BUCHIID BIVALVES FROM THE UPPER JURASSIC
AND LOWER CRETACEOUS OF EAST
GREENLAND

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ABSTRACT. Bivalves of the genera *Praebuchia* and *Buchia* described here occur in great abundance in the Oxfordian to Valanginian Stages of East Greenland. Fifteen species have been identified. Their stratigraphic range is roughly the same as in other Arctic areas, and a detailed zonation based on buchiid bivalves seems to be valid from Arctic Canada over East Greenland to Andey, Svalbard, Petschora River basin, Subarctic Urals, and northern Siberia. The following zones and beds have been recognized in East Greenland: The Upper Oxfordian *Praebuchia kirghisensis* Zone, the Kimmeridgian *Buchia concentrica* and *B. temnistrata* Zones, the Middle Volgian *B. mosquensis* Zone and *B. russiensis* beds, the Upper Volgian *B. fischeriana* beds, the Upper Volgian–lowermost Ryazanian *B. unschensis*–*B. terebratuloides* beds, the Lower Ryazanian *B. okensis* Zone, the Upper Ryazanian *B. volgensis* Zone, the uppermost Ryazanian–lower Lower Volgianian *B. inflata* Zone, the upper Lower Valanginian *B. keyserlingi* Zone, the Upper Valanginian–(?) Hauterivian *B. sublaevis* and *B. crassicolis* Zones.

The genus *Buchia* has been recognized at many localities in the Upper Jurassic and Lower Cretaceous of East Greenland (text-fig. 1). Madsen (1904), Ravn (1911), Spath (1936, 1947, 1952), Frebold (1933), Jeletzky (1965), Surlýk and Clemmensen (1975) and Surlýk (1973) all described and figured species of *Buchia*. Most of this material is restricted to scattered finds. A biostratigraphic scheme incorporating figured species of *Buchia* based on a large material collected in measured sections was constructed by Surlýk (1978a, b), and the present paper is the first monographic account of the Greenland material of this stratigraphically important genus, and its predecessor *Praebuchia*.

The material was collected by one of us (F.S.) in south Jameson Land in 1970 and 1971 and in Kuhn Ø and Wollaston Forland in 1974 (text-fig. 1 and fig. 9 in Surlýk 1978a). Material collected by F. Fürsch on Milne Land in 1977 has also been incorporated.

Species of *Praebuchia* and *Buchia* occur scattered throughout the Upper Oxfordian–Kimmeridgian dark mudstones of the Hareelv and Bernbjerg Formations (text-figs. 1, 2; Table 1) (Surlýk *et al.* 1973; Surlýk 1977). The shallow marine, coarse sandstones of the Lower Volgian–Lower Valanginian Raukelv Formation and the slightly deeper water silt- and sandstones of the Ryazanian–Lower Valanginian Hesteel Formation (Surlýk 1973) contain a more diverse *Buchia* fauna. The greatest density and diversity are, however, reached in the relatively deep-water conglomerates, sandstones, and mudstones of the Middle Volgian–Valanginian Wollaston Forland Group (Surlýk 1978a).

Some uncertainty still exists concerning the stratigraphic nomenclature across the Jurassic–Cretaceous boundary. The deposits of the Boreal faunal realm cannot yet be precisely dated within the framework of the Tithonian–Berriasian Stages of the Tethyan realm. Russian authors generally use the Volgian as the final Jurassic stage and the Berriasian as the basal Cretaceous stage in the boreal USSR. Casey (1973) suggested that the Volgian and Berriasian Stages overlapped and advocated the use of the Ryazanian Stage for the basal Cretaceous deposits until Tethyan–Boreal correlations were satisfactorily established. This usage has been followed in all subsequent work on the Jurassic–Cretaceous boundary strata in East Greenland (Surlýk *et al.* 1973; Surlýk 1973, 1977; 1978a, b; Birkelund, Callomon and Fürsch 1978).

TABLE 1. Lithostratigraphy of the Jurassic-Cretaceous boundary sequences in Jameson Land and Wollaston Forland, East Greenland.

TEXT-FIG. 1. Map showing the localities mentioned in the text and the distribution of the Upper Jurassic-Lower Cretaceous *Buchia*-bearing sediments.
TEXT-FIG. 2. Simplified geologic map of southern Jameson Land showing distribution of the Jurassic-Cretaceous boundary strata and main synsedimentary structural features. Modified from unpublished GGU map compiled by F. Sarlyk and T. Birkeland.
It is therefore also used in the present paper, although Zakharov (1981) in his monograph on *Buchia* of the Arctic USSR follows the general Russian practice. It should, however, be noted that Berriasian sensu Rossico is identical with the Ryazanian as defined on the Russian Platform (Casey 1973) and more or less identical with Berriasian/Ryazanian as used in Siberia (see Table 1).

The lithostratigraphic nomenclature follows Surlyk *et al.* (1973) and Surlyk (1973, 1977, 1978a) and the majority of the sections where buchiid bivalves have been collected are figured in these papers.

**SYSTEMATIC PALAEOENTOLOGY**

Boreai buchiid bivalves include two genera: *Praebuchia* Zakharov (1981) (Callovian–Oxfordian) and *Buchia* Rouillier (1845) (Oxfordian–Hauterivian) (text-fig. 3). In *Praebuchia* five species are recognized, while *Buchia* is represented by more than thirty species. The main difference between the two genera lies in the morphology of the hinge.

In *Praebuchia* the ligamental area is placed in the commissure plane, while in *Buchia* it forms an angle with this plane. *Praebuchia* is furthermore characterized by continuous grooves on the ligamental area anteriorly to the umbo, while in *Buchia* they are interrupted by a transverse ridge from the umbo (text-fig. 3). The ligament of *Praebuchia* was internal, whereas it was partly external in *Buchia*. *Buchia* possesses a well-developed byssal notch, while the margin of the ligamental area of *Praebuchia* is only slightly curved to allow the passage of an anterior auricle (Zakharov 1981).

Buchid bivalves are characterized by a rapid rate of evolutionary change, and show a wide geographical distribution within the Late Jurassic–Early Cretaceous of the Boreal Realm, where they occur in a wide variety of facies. Taken together, these features make buchiid bivalves extremely

**TEXT-FIG. 3.** A, hinge structure in *Buchia* (from Zakharov 1981, fig. 5) and *Praebuchia* (from Zakharov 1981, fig. 26). a, comparison of ligament structure and position in *Buchia* and *Praebuchia*. Upper row, left valves; middle row, right valves; lower row, transverse sections. Lamellar layer is shown in black, and fibrous layer is cross-hatched. The main portion of the shells is indicated with stippled ornamentation.
valuable for stratigraphic purposes and they have accordingly received considerable attention for more than a hundred years.

This has led to a proliferation of names, and at present about 150 specific names have been founded within the genus *Buchia* alone. This extreme splitting is, however, opposed by another group of workers, who have used a very broad species concept. Either approach by itself may be detrimental for sound stratigraphic work, and the taxonomy at species level has to be based on studies of large, well-preserved populations. A discussion of these problems is given by Zakharov (1981). Full synonymy lists are also given for each species by Zakharov (1981) and here we only include earlier references from Greenland.

**Family Buchiidae Cox, 1953**

**Genus Praebuchia Zakharov, 1981**

*Type species.* *Praebuchia orientalis* Zakharov, 1981

*Range.* Upper Callovian–Lower Oxfordian, northern Siberia.

*Praebuchia kirghisensis* (Sokolow, 1902)

Plate 72, figs. 1-3

1911 *Aucella kirghisensis* Raven, p. 455, pl. 32, fig. 2.

*Material.* About ten poorly preserved specimens from Wollaston Forland, sections 38 and 41 in Suryk (1977), and more than forty well-preserved specimens from Milne Land collected by F. Fürsich in 1977. Includes GGU 139450 (cf.), GGU 139451 (cf.) = MGUH 15341, GGU 139480 (cf.), GGU 235458 = MGUH 15348 (F. Fürsich coll.), GGU 235459 = MGUH 15349 (F. Fürsich coll.).

*Remarks.* Both casts and preserved valves of this eovalved species are easy to determine because of the lack of concentric ribs, their almost smooth surfaces, and moderately oblique angle (60°) between the hinge and median line. The shell is considerably inflated (Pl. 72, figs. 1, 2). The specimens from Milne Land are almost identical with specimens from Petshora River and Moscow region figured by Zakharov (1981, pl. 2).

*Stratigraphical occurrence.* The Milne Land material is from the Aldinger Elv Member (Upper Oxfordian Zones of *Amebeloberas glisseae* and *A. serratum*). The Wollaston Forland specimens occur in the Upper Oxfordian part of the Bernbjerg Formation (*A. serratum* and *A. regale* Zones). Raven’s (1911) specimen from Store Koldewey is from the Upper Oxfordian Klaft I Formation (Tables 2, 3).

In the northern part of the northern Eurasian Urals the species occurs throughout the Oxfordian but reaches peak abundances in the Upper Oxfordian (*A. alternans* Zone).

**Genus Buchia Roulllier, 1845**

*Type species.* *Avicula mosquensis* von Buch, 1844, p. 537.

*Range.* Lower–Middle Volgian of the Russian Plain.

*Buchia concentrica* (J. de C. Sowerby, 1829)

Plate 72, fig. 5

1911 *Aucella bronni* Raven, p. 455, pl. 32, fig. 5.

1911 *Aucella sinzovi* Raven, p. 456, pl. 32, fig. 3.

1911 *Aucella cf. reticulata* Raven, p. 458, pl. 32, fig. 4.

1935 *Aucella aff. bronni* Spath, p. 53, pl. 3, fig. 2; pl. 8, fig. 3.

*Material.* About ten specimens from Kahn Ø and Wollaston Forland (sections 1, 8, 40 in Suryk 1977). Includes GGU 139305, GGU 139331, GGU 139332 = MGUH 15329, GGU 139471 (cf.).
Remarks. The species is characterized by its distinct radial ribs crossed by concentric ribs resulting in the formation of reticulate ornamentation. The upper part of the right valve is slightly concave in typical specimens. The shell is strongly oblique (Pl. 72, fig. 5). Poorly preserved specimens can be mistaken for *B. tenuistriata*.

Stratigraphical occurrence. Upper Oxfordian of Milne Land and Store Koldewey, and Kimmeridgian of Milne Land, Wollaston Forland, and Kuhn Ø (up to and including the Zone of *Aulacostephanus mutabilis*) (Tables 2, 3).

*B. concentrica* has the widest geographic distribution within the Boreal Realm of the Oxfordian-Lower Kimmeridgian species of *Buchia*. It is particularly abundant in the Lower Kimmeridgian (Zones of *Pictonia baylei* and *Rasenia cymodoe*) of the Upper Kimmeridgian of East Greenland (*A. mutabilis* Zone) and is well preserved and the determination is questionable.

*Buchia lindstroemi* (Sokolow, 1908)
Plate 72, fig. 4

Material. Well-preserved internal mould of one right and one left valve from Milne Land collected by T. Birkelund and J. H. Callomon. Includes GGU 234071 = MGUH 15347 (F. Fürsich coll.)

Remarks. The species is characterized by its large adult size, strongly oblique shape, and ornamentation comprising strong closely but irregularly spaced folds with superimposed ribs. The less prominent radial ornamentation consists of weak striae.

Stratigraphical occurrence. In East Greenland the species has only been found in the Lower Kimmeridgian. This rare species occurs in the Upper Oxfordian-Lower Kimmeridgian of Eurasia and northern Alaska (Inlay 1959). It is everywhere associated with *B. concentrica*, but in northern Siberia ammonite evidence confirmed occurrences only in the Lower Kimmeridgian.

*Buchia tenuistriata* (Lahusen, 1888)
Plate 72, figs. 6-11; Plate 73, figs. 1, 2
1911 *Aucella tenuistriata* Ravn, p. 458, pl. 32, fig. 7.

Material. About twenty specimens from Kuhn Ø (section 8, Surløy 1977), and more than fifty specimens from the collection of Maync (1947). The latter are from a locality on the west coast of Kuhn Ø, but the exact location

EXPLANATION OF PLATE 72

All specimens except 9 are figured in natural size.


Fig. 3. Praebuchia cf. kirghisensis (Sokolow). GGU 139451. Internal cast of a large, strongly deformed right valve. Bernbjerg Formation, *Amoeboceras* (*P.*-) *serratum* Zone. Section 38, 228 m in Surløy 1977, fig. 16. Cardioceratid, south-west Wollaston Forland.

Fig. 4. Buchia lindstroemi (Sokolow). GGU 234071 (Fürsich coll. 1977). α, lateral view of left valve. β, lateral view of right valve, probably the same individual as in α.

Fig. 5. Buchia concentrica (J. de C. Sowerby). GGU 139332. Internal cast of right valve with flattened lower part. Bernbjerg Formation, *Aulacostephanus mutabilis* Zone. Section 8, 168 m in Surløy 1977, fig. 24. Eastern slope of Bernbjerg, south-west Kuhn Ø.

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is unknown. Includes GGU 139330 = MGUH 15328, GGU 139331 (cf.), GGU 139332 (cf.), GGU 139336 = MGUH 15330, GGU 139337 (cf.), GGU 139458 (cf.), GGU 139472 = MGUH 15342, (1240–87, Mayne coll.).

Remarks. *B. tenuistriata* is closely related to *B. mosquensis* (Pavlov 1907, p. 22, pl. 2, figs. 5–8) and is quite often mistaken for this species. Both species are extremely variable and satisfactory identifications can be made only on large samples. *B. tenuistriata* is characterized by its narrower and less oblique shell and in possessing more well-developed radial striation. The radial keel of the right valve is only feebly developed or totally absent. The left umbo is slightly prosogyrate and is obliquely truncated anteriorly.

Stratigraphical occurrence. The species occurs in the Lower and in particular Upper Kimmeridgian of Kuhn Ø, and in the Kimmeridgian at Danmarks Havn in southern Germania Land (Sykes and Surylk 1976). It occurs in great abundances in the Upper Kimmeridgian in the northern part of the European USSR and in northern Asia, but in some localities such at Petshora River it also occurs in the Lower Kimmeridgian together with *B. concentrica*.

*Buchia mosquensis* (von Buch, 1844)

Plate 73, figs. 3, 4

1904 *Aucella pallasii* Madsen, p. 178, pl. 6, fig. 7.
1936 *Buchia mosquensis* Spath, p. 98, pl. 42, fig. 1 (not 1e).

Material. About ten specimens from southern Jameson Land. Very common in the Perna Ryggen Member of Milne Land (F. Fürsch coll.). Includes GGU 143120 = MGUH 15346.

Remarks. The specimens are typical representatives of the species. The right valve possesses a keel which divides the surface of the valve into flat posterior and anterior parts. The anterior margin of the shell is broadly rounded. The left valve is inflated and has a twisted beak.

Stratigraphical occurrence. On Jameson Land the species occurs in the mainly Middle Volgian Sjøellandselv Member of the Fynselv Formation (Table 1) (Surylk et al. 1973) and in sandstones presumably of the same age at Aucellaev (Madsen 1904). The material from Milne Land described by Spath (1936) is also from the Middle Volgian, and collections by F. Fürsch can be dated as belonging to the Dorsoplanites šlovaškii, *D. maximus*, and Crendonites sp. Zones (Table 2).

In northern Eurasia the species has its first appearance in the Upper Kimmeridgian but reaches its main abundance in the Lower and Middle Volgian. It has never been found in the Upper Volgian. The species has been reported from the Lower and Upper Kimmeridgian by Paraketsov (1968), but his material can in our opinion be referred to *B. tenuistriata*.

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EXPLANATION OF PLATE 73

All specimens are figured in natural size.


Figs. 3–4. *Buchia mosquensis* (von Buch). GGU 143120. All specimens are internal moulds. 3a, lateral view of left valve. 3b, dorsal view of umbonal part of same valve as in 3a. 4, lateral view of right valve. Raukelv Formation, Sjøellandselv Member, Middle Volgian, 305 m above sea level. Southern Jameson Land.

Figs. 5–12. *Buchia russiaensis* (Pavlov). GGU 139393. All specimens are internal moulds. 5–8, lateral view of right valves. 9–12, lateral view of left valves. Lindemans Bugt Formation, Laugteites Ravine Member, *Epilaugteites vogulicus* Zone. Section 20, 88 m in Surylk 1978a, appendix. Niesen, northern Wollaston Forland.
SURLYK and ZAKHAROV, *Buchia*
Buchia russiensis (Pavlov, 1907)
Plate 73, figs. 5–12, Plate 74, figs. 1–4
1978a Buchia ex gr. volgensis Surlyk, p. 30, pl. 1, fig. 2; pl. 2, fig. 3.

Material. About sixty casts and moulds of left and right valves from western Kuhn Ø, section 5 in Surlyk (1978a) and locs. 7, 9, 10, 11 of Donovan (1964), and several casts and moulds from northern Wollaston Forland, section 20 of Surlyk (1978a). Includes GGU 139317 = MGUH 15327, GGU 139318, GGU 139319 (cf.), GGU 139321 (cf.), GGU 139323 (cf.), GGU 139393 = MGUH 15333, GGU 139342 = MGUH 15338, GGU 139433 (cf.).

Remarks. B. russiensis is geographically widespread and shows great variation both within and between populations. The present material is most closely related to populations from the Petschora and Vologa Rivers (D. maxinus–Laugelites groenlandicus Zones) (Zakharov 1981, pl. 15). The main characteristic of this type is the large size, and the left valves show great resemblances to B. volgensis in being inflated and in possessing a large incurved beak. Some of the left valves and most of the right valves correspond to the form called B. russiensis var. moionikensis by Jeletzky (1965, pl. 1, figs. 4, 5, 9). Several right valves are close to B. Fischeriana from northern Siberia (Zakharov 1981, pl. 21, fig. 22) and from Arctic Canada (Jeletzky 1966, pl. 8, figs. 2–6, 9), but differ in not having regular concentric ribs.

Stratigraphical occurrence. All the material comes from the Middle Volgian Zones of L. groenlandicus and Epilaugelites vogulicus. Outside East Greenland B. russiensis occurs in the Middle Volgian and the lowermost Upper Volgian (Zone of Kachpuriites fulgens) of the Petschora River basin. Populations composed of large-sized specimens are characteristic of the uppermost Middle Volgian.

Buchia Fischeriana (d’Orbigny, 1845)
Plate 74, figs. 5, 6
1978a Buchia aff. Fischeriana Surlyk, pl. 4, fig. 12 (some of the specimens on the slab of sandstone may belong to B. unschensici).

EXPLANATION OF PLATE 74

All specimens are figured in natural size.

Figs. 1–4. Buchia russiensis (Pavlov). 1–3, GGU 139317. All specimens are internal moulds. 1–2, lateral view of left valves. 3, lateral view of right valve. Lindemans Bugt Formation, Laugelites Ravine Member. Laugelites groenlandicus Zone. Section 5, 10 m in Surlyk 1978a, appendix. Laugelites Ravine, western Kuhn Ø. 4, GGU 139432, a, lateral view of left valve and b, dorsal view of umbonal part. Lindemans Bugt Formation, Laugelites Ravine Member, probably Laugelites groenlandicus Zone. West of Sillerendal, northern Wollaston Forland.

Figs. 5–6. Buchia Fischeriana (d’Orbigny). GGU 139417. 5, lateral view of left valve and 6, of right valve. Lindemans Bugt Formation, Niesen Member. 'Virgatosphinctes' teniscoptatus beds. Section 20, 175–180 m in Surlyk 1978a, appendix.

Figs. 7–9. Buchia terebratuloides (Lahusen). GGU 139429. 7a, b, c, lateral, posterior, and dorsal view of left valve. 8, lateral view of left valve. 9, lateral view of right valve. Lindemans Bugt Formation, Rigi Member, Upper Volgian, Section 14, 120 m in Surlyk 1978a, appendix.

Fig. 10. Buchia terebratuloides (Lahusen). GGU 138177. Lateral view of right valve. Hesteev Formation, Muslingelv Member, Hectoroceras kochi Zone. Muslingelv, southern Jameson Land.

Figs. 11–12. Buchia unschensici (Pavlov). GGU 138182. 11, lateral view of right valve. 12a, lateral and b, anterior view of left valve. Hesteev Formation, Muslingelv Member, Hectoroceras kochi Zone. Muslingelv, southern Jameson Land.

SURLYK and ZAKHAROV. Buchia
Material. About thirty specimens from Wollaston Forland, section 20 of Surløy (1978a), including GGU 139417 = MGUH 15334, GGU 139428.

Remarks. Correct identification is difficult because the material comprises only moulds of flattened densely packed specimens. The typical regular concentric ribs are, however, well preserved on a number of specimens, and the characteristic slight increase in obliquity of both valves can also be observed.

Stratigraphical occurrence. In East Greenland the species occurs in the top Middle Volgian (E. vogulicus Zone) and Upper Volgian ('Virgatosphinctes' tenuicostatus beds).

*B. fischeriana* has often been observed in the uppermost Middle Volgian (*Epivirgatites nikitini* Zone), in the Upper Volgian, and in the basal Rayanian of the central part of the Russian Plain. In northern Siberia the species has its greatest abundance in the Upper Volgian, where it occurs together with *B. unschensis*, *B. terebratuloides*, and *B. obliqua*. It is very rare in the basal Rayanian of northern Siberia, but occurs in the Middle Volgian–Lower Rayanian of Peary Land, North Greenland.

*Buchia terebratuloides* (Lahusen, 1888)

Plate 74, figs. 7–10

1947 *Buchia cf. terebratuloides* Spath, pl. 2, figs. 7, 8.

1947 *Buchia volgensis* Spath, pl. 1, fig. 9; pl. 3, fig. 5c (only).

1952 *Buchia volgensis* Spath, pl. 3, figs. 6, 7; pl. 4, fig. 4.

Material. More than fifty specimens from Wollaston Forland (sections 14, 20, and 45 of Surløy 1978a) and southernmost Jameson Land. In addition, the samples contain many poorly preserved specimens which cannot be safely determined but belong either to *B. terebratuloides* or to *B. unschensis*. Includes GGU 138177 = MGUH 15324, GGU 138181, GGU 138182, GGU 138183, GGU 138184 (cf.), GGU 138185, GGU 138187, GGU 138191, GGU 138193, GGU 139402, GGU 139403, GGU 139429 = MGUH 15337, GGU 139491, GGU 139502 (cf.).

Remarks. The specimens are mainly of medium size, slightly oblique, and relatively high. Both valves show equal convexity, but the beak of the left valve is more massive than of the right valve and is furthermore elongated and overhangs the hinge line. The concentric ribs are irregularly spaced and not uniform in relief. They are more weakly developed on the cast than on the outer surface of the shell.

Stratigraphical occurrence. *B. terebratuloides* occurs in the upper part of the Volgian ('*V.* tenuicostatus beds') and in the Lower Rayanian (P. maynchi and *Hectoroceras kochi* Zones). On the Russian Platform this species appears in the lowermost Upper Volgian (K. fulgens Zone), reaches its greatest abundance in the Upper Volgian *Craspedites* beds, and occurs only rarely in the lowermost Rayanian. In northern Siberia and in the Petschora River basin *B. terebratuloides* mainly characterizes the Upper Volgian. The same stratigraphic distribution is found at the Pacific coast of North America and in Arctic Canada (Jones, Bailey and Imlay 1969; Jeletzky 1973).

**EXPLANATION OF PLATE 75**

All specimens are internal moulds and are figured in natural size.

Fig. 1. *Buchia okensis* (Pavlov). GGU 138190. A, lateral view and B, anterior view, of left valve. The specimen was figured by Surløy 1973, pl. 1, fig. 1. Hesteel Formation, Muslingevl Member, *Hectoroceras kochi* Zone, Muslingevl, southern Jameson Land.

Fig. 2. *Buchia volgensis* (Lahusen). GGU 143101. A, lateral view and B, dorsal view of left valve. C, left view of right valve. Raukelv Formation, Fynselv Member, top beds, Upper Rayanian, 420 m above sea level. West of Fynselv, upper reach, southern Jameson Land.

Fig. 3. *Buchia inflata* (Lahusen). GGU 139439. A, lateral and B, anterior view of right valve. Palnoktes Bjerg Formation, Albrechts Bugt Member, Lower Valanginian, Section 35, 430 m, south side of Niesen, Wollaston Forland.
SURLYK and ZAKHAROV, *Buchia*
**Buchia unschensis** (Pavlov, 1907)

Plate 74, figs. 11–14

1947  *Buchia volgensis* Spath, p. 34, pl. 3, fig. 5a, b; (?) pl. 4, figs. 8–9; pl. 5, figs. 1–2.
1952  *Buchia volgensis* Spath, pl. 1, fig. 1; pl. 4, figs. 5, 7.

**Material.** More than twenty specimens (see also under *B. terebratuloides*) from Wollaston Forland (section 20 of Surlyk, 1978a) and southern Jameson Land. Includes GGU 138177 (cf.), GGU 138181, GGU 138182 = MGUH 15325, GGU 138185 (cf.), GGU 138187, GGU 138189 (cf.), GGU 139402, GGU 139403, GGU 139437 = MGUH 15339, GGU 139502 (cf.), GGU 143065 (cf.).

**Remarks.** The specimens are of medium to moderately large size for the species. The shell has a rounded non-oblique shape. The surface is covered by regularly spaced ribs of equal strength. The posterior part is broad and wing-like. The better-preserved specimens are strongly reminiscent of specimens from the lowermost *H. kochi* Zone of northern Siberia (Zakharov 1981, pl. 29, figs. 1–3). The only differences are the less convex valves, more narrow elongated beaks on the left valve, and less regular ribs of the East Greenland specimens. On the basis of these features Jeletzky (1973) referred the specimens figured by Spath (1947) to *B. terebratuloides* and *B. sp. nov. aff. okensis*.

Here we interpret the features as intraspecific variation within the Greenland material of *B. unschensis*.

**Stratigraphical occurrence.** In East Greenland the species occurs in the Upper Volgian (*V.* tepenicostatus beds) and Lower Ryazanian (*P. maynici–H. kochi* Zones). *B. unschensis* is widespread in the northerly (mainly Arctic) deposits of the Upper Volgian *Craspedites subdilus* Zone and the Lower Ryazanian *H. kochi* Zone. It is even more abundant in the Jurassic–Cretaceous boundary beds in northern Siberia, Petshora River, Spitzbergen, North Greenland, and probably in Arctic Canada (Jeletzky 1966, Zakharov 1981). It occurs together with *Hectoroceras* sp. in the lower part of the Ryazanian at the Oka River (Mesezhnikov et al. 1977, 1979).

**Buchia okensis** (Pavlov, 1907)

Plate 75, fig. 1

1973  *Buchia okensis* Surlyk, pl. 1, fig. 1.

**Material.** Two specimens from southern Jameson Land, GGU 138190 = MGUH 15326, GGU 138191.

**Remarks.** Identification is somewhat difficult as the material comprises only incomplete left valves. The surface of the moulds is sculptured by a few coarse concentric folds, which are strongest at the anterior margin and become more smooth towards the posterior margin. The coarsely ribbed specimens closely resemble basal Ryazanian forms from the Pakhsa Peninsula, northern Siberia (Zakharov 1981, pl. 35, figs. 1, 2), Vancouver, British Columbia (Jeletzky 1965, pl. 6, figs. 1, 3–5), northern Alaska (Imlay 1961, pl. 7, figs. 12, 17–20) and Canadian Arctic Archipelago (Jeletzky 1964, pl. 1, fig. 1). The specimens from Jameson Land differ in having more irregularly spaced folds.

**Stratigraphical occurrence.** In East Greenland the species occurs in the Lower Ryazanian (*H. kochi* Zone). *B. okensis* is widespread in the boreal Berriasian (Ryazanian) of both northern Eurasia and northern America. According to most authors the appearance of *B. okensis* indicates the start of the Cretaceous. It is, however, not found in the *Chetiaites sibiricus* Zone, nor in its time equivalent, the *Praetolitia maynici* Zone (see Surlyk 1978a) in northern USSR (Petshora and Chatanga Rivers) and in East Greenland. It first appears at the base of the *H. kochi* Zone and the last rare specimens occur in the *Surites analogus* Zone (Zakharov 1981). No representatives of *B. okensis* have been found in the *Bjarkia mesezhnikovi* Zone.

**Buchia volgensis** (Lahusen, 1888)

Plate 75, fig. 2

1978a  *Buchia volgensis* Surlyk, p. 32, pl. 6, figs. 1–5 (only).

**Material.** About seventy specimens from southern Jameson Land and Wollaston Forland, including GGU 139493, GGU 139503 (cf.), GGU 143028 (cf.), GGU 143094 (cf.), GGU 143101 = MGUH 15345, GGU 143143,
 Remarks. The Greenland material is typical of this well-known species (see e.g. Zakharov 1981).

Stratigraphical occurrence. In East Greenland B. volgensis occurs throughout the Ryazanian except for the basal Praetollia maynci Zone. B. volgensis is extremely widespread in the Boreal and Subboreal Ryazanian. In northern USSR the species appears above the Jurassic-Cretaceous boundary at the base of the H. kochi Zone (Zakharov 1977, 1979), and most of the earlier identifications from the Upper Volgian in the Middle Siberia (Saks 1972) are erroneous. The alleged specimens of B. volgensis from the Upper Volgian can probably all be explained as misidentified specimens of B. unschensis (Zakharov 1981, pl. 3, fig. 4).

The species has the same stratigraphic range in northern North America (Jeletzky 1965). All the specimens from the P. maynci Zone of East Greenland described by Spath (1947, 1952) as B. volgensis belong to B. unschensis or B. terebratuloides, while some cannot be identified (Jeletzky 1973, p. 52). The specimens described as B. ex gr. volgensis from the upper part of the Middle Volgian and as B. volgensis from the Upper Volgian by Surlyk (1978a) are here referred to B. russiensis (Pavlov).

*Buchia inflata* (Lahusen, 1888)

Plate 75, fig. 3; Plate 76, fig. 1

1965 (?) *Buchia inflata* Jeletzky, pl. 1, figs. 7–8.
1978a *Buchia keyserlingi* Surlyk, p. 33, pl. 7, figs. 4–5, (?) 6.


Remarks. *B. inflata* is represented by medium- and moderately large-sized, subtriangular, high and almost equilateral specimens. The surface is covered by regularly spaced concentric ribs. Several of the specimens compare well with material from northern Siberia, Subarctic Urals, and Petschora River (Zakharov 1981, pls. 43–47) and from Anday (Sokolow, 1912). The mode of growth of the right valve of several specimens (Surlyk 1978a, pl. 7, figs. 4, 5) much resembles *B. pacifica* from Vancouver, British Columbia (Jeletzky 1965, pl. 16, fig. 7), but strongly convex forms which are characteristic of samples from northern Siberia and British Columbia are absent from the Greenland material.

Stratigraphical occurrence. In East Greenland *B. inflata* occurs in the Lower Valanginian of Wollaston Forland and Kuhn Ø. The first appearance of *B. inflata* in northern Eurasia (Petschora and Cheta Rivers) is in the uppermost part of the Bojkaria meszehnikovzi Zone (uppermost Ryazanian). In northern Siberia the species reaches its greatest abundance in the Lower Valanginian (*Neotollia klimovskiensis* Zone) while it is very rare in uppermost Lower Valanginian.

*Buchia keyserlingi* (Trautschold, 1868)

Plate 76, figs. 2, 3; Plate 77, fig. 1

1874 *Aucella concentrica var. rugosa* Toula, p. 503, pl. 2, figs. 2–4.
1911 (?) *Aucella sp.* Ravn, p. 459, pl. 33, fig. 1.
1911 (?) *Aucella concentrica* Ravn, p. 461, pl. 32, figs. 9–10.
1911 (?) *Aucella prismata* Ravn, p. 460, pl. 32, figs. 11, 12.
1965 *Buchia keyserlingi* Jeletzky, pl. 19, figs. 1, 2, 5, 7.
1975 (?) *Buchia keyserlingi* Surlyk and Clemmensen, pp. 67, 69, fig. 9.
1978a *Buchia keyserlingi* Surlyk, p. 33, pl. 8, fig. 4 (non pl. 7, figs. 4–6).
1978b *Buchia keyserlingi* Surlyk, p. 80, fig. 7b, 8.

Material. More than 200 specimens from Kuhn Ø and Wollaston Forland (much of the material is from sections 10, 15, 18, 20, and 53 in Surlyk 1978a, and section 40 in Surlyk 1977). Including GGU 139349 (cf.), GGU 139350, GGU 139351 (cf.), GGU 139342 (cf.), GGU 139356, GGU 139357, GGU 139379 (cf.), GGU 139381, GGU 139382, GGU 139383 (cf.), GGU 139386 (cf.), GGU 139394, GGU 139395, GGU 139397 (cf.), GGU 139411, GGU 139412 (cf.), GGU 139413, GGU 139414, GGU 139421 (cf.), GGU 139440 (cf.), GGU 139441.
Remarks. _B. keyserlingi_ is by far the most abundant species of _Buchia_ from East Greenland and practically all the varieties described in the literature are represented.

The majority have a rounded outline and regularly spaced ribs (Pl. 76, fig. 2; Pl. 77, fig. 1; see also Surylk and Clemmensen 1975, fig. 9; Surylk 1978b, figs. 7f, f), near to the lectotype (Keyserling 1846, pl. 16, fig. 16; see also Zakharov 1981, pl. 50, fig. 4). These forms have in the earlier literature been called _B. keyserlingi_ var. _sibirica_ (Sokolow). Another form represented is close to the original specimen of Lathusen (1888, pl. 4, figs. 18–23; see also Zakharov 1981, pl. 54, fig. 3). Its main characteristic is the closely spaced ribs. The form is well known from Middle (?) Valanginian of the Arctic Canadian Archipelago (Jeletzky 1964, pl. 5, fig. 2) and from the _Temnoptychites syzranicus_ Zone of the Petshora River basin (Zakharov 1981, pl. 55, fig. 4). _B. keyserlingi_ var. _gigas_ (Crickmay) is probably a gerontic form of this closely ribbed variety. Such large specimens have also been found in East Greenland (Jeletzky 1965, pl. 9, fig. 1; Surylk 1978a, pl. 8, fig. 4) and have also been recorded from northern Siberia (Zakharov 1981, pl. 54, fig. 2) and Kong Karls Land (so-called variety _brasiliensis_, Blüthgen, 1936). A fairly rare variety with a smooth internal mould (Pl. 77, fig. 1) usually occurs together with ribbed varieties in the Lower Valanginian of the Anabar River, northern Siberia (Zakharov 1981, pl. 53). In large samples from eastern Wollaston Forland all transitions occur between the above-mentioned varieties.

_B. piriformis_ and _B._ sp. of Ravn (1911) are represented by internal moulds of the left valves only and determination is thus not definitive. It should be noted, however, that these specimens have a high shell, smooth surface of the moulds, and that the middle part of the valves display a strong convexity. These features are highly reminiscent of _B. sublævis_ from the Upper Valanginian of the Petshora River basin (Zakharov 1981, pl. 58).

Stratigraphical occurrence. In East Greenland _B. keyserlingi_ occurs in the Lower Valanginian of Kuhn Ø, Wollaston Forland, Hochstetter Forland, and probably Store Koldewey. _B. keyserlingi_ is typical of the Boreal Lower Valanginian, where it occurs in great abundance. The species does not occur in the Ryazanian, but in large samples of Ryazanian _B. unschenkii_ or _B. volgensis_ there will normally occur several specimens which strongly resemble _B. keyserlingi_. _B. keyserlingi_ reaches its maximum abundance in the middle part of the Valanginian (T. _syzranicus_ and _Polypytchites keyserlingi_ Zones). The species is rare in the Upper Valanginian, where other species such as _B. sublævis_ have taken over. The youngest occurrence is in northern Germany (Westphalia and Lower Rhine), where rare _B. ex gr. keyserlingi_ occur together with _Endemoceras_ of Early Hauterivian Age (Kemper 1975).

*Buchia sublævis* (Keyserling, 1846)

Plate 77, figs. 2–7

1978a (?) _Buchia sublævis_ Surylk, pl. 8, fig. 3.

Material. More than twenty specimens from Wollaston Forland, including GGU 139351 = MGUH 15331,

EXPLANATION OF PLATE 76

All specimens are figured in natural size.

Fig. 1. _Buchia inflexa_ (Lahusen). GGU 139352. a, whole specimen viewed from the left and b, right side. c, posterior view. d, dorsal view. Palmaokeks Bjerg Formation, Albrechts Bugt/Røddygen Member transition, Lower Valanginian, Section 10, Surylk 1978a, appendix. Perispinctes Ravine, eastern Kuhn Ø.

Figs. 2–3. _Buchia keyserlingi_ (Trautschold). GGU 139534. 2a, whole specimen viewed from left side and b, right side. c, dorsal view and d, posterior view. 3, lateral view of right valve. Palmaokeks Bjerg Formation, Albrechts Bugt Member. Lower Valanginian, Sumpdalen, north-east Wollaston Forland.
SURLYK and ZAKHAROV, Buchia
GGU 139384 (cf.), GGU 139385 (cf.), GGU 139386 (cf.), 139387 (cf.), GGU 139378 (cf.), GGU 139423 = MGHU 15343, GGU 139442 (cf.), GGU 139504, GGU 139523 = MGHU 15343, GGU 139535 (cf.), GGU 139536 (cf.).

Remarks. The material is dominated by small- and medium-sized specimens, while large specimens are absent. Accordingly, precise identification is not always possible. The moulds are smooth and straight and the left valves are slightly more convex than the right valves. Medium-sized specimens have a slightly prosogyrate beak. There is a considerable morphological overlap between B. keyserlingi, B. sublaevis, and B. crassicollis and one often needs populations to make correct identification. Single specimens can only be identified with some doubt. This is the case with a specimen from the Albrechts Bugt Member of Wollaston Forland (Surylk 1978a, pl. 8, fig. 3, and this paper Pl. 77, figs. 2–7). On the one hand the specimen recalls rare high forms of B. sublaevis from the Upper Valanginian (Dichotomites beds) at the Izhma River, Petschora basin (Zakharov 1981, pl. 56, fig. 3), while on the other hand it is reminiscent of younger B. crassicollis from the Homolosmites bojarkensis Zone (Zakharov 1981, pl. 60, figs. 5–7).

Stratigraphical occurrence. In East Greenland B. sublaevis occurs in the lower part of the Upper Valanginian in Wollaston Forland. In northern Siberia and Petschora River Basin the species has its first appearance at the Lower–Upper Valanginian boundary and reaches its greatest abundance in the Upper Valanginian (Dichotomites sp. Zone). Small- and medium-sized specimens are predominant in the uppermost Upper Valanginian (Dichotomites beds and Homolosmites bojarkensis Zone) of northern Siberia and East Greenland (Zakharov 1981, pl. 56, figs. 2–5, pl. 57, fig. 1). This is also characteristic in Arctic Canada (Dichotomites quinoxensis Zone) (Jeletzky 1964, pl. 11, fig. 3, pl. 13, figs. 7, 9, 10) and in the Upper Valanginian of northern Alaska (Inlay 1961, pl. 3, figs. 1–15).

_Buchia crassicollis_ (Keyserling, 1846)

Plate 77, fig. 8

1911 (?) _Aucellia crassicollis_ Raven, p. 459, pl. 32, fig. 8.
1978a _Buchia crassicollis_ Surylk, pl. 8, fig. 5.

Material. One specimen from Wollaston Forland (section 20, Surylk 1978a) and one specimen which is transitional to _B. sublaevis_ (section 15, Surylk 1978a); GGU 139387 (cf.), 139424 = MGHU 15336, 139535.

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EXPLANATION OF PLATE 77

All specimens are figured in natural size.

Fig. 1. _Buchia keyserlingi_ (Trautschold). GGU 139534. Smooth specimen. a, whole specimen viewed from the left side. b, posterior view. c, view from the right side. d, dorsal view. Locality as pl. 76, figs. 2–3.

Figs. 2–7. _Buchia sublaevis_ (Keyserling). GGU 139523. 2a, lateral view of left valve. 2b, posterior view. 3a, lateral view of right valve. 3b, dorsal view. 4a, dorsal view of left valve. 4b, lateral view. Palnakes Bjerg Formation Albrechts Bugt/Redryggen Member transition. Upper Valanginian, Section 53, 135 m in Surylk 1978a, appendix. East side of Redryggen, eastern Wollaston Forland. 5, GGU 139351. a, lateral view of left valve. b, posterior view. c, dorsal view. Palnakes Bjerg Formation, Albrechts Bugt, Redryggen Member transition, upper Lower Valanginian, Section 10, Surylk 1978a, appendix. Perispincites Ravine, eastern Kuhn Ø. 6, 7, GGU 139423. 6a, exterior view of left valve. 6b, posterior view. 7, exterior view of right valve (also figured by Surylk 1978a, pl. 8, fig. 3). Palnakes Bjerg Formation, Albrechts Bugt/Young Sund Member transition, Section 20, Upper Valanginian, 635 m in Surylk 1978a, appendix. Niesen, northern Wollaston Forland.

Fig. 8. _Buchia crassicollis_ (Keyserling). GGU 139424. a, exterior view of left valve. b, anterior view (also figured by Surylk 1978a, pl. 8, fig. 5). Palnakes Bjerg Formation, Albrechts Bugt Member, uppermost Valanginian or lowermost Hauterivian, Section 20, 688 m, top of Niesen. Northern Wollaston Forland.
SURLYK and ZAKHAROV, *Buchia*
Remarks. Only two rather poorly preserved external moulds of left valves are found. They are high and almost smooth with a strong constriction in the upper part. Such constrictions are characteristic but not diagnostic for *B. crassicollis* since they also occur in other species of *Buchia* (Zakharov 1981). The specimens from East Greenland compare well with material from (?) Upper Valanginian of northern Alaska (Imlay 1961, pl. 8, figs. 23–26) and also from the *Homolosomites bojarkensis* Zone of northern Siberia and Petschora River basin (Izhma River).

Stratigraphical occurrence. In East Greenland it occurs in the uppermost Valanginian of Wollaston Forland and probably Store Koldewey and Kuhn Ø. This stratigraphic level is considered to belong to the lowermost Haueterivian by most Russian authors (see below). There is no clear agreement on the stratigraphic range of *B. crassicollis* and of the stratigraphic position of the strata in which it occurs. Some workers (Saks and Shulgina 1974) prefer to place the latest marine beds of northern Siberia (*Homolosomites bojarkensis* Zone) in the Lower Haueterivian. These beds are rich in *B. crassicollis*. Other workers, however, place the equivalent horizons in the Upper Valanginian (Jetelzky 1965; Jones et al. 1969; Surylk 1978a).

STRATIGRAPHY

The most complete succession of *Buchia* zones has been established in northern Siberia, where eighteen zones were recognized from the Callovian to the Haueterivian (Zakharov 1977, 1979, 1981). The same interval is subdivided into forty-three ammonite zones and the *Buchia* zonation is thus well defined within the framework of the standard ammonite zonation (Table 3). While the great refinement of the latter makes it more powerful for detailed dating, the almost ubiquitous and profuse occurrence of *Buchia* in the Boreal Realm makes the *Buchia* zonation extremely useful (Tables 2, 3), especially in the absence of ammonites.

Surylk (1973, 1978a, b) described *Buchia* from the Middle Volgian–lowermost Valanginian of East Greenland within the framework of an ammonite zonation, while the remaining bulk of the Valanginian was subdivided into three *Buchia* zones (compare Table 2). In the present paper thirteen of the eighteen *Buchia* zones and beds known from northern Siberia are now recorded from the Upper Oxfordian–Upper Valanginian interval of East Greenland. The Siberian zones, which are assemblage zones, are precisely defined by Zakharov (1981). In most cases the East Greenland *Buchia*-bearing horizons can easily be correlated with the Siberian zones. In other cases a zonal assignment is less certain and the informal term *bed* is used. The *Buchia* zones and beds of East Greenland will now be described in ascending order.

1. *Praebuchia kirghisensis* Zone. This zone can be recognized by the presence of the index species in the Upper Oxfordian of Milne Land and the Bernbjerg Formation of Wollaston Forland. The lower boundary is difficult to establish precisely because buchid bivalves are absent in lower strata. *P. kirghisensis* reaches its maximum abundance in the *Amoeboceras serratum* and *A. regulare* Zones (Tables 2, 3) and has its last appearance approximately at the Oxfordian–Kimmeridgian boundary. Outside East Greenland, *P. kirghisensis* occurs widely on the Russian Plain, the Petschora River basin, in the southern Urals (Orenburg region), and in northern Siberia (Table 3).

2. *Buchia concentrica* Zone. This zone is represented in the *Cardioceras Klaft* Member of Milne Land, in the Bernbjerg Formation of Wollaston Forland and Kuhn Ø, and in the *Klaft 1* Formation of Store Koldewey. It is characterized by the index species and *B. Lindstroemi*. The lower boundary coincides with the Oxfordian–Kimmeridgian boundary throughout the Boreal Realm. The species ranges higher in East Greenland than elsewhere and the upper boundary of the zone is within the zone of *Aulacostephanus mutabilis* (Tables 2, 3). Outside East Greenland the zone has been recognized in northern Siberia, northern Urals, Petschora River basin, Spitzbergen, North Alaska, northern California, and in north-east Asia (Table 3).

3. *Buchia tenustriata* Zone. This zone has a restricted occurrence in East Greenland, where it has been demonstrated only in the Bernbjerg Formation of Kuhn Ø and at Danmarkshavn. The index species occurs together with *Amoeboceras (Euphranoceras) ex gr. sokolowi* and various aulacostephanid species. Numerous specimens have been found in the *Aulacostephanus mutabilis* Zone together with rare *B. concentrica*. The upper boundary of the zone cannot be safely ascertained because the adequate parts of the section have not yielded sufficient material. The upper part of the zone is supposed roughly to correlate with the ammonite zones of
<table>
<thead>
<tr>
<th>Stages</th>
<th>1 Ammonite zonation</th>
<th>2 Buchia zonation</th>
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<tbody>
<tr>
<td>Valangian</td>
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<td>Buchia crassicollii</td>
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<td></td>
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<td>Buchia sublaevis</td>
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<td></td>
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<td>Buchia keyserlingi</td>
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<td></td>
<td>Low.</td>
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<td>Upper.</td>
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<td>Buchia tersbratuloides</td>
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<td>Amoeboceras glosense</td>
<td>Praebuchia kirghisensis</td>
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<td></td>
<td>Cardioceras tenuicostatus</td>
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</tbody>
</table>

**TABLE 2.** Correlation of *Buchia* and ammonite zones and beds in East Greenland. Sources: 1, Surlyk (1977, 1978a); Surlyk et al. (1973); Sykes and Surlyk (1976); Birkeland et al. (1978). 2, Surlyk (1978a) and the present paper.
Aulacosteephyus eudoxia and *A. autissiodorensis* (Tables 2, 3). In the Volga and Petshora River basins and southern Urals the boundary relations are likewise unclear as *Buchia*-bearing continuous sections have not been found covering the Upper Kimmeridgian-Lower Volgian interval.

4. Buchia mosquensis Zone. Beds with *B. mosquensis* are well represented in the Middle Volgian of Milne Land. In Jameson Land it has been found in one locality in the Sjellandselv Member (Table 1), and it is also known from Store Koldewey. The zone of *B. mosquensis* has a wide distribution in the Boreal Realm and it contains beds with *B. mosquensis* s.s., *B. rugosa*, *B. russiensis*, and *B. taimyrensis* (Table 3).

5. Buchia russiensis beds. These beds have been found in the late Middle Volgian Laugskite Ravine and Rigi Members of Wollaston Forland and Kuhn Ø (Table 1). This horizon seems to correspond to the beds with *B. taimyrensis* in northern Siberia and in the Petshora River basin (Table 3).

6. *Buchia fischeriana* beds. In East Greenland *B. fischeriana* has a fairly long range, although it mainly occurs above *B. russiensis* in the top Laugskite Ravine and Niesen Members of Wollaston Forland, where it occurs with Upper Volgian *Virgatostrophites* (Tables 1-3).

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<tr>
<th>System</th>
<th>Stage</th>
<th>Northern Siberia</th>
<th>Eastern Greenland</th>
<th>Spitsbergen</th>
<th>Petshora River Basin</th>
<th>Canadian Arctic Region</th>
<th>Western British Columbia</th>
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</table>

7. *Buchia terebratuloides-Buchia unschenkii* beds. The Jurassic-Cretaceous boundary occurs in a sequence poor in *Buchia* and thus cannot be precisely placed within the *Buchia* zonation. The *Buchia terebratuloides-unschenkii* assemblage occurs together with *Virgatospinctes*, *Praeotellia*, and *Hectoroceras* in the Rigi and Niesen Members of Wollaston Forland and in the Muslingeely Member of Jameson Land (Table 1). The assemblage thus spans the Jurassic-Cretaceous boundary and characterizes the uppermost Volgian and the Lower Ryazanian.

8. *Buchia okensis* Zone. This zone has been recognized in the Muslingeely Member of Jameson Land (Suryk 1973). It occurs below *B. volgensis* together with abundant *B. unschenkii*, *B. terebratuloides*, and *B. fischeriana*. The zone is one of the best biostratigraphic markers in the Boreal Realm (Table 3; see also Jeletzky 1973).

9. *Buchia volgensis* Zone. The zone has been identified in the topmost part of the Fynselv Member and in the Muslingeely Member of southern Jameson Land and in the Rigi Member of Wollaston Forland (Table 1). The upper boundary cannot be precisely identified as the zone forms the top stratigraphic unit in Jameson Land and the correlatives of the Wollaston Forland section is poorly fossiliferous. *B. volgensis* occurs together with species of *Hectoroceras*, *Surites*, and (?) *Bojarikia*. The zone is mainly of Late Ryazanian Age, but the species also occurs in the top of the Lower Ryazanian Zone of *Hectoroceras koehi*. The reports of this zone by Spathe (1947, 1952) are, however, erroneous as his specimens belong to the *B. unschenkii-B. terebratuloides* group.

10. *Buchia inflata* Zone. This zone is well represented in the Paltanokes Byerg Formation of Wollaston Forland and Kuhn Ø (Suryk 1978a) (Table 1). It is characterized by several *Buchia* assemblages. In the basal part the index species occurs together with *B. volgensis*, while *B. keyserlingii* is abundant in the upper part of the zone.

11. *Buchia keyserlingii* Zone. The presence of this zone in East Greenland was established by Suryk (1978a). It is represented in the Paltanokes Bjerg Formation of Wollaston Forland and Kuhn Ø and it has a wide distribution in the Boreal Realm (Tables 1, 3). It extends even to the Sub-Boreal/Sub-Tethyan provinces (northern California, Mangysthal, Copet-Dagh, Sikhote-Alin) (Table 3; Zakharov 1977, 1979). In the North Atlantic region the species is known furthermore from north-west Europe, Anday and Spitzbergen. The *B. keyserlingii* Zone is easy to recognize and constitutes an excellent biostratigraphic marker in the Boreal Valanginian (Table 3).

12. *Buchia sublaeva* Zone. The zone was established in East Greenland by Suryk (1978a). It is represented in the younger parts of the Paltanokes Bjerg Formation (Table 1). The age of the zone is Late Valanginian. This is supported by the co-occurrence of ammonites belonging to *Dichosomites* spp. which may be conspecific with forms found in the Siberian *Homosomites bojarkensis* Zone. If this zone belongs to the Lower Hauterivian, the top part of the zone may, however, span the Valanginian-Hauterivian boundary (Table 3).

13. *Buchia crassicollis* beds. The beds with *B. crassicollis* are the youngest *Buchia*-bearing strata in East Greenland (Suryk 1978a). The age of this part of the sequence, which belongs to the Albrechts Bugt and Roddyggen Members (Table 1), cannot be precisely determined because ammonites found together with *B. crassicollis* are indeterminable. In accordance with Jeletzky (1973) a latest Valanginian age was proposed for the *B. crassicollis* beds (Suryk 1978a), while Russian geologists assign an Early Hauterivian Age for this level (see discussion in Jeletzky 1973). The presence of *B. crassicollis* in the top of the marine *Buchia*-bearing sequence is established almost everywhere in the Boreal Realm (Table 3).

**GEOLOGICAL IMPLICATIONS**

The present study of the *Praebuchia-Buchia* fauna of East Greenland has in most cases substantiated the previous age-assignments of the lithostratigraphic units (Suryk 1973, 1977, 1978a; Suryk et al. 1973; Sykes and Suryk 1976). Furthermore, some previously undated localities can now be firmly placed within the *Buchia* zonation, and the new datings have in a few cases led to considerable revisions of earlier ideas with significant geological implications (text-fig. 2). In particular, in southern Jameson Land the shallow marine coarse clastic Raukelv and Hesteberg Formations of the Kimmeridgian to Valanginian Age can now be further interpreted in terms of the controlling synsedimentary tectonics.

**Southern Jameson Land**

The strong tectonic phase extending across the Jurassic-Cretaceous boundary throughout most of the North Sea-northern North Atlantic region was in southern Jameson Land heralded by an abrupt
transition from upper slope black shales with channel sands to coarse, shallow marine sandstones. The sandstones are placed in the Raukavel Formation and the lowest faunas indicate an Early Volgian Age, while the higher beds contain successive faunas of Middle and Late Volgian and Ryazanian Age (Table 1) (Surlyk 1973; Surlyk et al. 1973). The Raukvel Formation represents several coarse sandy fan delta lobes separated by prodelta, lagoonal, and bay mudstones (Surlyk 1975). Approximately at the Volgian–Ryazanian boundary the southernmost Jameson Land was gently folded into three or more low anticlines and synclines with southward-plunging axes. The folding, which dies out towards the north, has been interpreted as caused by transgression in connection with lateral movements along a NW–SE cross-fault thought to be present in Scoresby Sund (text-fig. 1).

The deepest of the synclines forms a 10-km-wide submarine trough narrowing towards the north and with a southward-tilted axis (Surlyk 1973). It was filled with a 150-m-thick coarsening upwards black mudstone–siltstone–sandstone sequence deposited from the prograding fan deltas (Hesteel Formation on Table 1). This unconformable trough-fill constitutes the Hesteel Formation of Ryazanian–Early Valanginian Age. Sandy fan delta deposition continued in the surrounding shallow-water areas, and the higher parts of the Raukvel Formation are thus roughly contemporaneous with the Hesteel Formation. This interpretation was suggested by Surlyk (1973, p. 91), but the hypothesis was based on rather meagre faunal data. The present study confirms the earlier notions concerning the contemporaneity of the Hesteel and upper Raukvel Formation and B. volgensis of mid-Ryazanian Age has now been identified from the top of the Fynselv Member, which is the highest unit in the Raukvel Formation (Table 1).

The boundaries of the Raukvel Formation can be shown to be highly diachronous (Table 1). Along the easternmost outcrops the basal Raukvel Formation containing B. volgensis and Hectoroceras kochi of Lower Ryazanian Age overlies the lowermost Volgian top part of the Hareelv Formation, indicating the presence of a hiatus corresponding to almost all of the Volgian. To the west the presence of both the Lower, Middle, and Upper Volgian has been demonstrated on the basis of Ammonites (Surlyk et al. 1973; Surlyk 1973) and B. mosquensis. The boundary between the Raukvel and the underlying Hareelv Formation thus conceals a very small hiatus at maximum corresponding to a few Lower Volgian ammonite zones. The top of the Raukvel Formation is of Valanginian Age as indicated by the presence of cf. Polypychites mokuschenis in an outlier on the summit of J. P. Kochs Fjeld immediately west of the B. volgensis–H. kochi assemblage (Surlyk et al. 1973, pl. 4, fig. 5). The outlier was in earlier papers described under the Hesteel Formation. The Raukvel Formation shows marked thickness variation in both N.–S. and E.–W. directions. It has wedged out completely in south-east Jameson Land, where the Hesteel Formation rests directly on the Hareelv Formation. Along its eastern outcrop margin it is consistently about 100 m thick, and according to the new stratigraphic data it here corresponds mainly to the uppermost portion of the Raukvel Formation further westwards.

The thickness and stratigraphical completeness increase gradually in a westward direction. The maximum onshore thickness is not precisely known as the base of the formation is not exposed in this area, but it can be roughly estimated to be 400–500 m. Stratigraphically the Raukvel Formation in the western part of the area displays a probably unbroken Lower Volgian–Lower Valanginian sequence.

The strong E.–W. asymmetry of the Raukvel Formation suggests a position on a westward-tilted fault-block. The position of the western border fault is not known, but it is most likely a southwards continuation into Scoresby Sund of the main N.–S.-trending border fault, as also envisaged for the Upper Jurassic Hareelv Formation (Surlyk, Clemmensen, and Larsen 1981, fig. 11). This is supported by the nature of the contemporaneous deposits in Milne Land situated to the west of this fault. Here a condensed sequence of glauconitic fine-grained shelf sediments corresponds to the first phases of coarse-elastic syntectonic fan delta sedimentation of the Raukvel Formation.

In Milne Land fan delta sedimentation of the Hartz Fjeld Formation first started in the latest Middle Volgian. The lowest 45 m of this formation is of Middle Volgian Age. This is followed without any marked facies change by Valanginian, and all of the Upper Volgian–Ryazanian is absent (Birkelund et al. 1978).
Wollaston Forland–Kuhn Ø

The Buchia fauna of this region is well known from the work of Surlyk (1978a, table 1, fig. 1b), and the present study mainly supports the stratigraphic conclusions (see Table 1). The Niesen section of northern Wollaston Forland has, however, been used as a key section for the Volgian, Ryazanian, and Valanginian Stages in East Greenland. The exposed sequence is about 700 m thick. It is situated in a relatively deep part of the trough formed by antithetic block-faulting in Volgian–Valanginian times. The dominant facies are silty and sandy mudstones, sandstone turbidites, and reworked conglomerates described in detail by Surlyk (1978a).

The Middle Volgian rests with erosional and angular unconformity on dark mudstones of the Upper Oxfordian–Kimmeridgian Bernberg Formation with Praebuchia. It is followed by a seemingly uninterrupted sequence of Middle Volgian to Valanginian deposits which contain ammonites and Buchia throughout. The lithostratigraphic scheme of Surlyk (1978a) (see Table 1) can now be firmly placed within the Buchia zonation. The Lindemans Bugt Formation includes the B. russiensis, fischeriana, unschensis, terebratuloides, okensis, and volgensis Zones and beds. The formation is subdivided into three members with diachronous boundaries (Table 1). The lower Laugelte Ravine Member comprises mudstones with subordinate turbidites and reworked conglomerates representing the first phase of antithetic block faulting and the formation of coarse-grained submarine fans along the partly submerged western fault scarp. It is included in the russiensis and fischeriana beds. Towards the fault scarp and upwards it passes into the extremely coarse-grained, conglomeratic Rigi Member, which in its proximal parts includes the russiensis, fischeriana, unschensis, terebratuloides, okensis, and volgensis Zones and beds. In the more distal parts it interfingers with and is followed by the Niesen Member, which includes the unschensis, terebratuloides, volgensis, and possibly lower part of the inflata Zones and beds.

Submarine fan deposition continued into the Valanginian, but a regional transgression resulted in a change to more muddy sediment containing lesser amounts of conglomerates.

The proximal coarse-grained deposits characteristic of the inner and midfan environments are grouped into the Young Sund Member, which includes the inflata, keyserlingi, sublaevis, and probably also crassicollis Zones. The outer fan and basin environments were characterized by the mudstones with thin turbidites of the Albrechts Bugt Member including the same four zones. The easternmost block crest was exposed to erosion during part of the Valanginian and a fringe of sandstones constituting the Falskebugt Member was deposited on the proximal dip slope (Table 1). This member has only yielded fossils of the sublaevis Zone. Finally, the red mudstones of the Radbjerg Member characterizing isolated submerged crestal highs include the inflata, keyserlingi, sublaevis, and crassicollis Zones, although the lower zone may be absent.

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