essential deviations from *Teloceras* Mascke: the marked egression of the umbilical seam from the line of nodes, the high arching of the venter and rounding of the previously steep umbilical walls, and the marked decrease in the strength of the nodes. On the body chamber H/W increases to 0.71, far greater than any known values for undoubted species of *Teloceras* from western Europe (values of 0.40-0.50 are common at similar growth stages). In fact, whorl section and coiling closely resemble those of *S. frechi* Renz, type species of the subgenus *Stemmatoceras*; the only difference is in the more widely spaced, blunter primaries ending in more prominent tubercles.

**Stephanoceras (Stemmatoceras?) allani** (Warren, 1947)

Plate 12, figure 2


Remarks. — The holotype from the Highwood-Sheep River area in Alberta is by far the largest of this group (*D* = 277 mm) and has almost one whorl of body chamber preserved. The inner whorls are tightly coiled with the umbilical seam following the line of nodes; these are small, round and situated on the pronounced lateral shoulder; the umbilical wall is steep producing a deep and narrow umbilicus. Uncoiling and rounding commence about half a whorl
before the end of the phragmocone. The umbilical wall becomes rounded merging more gradually with the arched venter (H/W increases from 0.64 to 0.84). The strong primary ribs that on the inner whorls are conspicuously directed forward as they approach the umbilical seam, become blunt on the body chamber and obsolete near the end; nodes and secondary ribs also decline on the body chamber. This species is also transferred to *Stephanoceras* and somewhat tentatively placed in the subgenus *Stemmatocteras*; confirmation awaits data from the section of the inner whorls.

**Stephanoceras (Stemmatocteras?) albertense** (McLearn, 1928)  
Plate 13, figure 1

1928. *Stemmatocteras albertense* McLearn, p. 20, pls. V-VII.

**Remarks.** — The holotype is a fully septate, distorted specimen from Sheep Creek, Alberta, on which only one side of the phragmocone is preserved; most of the ventral parts of the ultimate whorl have been crushed. In dimensions of the outer whors and the long, curved primary ribs (18-20 per half-whorl) this specimen resembles *Stephanoceras* (s.s.) *itinsae* (McLearn) ?, but *S. albertense* appears to have more coronate inner whorls. It may differ from ‘*Stemmatocteras* palliseri’ McLearn in whorl section and coiling as suggested by Warren (1947, p. 68), and also has more primary ribs (18 vs. 13 per half-whorl at similar diameters). The relatively undistorted specimen from Ribbon Creek described and figured by Frebold (1957, p. 50; pl. 11, figs. 2a, b; pl. 23, figs. 1a-c) as ‘*Stemmatocteras albertense* McLearn’ is identical with *Stephanoceras itinsae* (McLearn) ? from the Queen Charlotte Islands. The inner whorls as measured by Frebold (p. 51) correspond in all dimensions with *S. itinsae* and the increase in whorl height on the last preserved whorl and fine, dense secondary ribbing strongly confirm identification with that species.

The inner whorls of the holotype, however, are poorly known so that its true affinity remains uncertain.

**Stephanoceras (Stemmatocteras?) palliseri** (McLearn, 1930)  
Plate 12, figure 1

1932b. *Stemmatocteras palliseri*; McLearn, p. 114, pl. 2; pl. 5, fig. 1.

**Remarks.** — The holotype from Mountain Park, Alberta, is a wholly septate specimen, somewhat distorted and corroded. The inner whorls seem to be broad and coronate with moderately rounded lateral shoulders, curved lower flanks grading into the steep umbilical slope and a moderately deep umbilicus. The last phragmocone whorl, however, is depressed elliptical with well-rounded lateral shoulder and arched venter. The primaries are prominent. The “*Stemmatocteras* cf. *S. palliseri* McLearn” described by Imlay from southern Alaska (1964, pp. B48, 49; pl. 20, figs. 5, 6; pl. 21, figs. 2, 4) also has similar dimensions and coiling with a corresponding decline in ornament on the body chamber. However, the Alaskan specimen has fewer primary ribs (12 vs. 16-19 per half-whorl at D = 130 mm) with larger nodes. Secondary ribs are more dense on the inner whorls of Imlay’s specimen but become broader and less dense (three secondaries per primary) on the body chamber. Since the section of the inner whorls is unknown, the subgeneric assignment of *S. palliseri* is uncertain. There is some resemblance to ‘*S.* albertense’ (see above).

**Stephanoceras? (Stemmatocteras?) ex gr. *S. acuticostatum*** (Weisert, 1932)  
Plate 5, figures 3-4; Text-figure 23b

1964. *Teloceras itinsae*; Imlay, p. B50, pl. 24, figs. 3, 4 (lectotype refigured), non figs. 1, 2, 5, 7 (= *Zemistephanus alaskensis* sp. nov.)

**Material.** — Three poorly preserved specimens from the Yakoun Formation at McKenzie Bay, Queen Charlotte Islands (type locality of “*Teloceras itinsae*”): a crushed phragmocone of 80 mm diameter (McM J1861) and a small fragment (McM J1860) from 10-15 m above the base of exposed formation and one fragmentary specimen with parts of the last two phragmocone whorls and of the body chamber (GSC MB858), collected by Sutherland Brown at the same general locality.

**Description.** — The holotype from McKenzie Bay is a well-preserved, possibly incomplete phragmocone of 70 mm diameter (Table 6). The phragmocone whorls are moderately depressed and not very wide (W/D ≈ 0.5) but subcoronate, with a narrowly curved lateral edge bearing prominent thick tubercles, and only gently curved inner flanks (with umbilical slope) and venter. The ornament consists of widely spaced, prominent primaries ending in the tubercles at about 3/5 whorl height, and coarse secondaries, three to four per primary; both primaries and secondaries are slightly projected (much of the curvature probably a result of the slight distortion). On the last preserved phragmocone whorl, the primaries withdraw somewhat from the umbilical seam and start to become blunt. The septal suture resembles that of typical stephanoceratids, with a much smaller L/U2 than E/L saddle and strongly retracted umbilical elements.

While the smaller topotype (J1861) closely resembles the holotype except for the poorer preservation, the larger
one (GSC MB 858) has a phragmocone diameter of about 100 mm and parts of the body chamber which reached 130-150 mm diameter. The ultimate phragmocone whorl differs from that of the smaller holotype only in the blunter primaries that are further withdrawn from the seam. Unfortunately, the specimen is preserved with only one side so that the exact width of the whorl is unknown (Text-fig. 23b). The body chamber becomes much more rounded in section, with strong negative allometry of height and (?)width growth, and probably becomes more evolute; the ornament becomes increasingly blunt. The incomplete preservation and partial distortion of the body chamber whorl, however, do not permit the complete reconstruction of the specimen, in particular with regard to the change in adult whorl section and coiling.

Remarks.—It appears that “Teloceras itinsae McLearn” closely resembles the European “subcoronates” of the ‘Teloceras’ acuticostatum group. The species group differs from true Teloceras as redefined herein in the narrow phragmocone whorls and the rounded outer whorl(s), and is placed in Stephanoceras (Stemmatoceras). This species group includes the similar, poorly known ‘77 T. itinsae’ and the European ‘77 Subblagdenia blagdeniformis Roché, and appears to mark the lower part of the T. blagdeni Subzone (Mouterde et al., 1971). This species group is also represented in New Guinea (cf. Boehm, 1913, pl. 3, fig. 2). The incomplete preservation of the holotype and topotypes of ‘T. itinsae’, however, makes definite comparison impossible.

If transferred to Stephanoceras, however, ‘Teloceras itinsae’ McLearn, 1932a, becomes a junior homonym of ‘Itinsaites’ itinsae McLearn, 1927, which is a true Stephanoceras (i.e., the definite microconch of S. ‘yakounense’ McLearn, 1930 9). ‘Teloceras itinsae’ would therefore need a new name (epithet), unless it can be demonstrated to be conspecific (and synonymous) with another described species. Since ‘Teloceras itinsae’ and the European ‘T.’ acuticostatum, ‘T.’ subblagdeni and ‘T.’ blagdeniformis are known from poorly preserved material only, no clear specific distinctions are evident to us. We therefore abstain from replacing the homonymous epithet. There is a remarkable resemblance to Zemistephanus alaskensis sp. nov. with which the rare “Teloceras itinsae” may be associated. Z. alaskensis is distinguished by the low, wide-spaced primaries on the juvenile whorls and their obsolescence on the outer whorls.

“Teloceras itinsae” is of appreciable biostratigraphic and chronologic significance. The name has been used erroneously by Imlay (1964) for a faunule or assemblage zone in South Alaska, based on misidentified Zemistephanus alaskensis sp. nov. “T. itinsae” has now been located stratigraphically at its type locality (McKenzie Bay) where it occurs within the range zone of Zemistephanus richardsonii. This provides good evidence for correlation with the (lower to middle) S. humphriesianum Standard Zone (D. romani Subzone).

Genus TELOCERAS Mascke, 1907

Type species.—Am. blagdeni J. Sowerby, 1818, by original designation.

Discussion.—Teloceras Mascke was originally distinguished from other stephanoceratids by its strong nodes, sharp umbilical shoulder and the great thickness of the whorls (Mascke, 1907, p. 31). The distinctiveness of this genus was further emphasized by Weisert (1932) and Schmidtill and Krumbeck (1938): although the complete body chamber was rarely preserved, the mature shell exhibited a diminishing sculpture, slight rounding of the whorl section and, in some forms, minor egression. Dr. J. Wiedmann kindly examined for us 40 large Swabian Teloceras, 3 of them with partial to complete body chamber, in the Geologisch-Paläontologisches Institut and Museum in Tübingen and one of us [Hall] has studied a number of almost complete specimens from the Inferior Oolite in the British Museum (Natural History). At least the outer whors of the phragmocone and the apical parts of the adult body chamber are coronate with strongly depressed, broad whorls and flat venter with large, round nodes along the acute lateral shoulder. Only the second half of the body chamber rounds markedly. In many specimens the venter is almost smooth as a result of the loss of secondary ribbing. In consultation with Dr. J. Callomon, Teloceras is distinguished at the genus level and defined to include as macroconchs only species with an extremely coronate, large adult stage.

A detailed discussion of the taxonomy and nomenclature of this genus is given under the Genus Stephanoceras.

Most North American species described under Teloceras, however, are here transferred either to Stephanoceras (Stemmatoceras), i.e. ‘T.’ dowlingi McLearn, ‘T.’ allani Warren and ‘T.’ itinsae McLearn [becoming a junior homonym of S. itinsae (McLearn)], or to Zemistephanus, i.e. ‘T.’ warreni McLearn.

Probably the only true Teloceras described from North

| Table 6.—Measurements (in mm) of “Teloceras itinsae”. |
|-----------------|-----|-----|-----|-----|
| Holotype (GSC 6481) | D | W | H | U |
| phragmocone | 71 | 36.5 | 22.5 | 32.5 |
| | 44 | 22 | 14.8 | 17.9 |

This provides good evidence for correlation with the (lower to middle) S. humphriesianum Standard Zone (D. romani Subzone).
America are the poorly preserved holotypes of 'Teloceras stelcki' Warren and 'Zemistephanus' crickmaysi Frebold, both from the Rock Creek Member of southern Alberta. These may be conspecific.

'T. stelcki' Warren (1947, p. 71, pl. VI, fig. 1) was based on a large (D = 232 mm) specimen with body chamber; but the right side and the inner whorls are missing and at least the body chamber is somewhat crushed. The preserved last whorl of the phragmocone (D = 140 mm) is typically corone with a sharp lateral edge bearing very prominent subconical tubercles. The primaries are strongly reduced to obsolete while the secondaries are comparatively dense, fine and projected (?due to distortion). The large body chamber (3/4 whorl; D = 230 mm) displays strong egression and rounding above 170 mm diameter, but this could be in part a result of distortion. In the absence of the inner whorls, it cannot be decided whether this is an unusual Teloceras or an exceptionally large corone Zemistephanus. The type material of this "species" is considered unsatisfactory and the name therefore is a nomen dubium.

Teloceras crickmaysi (Frebold, 1957) ?

1957. Zemistephanus crickmaysi Frebold, p. 52, pl. XXV, fig. 1; pl. XXVI, fig. 1; pl. XXVII, fig. 1.

The fully septate and fragmentary holotype from Rib­bon Creek, Alberta (reconstructed phragmocone D = 150-160 mm) is characterized by a deep, conical umbilicus, extremely broad and depressed cross-section, with only slightly arched venter and high, conical tubercles. Primary ribs are obsolete; from the tubercles situated on the acute lateral shoulder the relatively fine secondary ribs pass slightly projecting over the venter. There are about 11 tubercles per half-whorl and four secondary ribs to each tubercle on the last two whorls. Though there is slight egression of the last preserved whorl from the line of tubercles, there is no decline in the steepness of the umbilical wall, nor rounding of the whorl section, as in Zemistephanus (H/W = 0.53 → 0.50). One of us [Westermann] has collected several topotypes, including one specimen with body chamber. Rounding of the whorl section occurs only with the second half of the body chamber, much as in Teloceras of the T. blagdeni group. This species is distinguished from T. blagdeni in the reduction of the primaries, similar to T. banksii (Sowerby), and in the denser secondaries. It could be synonymous with the poorly known 'T. stelcki' Warren (nomen dubium) and is transferred to Teloceras. This species is of stratigraphic and chronologic significance, because it remains the only Teloceras in what has been called the "Teloceras fauna" (Warren, 1934) and indicates the T. blagdeni Subzone.

Family SPHAEROERATIDAE Buckman, 1920
Genus CHONDROCERAS Mascke, 1907

Type species.—Am. gervillii J. Sowerby, 1817 (by original designation).

Discussion.—McLearn (1927) erected two new genera for Bajocian sphaerocone ammonites from western Canada: Defonticeras, occurring in the Queen Charlotte Islands and Saxitoniceras, from Alberta. He later (1949) came to regard Defonticeras as a subgenus of the European Chondroceras Mascke.

'Defonticeras' McLearn was separated from the then mainly European genus Chondroceras by the latter having a "3-ridged mouth, somewhat regular umbilicus, and fine ribs sloping well forward near the anterior end of the ultimate whorl" (McLearn, 1929, p. 13). Comparison of larger collections of 'Defonticeras' from the Queen Charlotte Islands, Alberta and southern Alaska with plastotypes and figured specimens of European Chondroceras shows that in both groups sudden umbilical enlargement begins about two-thirds to one-half of a whorl before the aperture, corresponding to the beginning of the body chamber. Though a three-ridged mouth border is never seen in the eastern Pacific material, it is by no means universal in European species of Chondroceras either (see Westermann, 1956, pls. 1-3). Primary ribs on the body chamber of eastern Pacific species are coarser and more widely spaced than on European Chondroceras but it is believed this minor variation in ornamentation of the body chamber is insufficient to warrant separation, even at the subgeneric level, and 'Defonticeras' McLearn is here treated as synonymous with Chondroceras Mascke. This follows the classification adopted in the 'Treatise' (Arkell, 1957, p. L292).

The two species of 'Saxitoniceras' were separated from 'Defonticeras' by their less dissected suture line and less abrupt umbilical enlargement (McLearn, 1927, 1928). Again, these minor variations are not considered sufficient for generic or subgeneric distinction. Indeed, Chondroceras oblatum (Whiteaves) ? from the Queen Charlotte Islands, tentatively placed in 'Defonticeras' by McLearn (1929, p. 17) has a similarly simplified suture line (compare Text-fig. 26) and is regarded as conspecific with Saxitoniceras marshalli McLearn. 'Saxitoniceras' McLearn is also placed in synonymy with Chondroceras Mascke. Umbilical enlargement in 'Saxitoniceras' occurs suddenly over the last half- to quarter-whorl and is similar in character to that on 'Defonticeras'.

Westermann (1956) treated 'Defonticeras' and 'Saxitoniceras' as subgenera of Chondroceras; he later (1964a,
The two known species of smaller than Charlotte Islands are strongly dimorphic in that the macroconch with pp. 55, 64, 65) tentatively placed 'Saxitoniceras' as the corresponding microconch form. However, no 'Saxitoniceras' has been found with the macroconch 'Defonticeras' faunas on the Queen Charlotte Islands and indeed the corresponding microconchs are much smaller than 'Saxitoniceras' (see Pl. 14, fig. 8; Pl. 15, fig. 6). The two known species of Chondroceras from the Queen Charlotte Islands are strongly dimorphic in that the macroconch is approximately three times the size of the corresponding microconch. However, the apertural modifications in both dimorphs are similar: a constriction followed by a flared collar.

**Chondroceras oblatum** (Whiteaves, 1876) ♀ & ♂

Pl. 14, figures 1-8; Text-figures 24-26

Chondroceras oblatum ♀ (macroconch)

1876. *Ammonites loganianus* Form A Whiteaves, p. 29; pl. 4, figs. 2, 2a.
1929. *Defonticeras oblatum* (Whiteaves); McLearn, pp. 16, 17, pl. XV, fig. 1.
1956. *Chondroceras* (*Defonticeras*) *oblatum* (Whiteaves); Westermann, pp. 102-4; figs. 18, 61; pl. 11, figs. 4, 5.
1957. *Chondroceras marshalli* McLearn var.; Frebold, p. 54; pl. XXV, figs. 3a, b; pl. XXVI, figs. 2a, b.
1964a. *Chondroceras* (*Defonticeras*) *oblatum* (Whiteaves); Westermann, pp. 55, 64.

**Holotype.** — GSC 4964, on Pl. 14, figs. 1a, b collected by J. Richardson in 1872 and labelled "Skidegate Channel". McLearn (1929, p. 17) assumed this specimen came from the lower part of the Yakoun Formation at Richardson Bay on the south shore of Maudie Island. However, it does not resemble any of the specimens collected and described from that locality; it does agree closely with material from South Balch Island in Skidegate Inlet and the holotype may well have come from the lower Yakoun Formation exposed at this locality.

The holotype of 'Saxitoniceras' *marshalli* was originally described as from near the base of the Fernie Formation on the head waters of Sheep Creek, Alberta (McLearn, 1928, p. 22).

**Other Material.** — Eight macroconch specimens (McM J1795, 1832a-d, 1833 and 1834a, b) were obtained from several horizons in the lower Yakoun Formation of South Balch Island. Other specimens described as 'Saxitoniceras' *marshalli* came from the Rock Creek Member of the Fernie Group in Ribbon Creek, southern Alberta (Frebold, 1957), and the Tuxedni Formation of southern Alaska (Imlay, 1964). Further material from the Ribbon Creek locality in southern Alberta collected by Westermann (McM J1837a-f) and Hall (McM J1836a-f) was also studied.

**Description.** — The early phragmocone whorls are sphaeroconic with a rounded venter curving continuously onto the convex flanks and to the umbilical seam. The umbilicus is very narrow, usually representing less than ten percent of the shell diameter. Whorls depressed, with H/W = 0.65-0.75. Up to a diameter of 13 mm the shell is smooth. At greater diameters on the phragmocone the primary ribs are faint on the umbilical wall, somewhat stronger but never sharp on the lower flanks, almost rectiradiate, eight to 10 per half-whorl. There are 3.5 secondary ribs to each primary rib and they pass straight over the venter; tubercles are absent at all stages of growth.

The body chamber is two-thirds of a whorl in length, egression beginning at the last septum with sudden enlargement of the umbilicus to as much as 30 percent of the shell diameter. Near the aperture the whorl section remains depressed (H/W = 0.70-0.75), the venter remains broadly rounded, but the flanks are slightly flattened. There are eight or nine primary ribs on the last half-whorl, that are slightly prospiradite on the flanks and give rise to three secondary ribs per primary. Maximum diameters attained are 55-60 mm, and the aperture is marked by a narrow constriction followed by a smooth lip.

**Remarks.** — This species is clearly differentiated from *C. defontii* ♀ and Chondroceras n. sp. indet. ♀ by ribbing density and sutural complexity. *C. defontii* ♀ is characterised by complex sutures that are deeply incised whereas the suture of *C. oblatum* ♀ has broader saddles with small incisions. While also having a simple suture, Chondroceras n. sp. indet. ♀ has much denser and finer ribbing (12-14 primaries per half-whorl) and a broader whorl section than *C. oblatum* ♀ (H/W = 0.47-0.55 vs. 0.65-0.75 at similar diameters).

Comparison of the whorl dimensions of 'S' *marshalli* ♀ with *C. oblatum* ♀ shows that the two forms are similar (Text-fig. 24). They attain similar maximum diameters (58.7 mm for the holotype of *C. oblatum* ♀ and 51-66 mm for 'S.' *marshalli* ♀), have simplified sutures (Text-fig. 26), depressed whorl sections (H/W = 0.60-0.80) and seven to ten primary ribs on the last half-whorl of the body chamber with three secondaries to each primary. Thus *C. oblatum* (Whiteaves) and 'S.' *marshalli* McLearn are placed in synonymy, the former name taking precedence.

Chondroceras oblatum ♂ (microconch)

(This dimorph has not been previously described.)
Allotype. — McM J1794a, on Pl. 14, fig. 8, from the lower part of the Yakoun Formation, eastern shore of South Balch Island, Queen Charlotte Islands.

Other Material. — One other complete specimen, McM J1835, from 44 m above the base of the exposed Yakoun Formation on South Balch Island.

Description. — Microconchs are characterised by egression of the last quarter-whorl, which terminates with a nar-

Text-figure 24. — Bivariate plots of whorl width (W), whorl height (H), and umbilical diameter (U) against shell diameter (D) for Chondroceras oblatum $\alpha$, including the synonymous “Saxitoniceras marshalli”, respectively from Queen Charlotte Islands and southern Alberta. Based on 22 macroconchs and three microconchs, with several individual “growth lines” indicated. Insets are same graphs showing positions of best-fit mass curves. See Measurements for additional explanations.
Text-figure 25.—Cross-sections of *Chondroceras oblatum* ♀ and ♂; body chamber shaded. a-c, "Saxitoniceras marshalli" ♀ from southern Alberta, a-b, ×1.6 (McM J1836e, McM J1837g); c, ×12 (McM J1836f); d-e, juvenile whorls of macroconch at diameters indicated, ×1.5 (McM J1795b, McM J1795a); f, microconch ×4.5 (McM J1794b). See *Measurements* for additional explanations.

Row constriction followed by a smooth lip. Microconchs reach a maximum size of 19 mm, only one-third the size of the adult macroconchs. The shell is oblate with a broadly rounded venter, narrow umbilicus and convex flanks. Primary ribs are slightly prorsiradiate with seven on the last half-whorl; there are three secondaries to each primary rib at this stage. Dimensions and suture are similar to those of the macroconch (Text-figs. 24-26).

**Dimorphism.**—Text-figure 24 and Appendix 1 show that the whorl dimensions of the few known microconchs are very similar to those of the macroconchs. Ribbing style and density on the body chambers of the two dimorphs are similar, while the apertural modifications are identical: a narrow constriction followed by a broad, smooth collar. The macroconch is approximately three times the size of the microconch. No microconch specimens are known from the Ribbon Creek locality of southern Alberta.

Westermann (1964a, p. 65) considered that 'Saxitoniceras' *allani* was a possible microconch equivalent of 'Defonticeras' *oblatum*. However, the microconchs here described and figured from the macroconch type locality on South Balch Island are very much smaller than either the macroconch *C. oblatum* or 'S.' *allani*; no specimens similar to 'S.' *allani* have been found on the Queen Charlotte Islands.

**Chondroceras defontii** (McLearn, 1927) ♀ & ♂
Plate 15, figures 1-6; Text-figures 27-29

**Chondroceras defontii** ♀ (macroconch)
1927. *Defonticeras defontii* McLearn, p. 72; pl. 1, fig. 3.
1929. *Defonticeras defontii* McLearn; McLearn, pp. 13, 14; pl. XII, figs. 1-3.
1929. *Defonticeras colnetti* McLearn, pp. 15, 16; pl. XIII, figs. 4, 5.
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

Text-figure 26.— Sutural ontogenies for Chondroceras oblatum ♀ (left) and ♂ (center), from Queen Charlotte Islands (McM J1795a, McM J1794b); right, "Saxitoniceras marshalli" from southern Alberta (McM J1837h, McM J1836d). The position of the umbilical seam is marked by (See Measurements for additional explanations.

1929. Defonticeras elli McLearn, p. 16; pl. XIII, figs. 2, 3; pl. XIV, fig. 1.
1929. Defonticeras marchandi McLearn, pp. 14, 15; pl. XII, figs. 4, 5.
1949. Chondroceras (Defonticeras) defontii (McLearn); McLearn, pp. 10, 16.
1956. Chondroceras (Defonticeras) defontii (McLearn); Westermann, pp. 100-102; pl. 11, fig. 3; figs. 57, 59.
1964. Chondroceras defontii (McLearn); Imlay, p. B42; pl. 12, figs. 8, 11-14.

Holotype.—GSC 9009 on Plate 15, figures la,b, from talus on the ledges of the lower Yakoun Formation at Richardson Bay on the south shore of Maude Island, Queen Charlotte Islands.

Other Material.—Seven complete (some crushed) macroconchs (McM J1792a-f, J1829) and a number of body chamber fragments complete with aperture from the type locality.

Description.—Phragmocone whorls globose with broadly rounded venter, inflated flanks and short, steep umbilical wall (Text-fig. 28). Umbilicus very narrow, usually less than 10% of the shell diameter, and deep. Cross-section depressed with H/W ratios of 0.60-0.75. Primary ribs fairly strong, rectiradiate on the steep umbilical wall, then strongly curved forward on the lower flanks; 11 to 15 per half-whorl. Secondary ribs fine and closely spaced, up to 3.5 per primary, curved forward from the point of furcation and then crossing straight over the venter. Nodes not developed.

Egression of the body chamber abrupt, beginning close to the last septum, with a sudden increase in umbilical diameter from less than 10 percent to 20 to 25 percent of the shell diameter. The body chamber occupies one-half to two-thirds of a whorl and terminates with a strong constriction and a broad, smooth lip. There is a decrease in relative whorl width and height (Text-fig. 27) near the aperture but the whorl remains broadly rounded with H/W ratios of
Text-figure 28. — Cross-sections of *Chondroceras defontii* ♀ with body chamber shaded. a-b, × 1 (McM J1792c, McM J1792b); c, × 2 (McM J1792c). See *Measurements* for additional explanations.

Text-figure 27. — Bivariate plots of whorl width (W), whorl height (H) and umbilical diameter (U) against shell diameter (D) for *Chondroceras defontii* ♀ and ♂ (with synonyms) from Queen Charlotte Islands. Based on 13 macroconchs and one microconch, with several individual "growth lines". Insets are same graphs showing approximate positions of best-fit mass curves. See *Measurements* for additional explanations [In plot of U vs. D (lower right), U is measured on the ordinate axis].

0.65-0.75; the flanks become flattened with loss of the steep umbilical wall seen on earlier whorls. Maximum diameters are between 51 and 65 mm. Ornamentation on the body chamber remains strong to the aperture. Primary ribs are straight and more widely spaced but directed forward on the flanks with 10-13 on the last half-whorl. The density of secondary ribs is reduced to 2.5 to each primary and they are noticeably coarser than those on the phragmocone.

The mature suture (Text-fig. 29) is complex with deeply incised saddles. E/L is only a little higher than L/U₂ but U₂/U₃ is very short and broad. L is about as deep as E and trifid, while U₂ is broader and trifid. The umbilical lobes are short and not retracted.

Remarks. — *Chondroceras defontii* ♀ commonly has 10-13 primary ribs per half-whorl on the body chamber and last parts of the phragmocone and up to 15 per half-whorl on earlier whorls. This density is similar to that seen on *Chondroceras* sp. from MacKenzie Bay, but *C. defontii* ♀ has a more complex suture with longer and narrower lobes and much more deeply incised saddles; its whorl section is also narrower and higher.

*C. oblatum* (Whiteaves) ♀ is distinguished by having a simpler suture line with broader and less deeply incised saddles (compare Text-figs. 26, 29), fewer primary ribs on
the body chamber whorl and coarser secondary ribbing on the phragmocone. C. oblatum ♀ also has a broader cross-
section with H/W ratios of 0.60-0.65 compared with 0.65-0.75 on C. defontii ♀.

No specimens intermediate in size between the holotypes of C. defontii ♀ and the larger C. maudense (McLearn) from the same locality have been found and so the latter is retained as a separate, though poorly defined, species. A specimen described as C. defontii by Imlay (1964; pl. 12, fig. 8) has a diameter similar to that of the holotype of C. maudense (75 mm just behind the aperture) but has much finer, denser ribbing with 18 primary ribs on the last half-whorl.

The four species of 'Defonticeras' from Richardson Bay that were erected by McLearn (1929), were each based on a single specimen. C. colnetti was distinguished from C. defontii as being smaller with narrower whorls and a more strongly contracted body chamber. Table 7 shows that C. defontii, with a maximum shell diameter of 66 mm, is at the upper extreme of a range in shell sizes that includes C. colnetti, C. ellsi and C. marchandi and a number of other specimens of intermediate sizes. No whorl measurements from the phragmocone of C. colnetti are available as a result of poor preservation, so that relative contraction of the body chamber cannot be estimated; the body chamber is only slightly narrower than that on the holotype of C. defontii.

C. ellsi was characterized by having narrower and lower whorls, more rounded flanks, less arched venter and deeper saddles than the holotype of C. defontii. A slight difference in rounding of the venter and flanks is too subjective a basis for distinction. The published figures (McLearn, 1929; compare pl. XII, fig. 1 and pl. XIII, figs. 2, 3) show little difference in the suture; in addition, the suture illustrated for C. ellsi is probably almost a half-whorl before the last septum whereas that for C. defontii appears to be the last septum.

C. marchandi is at the lower extreme of the range for maximum shell diameter in this group and the relative width and height of the body chamber (phragmocone not preserved on the holotype) are similar to those of the other specimens from this locality (Table 7). Secondary ribs on the last half-whorl of the body chamber are not more numerous than on the other specimens of C. defontii, as stated by McLearn (1929, p. 15).

Chondroceras defontii ♂ (microconch)

(This dimorph has not been previously described.)

Allotype. — McM J1793a (Pl. 15, fig. 6) from Richardson Bay, Queen Charlotte Islands, 18-21 m above the exposed base of the Yakoun Formation.
Table 7. — Comparative measurements (in mm) for *Chondroceras defontii* (McLearn) ♀, with synonyms, from Richardson Bay, Queen Charlotte Islands.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Maximum Diameter</th>
<th>%V</th>
<th>%W</th>
<th>H%</th>
<th>H/W</th>
<th>P</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. dejontii</em></td>
<td></td>
<td></td>
<td></td>
<td>41</td>
<td>0.70</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>GSC 9009 (holotype)</td>
<td>66</td>
<td>24</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. colnetti</em></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>0.73</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>GSC 9012 (holotype)</td>
<td>68</td>
<td>28</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. elsi</em></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td>0.68</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>GSC 9013 (holotype)</td>
<td>62</td>
<td>23</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McM J1792a</td>
<td>61.5</td>
<td>25</td>
<td>55</td>
<td>40</td>
<td>0.68</td>
<td>13</td>
<td>31</td>
</tr>
<tr>
<td>McM J1792c</td>
<td>59.5</td>
<td>15</td>
<td>53</td>
<td>37</td>
<td>0.70</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>McM J1792e</td>
<td>59</td>
<td>23</td>
<td>57</td>
<td>39</td>
<td>0.68</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>McM J1792b</td>
<td>59</td>
<td>21</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McM J1792c</td>
<td>59</td>
<td>23</td>
<td>57</td>
<td>34</td>
<td>0.64</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>McM J1792d</td>
<td>54</td>
<td>14</td>
<td>52</td>
<td>38</td>
<td>0.67</td>
<td>12</td>
<td>30</td>
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<tr>
<td><em>C. marchandi</em></td>
<td></td>
<td></td>
<td></td>
<td>43</td>
<td>0.78</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>GSC 9011 (holotype)</td>
<td>51</td>
<td>19</td>
<td>55</td>
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<td></td>
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</tr>
</tbody>
</table>

Other Material. — McM J1792g and GSC 48594, from Richardson Bay, Queen Charlotte Islands.

Description. — Maximum diameter attained is 19 mm, about one-third the size of the corresponding macroconchs. The aperture is marked by a prominent, narrow constriction followed by a narrow, smooth lip; the body chamber occupies three-quarters of a whorl. The whorl section is slightly depressed with H/W = 0.60-0.75; the venter is broad and rounded, the flanks slightly flattened. Primary ribs are strong and curved forward; there are nine on the last half-whorl with about three secondaries to each primary. Phragmocone whorls have not been preserved.

Dimorphism. — The few measurements available from microconch specimens indicate that they are similar to the macroconch in relative whorl dimensions (Text-fig. 27). Microconchs attain about one-third the size of corresponding macroconchs. Style and density of ribbing on the body chamber are similar in both dimorphs; apertural modifications are also similar, consisting of a constriction followed by a smooth lip.

*Chondroceras allani* (McLearn, 1927) ♀

Pl. 15, figures 7, 8; Text-figures 30-33

1927. *Saxitoniceras allani* McLearn, p. 72; pl. 1, fig. 4.
1928. *Saxitoniceras allani* McLearn; McLearn, pp. 21, 22; pl. VIII, figs. 1, 2.
1956. *Chondroceras* (*Saxitoniceras*) *allani* (McLearn); Westermann, pp. 107, 108; pl. 12, fig. 3 (holotype re-figured).
1957. *Chondroceras allani* (McLearn); Frebold, p. 53; pl. XXVII, figs. 2a, b.
1964. *Chondroceras allani* (McLearn); Imlay, pp. 42, 43; pl. 12, figs. 4-7, 9, 10.
1964. *Chondroceras allani* (McLearn); Frebold, pp. 20, 21; pl. VIII, figs. 1-5.
1964. *Chondroceras* (*Defonticeras*) *allani* (McLearn); Westermann, p. 55, (microconch ♀).
1973. *Chondroceras allani* (McLearn); Imlay, p. 81; pl. 40, figs. 11, 12.

Holotype. — GSC 9021. According to the collector (quoted in McLearn, 1928, p. 22) the holotype came from the base of the Fernie Group on the headwaters of Sheep Creek, Alberta. Frebold (1957, p. 53) considers this stratigraphic position unlikely because the species is an index fossil in the Middle (= Lower, here) Bajocian Rock Creek Member which never forms the base of the Fernie.

Other Material. — Fourteen relatively complete specimens (McM J1830a-i, 1831a-e) from the Rock Creek Member at Ribbon Creek, southern Alberta are now available for quantitative study of the species.
Text-figure 31.—Bivariate plots of whorl width (W), whorl height (H) and umbilical diameter (U) against shell diameter (D) for *Chondroceras allani* ♀ from southern Alberta. Based on 15 macroconchs, with several individual “growth lines”. See Measurements for additional explanations.

**Description.**—The protoconch is elongated transverse to the direction of coiling, having a width of 0.60 mm and a diameter of 0.50 mm at the position of the proseptum. The nepionic constriction occurs at a diameter of 0.80 mm, the end of the first whorl (Text-fig. 30). Ornamentation first appears at $D = 5$ mm in the form of broad ribbing on the ventral region only. Faint primary ribs do not appear on the flanks until a diameter of about 12 mm is reached. Shell sphaeroconic, the phragmocone whorls moderately depressed ($H/W = 0.68-0.85$, mostly 0.75-0.80), with flattened flanks and a strongly arched venter (Text-fig. 33). The umbilicus is deep and narrow, commonly less than five percent of the shell diameter with almost vertical walls rounding smoothly onto the flanks (Text-fig. 31). Ornamentation is not strong. There are seven to nine primary ribs per half-whorl, strongly curved forward on the flanks with three to four secondary ribs to each primary. Secondary ribs arise by bifurcation and intercalation at 50 percent of the whorl height, curving forward on the upper flanks then crossing straight over the venter. Nodes are absent.

Strength and density of the ribbing remain unchanged on the body chamber except that the number of secondary ribs decreases to 2.0-2.5 per primary. The last half-whorl before the aperture bears seven to nine primary ribs curving forward on the flanks but not extending onto the smooth umbilical wall. Sudden umbilical enlargement, beginning about half a whorl before the aperture and corresponding approximately to the position of the last septum, is accompanied by a decrease in both the relative whorl width and height. The whorl section changes little ($H/W = 0.75-0.80$). The aperture is marked by a broad, shallow constriction, and a smooth lip.

**Remarks.**—*Chondroceras allani* ♀ and *C. oblatum* ♀ occur together in abundance in the Rock Creek Member of the Fernie Group at Ribbon Creek, southern Alberta. Comparison of six complete specimens of *C. allani* with fourteen complete specimens of *C. oblatum* shows that the former species has a consistently smaller adult diameter (41.5-50.0 mm vs. 51.2-65.7 mm). Phragmocone whorls of *C. allani* are
relatively narrower than those of *C. oblatum* from the Ribbon Creek locality (H/W = 0.75 vs. 0.68; W/D = 0.68 vs. 0.74 respectively).

Text-figure 32.—Sutural ontogeny for *Chondroceras allani*♀ (McM J1830c, McM J1830d). The position of the umbilical seam is marked by (. See Measurements for additional explanations.

Text-figure 33.—Cross-sections of *Chondroceras* with body chamber shaded. a-b, *C. allani*♀ from southern Alberta, respectively × 1.5 and × 3 (McM J1830g, McM J1830h); d-f, *C. n. sp. indet.*♀ from Queen Charlotte Islands; d-e (McM J1857b, McM J1857a) × 2, f (McM J1857a) × 5. See Measurements for additional explanations.

*Chondroceras* n. sp. indet.♀

Plate 15, figure 9; Text-figures 33, 34

*Material.*—Two incomplete phragmocones (McM J1857a, b) from the lowest exposed bed of the Yakoun Formation at MacKenzie Bay; they are the first *Chondroceras* recorded at this locality.

*Description.*—Shell globose with broad and gently arched venter and a deep, narrow umbilicus. Whorl section strongly depressed with H/W ratios of 0.50-0.65 (Table 8). Umbilical wall short, almost vertical, rounding strongly and abruptly onto the inflated flanks to produce an umbilical shoulder.

Primary ribs long and fine, beginning at the umbilical seam and extending beyond the umbilical shoulder; they are closely spaced with 12-14 per half-whorl at diameters between 13 and 33 mm. There are usually three secondary ribs to each primary. On the umbilical wall the primary ribs are straight but crossing onto the flanks become prorsiradiate; the fine secondary ribs cross straight over the venter. Nodes are not developed.
Text-figure 34. — Sutural ontogeny of Chondroceras n. sp. indet. (McM J 1857b). The position of the umbilical seam is marked by . See Measurements for additional explanations.

The suture is only moderately complex at a diameter of 11 mm, lacking any deep incisions of the saddles (Text-fig. 34). E is shallow and broad, L slightly deeper, broad and trifid. U₂ is very broad, shallow and trifid. I and Uₙ are of the same length and narrow.

Remarks. — These two phragmocones differ from C. defontii ♀ and C. oblatum ♀ in details of the septal suture, ribbing density and whorl shape. C. defontii ♀ has much more complex sutures with deeply incised saddles and narrow lobes. C. oblatum ♀ has fewer primary ribs per half-whorl (7-10 vs. 12-14 at D = 15-30 mm) and higher whorl section with a narrower venter. C. allani ♀ has fewer primary ribs per half-whorl (8-10 vs. 12-15) and a more compressed whorl section with H/W = 0.68-0.85 on the phragmocone whorls.
Table 8. — Measurements (in mm) for *Chondroceras* n. sp. indet ♂ from MacKenzie Bay, Queen Charlotte Islands.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>U</th>
<th>W</th>
<th>H</th>
<th>P</th>
<th>S</th>
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<tbody>
<tr>
<td>McM J1857a</td>
<td>16.0</td>
<td>—</td>
<td>14.0</td>
<td>7.6</td>
<td>14</td>
<td>42</td>
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<tr>
<td>&quot;</td>
<td>11.3</td>
<td>2.1</td>
<td>10.0</td>
<td>6.7</td>
<td>11</td>
<td>—</td>
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<tr>
<td>&quot;</td>
<td>7.8</td>
<td>1.5</td>
<td>6.5</td>
<td>4.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>5.8</td>
<td>1.1</td>
<td>4.4</td>
<td>2.6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>3.4</td>
<td>0.8</td>
<td>2.8</td>
<td>1.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>2.0</td>
<td>0.6</td>
<td>1.5</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>McM J1857b</td>
<td>33.0</td>
<td>—</td>
<td>34.0</td>
<td>16.0</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>&quot;</td>
<td>16.3</td>
<td>—</td>
<td>11.2</td>
<td>6.9</td>
<td>12</td>
<td>28</td>
</tr>
</tbody>
</table>

Order NAUTILIDA

Family NAUTILIDAE De Blainville, 1825

Genus *CENOCERAS* Hyatt, 1884

*Type species.* — *N. intermedius* J. Sowerby, 1816 (original designation).

*Discussion.* — *Cenoceras* is the most diverse of the post-Triassic nautiloids, represented by some 97 described species (Kummel, 1956, p. 361) with a cosmopolitan distribution throughout the Lower and Middle Jurassic. However, Jurassic nautiloids have only rarely been recorded from North America: four species representing two genera were described by Kummel (1954) and another two by Castillo and Aguilera (1895). *C. imlayi* (Kummel) is from the Kialagvik Formation of southern Alaska (the Aalenian *E. howelli* Zone of Westermann, 1964c) and *C. lupheri* (Kummel) is from the Weberg Formation of Oregon (“Sowerbyi” Zone).

Genus *EUTREPHOCERAS* Hyatt, 1894

*Type species.* — *Nautilus dekayi* Morton, 1834 (by original designation).

*Discussion.* — Morphological distinction between the two large nautiloid stocks represented by *Cenoceras* and *Eutrephoceras* appears difficult to maintain. According to the detailed discussions of Kummel (1956), *Eutrephoceras* has an...
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

?Eutrephoceras sp. indet.

Text-figure 36

Material. — Fully septate, internal mold about 90 mm in diameter, McM J1825a, from the lower part of the Yakoun Formation, about 38 m above the exposed base of the formation on South Balch Island.

Description. — Shell globose with slightly flattened sides converging towards the venter; umbilical shoulder broadly rounded and the widest part of the whorl (Text-fig. 36d). Umbilical wall vertical; umbilicus very narrow (15 percent of shell diameter). Whorls depressed with H/W = 0.68-0.74. No ornamentation preserved. Position of the siphuncle unknown. Suture with external ventral and lateral lobe, both broad and shallow; internal suture unknown.

Remarks. — E. montanensis Kummel from the Callovian Rierdon Formation in Montana has much narrower, compressed whorls (H/W = 1.3 vs. 0.68-0.74). Another specimen of Eutrephoceras has been recorded from the Bajocian Twin Creek Limestone in Wyoming (Kummel, 1954, p. 321), but it was not described or illustrated.

essentially smooth conch and globose whorl section while Cenoceras typically bears fine lirae and growth lines and has a more quadrate whorl section. The name Cenoceras is usually given to Upper Triassic - Middle Jurassic forms, while Eutrephoceras ranges from the Upper Jurassic to Miocene (Kummel, 1964, p. 449). However, the range of whorl shapes illustrated for Cenoceras (Pia, 1914, reproduced as figs. 8, 9, and 10 in Kummel, 1956) clearly includes forms that also appear within the range illustrated for Eutrephoceras (Kummel, 1956, fig. 13). There are specimens from the Cenomanian (Upper Cretaceous) of France in the McMaster University collections (McM K44) which bear fine lirae and growth lines. Eutrephoceras sp. indet. from the Queen Charlotte Islands, an apparently smooth-shelled form with globose whorl section, is of Early Bajocian (Middle Jurassic) age.

If ornamentation and whorl shape are used to separate Cenoceras and Eutrephoceras, then their supposed age difference must be disregarded. Indeed, Kummel (1954) has already listed several Middle Jurassic species that he considers belong to Eutrephoceras (p. 321).

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Appendix I. — Data and Regression Equations for the "mass curves" shown on Text-figures for each taxon. Statistics calculated on measurements from phragmocone whorls only. * indicates regression coefficient significantly different from zero at 5% level of significance. **indicates correlation coefficient significant at 5% level of significance.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Text-figure Number</th>
<th>Number of specimens</th>
<th>Number of individual measurements</th>
<th>Regression Equation</th>
<th>Standard error of slope</th>
<th>Correlation coefficient</th>
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<tbody>
<tr>
<td>Zemistephanus richardsoni</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(Whiteaves, 1876) ♀ &amp; ♂</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>D vs. W ♀ [macroconch]</td>
<td>5</td>
<td>16</td>
<td>67</td>
<td>Y = 0.67X — 0.54</td>
<td>.0104*</td>
<td>0.99**</td>
</tr>
<tr>
<td>D vs. W ♂ [microconch]</td>
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<td>5</td>
<td>22</td>
<td>Y = 0.63X — 0.64</td>
<td>.019*</td>
<td>0.98**</td>
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<tr>
<td>D vs. H ♀ [macroconch]</td>
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<td>73</td>
<td>Y = 0.38X — 0.24</td>
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<td>0.99**</td>
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<tr>
<td>D vs. U ♀ [macroconch]</td>
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<td>16</td>
<td>66</td>
<td>Y = 0.36X + 0.35</td>
<td>.0068*</td>
<td>0.98**</td>
</tr>
<tr>
<td>D vs. W ♀ [microconch]</td>
<td>5</td>
<td>5</td>
<td>19</td>
<td>Y = 0.42X — 0.37</td>
<td>.017*</td>
<td>0.98**</td>
</tr>
</tbody>
</table>

| Zemistephanus crickmayi              |                    |                     |                                   |                     |                         |                         |
| (McLearn, 1927) ♀                   |                    |                     |                                   |                     |                         |                         |
| D vs. W ♀ [microconch]               | 9                  | 13                  | 62                                | Y = 0.54X + 0.73    | .011*                   | 0.98**                  |
| D vs. H ♀ [microconch]               | 9                  | 13                  | 62                                | Y = 0.35X + 0.04    | .005*                   | 0.99**                  |
| D vs. U ♀ [microconch]               | 9                  | 13                  | 59                                | Y = 0.41X — 0.22    | .0057*                  | 0.99**                  |

| Stephanoceras ilinse                 |                    |                     |                                   |                     |                         |                         |
| (McLearn, 1927) ♀ & ♂               |                    |                     |                                   |                     |                         |                         |
| D vs. W ♀ [macroconch]               | 13                 | 13                  | 55                                | Y = 0.43X + 4.55    | .0117*                  | 0.97**                  |
| D vs. H ♀ [microconch]               | 13                 | 11                  | 40                                | Y = 0.53X + 0.46    | .014*                   | 0.98**                  |
| D vs. U ♀ [microconch]               | 13                 | 13                  | 55                                | Y = 0.31X + 1.22    | .006*                   | 0.98**                  |
| D vs. W ♀ [microconch]               | 13                 | 11                  | 40                                | Y = 0.33X + 0.08    | .0057*                  | 0.99**                  |
| D vs. H ♀ [microconch]               | 13                 | 13                  | 56                                | Y = 0.46X — 1.62    | .009*                   | 0.98**                  |
| D vs. U ♀ [microconch]               | 13                 | 11                  | 54                                | Y = 0.45X — 0.32    | .01*                    | 0.99**                  |

| Stephanoceras skidegatense           |                    |                     |                                   |                     |                         |                         |
| (Whiteaves, 1876) ♀ & ♂             |                    |                     |                                   |                     |                         |                         |
| D vs. W ♀ [macroconch]               | 18                 | 9                   | 25                                | Y = 0.38X + 3.57    | .017*                   | 0.97**                  |
| D vs. H ♀ [macroconch]               | 18                 | 9                   | 14                                | Y = 0.59X — 0.15    | .016*                   | 0.99**                  |
| D vs. U ♀ [macroconch]               | 18                 | 9                   | 25                                | Y = 0.31X + 0.68    | .0086*                  | 0.99**                  |
| D vs. W ♀ [microconch]               | 18                 | 9                   | 14                                | Y = 0.38X — 0.35    | .008*                   | 0.99**                  |
| D vs. H ♀ [microconch]               | 18                 | 9                   | 25                                | Y = 0.49X — 1.84    | .010*                   | 0.99**                  |
| D vs. U ♀ [microconch]               | 18                 | 9                   | 11                                | Y = 0.42X — 0.12    | .0056*                  | 0.99**                  |

| Chondroceras defontii                |                    |                     |                                   |                     |                         |                         |
| (McLearn, 1927) ♀                    |                    |                     |                                   |                     |                         |                         |
| D vs. W ♀ [macroconch]               | 27                 | 4                   | 8                                 | Y = 0.76X — 0.17    | .07*                    | 0.96**                  |
| D vs. H ♀ [macroconch]               | 27                 | 4                   | 8                                 | Y = 0.49X + 0.84    | .029*                   | 0.98**                  |
| D vs. U ♀ [macroconch]               | 27                 | 3                   | 7                                 | Y = 0.05X + 1.2     | .012*                   | 0.79**                  |
Appendix 2.—Measurements and data used in formal statistical comparisons of sexual dimorphs. Only measurements from phragmocone whorls were used; there are marked changes in growth ratios at the end of the nepionic whorl and the beginning of the body chamber. A single measurement from each specimen was used (all measurements are in mm).

<table>
<thead>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Zemistephanus richardsoni (Whiteaves, 1876) ♀</td>
<td>D</td>
<td>24</td>
<td>4</td>
<td>20</td>
<td>Y = 0.76X — 0.14</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>24</td>
<td>1</td>
<td>6</td>
<td>Y = 0.76X + 0.28</td>
<td>0.99</td>
</tr>
<tr>
<td>&quot;Saxitoniceras marshalli&quot; McLearn, 1927 ♀</td>
<td>D vs. W ♂ [macroconch]</td>
<td>24</td>
<td>9</td>
<td>48</td>
<td>Y = 0.79X — 0.31</td>
<td>0.018*</td>
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<tr>
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<td>D vs. H ♂ [macroconch]</td>
<td>24</td>
<td>9</td>
<td>48</td>
<td>Y = 0.51X + 0.03</td>
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<td>D vs. U ♂ [macroconch]</td>
<td>24</td>
<td>8</td>
<td>24</td>
<td>Y = 0.13X — 0.06</td>
<td>0.01*</td>
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<tr>
<td>Chondroceras allani (McLearn, 1927) ♀</td>
<td>D vs. W ♂ [macroconch]</td>
<td>31</td>
<td>8</td>
<td>46</td>
<td>Y = 0.69X — 0.05</td>
<td>0.009*</td>
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<tr>
<td></td>
<td>D vs. H ♂ [macroconch]</td>
<td>31</td>
<td>8</td>
<td>46</td>
<td>Y = 0.50X + 0.13</td>
<td>0.006*</td>
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<td>D vs. U ♂ [macroconch]</td>
<td>31</td>
<td>6</td>
<td>17</td>
<td>Y = 0.16X — 0.28</td>
<td>0.018*</td>
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</tbody>
</table>

Regression Analysis for Zemistephanus richardsoni

D vs. W ♀ Y = 0.679X — 1.06
♂ Y = 0.675X — 1.658
(a) Variance: F = 2.21; F<sub>0.05</sub>(9, 4) = 6.0; hypothesis of equal variances accepted
(b) Slopes: t = 0.06; t<sub>0.05</sub> (11) = 1.796; hypothesis of equal slopes accepted
(c) Intercepts: t = 23.33; t<sub>0.05</sub> (12) = 1.782; hypothesis of equal intercepts rejected

D vs. H ♀ Y = 0.383X — 0.4
♂ Y = 0.351X — 0.14
(a) Variance: F = 9.1; F<sub>0.05</sub>(9, 4) = 6.0; hypothesis of equal variances rejected

D vs. U ♀ Y = 0.385X — 0.38
♂ Y = 0.395 — 0.53
(a) Variance: F = 1.06; F<sub>0.05</sub>(7, 3) = 8.89; hypothesis of equal variances accepted
(b) Slopes: t = 0.17; t<sub>0.05</sub> (6) = 1.86; hypothesis of equal slopes accepted
(c) Intercepts: t = 20; t<sub>0.05</sub> (9) = 1.833; hypothesis of equal intercepts rejected

W vs. H ♀ Y = 0.556X + 0.334
♂ Y = 0.513X + 0.814
(a) Variance: F = 5.81; F<sub>0.05</sub>(9, 4) = 6.0; hypothesis of equal variances accepted
(b) Slopes: t = 0.4; t<sub>0.05</sub> (11) = 1.796; hypothesis of equal slopes accepted
(c) Intercepts: t = 10.5; t<sub>0.05</sub> (12) = 1.782; hypothesis of equal intercepts rejected
<table>
<thead>
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<td><em>Stephanoceras itinsae</em> (McLearn, 1927) ♀</td>
<td>31.0</td>
<td>15.7</td>
<td>9.9</td>
<td>—</td>
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<tr>
<td>[macroconch]</td>
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<td>15.6</td>
<td>9.1</td>
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<td></td>
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<td>—</td>
<td>—</td>
<td>12.2</td>
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</table>

| *Stephanoceras itinsae* (McLearn, 1927) ♂  | 24.8 | 13.9 | 8.6  | 11.2 |
| [microconch] | 15.0 | 9.0  | 5.0  | —    |
|              | 18.7 | 10.0 | 5.5  | 7.3  |
|              | 21.2 | 13.4 | 7.4  | 9.1  |
|              | 36.2 | 20.5 | 10.7 | 17.0 |
|              | 40.6 | 18.1 | 13.3 | 18.2 |
|              | 30.5 | 12.4 | 9.7  | 14.0 |
|              | 5.0  | 2.9  | 1.5  | 2.2  |
|              | 10.0 | 5.7  | 3.3  | 4.2  |
|              | 29.4 | 17.2 | 10.2 | 13.2 |

**Regression Analysis for *Stephanoceras itinsae***

D vs. W ♀  
\[ Y = 0.496X + 1.75 \]  
♀  \[ Y = 0.459 + 1.67 \]

(a) Variance: \( F = 1.95; F_{(9, 8)} = 3.39 \); hypothesis of equal variances accepted  
(b) Slopes: \( t = -0.445; t_{(9, 8)} = 1.753 \); hypothesis of equal slopes accepted  
(c) Intercepts: \( t = 4.76; t_{(9, 8)} = 1.746 \); hypothesis of equal intercepts accepted

D vs. W ♂  
\[ Y = 0.378X — 0.64 \]  
♀  \[ Y = 0.319X + 0.13 \]

(a) Variance: \( F = 2.17; F_{(9, 8)} = 3.23 \); hypothesis of equal variances rejected  
(b) Slopes: \( t = 1.79; t_{(9, 8)} = 1.753 \); hypothesis of equal slopes rejected  
(c) Intercepts: \( t = 9.02; t_{(9, 8)} = 1.753 \); hypothesis of equal intercepts rejected

D vs. U ♀  
\[ Y = 0.369X + 1.49 \]  
♀  \[ Y = 0.469X — 0.58 \]

(a) Variance: \( F = 16.6; F_{(6, 8)} = 3.58 \); hypothesis of equal variances rejected  
(b) Slopes: \( t = 0.016; t_{(6, 8)} = 1.753 \); hypothesis of equal slopes accepted  
(c) Intercepts: \( t = 1.5; t_{(6, 8)} = 1.753 \); hypothesis of equal intercepts accepted

W vs. H ♀  
\[ Y = 0.706X — 1.09 \]  
♀  \[ Y = 0.621X — 0.13 \]

(a) Variance: \( F = 1.1; F_{(9, 8)} = 3.39 \); hypothesis of equal variances accepted  
(b) Slopes: \( t = 0.016; t_{(9, 8)} = 1.753 \); hypothesis of equal slopes accepted  
(c) Intercepts: \( t = 1.5; t_{(9, 8)} = 1.753 \); hypothesis of equal intercepts accepted

<table>
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<th>U</th>
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<tr>
<td><em>Stephanoceras skidegatense</em> (Whiteaves, 1876) ♀</td>
<td>43.5</td>
<td>18.5</td>
<td>16.3</td>
<td>18.2</td>
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<tr>
<td>[macroconch]</td>
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<td>7.3</td>
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<td>9.3</td>
<td>11.4</td>
</tr>
</tbody>
</table>

| *Stephanoceras skidegatense* (Whiteaves, 1876) ♂  | 36.5 | 23.0 | 14.0 | 15.0 |
| [microconch] | 14.2 | 7.6  | 4.2  | —    |
|              | 43.4 | —    | —    | 18.6 |

**Regression Analysis for *Stephanoceras skidegatense***

D vs. W ♀  
\[ Y = 0.41X + 3.0 \]
♀  \[ Y = 0.69X — 2.2 \]

(a) Variance: \( F = 3.8; F_{(1, 8)} = 233.0 \); accept hypothesis of equal variances  
(b) Slopes: \( t = 1.89; t_{(6, 8)} = 2.015 \); accept hypothesis of equal slopes  
(c) Intercepts: \( t = 1.65; t_{(5, 6)} = 1.943 \); accept hypothesis of equal intercepts
Jurassic Cephalopods and Assemblage Zones: Hall and Westermann

D vs. H

\[ Y = 0.41X - 1.64 \]
\[ Y = 0.44X - 2.0 \]

(a) Variance: \( F = 0.8; F_{0.05}(6, 1) = 234.0 \); accept hypothesis of equal variances
(b) Slopes: \( t = 0.44; t_{0.05} = 2.015 \); accept hypothesis of equal slopes
(c) Intercepts: \( t = 0.642; t_{0.05} = 1.943 \); accept hypothesis of equal intercepts

W vs. H

\[ Y = 0.84X - 2.28 \]
\[ Y = 0.64X - 0.6 \]

(a) Variance: \( F = 3.2; F_{0.05}(6, 1) = 234.0 \); accept hypothesis of equal variances
(b) Slopes: \( t = 0.356; t_{0.05} = 2.015 \); accept hypothesis of equal slopes
(c) Intercepts: \( t = 0.608; t_{0.05} = 1.943 \); accept hypothesis of equal intercepts

Chondroceras oblatum (Whiteaves, 1876)

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"Saxitoniceras marshalli" McLearn, 1927

[= C. oblatum]

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Regression Analysis for Chondroceras oblatum and "Saxitoniceras marshalli"

D vs. W (C. oblatum)

\[ Y = 0.825X - 0.35 \]

(S. marshalli) \[ Y = 0.839X - 0.32 \]

(a) Variance: \( F = 26.9; F_{0.05}(9, 3) = 8.84 \); reject hypothesis of equal variances

D vs. H (C. oblatum)

\[ Y = 0.557X - 0.27 \]

(S. marshalli) \[ Y = 0.51X - 0.22 \]

(a) Variance: \( F = 0.944; F_{0.05}(9, 3) = 8.84 \); accept hypothesis of equal variances
(b) Slopes: \( t = 1.02; t_{0.05} = 1.812 \); accept hypothesis of equal slopes
(c) Intercepts: \( t = 1.33; t_{0.05} = 1.796 \); accept hypothesis of equal intercepts

W vs. H (C. oblatum)

\[ Y = 0.674X - 0.013 \]

(S. marshalli) \[ Y = 0.577X + 0.54 \]

(a) Variance: \( F = 4.18; F_{0.05}(9, 3) = 8.84 \); accept hypothesis of equal variances
(b) Slopes: \( t = 0.86; t_{0.05} = 1.812 \); accept hypothesis of equal slopes
(c) Intercepts: \( t = 0.817; t_{0.05} = 1.796 \); accept hypothesis of equal intercepts

"Saxitoniceras marshalli" McLearn, 1927

[= C. oblatum]

Chondroceras allani (McLearn, 1927)

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Chondroceras allani (McLearn, 1927)

[macroconch]
Regression Analysis for "Saxitoniceras marshalli" and Chondroceras allani

D vs. W (S. marshalli)  \[ Y = 0.839X - 0.32 \]
(C. allani)  \[ Y = 0.673X + 0.487 \]
(a) Variance: \( F = 4.96; F_{9.0.05}(9, 7) = 3.68; \) reject hypothesis of equal variances

D vs. H (S. marshalli)  \[ Y = 0.51X - 0.22 \]
(C. allani)  \[ Y = 0.483X + 0.62 \]
(a) Variance: \( F = 0.71; F_{9.0.05}(9, 7) = 3.68; \) accept hypothesis of equal variances
(b) Slopes: \( t = 0.16; t_{9.0.05} = 1.761; \) accept hypothesis of equal slopes
(c) Intercepts: \( t = 0.575; t_{9.0.05} = 1.753; \) accept hypothesis of equal intercepts

W vs. H (S. marshalli)  \[ Y = 0.577X + 0.54 \]
(C. allani)  \[ Y = 0.71X + 0.37 \]
(a) Variance: \( F = 2.93; F_{9.0.05}(9, 7) = 2.93; \) accept hypothesis of equal variances
(b) Slopes: \( t = 1.37; t_{9.0.05} = 1.761; \) accept hypothesis of equal slopes
(c) Intercepts: \( t = 1.84; t_{9.0.05} = 1.753; \) reject hypothesis of equal intercepts
JURASSIC CEPHALOPODS AND ASSEMBLAGE ZONES: HALL AND WESTERMANN

PLATES
EXPLANATION OF PLATE 1

(All figures natural size)

<table>
<thead>
<tr>
<th>Figure</th>
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<tbody>
<tr>
<td>1-5. <strong>Zemistephanus richardsoni</strong> (Whiteaves)</td>
<td>25</td>
</tr>
<tr>
<td>1. Complete specimen with aperture, McM J1797a, from bed a of Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands. Note egression of body chamber, rounded nodes and deep umbilicus.</td>
<td></td>
</tr>
<tr>
<td>2. Almost complete specimen, McM J1797d, from same bed as specimen shown in figure 1. Note egression of body chamber, loss of ribbing on body chamber, deep umbilicus and nodes of phragmocone.</td>
<td></td>
</tr>
<tr>
<td>3a-c. Phragmocone, McM J1797b, from same bed as specimens shown in figures 1 and 2.</td>
<td></td>
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<tr>
<td>4-5. Incomplete phragmocones and nuclei, from Fitz Creek Siltstone, southern Alaska (USGS Mesozoic, loc. 2999.3).</td>
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**Explanation of Plate 2**

*(All figures natural size)*

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<tr>
<td>1-4. <strong>Zemistephanus richardsoni</strong> (Whiteaves) ♂</td>
<td>25</td>
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<tr>
<td>1a-c. Allotype, complete specimen with lappet, McM J1796a, from bed a of Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands; c-e, phragmocone whorls. Note strong egression of body chamber, straight primaries and large conical nodes on phragmocone, and wider spacing of secondary ribbing on body chamber.</td>
<td></td>
</tr>
<tr>
<td>2a-b. Phragmocone with body chamber fragment bearing lappets. GSC 56686, from the Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands, a, aperture located in approximate position. Note large conical nodes and prominent ribbing.</td>
<td></td>
</tr>
<tr>
<td>3. Phragmocone, McM J1796b, from same bed as specimens shown in figure 1.</td>
<td></td>
</tr>
<tr>
<td>4. Incomplete phragmocone with body chamber bearing lappets, McM J1796c, from same bed as specimens shown in figures 1 and 3.</td>
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</table>

| 5-8. **Zemistephanus crickmayi** (McLearn) ♂ | 30 |
| 5a-d. Incomplete phragmocone with its nucleus, from Fitz Creek Siltstone, southern Alaska (USGS Mesozoic loc. 2999.4). |
| 6a-b. Incomplete phragmocone with beginning of body chamber, McM J1798a, from bed a of Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands. |
| 7. Body chamber with prominent ribbing, McM J1798e, from same bed as specimen shown in figure 1. |
| 8. Incomplete phragmocone and body chamber, McM J1798f, from same bed as specimen shown in figure 1. |
EXPLANATION OF PLATE 3

(All figures natural size)

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<th>Figure</th>
<th>Page</th>
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<tr>
<td>1a-b.</td>
<td>25</td>
<td>Zemistephanus carlottensis (Whiteaves) ♀</td>
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<td>Holotype, from Skidegate Inlet, Queen Charlotte Islands, GSC 5010.</td>
<td></td>
</tr>
<tr>
<td>2a-b.</td>
<td>25</td>
<td>Zemistephanus richardsoni (Whiteaves) ♀</td>
<td>25</td>
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<tr>
<td></td>
<td></td>
<td>Holotype, from Skidegate Inlet, Queen Charlotte Islands, GSC 5013.</td>
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**EXPLANATION OF PLATE 4**

(All figures natural size)

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</thead>
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<tr>
<td><em>Zemistephanus warreni</em> (McLear)</td>
<td>34</td>
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Holotype, almost completely septate, from Porcupine Creek, southern Alberta, UA JR114.
### Explanation of Plate 5

(Figures natural size unless otherwise indicated)

<table>
<thead>
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<th>Figure</th>
<th>Page</th>
<th>Description</th>
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<tr>
<td>1a, b. Zemistephanus alaskensis n. sp. ♀</td>
<td>32</td>
<td>Almost complete specimen with one whorl body chamber, McM J1858a, from bed c of the Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands. Note large conical nodes on phragmocone and broad blunt primaries. X 0.75.</td>
</tr>
<tr>
<td>2. Zemistephanus crickmayi (McLearn) ♂</td>
<td>30</td>
<td>Holotype, almost complete specimen, GSC 9016, from Yakoun Formation of Maude Island, Queen Charlotte Islands.</td>
</tr>
<tr>
<td>3-4. Stephanoceras (Stemmatoceras) ex gr. S. acuticostatum (Weisert)</td>
<td>49</td>
<td>3. Lectotype of &quot;Teloceras itinsai&quot; McLearn (nom. dub.), incomplete phragmocone and body chamber, GSC 56687, from same bed as specimen shown in figure 2. Note broad, flat venter. 4. Damaged phragmocone, McM J1861, from Yakoun Formation of Mackenzie Bay, Queen Charlotte Islands. Note broad, flat venter, lateral shoulder, and sharp primaries on inner whorls.</td>
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EXPLANATION OF PLATE 6

(All figures natural size)

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<tr>
<td>1-2. <strong>Stephanoceras (Stephanoceras) itinsae</strong> (McLearn)</td>
<td>37</td>
</tr>
<tr>
<td>1a-d. Phragmocone and its nucleus, UBC collections, unnumbered, from the Yakoun Formation of &quot;Harty's Island&quot;, Queen Charlotte Islands.</td>
<td></td>
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<tr>
<td>2. Phragmocone and half whorl of body chamber, GSC 56688, from the Yakoun Formation of Reef Island. Queen Charlotte Islands. Note egression of body chamber.</td>
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### Explanation of Plate 7

(Figures natural size unless otherwise indicated)

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</tr>
</thead>
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<td>1-4.</td>
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<td>1a, b.</td>
<td>Incomplete phragmocone, McM J1808g, from the Yakoun Formation of South Balch Island, eastern shore, Queen Charlotte Islands.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Phragmocone with half whorl of body chamber, GSC 56689, from the Yakoun Formation of Reef Island, Queen Charlotte Islands. Note eggression of body chamber.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Complete body chamber with aperture, GSC 56690, from Yakoun Formation of South Balch Island, Queen Charlotte Islands, × 0.5.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Almost complete specimen with aperture, lateral view, GSC 56691, from same locality as specimen shown in figure 3, × 0.5.</td>
<td></td>
</tr>
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EXPLANATION OF PLATE 8

(All figures natural size)

Figure 1-7. _Stephanoceras (Stephanoceras) itinsae_ (McLearn) .............................................

1a, b. 9 [macroconch]
Incomplete phragmocone, McM J1880, from Rock Creek Member of Fernie Group at Ribbon Creek, southern Alberta.

2-7. 2, 3, 4a-f, 5, 6a-c, 7a, b [microconch: 'Itinsaites']
2-3. Damaged specimens with peristome, bearing lappets, GSC 56692-3, from Yakoun Formation of South Balch Island, Queen Charlotte Islands.
4a-f. Complete specimen with lappet, entire specimen and parts of phragmocone, McM J1799a, from same locality as specimen shown in figures 2-3.
5. Fragment with well-preserved lappet, McM J1801b, from interval d at same locality as that from which the specimens shown in figures 2-4 were collected.
6a-c. Damaged specimen, McM J1800, with aperture, body chamber and phragmocone, from bed e at same locality as that from which the specimens shown in figures 2-5 were collected.
7a, b. Damaged specimen with body chamber, McM J1838, from Rock Creek Member of Fernie Group at Ribbon Creek, southern Alberta.
Explanation of Plate 9
(Figures natural size unless otherwise indicated)

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--- | ---
1-5. **Stephanoceras (Stephanoceras) skidegatense** (Whiteaves) | 43

1a-b. ? [macroconch]
Incomplete specimen with part of body chamber, lateral and ventral views, McM J1878, × 0.7, from bed d of Yakoun Formation at Richardson Bay, Queen Charlotte Islands. Note prominent sharp secondaries, with only two per primary on body chamber.

2-3. δ [microconch]
2a, b. Almost complete paratype of Whiteaves, GSC 56694, purchased by Dawson on Queen Charlotte Islands.
3a-c. Allotype, complete specimen with base of lappet: a, b, entire specimen and c, phragmocone, McM J1802b, collected from same bed as specimen shown in figure 1.

4-5. Inner whorls of juveniles (?), × 2.
4a, b. McM J1802f, from same bed as that from which specimens shown in figures 1 and 3 were collected.
5a, b. GSC 56695, from Yakoun Formation, "between MacKenzie Bay and Clapp Bay", Queen Charlotte Islands.
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(All figures natural size)

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1a-c. Stephanoceras skidegatense (Whiteaves) ♂ ........................................................... 43
   a, body chamber, b and c, phragmocone, McM J1802a, from bed d of the Yakoun Formation at Richardson Bay, Queen Charlotte Islands.

2-3. Stephanoceras sp. ♂ aff. S. skidegatense (Whiteaves) ........................................ 47
   From Yakoun Formation at Richardson Bay, Queen Charlotte Islands.
   2a, b. Phragmocone with part of body chamber, McM J1804, from bed c.
   3a, b. Phragmocone, McM J1806, from bed d.

4a-b. Stephanoceras (Stephanoceras) pyritosum caamanoi McLearn ♀ ............................ 47
   Holotype, almost completely septate, GSC 9056, from Yakoun Formation of South Balch Island, Queen Charlotte Islands.
EXPLANATION OF PLATE 11
(All figures natural size)

Figure Page
   Holotype, septate almost to the end. UA JR192, float in Miners Creek near Cadomin, Alberta.
2a, b. Stephanoceras (Stemmatoceras) dowlingi (McLearn) ♀ ........................................... 48
   Holotype, with part of body chamber. GSC 9050, from (?) Rock Creek Member, Fernie Group, at Ribbon Creek, southern Alberta.
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<td>1.</td>
<td><em>Stephanoceras (Stemmatoceras?) palliseri</em> (Warren) ♀</td>
</tr>
<tr>
<td></td>
<td>Holotype, UA JR115, from the Fernie Group, upper Whitehorse River, Mountain Park area, Alberta.</td>
</tr>
<tr>
<td>2.</td>
<td><em>Stephanoceras (Stemmatoceras?) allani</em> (Warren) ♀</td>
</tr>
<tr>
<td></td>
<td>Holotype, almost complete with 3/4 whorl body chamber, UA JR479, from the Rock Creek Member, Fernie Group, southern Alberta, × 6.6.</td>
</tr>
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(Figures natural size unless otherwise indicated)

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<tr>
<th>Figure</th>
<th>Page</th>
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</thead>
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<td>Holotype, UA JR113, from the Fernie Group, headwaters of Sheep Creek, Alberta.</td>
<td></td>
</tr>
<tr>
<td>2. &quot;<em>Stemmatoceras carri</em>&quot; Warren [= <em>Stephanoceras (S.) itinsae</em> ♀]</td>
<td>40</td>
</tr>
<tr>
<td>Lectotype (here designated), UA JR484, from the Rock Creek Member of the Fernie Group, six miles above the mouth of Whitehorse River near Cadomin, Alberta, × 0.8.</td>
<td></td>
</tr>
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<tr>
<th>Figure</th>
<th>Description</th>
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</thead>
<tbody>
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<td>1-7. Chondroceras oblatum (Whiteaves) ♀ [macroconch]</td>
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</tr>
<tr>
<td>1a, b. Holotype, complete, GSC 4964, from Skidegate Channel, Queen Charlotte Islands.</td>
<td></td>
</tr>
<tr>
<td>2. Distorted complete specimen, McM J1834a, from beds a - b, of the Yakoun Formation on South Balch Island, Queen Charlotte Islands.</td>
<td></td>
</tr>
<tr>
<td>3a, b. Complete specimen, McM J1836b, from the Rock Creek Member of the Fernie Group at Ribbon Creek, southern Alberta.</td>
<td></td>
</tr>
<tr>
<td>4a, b. Phragmocone, McM J1877, from undifferentiated Yakoun Formation of eastern shore of South Balch Island, × 2.</td>
<td></td>
</tr>
<tr>
<td>5a, b. Phragmocone, McM J1795, collected from same locality as specimen shown in figure 4, × 1.3.</td>
<td></td>
</tr>
<tr>
<td>6a, b. Complete specimen, McM J1836c, from the Rock Creek Member of the Fernie Group at Ribbon Creek, southern Alberta.</td>
<td></td>
</tr>
<tr>
<td>7. Phragmocone, McM J1832b, from base of interval d of the Yakoun Formation at South Balch Island.</td>
<td></td>
</tr>
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</table>

| 8. Chondroceras oblatum (Whiteaves) ♂ [microconch] | Page 52 |
| Allootype, complete specimen, McM J1794a, from undifferentiated Yakoun Formation of South Balch Island, Queen Charlotte Islands, × 2. |
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(Figures natural size unless otherwise indicated)

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1-6. Chondroceras defontii (McLearn) ................................................................. 54

1-5. ♀ [macroconch]
   1a, b. Holotype, complete, GSC 9009, from Richardson Bay, Queen Charlotte Islands.
   2. Complete specimen, McM J1792b, from bed c of the Yakoun Formation at Richardson Bay, Queen Charlotte Islands. Note sudden egression of body chamber and apertural constriction.
   3. Complete specimen, McM J1829, from bed a of same section as that from which the specimen shown in figure 2 was collected.
   4a, b. Complete specimen, GSC 56696, from the Yakoun Formation at Richardson Bay.
   5. Phragmocone, McM J1792, collected from same locality as the specimen shown in figure 4. Note dense, curved ribbing.

6. ♂ [microconch]
   Allotype, complete body chamber, McM J1793a, from bed d of the Yakoun Formation at Richardson Bay, × 1.5.

7-8. Chondroceras allani (McLearn) ♂ ............................................................... 58

7a, b. Almost complete specimen, McM J1830h, from the Rock Creek Member of the Fernie Group, Ribbon Creek, southern Alberta. Note curved primaries and egression of body chamber.

8. Almost complete specimen, McM J1831d, collected from the same locality as specimen shown in figure 7. Note curved primaries and egression of body chamber.

9a-c. Chondroceras sp. indet. ♂ ........................................................................... 60

Phragmocone, McM J1857a, from bed a of the Yakoun Formation at Mackenzie Bay, Queen Charlotte Islands; b-c, inner whorls with strongly curved ribbing, × 2.
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1. General view southward across Skidegate Inlet from Queen Charlotte City showing Channel Islands (South Balch Island on the left) with part of Maude Island behind ....... 7

2. Mackenzie Bay, Maude Island; interbedded shales and volcanogenic sandstones of the lower Yakoun Formation; horizon a, in which *Zemistephanus richardsoni* (Whiteaves) is abundant ................................................................. 9

3. Outcrop of lower Yakoun Formation on shore of Richardson Bay, Maude Island at high tide. Interbedded shales and sandstones with abundant *Chondroceras defontii* (McLearn) and *Stephanoceras skidegatense* (Whiteaves) ................................................. 11

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