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**NEW OR FORMERLY POORLY KNOWN,
BIOCHRONOLOGICALLY AND
PALEOBIOGEOGRAPHICALLY IMPORTANT
GASTROPLITINID AND CLEONICERATINID
(AMMONITIDA) TAXA FROM MIDDLE ALBIAN
ROCKS OF MID-WESTERN AND ARCTIC CANADA**

J.A. JELETZKY



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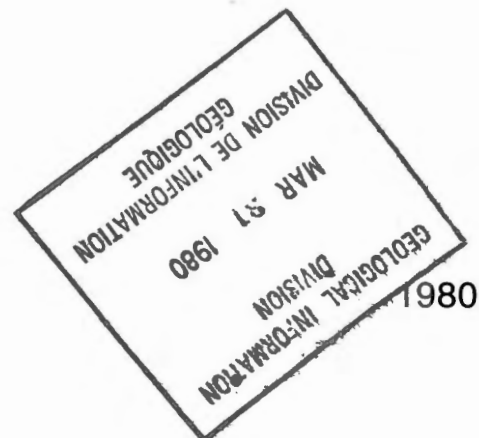
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NEW OR FORMERLY POORLY KNOWN, BIOCHRONOLOGICALLY AND PALEOBIOGEOGRAPHICALLY
IMPORTANT GASTROPLITINID AND CLEONICERATINID (AMMONITIDA) TAXA FROM
MIDDLE ALBIAN ROCKS OF MID-WESTERN AND ARCTIC CANADA

Abstract

The following new or poorly known, biochronologically and paleobiogeographically important ammonite taxa are described and figured from middle Albian rocks of the Canadian Western Interior Region and Sverdrup Basin:

1. Cleoniceratinae Whitehouse 1926
 - 1a. Cleoniceras (Cleoniceras) canadense sp. nov.
 - 1b. Cleoniceras (Grycia) densicostata sp. nov.
 - 1c. Cleogastrolites gen. nov. based on the unique species C. abberans sp. nov.
2. Gastrolitinae Wright 1952
 - 2a. Pseudogastrolites gen. nov. with the following species: 2a I. P. articus sp. nov. (genotype); and 2a II. P. nanus sp. nov.
 - 2b. Anagastrolites gen. nov. based on the unique species A. tozeri sp. nov.
 - 2c. Stotticeras gen. nov. based on the unique species S. crowense sp. nov.
 - 2d. Stelckiceras gen. nov. based on the unique species St. liardense (Whiteaves 1889).
 - 2e. Pseudopulchellia Imlay 1961 emend. with the following species: 2e I. Ps. pattoni Imlay 1961 (genotype); 2e II. Ps. balkwilli sp. nov.; 2e III. Ps. imlayi sp. nov.; and 2e IV. Ps. flexicostata (Imlay 1961).

The following upward sequence of middle Albian (in the sense of Spath, 1926 non Casey 1961 nec. Owen 1971) cleoniceratinid and gastrolitid faunas is inferred to exist in the Upper shale member of the Christopher Formation, Sverdrup Basin:

1. Cleoniceras (Cleoniceras) canadense fauna corresponding approximately to the lower part of Unnamed Zone F of the Canadian Western Interior Region and apparently to the Lyelliceras lyelli Subzone of the European Standard.
2. Pseudopulchellia flexicostata fauna corresponding approximately to the upper part of Unnamed Zone F of the Canadian Western Interior Region as well as apparently to the upper part of the Hoplites dentatus Zone and the lower part of the Euhoplites loricatus Zone combined.
3. Pseudogastrolites articus fauna corresponding approximately to the Pseudopulchellia pattoni Zone of the Canadian Western Interior Region and apparently to the upper part of Euhoplites loricatus Zone of the European standard and
4. Anagastrolites tozeri fauna corresponding approximately to the Stelckiceras liardense Zone of the Canadian Western Interior Region and apparently to the Dipoloceras cristatum Subzone of the European standard.

These gastrolitid faunas cannot be treated as regional paleontological zones as yet. However they are expected to become the basis of a new regional zonal standard valid for Canadian Arctic areas north of the Liard Plateau, northern and central Alaska and, possibly, the Pacific slope of Siberia.

The generalized Gastrolites sensu stricto Zone of the Canadian Western Interior Region is unknown in Sverdrup Basin. It appears to be represented there by the unfossiliferous 200 m thick or thicker shale interval separating the Pseudogastrolites articus and Anagastrolites tozeri faunas.

The Stotticeras crowense faunule is known only from a solitary locality in the Liard River area which is believed to represent the basal part of the Pseudopulchellia pattoni Zone. Stotticeras gen. nov. also occurs in central Alaska, where it appears to be associated with Pseudopulchellia flexicostata (Imlay). This genus is only questionably represented in the Sverdrup Basin.

Stelckiceras gen. nov. appears to be restricted to the Stelckiceras liardense Zone of the Canadian Western Interior Region which alone is believed to be correlative with the Dipoloceras cristatum Subzone of the European standard.

Contrary to the currently held ideas, it was not the Canadian Western Interior Basin but the Sverdrup Basin that represented the evolutionary center of the sub-family Gastrolitinae in mid-Albian time. Most of mid-Albian gastrolitid faunas of the Canadian Western Interior Basin (i.e. except its Gastrolites sensu stricto faunas) are not directly phylogenetically related. They represent, instead, a series of separate episodes of migration of elements of principal gastrolitid lineages which were endemic to and evolved uninterruptedly in the Sverdrup Basin. Each of these migration episodes ended in extinction.

The situation changes early in late Albian, following an apparently complete draining of the Sverdrup Basin, as the late Albian to early Cenomanian Neogastrolites stock was evidently endemic to the Canadian and American areas of the mid-continental basin. Neogastrolites does not appear to be a descendant of Gastrolites sensu stricto or any other mid-Albian gastrolitid stock of the Canadian Western Interior Region. It seems to be, instead, a derivative of Pseudopulchellia ex gr. Ps. balkwilli sp. nov. native to Sverdrup Basin via Stelckicerias gen. nov. True representatives of Gastrolites sensu stricto and Neogastrolites are unknown anywhere outside of the mid-continental basin of North America, except for the southern part of the Sverdrup Basin. All records of these genera in Alaska, on the Pacific slope of Siberia, in the European Arctic, and in England are considered to be erroneous. All these gastrolitids, such as Pseudogastrolites cantianus (Spath), Cleogastrolites subquadratus (Nagy) and other "Gastrolites" from Spitsbergen, Pseudopulchellia flexicostata (Imlay), "Gastrolites" spp. and "Paragastrolites" from northern and central Alaska, "Gastrolites" and "Neogastrolites" from the Pacific slope of Siberia, belong to other genera native to the Sverdrup Basin.

So far as is known, the mid-Albian generation of the mid-continental basin of North America was only tenuously and possibly intermittently, connected with the Sverdrup Basin. In its turn, the mid-Albian Sverdrup Basin was a relatively small inland sea which was only tenuously, and possibly intermittently, connected with the contemporary basins of Alaska, northern Asia and European Arctic. This is evidenced by relatively to extremely rare occurrence of all gastrolitid genera native to the Sverdrup Basin in these basins. This mid-Albian paleogeographic setup appears to be incompatible with that reconstruction of Albian paleogeography of the Boreal Region based on the assumption of a globe of modern mean diameter and surface curvature (i.e. on the tenets of the orthodox plate tectonic hypothesis) as this reconstruction postulates the existence of an improbably large Paleoarctic Ocean. Instead, this paleogeographic setup agrees well with that reconstruction of Albian paleogeography of the Boreal Region based entirely on the concept of an expanding Earth as least from the early Mesozoic to the present day.

Résumé

L'auteur décrit, avec l'aide d'illustrations, des taxa d'ammonites nouveaux ou mal connus qui ont été trouvés dans des roches datant du milieu de l'Albien, dans la région intérieure de l'Ouest canadien et dans le bassin Sverdrup. Ces spécimens revêtent une grande importance pour la biochronologie et la paléobiogéographie.

1. Cleoniceratinae, Whitehouse 1926
 - 1a. Cleoniceras (Cleoniceras) canadense, esp. nov.
 - 1b. Cleoniceras (Grycia) densicostata, esp. nov.
 - 1c. Cleogastrolites, gen. nov., basé sur l'espèce unique C. aberrans, esp. nov.
2. Gastrolitinae, Wright 1952
 - 2a. Pseudogastrolites, gen. nov., avec les espèces suivantes:
 - 2a I. P. arcticus, esp. nov. (génotype); 2a II. P. nanus, esp. nov.
 - 2b. Anagastrolites, gen. nov., basé sur l'espèce unique A. tozeri, esp. nov.
 - 2c. Stotticerias, gen. nov., basé sur l'espèce unique S. crowense, esp. nov.
 - 2d. Stelckicerias, gen. nov., basé sur l'espèce unique St. liardense (Whiteaves 1889).
 - 2e. Pseudopulchellia, Imlay 1961, avec les espèces suivantes:
 - 2e I. Ps. pattoni, Imlay 1961, (génotype); 2e II. Ps. balkwilli, esp. nov.; 2e III. Ps. imlayi, esp. nov.; 2e IV. Ps. flexicostata (Imlay 1961).

L'auteur présume l'existence, dans le membre schisteux supérieur de la formation de Christopher, dans le bassin Sverdrup, de la séquence ascendante suivante de faunes de cléonicératinidés et de gastrolitidés de l'Albien moyen (au sens de Spath, 1926 non Casey 1961 nec Owen 1971):

1. Cleoniceras (Cleoniceras) canadense, correspondant à peu près à la partie inférieure de la zone F (sans nom) de la région intérieure de l'Ouest canadien, et apparemment à la sous-zone Lyelliceras lyelli de la norme européenne;
2. Pseudopulchellia flexicostata, correspondant à peu près à la partie supérieure de la zone F (sans nom) de la région intérieure de l'Ouest canadien; cette faune serait aussi associée à la partie supérieure de la zone Hoplites dentatus et à la partie inférieure de la zone Euhoplites loricatus combinées.
3. Pseudogastrolites arcticus, correspondant à peu près à la zone Pseudopulchellia pattoni de la région intérieure de l'Ouest canadien, et apparemment à la partie supérieure de la zone Euhoplites loricatus de la norme européenne; et

4. Anagastroplites tozeri, correspondant à peu près à la zone Stelckiceras liardense de la région intérieure de l'Ouest canadien, et apparemment à la sous-zone Dipoloceras cristatum de la norme européenne.

Ces faunes de gastroplitinidés ne peuvent pas encore être considérées comme des zones paléontologiques régionales. Toutefois, on s'attend à ce qu'elles forment la base d'une nouvelle norme de classification des zones régionales, valable pour les régions de l'Arctique canadiennesituées au nord du plateau Liard, le nord et le centre de l'Alaska et peut-être la pente continentale de la Sibérie.

La zone généralisée Gastroplites de la région intérieure de l'Ouest canadien n'est pas présente en tant que telle dans le bassin Sverdrup. Il semble toutefois qu'elle y soit représentée par une couche de schistes argileux non fossilifères d'au moins 200 mètres d'épaisseur, qui s'interpose entre les faunes Pseudogastroplites articus et Anagastroplites tozeri.

La faune caractéristique Stotticeras crowense n'est connue que dans un endroit isolé dans la région de la rivière Liard, dont on croit qu'elle constitue la base de la zone Pseudopulchellia pattoni. Stotticeras, gen. nouv., se rencontre également dans le centre de l'Alaska, où il semble associé à Pseudopulchellia flexicostata (Imlay). Ce genre est représenté, quoique de manière discutable, dans le bassin Sverdrup.

Stelckiceras, gen. nouv., semble confiné à la zone Stelckiceras liardense de la région intérieure de l'Ouest canadien, la seule que l'on croit associée à la sous-zone Dipoloceras cristatum de la norme européenne.

Contrairement à ce que l'on croit généralement, c'est le bassin Sverdrup, et non le bassin intérieur de l'Ouest canadien, qui représentait le centre d'évolution de la sous-famille Gastroplitinae au milieu de l'âge albien. La plupart des faunes de gastroplitinidés du bassin intérieur de l'Ouest canadien qui datent de cette époque (sauf les faunes de Gastroplites à proprement parler) n'ont pas de liens phylogénétiques directs entre elles. Elles représentent plutôt autant d'épisodes distincts de la migration de membres de principales lignées de gastroplitinidés, qui étaient originaires du bassin Sverdrup et y ont évolué sans arrêt. Chacun de ces épisodes de la migration s'est terminé par une extinction.

La situation a changé au début de l'Albien supérieur, à la suite d'un assèchement apparemment total du bassin Sverdrup; le stock de Neogastroplites de l'Albien supérieur et du Cénomaniens inférieur était, de tout évidence, originaire des régions canadiennes et américaines du bassin médio-continental. Neogastroplites ne semble pas être un descendant de Gastroplites à proprement parler ou de tout autre stock de gastroplitinidés de la région intérieure de l'Ouest canadien qui date du milieu de l'Albien. Il semble plutôt descendre de Pseudopulchellia ex. gr. Ps. balkwilli, esp. nouv., originaire du bassin Sverdrup, par l'intermédiaire de Stelckiceras, gen. nouv. On ne connaît pas de représentants véritables de Gastroplites s. str. et de Negastroplites à l'extérieur du bassin médio-continental de l'Amérique du Nord, sauf dans la partie sud du bassin Sverdrup. C'est à tort que l'on aurait enregistré ces genres en Alaska, sur la pente continentale de la Sibérie, dans l'Arctique européen et en Angleterre. Tous ces gastroplitinidés, comme Pseudogastroplites cantianus (Spath), ? Cléogastroplites subquadratus (Nagy) et autres "Gastroplites" du Spitsbergen, Pseudopulchellia flexicostata (Imlay), "Gastroplites" spp. et "Paragastroplites" spp. du nord du centre de l'Alaska, "Gastroplites" et "Neogastroplites" de la pente continentale de la Sibérie, appartiennent à d'autres genres originaires du bassin Sverdrup.

Pour autant que l'on sache, la production du bassin médio-continental de l'Amérique du Nord au milieu de l'Albien ne présente que les liens fragiles, et peut-être intermittents, avec le bassin Sverdrup. Ce dernier, à la même époque, consistait en une mer intérieure relativement petite qui, à son tour, ne présentait que des liens fragiles, et peut-être intermittents, avec les bassins contemporains de l'Alaska, de l'Asie nordique et de l'Arctique européen. La preuve nous en est fournie par la rareté relative et parfois même extrême, dans ces bassins, de tous les genres de gastroplitinidés originaires du bassin Sverdrup. Cette situation paléogéographique de l'Albien moyen semble incompatible avec la reconstruction de la paléogéographie albiennne de la région boréale, basée sur l'hypothèse d'un globe dont le diamètre moyen et la courbure sont ceux d'aujourd'hui (c'est-à-dire sur l'hypothèse classique de la tectonique des plaques), étant donné que cette reconstruction présuppose l'existence d'un océan paléo-Arctique d'une étendue improbable. En revanche, cette situation paléogéographique est facilement conciliable avec la reconstruction de la paléogéographie albiennne de la région boréale, si l'on se base entièrement sur l'hypothèse d'une expansion du globe du moins depuis le début du Mésozoïque jusqu'à nos jours.

**NEW OR FORMERLY POORLY KNOWN, BIOCHRONOLOGICALLY AND PALEOBIOGEOGRAPHICALLY
IMPORTANT GASTROPLITINID AND CLEONICERATINID (AMMONITIDA) TAXA FROM
MIDDLE ALBIAN ROCKS OF MID-WESTERN AND ARCTIC CANADA**

INTRODUCTION AND ACKNOWLEDGMENTS

One important objective of this preliminary report is to validate five biochronologically and paleobiogeographically important new genera of mid-Albian ammonites belonging to the sub-families Gastroplitinae and Cleoniceratinae in time to be included in the second edition of the Ammonoidea Volume of the Treatise on Invertebrate Paleontology. Most of these genera from mid-Western and Arctic Canada are based on type species that are new to the science. Illustrations and brief diagnoses of these type species and also of a few other new or poorly known gastroplitinid and cleoniceratinid taxa have been included in this report. Complete descriptions of all these taxa and those of many other, mostly new gastroplitinid species from Sverdrup Basin and Canadian Western Interior region form part of the almost completed manuscript: "Mid-Albian gastroplitinid ammonites of the Christopher Formation, Sverdrup Basin in relation to allied forms from mid-western Canada, Alaska and Northern Eurasia". This comprehensive, richly illustrated manuscript will be submitted for publication in the GSC Bulletin series. However, it certainly would not be published in time to permit the inclusion of the above mentioned new taxa into the Ammonoidea Volume of the Treatise.

Another important objective of this report is to publish, in advance of the final report, the highlights of new, only regionally valid biochronological subdivisions for the middle Albian rocks of the Canadian Western Interior and Arctic regions of Canada that resulted from a detailed study of their previously insufficiently known gastroplitinid faunas. This is especially urgent in the case of Sverdrup Basin as only some representatives of its exceptionally well preserved and prolific but largely endemic gastroplitinid faunas have been previously figured under informal names (Jeletzky, 1964). Furthermore, hardly any detailed information about the rather peculiar stratigraphic sequence, age, and correlation of these Sverdrup Basin faunas has been published so far.

The nomenclatorial, taxonomical and biochronological data provided in this report should enable geologists of the Geological Survey of Canada and other interested persons to substitute easily the new, more refined regional biochronological standards and the new, nomenclatorially valid generic and specific names of the zonal indices for the rather crude biochronological units and cumbersome fossil names now in use (e.g. Jeletzky, 1964 and in intradepartmental fossil reports).

In addition to their regional biochronological importance, the gastroplitinid faunas of mid-continental and Arctic Canada are critical to the understanding of phylogenetic, palaeobiogeographic and biochronological relationships of similar but relatively rare, mostly poorly preserved and therefore misunderstood mid-Albian gastroplitinid faunas of Alaska (Imlay, 1961), Pacific slope of Siberia (Verestchagin et al., 1965; Pergament, 1977; Avdeiko, 1968), European Arctic (Nagy, 1970) and England (Spath, 1937; Owen, 1973).

Thanks are due to H.R. Balkwill, T.P. Poulton, D.F. Stott, R. Thorsteinsson, E.T. Tozer and H. Trettin, all of the Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology and to A.H. McNair, Geology Department, Dartmouth College, Hannover, New Hampshire, U.S.A. who collected the bulk of gastroplitinid and cleoniceratinid ammonites described in this report and provided the writer with relevant stratigraphical information.

Thanks also go to the geologists and administrators of the following oil companies: Panarctic Company of Canada, Ltd., Calgary, Alberta; Triad Oil Co. Ltd. of Canada, Calgary, Alberta; Sproule Stratigraphic Services Ltd., Calgary, Alberta; and Canada-City Services Ltd., Calgary, Alberta who provided the writer with important gastroplitinid and cleoniceratinid specimens and with pertinent stratigraphical information about their paleontological collections.

C.R. Stelck (Geology Department, University of Alberta, Edmonton, Alberta), H.G. Owen, M.K. Howarth, and H.W. Ball (Palaeontology Department, British Museum (Natural History), London, Great Britain), F.J. Collier and Ralph Imlay (respectively of the U.S. National Museum and the United States Geological Survey, Washington, D.C., U.S.A.), and D. Worsley (Curator, Paleontology Department, University of Oslo, Norway) have kindly permitted study of pertinent specimens and types in their care, provided plaster casts and/or originals of paleontological types and gave valuable paleontological and stratigraphical advice.

F.M. McLaughlin and K. Vincent drew most of the ammonite suture lines published in this report, ably supervised the photographing of all specimens published therein, prepared final figures from rough drafts supplied by the writer and helped in many other ways. All ammonite photographs reproduced in this report have been taken by J. White.

SYSTEMATIC PALEONTOLOGY

Subfamily Cleoniceratinae Whitehouse 1926

Genus *Cleoniceras* Parona and Bonarelli 1897

Subgenus *Cleoniceras* sensu stricto

The early and middle Albian cleoniceratinid ammonites of the Sverdrup Basin are to be described monographically in a special report now in preparation. However, it was decided to include herein a brief description and figures of a new *Cleoniceras* sensu stricto species because of its outstanding paleobiogeographical interest, regional stratigraphical value and importance for dating the Canadian mid-Albian gastropplitinid faunas in terms of the European zonal standard. This decision was also prompted by the circumstance that the validity of all previous records of the subgenus *Cleoniceras* sensu stricto in Arctic and Western North America have been either questioned or denied by European workers (e.g. Casey, 1966, p. 553, 554; Nagy, 1970, p. 36, 37; Owen, 1971, p. 138).

Cleoniceras (Cleoniceras) canadense sp. nov.

Plate 1, figures 5,6, Plate 2, figures 1,2,4,5
1970-77 *Cleoniceras (Cleoniceras)* sp. nov. aff. *C. (C.) tailleuri* Imlay, 1961 and *C. (C.) cleon* (d'Orbigny, 1850) in a number of unpublished internal and external fossil reports of the GSC by Jeletzky.

Holotype. The specimen GSC 57906 reproduced in Plate 1, figure 5 and Plate 2, figure 2B-D is designated herewith the holotype of *Cleoniceras (Cleoniceras) canadense* sp. nov.

Diagnosis. A *Cleoniceras (Cleoniceras) morgani*-like species which differs from it in a considerably earlier (at whorl diameter of 50 mm or less) loss of sculpture, prevalence of bifurcation of ribs at all ornamented growth stages, fairly common presence of feeble bullae in an early growth stage (especially in the *Sonneratia*-like stage), generally less denticulated appearance of intermediate and adult external suture line, generally more slender proportions of its lobes and markedly asymmetrically bifid appearance of the lateral lobe. From other comparable European and North American species the new species differs in the same features as *C. (C.) morgani*.

Material. Two specimens (including the holotype) from GSC loc. 89755, one specimen from GSC loc. C-4659, two specimens from GSC loc. C-22253, one specimen from GSC loc. C-4711, and one specimen from GSC loc. 89749.

Remarks. *Cleoniceras (Cleoniceras) canadense* sp. nov. belongs to that European species group of the subgenus which combines a weak development (mostly weak elevations rather than well-formed bullae) or complete absence of umbilical bullae at the early, pronouncedly sculptured growth stage with high and narrowly arched whorl shape and a total loss of sculpture in the final stages of growth. Among representatives of this species group, such as *C. (C.) leightonense* Spath 1942, *C. (C.) morgani* Spath 1927 and *C. (C.) strigosum*

Casey 1966, *C. (C.) canadense* sp. nov. resembles most closely *C. (C.) morgani* Spath. Most significantly it shares with *C. (C.) morgani* a sturdy, *Sonneratia*-like shape in early growth stage which ends at the whorl diameter of 8 to 10 mm. The beginning of this stage was not seen (Pl. 2, fig. 5A-D). This *Sonneratia*-like stage is ornamented by prominent, sharp-topped ribs most of which bifurcate low on the flank. Most of the ribs of the observed part of this growth stage are feebly bullate at the branching points or at least distinctly elevated between the umbilical shoulder and branching point (Pl. 2, fig. 5C). The ribs are forward bent and distinctly weakened on the venter throughout this growth stage (Pl. 2, figs. 3A, 5D).

The *Sonneratia*-like growth stage grades rapidly into intermediate growth stage which is characterized by a whorl that is subtrigonal shaped in cross-section and is higher than wide (Pl. 2, figs. 2C, D). This *C. (C.) morgani*-like intermediate growth stage is ornamented by elevated sharp-topped ribs, most of which bifurcate low on the flanks. Some relatively rare ribs trifurcate there whereas other ribs remain single. Most of the primaries are distinctly elevated at the branching points, only a few are distinctly bullate (Pl. 2, fig. 2B). The ribs are flexuous on the flank and markedly bent forward on the venter. Most of the ribs are either distinctly weakened or interrupted on the subacute to very narrow, arched venter.

The ribs become low, ill-defined and round-topped at about the whorl diameter of 30 to 35 mm. Thereafter they fade rapidly (over one quarter to one half whorl) until all traces of ornament are lost at the whorl diameter of 50 mm or less. This event defines the beginning of the adult growth stage. The largest known still *C. (C.) morgani*-like shaped and proportioned specimen (Pl. 2, fig. 1A) exhibits the very beginning of the, apparently, adult living chamber at its broken off oral end where the whorl diameter is about 75 mm. Judging by the oralmost shell diameter of about 117 mm, this specimen may have reached a final shell diameter of about 180 mm.

The funnel-like, moderately involute (21 to 25%) umbilicus (Pl. 2, figs. 1A, 2A) has a straight, obliquely oriented wall and a broadly, almost regularly rounded shoulder.

The intermediate (Pl. 1, fig. 6), and also the latest observed, presumably adult, external suture line (Pl. 1, fig. 5) is similar to that of *C. (C.) quercifolium* (Casey, 1966, Text-fig. 215e) in the degree of elongation and slenderness of all lobes, markedly asymmetrically bifid appearance of the ventral lobe and a relatively insignificant denticulation. It differs markedly from the equivalent suture lines of *C. (C.) morgani* (e.g. Spath, 1942, p. 702, 703, Text-figs. 247, 248) with their considerably wider, almost symmetrical lateral lobes, appreciably wider and stubbier auxiliary lobes, and a generally greater degree of denticulation. The external suture lines of *C. (C.) morgani* and *C. (C.) leightonense* have a considerably more primitive (i.e. *Anadesmoceras*-like) appearance

than that of *C. (C.) canadense*. This taxonomically important distinction is probably related to the older age of the English species and their closer genetic ties with the ancestral *Sonneratia*. On this basis the Canadian species could be a descendant of *C. (C.) morgani* which had migrated to the Sverdrup Basin at the end of early Albian.

C. (C.) canadense sp. nov. differs from all other European species in the same way as does *C. (C.) morgani* Spath (compare Casey, 1966, p. 565, 566). From the Alaskan (Imlay, 1961) and the Canadian Western Interior (Jeletzky, 1964, Pl. XXVI, fig. 14) *C. (C.) tailleuri* Imlay 1966, the Sverdrup Basin species differs in a cross-section which is considerably sturdier and converges more rapidly adventrally (compare Pl. 2, figs. 1C, 2C, D with Imlay, 1961, Pl. 20, fig. 4). Furthermore, *C. (C.) tailleuri* Imlay has almost straight flanks and an appreciably wider umbilicus with a subangular umbilical shoulder (Imlay, 1961, Pl. 20, fig. 5).

These morphological distinctions appear to be ample for the full specific separation of *C. (C.) canadense* sp. nov. from its closest European and Alaskan allies.

Stratigraphic relationships, age and correlation. *Cleoniceras (Cleoniceras) canadense* sp. nov. is selected as the index fossil of *Cleoniceras (Cleoniceras) canadense* fauna the stratigraphic relationships, age and correlation of which will be discussed below in the section on Stratigraphy and Biochronology.

Subgenus *Grycia* Imlay 1961

Cleoniceras (Grycia) densicostata sp. nov.

Plate 1, figures 1-4, Plate 2, figure 3;
Plate 3, figure 4; Plate 9, figure 2

Type specimen. Specimen GSC 57904, reproduced in Plate 1, figure 2, Plate 2, figure 3A-D of this report, is designated herewith as the holotype of *Cleoniceras (Grycia) densicostata* sp. nov.

Material. Five well-preserved but incomplete specimens, including the holotype, from GSC loc. C-22253.

Diagnosis. A *Cleoniceras (Grycia)* species characterized by an exceptionally dense and fine, evenly spaced ribbing habit consisting of 13 to 16 very short, nonbullate primary ribs and 30 to 40 flexuous, round-topped *Cleoniceras (Cleoniceras) strigosum*-like secondary ribs per whorl. This ribbing habit extends at least onto the earliest part of adult living chamber without its ribs increasing markedly in width and prominence.

Remarks. *Cleoniceras (Grycia) densicostata* sp. nov. is extremely interesting in being morphologically, and presumably phylogenetically, transitional between more coarsely and/or irregularly ribbed *Cleoniceras (Grycia)* ex gr. *sablei-whittingtoni* (compare Nagy, 1970, Pl. 1, figs. 8-11, Pl. 2, figs. 1-4) on the one hand

and *Pseudopulchellia flexicostata* (Imlay) on the other. The exceptionally dense and fine, evenly spaced ribbing habit of *C. (G.) densicostata* sp. nov. consisting of 13 to 16 very short, nodeless primary ribs and 30 to 40 flexuous, round-topped secondary ribs, and particularly the persistence of this habit at least onto the earliest part of the adult living chamber (Pl. 2, fig. 3A, B), differentiates this species from all known representatives of *C. (G.)* ex gr. *sablei-whittingtoni*. The invariably broadly round-topped appearance of ribs of *C. (G.) densicostata* sp. nov. is another, equally reliable distinguishing feature. Even the coarsest and most sparsely ribbed representatives of *C. (G.) densicostata* sp. nov. (Pl. 3, fig. 4A) differ markedly in these respects from *C. (G.)* ex gr. *sablei-whittingtoni*.

When considered alone, the dense, fine and flexuous (but apparently never sigmoidal) ribbing habit of *C. (G.) densicostata* (Pl. 2, fig. 3A, B), resembles closely that of those extremely densely and finely ribbed morphological variants of *Pseudopulchellia flexicostata* (Imlay) which either do not develop markedly adventrally widening, flat-topped or round-topped (i.e. *Pseudogastrolites*-like) secondaries on the adult penultimate and adult ultimate whorls or develop only a small percentage of such ribs (e.g. Pl. 5, figs. 1, 3A, B). However, none of the studied specimens of *C. (G.) densicostata* sp. nov., including the apparently adult holotype, develops the flattened, *Gastrolites stantoni*-like venter diagnostic of the adult growth stage of *Pseudopulchellia flexicostata*.

The morphology of the intermediate and adult external suture line of *Cleoniceras (Grycia) densicostata* sp. nov. is extremely variable. One extreme, exemplified by the holotype (Pl. 1, figs. 1, 2) is characterized by a broadstemmed, short and shallowly denticulated lateral lobe with three subequal terminal branches arranged in a feebly asymmetrically trifid fashion. Furthermore, this suture line has only four auxiliary lobes which are all short, stubby and shallowly denticulated. This variant of the suture line resembles the equivalent suture lines of other *Cleoniceras (Grycia)* species (e.g. Nagy, 1970, Fig. 8a-c) and of some representatives of the subgenus *Cleoniceras* (e.g. Casey, 1966, Text-fig. 215d, e, f, g). However, it is quite unlike that of *Pseudopulchellia flexicostata* (Pl. 1, figs. 13-16), or for that matter unlike those of any other *Pseudopulchellia* species described in this report.

The other morphological extreme, exemplified by the very coarsely and distantly ribbed specimen GSC 57905 (Pl. 1, figs. 3, 4; Pl. 9, fig. 2) is characterized by a much more slenderly proportioned, pronouncedly asymmetrical bifid, and much more deeply denticulated lateral lobe. The third or adumbulicalmost terminal branch of that lobe, which is subequal to the other two branches in the holotype (Pl. 1, figs. 1, 2) is very much reduced in size in the extreme variant here discussed (Pl. 1, figs. 3, 4). In the specimen GSC 57905, this branch looks like one of the lobules of the middle branch which

thus becomes the adumbilical branch. Furthermore, the suture line of the extreme variant exemplified by the specimen GSC 57905 has five very strongly attenuated and long auxiliary lobes all of which are much more richly and deeply denticulated than their equivalents in the other variant (compare Pl. 1, figs. 1, 2 with Pl. 1, figs. 3, 4).

The narrow and elongate proportions of the lateral lobe of the extreme variant exemplified by the specimen GSC 57905 resemble closely those of the lateral lobe of *Pseudopulchellia imlayi* sp. nov. and those of the least denticulated variants of the lateral lobe of *Ps. flexicostata* (Imlay). However, the degree of denticulation of that lobe, the length and slenderness of its branches, and the acute tips of its lobules are all similar to those of *Ps. balkwilli* sp. nov. All auxiliary lobes of the here discussed sutural variant of *Cleoniceras (Grycia) densicostata* sp. nov. resemble closely their equivalents in the suture line of *Ps. balkwilli* sp. nov. (compare Pl. 1, figs. 21-23). The external suture lines of some of the unfigured representatives of *C. (G.) densicostata* sp. nov. appear to be transitional between the above-described morphological extremes.

The persistence of *Cleoniceras (Grycia)*- or *Cleoniceras (Cleoniceras)*-like whorl shape and ornament onto the early part of adult living chamber of *C. (G.) densicostata* sp. nov. indicates the placement of this species into the subgenus *Grycia* Imlay 1961. However, the *Pseudopulchellia flexicostata*-like ribbing habit of *C. (G.) densicostata* sp. nov., the *Pseudopulchellia*-like appearance of the external suture line in one of its extreme morphological variants, and its occurrence in the *Cleoniceras (Cleoniceras) canadense* beds stratigraphically closely below the *Pseudopulchellia flexicostata* beds (Fig. 1) suggest strongly that *C. (G.) densicostata* is a direct ancestor of *Ps. flexicostata*.

The infraspecific range of variation of *C. (G.) densicostata* is but poorly known because of the small number of specimens available. However, there is no doubt that this species is highly variable. Therefore, and because of the local presence of very rare representatives of *Pseudopulchellia* aff. *flexicostata* (Imlay) in the *Cleoniceras (Cleoniceras) canadense* beds (e.g. at GSC loc. 98749), the writer expects the future discovery of many transitional forms connecting *C. (G.) densicostata* and *Ps. flexicostata* in the intervening (so far ammoniteless) beds of the Upper shale member of the Christopher Formation. If and when this actually happens, it would become impossible to draw any sharp, natural boundary between the subgenus *Grycia* of the subfamily Cleoniceratinae and the genus *Pseudopulchellia* of the Gastroplitinae (Fig. 2).

Stratigraphic relationships, age and correlation. All known representatives of *Cleoniceras (Grycia) densicostata* sp. nov. have been found at GSC loc. 22253 in the *Cleoniceras (Cleoniceras) canadense* fauna. The stratigraphic relationships, age and correlation of this fauna are discussed below in the section on Stratigraphy and Biochronology.

Cleogastrolites gen. nov.

Type species. *Cleogastrolites aberrans* gen. et sp. nov. (described herein).

Diagnosis. A ?cleoniceratinid genus in which the intermediate whorls are shaped like those of a sturdy *Cleoniceras (Cleoniceras)* or a slender *Sonneratia (Pseudosonneratia)* and ornamented by bifurcating rib bundles bearing distinct swellings or feeble bullae at the branching points. These bullate bundles become predominantly trifurcate on the oral half of adult penultimate whorl and at least on the apical half of adult ultimate whorl where the whorl shape becomes *Paragastrolites*-like. The secondaries are interrupted on the venter of intermediate whorls and distinctly weakened on the venter of adult penultimate and adult ultimate whorls. The planulate venter and *Gastrolites*-like subrectangular whorl shape are restricted to the adult ultimate whorl. The generally *Pseudogastrolites*-like external suture line is more simplified than that of any other cleoniceratinid or gastroplitinid genus and has uniquely wide and short lobes.

Remarks. The presence of distinct adumbilical swellings or bullae and the prevalence of trifurcate rib bundles on the oral half of the adult penultimate whorl and at least the apical half of adult ultimate whorl of *Cleogastrolites* sharply differentiates this genus from its closest gastroplitinid homoeomorph *Pseudogastrolites*. The corresponding growth stages of all *Pseudogastrolites* species described in this report are ornamented only by either well or indistinctly formed dichotomous rib bundles with varying ratios of intercalated single ribs. Furthermore, *Pseudogastrolites* is invariably devoid of any swellings, let alone regular bullae or tubercles, on the branching points of primary ribs. The mid-ventral interruption of secondary ribs on the intermediate whorls of *Cleogastrolites aberrans* gen. et sp. nov., and their distinct mid-ventral weakening on the adult penultimate and adult ultimate whorls is also absent in all *Pseudogastrolites* species known. Finally, the secondary ribs of *Cleogastrolites* either do not widen adventrally or only widen insignificantly in this direction. The suture line of *Cleogastrolites* resembles most closely those of *Pseudogastrolites* and *Gastrolites sensu stricto* in all its general features, including the presence of only four auxiliary lobes in the adult growth stage. However, it is more simplified and has considerably wider and shorter lobes than any equivalent external suture lines known in these two genera. The relative shortening, widening, and simplification of terminal branches of the lateral lobe is particularly striking (Pl. 1, figs. 10-12). As it is now known, the external suture line of *Cleogastrolites* appears to be unique among the Gastroplitinae and Cleoniceratinae in the degree of its simplification and the relative width and shortness of all its lobes. These features are believed to be of a generic rank.

From the somewhat less similar *Gastropplites* sensu stricto, *Cleogastropplites* gen. nov. differs strongly in the prevalence of trifurcate rib bundles in the adult growth stage, persistence of the prominent sculpture without any weakening at least onto the early part of the adult living chamber, exceptionally simplified external suture line with uniquely widened and shortened lobes, and the much smaller size of the adult shell.

From all other presently known gastropplitinid genera *Cleogastropplites* gen. nov. differs strongly in the prevalence of trifurcate rib bundles in the adult growth stage, exceptionally simplified external suture line with uniquely widened and shortened lobes, and in a number of other, previously mentioned *Pseudogastropplites*-like morphological features.

Except for the replacement of narrowly rounded, sturdily subelliptically shaped (i.e. *Cleoniceras* (*Cleoniceras*) *morgani*-like) intermediate whorls by the *Gastropplites* (*Paragastropplites*)-shaped adult whorls, *Cleogastropplites* looks very much like the intermediate whorls of a sturdy *Cleoniceras* (*Cleoniceras*). Some of such European *Cleoniceras* (*Cleoniceras*) forms, furthermore, are known to develop a distinctly flattened venter on the intermediate whorls (e.g. *Cleoniceras* (*Cleoniceras*) *janneli* (Parent) or *C. (C.) imitator* Casey; see Casey, 1966, p. 561, 570, Pl. XCII, figs. 2b, 6b, Text-fig. 213). It is suggested accordingly that *Cleogastropplites* gen. nov. is an evolutionary offshoot of one of sturdy whorled *Cleoniceras* (*Cleoniceras*) species which exhibit a distinctly flattened venter (Fig. 2). According to this hypothesis, *Cleogastropplites* is not directly genetically related to either *Pseudogastropplites* or *Gastropplites* sensu stricto which are believed to be derivatives of *Cleoniceras* (*Grycia*). It appears to be an independent, probably short-lived lineage which evolved in the same general direction as did the younger presumably *Cleoniceras* (*Grycia*)-derived *Pseudogastropplites* and *Gastropplites* sensu stricto lineages (Fig. 2). This parallel evolution may be responsible for the *Gastropplites* (*Paragastropplites*) *spiekeri*-like adult morphology of *Cleogastropplites*.

Time range and geographic distribution. In Sverdrup Basin, *Cleogastropplites* is only known from the presumably lowermost middle Albian *Cleoniceras* (*Cleoniceras*) *canadense* beds on Amund Ringnes Island (Fig. 1). The genus appears to be represented by the specimen USNM 128739 (Imlay, 1961, Pl. 17, figs. 10, 11) in the unnamed, presumably lower middle Albian rocks of central Alaska. Furthermore, the genus is questionably represented in Spitsbergen by the solitary holotype of "*Gastropplites*" *subquadratus* Nagy 1970. This specimen apparently was collected in the equivalents of the European *Euhoplites lautus* Zone (Nagy, 1970, p. 19, 23, 24, Fig. 3). Should these foreign occurrences of *Cleogastropplites* be confirmed by additional better preserved material, it would range through most of the middle Albian substage and from Sverdrup Basin to Spitsbergen. The genus is not known to occur in the Western Interior region of North America.

Cleogastropplites aberrans sp. nov.

Plate 1, figures 10-12, Plate 3, figures 5, 7, Plate 9, figure 3

Type specimen. The presumably adult specimen GSC 57908 reproduced in Plate 1, figure 10, 11 and Plate 3, figures 5A-F is designated here-with the holotype of *Cleogastropplites aberrans* sp. nov.

Diagnosis. Because of the monotypic character of *Cleogastropplites*, the specific diagnosis of *C. aberrans* does not differ from the generic diagnosis (see there).

Material. Two well-preserved but fragmentary specimens from GSC loc. 22253.

Stratigraphic relationships, age and correlation. *Cleogastropplites aberrans* sp. nov. is only known from *Cleoniceras* (*Cleoniceras*) *canadense* beds at GSC loc. 22253. Stratigraphic relationships, age and correlation of these beds are discussed in the description of *C. (C.) canadense* fauna in the section on Stratigraphy and Biochronology.

Subfamily Gastropplitinae Wright 1952

Pseudogastropplites gen. nov.

Type species. *Pseudogastropplites arcticus* sp. nov. (described below).

Diagnosis. Small (maximum adult shell diameter 60 mm or less), gastropplitinid ammonites in which rounded and symmetrical secondary ribs gradually but pronouncedly widen and strengthen adventrally until they become fold-like on the ventral shoulder and venter. These ribs cross the venter without becoming forward bent, narrowed, weakened or interrupted. Round-bottomed depressions separating the ribs are either equally wide or more narrow than they. Neither the primary nor the secondary ribs are bullate or nodose anywhere. The *Gastropplites*-like planulate venter and subquadrate cross-section of the whorl are restricted to the adult ultimate whorl, all previous whorls being *Cleoniceras*- to *Desmoceras*-like. Strong, regularly bifurcating ornament persists to the oral end of adult living chamber.

Remarks: *Gastropplites* McLearn 1930 differs from *Pseudogastropplites* in:

1. All primary and secondary ribs of *Gastropplites* being much higher and thinner. They are characteristically sharp-topped instead of round-topped and, as a rule, slightly to pronouncedly asymmetrical (i.e. with the posterior flank steeper than the anterior flank) instead of symmetrical in cross-section throughout their length. These distinctions are equally present in the shell-covered specimens and the internal casts (Jeletzky, 1964, Pl. XXVII, figs. 2, 4-6, 8, Pl. XXVIII, figs. 1-3, Pl. XXIX, figs. 1-4, Pl. XXX, figs. 1-3, Pl. XXXII, fig. 6).

2. Except for the morphologically, and presumably phylogenetically, most primitive forms, such as *Gastroplites stantoni* McLearn and *G. aff. stantoni* (= *G. flexicostatus* Jeletzky, 1964 non Imlay 1961; see Jeletzky, 1964, Pl. XXIX, figs. 3, 4), *Gastroplites* differs from *Pseudogastroplites* in the primary ribs being distinctly elevated and either feebly (e.g. in *G. kingi* and *G. canadensis* sensu lato; see Jeletzky, 1964, Pl. XXVII, fig. 4a, Pl. XXVIII, fig. 1A) or markedly (e.g. in *G. allani*, *G. (Paragastroplites) spiekeri* and *G. anguinus*; see Jeletzky, 1964, Pl. XXVII, figs. 6A, 8A, Pl. XXX, fig. 2B) bullate at the branching points, at least in the intermediate growth stages.

3. In secondary ribs of *Gastroplites* either not widening adventrally or becoming only up to one and a half times wider on the ventral shoulder and venter as compared with their inception points. Furthermore, these ribs become feebly elevated to bullate and feebly to markedly claviform (because of adoral bends) on the ventral shoulder. These claviform bends of secondary ribs on the ventral shoulder are commonly accentuated by their weakening or interruption on the venter (Jeletzky, 1964, Pl. XXVII, fig. 8A, B, Pl. XXVIII, figs. 1A, B, 3A, B, Pl. XXIX, figs. 1A-D, 2A-C, 3A, 4A, B, Pl. XXX, fig. 2A-D).

4. In secondary ribs forming invariably feeble (in *Gastroplites canadensis* f. typ.; see Jeletzky, 1964, Pl. XXVII, fig. 4b) to pronounced (in all other forms; see Jeletzky, 1964, Pl. XXVII, fig. 8b, Pl. XXVIII, figs. 1b, 3b, Pl. XXIX, figs. 2c, 4b, Pl. XXX, figs. 2c, d, 3b) forward loops on the planulate to feebly convex venter of all sculptured whorls. These ventral parts of secondary ribs are separated by depressions which are (unlike those of *Pseudogastroplites*) two to more than three times wider than the ribs. Furthermore, the ventral parts of the ribs mostly become either weakened or almost completely obliterated in the mid-venter.

5. In characteristic loss of most or all of the shell sculpture on the adult living chamber (Jeletzky, 1964, Pl. XXVIII, fig. 2, 3A, Pl. XXIX, fig. 2a, b, Pl. XXX, fig. 1a-c);

6. In the restriction of the planulate venter and square whorl shape to one and a half to two and a half (approx.) intermediate whorls (Jeletzky, 1964, Pl. XXVII, fig. 6b, Pl. XXVIII, fig. 3b, Pl. XXIX, fig. 2d). This contrasts with the restriction of such *Gastroplites*-like whorl to the adult ultimate whorl of *Pseudogastroplites* gen. nov.

7. In a much larger size of adult shell which fluctuates between 120 and 150 mm in diameter (see Jeletzky, 1964, Pl. XXVIII, figs. 2, 3A, Pl. XXIX, fig. 4A-C, Pl. XXX, fig. 1A-C). This contrasts with *Pseudogastroplites* gen. nov., the adult shells of which are not known to exceed 60 mm in diameter and mostly do not exceed 50 mm in diameter.

True *Gastroplites* is all but restricted to the Western Interior Region of Canada (one undescribed species occurs in Sverdrup Basin)

where *Pseudogastroplites* gen. nov. is not known to occur. All previous records of *Gastroplites* outside of the Western Interior Region of Canada are probably due to misidentification of *Pseudogastroplites* or other gastroplitinid genera described below. This applies in particular to "*Gastroplites*" *cantianus* Spath 1937, which is a typical adult representative of *Pseudogastroplites* closely related to *P. arcticus* sp. nov. The unique holotype of *P. cantianus* (Spath 1937) is reproduced in this paper (Pl. 10, fig. 2A-E) to illustrate its *Pseudogastroplites* nature. The latter is indicated, in particular, by a marked crowding of the adoralmost few external suture lines clearly discernible on the better preserved flank of the specimen (Pl. 10, fig. 2B) in combination with the persistence of strong sculpture all over the preserved part of adult living chamber (Pl. 10, figs. 2A, B).

The writer's identification of "*Gastroplites*" *cantianus* (e.g. Jeletzky, 1964, p. 88, Pl. XXX, fig. 2) in the generalized *Gastroplites* Zone of the Canadian Western Interior region is an error. This specimen is an intermediate whorl of a form of *G. (G.) canadensis* transitional to *G. (G.) kingi* as attested by the characteristic ribbing habit, planulate appearance of the inner whorl, and distinct fading of the sculpture toward its broken oral end.

From the genus *Pseudopulchellia* Imlay 1961 as emended below (see p. 15), *Pseudogastroplites* gen. nov. differs:

1. In its much more simple, stubby and rounded external suture line (compare Pl. 1, figs. 7-9 with Pl. 1, figs. 13-18, 21-23) at all investigated growth stages.
2. In details of its ornament. Though the ribbing habits of *Pseudopulchellia* and *Pseudogastroplites* are similar in part, the ribs of *Pseudopulchellia* differ in being distinctly dichotomously bundled on early and intermediate whorls only. Because of a characteristic loss of sculpture on the lower flank, *Pseudopulchellia* ribs become mostly to almost invariably single on the adult ultimate whorl. Furthermore, these adult ribs become much heavier, much more prominent, and much more sparse than those of the intermediate whorls (including adult penultimate whorl).
3. In the venter being characteristically narrow and feebly to moderately arched instead of planulate. However, there are exceptions to this rule among the earliest (e.g. *Pseudopulchellia flexicostata*) as well as the latest (undescribed *Ps. aff. Ps. pattoni* Imlay) known representatives of the genus.
4. In secondary ribs being markedly weakened or completely effaced on the venter. This commonly results in a distinctly bullate appearance of the strongest swollen and elevated adventral segments of these ribs.
5. In the shell being characteristically more slender and more involute. However, there are exceptions which include the type species of *Pseudopulchellia* (i.e. *Ps. pattoni* Imlay).

It must be pointed out that it is the oldest known *Pseudopulchellia* species, such as *Ps. flexicostata* (Imlay), that resemble the oldest known, still undescribed *Pseudogastrolites* species most closely. This indicates that *Pseudogastrolites* gen. nov. is a peculiarly and strongly specialized offshoot of the *Pseudopulchellia* stem which arose, in turn, from the long-lasting *Cleoniceras* (*Grycia*) stem of Cleoniceratinae. These two events must have taken place in the *Cleoniceras* (*Cleoniceras*) *canadense* beds of Sverdrup Basin judging by the presence of transitional forms connecting these three lineages there (Fig. 2).

The morphological distinctions of *Pseudogastrolites* from *Stelckiceras* gen. nov., *Cleogastrolites* gen. nov., *Anagastrolites* gen. nov. and *Stotticeras* gen. nov. are discussed below in the descriptions of these genera.

Time Range. Mid-Albian. *Pseudogastrolites* gen. nov. is known to range from presumed Canadian equivalents of the *Lyelliceras lyelli* Subzone to the *Dipoloceras cristatum* Subzone inclusive (Fig. 2).

Geographic range. Arctic Canada (Sverdrup Basin; type species and three mostly unpublished species), Alaska (under the name of *Gastrolites*; Imlay, 1961), Pacific Slope of Siberia (under the name of *Gastrolites*; Avdeiko, 1968), England ("*Gastrolites*" *cantianus* Spath 1937), and possibly Spitsbergen (? "*Gastrolites*" sp. nov. A; Nagy, 1970). The genus is as yet unknown in the Western Interior of North America.

Pseudogastrolites arcticus sp. nov.

Plate 1, figure 7, Plate 3, figure 8A, B,
Plate 8, figure 4A, B

1964 *Gastrolites* aff. *canadensis* Jeletzky, p. 90,
expl. of Pl. XXXI, figs. 3A, 3B (only these)

Type specimen. The specimen GSC 17422 figured by Jeletzky (1964, Pl. XXXI, fig. 3) and herein (Pl. 1, fig. 7, Pl. 3, figs. 8A, 8B) is designated herewith the holotype of *Pseudogastrolites arcticus* sp. nov.

Diagnosis. A *Pseudogastrolites* species which differs from *P. cantianus* Spath in a greater number of primary and secondary ribs (13-15 and 27-28 respectively in the material studied as against 10 and 22 in the holotype of *P. cantianus*; compare Pl. 3, fig. 8A, B, Pl. 8, fig. 4A, B with Pl. 10, fig. 2A, B) on the adult ultimate whorl and in a considerably greater length and slenderness of the adult lateral lobe (compare Pl. 1, fig. 7 with Spath, 1937, Text-fig. d).

Material. Four specimens, including the holotype, from GSC loc. 40606 and one specimen from GSC loc. 40602.

Stratigraphic relationships, age and correlation. *Pseudogastrolites arcticus* is selected as the name fossil of gastrolitid fauna which is discussed below in the section on Stratigraphy and Biochronology.

Pseudogastrolites nanus sp. nov.

Plate 1, figures 8, 9, Plate 3, figures 6A-D,
Plate 4, figures 1, 3, 4

1964 *Gastrolites* aff. *canadensis* Jeletzky, p. 90,
expl. of Pl. XXXI, fig. 4 (non fig. 3)

Type specimen. The specimen GSC 17423 originally figured by Jeletzky (1964, Pl. XXXI, fig. 4) and reproduced in Plate 1, figure 8, Plate 3, figure 6 is designated herewith as the holotype of *Pseudogastrolites nanus* sp. nov.

Diagnosis. A *Pseudogastrolites* species combining exceptionally slender, almost *Pseudopulchellia*-like whorl proportions (width/height ratio fluctuates from 0.61 to 0.79) and shape with a uniquely small size of adult shell which is not known to exceed 28.2 mm.

Material. Seven specimens (including the holotype) from GSC loc. 43618, three specimens from GSC loc. C-22695, and one only tentatively identified specimen from GSC loc. C-26600.

Remarks. *Pseudogastrolites nanus* sp. nov. cannot be interpreted as a halfgrown form of another, larger *Pseudogastrolites* species because of a considerable crowding of its adoralmost suture lines. This crowding is coupled with a rapid transformation of a narrowly rounded, *Cleoniceras*-like venter of the intermediate whorl (Pl. 4, figs. 3, 4) into an only slightly convex, *Gastrolites stantoni*-like venter within the earliest quarter of the adoralmost preserved whorl of the holotype (Pl. 3, fig. 6C, D) and several other specimens exhibiting part or all of the living chamber (e.g. Pl. 4, figs. 1C, D). As pointed out in the generic description of *Pseudogastrolites*, the *Gastrolites*-like venter is restricted to the adult ultimate whorl of that genus.

As *Pseudogastrolites nanus* sp. nov. was not found in association with other larger *Pseudogastrolites* forms, it is not likely to be a micromorph (i.e. a male according to the currently popular ideas) of *P. arcticus* sp. nov. or for that matter any other larger *Pseudogastrolites* species.

In addition to the uniquely small size of the adult, which is somewhat less than two thirds of that of *P. cantianus* (Spath) and *P. arcticus* sp. nov., *P. nanus* sp. nov. differs from the two above-mentioned species in its relatively speaking (i.e. in relation to the shell's size), considerably heavier and more closely spaced adult primary and secondary ribs.

The adult external suture line of *P. nanus* sp. nov. differs from that of *P. cantianus* (Spath) in the same features as does that of *P. arcticus* sp. nov. The adult external suture lines of *P. nanus* sp. nov. and *P. arcticus* sp. nov. do not seem to be distinguishable (compare Pl. 1, fig. 7 with Pl. 1, figs. 8, 9).

Stratigraphy, age and correlation.

Pseudogastrolites nanus sp. nov. forms part of *Pseudopulchellia flexicostata* fauna which is discussed below in the section on Stratigraphy and Biochronology.

Anagastrolites gen. nov.

1964 "*Gastrolites*" (a new genus?) Jeletzky, p. 90
(expl. of Pl. XXXI, figs. 2, 6)

Type species. *Anagastrolites tozeri* sp. nov.
(described below).

Diagnosis. Small (adult shell diameter is either less than or does not exceed 70 mm), *Pseudogastrolites*-like shaped gastrolitids in which the predominantly bifurcating, round-topped, non-bullate ribs are thin and subdued, except on the oral part of the adult living chamber where they become strongly elevated but neither markedly widened nor flattened. Secondary ribs are weakened to almost effaced on the venter, except on the oral part of the adult living chamber where they are especially prominent on the ventral shoulder and venter and where their strengthened ventral parts form pronounced forward bends. The generally *Pseudopulchellia flexicostata*-like intermediate and adult external suture lines are strongly crowded beginning with the early part of the adult penultimate whorl and overlap extensively on the adoralmost quarter whorl of the adult phragmocone.

Remarks. In spite of the *Pseudogastrolites*-like whorl shape and proportions, the predominantly dichotomous rib bundling, persistence of sculpture to the oral end of the adult living chamber, and small size of adult, *Anagastrolites* must be excluded from that genus because of:

1. Appreciable to marked weakening of secondary ribs on the venter of all whorls studied with the exception of oral part of the adult living chamber;
2. Generally subdued appearance of sculpture, except on the oral part of the adult living chamber where it varies from moderate to prominent in comparison with the sculpture on earlier whorls, with those parts of secondary ribs crossing ventral shoulders and the venter being particularly prominent;
3. The prevalence of fine, *Gastrolites*-like proportioned but round-topped ribbing on all investigated parts of the shell. The secondary ribs of *Anagastrolites* generally lack the *Pseudogastrolites*-like adventral thickening and widening. Even the exceptionally prominent secondaries of the oral part of adult living chamber only rarely become widened similar to *Pseudogastrolites* and strongly elevated on the upper flank and on the ventral shoulder;
4. The rather more florid, richly and deeply denticulated and narrowly stemmed appearance of those parts of intermediate and adult suture lines beginning with the ventral lobe and ending with the second auxiliary lobe. These suture lines are similar to those of *Pseudopulchellia flexicostata* (compare Pl. 1, figs. 19, 20 with Pl. 1, figs. 13-16);
5. Strong crowding of half grown to adult external suture lines beginning with the early part of adult penultimate whorl and culminating in their extensive overlap on the adoralmost quarter whorl of adult phragmocone (Pl. 1, fig. 19, Pl. 8, fig. 6A).

From the more similar *Pseudopulchellia* Imlay 1961 emend. *Anagastrolites* differs in:

1. A general absence of *Pulchellia*-like widening and thickening of secondary ribs on the upper flank and ventral shoulder;
2. Retention of predominantly well defined, bifurcating ribbing habit to the oral end of adult living chamber;
3. Significantly wider, moderately involute proportions of the umbilicus;
4. Absence of any weakening, let alone interruption, of secondary ribs on the oral part of adult living chamber and their pronounced forward bends there; and
5. A *Pseudogastrolites*-like widening and flattening of the venter of the adult ultimate whorl.

These morphological differences appear to be ample for the generic separation of *Anagastrolites* from *Pseudopulchellia*.

From *Gastrolites* McLearn 1930 sensu stricto *Anagastrolites* gen. nov. differs strongly in:

1. Retention of sculpture to the oral end of adult ultimate whorl and its considerable coarsening and strengthening on the oral part of adult living chamber. All known species of *Gastrolites* sensu stricto, become, in contrast, smooth on the adult ultimate whorl and in some specimens on the adult penultimate whorl as well;
2. Complete absence of either swellings or bullae at the branching points of secondary ribs;
3. Prevalence of fine subdued ribbing on all investigated parts of the shell preceding the oral part of adult living chamber. All known representatives of *Gastrolites* sensu stricto are characterized, instead, by the presence of prominent, mostly bullate ribbing on the equivalent growth stage.
4. The restriction of *Gastrolites*-like flattened venter and narrowly rounded to rounded-angular ventral shoulders to the adult ultimate whorl;
5. Much more florid, richly and deeply denticulated, and more narrowly stemmed appearance of halfgrown to adult suture lines beginning with the ventral lobe and ending with the second auxiliary lobe. These suture lines match closely those of *Ps. flexicostata* (Imlay).
6. Strong crowding of halfgrown to adult external suture lines beginning with the early part of adult penultimate whorl. This crowding culminates with their extensive overlap on the adult ultimate whorl. *Gastrolites* sensu stricto suture lines are becoming crowded on the adult ultimate whorl only and do not overlap significantly even immediately before adult living chamber (Jeletzky, 1964, Pl. XXX, fig. 1A; this paper, Pl. 9, fig. 5).

These fundamental differences indicate that the similar morphological features of *Anagastrolites* and *Gastrolites* sensu stricto are a matter of homoomorphy only and that these two genera are not directly genetically related.

Anagastrolites gen. nov. differs from the genus *Stelckicerias* gen. nov. in:

1. A general absence of *Pulchellia* and *Pseudopulchellia*-like widening and thickening of secondary ribs on the upper flank and venter;
2. Restriction of the *Gastrolites*-like flattened venter and narrowly rounded to rounded-angular ventral shoulders to the adult ultimate whorl;
3. Considerably wider, moderately involute proportions of the umbilicus;
4. The pronouncedly asymmetrically bifid *Pseudopulchellia flexicostata*-like appearance of the lateral lobe which contrasts with the asymmetrically to almost symmetrically trifid appearance of the same lobe in *Stelckicerias* gen. nov. and
5. Much smaller dimensions of the adult shell.

From *Neogastrolites* McLearn 1931, *Anagastrolites* gen. nov. differs markedly in:

1. A complete absence of multinodose ornament characteristic of the intermediate growth stage of most representatives of *Neogastrolites*;
2. Retention of sculpture to the oral end of the adult living chamber and its marked strengthening on the oral part of this chamber. All representatives of *Neogastrolites*, including those that lack nodes, become smooth in the late growth stages; and
3. Narrow-stemmed, markedly asymmetrically bifid appearance of lateral lobe. The lateral lobes of all known representatives of *Neogastrolites* are almost symmetrically to asymmetrically trifid. Furthermore, their stems are relatively much wider and shorter, and have adapically contracting subtriangular shapes (compare Reeside and Cobban, 1960, Figs. 11, 14, 15, 18, 19, 20, 23, 27; Jeletzky, 1964, Pl. XXXIV, fig. 5, Pl. XXXV, fig. 4B, Pl. XXXVI, fig. 5B).

The still insufficiently understood genus *Irenicoceras* Warren and Stelck 1958 differs from *Anagastrolites* gen. nov. in being a very slender, involute shell and in having a distinctly *Gastrolites*- and *Pseudogastrolites*-like suture line with a wide and short, asymmetrically bifid lateral lobe. Furthermore, the adult shell of *Irenicoceras* is much larger than that of *Anagastrolites*.

The also insufficiently understood genus *Beatonoceras* Warren and Stelck 1958 differs from *Anagastrolites* in being a very slender, completely involute shell, in the presence of ventro-lateral nodes on penultimate whorl and in the complete loss of sculpture on adult ultimate whorl. Furthermore, the lateral lobe of its suture line is asymmetrically trifid instead of asymmetrically bifid and *Neogastrolites*-like shaped. Finally, *Beatonoceras* is a very much larger shell.

The morphological distinctions of *Anagastrolites* from *Stotticeras* are discussed in the description of the latter.

Finally, *Cleogastrolites* gen. nov. differs from *Anagastrolites* gen. nov. markedly in the predominantly trifurcate character of its adult ribbing habit, presence of ventro-lateral nodes, a uniquely simplified character of its halfgrown and adult suture line, and in the persistence of a distinct weakening of secondary ribs on the venter onto the adult living chamber.

In spite of the above discussed unique combination of morphological features, *Anagastrolites* gen. nov. is morphologically similar to other gastrolitid genera occurring in the Christopher Formation and appears to be closely allied to them. Therefore, and because of its younger age compared to most representatives of the other genera (except for the undescribed *Pseudopulchellia* aff. *Ps. pattoni* Imlay), *Anagastrolites* appears to be a descendant of one of the older gastrolitid genera endemic to the Sverdrup Basin.

The presence of a number of morphological features in common with *Pseudogastrolites* gen. nov., such as the general shape and proportions of the whorl, persistence of distinctly bifurcating sculpture to the oral end of adult living chamber, and the late appearance of *Gastrolites*-like venter, seems to suggest that *Anagastrolites* is a direct descendant of *Pseudogastrolites*. However, this hypothesis is contradicted by the fine, subdued appearance of primary and secondary ribs on the flanks of *Anagastrolites* and the distinct weakening of secondary ribs in all its investigated growth stages, except for the adult living chamber. Only on the latter do these mostly bifurcating ribs become prominent and more heavily built than before. Furthermore, even the adventral and ventral parts of the secondaries on the oral part of the adult living chamber of *Anagastrolites* do not become *Pseudogastrolites* and *Pseudopulchellia*-like widened and elevated. Nor do their distinctly strengthened adventral parts cross the venter strictly transversally as do those of all *Pseudogastrolites* species.

Another morphological feature conflicting with the derivation of *Anagastrolites* from *Pseudogastrolites* is the florid, strongly and deeply denticulated, narrow-stemmed appearance of the principal elements of the half-grown and adult suture lines of *Anagastrolites*. These suture lines strongly resemble the equivalent suture lines of *Pseudopulchellia flexicostata* (Imlay) in these respects.

The initial strong crowding followed by significant overlap of adjacent semiadult and adult suture lines of *Anagastrolites* is also against its derivation from *Pseudogastrolites* as the adult suture lines of the latter genus are well spaced almost to the beginning of the adult living chamber. Only the oralmost few adult suture lines of *Pseudogastrolites* are either more closely spaced than the preceding suture lines or begin to touch each other, in part. However, none of these oralmost adult suture lines is known to overlap. Here again the suture lines of *Anagastrolites* gen. nov.

resemble the equivalent suture lines of *Pseudopulchellia*, and especially those of *Ps. flexicostata* (Imlay) which become crowded and in some specimens begin to touch on the earliest part of the penultimate whorl (e.g. Pl. 1, figs. 16, 18). Furthermore, the oralmost adult suture lines of some of these *Pseudopulchellia* forms (e.g. those of *Ps. flexicostata*) overlap like those of *Anagastroplites* (compare Pl. 1, fig. 16 with Pl. 1, fig. 19).

The above features of the ornament and the character of the suture line is suggestive of *Anagastroplites* being a direct descendant of *Pseudopulchellia*. However, some other characters and the ontogenetic development of *Anagastroplites* sculpture seems to conflict with the *Pseudopulchellia*-like character of its external suture line. *Pseudopulchellia* is, generally speaking, characterized by the development of strongly adventrally strengthened and widened, sparse ribs on the adult living chamber. Furthermore, its secondaries are, as a rule, either weakened or almost interrupted on the venter at all growth stages studied, including the adult living chamber. However, such characteristic features of *Anagastroplites* sculpture as the strengthening of the sculpture on the oral part of adult living chamber and the loss of the midventral weakening of secondaries there, do occur in some of the earliest *Pseudopulchellia* known. For example, the ribs of the particularly closely and finely ribbed representatives of *Ps. flexicostata* (Imlay) may become markedly strengthened throughout their extent (including the lower flank) on the adult living chamber in comparison with the earlier whorls. This change of sculpture (Pl. 5, fig. 1) resembles particularly closely that occurring in *Anagastroplites tozeri* sp. nov. as the ribs themselves do not become markedly widened and more prominent on the upper flank, in contrast with those of all other *Pseudopulchellia* species studied. Nor do these ribs become sparser on the living chamber in comparison with the early whorls.

It must be pointed out in this connection that the above-described ribbing habit of *Anagastroplites* and its ontogenetic development also resemble closely that of some *Cleoniceras* (*Grycia*) forms. For example, a strengthening and coarsening of the ornament in the course of ontogeny is known to occur in *Cleoniceras* (*Grycia*) ex gr. *sablei-whittingtoni* (e.g. Nagy, 1970, p. 36, Pl. 2, figs. 1-4) and in the *Cleoniceras* (*Grycia*) *densicostata* sp. nov. from the *Cleoniceras* (*Cleoniceras*) *canadense* fauna of Sverdrup Basin (Pl. 2, fig. 3B).

However, it does not seem feasible to derive *Anagastroplites* directly from any of the above-mentioned *Cleoniceras* (*Grycia*) species for the following reasons:

1. Their secondary ribs are markedly weakened to almost interrupted at all growth stages, including the adult living chamber; and
2. The intermediate and adult suture lines of *Cleoniceras* (*Grycia*) *densicostata* sp. nov. as well as those of *C. (G.) ex gr. sablei-whittingtoni* (e.g. Nagy, 1970, Text-figs. 8a-c), differ, as a rule, from those of *Anagastroplites* markedly in having only four auxiliary lobes and in their ventral lobes being asymmetrically trifid instead of asymmetrically bifid.

The sum total of the taxonomically important morphological features shared by *Anagastroplites* and *Pseudopulchellia flexicostata* (Imlay) exceeds that shared with any other known gastroplitinid of Sverdrup Basin. Therefore, it is suggested that *A. tozeri* sp. nov. is a direct descendant of this most primitive *Pseudopulchellia* species known in spite of a considerable thickness of strata separating the stratigraphically closest occurrences of these two forms (Fig. 2).

Anagastroplites tozeri sp. nov.

Plate 1, figures 19, 20,
Plate 8, figures 1, 5, 6

1964 "Gastroplites" (a new genus?) sp. nov. A, Jeletzky, p. 90 (expl. of Figs. 2, 6), Pl. XXXI, figs. 2, 6

Type specimen. The adult specimen GSC 17420 figured by Jeletzky (1964, Pl. XXXI, fig. 2) and reproduced in Plate 8, figure 1A-I of this paper is designated herewith the holotype of *Anagastroplites tozeri* sp. nov. Its adult suture line is reproduced in Plate 1, figures 19, 20.

Derivation of name. Named after E.T. Tozer of the Geological Survey of Canada, Ottawa, Ontario in recognition of his distinguished research of Mesozoic geology and paleontology of the Canadian Arctic Archipelago.

Material. Five specimens from GSC loc. 25883. This material includes the above designated holotype. Two specimens from GSC loc. 47514.

Diagnosis. Because of the monotypic character of *Anagastroplites* gen. nov., the specific diagnosis of *A. tozeri* sp. nov. does not differ from the generic diagnosis (see there).

Stratigraphy, age and correlation. *Anagastroplites tozeri* sp. nov. is selected the name fossil of a gastroplitid fauna which is discussed below in the section on Stratigraphy and Biochronology.

Stotticeras gen. nov.

Type species. *Stotticeras crowense* sp. nov. (described and figured herein).

Derivation of name. After D.F. Stott, Geological Survey of Canada in recognition of his research on the stratigraphy of Cretaceous rocks in the Western Interior Region of Canada.

Diagnosis. Large gastroplitinid ammonites combining the *Gastroplites*-like loss of ornament on the adult ultimate whorl and the presence of *Gastroplites*-like umbilical bullae with heavy *Pseudogastroplites*-like secondary ribs on the intermediate whorls. Adult suture line is characterized by long- and slender-stemmed, extremely strongly and deeply denticulated lobes. Its lateral lobe is almost symmetrically bifid to feebly asymmetrically bifid. The adjacent suture lines are crowded like those of *Anagastroplites*.

Remarks. In spite of its superficially *Gastrolites*-like appearance, *Stotticeras* must be excluded from this genus because of the *Pseudogastrolites*-like appearance of its secondary ribs combined with an entirely different morphology of the adult suture line (Pl. 6, figs. 1A, 2, 3, Pl. 9, fig. 1, Pl. 1, fig. 26). The latter is unlike the strongly simplified *Gastrolites* suture line with its markedly asymmetrically bifid lateral lobe and stubby, palm-like shaped auxiliary lobes (Pl. 9, figs. 4, 5). The superficial similarity of *Stotticeras* to *Gastrolites* is, therefore, a matter of homeomorphy only (see p. 34, 35 for further details).

From *Pseudogastrolites*, *Stotticeras* differs strongly in all its *Gastrolites*-like features, such as the obliteration of sculpture on the adult ultimate whorl and the presence of umbilical bullae on intermediate whorls. The adult external suture line of *Stotticeras* is even more unlike that of *Pseudogastrolites* than that of *Gastrolites*. *Stotticeras* finally, has much bigger shell than *Pseudogastrolites*. Therefore, the *Pseudogastrolites*-like appearance of secondary ribs of *Stotticeras* appears to be a result of homeomorphical development.

Stotticeras differs from the superficially similar and similarly large *Stelckiceras* in the loss of sculpture on the adult ultimate whorl and in the presence of umbilical nodes on intermediate whorls. Although the adult external suture line of *Stotticeras* is just as complexly denticulated as that of *Stelckiceras* and possesses similarly long- and narrow-stemmed lobes, it differs significantly in that its lateral lobe ranges from almost symmetrically bifid to but feebly asymmetrically bifid (instead of almost symmetrically trifid in *Stelckiceras*; compare Pl. 1, figs. 24, 25 with Pl. 1, fig. 26).

The similarly complex and narrow-stemmed, expressly *Pseudopulchellia*-like character of adult external suture lines of *Stelckiceras* and *Stotticeras* are combined with the closely similar, equally *Pseudopulchellia*-like character of secondary ribs of these two genera. Therefore, they appear to be differently specialized offshoots of *Pseudopulchellia balkwilli* sp. nov. (see p. 18, 19 and Jeletzky, 1964, Pl. XXXI, fig. 3, Pl. XXXII, fig. 4) which inherited from it a combination of round-topped *Pseudogastrolites*-like ribs with an unusually complex adult external suture line. This origin of *Stotticeras* is favoured by the writer (Fig. 2).

In spite of its assumed descent from *Pseudopulchellia*, *Stotticeras* differs strongly from all its known representatives in complete obliteration of sculpture on the adult ultimate whorl combined with the presence of umbilical bullae on the intermediate whorls and the broadly tabulate *Gastrolites*-like appearance of its venter. Furthermore, the adult suture line of *Stotticeras* differs from the equivalent suture line of *Pseudopulchellia* in a much more narrow stemmed, almost symmetrically bifid appearance of the lateral lobe. Even the most *Stotticeras*-like adult suture lines known in *Pseudopulchellia* lack these features. In the writer's opinion these distinctions are ample for the full generic separation of *Stotticeras* from the presumably ancestral *Pseudopulchellia* (Fig. 2).

From *Cleogastrolites*, *Stotticeras* differs first of all in an entirely different character of its adult suture line. Furthermore, it lacks the predominantly trifurcate adult bundling habit of *Cleogastrolites*, has much more slender whorl proportions and a much narrower umbilicus than the latter. Finally, it is a much larger shell than *Cleogastrolites*.

From *Anagastrolites*, *Stotticeras* differs in the loss of ornament on the adult ultimate whorl, the presence of umbilical bullae on the intermediate whorls, and in the *Pseudogastrolites*-like character of its secondary ribs. Furthermore, its adult suture line is considerably more florid than that of *Anagastrolites* and has an almost symmetrically bifid (instead of an asymmetrically bifid) lateral lobe.

Neogastrolites differs from *Stotticeras* in the considerably less denticulated, stubbier appearance of all lobes of its adult suture line. This *Neogastrolites* suture line has an almost symmetrically trifid, broad-stemmed ventral lobe which is quite unlike that of *Stotticeras*. The stouter variants of most *Neogastrolites* species differ also in the presence of either ventro-lateral or of ventro-lateral and medioventral nodes.

Beattonoceras Warren and Stelck 1958 differs from *Stotticeras* in the presence of distinct ventrolateral nodes and the absence of umbilical nodes on the penultimate whorl. Furthermore, its external suture line (Warren and Stelck, 1958, Pl. XIII, fig. 1-3, Pl. XV, figs. 2, 4) has much shorter, broad-stemmed lobes and an asymmetrically trifid, downward-tapering lateral lobe. This suture line is similar to that of *Neogastrolites*.

Irenicoceras Warren and Stelck 1958 differs from *Stotticeras* in the persistence of its bifurcating but much more dense and sharp-topped ribbing habit to the oral end of adult living chamber. Furthermore, it is a fully involute shell with secondary ribs which are distinctly inflated on the ventral shoulder. In combination with a pronounced age difference, these distinctions are judged to be ample for a full generic separation of *Irenicoceras* and *Stotticeras*. However, the close morphological similarity of their adult suture lines (compare Warren and Stelck, 1958, Pl. V, figs. 2, 3 with Pl. 1, fig. 26 of this paper), is suggestive of *Irenicoceras* belonging to the same genetic stock, and possibly to the same lineage, as *Pseudopulchellia balkwilli* sp. nov. from Sverdrup Basin (i.e. *Gastrolites*? (*Paragastrolites*?) sp. nov. aff. *liardense* of Jeletzky, 1964, Pl. XXXI, fig. 3; Pl. XXXII, fig. 4) and *Stelckiceras* (see Fig. 2).

Geographic distribution and time range. Outside of its only known occurrence in the Western Interior Region of Canada (see description of *Pseudopulchellia pattoni* Zone below), *Stotticeras* occurs in the mid-Albian Shaktolik Group at Bishops Rock in central Alaska. This is indicated by the characteristically long- and slender-stemmed, richly and strongly denticulated appearance of all visible elements of the suture line, the symmetrically bifid character of the lateral lobe, and the crowding of adjacent sutures

of the specimen USNM 128740 identified as *Gastroplites kingi* by Imlay (1961, Pl. 17, fig. 9) and refigured in Plate 9, figure 6 of this paper. In combination with the heavy, adventrally widening appearance of secondary ribs and the *Gastroplites*-like venter, these features indicate the re-determination of this specimen as *Stotticeras* sp. indet. The presence of *Pseudopulchellia flexicostata* (Imlay) in this section of Shaktolik Group (e.g. specimen USNM 128752; see Imlay, 1961, Pl. 18, fig. 3) supports this conclusion in suggesting that the beds concerned are considerably older than the generalized *Gastroplites* Zone. Because of its apparent association with *Ps. flexicostata*, this central Alaskan occurrence of *Stotticeras* may correspond to *Pseudopulchellia flexicostata* beds and the presumably correlative upper part of Unnamed Zone F rather than to the next younger *Pseudopulchellia pattoni* Zone (Fig. 1).

The only other possible occurrence of *Stotticeras* is at the GSC loc. 47638 in the strongly faulted Christopher Formation, north of Stolz Range, Axel Heiberg Island where the only ammonite fragment found is tentatively assigned to *Stotticeras* and tentatively correlated with the lower part of *Pseudopulchellia pattoni* Zone (see Fig. 1).

Because of the above considerations, the genus *Stotticeras* is believed to occur in the lower part of *Pseudopulchellia pattoni* Zone and, possibly, to range down into the upper part of the Unnamed Zone F. The data available are too scarce and too uncertain to make any suggestions concerning its complete time range.

Stotticeras crowense sp. nov.

Plate 1, figure 26, Plate 6, figures 1, 2, 3, Plate 9, figure 1

Holotype. Specimen GSC 57915, reproduced in Plate 1, figure 26, Plate 6, figure 3, Plate 9, figure 1 is selected herewith as the holotype of *Stotticeras crowense* sp. nov.

Diagnosis. Because of the monotypic character of *Stotticeras*, the specific diagnosis of *S. crowense* sp. nov. does not differ from the generic diagnosis (see there).

Material. Three well-preserved but fragmentary specimens and several fragments from GSC loc. 69198.

Stratigraphy, age and correlation. The only known occurrence of *Stotticeras crowense* sp. nov. is treated tentatively as a faunule of the *Pseudopulchellia pattoni* fauna. See section on Stratigraphy and Biochronology for further details.

Stelckiceras gen. nov.

Type species. *Placenticeras (Perezianum?* var.) *liardense* Whiteaves 1889.

Derivation of name. After C.R. Stelck, Department of Geology, University of Alberta, Edmonton in recognition of his contributions to Cretaceous paleontology and stratigraphy of western Canada.

Diagnosis. Superficially *Pseudopulchellia*-like gastroplitinids which are characterized by the following combination of morphological features:

1. Asymmetrically to symmetrically trifold appearance of lateral lobe which is mostly, but not invariably, combined with its extreme length, its slender, narrow-stemmed proportions, and very deep indentation and frilling of its branches;
2. Strongly frilled and attenuated but otherwise *Pseudopulchellia balkwilli*-like appearance of all observed auxiliary lobes;
3. Predominantly subtriangular cross-section of ribs, combined with a pronounced adventral widening and increase in prominence, and fold-like, mostly but not invariably, nodeless (i.e. generally *Pseudopulchellia*-like) appearance;
4. Persistence of closely spaced mostly, or at least partly, bifurcating ribbing habit to the oral end of adult living chamber; and
5. Broad, *Gastroplites canadensis*-like proportions and truncation of the venter combined with an exceptionally early appearance (at least on the fourth whorl before the adult ultimate whorl) of this venter.

Remarks. The following comments on the morphology and affinities of *Stelckiceras* gen. nov. are based on results of a study of some moderately to strongly deformed but not completely flattened, halfgrown to presumably adult representatives of *Stelckiceras liardense* (Whiteaves, 1889). These specimens are exceptional in exhibiting a relatively feebly deformed venter (e.g. Pl. 7, fig. 2, Pl. 10, fig. 4B) and reasonably well preserved, albeit incomplete, intermediate and adult suture lines (Pl. 4, figs. 2, 5, Pl. 5, fig. 2; Pl. 7, figs. 2, 6, Pl. 1, figs. 24, 25). The genus *Stelckiceras* gen. nov. being monotypic, a redescription of *S. liardense* itself shall not be attempted in this paper.

Though all its known examples are incomplete (e.g. Pl. 1, figs. 24, 25, Pl. 4, figs. 2, 5, Pl. 5, fig. 5), the previously unknown external suture line is the most distinctive morphological feature of *Stelckiceras*. Therefore, it shall be described in some detail.

The intermediate and adult external suture lines of *Stelckiceras liardense* (Whiteaves) - the only known representative of *Stelckiceras* gen. nov. - are characterized by an unusually (i.e. for the subfamily Gastroplitinae) strong and deep denticulation of all their elements accessible for study (Pl. 1, figs. 24, 25, Pl. 4, figs. 2, 5, Pl. 5, fig. 5). Another distinguishing feature of these suture lines is strongly asymmetrically trifold to symmetrically trifold appearance of the lateral lobe and of all auxiliary lobes accessible for study. Finally, these suture lines are invariably closely spaced to overlapping in part.

Except for the above mentioned characteristic features, the suture lines of *St. liardense* (Whiteaves) are extremely variable. One extreme, exemplified by the specimen GSC 57913 (Pl. 1, fig. 24) and prevalent in the material studied, is characterized by a strong attenuation and elongation of stems, principal

branches and lobules of all lobes accessible for study. This extreme attenuation of lobes, their terminal branches, and lobules is accompanied by their exceptionally strong and deep frilling. The same exceptionally strong attenuation, elongation and frilling characterize the accessory lobes and lobules of all investigated saddles of this extreme variant. The saddles of the variant are much wider than the preceding lobes. The ventral lobe of the variant is pronouncedly asymmetrically trifid (Pl. 5, fig. 2) to almost asymmetrically bifid (Pl. 4, fig. 2). If the latter, this lobe resembles strongly the adult ventral lobe of *Pseudopulchellia balkwilli* sp. nov. (Pl. 1, figs. 21-23, Pl. 9, fig. 7) except for its considerably more slender proportions. All auxiliary lobes of the variant are symmetrically to, more rarely, asymmetrically trifid. This extreme type of the suture-line is designated herewith the *Pseudopulchellia*-like variant.

The other considerably less common morphological extreme exemplified by the specimen GSC 57914 (Pl. 1, fig. 25, Pl. 4, fig. 5) and by the paratype of Whiteaves (1889) reproduced by Jeletzky (1964, Pl. XXXII, fig. 2) is characterized by relatively much wider and shorter lobes which are not more than two times longer (mostly less) than they are wide. The ventral lobe of this extreme variant is almost symmetrically trifid and only slightly longer than it is wide. The flanks of the ventral lobe may be either subparallel or distinctly tapering apically. All auxiliary lobes accessible for study are either symmetrically or almost symmetrically trifid. Though all studied elements of the here discussed suture line are strongly and deeply denticulated, they are considerably simplified in comparison with their equivalents in the previously discussed *Pseudopulchellia*-like variant. On the whole, the suture line of the here discussed variant is similar to that of *Neogastrolites* (compare Pl. 1, fig. 25, Pl. 4, fig. 5 with Reeside and Cobban, 1960, Text-figs. 11, 14, 15, 18, 19, 20, 23, 27; Jeletzky, 1964, Pl. XXXIV, fig. 5, Pl. XXXV, fig. 4B, Pl. XXXVI, fig. 5B). Therefore, it is designated the *Neogastrolites*-like variant of the suture line.

The *Pseudopulchellia*-like variant of the suture line is connected by transitions (e.g. Pl. 4, fig. 2) with the *Neogastrolites*-like variant. Furthermore, the specimens possessing these two types of suture line always were found in association and appear to have the same vertical range. Therefore, these variants of the suture line are interpreted as morphological extremes of a normal infraspecific variation of *St. liardense*.

The *Pseudopulchellia*-like variant of the suture line and the suture line transitional to its extreme *Neogastrolites*-like variant were only observed in those strongly prevalent representatives of *Stelckicerias liardense* (Whiteaves), the primary ribs of which are devoid of any ventral bullae or swellings. The *Neogastrolites*-like variant of the suture line was, in contrast, observed only in those

rare representatives of *St. liardense* which bear either distinct swellings or well-developed bullae on the branching points of their primary ribs (e.g. Pl. 4, fig. 5; and Jeletzky, 1964, Pl. XXXII, fig. 2). Furthermore, the secondary ribs of these bullate specimens tend to become especially strongly widened and prominent on the ventral shoulders where the ribs may become distinctly elevated.

The fourth and last observed auxiliary lobe is situated just short of the umbilical shoulder (Pl. 1, fig. 24, Pl. 5, fig. 5). This leaves ample room for the fifth, and perhaps the sixth, auxiliary lobe on the umbilical wall of *St. liardense*. However, this area is either very poorly preserved or completely invisible in all examples of *St. liardense* suture lines available for study. Therefore, it was impossible either to count the auxiliary lobes situated on the umbilical wall or observe their structural details. This made it impossible to test conclusively the validity of Jeletzky's (1964, p. 92, explanation of Pl. XXXII, fig. 2) suggestion that the suture line of *St. liardense* "has a smaller number of auxiliary lobes than that of *Gastrolites (Paragastrolites) spiekeri*".

The above-discussed florid, extremely strongly and deeply denticulated suture line of *Stelckicerias* is quite unlike that of the *Gastrolites sensu stricto*. This conclusion is equally applicable to its *Pseudopulchellia*- and *Neogastrolites*-like variants. These morphological distinctions of suture lines of *Stelckicerias* and *Gastrolites sensu stricto* are indubitably taxonomically significant on the generic level as the *Gastrolites* suture lines exhibit a distinct evolutionary trend toward simplification. Namely, the suture line of its latest known representatives (e.g. *G. allani* and *G. (Paragastrolites) spiekeri*; see Jeletzky, 1964, Pl. XXVII, fig. 6A, Pl. XXX, fig. 1A, Pl. XXXII, fig. 6; this paper, Pl. 9, fig. 4) are the most simplified (almost pseudoceratitic in *G. (P.) spiekeri*) and have entirely different shaped, asymmetrically bifid lateral lobes. The sutures of its earliest known representatives (e.g. *G. stantoni* McLearn, *G. kingi* McLearn and *G. aff. stantoni* McLearn; see McLearn, 1933, Pl. 1, figs. 9, 10; this paper, Pl. 9, fig. 5) are more complex and approach more closely the suture lines of *Pseudopulchellia* ex gr. *imlayi* sp. nov. This trend toward a simplification of suture line in *Gastrolites* is incompatible with the derivation of much more complex and morphologically different suture line of *Stelckicerias* from it. This conclusion agrees well with the entirely different, *Pseudopulchellia*-like morphology of secondary ribs of *Stelckicerias*, persistence of sculpture all the way to the oral end of its adult living chamber, etc. In view of these far-reaching morphological distinctions, the similarity of *Stelckicerias* and *Gastrolites* in some other respects (i.e. the early appearance of planulate venter, presence of forward bends of secondary ribs on the venter and their weakening there) appear to be the result of a convergent evolution (see section on Phylogeny and Palaeobiogeography for further details).

From *Pseudogastrolites*, *Stelckiceras* differs first of all in the morphology of its adult external suture line. As with the *Gastrolites* suture line, these distinctions are too far reaching to derive *Stelckiceras* from *Pseudogastrolites*. The external morphology of *Stelckiceras* is rather similar to that of *Pseudogastrolites* and the former differs largely in the marked weakening to almost complete obliteration of secondary ribs on the venter, the predominantly subtriangular cross-section of these ribs on the flanks (Pl. 4, fig. 2, Pl. 5, fig. 2, Pl. 10, fig. 4A), their distinct to pronounced forward bends on the venter and a much earlier appearance of tubular venter. Other distinctions of *Stelckiceras* from *Pseudogastrolites* consist in its much more slender whorl proportions, involute umbilicus, and the very much larger size of the adult shell which is known to reach 38 cm in diameter (e.g. Pl. 7, fig. 6).

Most representatives of the genus *Neogastrolites* differ markedly from *Stelckiceras liardense* in the multinodose appearance of their intermediate growth stages and in a complete loss of sculpture in the late growth stages. Those representatives of *Neogastrolites* which lack nodes differ in a complete loss of sculpture in the late growth stages. Furthermore, the semiadult to adult external suture lines of *Neogastrolites* differ, as a rule, from those of *Stelckiceras* in relatively much wider and shorter adapically contracting stem parts of their lateral and auxiliary lobes (compare Reeside and Cobban, 1960, Figs. 11, 14, 15, 18, 19, 20, 23, 27; Jeletzky, 1964, Pl. XXXIV, Fig. 5, Pl. XXXV, fig. 4B, Pl. XXXVI, fig. 5B). Finally, all *Neogastrolites* species known occur in upper Albian to lower Cenomanian beds which are younger than the latest middle Albian beds containing *Stelckiceras liardense* (Jeletzky, 1968, p. 19-23, Fig. 1; 1971, p. 9, Fig. 2; this paper, Fig. 2). However, the *Neogastrolites*-like appearance of the suture line in some morphologically extreme and rare representatives of *Stelckiceras liardense* combined with the presence of umbilical bullae in these extreme forms suggest that the older *Stelckiceras* is an ancestor of *Neogastrolites* (see section on Phylogeny and Palaeobiogeography for further details).

The genus *Irenicoceras* Warren and Stelck, 1958 has a closely similar whorl shape and ribbing habit (Warren and Stelck, 1958, p. 38, Pls. V, VI, Pl. VII, fig. 1). However, it differs sharply in being an involute shell, in the lateral bifurcation of ribs and last but not least in the distinctly *Gastrolites* like morphology of its wide and short lateral lobe split into two branches by a well-defined, deep indentation (Warren and Stelck, 1958, p. 38, Pl. V, figs. 2, 3).

Beattonoceras Warren and Stelck 1958 has a more similar suture line with an asymmetrically trifid lateral lobe. However, the latter is relatively wider and more strongly frilled. All auxiliary lobes of *Beattonoceras* (Warren and Stelck, 1958, Pl. XI, fig. 3) spread palm-like like those of *Gastrolites* instead of tapering adapically like those of *Stelckiceras liardense*. Whorl shape and sculpture of *Beattonoceras* (Warren and Stelck, 1958, p. 41) furthermore, are quite unlike those of *Stelckiceras*.

The genus *Pseudopulchellia* Imlay 1961, as re-interpreted in this report, is indubitably closely related to *Stelckiceras* because of the already discussed, extremely similar morphology of intermediate and adult external suture lines of these two genera. Nevertheless, the external suture lines of the two genera differ significantly in the already discussed details of the lateral lobe. Furthermore, *Stelckiceras* differs from *Pseudopulchellia* in the broadly planulate (instead of narrow and mostly somewhat to considerably convex), *Gastrolites canadensis*-like venter, a much earlier appearance (at least on the fourth whorl from the adult penultimate whorl) of this *Gastrolites*-like venter, and the persistence of closely spaced, predominantly or at least partly dichotomous ribbing habit to the oral end of adult living chamber. These morphological distinctions, finally, are combined with the so far almost mutually exclusive geographical ranges of *Stelckiceras* and *Pseudopulchellia*. Therefore, *Stelckiceras* is obviously generically distinct from the apparently ancestral *Pseudopulchellia*.

The above-discussed sharp morphological distinctions of *Stelckiceras* from all similar gastrolitid genera and its occurrence in a well-defined zone immediately overlying the generalized *Gastrolites* Zone and underlying the generalized *Neogastrolites* Zone (Jeletzky, 1968, p. 19) requires its assignment to a new genus.

Stelckiceras appears in the Albian basin of the Western Interior of Canada suddenly and without any known predecessors in the topmost part of the generalized *Gastrolites sensu stricto* Zone (Jeletzky, 1968, p. 17, 18, Fig. 1). Because of the previously discussed close morphological similarity to *Pseudopulchellia balkwilli* sp. nov., it appears to be a direct descendant of this *Pseudopulchellia* species group which inhabited the mid-Albian generation of Sverdrup Basin. The presence of *Pseudopulchellia* forms morphologically similar and apparently genetically related to *Stelckiceras* in the mid-Albian rocks of the Sverdrup Basin indicates that this genus is a specialized offshoot of the boreal hoplitid stock which invaded the Canadian Western Interior sea sometime in late mid-Albian time (Fig. 2). Following the inferred extinction of the genuine *Gastrolites* stock in this basin, *Stelckiceras* became a predominant element of the latest mid-Albian ammonite fauna of this inland sea.

The stratigraphy, age and correlation of *Stelckiceras* Zone are discussed below in the section on Stratigraphy and Biochronology.

Pseudopulchellia Imlay 1961 emend.

Type species. *Pseudopulchellia pattoni* Imlay 1961.

Diagnosis. High- and slender-whorled, involute to moderately involute gastrolitidids ornamented by fold-like ribs which markedly increase in prominence and widen markedly adventrally. These generally speaking *Pseudogastrolites*-like ribs may be either flat-topped or regularly rounded in cross-section. The ribs may be either single or bifurcating on intermediate whorls but become predominantly or invariably single on outer (mostly adult

ultimate whorl only) whorls of most representatives where the lowermost flanks tend to become smooth. The fold-like ribs are, as a rule, much coarser and sparser on the adult living chamber than on the phragmocone. The ribs are, as a rule, either strongly weakened or interrupted on the venter, which is mostly narrowly rounded and high-arched (*Cleoniceras*-like) on intermediate whorls but broadly rounded and low arched on the adult ultimate whorl. However, the venter may be *Paragastrolites spiekeri*- or even *Gastrolites canadensis*-like flattened on the oral part of the adult penultimate and on the adult ultimate whorl of the most primitive forms.

Historical remarks. The genus *Pseudopulchellia* was erected by Imlay (1961, p. 65, Pl. 18, figs. 1-5, 9) for some very poorly preserved, fragmentary ammonites found in the Albian rocks of northern and central Alaska. This material was rather difficult to interpret and the writer (Jeletzky, 1964, p. 90, 92, Pl. XXXI, figs. 3, 7, Pl. XXXII, figs. 1-5) originally failed to notice strong affinities of some well-preserved gastrolitid ammonites from mid-Albian rocks of Sverdrup Basin with *Pseudopulchellia*. However, a subsequent more detailed study revealed the presence of many *Pseudopulchellia*-like ammonites in the mid-Albian gastrolitid faunas of Sverdrup Basin. This study resulted in the far reaching reappraisal of the morphology, phylogenetic relationships and time range of *Pseudopulchellia* proposed below (Fig. 2).

The original diagnosis of *Pseudopulchellia* (Imlay, 1961, p. 65) is a summary of principal morphological features of *Ps. pattoni* Imlay which was its only known representative at that time. The partial morphological non-correspondence of such close allies of *Pseudopulchellia* as *Gastrolites?* (*Paragastrolites?*) n. sp. aff. *liardense* Jeletzky (1964, Pl. XXXI, figs. 3, 7, Pl. XXXII, fig. 4), the Canadian representatives of "*Paragastrolites*" *flexicostatus* Imlay, and other Sverdrup Basin forms described below to its original diagnosis put before the writer a choice either to erect a new genus to include them or to amend the diagnosis of *Pseudopulchellia* so as to permit their inclusion within it. The second option was taken because all morphological features considered to be diagnostic of *Pseudopulchellia* exhibit a much greater range of variation than it was previously stated (e.g. Imlay, 1961, p. 65).

For example, the *Pseudogastrolites*-like, relatively abundant and closely spaced, bifurcating rib bundles characteristic of all *Pseudopulchellia*-like forms of the Sverdrup Basin appear to be irrelevant for their generic assignment. In the writer's opinion, all presently known Alaskan and Canadian material of *Ps. pattoni* exhibits only its adult growth stage consisting of the adult ultimate whorl and oral part of the adult penultimate whorl. This adult growth stage has a different, highly variable but much more *Ps. pattoni*-like ornamentation in most of the Sverdrup Basin forms. In these forms the intermediate *Pseudogastrolites*-like ribbing habit is mostly replaced by that consisting of single, very

broad and sparse ribs on the adult ultimate whorl because of the loss of sculpture on its lower flank. These adult ribs may be flat-topped and steep-flanked, and so *Ps. pattoni*-like, in some forms (e.g. in the still undescribed *Ps. aff. Ps. pattoni*). In some forms, such as *Ps. balkwilli* sp. nov. and *Ps. imlayi* sp. nov. (see below), these ribs are invariably round-topped. Finally, in the adults of some extreme forms, such as *Pseudopulchellia flexicostata* (Imlay), the adventrally widened, either flat-topped or round-topped ribs are commonly associated with round-topped but narrow (i.e. *Cleoniceras*-like) ribs. Furthermore, the Sverdrup Basin population samples of *Ps. flexicostata* include some adults which retain the intermediate dichotomous ribbing habit to the oral end of adult living chamber. The ratios of flat-topped, round-topped, and *Cleoniceras*-like ribs vary greatly from one adult specimen to another in this oldest known, presumably most primitive *Pseudopulchellia*-like form.

The ribbing habit of *Pseudopulchellia pattoni* Imlay obviously falls well within this range of variation of adult ribbing habit of the Canadian *Pseudopulchellia*-like forms. Therefore it cannot be assigned more than specific rank. On that basis it is assumed that the still unknown intermediate whorls of *Ps. pattoni* possess the same bifurcating, *Pseudogastrolites*-like ribbing habit as the *Pseudopulchellia*-like forms of Sverdrup Basin. The occasional occurrence of bifurcation in the Alaskan (Imlay, 1961, Pl. 18, figs. 3, 5) and the Canadian (Pl. 7, figs. 4, 5) representatives of *Pseudopulchellia pattoni* agrees well with this idea.

Because of the above considerations, *Pseudopulchellia pattoni* Imlay appears to be the morphologically most aberrant and presumably the most specialized representative of a genetically closely related but morphologically highly variable species group of gastrolitid ammonites. Most of the Sverdrup Basin representatives of this species group appear to be somewhat older, less specialized forms than *Ps. pattoni*.

The morphological distinctions of *Pseudopulchellia* emend. from its closest known ally *Pseudogastrolites* gen. nov. have already been discussed in the description of the latter. The morphological distinctions from *Stelckiceras* gen. nov., *Stotticeras* gen. nov., *Anagastrolites* gen. nov. and *Cleogastrolites* gen. nov. were also discussed in their descriptions.

From *Gastrolites* sensu stricto (also from the subgenus *Paragastrolites* Imlay 1961), all known representatives of *Pseudopulchellia* Imlay emend. differ, first of all, in the *Pseudogastrolites*-like morphology of their ribs (including the absence of umbilical bullae) combined with the generally speaking more florid and more deeply denticulated appearance of their intermediate and adult suture lines (compare Jeletzky, 1964, Pl. XXVII, figs. 4C, 6A, 8A, Pl. XXX, figs. 1A, 2B, Pl. XXXII, fig. 6). This applies even to the simplest known adult external suture lines of *Ps. imlayi* sp. nov.

(Pl. 1, figs. 17, 18) and *Ps. flexicostata* (Imlay) (Pl. 1, figs. 13-16). Another important distinction consists in the much later appearance of broadly arched to almost planulate (i.e. *Gastropulchellia stantoni*- or *G. (P.) spiekeri*-like) venter in *Pseudopulchellia*. Finally, the shell sculpture of *Pseudopulchellia* persists right to the mouth border of adult living chamber without any signs of weakening, except on the adumbilicalmost part of the flank. Furthermore, it becomes more prominent and coarser on the adult living chamber of most species. The sculpture of *Gastropulchellia sensu stricto*, in contrast, first declines and then disappears completely on the adult ultimate (and sometimes on the adult penultimate) whorl.

Pseudopulchellia cannot be confused easily with *Neogastropulchellia* primarily because of the symmetrically to asymmetrically trifid (instead of asymmetrically to symmetrically bifid) appearance of lateral lobes of all hitherto described *Neogastropulchellia* species (compare Reeside and Cobban, 1960, Figs. 11, 18, 19, 20, 23, 24, 27; Warren and Stelck, 1958, Pl. IX, figs. 2, 3; Jeletzky, 1964, Pl. XXXIV, fig. 5, Pl. XXXV, fig. 4B, Pl. XXXVI, fig. 5B). Furthermore, many of *Neogastropulchellia* forms known differ from *Pseudopulchellia* in their pronounced ornament. Other *Gastropulchellia*-like forms of the genus differ in having *Gastropulchellia*-like ribbing habit on the inner whorls and in losing all sculpture on the outer whorls.

The genus *Beattonoceras* Warren and Stelck 1958 differs from *Pseudopulchellia* in the presence of a row of faint ventrolateral nodes, the almost symmetrically trifid appearance of the lateral lobe, and in the ornament becoming either completely or at least largely lost in the adult ultimate whorl (Warren and Stelck, 1958, p. 41, Pl. X, fig. 3, Pl. XI, figs. 1, 3, Pl. XII, figs. 1-5, Pl. XIII, figs. 1, 3, Pl. XV, figs. 2-4). This poorly known genus is either closely allied to or, possibly, synonymous with *Neogastropulchellia*.

Finally, the genus *Irenicoceras* Warren and Stelck, 1958 differs in the persistence of closely spaced, commonly bifurcating ribbing habit to the oral end of the adult ultimate whorl and in the persistence of ribs across the venter. This genus is more similar morphologically to *Stelckiceras* gen. nov. than it is to *Pseudopulchellia* and may well be its descendant.

Though *Cleoniceras (Grycia)* is placed by the writer in the subfamily Cleoniceratinae, it appears to be a direct ancestor of *Pseudopulchellia*. Some forms of *Cleoniceras (Grycia)*, therefore, may be very difficult to distinguish from such early and primitive forms of *Pseudopulchellia* as *Ps. flexicostata* (Imlay), *Ps. imlayi* sp. nov., and particularly from the relatively fine and closely ribbed *Ps. balkwilli* sp. nov. These early mid- to late mid-Albian *Pseudopulchellia* species appear to be connected by transitions with such early mid-Albian forms as *Cleoniceras (Grycia) densicostata* sp. nov. (Pl. 2, fig. 3A-D) and the late early Albian "*Cleoniceras (Anadesmoceras?)* aff. *subbaylei*" of Jeletzky (1964, p. 74, Pl. XXIII, figs. 3, 4, 6) which was more recently reinterpreted as an aberrant *Cleoniceras*

(*Grycia*). The shape and ornamentation of early and intermediate whorls of *Cleoniceras (Grycia) densicostata* sp. nov. may be indistinguishable from those of the equivalent whorls of particularly slender and finely ribbed variants of *Pseudopulchellia balkwilli* sp. nov. (compare Pl. 3, fig. 4A-C with Pl. 3, fig. 2A-C). However, the adult penultimate and adult ultimate whorls of *Cleoniceras (Grycia) densicostata* sp. nov. do not develop any broad and sparse, predominantly single ribs diagnostic of the adult penultimate and adult ultimate whorls of this *Pseudopulchellia* species. These fold-like single ribs appear even earlier in the ontogeny of other *Pseudopulchellia* species concerned (e.g. Pl. 3, fig. 1A, B, Pl. 7, fig. 3A, C). Furthermore, the adult external suture line of *Cleoniceras (Grycia) densicostata* sp. nov. generally has only four auxiliary lobes while all known suture lines of *Pseudopulchellia* have five to six auxiliary lobes.

The most strongly sculptured representatives of "*Cleoniceras (Anadesmoceras?)* aff. *subbaylei*" (see Jeletzky, 1964, Pl. XXIII, figs. 3A, B, 6A-C) are even more similar to such more coarsely and sparsely ribbed *Pseudopulchellia* as *Ps. imlayi* sp. nov. and *Ps. balkwilli* sp. nov. (Pl. 3, figs. 1, 3, Pl. 8, fig. 2A, C) as they do develop sparse and broad, fold-like ribs on the adult ultimate whorl. Furthermore, the cross-section of their adult living chamber becomes extremely like that of *Ps. ex gr. balkwilli-imlayi*. However, the *Pseudopulchellia imlayi*-like ribs of this "*Cleoniceras (Anadesmoceras?)* aff. *subbaylei*" remain dichotomously bundled throughout in a *Cleoniceras (Grycia)*-like fashion. Furthermore, the primary ribs of the most strongly ornamented representatives of this form are bullae-like thickened at the umbilical shoulder (e.g. Jeletzky, 1964, Pl. XXIII, fig. 3A).

It is to be expected that in the future it will be found impossible to assign generically some of the transitional forms between above-discussed *Cleoniceras (Grycia)* forms on the one hand and the primitive *Pseudopulchellia flexicostata-balkwilli-imlayi* on the other.

Among the *Pseudopulchellia* species of the Sverdrup Basin, it is the oldest and morphologically the most primitive (i.e. the most *Cleoniceras (Grycia)*-like) species - *Ps. flexicostata* (Imlay) - that resembles most closely the approximately contemporary (i.e. *P. nanus* sp. nov.) or somewhat younger (i.e. *P. arcticus* sp. nov.) *Pseudogastropulchellia* species of the same basin. It is inferred, therefore, that the genus *Pseudogastropulchellia* gen. nov. is an offshoot of those morphological variants of *Ps. flexicostata* (Imlay) which combine the broad planulate venter of the adult living chamber with strong *Pseudogastropulchellia* like secondary ribs which cross the venter without any weakening. The holotype of *Ps. flexicostata* (Imlay) is a good example of such presumably ancestral forms, except for the strong weakening of the adumbilical parts of its ribs (see Imlay, 1961, Pl. 18, figs. 10, 11). As *Pseudogastropulchellia nanus* sp. nov. is an obviously more slender and in other features is a more *Pseudopulchellia*-like form than the younger *P. arcticus* sp. nov., *Pseudopulchellia* emend. and *Pseudogastropulchellia* apparently evolved in different directions (Fig. 2).

As pointed out in the description of *Anagastroplites* gen. nov. it appears to be another direct descendant of *Pseudopulchellia flexicostata* (Imlay). These inferred phylogenetic relationships suggest a somewhat explosive phase of evolutionary radiation at the onset of the evolutionary history of *Pseudopulchellia* emend. (Fig. 2).

The previously discussed, inferred branching of the genera *Gastroplites* sensu stricto, *Stelckicerias* gen. nov. and *Stotticerias* gen. nov. from *Pseudopulchellia* ex gr. *balkwilli-imlayi* n. sp., which are somewhat younger and morphologically more advanced than *P. flexicostata* (Fig. 2), suggest another burst of evolutionary radiation later in the evolutionary history of *Pseudopulchellia* emend. Because of these considerations, *Pseudopulchellia* emend. appears to be a "mother genus" of most mid-Albian gastroplitinid genera occurring in the Sverdrup Basin and in the Western Interior Region of Canada (Fig. 2).

Pseudopulchellia pattoni Imlay 1961

Plate 7, figures 4, 5

1961 *Pseudopulchellia pattoni* Imlay, p. 65, Pl. 18, figs. 1-5, 9

1971 *Pseudopulchellia pattoni* Jeletzky, p. 8, 45, Text-fig. 2

1975 *Pseudopulchellia pattoni* Stott, p. 457

Type specimen. The specimen USNM 128772 reproduced by Imlay (1961, Pl. 18, fig. 5) is the holotype of *Pseudopulchellia pattoni* Imlay by original designation.

Material. The definitively identifiable Canadian material of *Pseudopulchellia pattoni* Imlay consists of three fragmentary specimens from GSC loc. 42272 (Pl. 1, figs. 4, 5), five fragmentary specimens from GSC loc. 84117 and two fragmentary specimens from GSC loc. 84118. Furthermore, poorly preserved fragments of gastroplitinids, possibly belonging to *Pseudopulchellia pattoni* have been found at GSC locs. 46515 and 80768.

Remarks. So far as is known, the Canadian representatives of *P. pattoni* Imlay do not differ materially from the North Alaskan representatives of the species, as described by Imlay (1961, p. 65), except:

1. In an occasionally distinct bifurcation of ribs on the lower flank (Pl. 1, fig. 4). This feature, however, is interpreted to be of an individual to infraspecific value only as the two adoralmost visible ribs of the holotype of *P. pattoni* (see Imlay, 1961, Pl. 18, fig. 5) form a somewhat indistinct dichotomous bundle. Furthermore, the same is true of the second and third ribs from the oral end of the paratype of *P. pattoni* (see Imlay, 1961, Pl. 18, fig. 3). The correctness of these observations was confirmed by the study of a plaster cast of the holotype of *P. pattoni*. It is concluded

accordingly that the ribs of *P. pattoni* may occasionally form indistinct to well defined dichotomous bundles of the gastroplitinid type; and

2. In upper parts of some ribs being strongly swollen and fold-like but devoid of completely flattened tops sharply delimited from the adjacent flanks. The top parts of these ribs of Canadian representatives of *Ps. pattoni* are, instead, distinctly less arched than their adjacent slopes (Pl. 1, fig. 4). Such relatively rare ribs may be indistinguishable from the upper parts of secondaries of *Pseudogastroplites* (see there for further details). As with the occasional bifurcation of ribs, this *Pseudogastroplites*-like appearance of some ribs is interpreted as of an individual to infraspecific value only. First, these ribs are rare in the Canadian material of *Ps. pattoni* studied. Second, similar, *Pseudogastroplites*-like ribs occur rarely in at least one of the paratypes of *Ps. pattoni* (see Imlay, 1961, Pl. 18, fig. 1).

The holotype of *Pseudopulchellia pattoni* Imlay 1961 has about twelve ribs per exposed part of its fragmentary outer whorl believed to be the adult ultimate whorl. Of these ribs, only one definitely splits in two at the sub-angular umbilical shoulder so that the rest can only be referred to as undivided ribs. However, there may be another primary rib which splits into two secondaries within the poorly and incompletely preserved earliest exposed part of the whorl. If so, the holotype would have at least two bifurcating primaries in this whorl.

Though the holotype of *Pseudopulchellia pattoni* (see Imlay, 1961, Pl. 18, fig. 5) is distorted and therefore unfit for exact measurement, it is possible to estimate the width of its umbilicus as being in order of 25 per cent of the shell's diameter (i.e. estimated width of the umbilicus is 11.5 mm and the estimated shell diameter is 46 mm). On the above basis, the umbilicus of *Ps. pattoni* is among the widest known in the *Pseudopulchellia*. This shallow, step-like and moderately involute umbilicus is considerably wider and more shallow than the fully involute, subvertical and funnel-like umbilicae of *Ps. balkwilli* sp. nov. and *Ps. flexicostata* Imlay. Of the better preserved *Pseudopulchellia* forms known, only *Ps. imlayi* sp. nov. has an umbilicus which is either wider or comparably wide, and similarly shallow and step-like as that of the holotype of *Ps. pattoni*.

Like the North Alaskan material of *Ps. pattoni*, the scarce, poorly preserved Canadian material does not exhibit any sign of an external suture line.

Stratigraphy, age and correlation.

Pseudopulchellia pattoni Imlay is designated as the name fossil of an independent gastroplitinid zone. See section on Stratigraphy and Biochronology for further details.

Pseudopulchellia balkwilli sp. nov.

Plate 1, figures 21-23, Plate 3, figures 2A-C, Plate 8, figures 2A-C, Plate 9, figure 7

1964 *Gastroplices?* (*Paragastroplices?*) n. sp. aff. *liardense* Jeletzky, p. 90 (expl. of Pl. XXXI, fig. 3), p. 92 (expl. of Pl. XXXII, fig. 4), Pl. XXXI, fig. 3, Pl. XXXII, fig. 4.

Type specimen. The specimen GSC 17421 from GSC loc. 43618 originally figured by Jeletzky (1964, Pl. XXXI, fig. 3) and reproduced in Plate 8, figures 2A-C of this paper, is designated herewith as the holotype of *Pseudopulchellia balkwilli* sp. nov. Its intermediate and adult suture lines are reproduced in Plate 1, figures 21, 22 of this report. As already noted by Jeletzky (1964, p. 90, expl. of Pl. XXXI, fig. 3) a pathological swelling probably related to a collision-caused break of the shell occurs on the right flank and venter of the middle part of the oralmost preserved, entirely septate whorl. However, this pathological swelling, which was obviously healed one-sixth of the whorl later, does not disfigure the specimen significantly. Therefore, it does not affect its usefulness as the holotype of *Ps. balkwilli* sp. nov.

Derivation of name. For H.R. Balkwill, Geological Survey of Canada in recognition of his geological work in the Canadian Arctic.

Material. Three well-preserved but fragmentary specimens from GSC loc. 43618.

Diagnosis. *Pseudopulchellia* species in which the *Pseudogastroplices*-like ribs are fairly thin, exceptionally numerous (10-14 primaries and 30-38 secondaries per whorl), and very closely spaced on the intermediate *Cleoniceras* (*Cleoniceras*)-shaped whorls. These ribs rapidly become very heavy, adventrally prominent and sparse (some 20 to 25 secondaries per whorl) on the oral third of adult penultimate whorl and remain so throughout the adult ultimate whorl. Except on adult ultimate whorl where the lower quarter of flanks is smooth, the ribs mostly form ill-defined dichotomous and, more rarely, trichotomous bundles with barely visible branching points situated at or closely above the umbilical shoulder. The ribs' cross-section remain regularly rounded throughout; they do not become flat-topped and steep-sided in cross-section even on the ventral shoulder and venter. The generally *Cleoniceras* (*Cleoniceras*)-like intermediate and adult external suture lines are uniquely strongly denticulated and florid for the genus. All auxiliary lobes are exceptionally long and slender whereas all saddles, including the lateral saddle, are exceptionally wide. The exceptionally long and slender terminal branches of the wide to very wide adult lateral lobe are strongly asymmetrically bifid. The significantly longer adumbilical branch is directed subtransversally in the adult state while the adventral branch is strongly inclined outward. These two branches are, in contrast, subtransversal in the intermediate growth stages.

Remarks. *Pseudopulchellia balkwilli* sp. nov. differs from the closely allied *Ps. imlayi* sp. nov. in:

1. Many more primary and secondary ribs per whorl in the intermediate *Cleoniceras* (*Cleoniceras*)-like shaped growth stage. Unlike *Ps. balkwilli* sp. nov., *Ps. imlayi* sp. nov. is not known to have more than 11 primaries and 26 or 28 secondaries per intermediate whorl.
2. An in general more florid and more deeply denticulated appearance of intermediate and adult external suture lines.
3. One and half to more than two times as wide and much more shallow proportions of the main body of intermediate and adult lateral lobes. Unlike *Ps. balkwilli* sp. nov. where the main body of this lobe is always wider than long, that of *Ps. imlayi* sp. nov. is always longer than wide. Therefore the tops of its terminal branches almost meet at the base of the main body in *Ps. imlayi* sp. nov.
4. The lateral lobe of *Ps. balkwilli* sp. nov., remaining almost symmetrically bifid with both terminal branches directed almost subtransversally in relation to the whorl's radius until its whorl diameter reaches 20 to 25 mm. The lateral lobe of *Ps. imlayi* sp. nov., in contrast, is markedly asymmetrically bifid already at whorl's diameter of 8 mm (possibly already earlier). Furthermore, its adventral terminal branch is directed obliquely outward forming an angle of 30 to 35 degrees with the direction of the adjacent part of umbilical wall.
5. The umbilicus of *Ps. balkwilli* sp. nov. being appreciably more involute (16-20%) than that of *Ps. imlayi* sp. nov. (30-33%).

These morphological distinctions are judged to be ample for a specific differentiation of *Ps. balkwilli* sp. nov. and *Ps. imlayi* sp. nov. considering that the two forms occur exclusively at different, geographically distant fossil localities and are associated with different gastroplicitid ammonites which appear to be of a somewhat different age.

Pseudopulchellia pattoni Imlay 1961 differs sharply from *Ps. balkwilli* sp. nov. in the flat-topped and steep-sided cross-section of the vast majority of its ribs. This feature, which is completely absent in all studied representatives of *Ps. balkwilli* sp. nov., permits an easy differentiation of fragments of these two species. *Pseudopulchellia pattoni* is, furthermore, a much smaller form, the whorls of which are not known to exceed 28 mm in diameter. The holotype of *Ps. pattoni* and some at least of its paratypes (compare Imlay, 1961, Pl. 18, figs. 3, 4, 5) also have a smaller number of ribs per whorl (probably between 8 and 12) than *Ps. balkwilli* sp. nov. However, other specimens included into this species by Imlay (1961, Pl. 18, figs. 1, 2) have a larger number of ribs per whorl which is comparable with that observed on the adult ultimate whorl of *Ps. balkwilli* sp. nov. (Pl. 9, fig. 7).

Stratigraphic relationships, age and correlation. At its only known GSC locality 43618, *Pseudopulchellia balkwilli* sp. nov. is associated with *Pseudogastrolites nanus* sp. nov. Therefore, *Pseudopulchellia balkwilli* sp. nov. is considered to form part of *Pseudopulchellia flexicostata* fauna, which is discussed below in the section of Stratigraphy and Biochronology.

Pseudopulchellia imlayi sp. nov.

Plate 1, figures 17, 18, Plate 2, figures 1, 3, Plate 8, figure 3

1964 *Gastrolites?* (*Paragastrolites?*) n. sp. aff. *liardense* Jeletzky, p. 90 (expl. of Pl. XXXI, fig. 7), Pl. XXXI, figs. 7A-D

Type specimen. Specimen GSC 17425, which was figured by Jeletzky (1964, Pl. XXXI, fig. 7) in part and is reproduced in its entirety in Plate 3, figures 1A-C, Plate 8, figures 3A-C of this report, is designated herewith the holotype of *Pseudopulchellia imlayi* sp. nov.

Derivation of name. For Ralph Imlay, United States Geological Survey, Washington, D.C., U.S.A. in recognition of his paleontological research of Cretaceous ammonite faunas of western and Arctic North America.

Material. Two well-preserved but fragmentary specimens (including the holotype) and eight readily identifiable fragments from GSC loc. 40602. One well-preserved, almost complete phragmocone from GSC loc. C-11432.

Diagnosis. A *Pseudopulchellia* species characterized by the ornament of intermediate whorls which is more coarse and widely spaced than that of *Ps. balkwilli* sp. nov. (no more than 11 primaries and 28 secondaries per whorl) but considerably more refined and dense than that of *Ps. pattoni*, an exceptionally wide umbilicus of 30 to 33 per cent and uniquely strongly simplified adult and intermediate external suture lines with subrounded and round-tipped lobules. The lateral lobe has the main body which is always longer than wide; it becomes markedly asymmetrically bifid beginning with whorl diameter of 8 mm or even less. Adult ornament and whorl shape as in *Pseudopulchellia balkwilli* sp. nov.

Remarks. The morphological features distinguishing *Pseudopulchellia imlayi* from *Ps. balkwilli* sp. nov. and *Ps. flexicostata* (Imlay) have been discussed in the descriptions of these species.

From *Ps. pattoni* Imlay our species differs in the regularly rounded cross-section of its strongly swollen and sparse ribs which persists throughout all known growth stages. These growth stages include several examples of the oralmost part of adult living chamber (Pl. 3, fig. 3A). Other distinguishing features include a larger size of *Ps. imlayi* sp. nov. and the greater number of ribs per whorl.

The strongly simplified character of the semi-adult and adult external suture lines of *Ps. imlayi* sp. nov. as compared with that of the equivalent suture lines of *Ps. balkwilli* sp. nov. and the presumably ancestral *Ps. flexicostata*

(Imlay) suggest that it is a specialized offshoot of *Pseudopulchellia* stock endemic to the Sverdrup Basin and presumably ancestral to the *Gastrolites* sensu stricto of the Canadian Western Interior Region (Fig. 2).

Stratigraphic relationships, age and correlation. All fossil localities where *Pseudopulchellia imlayi* sp. nov. was found are either known (GSC loc. 40602) or inferred (GSC loc. C-11432) to form part of *Pseudogastrolites arcticus* beds. The stratigraphic relationships, age, and correlation of these beds and fossil localities are discussed below in the section on Stratigraphy and Biochronology.

Pseudopulchellia flexicostata (Imlay 1961)

Plate 1, figures 13-16, Plate 5, figures 1, 3-5, Plate 7, figure 4

1961 *Paragastrolites flexicostatus* Imlay, p. 63, Pl. 18, figs. 10-20

1961 *Gastrolites kingi* Imlay, Pl. 17, figs. 12, 13

1961 *Gastrolites* cf. *G. allani* Imlay, Pl. 16, figs. 11, 12

?1961 *Paragastrolites spiekeri* Imlay, Pl. 19, figs. 9, 10, 12

?1965 *Neogastrolites americanus* Verestchagin and Terekhova in Verestchagin et al., p. 34, Pl. 18, fig. 5

Type specimen. The specimen USNM 128757 reproduced by Imlay (1961, Pl. 18, figs. 10, 11) is the holotype of *Pseudopulchellia flexicostata* (Imlay 1961) by original designation. This specimen is an apparently adult living chamber with a segment, about 5 mm long, of oralmost part of the phragmocone preserved at the apical end.

Canadian material. Seven almost complete to fragmentary, mostly strongly deformed to laterally flattened and deeply weathered specimens and a few identifiable fragments from GSC loc. C-26600. Three fragmentary but mostly undeformed specimens from GSC loc. 44044.

Revised diagnosis. A *Pseudopulchellia* species combining an involute umbilicus with an almost completely flattened, *Gastrolites stantoni*-like venter of adult penultimate and ultimate whorls and flat, subparallel flanks of adult ultimate whorl. The umbilical wall of adult ultimate and penultimate whorls is uniquely high for the genus and oriented subvertically. The ribs do not become appreciably more widened, prominent, and sparser on the adult ultimate whorl in comparison with intermediate whorls. The ornament of intermediate and adult growth stages is highly variable. Some extreme representatives are characterized by prevalence of flat-topped and steep-flanked, markedly adventrally widening secondary ribs. Other extreme representatives retain the prominent but thin to fairly thin, round-topped to sharp-topped ribbing habit to the oral end of the adult living chamber. Intermediate forms may exhibit various combinations of these extreme ribbing habits. Secondary ribs are weakened to almost effaced on the venter of intermediate whorls, including the adult

EUROPEAN ZONAL STANDARD			AMMONITE FAUNAS OF SVERDRUP BASIN					ZONAL STANDARD OF THE CANADIAN INTERIOR REGION				
Sub-stages	Zones	Subzones	Banks Island	Ellef Ringnes Island	Amund Ringnes Island	Axel Heiberg Island	Ellesmere Island	Sub-stages	Zones			
UPPER ALBIAN (PART)	Mortonicerus inflatum	Callihoplites auritus	Nonmarine Rocks of Hassel Formation					UPPER ALBIAN (PART)	Generalized Neogastropilites Zone (part)			
		Hysterocheras varicosum								?	?	?
		Hysterocheras orbigny	Neogastropilites n. sp. aff. selwyni	Marine but so far ammoniteless basal beds of Hassel Formation						?		
MIDDLE ALBIAN	Euhoplites lautus	Dipoloceras cristatum	?	Pseudopulchellia aff. Ps. pattoni faunule	?	Anagastropilites tozeri faunule	?	MIDDLE ALBIAN	Stelckicerus liardense			
		Anahoplites daviesi		?		?						
		Euhoplites nitidus		?		?						
	Euhoplites loricaus	Euhoplites meandrinus	Pseudogastropilites arcticus faunule	Pseudogastropilites arcticus faunule	?	?	?		Pseudopulchellia pattoni			
		Mojsisoviczia subdelaruei	?	?		? Stotticerus sp. indet. faunule	?			?		
		Dimorphoplites niobe	Pseudopulchellia flexicostata and Pseudogastropilites nanus faunules	Pseudogastropilites nanus faunule		?	?			?		
		Anahoplites intermedius									?	
		Hoplites spathi										?
	Lyelliceras lyelli	Cleoniceras (Cleoniceras) canadense fauna	Cleoniceras (Cleoniceras) canadense fauna	Cleoniceras (Cleoniceras) canadense fauna	?							
	?	?	?	?	?	?	?		Stotticerus crowense faunule			
	LOWER ALBIAN (PART)	Dovuilleicerus mammillatum	Dovuilleicerus inaequinodum (= Hoplites eodentatus)	Arcthoplites belli fauna	Sandstone unit crowning Kcl member of Christopher Formation				Arcthoplites belli and Cleoniceras (Grycia) n. sp. aff. sablei fauna	LOWER ALBIAN (PART)	Beudanticeras (Grantzicerus) ex gr. affine	Arcthoplites (s. lato) spp. (undivided)
			Dovuilleicerus monile									

Figure 1. Suggested stratigraphic relationships, age, and correlation of mid-Albian gastropilitinid faunas and faunules of Sverdrup Basin.

KV

penultimate whorl. However, they may be either weakened or prominent and *Pseudogastropylites*-like shaped on the venter of the adult ultimate whorl. The intermediate and adult suture lines combine the generally *Pseudopulchellia imlayi*-like low degree of denticulation and subrounded appearance of lobules with a large and unusually wide lateral lobe, which resembles that of *Pseudopulchellia balkwilli* sp. nov. in these respects. The third auxiliary lobe straddles the umbilical shoulder.

Historical remarks. Jeletzky (1964, p. 86, expl. of Pl. XXIX, figs. 3, 4) accepted Imlay's (1961, p. 63) original assignment of *Pseudopulchellia flexicostata* to his new genus *Paragastropylites* which he interpreted as a subgenus of *Gastropylites* McLearn 1930. Jeletzky (ibid., Pl. XXIX, figs. 3, 4), furthermore, had interpreted some exceptionally high-whorled and involute gastropylitids from the Peace River Foothills as *Gastropylites* (*Paragastropylites*) *flexicostatus* Imlay. However, these forms are re-interpreted in this paper (e.g. Pl. 9, fig. 5) as nodeless representatives of *Gastropylites* sensu stricto closely allied to and possibly conspecific with *G. stantoni* McLearn.

Remarks. In spite of a pronounced infra-specific variability of most morphological features of *Pseudopulchellia flexicostata* (Imlay), it differs consistently from all other *Pseudopulchellia* species known in:

1. The absence of a pronounced increase in the width and prominence of secondary and primary ribs anywhere on the adult ultimate whorl. Nor do the ribs become appreciably sparser on this whorl in comparison with the preceding whorls.
2. The subvertical orientation and greater height of the umbilical wall of adult penultimate and ultimate whorls. The umbilicus of *Ps. flexicostata* (Imlay) becomes deeper and more involute on these whorls in comparison with the preceding whorls; and
3. The appearance of narrowly planulate, *Gastropylites stantoni*-like venter already on the early (instead of late) part of adult penultimate whorl.

In addition to these general distinctions, *Ps. flexicostata* (Imlay) differs from the individual *Pseudopulchellia* species known in the following features:

1. The intermediate and adult suture lines of *Ps. flexicostata* beginning with whorl diameter of about 6 mm have only three auxiliary lobes on the flank. This contrasts with the invariable presence of four auxiliary lobes on the flanks of *Ps. imlayi* sp. nov., and *Ps. balkwilli* sp. nov. Unlike *Ps. flexicostata* (Imlay), it is the fourth auxiliary lobe that straddles the umbilical shoulder in the two latter species. This distinction is coupled with the greater relative height of the intermediate and adult umbilical wall in *Ps. flexicostata* (Imlay).

2. The ribbing habit of the intermediate and adult sculptural stages of *Ps. flexicostata* (Imlay) differs from that of *Ps. balkwilli* sp. nov. in a considerably lesser number of primaries and secondaries per whorl. Their numbers (11 to 14 primaries and 22-23 secondaries) approach closely those characteristic of *Ps. imlayi* sp. nov. At the same time these rib numbers are greater than those characteristic of *Ps. pattoni* Imlay. It should be pointed out in this connection that this difference in rib numbers per whorl is only valid for the holotype and the small paratype of *Ps. pattoni* Imlay (see Imlay, 1961, Pl. 18, fig. 3, 4). The other two paratypes of *Ps. pattoni* (see Imlay, 1961, Pl. 18, figs. 1, 2) have a larger number of single ribs per whorl which approaches that of the holotype of *Ps. flexicostata*. However, they still differ from *Ps. flexicostata* (Imlay) in the prevalence of single ribs.

The distinctions of *Ps. flexicostata* (Imlay) from the morphologically similar *Cleonicerias* (*Grycia*) *densicostata* sp. nov. and the inferred phylogenetic relationships of these two species have already been discussed in the description of the latter form.

Stratigraphy, age and correlation.

Pseudopulchellia flexicostata (Imlay) is selected as the name fossil of a gastropylitid fauna of the Sverdrup Basin which is discussed below in the section on Stratigraphy and Biochronology.

STRATIGRAPHY AND BIOCHRONOLOGY

SVERDRUP BASIN FAUNAS

The cleoniceratinid and gastropylitid taxa of Sverdrup Basin are assigned to several discrete faunas (see Fig. 1) because of their known or inferred stratigraphic relationships within the Upper shale member of the Christopher Formation and inferred correlation with mid-Albian paleontological zones of the Canadian Western Interior Region and northwestern Europe. These regional faunas are discussed below in an ascending order. The beds containing them cannot be treated as regional paleontological zones as yet because of the scarcity of the data available. They are accordingly designated as *Cleonicerias* (*Cleonicerias*) *canadense* beds, etc. However, these regional beds are expected to become the basis of a new regional zonal standard valid for the Canadian Arctic areas situated north of the Liard Plateau, northern and central Alaska and, possibly, the Pacific slope of Siberia.

Cleonicerias (*Cleonicerias*) *canadense* fauna

Stratigraphical relationships, and composition.

The widespread and prolific *Cleonicerias* (*Cleonicerias*) *canadense* fauna (Fig. 1) is critical for the correct dating and correlation of all other middle Albian ammonite faunas of the Christopher Formation. Therefore, its stratigraphical relationships and composition shall be discussed in some detail.

At GSC loc. C-4711, 89755, occurring in the basal beds of the informal Upper shale member (i.e. Kcu of Balkwill) on Axel Heiberg Island, Skaare Fiord (Lat. 78°30'N; Long. 88°30'W) *Cleoniceras (Cleoniceras) canadense* sp. nov. is associated with *Cleoniceras (Cleoniceras) sp. nov. aff. strigosum* Casey and other *Cleoniceras (Neusaynella)*-like cleoniceratinids possibly conspecific with *C. discoides* Avdeiko 1968, a solitary representative of *Pseudogastrolites sp. nov. indet. A* (previously identified as *?Pseudopulchellia sp. nov.* in an unpublished fossil report), a solitary specimen of *Beudanticeras (Beudanticeras) ex aff. beudanti* (Brogniart), numerous well-preserved *Beudanticeras (Grantzicerias) affine* (Whiteaves), numerous and well-preserved *B. (G.) glabrum* (Whiteaves), and some generically indeterminate *Grycia*-like cleoniceratinids.

GSC loc. C-22253 occurs in the basal beds of the Upper shale member on Northern Amund Ringnes Island in the bed of Stratigrapher River at Latitude 78°45'N, Longitude 97°40'W. There *Cleoniceras (Cleoniceras) canadense* sp. nov. is associated with a solitary specimen of *Pseudopulchellia sp. nov. indet. B*, two specimens of *Cleogastrolites aberrans* gen. et sp. nov., numerous and well-preserved representatives of *Beudanticeras (Grantzicerias) glabrum* (Whiteaves), some feebly sculptured to almost entirely smooth *Cleoniceras (Neusaynella)*-like cleoniceratinids closely resembling *Cleoniceras (sensu lato) discoides* Avdeiko, 1968, and several excellently preserved representatives of *Cleoniceras (Grycia) densicostata* sp. nov. described above.

GSC loc. C-4659 situated on Axel Heiberg Island at Latitude 78°57'50"N; Longitude 94°00'29"W is also situated in the basal beds of the Upper shale member. In this collection *Cleoniceras (Cleoniceras) canadense* sp. nov. is associated with *Beudanticeras (Grantzicerias) affine* (Whiteaves) and *Cleoniceras (Grycia?) sp. indet.*

Finally, GSC loc. 89749 is situated 15 m above the base of the Upper shale member on Ellesmere Island (Blackwelder Anticline). There *Cleoniceras (Cleoniceras) canadense* sp. nov. is associated with a solitary representative of *Pseudopulchellia sp. nov. aff. flexicostata* (Imlay), very rare *Cleoniceras (Grycia) sp. indet.*, well-preserved representatives of *Beudanticeras (Grantzicerias) affine* (Whiteaves) and *B. (G.) glabrum* (Whiteaves), and rare *Cleoniceras (sensu lato) aff. C. discoides* Avdeiko 1968.

Because of the presence of *Cleoniceras (Cleoniceras) canadense* sp. nov. and *Beudanticeras ex gr. affine-glabrum* at all above-discussed fossil localities and their similar position at the base of the Upper shale member of the Christopher Formation (Fig. 1), they appear to represent the faunal phases of one and the same *Cleoniceras (Cleoniceras) canadense* fauna.

Correlation with the Canadian Western Interior standard. The *Cleoniceras (Cleoniceras) canadense* fauna is definitely younger than the redefined late early Albian *Arcthoplites* spp. fauna (see Jeletzky, 1975, p. 241, 242, Fig. 3) of the Western Interior Region of Canada. First, no representatives of *Arcthoplites sensu lato* have

been found at any of the known localities of the *Cleoniceras (Cleoniceras) canadense* fauna. Second, on Ellesmere Island the *Arcthoplites* spp. fauna, including *A. belli* (McLearn) and *Cleoniceras (Grycia) sp. nov. indet.* (formerly identified as *Cleoniceras (Anadesmoceras?) aff. subbaylei* Spath; see Jeletzky, 1964, Pl. XXII, figs. 3, 4, 6), occurs 2.4 m stratigraphically below the regionally widespread sandstone unit crowning that Lower shale member of the Christopher Formation designated Kc1 by Balkwill (in press). All known localities of the *Cleoniceras (Cleoniceras) canadense* fauna occur, in contrast, immediately above that sandstone unit (Fig. 1).

The abundant presence of *Beudanticeras (Grantzicerias) affine* (Whiteaves) and *B. (G.) glabrum* (Whiteaves) in the *Cleoniceras (Cleoniceras) canadense* fauna neither indicates nor suggests a late early Albian age. As already pointed out by Jeletzky (1975, p. 241, 242, Fig. 3), these *Beudanticeras (Grantzicerias)* forms range well above the restricted upper lower Albian *Arcthoplites* spp. Zone in the Western Interior Region of Canada. They range right through the Unnamed Zone F of Jeletzky (1968, p. 17, 18, Fig. 1), which contains no other ammonite, and which must correspond to some early part of the middle Albian substage because of its stratigraphic position. However, these *Beudanticeras (Grantzicerias)* forms are not known to range up either into any part of the generalized *Gastrolites* Zone or into the next older *Pseudopulchellia pattoni* Zone of the Western Interior Region of Canada (see Jeletzky, 1975, p. 241, 242, Fig. 3; this paper Figs. 1, 2). The Sverdrup Basin occurrences of these *Beudanticeras (Grantzicerias)* species in the *Cleoniceras (Cleoniceras) canadense* fauna are also stratigraphically above the highest known occurrence of the *Arcthoplites* spp. fauna in that basin. The same situation prevails in Alaska where *Cleoniceras (Cleoniceras) tallieuri* Imlay was found in the Torok Formation at the level some 213.5 m above the *Subarcthoplites* fauna (Imlay, 1961, p. 4, 9).

The rare presence of *Pseudogastrolites* spp. and *Pseudopulchellia aff. flexicostata* (Imlay) in the *Cleoniceras (Cleoniceras) canadense* fauna also suggests its post-*Arcthoplites* spp. age as representatives of these two genera were never found associated with *Arcthoplites* either in the Canadian Western Interior Region or in the Sverdrup Basin.

Because of the above considerations, *Cleoniceras (Cleoniceras) canadense*-bearing beds of the Christopher Formation are correlative with the lower part of Zone F of the Canadian Western Interior Region as restricted in this paper (Fig. 1).

Intercontinental correlation and age. The correlation of *Cleoniceras (Cleoniceras) canadense* fauna with the Albian zonal standard of Western Europe depends on the dating of the *Arcthoplites* spp. Zone. As pointed out repeatedly by Canadian and American workers, including the writer (Jeletzky, 1975, p. 241, 242, Fig. 3; 1977, p. 110; Text-fig. 5), this North American boreal zone is approximately correlative with the *Douvilleicerias mammillatum* Zone in the sense of Spath (1926, 1941) non Casey (1961) nec

Owen (1971, 1973). As stressed by Jeletzky (1977, p. 110), the exclusion of the Inaequinodum Subzone from *Douvilleiceras mammillatum* Zone and its transfer to the middle Albian *Hoplites dentatus* Zone proposed by Casey (1961) and Owen (1971, 1973) is impractical for a North American worker whose principal basis for an intercontinental correlation of the North Pacific *Brewericeras hulenense* and *Douvilleiceras* spp. Zone (and hence of the correlative *Arcthoplites* spp. Zone) is the total range of the genus *Douvilleiceras* on the Pacific coast of North America. It is for that reason that the writer (1977, p. 110 and in this paper) continues to adhere to Spath's (1926, 1941) concept of a *Douvilleiceras mammillatum* Zone. However, he considers this *Douvilleiceras mammillatum* Zone to be upper lower Albian in its entirety in accordance with current usage (see Jeletzky, 1975, p. 241, 243, Fig. 3 for further details).

The North Pacific *Brewericeras hulenense* and *Douvilleiceras* spp. Zone corresponds approximately to the *Arcthoplites* spp. Zone of mid-continental and Arctic Canada and northern Alaska as the two faunas mingle in southeastern Alaska and on Queen Charlotte Islands (see Jeletzky, 1977, p. 110 for further details). Furthermore, *Arcthoplites jachromensis* and other *Arcthoplites* forms were found in association with *Brewericeras* cf. *hulenense* in Spitzbergen (Nagy, 1970, p. 21).

The above data suggest strongly that the *Cleonicer* (*Cleonicer*) *canadense* fauna of the Sverdrup Basin is younger than any part of the *Douvilleiceras mammillatum* Zone sensu Spath (1926). This correlation is, accordingly, favoured by the writer (Fig. 1). On this basis the *Cleonicer* (*Cleonicer*) *canadense* fauna is treated herein as younger than the Inaequinodum Subzone (= *Hoplites* (*Isohoplites*) *eodentatus* Subzone of Casey (1961, p. 498) and Owen (1971, p. 119)) and correlative with the younger part of their *Hoplites dentatus* Zone beginning with the next younger *Lyelliceras lyelli* Subzone (formerly *Hoplites benettianus* Subzone) of Owen (1971, p. 119-121). This interpretation agrees well with the fact that the *Lyelliceras lyelli* Subzone contains the youngest representatives of *Cleonicer* (*Cleonicer*) known in western Europe (Owen, 1971, p. 153, faunal list).

The *Cleonicer* (*Cleonicer*) *canadense* beds could conceivably range up above the *Lyelliceras lyelli* Subzone of the western European standard. The subgenus *Cleonicer* sensu stricto obviously reached the Sverdrup Basin long after its first appearance in the European Boreal Subprovince (i.e. in the middle Tardefurcata Zone; Casey, 1966, p. 553). Furthermore, it evidently survived longer in Arctic Canada and elsewhere in the North American Boreal Subprovince than it did in England and western Europe. This is indicated by the recent descriptions of, in the writer's opinion, rather typical *Cleonicer*, which belong to subgenus *Cleonicer* sensu stricto, high in the middle Albian sequences of Northern Alaska (Imlay, 1961) and northern California (Murphy and Rodda, 1959). However, neither of these *Cleonicer* is closely allied on the specific level to any of the *Cleonicer* (*Cleonicer*) forms of the *Cleonicer* (*Cleonicer*)

canadense fauna. Furthermore, these Sverdrup Basin *Cleonicer* (*Cleonicer*) forms are not known to range up even into the next younger beds carrying *Pseudopulchellia flexicostata* fauna. Therefore, and because of the presence of several younger, still mid-Albian gastroplitinid faunas in the Sverdrup Basin (Fig. 1), the writer prefers to correlate the *Cleonicer* (*Cleonicer*) *canadense* fauna of the Sverdrup Basin with *Lyelliceras lyelli* Subzone alone.

Pseudopulchellia flexicostata fauna

Because of their similar stratigraphic position and close faunal affinities the *Pseudopulchellia flexicostata* and *Pseudogastrolites nanus* faunules discussed below are tentatively grouped together as faunal phases of the widespread and biochronologically important *Pseudopulchellia flexicostata* fauna. Therefore, only the fossil localities and faunal compositions of these two faunules will be discussed separately. These faunules will be treated as a unit - the *Pseudopulchellia flexicostata* fauna - where their stratigraphic relationships with other faunas of the Upper member of the Christopher Formation, regional and external correlation, and age are concerned.

Pseudopulchellia flexicostata faunule

Localities and composition of faunule. A faunule consisting almost exclusively of *Pseudopulchellia flexicostata* (Imlay, 1961) was so far only found at two fossil localities (GSC locs. C-26600, 44044) on Ellef Ringnes Island. Of these localities, GSC loc. C-26600 occurs only about 30 m stratigraphically above the base of the Upper member of the Christopher Formation named Kcu by Balkwill (in press). The exact stratigraphic position of GSC loc. 44044 is not known. However, it was probably collected at the same stratigraphic level because the type of preservation of ammonites and the type of concretions containing them are identical at both localities.

Only *Pseudopulchellia flexicostata* (Imlay 1961) was found at GSC loc. 44044. At GSC loc. C-26600, however, it is associated with a poorly preserved, solitary representative of *Pseudogastrolites* cf. *nanus* sp. nov. and *Inoceramus* cf. *anglicus* Woods.

Pseudogastrolites nanus faunule

Localities and composition of faunule. The faunule including numerous well-preserved representatives of *Pseudogastrolites nanus* sp. nov., among other fossils, and named accordingly, is so far only known definitively from GSC loc. 43618 on Ellef Ringnes Island and from GSC loc. C-22695 on northern Amund Ringnes Island. However, the previously mentioned GSC loc. C-26600 of *Pseudopulchellia flexicostata* faunule on Ellef Ringnes Island is believed to be a faunal phase of *Pseudogastrolites nanus* faunule because of a similar stratigraphic position and the presence of a solitary representative of *P.* cf. *nanus* sp. nov.

The fossils found together with *Pseudogastrolites nanus* sp. nov. at GSC loc. 43618 on Ellef Ringnes Island are:

1. A peculiar ammonite figured by Jeletzky (1964, Pl. XXXI, fig. 3) as *Gastrolites* (*Paragastrolites?*) sp. nov. aff. *liardense* (Whiteaves, 1889) and described herein as *Pseudopulchellia balkwilli* sp. nov. (see p. 18); and
2. A specifically indeterminate representative of *Desmoceras* sensu lato, which was previously identified as *Puzosia?* sp. indet. in an unpublished fossil report to A.H. McNair. At GSC loc. C-22695, *Pseudogastrolites nanus* sp. nov. is associated with a peculiar, still insufficiently understood but apparently cleoniceratinid ammonite assigned herein tentatively to *Cleoniceras* (*Grycia*) sp. nov. aff. *C. (G.) sablei* Imlay and *Desmoceras* sp. indet. sensu lato. This *Desmoceras* sensu lato appears to be conspecific with the form occurring at GSC loc. 43618.

Stratigraphy and regional correlation of *Pseudopulchellia flexicostata* and *Pseudogastrolites nanus* faunules. The *Pseudogastrolites nanus* faunule is definitely younger than the *Cleoniceras* (*Cleoniceras*) *canadense* fauna as GSC loc. C-22695 occurs about 34.5 m stratigraphically above GSC loc. C-22253 of the latter fauna in the Stratigrapher River section on northern Amund Ringnes Island (H.R. Balkwill, written com., Dec., 1977).

Though the *Pseudogastrolites nanus* faunule is not definitely known to co-exist in one section with *Pseudopulchellia flexicostata* faunule, the already mentioned (see p. 23) occurrence of a solitary *Pseudogastrolites* cf. *P. nanus* sp. nov. in association with prevalent *Ps. flexicostata* (Imlay) at GSC loc. C-26600 on Ellef Ringnes Island and the stratigraphic position of this locality about 30 m stratigraphically above the Sandstone unit crowning the Lower shale member Kc1 of the Christopher Formation indicate a very close relationship of these two faunules. Because of these considerations, they may represent faunal phases of one and the same major fauna designated as *Pseudopulchellia flexicostata* fauna earlier in this section (see p. 23, Fig. 1).

The stratigraphic relationships of *Pseudogastrolites nanus* and *Pseudopulchellia flexicostata* faunules combined, with the *Pseudogastrolites arcticus* fauna of Banks Island are somewhat difficult to work out. Firstly, neither of these faunules was found in proximity of, let alone in the same section as, the typical *Pseudogastrolites arcticus* fauna. Secondly, the two faunas do not have any ammonite species in common. Thirdly, and finally the stratigraphically distinctive Sandstone unit crowning the Lower shale member Kc1 is not known to exist on Banks Island to which the definitely recognized occurrences of *Pseudogastrolites arcticus* fauna are so far restricted. However, the presence of *Pseudopulchellia imlayi* sp. nov., which is one of the most characteristic species of the *Pseudogastrolites arcticus* fauna, at GSC loc. C-11432 on Ellef Ringnes Island provides an indication of the probable stratigraphic and age relationships of these two faunas.

According to H.R. Balkwill (written com., Dec., 1977), GSC loc. C-11432 of the Cape Cairo-Helicopter Dome section occurs in the interval 55 to 90 m stratigraphically above GSC loc. C-26600 containing prevalent *Pseudopulchellia flexicostata* (Imlay) in the association with a solitary representative of *Pseudogastrolites* cf. *nanus* sp. nov. Although GSC loc. C-11432 is only tentatively correlated with the *Pseudogastrolites arcticus* fauna of Banks Island (see p. 25, 26), these stratigraphic relationships suggest that *Pseudogastrolites arcticus* fauna is younger than the *Pseudopulchellia flexicostata* and *Pseudogastrolites nanus* faunules combined (Fig. 1).

At GSC loc. 43618, *P. nanus* sp. nov. is associated with the morphologically, and presumably phylogenetically, peculiar *Pseudopulchellia balkwilli* sp. nov. This *Pseudopulchellia* form appears to be more advanced morphologically than *Ps. flexicostata* (Imlay) and does not occur in association with the latter species at GSC locs. C-26600 and 44044. Therefore, GSC loc. 43618 may possibly represent a somewhat younger faunal phase of the *Pseudogastrolites nanus* faunule than GSC locs. C-26600 and 44044 inferred to represent its *Pseudopulchellia flexicostata* faunal phase. However, it is equally possible that *Ps. balkwilli* sp. nov. and *Ps. flexicostata* (Imlay) are essentially contemporary but ecologically mutually exclusive (or almost mutually exclusive) species and this hypothesis is tentatively accepted as valid in this report.

Because of the stratigraphical position of the *Anagastrolites tozeri* fauna in the topmost beds of Christopher Formation, 200 to 300 m or more stratigraphically above GSC locs. C-11432, C-22695 and C-26600, there does not seem to be any doubt of its being younger than either the *Pseudopulchellia flexicostata* fauna (i.e. the *Pseudopulchellia flexicostata* and *Pseudogastrolites nanus* faunules combined) or the *Pseudogastrolites arcticus* fauna.

Correlation of *Pseudopulchellia flexicostata* fauna with the Canadian Western Interior and European zonal standards. The general mid-Albian age of the *Pseudopulchellia flexicostata* fauna is indicated by:

1. Its inferred stratigraphic position below the *Pseudogastrolites arcticus* fauna; and
2. Its well-established stratigraphic position above *Cleoniceras* (*Cleoniceras*) *canadense* fauna. On the one hand, *Pseudopulchellia flexicostata* fauna appears to be older than the upper, but not the uppermost, middle Albian *Pseudopulchellia pattoni* Zone of the Canadian Western Interior Region with which the *Pseudogastrolites arcticus* fauna appears to be correlative (see p. 26, Fig. 1). On the other hand, it appears to be younger than the lower part of lowermost middle Albian Unnamed Zone F of the same region with which the *Cleoniceras* (*Cleoniceras*) *canadense* fauna appears to be correlative (see p. 21, Fig. 1). These considerations suggest the correlation of the *Pseudopulchellia flexicostata* fauna with the upper part of the Unnamed Zone F of the Canadian Western Interior Region as restricted in this paper (see p. 27, 28). As

pointed out in a subsequent section, this part of the Unnamed Zone F seems to be correlative with the upper part of the *Hoplites dentatus* Zone and the lower part of the *Euhoplites loricatus* Zone of northwestern Europe and England (Fig. 1). Attempts at such a refined intercontinental correlation are, of course, little more than educated guesses.

Pseudogastrolites arcticus fauna

Stratigraphy and regional distribution. The only two fossil localities (i.e. GSC locs. 40602, 40606) which yielded *Pseudogastrolites arcticus* sp. nov. on Banks Island are confined stratigraphically between the upper lower Albian fossil localities which yielded *Arcthoplites* spp. fauna (i.e. GSC locs. 40605, 40603, 39991) (see Thorsteinsson and Tozer, 1962, p. 64), where *Arcthoplites* is still named *Lemuroceras* below and the lower upper Albian beds containing *Neogastrolites* sp. nov. aff. *N. selwyni* McLearn above (Jeletzky, 1971, p. 47; Plauchut, 1971, p. 674). This fauna is, therefore, of a general mid-Albian age.

A further refinement of the age of *Pseudogastrolites arcticus* sp. nov. can only be attempted on the basis of affinities of other ammonites of this fauna as its name fossil is not known to occur anywhere else. At GSC loc. 40606 situated 64 m stratigraphically below the top of Christopher Formation *Pseudogastrolites arcticus* sp. nov. is accompanied by a poorly preserved, generically uncertain cleoniceratinid possibly belonging to *Cleoniceras* (*Grycia*) *whittingtoni* Imlay 1961 (previously identified as ?*Cleoniceras* sp. indet. in an unpublished fossil report), *Beudanticeras* (*Grantzicerias*) *affine* (Whiteaves 1882) and *Inoceramus* cf. *anglicus* Woods. For some reason, GSC loc. 40606 was not cited by Thorsteinsson and Tozer (1962).

At GSC loc. 40602, the solitary, readily identifiable fragment of *Pseudogastrolites arcticus* sp. nov. is associated with the same poorly preserved, generically uncertain cleoniceratinid ammonite as in GSC loc. 40606, numerous and well preserved, albeit fragmentary, *Pseudopulchellia imlayi* sp. nov. (previously identified as *Gastrolites*? (*Paragastrolites*?) sp. nov. aff. *liardense* (Whiteaves); see Thorsteinsson and Tozer, 1962, p. 64), solitary specimen of *Pseudopulchellia* aff. *Ps. imlayi* sp. nov., *Cleoniceras* (*Grycia*) *whittingtoni* Imlay 1961 (previously identified as *Cleoniceras*? sp. indet.; see Thorsteinsson and Tozer, 1962, p. 64), *Beudanticeras* (*Grantzicerias*) cf. *B. affine* (Whiteaves) (a single fragment not previously recognized as such), a solitary specimen of ?*Arcthoplites* sp. indet., and *Inoceramus* cf. *I. cadottensis* McLearn.

The only other fossil locality apparently referable to the *Pseudogastrolites arcticus* fauna is the previously mentioned GSC loc. C-11432 on Ellef Ringnes Island (see p. 24). This has yielded a solitary representative of *Pseudopulchellia imlayi* sp. nov. in association with the only representative of a primitive but true *Gastrolites* sensu stricto (i.e. *Gastrolites* sp. nov. aff. *G. stantoni* McLearn) the writer has seen from the Sverdrup

Basin. In spite of the apparent absence of *Pseudogastrolites arcticus* sp. nov. and *Beudanticeras* (*Grantzicerias*) ex gr. *affine-glabrum* in this sparse fauna, GSC loc. C-11432 is assigned tentatively to the *Pseudogastrolites arcticus* fauna in this paper. Consequently, GSC locs. 40602, 40606, and C-11432 are interpreted herein as faunal phases of one and the same major ammonite fauna occurring in the middle part of the Upper member of the Christopher Formation.

Regional correlation. The *Pseudogastrolites arcticus* and *Cleoniceras* (*Cleoniceras*) *canadense* faunas have not yet been found in the same section. Furthermore, the principal fossil localities of *Pseudogastrolites arcticus* fauna on Banks Island (i.e. GSC locs. 40602, 40606) cannot be related stratigraphically to any of the presently known fossil localities of *Cleoniceras* (*Cleoniceras*) *canadense* fauna because of the absence there of the Sandstone unit comprising the topmost part of the Lower shale member. Nevertheless, there does not seem to be much doubt that *Pseudogastrolites arcticus* fauna occurs higher stratigraphically than the *Cleoniceras* (*Cleoniceras*) *canadense* fauna and is appreciably younger than the latter.

The best stratigraphic evidence available is the previously discussed (p. 24) occurrence of GSC loc. C-11432, which appears to represent a faunal phase of *Pseudogastrolites arcticus* fauna, 65 to 90 m stratigraphically above GSC loc. C-26600 containing *Pseudopulchellia flexicostata* fauna. The latter occurs, in turn, about 30 m stratigraphically above the top of the above-mentioned Sandstone unit which is the characteristic level of the *Cleoniceras* (*Cleoniceras*) *canadense* fauna (see p. 21, 22). Furthermore, the *Cleoniceras* (*Cleoniceras*) *canadense* fauna did not yield any of the ammonites of the *Pseudogastrolites arcticus* fauna, with the sole exception of the long-ranging *Beudanticeras* (*Grantzicerias*) *affine*. Even the *Cleoniceras* (*Grycia*) species of these two faunas are specifically distinct. This circumstance, combined with the common presence of representatives of *Pseudopulchellia* and *Pseudogastrolites* in the *Pseudogastrolites arcticus* fauna and their extreme rarity in the (*Cleoniceras* (*Cleoniceras*) *canadense* fauna, strongly supports the conclusion that the former fauna is the younger of the two.

The stratigraphic evidence presented in the previous paragraphs of this section, and earlier in the description of the *Pseudopulchellia flexicostata* fauna (p. 24), suggests strongly that the *Pseudogastrolites arcticus* fauna is also younger than this fauna and this conclusion is endorsed by the writer. As in the case of the *Cleoniceras* (*Cleoniceras*) *canadense* fauna, the evidence of a stratigraphic superposition of GSC loc. C-11432 on GSC loc. C-26600 in the Cape Cairo-Helicopter Dome section is supported by the total dissimilarity of the ammonite species of the two faunas concerned.

The occurrence of GSC loc. 40606 containing *Pseudogastrolites arcticus* on Banks Island about 64 m stratigraphically below the upper contact of the Christopher Formation combined with the presence of *Neogastrolites*

sp. nov. aff. *N. selwyni* McLearn in the immediately overlying basal beds of the Hassel Formation suggests that *Pseudogastrolites arcticus* fauna is older than the *Anagastrolites tozeri* fauna of Ellef Ringnes and Axel Heiberg Islands. The same conclusion is indicated by the stratigraphic position of the presumably correlative GSC loc. C-11432 on Ellef Ringnes Island about 200 m stratigraphically below the upper contact of the Christopher Formation (H.R. Balkwill, pers. comm., Dec., 1977). This conclusion is confirmed by the fact that an adjacent fossil locality on this island, which occurs in the topmost beds of the formation, contains elements of *Anagastrolites tozeri* fauna (e.g. *Pseudopulchellia* aff. *pattoni* Imlay at GSC loc. 44046).

External correlation and age. Because of its inferred superposition (described previously) on beds containing *Pseudopulchellia flexicostata* fauna, *Pseudogastrolites arcticus* fauna appears to be younger than any part of the Unnamed Zone F of the Western Interior Region of Canada. Because of its occurrence stratigraphically well below the beds containing *Anagastrolites tozeri* fauna, *Pseudogastrolites arcticus* fauna appears to be older than the *Stelckicerias liardense* Zone of the Western Interior Region standard. These considerations suggest the correlation of the *Pseudogastrolites arcticus* fauna either with the generalized *Gastrolites* sensu stricto Zone or with the *Pseudopulchellia pattoni* Zone of that standard. However, this correlation seems to be in conflict with the common presence of *Beudanticeras (Grantzicerias) affine* (Whiteaves) in the *Pseudogastrolites arcticus* fauna (i.e. at GSC locs. 40602, 40606). As already pointed out by Jeletzky (1975, p. 242, Text-fig. 3), *Beudanticeras (Grantzicerias) affine* is not known to range up into any part of the generalized *Gastrolites* Zone which was interpreted at that time to include the *Pseudopulchellia pattoni* Subzone. This observation is still valid, to the best of the writer's knowledge. Therefore, one might feel inclined to treat the *Pseudogastrolites arcticus* fauna as somewhat older than the *Pseudopulchellia pattoni* Zone and to correlate it with the topmost part of the immediately underlying, Unnamed Zone F of the Canadian Western Interior Region as restricted in this report. However, the presence of the still undescribed, primitive but true *Gastrolites* sensu stricto (i.e. *G. n.* sp. aff. *G. stantoni* McLearn) at GSC loc. C-11432 is against this correlation. Furthermore, the time ranges of such widespread but long-ranging forms as *Beudanticeras (Grantzicerias) ex gr. affine-glabrum* are apt to differ somewhat from one large region to another. Because of these considerations and the previously proposed correlation of the next older *Pseudopulchellia flexicostata* fauna with the upper part of the Unnamed Zone F, the writer prefers to correlate the *Pseudogastrolites arcticus* fauna with *Pseudopulchellia pattoni* Zone (Fig. 1). The next younger *Anagastrolites tozeri* fauna of the Sverdrup Basin appears to be correlative already with the *Stelckicerias liardense* Zone of the Canadian Western Interior standard. Therefore, the equivalents of the generalized

Gastrolites sensu stricto Zone of that standard appears to be represented in the Sverdrup Basin only by the so far unfossiliferous, 64 m to 200 m interval separating the *Pseudogastrolites arcticus*-bearing beds from the topmost beds of Christopher Formation carrying *Anagastrolites tozeri* fauna.

The above-proposed correlation of the *Pseudogastrolites arcticus* fauna with the *Pseudopulchellia pattoni* Zone suggests its correlation with the middle middle Albian Stage in the sense of Spath (1926, 1941). On the rather tenuous grounds discussed below under the description of *Pseudopulchellia pattoni* Zone this Sverdrup Basin fauna may be correlative with the upper part of the *Euhoplites loricatus* Zone of Western Europe (Fig. 1).

In the writer's opinion, the above considerations are more weighty than the close morphological similarity of *Pseudogastrolites arcticus* sp. nov. to *P. cantianus* (Spath) which would suggest a younger age of *Pseudogastrolites arcticus* fauna and a correlation of *Pseudogastrolites arcticus* beds with the uppermost middle Albian Cristatum Subzone of the English standard. However, the present uncertainty about the exact age of the generalized *Gastrolites* Zone in the terms of the European zones does not permit the ruling out of this alternative correlation.

Anagastrolites tozeri fauna

Because of their similar stratigraphic position in the apparently geologically contemporary topmost 30.5 m of the Christopher Formation, the *Anagastrolites tozeri* and *Pseudopulchellia* aff. *Ps. flexicostata* faunules discussed below are tentatively grouped together as essentially contemporary faunal phases of *Anagastrolites tozeri* fauna. Therefore, only the fossil localities and faunal composition of these two faunules will be discussed separately. In contrast, these faunules will be treated as a unit - the *Anagastrolites tozeri* fauna - where their stratigraphic relationships with other faunas of the Upper member of the Christopher Formation, regional and external correlation, and age are concerned.

Anagastrolites tozeri faunule

Localities and composition of faunule. The *Anagastrolites tozeri* faunule has so far only been found at two localities (GSC locs. 25883, 47514) on Axel Heiberg Island. This extremely depauperated faunule does not contain any ammonites other than *Anagastrolites tozeri* gen. et sp. nov. Therefore, it can only be dated using its stratigraphic relationships with other better dated ammonite faunas of the Christopher Formation.

GSC loc. 25883, which has yielded the bulk of *Anagastrolites tozeri* faunule, including the holotype of the index species, is situated very high in the Upper member of the Christopher Formation named Kcu by H.R. Balkwill (in press). This locality occurs within the uppermost 30.5 m of this formation below its well exposed contact with the overlying Hassel Formation (Tozer in Fortier et al., 1963, p. 455, Text-fig. 33).

GSC loc. 47514, which yielded the rest of specimens of *Anagastrolites tozeri*, also occurs in the topmost beds of the same member directly beneath the well exposed contact of the Christopher and Hassel Formations (H. Trettin, pers. com., Jan., 1978).

Pseudopulchellia aff. *Ps. pattoni* faunule

Localities and composition of faunule. The *Pseudopulchellia* aff. *Ps. pattoni* faunule has so far only been found on Ellef Ringnes Island (GSC loc. 44046) in the topmost beds of Christopher Formation (see p. 25, 26 for further details). This extremely depauperate faunule does not contain any other ammonites and so must be dated on its stratigraphic relationships with other more diagnostic gastrolitid faunas.

Stratigraphy and regional correlation of *Anagastrolites tozeri* and *Pseudopulchellia* aff. *Ps. pattoni* faunules.

The stratigraphic position of *Anagastrolites tozeri* and *Pseudopulchellia* aff. *Ps. pattoni* faunules in the topmost beds of the Christopher Formation stratigraphically well above all other gastrolitid faunas of the formation leaves no doubt about their being the youngest mid-Albian gastrolitid faunas known in the region. This is particularly evident in the case of the *Pseudopulchellia* aff. *Ps. pattoni* faunule of Ellef Ringnes Island which was found about 200 m stratigraphically above the next older faunule (i.e. GSC loc. C-11432) assigned to the *Pseudogastrolites arcticus* fauna.

Neither *Pseudogastrolites arcticus* nor *Pseudopulchellia flexicostata* has yet been found on Axel Heiberg Island. However, the local *Anagastrolites tozeri* faunule is believed to occur well above the beds of the Christopher Formation equivalent to those containing these faunules on Ellef Ringnes Island and elsewhere. Namely, the *Pseudogastrolites arcticus* and *Pseudopulchellia flexicostata* faunas invariably occur well below the top of the Kcu Member of the Christopher Formation on Ellef Ringnes, Amund Ringnes and Banks Island. There the stratigraphic positions of the known localities of the younger *Pseudogastrolites arcticus* fauna range from 200 m to 64 m below the upper contact of the Christopher Formation. Wherever the stratigraphic relationships of *Pseudogastrolites arcticus* and *Pseudopulchellia flexicostata* faunas with the *Cleoniceras* (*Cleoniceras canadense*) fauna are known (e.g. for GSC locs. C-26600 and C-11432 or for GSC locs. C-22695 and C-22253; see p. 21, 22 for further details), these three faunas occur within 61 m from each other. This is in contrast with the stratigraphic interval of about 549 m which separates *Anagastrolites tozeri* faunule from the Sandstone member, which is characteristically associated with the *Cleoniceras* (*Cleoniceras canadense*) fauna (e.g. GSC loc. C-4711) in the area, in the Amarok River section on Axel Heiberg Island (Tozer in Fortier et al., 1963, p. 454, 455, Text-fig. 33).

As with the other gastrolitid faunas of Sverdrup Basin, the upper age limit of the faunules comprising *Anagastrolites tozeri* fauna is provided by the presence of the *Neogastrolites* sp. nov. aff. *N. selwyni* fauna in the basal beds of the overlying Hassel Formation (Jeletzky, 1971, p. 47 and earlier in this paper). The *Neogastrolites* sp. nov. aff. *N. selwyni* fauna has so far been found only on Banks Island. However, the correlative marine basal beds occur also in the Hassel Formation of Ellef Ringnes Island and elsewhere in the Sverdrup Basin (Balkwill, in press). Furthermore, the writer was informed by H.R. Balkwill (pers. com., Nov. 30, 1977) that it seems unlikely that the transitional contact between high marine Christopher Formation and nonmarine Hassel Formation is markedly diachronic from one part of Sverdrup Basin to another. Because of these considerations it is concluded that the *Anagastrolites tozeri* fauna is only slightly older than the *Neogastrolites* sp. nov. aff. *N. selwyni* fauna and that the presence of any additional, biochronologically significant ammonite fauna(s) in the thin interval separating the two is unlikely. This reasoning is, of course, applicable to both the *Pseudopulchellia* aff. *Ps. pattoni* and the *Anagastrolites tozeri* faunules comprising this fauna.

Interregional correlation and age. As already mentioned, the beds containing *Pseudopulchellia* aff. *Ps. pattoni* and *Anagastrolites tozeri* faunules are immediately and gradationally overlain by basal marine beds of the Hassel Formation which appear to be equivalent to its *Neogastrolites* sp. nov. aff. *N. selwyni*-bearing basal beds on Banks Island. Consequently neither of these faunules of the *Anagastrolites tozeri* fauna can be much older than the basal part of the generalized *Neogastrolites* Zone of the Canadian Western Interior Region. At the same time the *Pseudopulchellia* aff. *Ps. pattoni* faunule is separated from the underlying beds referable to the *Pseudogastrolites arcticus* fauna (i.e. GSC loc. C-11432; see p. 24 for further details) by an approximately 200 m thick interval of the so far unfossiliferous shale (H.R. Balkwill, written com., Dec., 1977). Because of the inferred correspondence of the *Pseudogastrolites arcticus* fauna to the *Pseudopulchellia pattoni* Zone of the Canadian Western Interior Region, this unfossiliferous interval appears to be correlative with the generalized *Gastrolites sensu stricto* Zone of the same region (see p. 25, 26 and Fig. 1 for further details).

Because of the above considerations, the *Anagastrolites tozeri* fauna as a whole is correlated tentatively with part or? all of the *Stelkiceras liardense* Zone of the Canadian Western Interior Region.

Because of the inferred approximate correspondence of the *Stelkiceras liardense* Zone to the uppermost middle Albian *Dipoloceras cristatum* Subzone of the western European standard (see p. 32 for further details), the same latest mid-Albian age is suggested tentatively for the *Anagastrolites tozeri* fauna of the Sverdrup Basin.

Unlike the Sverdrup Basin gastroplitinid faunas and faunules, the stratigraphic succession and regional extent of most of the mid- to late Albian gastroplitinid faunas of the Canadian Western Interior Region are well established (McLearn, 1945; McLearn and Kindle, 1950; Stelck et al., 1956; Stelck, 1958; Warren and Stelck, 1958, 1969; Reeside and Cobban, 1960; Jeletzky, 1964, 1968, 1971, 1977). Therefore, most of the beds containing these faunas have been recognized as well established, regional biochronological zones and subzones for a number of years and will be treated as such in this paper. The new *Stotticeras crowense* gen. et sp. nov. faunule is the only exception (Fig. 2).

Most of the information provided in the recent reports of the writer (Jeletzky, 1964, 1968, 1971) is still valid. Therefore, this account of the Canadian Western Interior zones and subzones will be largely limited to the additions and revisions necessitated by additional data which became available after the compilation of the above mentioned reports.

Zone F

This unnamed zone was introduced by Jeletzky (1968, p. 17) for that part of Fort St. John Group and its equivalents in northern Alberta and northeastern British Columbia underlain conformably by rocks containing *Arcthoplites* spp. (referred to as *Lemuroceras* by Jeletzky, 1968, p. 16, Fig. 1) and *Beudanticeras (Grantziceras) affine* and overlain conformably by rocks containing *Gastroplites* fauna. That part of Fort St. John Group was left unnamed by Jeletzky (1968, p. 17, 18) because it did not yield any diagnostic ammonites, or for that matter any other diagnostic fossils. Because of the stratigraphic position of the Zone F between the upper lower Albian *Arcthoplites* spp. and *Beudanticeras (Grantziceras) affine* Zone below and the apparently uppermost middle Albian *Gastroplites* Zone above, Jeletzky (1968, p. 18) tentatively correlated it with the bulk of the middle Albian Substage.

Subsequent to the compilation of his 1968 paper, the writer realized that *Beudanticeras (Grantziceras) affine* and *B. (G.) glabrum* range considerably higher than do the *Arcthoplites* spp. and that these *Beudanticeras (Grantziceras)* species occur alone in rocks of Zone F that otherwise lack ammonites (e.g. in the basal member of Peace River Formation; see Wickenden, 1951, p. 4, 6). *Arcthoplites* spp. and *Beudanticeras (Grantziceras) affine* Zone was accordingly renamed *Arcthoplites* spp. Zone in order to stress the unsuitability of *Beudanticeras affine* as its zonal index and to restrict the zone to those beds correlative with the *Brewericeras hulenense* and *Douvilleiceras* spp. Zone of the Pacific slope of Canada (Jeletzky, 1971, p. 8, Fig. 2; 1975, p. 241, 242, Fig. 3; 1977, p. 110, Fig. 4). This was done in order to assure the closest possible correspondence of the *Arcthoplites* spp. Zone with the upper lower Albian (previously treated as lower middle; see Jeletzky, 1968, p. 16,

Fig. 1) *Douvilleiceras mammillatum* Zone of western Europe in the sense of Spath (1923, 1926, 1941) non Casey (1961) nec Owen (1971, 1973). At the same time it became obvious that the top-most beds included in Zone F contain *Pseudopulchellia pattoni* Imlay, and some other peculiar gastroplitids described as *Stotticeras crowense* gen. and sp. nov. in this paper. These beds comprising the upper part of the Hulcross shale member of the Commotion Formation, equivalent beds of the Shaftesbury Formation (see Stott, 1975, p. 457 and p. 29 of this paper for further details) and presumably the upper 91.5 m of the Scatter Formation were accordingly separated from Zone F and designated as *Pseudopulchellia pattoni* Zone (Jeletzky, 1971, p. 9, Fig. 2). So far as is known, the *Pseudopulchellia pattoni* Zone does not contain any *Beudanticeras (Grantziceras)* species. This zone will be discussed in a greater detail below in a special section.

The remaining greater part of Zone F characterized by the presence of *Beudanticeras (Grantziceras) ex gr. affine-glabrum* alone continues under that name in this paper (Fig. 1).

As already pointed out in the discussion of the *Cleoniceras (Cleoniceras) canadense* and *Pseudopulchellia flexicostata* faunas of the Sverdrup Basin, the local beds containing these faunas are correlative with most or all of the Unnamed Zone F of the Canadian Western Interior as restricted in this paper.

For reasons presented above in the discussion of age and correlation of these Sverdrup Basin faunas, the *Cleoniceras (Cleoniceras) canadense* fauna appears to be approximately correlative with the *Lyelliceras lyelli* Subzone of the *Hoplites dentatus* Zone (sensu Spath, 1923, 1926). The overlying *Pseudopulchellia flexicostata* fauna is inferred to be correlative with the remaining upper part of *Hoplites dentatus* Zone (i.e. its *Hoplites spathi* Subzone) and with the lower part of the overlying *Euhoplites loricatus* Zone (i.e. its *Anahoplites intermedius* and *Discohoplites niobe* Subzones) of the western European standard. The Unnamed Zone F is, therefore, assumed to correspond to all these western European subzones and zones (Fig. 1).

Pseudopulchellia pattoni Zone

As already mentioned in the description of Zone F, the *Pseudopulchellia pattoni* Zone embraces beds which were previously placed in the uppermost part of that unnamed zone.

The *Pseudopulchellia pattoni* Zone was originally proposed and defined around 1967 in unpublished intradepartmental reports, following the discovery of the name fossil in the Hulcross Member of the Commotion Formation by D.F. Stott. The zone was indicated in a correlation table published in 1971 as the basal subzone of generalized *Gastroplites* Zone (Jeletzky, 1971, p. 8, Fig. 2) and was also discussed as such by Stott (1970, p. 68, 69; 1975, p. 446, 457, Text-fig. 3). However, it was neither formally defined nor described.

Stratigraphic relationships and geographic range. The stratigraphic position and the regional extent of the beds containing *Pseudopulchellia pattoni* fauna being reasonably well established, the writer proposes to treat it as a full zone. The best preserved Canadian representatives of *Pseudopulchellia pattoni* have been described in an earlier section of this report.

All definitive records of *Pseudopulchellia pattoni* Zone in the Western Interior Region of Canada are so far confined to the Peace River Foothills. According to the stratigraphic data provided by D.F. Stott, most of fossil localities containing this species in this area (e.g. GSC locs. 42272, 84117, 84118) are in the topmost 30.5 m or so of the Hulcross Member of the Commotion Formation. All of these localities have yielded only *Pseudopulchellia pattoni*. However, other fossil localities occurring near the top of Hulcross Member (e.g. GSC locs. 42269, 46515) contain a *Gastrolites kingi* fauna either devoid of *Ps. pattoni* (e.g. GSC loc. 42269) or containing very rare fragments apparently referable to this form (e.g. GSC loc. 46515). The only apparent record of the *Gastrolites kingi* fauna in beds older than the uppermost 30.5 m of the Hulcross Member is that in the beds assigned by Stott in the label to: "the Middle Commotion equivalent = Hulcross Mbr. equival., low in sequence)". This GSC loc. 46520 is situated in a gully off a road, northeast of Gates on Peace River, Charlie Lake map-area, B.C. However, *Gastrolites kingi* McLearn, *G. aff. G. canadensis* (Whiteaves), and *G. aff. stantoni* McLearn (= *G. flexicostata* Jeletzky 1964 non Imlay 1961 of interdepartmental reports) of this fauna were found in the talus. According to Stott (pers. com., Dec. 5, 1977) they are quite likely derived from upslope where the beds of the Boulder Creek Member may be present. This explanation is tentatively accepted as valid in this paper.

The writer (Jeletzky, 1971, p. 8, Fig. 2) inferred from the above-discussed data that *Pseudopulchellia pattoni* Imlay characterizes the uppermost 30.5 m of the Hulcross Member and its argillaceous equivalents in the Peace River Foothills. So far as is known, this zone is mostly characterized by the presence of *Ps. pattoni* alone. However, it seems to contain in some places the oldest known representatives of *Gastrolites sensu stricto*, such as *G. aff. kingi* McLearn and *G. aff. stantoni* McLearn either alone or in association with *Ps. pattoni*. The *Pseudopulchellia pattoni* and *Gastrolites kingi* faunas appear to overlap also in the basal part of the Boulder Creek Member where *Gastrolites kingi* fauna is prevalent and *Ps. pattoni* is rare.

The isolated record of poor ammonites resembling *Pseudopulchellia pattoni* in the Buckingham Formation in the Fort Nelson area (GSC loc. 80768) does not help in determining the stratigraphic position of its zone in relation to other paleontological zones of the Canadian Western Interior Region as no other ammonites were found at that locality and its stratigraphic position in relation to the subzones of the generalized *Gastrolites sensu stricto* Zone is uncertain.

The faunule of *Stotticeras crowense* gen. et sp. nov. found by D.F. Stott at GSC loc. 69198 some 91.5 m stratigraphically below the top of Scatter Formation on Crow River is interpreted tentatively as a faunal phase of *Pseudopulchellia pattoni* Zone because of its stratigraphic position closely below the basal beds of the Lepine Formation containing typical fauna of *Gastrolites kingi* Subzone (see description below). However, it is possible that this faunule is older and corresponds to the restricted Zone F of this paper. The presence of *Stotticeras?* sp. indet. faunule in the Christopher Formation of Sverdrup Basin and its possible equivalence to the *Pseudopulchellia pattoni* Zone were already discussed in the description of *Stotticeras* (see p. 12 and Fig. 1).

The North Alaskan occurrence of *Pseudopulchellia pattoni* also does not help in determining the stratigraphic position of its zone in relation to other paleontological zones of the Canadian Western Interior Region. The only known fossil locality (i.e. USGS Mes. loc. 24427) of the zone in the Tuktu Formation did not yield any other fossils whatsoever (Imlay, 1961, p. 33, Table 10) and the stratigraphic relationship of this *Pseudopulchellia pattoni* locality with the *Pseudopulchellia flexicostata* fauna dominating this formation is not mentioned by Imlay (1961, p. 9-11, 14, Tables 5, 6).

External correlation and age. As with the underlying Zone F, the external (i.e. inter-regional and intercontinental) correlation and dating of *Pseudopulchellia pattoni* Zone depends ultimately on its stratigraphic position between the upper Lower Albian *Archtholites* spp. Zone below and the late but not the latest middle Albian *Gastrolites sensu stricto* Zone above. More precisely the dating of the lower boundary of *Pseudopulchellia pattoni* Zone depends on the inferred approximate equivalence of the restricted Zone F with the *Cleonicerias* (*Cleonicerias*) *canadense* and *Pseudopulchellia flexicostata* beds of the Sverdrup Basin, which, in turn, appear to be correlative with the *Hoplites dentatus* Zone and the lower part of *Euhoplites loricatus* Zone of Western Europe and England. The dating of the upper boundary of *Pseudopulchellia pattoni* Zone depends on the correlation of the *Gastrolites sensu stricto* Zone with the *Anahoplites daviesi* and *Euhoplites nitidus* Subzones of the *Euhoplites lautus* Zone proposed in this paper (see p. 32, 33). On these admittedly tenuous grounds *Pseudopulchellia pattoni* Zone appears to be correlative with the upper part of the *Euhoplites loricatus* Zone (i.e. its *Mojsisovicsia subdelaruei* and *Euhoplites meandrinus* Subzones) of western Europe (Fig. 1).

Gastrolites sensu stricto Zone

The writer's ideas concerning the time range of the genus *Gastrolites*, subdivision of the *Gastrolites sensu stricto* Zone, its occurrence outside of the Canadian Western Interior Region, its intercontinental correlation, and age in terms of the European zones and international standard stages have changed rather drastically since the status of this

zone was last appraised (Jeletzky, 1968, p. 18, Fig. 1; 1971, p. 8, 44-45, Fig. 2). Some of these changes, such as the exclusion of *Stelckiceras liardense* and *Pseudopulchellia pattoni* Zones from the generalized *Gastropilites sensu stricto* Zone are being dealt with in the descriptions of these zones. Because of the exclusion of these zones, the span of the *Gastropilites sensu stricto* Zone proposed in this paper is much restricted in comparison with that favoured earlier (e.g. Jeletzky, 1971, p. 8, Fig. 2) and already used by some geologists (e.g. Stott, 1970, p. 68, 69, 71; 1975, p. 446, 457, Fig. 3) working in the Canadian Western Interior Region. The following account will, accordingly, be concerned largely with the subdivision and inter-continental correlation of the *Gastropilites sensu stricto* Zone as restricted herein.

Stratigraphic relationships and geographic range. The revision of various *Gastropilites*-like ammonites previously placed in the genus *Gastropilites* McLearn 1930 carried out in the previous sections of this paper indicates that the *Gastropilites sensu stricto* Zone is restricted to that part of the western flank of the Albian mid-continental basin of North America embracing the Peace River Foothills and Plains and the adjacent parts of the Liard Plateau. The only authentic occurrence of *Gastropilites sensu stricto* outside of this region known to the writer is that of *G. n. sp. aff. stantoni* McLearn in the *Pseudogastropilites arcticus* fauna of Sverdrup Basin. However, as already pointed out in the discussion of that fauna, it appears to be correlative with the *Pseudopulchellia pattoni* Zone where the true *Gastropilites* makes its first appearance. All other claims of the presence of *Gastropilites sensu stricto*, and hence of its zone, outside of the Peace River-Liard region of the mid-continental basin were found to be based on misidentification of various gastropilitinid ammonites belonging to genera *Pseudogastropilites* gen. nov. and *Pseudopulchellia* Imlay 1961 as re-defined in this paper. This regional restriction of *Gastropilites sensu stricto* fauna was obviously caused by a regression of mid-Albian seas in many (but by no means all!) regions of mid-continental and Arctic North America (Jeletzky, 1971, p. 44, 45; Owen, 1973, p. 152, 153, Fig. 3; and in the next section of this paper). The discreditation of all *Gastropilites sensu stricto* records outside of the Sverdrup Basin indicates that the isolation of the late mid-Albian boreal basins of North America was even stronger than suggested by Owen (1973, p. 153, Fig. 3). Judging by the so far complete absence of true *Gastropilites* in the apparently equivalent upper part of the Upper Member of Christopher Formation (i.e. unfossiliferous beds above those containing *Pseudogastropilites arcticus* fauna), the widespread and strong mid-Albian uplift of the Mackenzie Salient (Jeletzky, 1971, p. 45) may have resulted in an almost complete (or even a complete?) closure of the northern outlet of the mid-continental basin during the *Gastropilites sensu stricto* time.

There is no need to discuss the specific occurrences of *Gastropilites sensu stricto* fauna within the Peace River-Liard Region and the resulting correlation of its mid-Albian geological formations as this subject was ably summarized in recent publications of Stott (1967, 1968a, 1968b, 1970, 1975).

Subzones. What appears to be the first attempt to subdivide the *Gastropilites sensu stricto* Zone into paleontological subzones and to use these subdivisions biochronologically was undertaken by Henderson (1954, p. 2270, 2285, 2286). This worker has provided the following concise definition of his subdivisions in the abstract of his paper (Henderson, 1954, p. 2270): "A lower *Gastropilites* horizon is used as a basis to correlate the upper (sandstone and shale) part of the Scatter Formation with the middle member of the Buckingham Formation in East Peace River foothills, and with the Cadotte member of the Peace River formation. An upper *Gastropilites* horizon is used as basis to correlate a part of the Lepine formation with a central part of the Hasler Formation in East Peace River foothills." Henderson (ibid.) did not indicate which particular *Gastropilites* species are diagnostic of his horizons and the above-mentioned correlation of individual formations proved to be grossly imprecise and even altogether wrong in part. However, the general idea was undoubtedly valid, as it will be shown below. Imlay (1961, p. 62) has already suggested the correspondence of the lower horizon of Henderson (ibid.) to the *Gastropilites kingi* Zone.

Another proposal to subdivide *Gastropilites sensu lato* Zone of the Peace River area was undertaken by Stelck et al. (1956, p. 9). These workers suggested the following sequence of faunas within the beds assigned by McLearn (1945) and McLearn and Kindle (1950) to that zone (upward sequence): 1. *Lophidiaster* cf. *silentiensis*; 2. *Gastropilites canadensis*; 3. *Gastropilites* cf. *cantianus*; and 4. *Inoceramus* cf. *comancheanus*. No stratigraphic detail was provided either in 1956 or later (Stelck, 1975, p. 255) and the writer (Jeletzky, 1968, p. 18) was, and still is, unable to confirm the validity of this sequence of faunas using collections of fossils from the *Gastropilites sensu stricto* Zone available to him. However, a different subdivision of the *Gastropilites sensu stricto* Zone appears to be feasible using vertical distribution of *Gastropilites kingi* McLearn and *Gastropilites allani* McLearn within the zone. This subdivision into a lower *Gastropilites kingi* Subzone and an upper *Gastropilites allani* Subzone was suggested in 1967-1968 in unpublished intradepartmental fossil reports. However, it was neither discussed nor tabulated in any of the publications of the writer.

The most convincing evidence for the existence of *Gastropilites kingi* and *Gastropilites allani* subzones is provided by rich and mostly well to fairly well preserved *Gastropilites sensu stricto* faunas collected stratigraphically by D.F. Stott in 1965 in the following three sections of basal Lepine Formation in Toad

River map-area and identified by the writer. According to the stratigraphic information provided by the collector these faunas are distributed as follows:

1. Type section of the Lepine Formation situated on east side of Liard River, opposite Lepine Creek (Lat. 59°26'N; Long. 124°46'W) contains the following upward sequence of *Gastrolites sensu stricto* faunas:

1a. GSC loc. 69196 collected from talus at the base of the formation as defined by the siltstone equivalent of the upper Scatter Formation includes: common *Gastrolites kingi* McLearn and transitional forms to *G. canadensis* (Whiteaves) as well as common *G. allani* McLearn and transitional forms to *G. kingi* McLearn. According to D.F. Stott, this fauna may be far out of place. This may account for the presence of typical *G. allani* McLearn so low in the sequence (compare sections 2 and 3).

1b. GSC loc. 69193 collected from talus at the level about 30.5 m stratigraphically above the formation's base includes common *Gastrolites allani* McLearn and transitional forms between this species and *G. kingi* McLearn, rare *G. canadensis* (Whiteaves) (slender variant), rare *G. aff. canadensis* (Whiteaves), and rare *G. (Paragastrolites) cf. spiekeri* McLearn. Here again the fauna may be far out of place. This may account for the presence of typical *G. allani* McLearn by falling or sliding down from higher levels.

1c. GSC loc. 69195 collected at the level 30.5 to 45.7 m above formation's base includes only numerous *Gastrolites allani* McLearn.

1d. GSC loc. 69192 collected at the level about 45.7 m above the formation's base includes common *Gastrolites allani* McLearn and transitional forms between this form and *G. kingi* McLearn, rare *G. canadensis* (Whiteaves) (slender variant) and rare *G. (Paragastrolites) spiekeri* McLearn.

1e. GSC loc. 69194 situated also about 45.7 m stratigraphically above the formation's base has yielded only a single poorly preserved specimen each of *Gastrolites cf. stantoni* McLearn and *Gastrolites sp. indet.*

1f. GSC loc. 69172 situated also about 45.7 m stratigraphically above the formation's base has yielded *Gastrolites allani* McLearn, *G. canadensis* (Whiteaves), *G. (Paragastrolites) spiekeri* McLearn, and *Gastrolites sp. indet.*

1g. The next younger GSC loc. 69191, situated about 61 m stratigraphically above the formation's base but collected from talus, contains numerous typical representatives of *Gastrolites allani* McLearn and a solitary specimen of *Stelckiceras liardense* (Whiteaves).

The stratigraphically higher fossil localities of this section still contain *Gastrolites allani* McLearn but are interpreted to form part of *Stelckiceras liardense* Zone and are discussed in its description.

2. Section of the Lepine Formation situated in a small gully on the east side of Liard River, downstream from Garbutt Creek (Lat. 59°25'N; Long. 124°46'W) contains the following upward sequence of *Gastrolites sensu stricto* faunas:

2a. GSC loc. 69178 collected from talus at the level about 30.5 m stratigraphically above siltstone equivalent to upper Scatter sandstone of the Section #3 and about 230 m above top of lower Scatter sandstone has yielded only *Gastrolites kingi* McLearn and its morphological variants.

2b. GSC loc. 69173 collected from talus at the level about 77 m stratigraphically above the previously mentioned siltstone has yielded *Gastrolites cf. kingi* McLearn, *G. cf. canadensis* (Whiteaves), and *Gastrolites sp. indet.*

2c. GSC loc. 69177 collected at about the same level as last has yielded *Gastrolites (Paragastrolites) spiekeri* McLearn and *Gastrolites sp. indet.*

2d. GSC loc. 69175 situated in the interval from 77 to 91.5 m above the previously mentioned siltstone but collected from talus has yielded numerous *Gastrolites* forms transitional between *G. kingi* McLearn and *G. allani* McLearn. Among them, forms approaching *G. kingi* are more common than those approaching *G. allani*. Other than these transitional forms this fauna includes only common *G. canadensis* (Whiteaves) and its variants.

2e. GSC loc. 69176 situated about 91.5 m stratigraphically above the previously mentioned siltstone has yielded predominant *Gastrolites aff. allani* McLearn, less common *G. allani* McLearn, rare *G. canadensis* (Whiteaves) and a solitary representative of *G. aff. stantoni* McLearn (= *G. flexicostata* Jeletzky 1964 non Imlay, 1961).

2f. The highest GSC loc. 69174 of this section situated about 115 m stratigraphically above the previously mentioned siltstone has only yielded indeterminate gastrolitid ammonites.

3. Section of basal Lepine Formation overlying the type section of the Scatter Formation, on Scatter River (Lat. 59°37'N; Long. 124°40'W) contains the following upward sequence of *Gastrolites sensu stricto* faunas:

3a. GSC loc. 69170 collected from talus just above top of upper Scatter sandstone has yielded: prevalent *Gastrolites kingi* McLearn, rare *G. aff. canadensis* (Whiteaves), and rare *G. (Paragastrolites) spiekeri* McLearn.

3b. GSC loc. 69168 collected from talus 23 to 27 m above top of upper Scatter sandstone yielded: prevalent *Gastrolites canadensis* (Whiteaves) and rare *G. kingi* McLearn.

3c. GSC loc. 69171 collected in place about 24 m stratigraphically above top of upper Scatter yielded only *Gastrolites kingi* McLearn and its variants.

Section #3 is characterized by the prevalence of *Gastrolites kingi* and its variants and a complete absence of *G. allani* and the same is true of the equivalent basal beds of the Section #2 up to the level 76 m (250 feet). Even more important, *G. allani* and forms transitional between it and *G. kingi* only appear at the levels between 76 to 91.5 m in this section where typical *G. kingi* is already absent. Still higher at the 91.5 m level, *G. allani* and allied forms are prevalent and *G. kingi* is absent.

Section #1 exhibits a similar gradual replacement of *G. kingi* and allied forms by *G. allani* and allied forms until only the latter form group remains in the highest part of *Gastroplites* Zone between the levels 45.7 to 76.2 m which already contains rare *Stelckiceras liardense* (i.e. GSC locs. 69191, 69187). The only difference compared with Sections 2 and 3 is the much earlier appearance of *G. allani* and transitional forms to *G. kingi*. In Section #1 these forms were found at the base of the Lepine Formation in association with numerous *G. kingi* et var. As pointed out by the collector, this aberration may well be caused by their derivation from the higher beds. However, it may reflect an actually earlier appearance of *G. allani* f. typ. et var. in this section as a similar situation was also observed in the Peace River Foothills (see p. 33). It is also possible, because of the unfossiliferous nature of the upper Scatter Formation and its siltstone equivalent, that the base of the Lepine Formation is somewhat diachronic between Section #1 and the other two sections. If one accepts this explanation, the *Gastroplites kingi* beds are only represented by the unfossiliferous siltstones equivalent of the Scatter in Section #1.

Generally speaking, the separation of the lower *Gastroplites kingi* fauna and the upper *Gastroplites allani* fauna is quite evident in the sections discussed above. The latter species appears to be a direct descendant of the former because of the presence of numerous transitional forms between the two at intermediate levels. *Gastroplites canadensis* (Whiteaves) and *Gastroplites (Paragastroplites) spiekeri* do not seem to have a clearcut subzonal value, even though they appear to be more common in *Gastroplites allani* Subzone than in the underlying *Gastroplites kingi* Subzone. Other *Gastroplites* forms are too rare for any kind of biochronological evaluation.

The situation in the northern Foothills of the Rocky Mountains between the valley of Pine River and the Peace River Canyon is somewhat confusing. In this area where the *Gastroplites kingi* fauna was originally found, (McLearn, 1931), most of the fossil localities which yielded representative *Gastroplites sensu stricto* fauna are dominated by typical representatives of *G. kingi* McLearn and its varieties. This fauna lacks *G. allani* McLearn and allied forms diagnostic of the *Gastroplites allani* Subzone on Liard River (see above). Other *Gastroplites* forms found in these collections are: *Gastroplites ex aff. canadensis* McLearn (which do not include any typical representatives of that species), *G. (Paragastroplites) spiekeri* McLearn, *Gastroplites aff. stantoni* McLearn (= *G. flexicostata* Jeletzky 1964 non Imlay 1961), some other peculiar but insufficiently understood *Gastroplites sensu stricto* forms, and some generically uncertain *gastroplitinids* resembling *Pseudopulchellia flexicostata* (Imlay) and *Pseudogastroplites* sp. indet. As already mentioned in the description of *Pseudopulchellia pattoni* Zone, *Ps. pattoni* Imlay or forms closely resembling it are locally present in these fossil collections. This variegated *Gastroplites* fauna, which is assigned herein to the *Gastroplites kingi* Subzone, includes

GSC locs. 13799, 28117, 88031, 88033 and 88035 collected on Maurice Creek, GSC locs. 9526, 9527 and 46515 collected on Starfish (=Deep) Creek, and GSC loc. 6610 collected in Peace River Canyon opposite the mouth of Deep (=Starfish) Creek. All of these collections are from the basal part of the attenuated, predominantly argillaceous facies of Boulder Creek Member of the Commotion Formation according to the stratigraphical data provided by D.F. Stott. GSC loc. 46520 containing the same *Gastroplites kingi* fauna was reported as occurring in the middle part of the underlying Hulcross Member (Stott, 1968a, p. 80). However, it was collected on the float of that member according to Stott (pers. com., Dec. 2, 1977) and is accordingly assumed to be derived from the overlying equivalent of the Boulder Creek Member.

Some other examples of *Gastroplites sensu stricto* fauna found in the same area differ from the above-described examples of *Gastroplites kingi* fauna in containing rare to common specimens of *Gastroplites aff. allani* McLearn, typical *G. allani* McLearn and/or its particularly strongly nodose "*Neogastroplites selwyni*-like" variant. All these forms appear to be indistinguishable from representatives of the same species found in the *Gastroplites allani* Subzone of the Lepine Formation. At some localities, as for example GSC loc. 37683, which is the type locality of *Gastroplites kingi* McLearn (1931) on Deep (=Starfish) Creek, *G. allani* McLearn was found in association with the prevalent *G. kingi* f. typ. and its variants. However, at some other localities, such as GSC locs. 25720, 25733 (=32340), and 83442 situated on the northern side of Peace River in the vicinity of Hudson Hope, *G. kingi* and its variants are either rare or absent and the common *G. allani* McLearn et var. is associated with such equally or even more common forms as *G. (Paragastroplites) spiekeri* McLearn, *G. anguinus* McLearn, and *G. ex aff. canadensis* McLearn (the same forms as in the other group of lots). This fauna may also include other still undescribed, very slender *Gastroplites aff. stantoni* McLearn superficially similar to *Pseudopulchellia flexicostata* (Imlay) and previously identified as *Gastroplites flexicostatus* Imlay in some unpublished intradepartmental fossil reports. According to D.F. Stott (pers. com., Dec. 2, 1977), all above-mentioned *Gastroplites sensu stricto* collections from the vicinity of Hudson Hope must have been derived either from the basal beds of the Boulder Creek Member or from its argillaceous equivalents previously mistaken for the Hasler Formation. Those collections that were collected from the float (e.g. GSC locs. 25720, 25733) could not have been derived from unrecognized younger Cretaceous beds (i.e. true Hasler equivalents) as the top of the about 23 m thick Boulder Creek equivalent has been cut out by the Quaternary drift in that area.

Because of the above considerations and the association of *Gastroplites allani* with prevalent *G. kingi* f. typ. et var. at the GSC loc. 37683 on Deep (=Starfish) Creek, the above-described faunal association of GSC locs. 25720, 25733 (=32340) and 83442 cannot be much younger

than the previously discussed more typical *Gastropilites kingi* fauna found in the other group of fossil collections. This faunal association appears, however, to be so much more advanced in comparison with the more typical *Gastropilites kingi* fauna that it is tempting to infer the presence of two successive, closely related *Gastropilites sensu stricto* faunas in the attenuated, slowly deposited argillaceous equivalent of the Boulder Creek Member of the Peace River Canyon area. The more typical *Gastropilites kingi* fauna would then represent the main part of *Gastropilites kingi* Subzone whilst the *Gastropilites allani*-bearing fauna would represent its upper part transitional to *Gastropilites allani* Subzone. Alternatively, the faunal association of GSC locs. 25720, 25733 (=32340) and 83442 can be interpreted as a peculiar, geologically contemporary faunal phase of the more typical *Gastropilites kingi* fauna. This hypothesis finds support in the presence of what may be the same peculiar faunal phase of the *Gastropilites kingi* Subzone at the GSC loc. 69196, etc. from the basal Lepine Formation (see p. 32). However, this faunal phase of the basal Lepine Formation also admits of several interpretations and seems to be best interpreted as a subsequently mixed fauna.

As nearly all critical collections in the Peace River Foothills and on Liard River were obtained from talus, no definitive solution of the problem is possible at present. However, if *Gastropilites allani* McLearn and its varieties actually do appear locally in the *Gastropilites kingi* Subzone, as seems likely, the recognition of *Gastropilites allani* Subzone must be based largely on other criteria, such as the absence of peculiar heavily and/or closely ribbed *Gastropilites ex aff. canadensis* McLearn, the presence of similarly heavily ribbed representatives of *G. aff. kingi*, the absence of *G. kingi* f. typ. and its variants, and the presence of typical *G. canadensis* McLearn.

It is difficult to say whether or not the *Gastropilites kingi* and *Gastropilites allani* subzones are present in the Cadotte Member of the Peace River Formation. The relative stratigraphic levels of all older *Gastropilites* collections available to the writer (e.g. those used by McLearn, 1933) are unknown and all of these collections include from one to a few *Gastropilites* specimens only. Except for Wickenden's (1951) collection (GSC loc. 18309), no newer *Gastropilites* collections were available to the writer. It should be noted, however, that *Gastropilites kingi* McLearn and its variants diagnostic of *Gastropilites kingi* Subzone in the basal Lepine Formation and in the basal Boulder Creek Member of the Commotion Formation are totally absent in all *Gastropilites* collections from the 21.3 m thick Cadotte Member made by McLearn (1918, 1933) and older early workers. As noted by McLearn (1933, p. 13), all these collections are from the interval "five or six to about twenty miles below the mouth of Cadotte River". Because of the apparent absence of all typical forms of *Gastropilites kingi* Subzone combined with the presence of typical representatives of *Gastropilites canadensis* McLearn and *G. allani* McLearn, all *Gastropilites* forms described by McLearn (1933) are assigned tentatively to the *Gastropilites allani* Subzone.

Typical representatives of *Gastropilites kingi* McLearn have been identified by Reeside and Cobban (1960, Pl. 8, figs. 5-9, 13, 14) and the writer from the upper third of Cadotte Member in Section No. 6 of Wickenden (1951, p. 23) which is situated higher upstream opposite the mouth of Cadotte River. No other *Gastropilites* species occur in this collection (GSC loc. 18309) which includes only four specifically determinable specimens. This occurrence of *Gastropilites kingi* fauna is somewhat suggestive of the presence of individualized *Gastropilites kingi* and *Gastropilites allani* subzones in the Cadotte Member. However, additional collecting is needed to either confirm or reject this suggestion. Furthermore, it appears to conflict with the recorded occurrence of *Gastropilites canadensis* in the underlying Harmon Shale Member of Peace River Formation (Stelck et al., 1956, p. 10).

It is because of the above-described apparent commingling of *Gastropilites kingi* and *Gastropilites allani* faunas combined with the scarcity of sections where they were collected in superposition that the writer prefers to treat them as subzones of generalized *Gastropilites sensu stricto* Zone.

Intercontinental correlation and age. The absence of true *Gastropilites* in the *Dipoloceras cristatum* Subzone of England and its Spitzbergen equivalents and the absence of *Pseudogastropilites cantianus* (Spath) in the *Gastropilites sensu stricto* Zone of the Canadian Western Interior Region documented in this paper (see p. 6) refutes its accustomed intercontinental correlation. Namely, it discredits the correlation of the *Gastropilites sensu stricto* Zone with the European Subzone of *Dipoloceras cristatum* proposed by Spath (1937) and adhered to by McLearn (1945), McLearn and Kindle (1950, p. 96), Stelck et al. (1956, p. 6, 19), Jeletzky (1968, p. 15, 18), Owen (1971, p. 137, 138; 1973, p. 149, 153, Fig. 1) and other European and North American authors.

A direct correlation of the Canadian *Gastropilites sensu stricto* Zone with the European zonal standard became impossible after the above-mentioned new evidence became available (Jeletzky, 1977, p. 113). However, the reported presence of such *Dipoloceras cristatum* Subzone forms as *Dipoloceras cf. fredericsburgense* Scott, *Inoceramus comancheanus* Cragin and *I. bellvuensis* Reeside in the next younger *Stelckiceras liardense* Zone (Stelck et al., 1956, p. 6, 9; Stelck, 1958, p. 3, 6), and subsequently of "a keeled ammonite close to *Manuaniceras cf. supani* (Lasswitz)" (Stelck, 1975, p. 208), suggests strongly that the accustomed intercontinental correlation of the *Gastropilites* Zone was erroneous anyway. It is much more logical to correlate the *Stelckiceras liardense* Zone alone with the *Dipoloceras cristatum* Subzone than to try to correlate the latter subzone with a sequence, several hundred metres thick, of Fort St. John rocks containing no less than four distinctive ammonite faunas as does Owen (1973, p. 137). The lack of proportion involved in this correlation prompted the writer (Jeletzky, 1968, Fig. 1) to correlate the *Gastropilites sensu stricto* Zone with both the *Dipoloceras cristatum* and the

Anahoplites daviesi Subzones in spite of the lack of any supporting evidence. Now when the traditional intercontinental correlation of the *Gastropilites sensu stricto* Zone is discredited and the diagnostic fossils of *Dipoloceras cristatum* Subzone appear to be restricted to the next younger *Stelckiceras liardense* Zone, the writer proposes to correlate all of the *Gastropilites sensu stricto* Zone with the upper part of the *Euhoplites lautus* Zone. However, this Canadian zone includes two ammonite subzones. This makes it unlikely that it all could correspond to but one European subzone. Therefore, the writer prefers to correlate only the *Gastropilites allani* Subzone with the *Anahoplites daviesi* Subzone and suggests a correlation with the still older mid-Albian *Euhoplites nitidus* Subzone for the next older *Gastropilites kingi* Subzone (Fig. 1). *Gastropilites kingi* Subzone is unlikely to include any older middle Albian beds. This is suggested by its superposition on the *Pseudopulchellia pattoni* Zone and the apparently equivalent *Pseudogastropilites arcticus* beds of the Sverdrup Basin which are, in turn, superimposed on the *Pseudopulchellia flexicostata* and *Cleoniceras (Cleoniceras) canadense* beds. As already pointed out, these zones appear to be correlative with the whole of the *Hoplites dentatus* Zone and the lower part of the *Euhoplites loricatus* Zone.

Stelckiceras liardense Zone

Historical remarks. For a long time after the discovery of the original material of *Stelckiceras liardense* on Liard River near Old Fort Halkett by R.G. McConnell (see Whiteaves, 1889, p. 158), this species was only found in that particular area in those shales of Fort St. John Group which were subsequently named the Lepine Formation (e.g. Kindle, 1944; McLearn and Kindle, 1950, p. 89, 91, 93; Stelck et al., 1956, p. 3, 6; Jeletzky, 1968, p. 16, 19). Kindle (1944) and McLearn and Kindle (1950, p. 91, 93) recognized that *Stelckiceras liardense* occurs stratigraphically above *Gastropilites sensu stricto* fauna which was found in the basal beds of the Lepine Formation. However, they were far from certain that it represents a regional paleontological zone younger than the *Gastropilites* Zone. The *Stelckiceras liardense* fauna was apparently originally given a zonal status by Stelck et al. (1956, p. 9), who placed its index fossil into *Gastropilites*. This action was endorsed by Jeletzky (1968, p. 16, 19) following the discovery of *Stelckiceras liardense* in the middle part of the Buckingham Formation (GSC loc. 14772) and the Shaftesbury Formation (GSC loc. 84123).

Stratigraphic relationships and geographic range. The exact stratigraphic relationships of the *Stelckiceras liardense* and *Gastropilites sensu stricto* faunas in the type area of Lepine Formation were clarified by detailed field work of D.F. Stott in 1967. The results of this work have been summarized only briefly (Stott, 1975, p. 457). According to Stott (written com., Nov. 20, 1967), *Stelckiceras liardense* ranges between 61 to 244 m above the assigned base of Lepine Formation in its type section and elsewhere in Toad River area,

northeastern British Columbia. No fossils of any kind were found stratigraphically higher in these about 610 m thick sections of the Lepine Formation.

Stelckiceras liardense was the only gastropilite ammonite found at the levels 122 m (GSC loc. 69179), 198-213 m (GSC loc. 69180) and 228.6 to 243.8 m (GSC loc. 69185). However, rare representatives of *Stelckiceras liardense* were found in association with *Gastropilites allani* McLearn (prevalent), *G. (Paragastropilites) spiekeri* McLearn (less common) and *Gastropilites* sp. indet. morphologically (but not phylogenetically!) transitional between *G. allani* and *Neogastropilites selwyni* (rare) at 76 m (GSC loc. 69187). Only a solitary representative of *Stelckiceras liardense* was found yet lower, at a level about 61 m above the base of Lepine Formation, in association with common *Gastropilites allani* McLearn (GSC loc. 69191).

These stratigraphic results of Stott's (1975, p. 457 and unpublished) suggest strongly that no biochronologically significant ammonite faunas exist in the unfossiliferous shale intervals which continue to separate the *Gastropilites sensu stricto* and *Stelckiceras liardense* faunas in other sections of the Fort St. John Group (e.g. in the Buckingham Formation and in the Shaftesbury Formation). Consequently the writer decided to abolish the unfossiliferous Zone G previously proposed (Jeletzky, 1968, p. 19) for such intervals and to divide them arbitrarily between the *Gastropilites allani* Subzone of the *Gastropilites sensu stricto* Zone on the one hand and the *Stelckiceras liardense* Zone on the other.

The intervals of apparently unfossiliferous rocks separating the *Stelckiceras liardense* fauna from the lowermost occurrences of *Neogastropilites* fauna in a number of areas, as for example in the upper part of the type Lepine Formation (see above), the lower part of Goodrich sandstone, the upper part of the underlying Hasler Formation (Warren and Stelck, 1969, p. 532, 533), and the upper part of Buckingham Formation remain unbridged by any kind of diagnostic fossils. These unfossiliferous intervals are arbitrarily divided between the *Stelckiceras liardense* and *Neogastropilites* zones in the same way as the interval separating the *Gastropilites sensu stricto* and *Stelckiceras liardense* zones (see above).

To the best knowledge of the writer, the *Stelckiceras liardense* fauna has not yet been found anywhere in the mid-continental basin of North America apart from the previously mentioned occurrences in the Lower Lepine Formation, lower Shaftesbury Formation (GSC loc. 84123), and middle Buckingham Formation (GSC loc. 14772). Nor has this fauna been found anywhere in Arctic North America outside the basin.

Judging by the previously discussed, inferred lateral replacement of the *Stelckiceras liardense* fauna by the *Anagastropilites tozeri* fauna in Sverdrup Basin (see p. 27 for further details), the former fauna was confined to the Western Interior Basin of Canada following its far-reaching (possibly total?) isolation from the Arctic North American basins in the wake of the widespread interregional mid-Albian regression in Arctic North America (Jeletzky, 1971, p. 47 and earlier in this paper).

Intercontinental correlation and age. The intercontinental correlation of *Stelckicerus liardense* Zone has already been discussed in connection with the description of age and correlation of the *Gastrolites* sensu stricto Zone (see p. 33, 34). For reasons presented there, the *Stelckicerus liardense* Zone is interpreted as of the latest mid-Albian age in terms of the zonal and substage scheme adopted in this paper (Fig. 1).

REMARKS ON PHYLOGENY, FAUNAL MIGRATIONS AND PALEOBIOGEOGRAPHY

This study of mid-Albian ammonites of mid-western and Arctic Canada indicates that, contrary to the earlier ideas, the still imperfectly known mid-Albian gastrolitid and cleoniceratinid faunas of the Sverdrup Basin are rather diversified on the specific and generic level. Most of them contain two or more ammonite species (sometimes as many as seven) belonging to two or more (sometimes as many as five) conservatively defined gastrolitid and cleoniceratinid genera. Furthermore, most of the species and genera described in this paper are closely allied with one another. This applies even to the genera belonging to two different subfamilies, as for example the subgenus *Cleoniceras* sensu stricto and the subgenus *Grycia* on the one hand and the genera *Pseudopulchellia* emend. and *Pseudogastrolites* gen. nov. on the other. Finally, a number of gastrolitid and cleoniceratinid taxa of the Sverdrup Basin are morphologically highly variable and appear to be connected by morphologically transitional forms. This is true not only of the species but of some genera as well (e.g. *Cleoniceras (Grycia) densicostata* sp. nov. and *Pseudopulchellia flexicostata* (Imlay)). Only a few such cases have been discussed in the systematic part of this paper, as other cases concern previously known species and genera.

The above data suggest strongly that all of the gastrolitid and cleoniceratinid species and genera of the informal Upper shale member of the Christopher Formation described and figured in this paper are endemic taxa. For reasons explained earlier in the specific and generic descriptions, all these taxa apparently evolved out of at least two intercontinentally distributed subgenera of *Cleoniceras* sensu lato which migrated into the Sverdrup Basin in the latest early Albian (Fig. 2). Thereafter, the endemic "daughter" genera were largely, but not entirely, confined to the Sverdrup Basin and evolved therein almost until the "moment" when the basin was completely drained in the early late Albian (i.e. early Hassel time).

The only major break in the evolution of the gastrolitid and cleoniceratinid genera of the Sverdrup Basin is represented by the about 200 m thick interval of the Upper shale member which is devoid of ammonites. This interval separates the *Pseudogastrolites arcticus* beds from the overlying *Anagastrolites tozeri* beds and apparently corresponds to the generalized *Gastrolites* Zone of the Canadian Western Interior Region

(Figs. 1, 2). However, this faunal break must be more apparent than real as the still undescribed *Pseudopulchellia* aff. *Ps. pattoni* Imlay and the *Anagastrolites tozeri* sp. nov. occurring above the faunal break are obviously endemic forms genetically connected with those occurring below it (Figs. 1, 2). The possible complete emigration of *Pseudogastrolites* and *Gastrolites* sensu stricto and the extinction of *Cleoniceras (Grycia)* at that time may well be fictitious events simulated by the scarcity of data presently available.

The writer's current ideas about the genetic ties, evolution, and migrations of mid-Albian gastrolitid and cleoniceratinid genera of the Sverdrup Basin described in this paper are summarized in Figure 2.

In contrast to the mid-Albian gastrolitid and cleoniceratinid faunas of the Sverdrup Basin, the much better known mid-Albian gastrolitid faunas of the Western Interior Region of Canada are distinctly depauperated on the specific and generic levels. This paper is concerned only with genera as the numerous species of the region were not discussed in it.

The depauperation of the mid-continental gastrolitid faunas is illustrated by the fact that no cleoniceratinid genera are so far known in these faunas and that none of them contain more than two gastrolitid genera (excluding the rather doubtful subgenus *Paragastrolites* Imlay 1961). A number of these faunas contain but one gastrolitid genus, or even a solitary ammonite genus of different affinities (e.g. *Beudanticeras (Grantzicerus)*).

None of the gastrolitid genera of the Canadian Western Interior Region, with the sole exception of the rather doubtful subgenus *Paragastrolites*, is known to include any forms which are either obviously or probably transitional to other genera occurring in adjacent zones or subzones. Furthermore, no gastrolitid ammonites whatsoever are known to exist in a thick sequence of lower middle Albian beds inferred to correspond to the *Cleoniceras (Cleoniceras) canadense* and *Pseudopulchellia flexicostata* beds of the Sverdrup Basin (Figs. 1, 2). For reasons presented below, this interval represents a total break in evolution of this stock within the region.

The oldest gastrolitid genus known in the Western Interior Region of Canada is *Stotticerus* gen. nov. This genus is so far known from one fossil locality only, which corresponds either to the basal part of the *Pseudopulchellia pattoni* Zone or to the uppermost part of the restricted Zone F (Fig. 1). As already mentioned, no gastrolitid ammonites whatsoever are known to be present in the underlying Zone F (or its remaining larger part) and *Stotticerus* obviously is not directly genetically related to any of the cleoniceratinid genera occurring in the next older upper lower Albian *Arcthoplites* spp. Zone. Outside of the Western Interior Region, *Stotticerus* is morphologically similar only to *Pseudopulchellia balkwilli* sp. nov. of the Sverdrup Basin (see p. 11, 18). It is accordingly interpreted as an evolutionary offshoot of this *Pseudopulchellia* species group

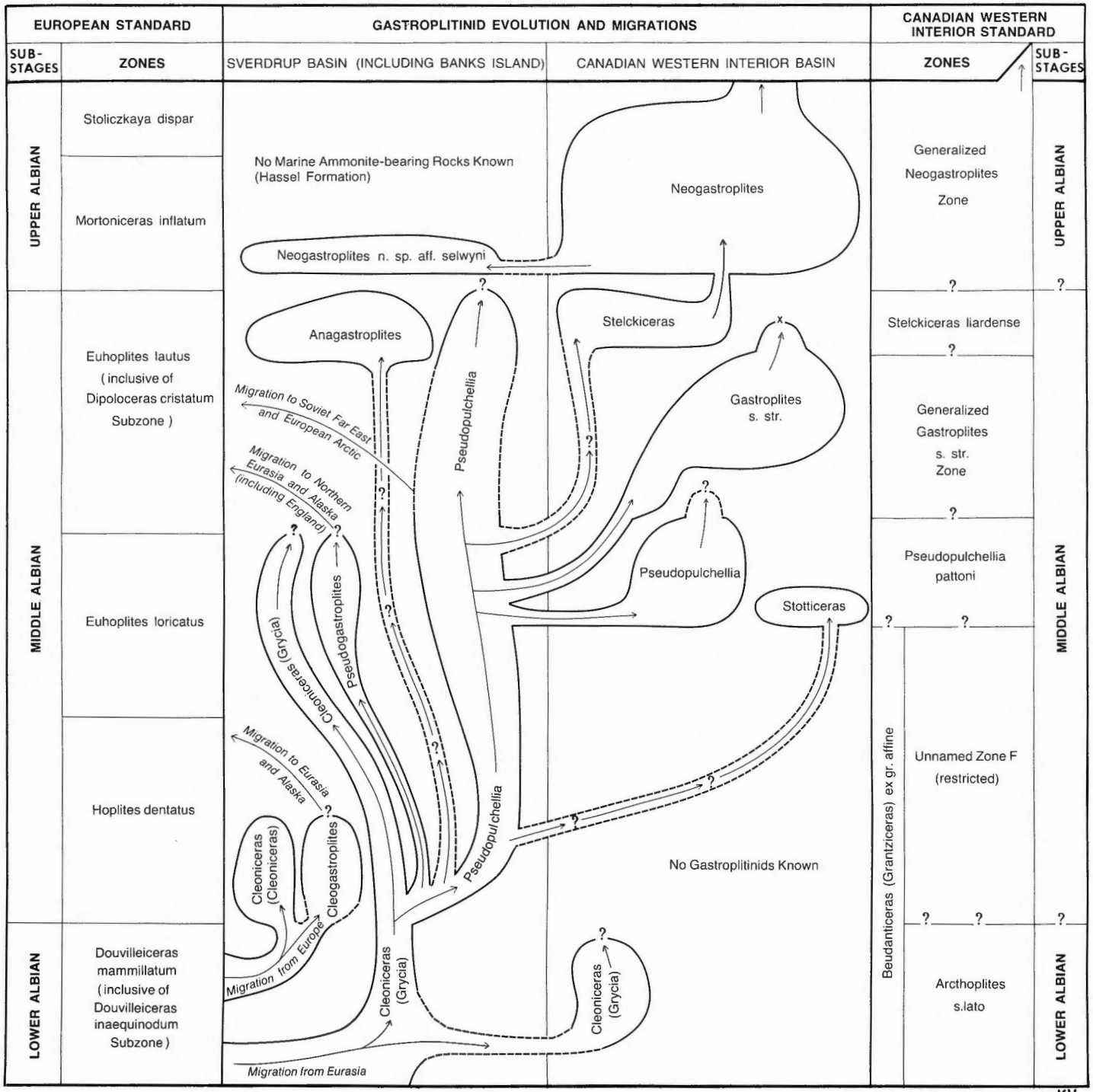


Figure 2. Suggested course of evolutionary development and migrations of mid-Albian cleoniceratinid and gastropilitinid ammonites in the Sverdrup and the Canadian Western Interior Basins.

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which migrated into the Western Interior of Canada and Central Alaska from that basin (Fig. 2). This agrees well with its presence in Central Alaska and its questionable presence in Sverdrup Basin (Fig. 1). No younger gastropplitinid genera in the Canadian Western Interior Region resemble *Stotticeras* closely enough to be interpreted as its descendants. *Stotticeras* is assumed accordingly to have died out without issue, in that region at least (Fig. 2). The same is probably true of Central Alaska.

The genus *Pseudopulchellia* Imlay 1961 appeared in the Western Interior Region of Canada either at the same time as or, possibly, somewhat later than *Stotticeras*. In that region *Pseudopulchellia* is so far represented by only one morphologically most aberrant species *Ps. pattoni* Imlay. This species is definitely younger than *Pseudopulchellia flexicostata* (Imlay) of the Sverdrup Basin and apparently younger than *Ps. balkwilli* sp. nov. of the same basin (Fig. 1) as it appears suddenly in the uppermost 30.5 m of the Hulcross Member of the Commotion Formation. These beds, which were designated the *Pseudopulchellia pattoni* Zone (see p. 28, 29 for further details), appear to correspond to the *Pseudogastropplites arcticus* beds of the Sverdrup Basin in which neither *Pseudopulchellia pattoni* itself nor any closely related forms are known to occur so far. *Pseudopulchellia pattoni* Imlay is thus a cryptogenic species in the Canadian Western Interior Region of Canada, and apparently in Northern Alaska as well. The only closely related forms are the slightly older *Pseudopulchellia* forms - especially *Ps. flexicostata* (Imlay) - of the Sverdrup Basin. Therefore, *Ps. pattoni* Imlay has to be derived from them, although no transitional forms are known as yet (Fig. 2). Following its immigration to the Canadian Western Interior Region and a brief existence there, *Ps. pattoni* Imlay disappears suddenly in the basal beds of the generalized *Gastropplites* Zone. It is totally morphologically dissimilar and obviously not directly related genetically to any of the contemporary or younger *Gastropplites* sensu stricto species. Nor is it possible to relate *Ps. pattoni* directly to the *Stelckiceras* gen. nov. of the next younger regional zone as this genus is similar to and apparently a direct descendant of a more primitive *Pseudopulchellia* ex gr. *balkwilli* sp. nov. (see p. 11, 18).

The *Gastropplites* sensu stricto stock of the Western Interior Region of Canada does not appear to have any ancestors in this region either. So far as known, the oldest representatives of the genus - *G. kingi* McLearn and *G. aff. stantoni* McLearn - appear suddenly in the *Pseudopulchellia pattoni* Zone which is underlain directly by Zone F (Jeletzky, 1968, p. 17, 18, Fig. 1) which is devoid of gastropplitinid ammonites. As already mentioned, only cleoniceratinid ammonites which are quite dissimilar and obviously unrelated to the *Gastropplites* sensu stricto are known to occur in the next older upper lower Albian *Arcthoplites* spp. Zone. Outside of the Western Interior Region of Canada, however, there are gastropplitinid forms which resemble closely the nodeless *Gastropplites stantoni* McLearn and appear to be its direct ancestors. One of

these is *Pseudopulchellia imlayi* sp. nov. occurring in the Christopher Formation of Sverdrup Basin. This species possesses an external suture line closely resembling that of the early *Gastropplites* sensu stricto in the degree of simplification of all its elements and the exceptionally narrow and slender proportions of its ventral lobe. The sculpture of *Ps. imlayi* sp. nov. is rather variable and some forms apparently forming its extreme morphological variants exhibit considerably finer, distinctly *Gastropplites*-like secondary ribs which fade markedly on the adult living chamber. As *Ps. imlayi* sp. nov. occurs in *Pseudogastropplites arcticus* beds, which appear to be correlative with *Pseudopulchellia pattoni* Zone of the Western Interior Region of Canada (Fig. 1), it is a suitable ancestor for *Gastropplites* sensu stricto.

The proposed derivation of *Gastropplites* sensu stricto from *Pseudopulchellia* ex gr. *imlayi* sp. nov. is supported by the presence in beds apparently correlative with those containing the *Pseudogastropplites arcticus* fauna (e.g. at GSC loc. 11432) of a still undescribed *Gastropplites* n. sp. aff. *stantoni* McLearn. This early and uniquely primitive (still markedly *Pseudopulchellia*- and *Pseudogastropplites*-like) form is the only true representative of *Gastropplites* sensu stricto known to the writer outside of the Western Interior Region of Canada.

Although the data available are incomplete, there seems to be little doubt that the earliest phases of the evolution of *Gastropplites* sensu stricto occurred not in the Western Interior Region of Canada but in the Sverdrup Basin. So far as known, only such typical representatives of the genus as *G. stantoni* McLearn and *G. kingi* McLearn succeeded in migrating into the mid-Albian generation (i.e. in *Pseudopulchellia pattoni* time; see Fig. 2) of the Canadian Western Interior sea.

Unlike *Stotticeras* and *Pseudopulchellia*, *Gastropplites* sensu stricto evidently succeeded in establishing itself temporarily in the Canadian Western Interior basin. This is evidenced by its startling morphological variability, gradual evolutionary changes of the suture line, which ends in the almost pseudoceratitic suture line of *Gastropplites (Paragastropplites) spiekeri*, and the previously discussed subdivisibility of the generalized *Gastropplites* Zone into *Gastropplites kingi* Subzone below and *Gastropplites allani* Subzone above (see preceding section).

The startling morphological variability of *Gastropplites* sensu stricto in the Canadian Western Interior Basin appears to be attributable to this genus being almost the only ammonite that existed in this semi-isolated inland sea during the *Gastropplites* sensu stricto time. This must have resulted in *Gastropplites* sensu stricto rapidly evolving in different directions (like Darwin's famous finches of the Galapagos Islands) in order to fill out various ecological niches which were vacant because of an almost complete absence of competitors.

In spite of the successful colonization of the Canadian Western Interior basin, *Gastropplites* sensu stricto apparently did not succeed in surviving there for long. As already pointed out (p. 13), *Stelckiceras* gen. nov. of the next younger *Stelckiceras liardense* Zone is not a direct

descendant of *Gastrolites* sensu stricto but an only indirectly related gastrolitidid homoeomorph. In addition to the dissimilar external suture lines, this is indicated by a complete absence of transitional forms connecting *Stelckicerias* and *Gastrolites* sensu stricto. As pointed out in the description of stratigraphic relationships of *Stelckicerias*, the first, already quite typical representatives of that genus occur rarely in beds of the Unnamed Zone H of Jeletzky (1968, p. 19, Fig. 1) containing equally typical representatives of *Gastrolites* sensu stricto. The latter disappear suddenly somewhat higher in the *Stelckicerias liardense* Zone. This brief co-existence of typical representatives of *Gastrolites* sensu stricto and *Stelckicerias* combined with a total absence of any gastrolitidid forms which could be interpreted as transitional between the two genera indicates that *Stelckicerias* is a migrant from elsewhere. Nor are there any gastrolitidid forms in the older middle Albian rocks of the Canadian Western Interior of Canada which could be interpreted as ancestors of *Stelckicerias*. Therefore, and because of its far-reaching morphological similarity (notably in the character of external suture line; see p. 13) to *Pseudopulchellia balkwilli* sp. nov., which forms part of the somewhat older *Pseudogastrolites arcticus* fauna of Sverdrup Basin, *Stelckicerias* evidently is yet another migrant from that basin (Fig. 2).

The genus *Neogastrolites* McLearn 1933, which makes its first appearance in the lower-most upper Albian beds overlying those containing *Stelckicerias liardense* (Whiteaves) (Fig. 2), was traditionally interpreted as an immediate descendant of *Gastrolites* sensu stricto (e.g. McLearn, 1931, 1933; Warren and Stelck, 1958, p. 13, 15, Pl. I). However, in the writer's opinion, the oldest known *Neogastrolites* ex gr. *haasi-selwyni* are not directly genetically connected with *Gastrolites* sensu stricto, in spite of the already mentioned (p. 13, 14), rather *N. selwyni*- or *N. haasi*-like ribbing habit of some of its latest known representatives (e.g. *G. allani* McLearn; see Pl. 7, fig. 3). The purely homoeomorphic nature of this morphological similarity is revealed by pronounced morphological distinctions of the suture line of these particular *Gastrolites* forms from equivalent suture lines of all known *Neogastrolites* species. As already mentioned (p. 13), the suture line of *Gastrolites* sensu stricto gradually becomes more and more simplified in the course of its evolution until it becomes almost pseudo-ceratic in its youngest representatives known (i.e. *G. allani* and *G. (Paragastrolites) spiekeri*; see Jeletzky, 1964, Pl. XXVII, figs. 6A, 8A, Pl. XXX, fig. 1, Pl. XXXII, fig. 6). The evidently strongly specialized character of this suture line and the pronouncedly asymmetrically bifid appearance of its lateral lobe is suggestive of the terminal phase of evolution of *Gastrolites* sensu stricto which ended with its extinction. Even if it did not, the relatively much more generalized, florid, and deeply denticulated external suture line of *Neogastrolites* with its downward-tapering, asymmetrically trifid

lateral lobe (Jeletzky, 1964, Pl. XXXIV, fig. 5, Pl. XXXV, fig. 4B, Pl. XXXVI, fig. 5B) could hardly evolve out of that of *G. allani* McLearn and *G. (P.) spiekeri* McLearn considering the previously mentioned general evolutionary trend of the *Gastrolites* sensu stricto suture line. Furthermore, the somewhat less specialized external suture lines of earlier *Gastrolites* forms (e.g. Jeletzky, 1964, Pl. XXVII, figs. 2A, 4C) are just as unlike the *Neogastrolites* suture line in principle as are the suture lines of its latest known representatives (see Pl. 9, figs. 4 and 5).

Though not directly related to *Gastrolites*, *Neogastrolites* appears to be an endemic genus in the Canadian Western Interior Basin. In the writer's opinion it is a direct descendant of *Stelckicerias* gen. nov. As already mentioned in the description of *Stelckicerias* (see p. 13, 14) the suture lines of these two genera belong to the same asymmetrically trifid type. Although the suture line of *Stelckicerias* mostly has much more narrow stemmed, relatively longer and more richly and deeply denticulated lobes, it is rather variable. One extreme variant of this suture line is rather *Neogastrolites*-like in possessing an unusually wide and, sometimes, downward-tapering, relatively less denticulated lateral lobe (Pl. 1, fig. 25). The auxiliary lobes of this variant are also considerably wider and less denticulated than their counterparts in the typical (so called *Pseudopulchellia*-like) suture line. Furthermore, this extreme variant of *St. liardense* Whiteaves combines the *Neogastrolites*-like external suture line with the presence of distinct to well-expressed umbilical bullae and particularly prominent, sometimes distinctly protruding, adventral parts of secondary ribs. This combination of morphological features and the stratigraphic position of *Stelckicerias liardense* Zone directly underneath *Neogastrolites* Zone suggests strongly the derivation of earliest binodose *Neogastrolites* ex gr. *haasi-selwyni* from *Stelckicerias liardense* (Whiteaves) via its previously mentioned extreme morphological variant. This idea is tentatively accepted as valid in this paper (Fig. 2). The direction of evolutionary trend *Pseudopulchellia* ex gr. *balkwilli* sp. nov. → *Stelckicerias* → *Neogastrolites* ex gr. *haasi-selwyni* must have paralleled closely that connecting *Pseudopulchellia* ex gr. *imlayi* sp. nov. with *Gastrolites*. Namely, it consisted of the appearance and gradual strengthening of umbilical and ventrolateral nodes, gradual loss of sculpture on the adult ultimate whorl, and gradual simplification of external suture line.

This analysis of the mid-Albian gastrolitidid faunas of the Sverdrup Basin and the Western Interior Region of Canada invalidates the generally accepted hypothesis that the latter region was the evolutionary center of the subfamily Gastrolitinae ever since its branching off of the late early Albian Cleoniceratinae somewhere in the North American Arctic (e.g. Warren and Stelck, 1959, p. 18, 19; Jeletzky, 1971, p. 14). Even the incomplete data now available about the mid-Albian gastrolitidid faunas of the Sverdrup Basin indicate that it was the birthplace of Gastrolitinae and the evolutionary center of the subfamily throughout the middle Albian

(Fig. 2). Most of the middle Albian gastroplitinid faunas of the Canadian Western Interior Region represent, in contrast, a series of unrelated southward migrations from the Sverdrup Basin. The situation changed only with the emergence of the *Neogastropplites* stock at the onset of the late Albian as the evolution of that genus and related late Albian and early Cenomanian genera obviously had taken place within the mid-continental basin of North America (e.g. Warren and Stelck, 1958, 1959, p. 18, 19; Reeside and Cobban, 1960).

The extremely sporadic and mostly rare to solitary occurrence of the mid- and late Albian gastroplitinids outside of the Sverdrup Basin and the Western Interior Basin of North America (e.g. Spath, 1937; Imlay, 1961; Nagy, 1970; Verestchagin et al., 1965; Avdeiko, 1968; Pergament, 1977) suggests that the Sverdrup Basin was not only the principal but almost the only evolutionary center of the mid-Albian gastroplitinids.

It appears that only some members of the mid-Albian gastroplitinid lineages of Sverdrup Basin were able to migrate into other basins of the Boreal Realm and even fewer members were able to survive in these basins for longer periods of time and to establish temporary, endemic evolutionary centers there. So far as known, this only happened with the *Gastropplites* sensu stricto stock and the *Neogastropplites* stock in the mid-continental basin of North America. Of these two endemic lineages, only the *Gastropplites* sensu stricto stock existed simultaneously with the main evolutionary lineages of gastroplitinids in Sverdrup Basin for any length of time (Fig. 2). The evolution of the *Neogastropplites* lineage in the mid-continental basin of North America, in contrast, had taken place either largely or entirely after these principal gastroplitinid lineages of the Sverdrup Basin became extinct because of draining of the basin in the wake of the interregional latest middle to ?early late Albian regression in Arctic North America. This is indicated, in particular, by the fact that the latest gastroplitinid fauna known in the Sverdrup Basin (i.e. the *Neogastropplites* n. sp. aff. *N. selwyni* fauna; see Jeletzky, 1971, p. 47 and earlier in this paper) is not known to contain any endemic gastroplitinids. This fauna appears to be an offshoot of the *Neogastropplites* plexus which migrated into the southernmost part of the Sverdrup Basin (?Banks Island area only) from the Canadian Western Interior Basin after the extinction of endemic gastroplitinids (Fig. 2).

So far as known, only members of those mid-Albian gastroplitinid lineages which inhabited the Sverdrup Basin were able to migrate outside of Arctic Canada (Figs. 2, 3). As already pointed out in the systematic chapter of this paper, all identifications of *Gastropplites* in Alaska (Imlay, 1961), Spitsbergen (Nagy, 1970), and England (Spath, 1937) are erroneous. They pertain invariably to earlier mid-Albian gastroplitinid genera endemic to Sverdrup Basin. Furthermore, the writer questions the validity of all Soviet records

of *Gastropplites* sensu stricto and *Neogastropplites* in northeastern Siberia. All ammonites figured as such in the Soviet literature (e.g. Avdeiko, 1968, Pl. XIII, fig. 2, 3, 5, Pl. XIV, fig. 4, Pl. XV, fig. 5; Verestchagin et al., 1965, Pl. 18, figs. 5, 6) appear to be primitive *Pseudopulchellia* ex gr. *flexicostata-imalayi*, *Cleoniceras* (*Grycia*), or *Pseudogastropplites*. The same is probably true of other undocumented records of *Gastropplites* sensu stricto and *Neogastropplites* in northeastern Siberia (e.g. Pergament, 1977, p. 179, 180).

Of the endemic Canadian Western Interior gastroplitinid genera, only the most primitive representatives of *Gastropplites* sensu stricto and the most primitive representatives of *Neogastropplites* are known outside of that region. Furthermore, they are only known in the Sverdrup Basin. The presence of still undescribed *Gastropplites* n. sp. aff. *stantoni* in the Sverdrup Basin apparently reflects not its northward migration but the naissance of *Gastropplites* sensu stricto in the Sverdrup Basin out of the endemic *Pseudopulchellia* ex gr. *imalayi* (Fig. 2). This leaves us with but one authentic case of northward migration of the endemic gastroplitinid genera of the Canadian Western Interior region - that of the *Neogastropplites* n. sp. aff. *N. selwyni* McLearn (Fig. 2). So far as known, this fauna did not penetrate anywhere beyond Banks Island area which is only conditionally treated herein as a part of the Sverdrup Basin.

It follows from the palaeobiogeographic restriction of the mid-Albian gastroplitinid faunas that the Canadian Western Interior Basin was only tenuously connected with the Sverdrup Basin and had no other northern or western outlets. This mid-Albian seaway, which was inferred to extend across the Mackenzie Lowlands and Banks Island area by Stelck (1958, Fig. 3), Jeletzky (1971, p. 44, 45) and Owen (1973, Figs. 2, 3), was probably narrow and shallow, for the most part at least. Its waters may have been brackish locally because of the probable influence of large rivers which must have been draining the rising mid-Albian tectonic landmass situated immediately westward. Alternatively, the waters of this seaway may have been intermittently brackish and normally saline following short-lived negative and positive pulsations of the region. Finally, this seaway may have been open at certain times only when the whole region was subsiding. These suggested mid-Albian paleogeographic conditions agree well with the occurrence of a strong regional uplift or uplifts of the Mackenzie Salient in mid-Albian time inferred by Jeletzky (1971, p. 45).

Except for the above-discussed mid-continent basin of North America, the gastroplitinids endemic to the Sverdrup Basin are rare and restricted outside of that basin. So far as known, even the adjacent northern and central Alaska (Imlay, 1961) has yielded only rare representatives of some of their Sverdrup Basin genera. The same appears to be true of the Pacific Slope of Siberia, judging by data provided by Soviet workers (e.g. Verestchagin et al., 1965; Avdeiko, 1968; Pergament, 1977). Only solitary representatives

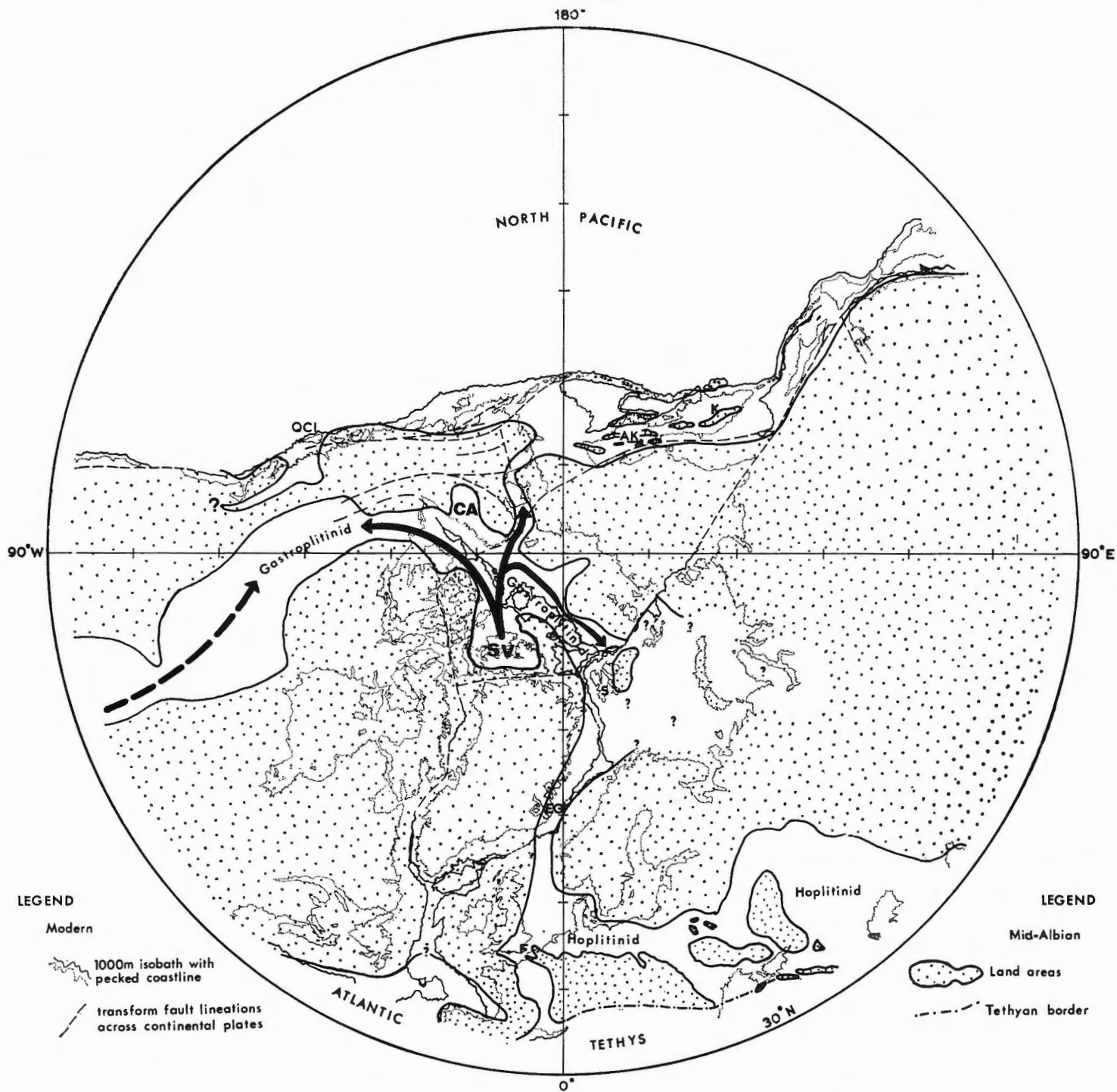


Figure 3. Reconstruction of mid-Albian paleobiogeography of the Boreal Region and adjacent areas. Modified from Owen's (1973, p. 152, 153, Fig. 3) reconstruction which should be consulted for explanation of his legend and the basic underlying principles. As pointed out in the text (see p. 41), the writer follows Owen (loc. cit.) in accepting the validity of the concept of an expanding Earth at least from the early Mesozoic to the present day.

Legend: SV. - Sverdrup Basin. CA. - Central Alaskan basin. Solid arrows indicate the inferred directions of outward migrations of mid-Albian gastroplitinid ammonites from their evolutionary centre in the Sverdrup Basin. Dashed arrow indicates migration of mortoniceratids into the Canadian Western Interior Basin in the latest mid-Albian (i.e. *Stelckiceras liardense* time).

of some of these gastroplitinids, finally, are known in the European Arctic (Nagy, 1970) and England (Spath, 1937, 1923-43). This suggests strongly that the mid-Albian generation of Sverdrup Basin was a strongly restricted marine basin which was only tenuously, and possibly only intermittently, connected with the contemporary marine basins of Alaska, northern Asia, European Arctic, and northwestern Europe.

Concluding, it must be pointed out that the paleogeographical data presented in this section support that reconstruction of the Albian paleogeography of the Boreal Region based: "entirely on the concept of an expanding Earth at least from the early Mesozoic to the present day" (Owen, 1973, p. 153, Fig. 3). Conversely, these data appear to be incompatible with the conventional, i.e. orthodox plate tectonic, reconstruction of the Boreal Region which postulates a globe of modern mean diameter and curvature for Albian times (Owen, 1973, p. 151, Fig. 2). If this reconstruction, which postulates the existence of an exceptionally wide Arctic Ocean in the Albian, was correct, the mid-Albian gastroplitinids of Sverdrup Basin should have been able to migrate freely through most or all of the Boreal Realm. However, this obviously was not the case which suggests the validity of palaeogeographic and palaeobiogeographic relationships summarized in Figure 3.

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Plates 1-10

All fossils are reproduced in natural size unless it is otherwise indicated in the descriptions of corresponding figures. The beginning of living chamber is marked by an arrow whenever appropriate.

PLATE I

- Figure 1. *Cleonicerias (Grycia) densicostata* sp. nov. Holotype. Adult suture lines of the specimen reproduced on Pl. 2, fig. 3. GSC 57904.
- Figure 2. *Cleonicerias (Grycia) densicostata* sp. nov. Holotype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 2, fig. 3. GSC 57904.
- Figure 3. *Cleonicerias (Grycia) densicostata* sp. nov. Paratype. Adult suture lines of the specimen reproduced in Pl. 3, fig. 4. GSC 57905
- Figure 4. *Cleonicerias (Grycia) densicostata* sp. nov. Paratype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 3, fig. 4. GSC 57905.
- Figure 5. *Cleonicerias (Cleonicerias) canadense* sp. nov. Holotype. Adult suture lines of the specimen reproduced in Pl. 2, fig. 2. GSC 57906.
- Figure 6. *Cleonicerias (Cleonicerias) canadense* sp. nov. Paratype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 2, fig. 5. GSC 57938.
- Figure 7. *Pseudogastrolites arcticus* sp. nov. Holotype. Adult (oralmost) suture line of the specimen reproduced in Pl. 3, fig. 8A. GSC 17422.
- Figure 8. *Pseudogastrolites nanus* sp. nov. Holotype. Adult suture line of the specimen reproduced in Pl. 3, fig. 6B. GSC 17423.
- Figure 9. *Pseudogastrolites nanus* sp. nov. Paratype. Adult suture line of an otherwise unfigured specimen. GSC 57907, xl.
- Figure 10. *Cleogastrolites aberrans* sp. nov. Holotype. Oralmost suture lines (well preserved) of the specimen reproduced in Pl. 3, fig. 5C. GSC 57908.
- Figure 11. *Cleogastrolites aberrans* sp. nov. Holotype. Adult suture lines at the level about half whorl before the end of adult phragmocone reproduced in Pl. 3, fig. 5C (somewhat weathered in part). GSC 57908.
- Figure 12. *Cleogastrolites aberrans* sp. nov. Paratype. Halfgrown (or semiadult) suture lines of the specimen reproduced in Pl. 3, fig. 7D at the level about half whorl before its broken off oral end. GSC 57909.
- Figure 13. *Pseudopulchellia flexicostata* (Imlay 1961) intermediate (or semiadult) suture lines of the sturdiest representative of the species known, reproduced in Pl. 6, fig. 4A at the whorl diameter of 18 mm. Hypotype. GSC 57910.
- Figure 14. *Pseudopulchellia flexicostata* (Imlay 1961). Early suture lines of the otherwise unfigured slender representative at whorl diameter about 6 mm. Hypotype. GSC 57911.
- Figure 15. *Pseudopulchellia flexicostata* (Imlay 1961). Early suture lines of the same sturdiest representative of the species known as in Fig. 13 but at the whorl diameter about 8.5 mm. Hypotype. GSC 57910.
- Figure 16. *Pseudopulchellia flexicostata* (Imlay 1961). Adult suture lines of the moderately sturdy representative of the species reproduced in Pl. 5, fig. 3B at the whorl diameter of about 14 mm. GSC 57912.
- Figure 17. *Pseudopulchellia imlayi* sp. nov. Holotype. Adult suture lines on the outer whorl of the specimen reproduced in Pl. 3, fig. 1A. GSC 17425.
- Figure 18. *Pseudopulchellia imlayi* sp. nov. Holotype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 3, fig. 1A but at the whorl diameter of 17 mm (on inner whorl). Holotype. GSC 17425.
- Figure 19. *Anagastrolites tozeri* sp. nov. Holotype. Somewhat weathered adult suture lines of the specimen reproduced in Pl. 8, fig. 1A at the whorl diameter of 17 to 18 mm. GSC 17420.
- Figure 20. *Anagastrolites tozeri* sp. nov. Holotype. Well-preserved intermediate (or semiadult) suture line of the specimen reproduced in Pl. 8, fig. 1E-G at the whorl diameter of about 12 mm. GSC 17420.
- Figure 21. *Pseudopulchellia balkwilli* sp. nov. Holotype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 8, fig. 2 at approximate whorl diameter of about 19 mm. Only one of these sutures is visible on the flank reproduced in Pl. 8, fig. 2A. Other sutures are on the unfigured flank. GSC 17421.
- Figure 22. *Pseudopulchellia balkwilli* sp. nov. Holotype. Adult suture lines of the specimen reproduced in Pl. 8, fig. 2A at the approximate whorl diameter of 36 mm (at the oral end of the specimen). GSC 17421.
- Figure 23. *Pseudopulchellia balkwilli* sp. nov. Paratype. Oralmost adult suture lines of the specimen reproduced in Pl. 9, fig. 7. GSC 17434.
- Figure 24. *Stelckicerias liardense* (Whiteaves 1889). Hypotype. Adult suture line of the otherwise unfigured specimen at approximate whorl diameter of 92 mm. This suture line is typical of the *Pseudopulchellia*-like variant of the species. The adventralmost branch of the ventral lobe is only preserved in part and the ventral lobe is not preserved at all. Hypotype. GSC 57913.
- Figure 25. *Stelckicerias liardense* (Whiteaves 1889). Hypotype. Presumably intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 4, fig. 5 at the approximate whorl diameter of 37 mm. This suture line is typical of the *Neogastrolites*-like variant of the species. The ventral lobe is not preserved. GSC 57914.
- Figure 26. *Stotticerias crowense* sp. nov. Holotype. Intermediate (or semiadult) suture lines of the specimen reproduced in Pl. 6, fig. 3; Pl. 9, fig. 1 at approximate whorl diameter of 43 mm. GSC 57915.

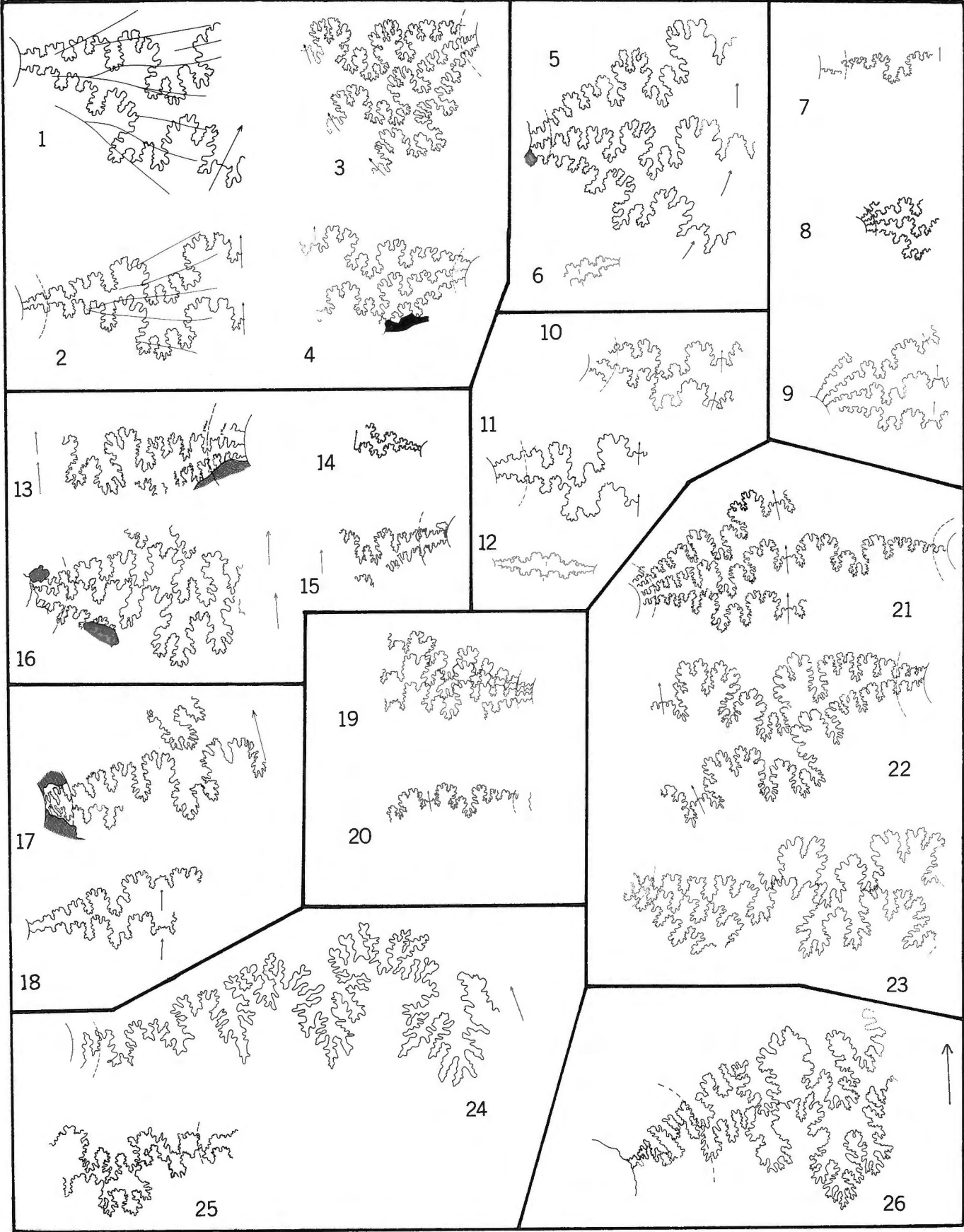


PLATE 2

Figure 1A-C. *Cleoniceras (Cleoniceras) canadense* sp. nov. Hypotype. GSC loc. C-022253. GSC 57916. *Cleoniceras (Cleoniceras) canadense* beds. Earliest mid-Albian. Christopher Formation. Basal beds of the Upper shale member immediately above the Sandstone unit crowning the Lower shale member of Balkwill (in press). Canadian Arctic Archipelago, N.W.T. Amund Ringnes Island, in the bed of Stratigrapher River at Lat. $78^{\circ}45'N$, Long. $97^{\circ}40'W$. Typical ?adult representative with only the earliest part of the ?adult living chamber preserved. 1A. Lateral view. 1B. Ventral view of oralmost third of the whorl. 1C. Cross-section of the oral end and ventral view of the earliest third of the whorl.

Figure 2A-D. *Cleoniceras (Cleoniceras) canadense* sp. nov. Holotype. GSC loc. 89755. GSC 57906. The same beds, formation, age and locality as for the specimen reproduced in fig. 4. Intermediate, fully septate whorl exhibiting the transition from the pronouncedly sculptured intermediate growth stage to the smooth adult growth stage. 2A. Lateral view of the flank which exhibits more advanced feebly sculptured to smooth growth stage. 2B. Lateral view of the other flank which exhibits earlier, pronouncedly sculptured growth stage. 2C. Ventral view of the earliest third of the whorl. 2D. Ventral view of the middle third of the whorl.

Figure 3A-D. *Cleoniceras (Grycia) densicostata* sp. nov. Holotype. GSC loc. C-022253. GSC 57904. The same locality, etc. as for the specimen reproduced in fig. 1. Typical adult representative with only the earliest part of the living chamber preserved. 3A. Lateral view of the mostly shell-covered flank. 3B. Lateral view of the other flank mostly preserved as an internal cast and exhibiting well-preserved suture lines. 3C. Ventral view of the oralmost third of the whorl. 3D. Cross-section of the oral end and ventral view of the earliest quarter of the whorl.

Figure 4A-D. *Cleoniceras (Cleoniceras) canadense* sp. nov. Hypotype. GSC loc. C-004711, GSC 57917. The same beds, formation, and age as for the specimen reproduced in fig. 1. Canadian Arctic Archipelago, N.W.T. Axel Heiberg Island, Skaare Fiord, Lat. $78^{\circ}30'N$, $88^{\circ}30'W$. An extremely slender but otherwise typical juvenile whorl with a but feebly developed *Sonneratia*-like growth stage. Note an abrupt coarsening of the ornament on the oralmost preserved part of the whorl and the appearance of umbilical bullae there (fig. 4B). 4A. Lateral view of the somewhat worn flank. 4B. Lateral view of the other, better preserved flank. 4C. Ventral view of the prominently and coarsely ribbed oralmost third of the whorl. 4D. Cross-section of the oral end and ventral view of the earliest, much more finely ribbed third of the whorl.

Figure 5A-D. *Cleoniceras (Cleoniceras) canadense* sp. nov. Hypotype. GSC loc. C-022253, GSC 57938. The same locality, etc. as for the specimen reproduced in fig. 1. An extremely sturdy but otherwise typical juvenile whorl featuring a typically developed *Sonneratia*-like growth stage. Note the same coarsening of the sculpture as in the specimen reproduced in fig. 4A, B coupled with the appearance of well developed umbilical nodes (figs. 5B, C). 5A. Lateral view of the somewhat worn flank. 5B. Lateral view of the other better preserved flank. 5C. The same view as in fig. 1B but x2 to exhibit the umbilical nodes and the external suture line. 5D. Cross-section of the oral end and ventral view of the considerably worn earliest third of the whorl.

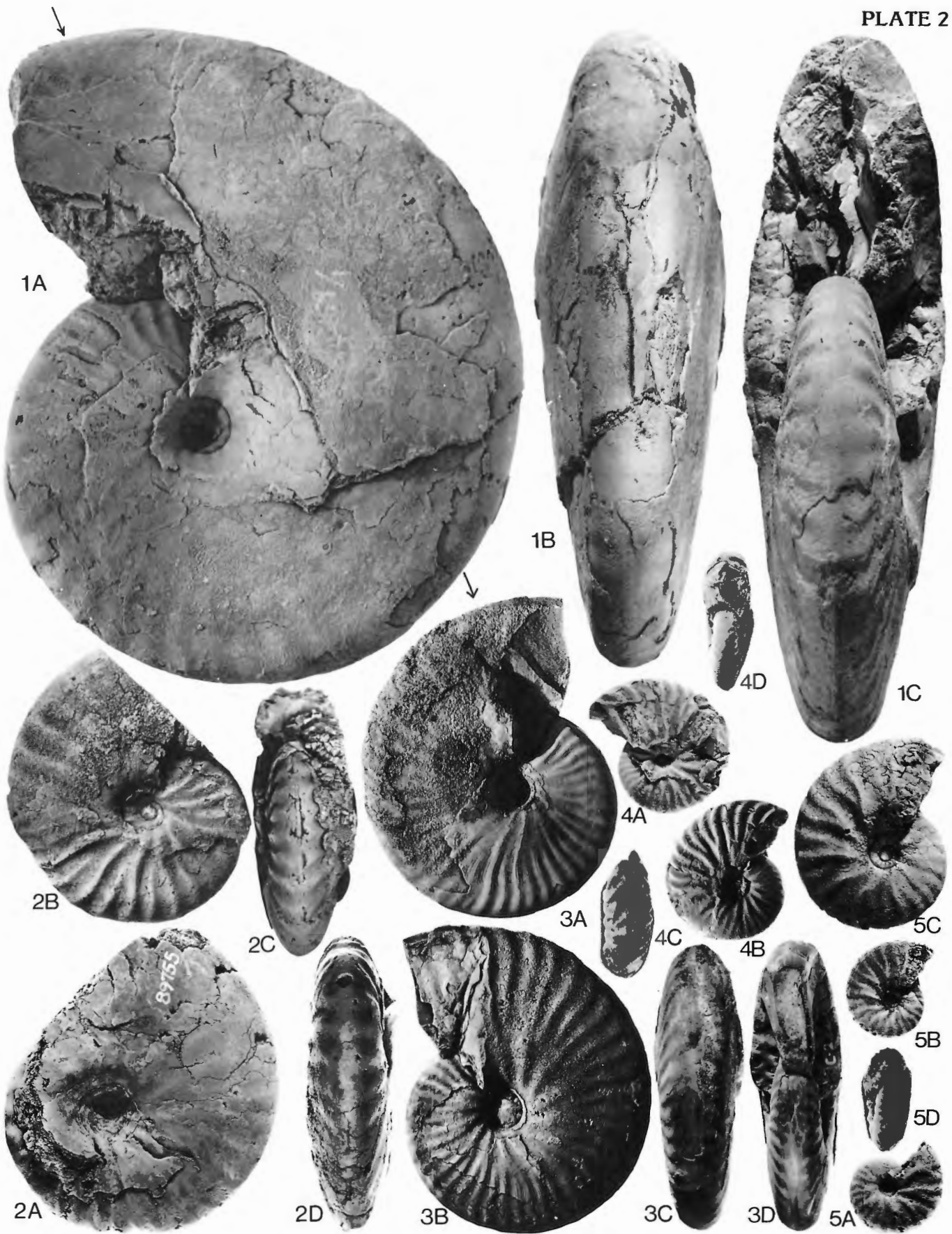


PLATE 3

Figure 1A-C. *Pseudopulchellia imlayi* sp. nov. Holotype. GSC loc. 40602, GSC 17425. *Pseudogastropylites arcticus* beds. Middle mid-Albian. Christopher Formation. Banks Island, Canadian Arctic Archipelago, N.W.T. East bank of Thomsen River, about 12.8 km north of confluence of Muskox and Thomsen Rivers. Stratigraphic position within the Christopher Formation uncertain. An almost complete, undeformed intermediate whorl (see also Pl. 8, fig. 3A-C) enclosed in fragmentary adult penultimate whorl (wholly septate). 1A. Lateral view of the complete specimen. 1B. Lateral view of the other flank with most of the outer whorl taken off to expose the inner whorl. Note the considerably wider spaced and coarser ribbing habit of the inner whorl as compared with the equivalent part of the whorl of *Pseudopulchellia balkwilli* sp. nov. reproduced in fig. 2A. 1C. Cross-sections of all preserved whorls. Note the *Cleoniceras* (*Grycia*)-like cross-section of the inner and intermediate whorls and its replacement by a *Gastropylites* (*Paragastropylites*) *spiekeri*-like cross-section on the earliest preserved part of penultimate whorl.

Figure 2A-C. *Pseudopulchellia balkwilli* sp. nov. Topotype. GSC loc. 43618, GSC 57918. *Pseudogastropylites nanus* beds. Middle mid-Albian. Christopher Formation. Ellef Ringnes Island. Southeast of Dumbbell Dome. Exact location and stratigraphic position within the Christopher Formation unknown. However, they are assumed to be about the same as for the GSC loc. C-022695 on northern Amund Ringnes Island. Intermediate (probably second before adult ultimate) wholly septate whorl of an extremely slender and finely ribbed variant of the species. 2A. Lateral view of the flank which exposes the earliest quarter of the whorl concealed on the other flank. 2B. Lateral view of the other flank which exposes the oralmost quarter of the whorl missing on the other flank. 2C. Ventral view of the oralmost one-third of the whorl preserved. The secondary ribs are completely effaced on the venter.

Figure 3A-B. *Pseudopulchellia imlayi* sp. nov. Topotype. The same locality, etc. as for the holotype reproduced in fig. 1. GSC 57919. Fragment of an adult living chamber with well-preserved cross-section and ornament. 3A. Lateral view of the best preserved flank. The umbilicus is strongly deformed. 3B. Cross-section of the living chamber and those of two intermediate whorls.

Figure 4A-C. *Cleoniceras* (*Grycia*) *densicostata* sp. nov. Topotype. GSC loc. C-022253. GSC 57905. *Cleoniceras* (*Cleoniceras*) *canadense* beds, earliest mid-Albian. Christopher Formation, basal beds of the Upper shale member immediately above the Sandstone unit crowning the Lower shale member of Balkwill (in press). Northern Amund Ringnes Island, Canadian Arctic Archipelago, N.W.T. In bed of Stratigrapher River, Lat. 78°45'N, Long. 97°40'W. Intermediate, fully septate whorl of the extremely coarsely and sparsely ribbed variant of the species. 4A. Lateral view of the flank preserved as an internal cast. Note the *Pseudopulchellia flexicostata*-like appearance of external suture lines. 4B. Ventral view of the rather strongly weathered, oralmost preserved part of the whorl. 4C. Cross-section of the oral end and ventral view of the well preserved, earliest exposed one-third of the whorl.

Figure 5A-F. *Cleogastropylites aberrans* sp. nov. Holotype. GSC loc. C-022253, GSC 57908. The same locality, etc. as for the specimen reproduced in fig. 4. Adult representative of the species with the earliest part of the living chamber preserved. 5A. Lateral view of the flank with the best preserved umbilical bullae. 5B. Lateral view of the other flank with well preserved trifurcating rib bundles. 5C. The same view as in fig. 5A but x2 to display the typically simplified suture lines. 5D. Ventral view of the middle third of the venter. 5E. Cross-section of the oral end and ventral view of the earliest exposed part of the whorl. Note the broadly rounded venter and the *Arcthopylites*-like cross-section of the earliest part of the whorl and its replacement by a *Gastropylites stantoni*-like cross-section at the oral end of the specimen. 5F. Ventral view of the oralmost third of the whorl.

Figure 6A-D. *Pseudogastropylites nanus* sp. nov. Holotype. GSC loc. 43618. GSC 17423. The same locality, etc. as for the specimen reproduced in fig. 2. A typical adult representative of the species with about half whorl of the living chamber preserved. Compare with the specimen reproduced in Pl. 4, fig. 1. 6A. Lateral view of the best preserved flank. 6B. Lateral view of the other, considerably weathered flank which exhibits fairly well preserved suture lines. 6C. Ventral view of the oralmost third of the specimen. 6D. Cross-section of the oral end and ventral view of the earliest exposed third of the whorl. Note the broadly rounded cross-section of the earliest visible part of the whorl and its replacement by a rectangular, *Gastropylites*-like cross-section on the oral end of the specimen.

Figure 7A-D. *Cleogastropylites aberrans* sp. nov. Topotype. GSC loc. C-022253, GSC 57909. The same locality, etc. as for the specimen reproduced in fig. 4. A halfgrown representative of the species which displays an abrupt replacement of the relatively fine but sparse, nonbullate juvenile ribbing habit by the prominent and heavy, bifurcating ribs with distinct umbilical bullae (fig. 7A, D). The whorl's cross-section becomes much more sturdy and broadly ventered but not yet planulate-ventered in the course of the ontogeny (fig. 7B, C). 7A. Lateral view of the best preserved flank. 7B. Ventral view of the oralmost third of the whorl. 7C. Cross-section of the oral end and ventral view of the earliest visible third of the whorl with the chevron-like bends of secondary ribs. 7D. Same view as in fig. 7A. but x2 to show extremely simplified, almost pseudoceratitic appearance of intermediate suture lines.

Figure 8A-B. *Pseudogastropylites arcticus* sp. nov. Holotype. GSC loc. 40606. GSC 17422. *Pseudogastropylites arcticus* beds. Middle mid-Albian. Christopher Formation. Banks Island, Canadian Arctic Archipelago, east bank of Thomsen River, about 19.2 km north of confluence of Muskox and Thomsen Rivers, 64 m stratigraphically below the top of the formation. A fragmentary, partly distorted adult ultimate whorl including about one-half whorl of the living chamber. 8A. Lateral view. 8B. Ventral view of the undistorted earliest part of the living chamber.

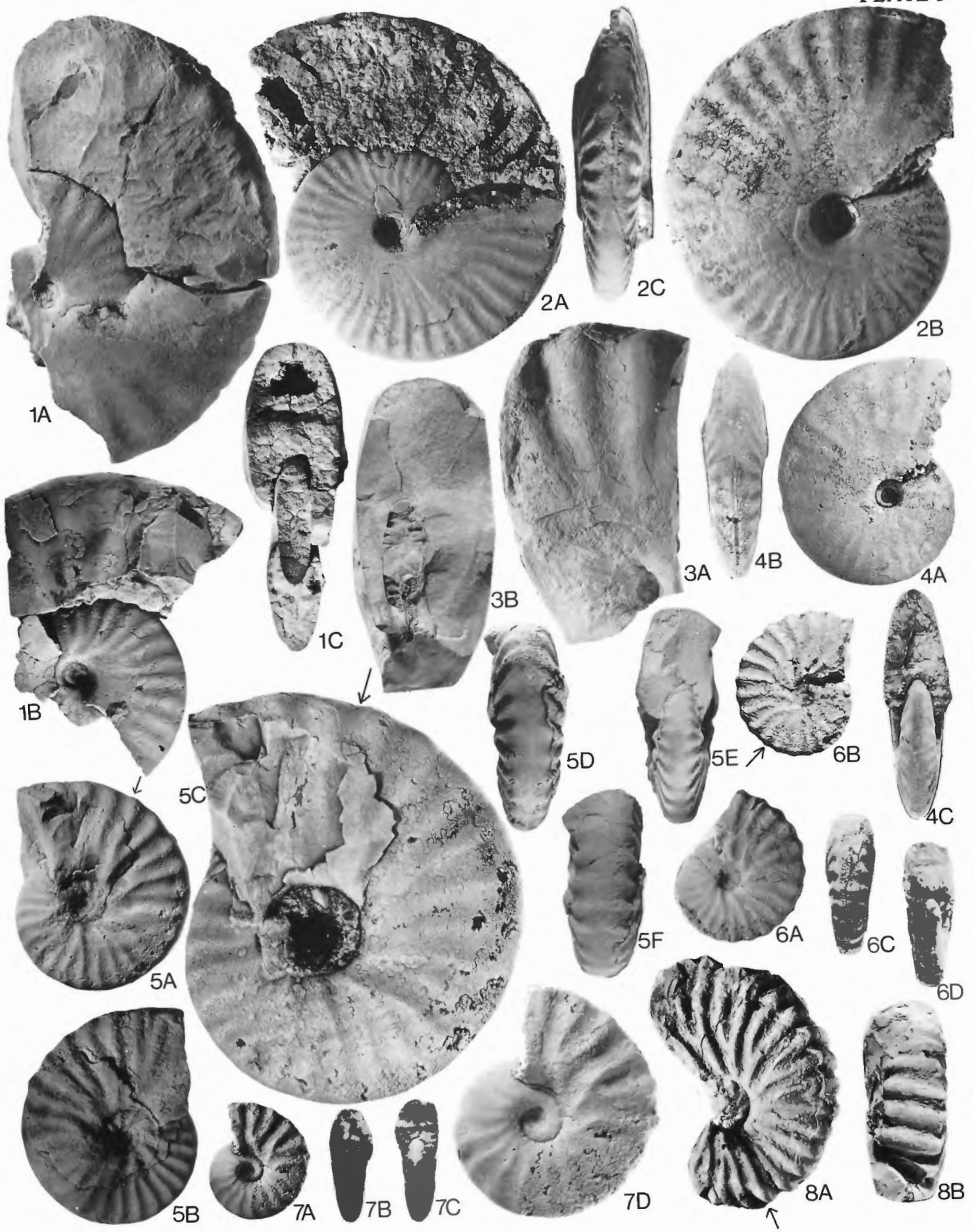


PLATE 4

Figure 1A-D. *Pseudogastrolites nanus* sp. nov. Hypotype. GSC loc. C-022695, GSC 57920. *Pseudogastrolites nanus* beds. Early mid-Albian. Christopher Formation. Same section as for GSC loc. C-022253 but collected about 34.5 m stratigraphically above the base of the Upper shale member. Northern Amund Ringnes Island, Canadian Arctic Archipelago, N.W.T. In bed of Stratigrapher River, Lat. 78°45'N, Long. 97°40'W. Typical adult representative with an about one-half whorl of the living chamber preserved. 1A. Lateral view. 1B. Lateral view of other flank with oralmost part of adult living chamber broken off. 1C. Cross-section of oral end and the ventral view of earliest part of ultimate whorl. 1D. Ventral view of the middle third of adult living chamber.

Figure 2. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 69181, GSC 57921. *Stelckiceras liardense* Zone. Latest mid-Albian. Lepine Formation. Crow River, Toad River map-area, B.C., Lat. 59°55'N, Long. 124°45'W. From lower, but not the lowermost, part of the formation above the upper Scatter sandstone. Almost complete (three quarters of a whorl of ?adult living chamber preserved) but mostly flattened ?adult representative of a sharp and angular-ribbed, non-nodose form. The well-preserved suture line is transitional between those of the *Pseudopulchellia*- and *Neogastrolites*-like variants. The oralmost two suture lines are inked in.

Figure 3A-F. *Pseudogastrolites nanus* sp. nov. Topotype. GSC loc. 43618, GSC 57922. Canadian Arctic Archipelago, N.W.T. Ellef Ringnes Island. South of Eastern Dumbbell Dome, Christopher Formation. Exact stratigraphic position unknown but presumed to be in the Upper shale member at about the same level as the GSC loc. C-022695. A half grown, somewhat deformed, fully septate specimen. The venter is broadly rounded throughout (fig. 3C, F) and the *Pseudogastrolites*-like, heavy secondaries are restricted to the oral half of the whorl (fig. 3A, D). The ribs are almost effaced on the *Cleoniceras* (*Grycia*)-like rounded venter (fig. 3B, E). 3A. Lateral view. 3B. Ventral view of adoral third of the whorl. 3C. Cross-section of the oral end and the ventral view of the earliest third of the whorl. 3D. Same view as in fig. 3A but x2. 3E. Same view as in fig. 3B but x2. 3F. Same view as in fig. 3C but x2.

Figure 4A-E. *Pseudogastrolites nanus* sp. nov. Topotype. GSC loc. 43618, GSC 57939. Same locality, formation and age as for the specimen reproduced in fig. 3A-F. A juvenile, almost undeformed representative with a part of juvenile living chamber preserved. Although considerably smaller than the halfgrown specimen reproduced in fig. 3A-F, the specimen GSC 57939 represents the same *Cleoniceras* (*Grycia*)-like growth stage. 4A. Lateral view. 4B. Ventral view of oralmost third of the whorl. 4C. Cross-section of the oral end of the whorl. 4D. Same view as in fig. 4A but x2. 4E. Same view as in fig. 4B but x2.

Figure 5. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 69180, GSC 57914. The same formation and age as for the specimen reproduced in fig. 2. Collected on the east side of Liard River, north of Lepine Creek, Toad River map-area, B.C., Lat. 59°29'N, Long. 124°46'W. Level about 198 to 213.3 m above upper Scatter sandstone.

A ?juvenile, almost completely flattened representative of the *Neogastrolites*-like variant of *Stelckiceras liardense*. The earliest part of ?juvenile living chamber is preserved. The phragmocone part of the whorl exhibits a series of typical *Neogastrolites*-like suture lines. Two well-preserved umbilical bullae are visible at the oral end of the whorl. The strongly adorally swollen secondaries are roundtopped in contrast to sharp-topped secondaries of the specimen reproduced in fig. 2.



PLATE 5

Figure 1. *Pseudopulchellia flexicostata* (Imlay 1961). Hypotype. GSC loc. C-026600, GSC 57923. *Pseudopulchellia flexicostata* beds, early but not the earliest mid-Albian. Christopher Formation, Upper shale member, about 30 m stratigraphically above the top of Sandstone unit crowning the Lower shale member of Balkwill (in press). Ellef Ringnes Island, Canadian Arctic Archipelago, Lat. 78°35'N, Long. 99°38'W. Somewhat weathered and almost completely flattened adult ultimate whorl of extremely prominent and finely ribbed variant which resembles particularly closely *Cleoniceras* (*Grycia*) *densicostata* sp. nov. (see Pl. 2, fig. 4). The specimen includes about one-quarter whorl of the living chamber. Lateral view of the only preserved flank.

Figure 2. *Stelkiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 69179, GSC 57924. *Stelkiceras liardense* Zone. Latest mid-Albian. Lepine Formation, east side of Liard River, north of Lepine Creek opposite Chimney Creek, Section ST-65-9. Lat. 58°29'N, Long. 124°46'W. Collected at the level about 122 m above the top of upper Scatter sandstone, Toad River map-area, B.C. A medium-sized, presumably intermediate, almost completely flattened but otherwise well-preserved whorl with the completely preserved living chamber. According to its inked in oralmost suture line and nodeless ribs the specimen belongs to the *Pseudopulchellia*-like extreme variant of the species. Note that the secondaries are almost completely effaced on the preserved parts of the venter. Lateral view of the only exposed flank.

Figure 3A-B. *Pseudopulchellia flexicostata* (Imlay 1961). Hypotype. GSC loc. 44044, GSC 57912. *Pseudopulchellia flexicostata* beds, early but not the earliest mid-Albian. Christopher Formation, Ellef Ringnes Island, due west of north end of Dumbbell Dome. Reported to have been collected within the lower half of Christopher Formation but the footage from its top is unknown. The writer believes that the GSC loc. 44044 is actually situated at the same level as the GSC loc. C-026600. A considerably distorted, fragmentary adult ultimate whorl of a moderately sturdy variant with about one-half whorl of the living chamber preserved. The ribs are moderately heavy and flattopped in part on the phragmocone. However, they weaken rapidly on its oralmost part and become very weak on the living chamber. 3A. Lateral view of the only preserved flank of the complete specimen. 3B. Same view as in 3A but with most of the living chamber removed to expose the stronger ribbed penultimate whorl.

Figure 4A-D. *Pseudopulchellia flexicostata* (Imlay 1961). Hypotype. GSC loc. C-026600, GSC 57925. The same locality etc. as for the specimen reproduced in fig. 1. An almost undeformed but strongly weathered in part fragment of adult ultimate whorl of a slender, feebly sculptured variant of the species. The oral quarter of the preserved half of the ultimate whorl is occupied by the living chamber. 4A. Lateral view. Only the sculpture of the phragmocone is preserved as the wall of the living chamber is almost entirely destroyed. An almost undeformed early juvenile whorl is visible inside of the living chamber. 4B. Cross-section of the adult ultimate whorl and that of the early part of adult penultimate whorl. Note the narrowly rounded, *Cleoniceras* (*Grycia*)-like cross-section of the venter of the penultimate whorl and its replacement by a broadly rounded, low-arched *Arcthoplites*-like venter on the end part of the same whorl. 4C. Ventral view of the preserved part of adult ultimate whorl. Note the rapid replacement of the *Arcthoplites*-like shaped venter of the earliest preserved part of the whorl by a much wider, almost completely flattened, *Gastroplites* (*Paragastroplites*) *spiekeri*-like venter in the undeformed, middle part of the whorl. 4D. Enlarged lateral view of the early juvenile whorl visible in fig. 4A elucidating details of its fine sculpture, x2.

Figure 5A-C. *Pseudopulchellia flexicostata* (Imlay 1961). Hypotype. GSC loc. C-026600, GSC 57926. The same locality, etc. as for the specimen reproduced in fig. 1. Somewhat deformed but almost completely preserved adult ultimate whorl of the sturdy, extremely heavily and broadly ribbed variant. The specimen is the largest representative of *Ps. flexicostata* known to the writer. 5A. Lateral view. The adventral parts of secondary ribs are flattopped, steep-flanked and *Pseudopulchellia pattoni*-like widened throughout the living chamber and on the oralmost part of the phragmocone. Only on the apicalmost one-sixth of the whorl exposed do they have shape and proportions normal for the heavily and broadly ribbed adult representatives of the species (compare fig. 5B). This unique appearance of adult secondary ribs is believed to be caused by an injury (an unsuccessful attack by a carnivorous animal). The shell is strongly deformed and locally punctured just before the level where the broadened and flattopped secondaries make their first appearance. These subsequently healed tooth marks are indicated by black triangles. 5B. Lateral view of the early part of the other flank where the ribs have a normal appearance. 5C. Ventral view of the partly deformed oralmost third of the whorl shown in fig. 5A. Note the almost completely planulate, *Gastroplites* (*Paragastroplites*)-like shape of the undeformed part of the venter at the lower margin of the photograph.

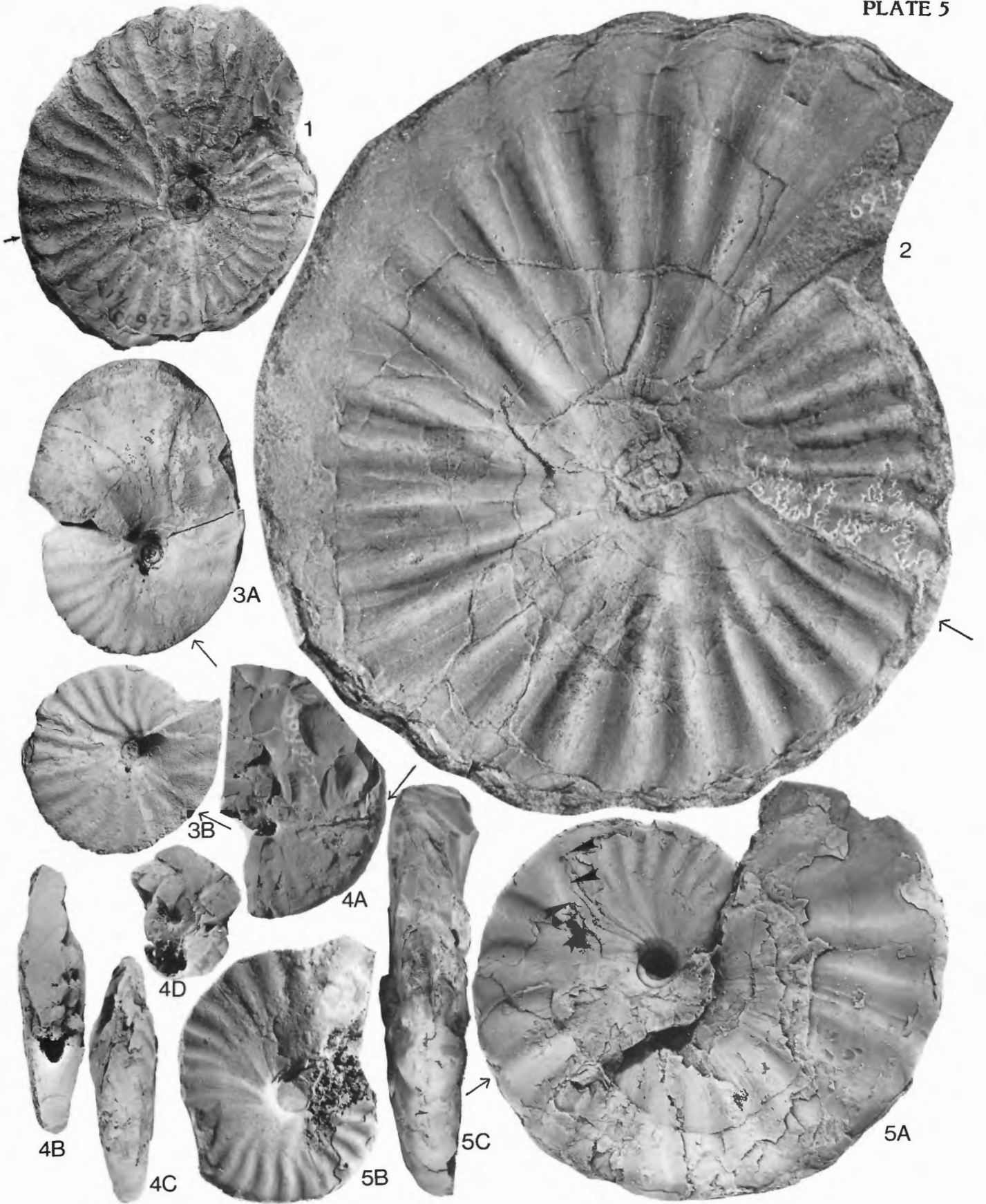


PLATE 6

Figure 1A-B. *Stotticeras crowense* sp. nov. Topotype. GSC loc. 69198, GSC 57927. ?Lower part of *Pseudopulchellia pattoni* Zone. Middle mid-Albian. Scatter Formation, Crow River, Lat. 59°55'N, Long. 124°45'W. Collected about 91.5 m stratigraphically below the top of the formation. Fragment of an intermediate whorl of a relatively feebly deformed, exceptionally heavily ribbed and pronouncedly adumbilically bullate representative of the species. 1A. Lateral view. 1B. Ventral view.

Figure 2. *Stotticeras crowense* sp. nov. Topotype. GSC loc. 69198, GSC 57928. The same locality, etc. as for the specimen reproduced in fig. 1. A strongly deformed intermediate whorl of a typical (i.e. more finely ribbed and less pronouncedly bullate representative than the specimen reproduced in fig. 1) representative of the species. Lateral view.

Figure 3. *Stotticeras crowense* n. sp. Holotype. GSC loc. 69198. GSC 57915. The same locality, etc. as for the specimen reproduced in fig. 1. Oral part of ?adult penultimate and apical part of ?adult ultimate whorl of a strongly deformed, typical representative of the species. Only a few centimetres long earliest part of ?adult living chamber is preserved. Typically developed, pronounced ornament of the intermediate whorls is restricted to the earliest exposed part of penultimate whorl. Farther adorally the ornament fades rapidly until the shell becomes completely smooth on the oralmost preserved part of the specimen. Typical external suture lines are exposed on the earliest exposed part of the whorl.

Figure 4A-E. *Pseudopulchellia flexicostata* (Imlay 1961). Hypotype. GSC loc. C-026600. GSC 57910. *Pseudopulchellia flexicostata* beds, early but not the earliest mid-Albian. Christopher Formation, Upper shale member, about 30 m stratigraphically above the top of Sandstone unit crowning the Lower shale member of Balkwill (in press). Ellef Ringnes Island, Canadian Arctic Archipelago, Lat. 78°35'N, Long. 99°38'W. Fragmentary adult penultimate whorl and a fragment of adult ultimate whorl of an extremely sturdy variant which is broadly but low and sparsely ribbed. 4A. Lateral view of complete specimen. 4B. Lateral view of preserved part of the other flank. This undeformed fragment of adult penultimate whorl exposes an excellently preserved, diagnostic umbilicus and heavy but low primary and secondary (arrows) ribs. 4C. Ventral view of the living chamber exhibiting extremely widened but low and sparse secondary ribs on the left ventral shoulder (marked by arrows). 4D. Cross-section of oral end of the fragment of living chamber. This square-shaped and flat-ventered cross-section contrasts with the enclosed broadly rounded, *Arcthoplites*-like cross-section of the penultimate whorl. 4E. Ventral view of the heavily ribbed earliest exposed part of penultimate whorl and the poorly preserved cross-section of the apical end of the fragment of adult living chamber. The low-arched appearance of the venter of the living chamber appears to be caused by its deformation and weathering.

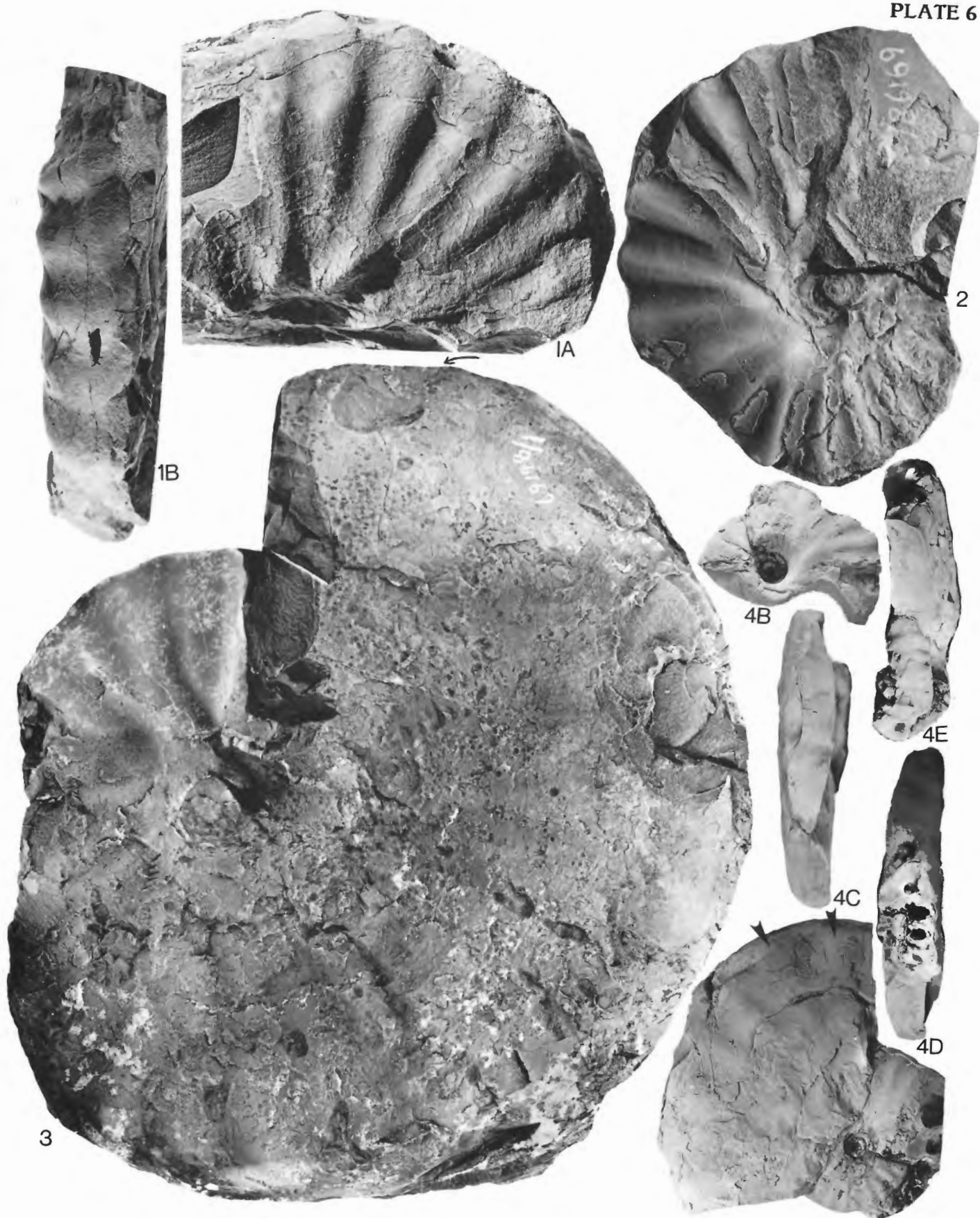


PLATE 7

Figure 1. *Stelckiceras liardense* (Whiteaves 1889). Paratype. No GSC loc. number. GSC 4808a. This is one of the four cotypes of Whiteaves (1889, p. 158). *Stelckiceras liardense* Zone, latest mid-Albian. Lepine Formation, Liard River below old Fort Halkelt, northeastern British Columbia. Collected by R.G. McConnell, 1887. Fragment of an almost completely flattened, wholly septate, early whorl largely preserved as an internal cast. The poorly preserved suture lines appear to be just as complex as those of much larger specimens.

Figure 2. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 14772, GSC 57929. *Stelckiceras liardense* Zone, latest mid-Albian. Buckinghorse Formation (middle part). Collected in an irregular nodular layer in a cliff of the left bank of Sikanni River occurring at its sharp bend below big island 12 km above the Alaska Highway. An exceptionally well preserved, relatively feebly deformed upper flank and venter of a medium-sized, intermediate whorl. Note the abrupt character of the ventral shoulder, planulate character and considerable width of the generally *Gastroplites canadensis*-like venter, and a strong weakening of secondary ribs on the venter.

Figure 3. *Gastroplites allani* McLearn 1931. Hypotype. GSC loc. 69187. GSC 57930. *Gastroplites allani* Subzone of generalized *Gastroplites* Zone. Late, but not the latest, mid-Albian. Type locality of Lepine Formation (basal) on east side of Liard River, opposite Lepine Creek. Collected on the float at the level about 76.2 m stratigraphically above siltstone equivalent of the upper Scatter sandstone and about 274.5 m above top of the lower Scatter sandstone. Lat. 59°26'N, Long. 124°46'W. Toad River map-area, B.C. Rubber mold prepared of the excellently preserved undeformed external cast of a complete intermediate whorl. Note the completely preserved horn-like protuberance of the oral margin. This morphologically extreme, pronouncedly nodose variant of *G. allani* is superficially similar to *Neogastroplites* ex gr. *haasi-selwyni*. Lateral view.

Figure 4. *Pseudopulchellia pattoni* Imlay 1961. Hypotype. GSC loc. 42272. GSC 57931. *Pseudopulchellia pattoni* Zone, middle part of mid-Albian. Commotion Formation. High (presumably within the uppermost 30.5 m) in the Hulcross Member. Ridge N. of Moberly River and E of Highrise Creek. Pine Pass map-area, B.C. Fragments of two typical, presumably adult specimens preserved as internal casts. Only a few, poor fragments of external suture lines are preserved.

Figure 5. *Pseudopulchellia pattoni* Imlay 1961. Hypotype. The same locality, etc. as for the specimens reproduced in fig. 4. GSC 57932. Fragment of a small-sized but presumably adult whorl of a specimen which is particularly similar to the holotype in shape and proportions of its ribs but exhibits at least one dichotomous rib bundle.

Figure 6. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 41602, GSC 57933. *Stelckiceras liardense* Zone, latest mid-Albian. Lepine Formation. East bank of Liard River, 16 km north of Toad River. Lateral view of the largest, almost completely preserved adult representative of the species known to the writer. This almost completely flattened specimen has the maximum shell diameter of about 380 mm (see ruler on the right for scale). The beginning of adult living chamber is marked by an arrow. Although the ribs become low and roundtopped on the living chamber, they persist right to its oral end. Poorly preserved terminal suture lines visible on the earliest exposed part of the whorl appear to be typical of the *Pseudopulchellia*-like variant of the species.

Figure 7. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 69180, GSC 57934. *Stelckiceras liardense* Zone. Latest mid-Albian. Lepine Formation. East side of Liard River, north of Lepine Creek, opposite Chimney Creek, Section SI-65-9, about 198.2 to 213.3 m stratigraphically above the upper Scatter sandstone, Lat. 59°29'N, Long. 124°46'W. A complete but almost entirely flattened early whorl of extremely closely and finely ribbed representative of the species.

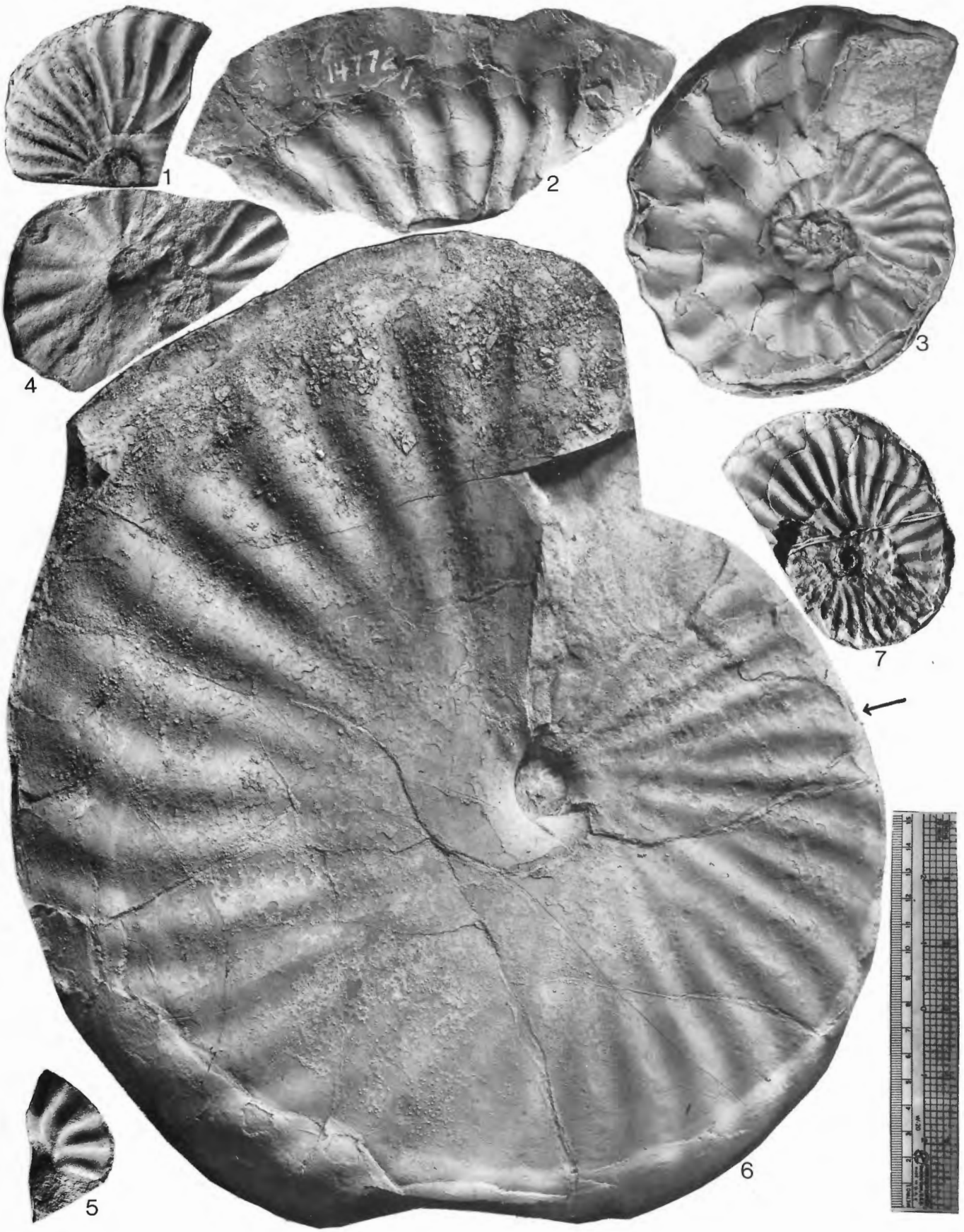


PLATE 8

Figure 1A-J. *Anagastrolites tozeri* sp. nov. Holotype. GSC loc. 25883, GSC 17420. *Anagastrolites tozeri* beds, latest mid-Albian. Christopher Formation, Upper shale member. Collected within the uppermost 30.5 m of the formation stratigraphically below its contact with the Hassel Formation. Axel Heiberg Island, Canadian Arctic Archipelago, N.W.T. Prominent ridge on east side of Amarok River, south side of Strand Fiord. Excellently preserved, undeformed, virtually complete adult ultimate whorl which permits the study of inner whorls. 1A. Lateral view of the complete specimen. 1B. Same view as 1A but with the oralmost part of adult living chamber taken off to expose the oral part of penultimate whorl. 1C. Cross-section of the oral end and ventral view of the earliest third of adult ultimate whorl. Note the relatively narrow, low-arched appearance and the markedly trapezoidal cross-section of this part of the whorl. This *Arcthoplites*-like whorl shape is then gradually transformed into a *Gastrolites* (*Paragastrolites*) *spiekeri*-like cross-section characteristic of the adult living chamber. 1D. Ventral view of the oralmost third of adult ultimate whorl. Note its broadventered appearance combined with a characteristic strengthening of pronouncedly forward bent secondaries on the venter. 1E. Lateral view of the unfigured flank of the earliest quarter of the whorl exposed in 1B. This whorl encloses the about three-quarter whorl long segment of a juvenile whorl (approx. third whorl before the adult ultimate whorl) representing the end phase of the regularly rounded and smooth *Desmoceras*-like growth stage and the earliest phase of the *Sonneratia*-like growth stage. 1F. Oral cross-section of the whorl reproduced in 1E and the ventral view of the smooth and regularly rounded earliest exposed third of the juvenile whorl. 1G. The same view as in 1E but x3. This photograph elucidates the ribbing habit of the juvenile whorl and the characteristically complex, already crowded to overlapping external suture lines of the penultimate whorl. 1H. The same view as in 1F but x3. This enlarged photograph elucidates the almost entirely smooth appearance of the venter of the earliest exposed third of the juvenile whorl. This whorl only bears one or two faint constrictions. 1I. Same view as in 1F and 1G but tilted backward to bring the middle third of the venter of the juvenile whorl into the view. This part of the venter displays an abrupt appearance of heavy and sparse, *Sonneratia*-like secondary ribs. 2J. Ventral view of the whorl's fragment displayed in 1E and 1F. Note the characteristic weakening or almost complete obliteration of secondary ribs on the venter, x3.

Figure 2A-C. *Pseudopulchellia balkwilli* sp. nov. Holotype. GSC loc. 43618, GSC 17421. *Pseudogastrolites nanus* beds, middle part of mid-Albian. Christopher Formation. Presumably from the Upper shale member of Balkwill (in press) but no data about stratigraphic position are available. Ellef Ringnes Island, Canadian Arctic Archipelago, N.W.T. South of Dumbbell Dome (exact location unknown). Undeformed, excellently preserved, wholly septate penultimate whorl of a presumably adult representative of the species. 2A. Lateral view of the flank which is preserved as an internal cast. A localized pathological swelling occurs in the middle third of the venter (marked by an arrow). This ?injury must have been healed rapidly as the shell regained its normal shape thereafter. Note excellently preserved, characteristically complex and crowded suture lines adorally of the pathological swelling. 2B. Cross-section of oral end and ventral view of the earliest exposed third of the whorl. The latter has an entirely *Cleonicerias* (*Grycia*)-like shape and proportions contrasting with the *Gastrolites* (*Paragastrolites*) *spiekeri*-like shape and proportions of the oral end of the whorl. 2C. Ventral view of the middle third of the whorl. Note the gradual oralward change of whorl's proportions and shape discussed under 2B.

Figure 3A-C. *Pseudopulchellia imlayi* sp. nov. Holotype. GSC loc. 40602, GSC 17425. *Pseudogastrolites arcticus* beds, middle part of mid-Albian. Upper part of the Christopher Formation; exact stratigraphic position within the formation unknown. Banks Island, Canadian Arctic Archipelago, N.W.T. Collected in place on the east bank of Thomsen River, about 12.8 km north of junction of Thomsen and Muskox Rivers. Inner whorl of the holotype reproduced in Pl. 3, fig. 1 extracted and figured separately to illustrate its characteristic features and the extremely simplified character of the suture line. 3A. Lateral view. 3B. Cross-section of the whorl. 3C. Ventral view of the oral third of the whorl.

Figure 4A-B. *Pseudogastrolites arcticus* sp. nov. Topotype. GSC loc. 40606, GSC 57935. *Pseudogastrolites arcticus* beds, middle part of mid-Albian. Christopher Formation. Banks Island, Canadian Arctic Archipelago, N.W.T. According to the label this specimen was collected "weathering out of shale outcrops - 64 m below upper contact of Christopher Formation" on the east bank of Thomsen River at the point about 19.2 km north of junction of Muskox and Thomsen Rivers. Fragment of adult living chamber of a representative of the species which is more sparsely ribbed than the holotype. The specimen is strongly deformed and its original whorl proportions cannot be established. 4A. Lateral view. 4B. Ventral view.

Figure 5A-H. *Anagastrolites tozeri* sp. nov. Hypotype. GSC loc. 47514, GSC 57936. *Anagastrolites tozeri* beds, latest mid-Albian. Christopher Formation, Upper shale member. Southern Axel Heiberg Island, Canadian Arctic Archipelago, N.W.T. Glacier Fiord Section(?) about 2136 m southeast of southeast end of Glacier Fiord. Collected 24.4 m stratigraphically below the base of Hassel Formation. An exceptionally well preserved and undeformed, juvenile representative of the species with an almost completely preserved living chamber. This specimen represents the later phase of the *Sonneratia*-like growth stage immediately following that represented by the juvenile whorl of the holotype reproduced in figs. 1E, F, G, I. 5A. Lateral view. 5B. Ventral view of the oralmost third of the whorl. 5C. Cross-section of the oral end and ventral view of the earliest third of the whorl. 5D. Ventral view of the middle third of the whorl. 5E. The same view as in 5A but x2 to elucidate details of the ribbing habit. 5F. Ventral view of the apical half of the whorl x2 to elucidate details of the ribbing habit. 5G. The same view as in 5D but x2 to elucidate details of the ribbing habit. 5H. The same view as in 5C but x2.

Figure 6A-B. *Anagastrolites tozeri* sp. nov. Hypotype. GSC loc. 47514, GSC 17424. The same locality, etc. as for the specimen reproduced in fig. 5. The largest adult representative of *Anagastrolites tozeri* sp. nov., known. Most of adult living chamber is preserved. Except for larger size, this specimen does not differ materially from the holotype of the species. 6A. Lateral view. Note the characteristic complexity, strong crowding and partial overlap of the oralmost suture lines. 6B. Cross-section of the oral end and ventral view of the earliest third of the whorl. 6C. Ventral view of the oralmost third of the whorl.

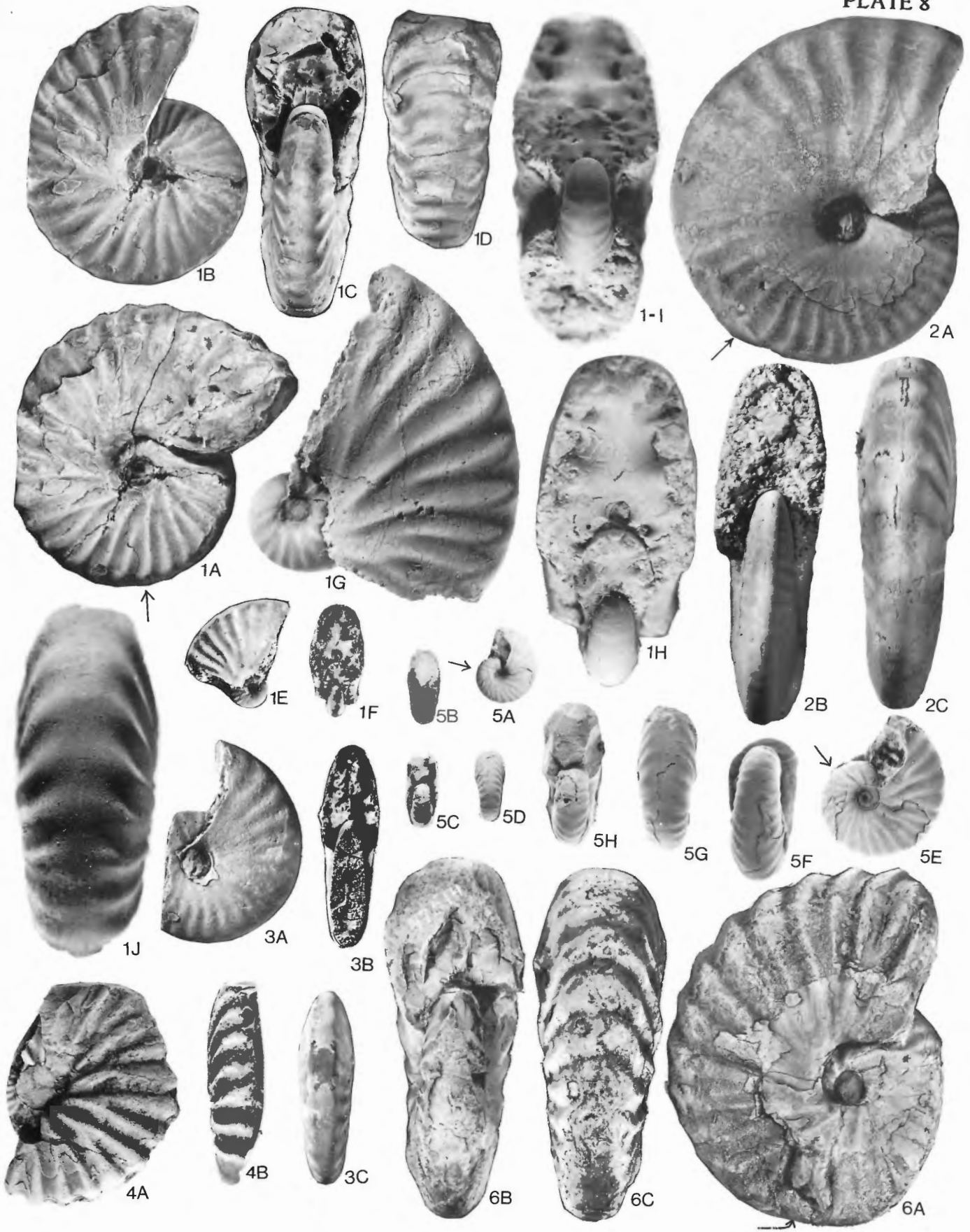


PLATE 9

Figure 1. *Stotticeras crowense* sp. nov. Holotype. GSC loc. 69198, GSC 57915. The earliest exposed part of the whorl reproduced in Pl. 6, fig. 3. Unwhitened lateral view, x2 to display details of characteristically complex, strongly crowded, and partly overlapping external suture lines characteristic of *Stotticeras* gen. nov.

Figure 2. *Cleonicerias (Grycia) densicostata* sp. nov. Topotype. GSC loc. C-022253, GSC 57905. Lateral view of the specimen reproduced in Pl. 3, fig. 4A. Unwhitened to display the details of *Pseudopulchellia flexicostata*-like external suture lines of this specimen.

Figure 3. *Cleogastrolites aberrans* sp. nov. Topotype. GSC loc. C-022253, GSC 57909. Lateral view of the specimen reproduced in Pl. 3, fig. 7A-D. Unwhitened and x3 to display the extremely strongly simplified character of intermediate external suture lines of this specimen which is diagnostic of the genus *Cleogastrolites* gen. nov.

Figure 4. *Gastrolites (Paragastrolites) spiekeri* McLearn 1931. Holotype. GSC 6339. Some part of generalized *Gastrolites* Zone. Late, but not the latest, mid-Albian. Upper member of the Peace River Sandstone. North bank of Peace River, 12.8 km below Cadotte River, Alberta. Internal cast of a wholly septate, essentially undeformed intermediate whorl. Lateral view with one of external suture lines painted white. Introduced to illustrate the pronounced contrast between this extremely strongly simplified, almost pseudoceratitic suture line with its characteristically shortened and round-tipped lobes and lobules and the incomparably more complex suture line of *Stotticeras crowense* sp. nov. (compare fig. 1) with its characteristically long, narrow stemmed, sharp-tipped lobes and lobules. See text (p. 11, 35) for further details.

Figure 5. *Gastrolites* (sensu stricto) aff. *stantoni* McLearn 1931. GSC loc. 6611, GSC 57937. Some part (?lower or *Gastrolites kingi* Subzone) of generalized *Gastrolites* Zone. Late, but not the latest, mid-Albian. Upper member of Peace River sandstone. North bank of Peace River, 3.2 km below the mouth of Cadotte River. Segment of the adoralmost part of presumably adult phragmocone of a typical representative of this primitive nonnodose form of *Gastrolites*. Introduced to illustrate the marked contrast existing between the most complex *Gastrolites* suture lines known and those of *Stotticeras crowense* sp. nov. (compare fig. 1). See description of fig. 4 and in the text (p. 11, 35) for further details.

Figure 6. *Stotticeras* sp. indet. USNM. 128740 from Shaktolik Group, Bishops Rock on Yukon River, central Alaska, U.S.A., USGS Mes. loc. 2927. Presumably collected in the equivalents of *Pseudopulchellia pattoni* Zone and of the middle mid-Albian age. This is an unwhitened photograph of the original to *Gastrolites kingi* Imlay 1961 non McLearn 1931 figured by Imlay (1961, Pl. 17, figs. 9, 16). Some chalk was rubbed into the suture lines to make them more distinct. Lateral view, x2. Introduced to illustrate the extremely close resemblance of the external suture lines of the Alaskan gastrolitid with those of *Stotticeras crowense* sp. nov. (compare fig. 1) and *Pseudopulchellia balkwilli* sp. nov. (compare fig. 7). See text (p. 11, 35) for further details concerning the genetic and taxonomic interpretation of these suture lines.

Figure 7. *Pseudopulchellia balkwilli* sp. nov. Topotype. GSC loc. 43618, GSC 17434. *Pseudogastrolites nanus* beds. Middle mid-Albian. Christopher Formation. Exact stratigraphic position unknown but the locality is presumed to represent the same part of the Upper shale member of Balkwill (in press) as the other localities (e.g. GSC loc. C-022695) of *Pseudogastrolites nanus* fauna. Ellef Ringnes Island, Canadian Arctic Archipelago, N.W.T., south of Dumbbell Dome (exact location unknown). An almost complete adult ultimate whorl of a typical representative of the species. This mostly shell-covered, strongly deformed specimen includes about one-half whorl of adult living chamber. Unwhitened lateral view to display details of well preserved adoralmost adult suture lines. See Jeletzky (1964, Pl. XXXII, fig. 4A) for the whitened lateral view of this specimen. Introduced to illustrate the strong resemblance of external suture line of *Pseudopulchellia balkwilli* sp. nov. to those of *Stotticeras crowense* sp. nov. (compare fig. 1) and *Stelckiceras liardense* (Whiteaves) (compare Pl. 4, fig. 2, Pl. 5, fig. 2).

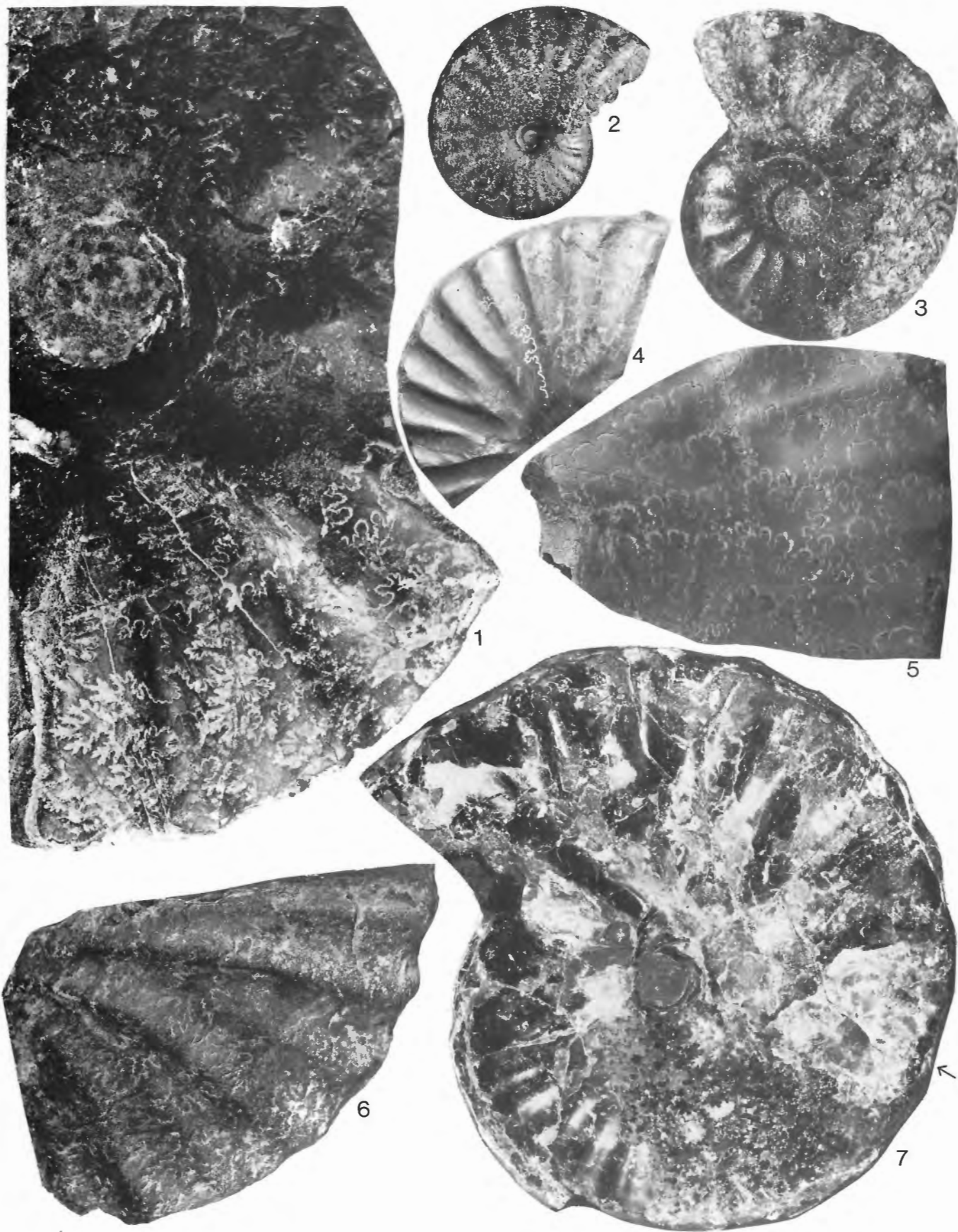


PLATE 10

Figure 1A-B. *Gastroplites* (sensu stricto) aff. *stantoni* McLearn 1931. GSC loc. 6611, GSC 57937. Some part (?lower or *Gastroplites kingi* Subzone) of generalized *Gastroplites* Zone. Late, but not the latest, mid-Albian. Upper member of Peace River sandstone. North bank of Peace River, 3.2 km below the mouth of Cadotte River. 1A. Lateral view. 1B. Ventral view. See Pl. 9, fig. 5 for the reproduction of the suture line of this specimen.

Figure 2A-E. *Pseudogastroplites cantianus* (Spath 1937). Holotype. British Museum (Nat. Hist.) C.41556. Latest middle Albian, Junction Bed 8, Cristatum Subzone. Gault Formation. Folkestone, England. Photographs of a plaster cast kindly supplied by H. Owen, British Museum (Natural History). Introduced for comparison with the Canadian representatives of *Pseudogastroplites* gen. nov. described and figured in this paper. 2A. Lateral view. 2B. Lateral view of the other flank with excellently preserved suture lines. The few adoralmost suture lines are markedly crowded as compared with the earlier suture lines visible on the same flank. The arrow marks the beginning of adult body chamber. 2C. Cross-section of the oral end and the ventral view of the earliest part of the whorl. Note the broadly rounded cross-section of this part of the whorl which contrasts with the subrectangular, almost flat ventered cross-section of the oral end. 2D. Ventral view of the adoralmost preserved third of the whorl. Note the straight, fold-like appearance of secondary ribs. 2E. Ventral view of the earliest exposed third of the venter. The secondary ribs are again straight and fold-like.

Figure 3A-B. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 14772, GSC 61348. *Stelckiceras liardense* Zone. Buckingham Formation (middle part). Collected in an irregular nodular layer in a cliff of the left bank of Sikanni River occurring at its sharp bend below big island 12 km above Alaska Highway. The smallest definitively identifiable juvenile representative of *S. liardense* known to the writer. The ribbing habit closely resembles that of the medium-sized representatives of the species (e.g. Pl. 7, fig. 2). The character of the venter is uncertain as the specimen is almost completely flattened. 3A. Lateral view, x1. 3B. Same view as in 3A but x2 to elucidate fine details of the ribbing habit.

Figure 4A-B. *Stelckiceras liardense* (Whiteaves 1889). Hypotype. GSC loc. 69181, GSC 61347. *Stelckiceras liardense* Zone, latest mid-Albian. Lepine Formation, Toad River map-area, Crow River, Lat. 59°55'N, Long. 124°45'W. Lower, but not the lowermost, part of the formation above upper Scatter sandstone. A medium-sized ?living chamber with the but feebly deformed venter in its earliest preserved part (fig. 4A). The ribs are triangular in cross-section and sharptopped. Unlike the ribs of most other representatives of *S. liardense* (e.g. Pl. 4, fig. 5, Pl. 5, fig. 2, Pl. 7, figs. 2, 6, 7), they widen but slightly in the proximity of the ventral shoulder. 4A. Lateral view. 4B. Ventral view of the least deformed, earliest part of the whorl. So far as possible to judge, the venter is only preserved to about its middle.



