Upper Jurassic-Lower Createaceous *Buchia* from Andøy, northern Norway

V. A. ZAKHAROV, F. SURLYK and A. DALLAND

Zakharov, V. A., Surlyk, F. & Dalland, A.: Upper Jurassic-Lower Cretaceous *Buchia* from Andøy, northern Norway. *Norsk Geologisk Tidsskrift*, Vol. 61, pp. 261–269. Oslo 1981.

A systematic study of the *Buchia* fauna from Upper Jurassic and Lower Cretaceous strata of Andøy, northern Norway, indicates the presence of the upper Middle Volgian, probably most of the Upper Volgian, the uppermost Ryazanian, and all of the Valanginian. The Andøy succession, which is more complete than hitherto assumed, can be successfully placed within the framework of the comprehensive *Buchia* zonation worked out for the Oxfordian-Valanginian of the Boreal Realm. The main breaks in the sequence, probably caused by the Late Kimmerian tectonic phase, seem to correspond to the Upper Kimmeridgian and the Lower to lower Upper Ryazanian.

V. Zakharov, Institute of Geology & Geophysics, Siberian Branch of the Academy of Sciences of the USSR, University Street 3, Novosibirsk, 630090 USSR.
F. Surlyk, Geological Survey of Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.
A. Dalland, Geological Institute (A), University of Bergen, Norway.

The presence of Mesozoic strata in Andøy, northern Norway has been known since the middle part of the last century. While the locality is of considerable interest as it represents the only onshore Mesozoic outcrop in Norway, relatively little field work has been carried out so far, mainly owing to the poor quality of the exposures. Recent field work by the University of Bergen involving extensive excavations yielded the material to be described here. The present lithostratigraphic scheme was proposed by Dalland (1975, 1980), who also gave a general review of the geology as it is known today.

Biostratigraphic studies have been made on ammonites, buchiid bivalves, spores and pollen by Sokolov (1912) and Birkelund et al. (1978), and on foraminifera by Løfaldli & Thusu (1979).

Although macrofossils are relatively sparse in the Jurassic-Cretaceous boundary strata, the presence of Middle and possible Upper Volgian, Upper Ryazanian, and Lower Valanginian was demonstrated on the basis of ammonites and two species of *Buchia* by Birkelund et al. (1978).

In the present paper, new material of *Buchia* is described, leading to the recognition of six biostratigraphic zones or beds, and making it possible to place the whole of the Middle Volgian-Valanginian sequence in Andøy within the standard *Buchia* zonation established for the Boreal Realm (Zakharov 1980).

A detailed bio- and lithostratigraphic correlation with East Greenland (Surlyk et al. 1973; Surlyk 1973, 1977, 1978a, b, Surlyk & Zakharov, in press) has also been made. This is of considerable value in the environmental and tectonic interpretation of the poorly exposed and areally very restricted Andøy sequence.

Stratigraphic palaeontology

All specimens of *Buchia* found on Andøy belong to well-known species which have recently been described in detail by Zakharov (1981) from the Arctic U.S.S.R., and from East Greenland by Surlyk & Zakharov (in press). The rather sparse material from Andøy does not yield any important additions to our knowledge of the morphological features of individual species. It is therefore unnecessary to present detailed systematic descriptions. A number of biostratigraphically important *Buchia* assemblages can be recognized, and these are described in ascending order. The most important specimens are figured. In some cases an assemblage can be referred to a well defined standard zone, while in other cases a zonal assignment is less certain and the informal suffix *bed* is used. The *Buchia* zones are assemblage zones (Zakharov 1981) and the name giving species mainly has a longer time-range than its zone. The same species is

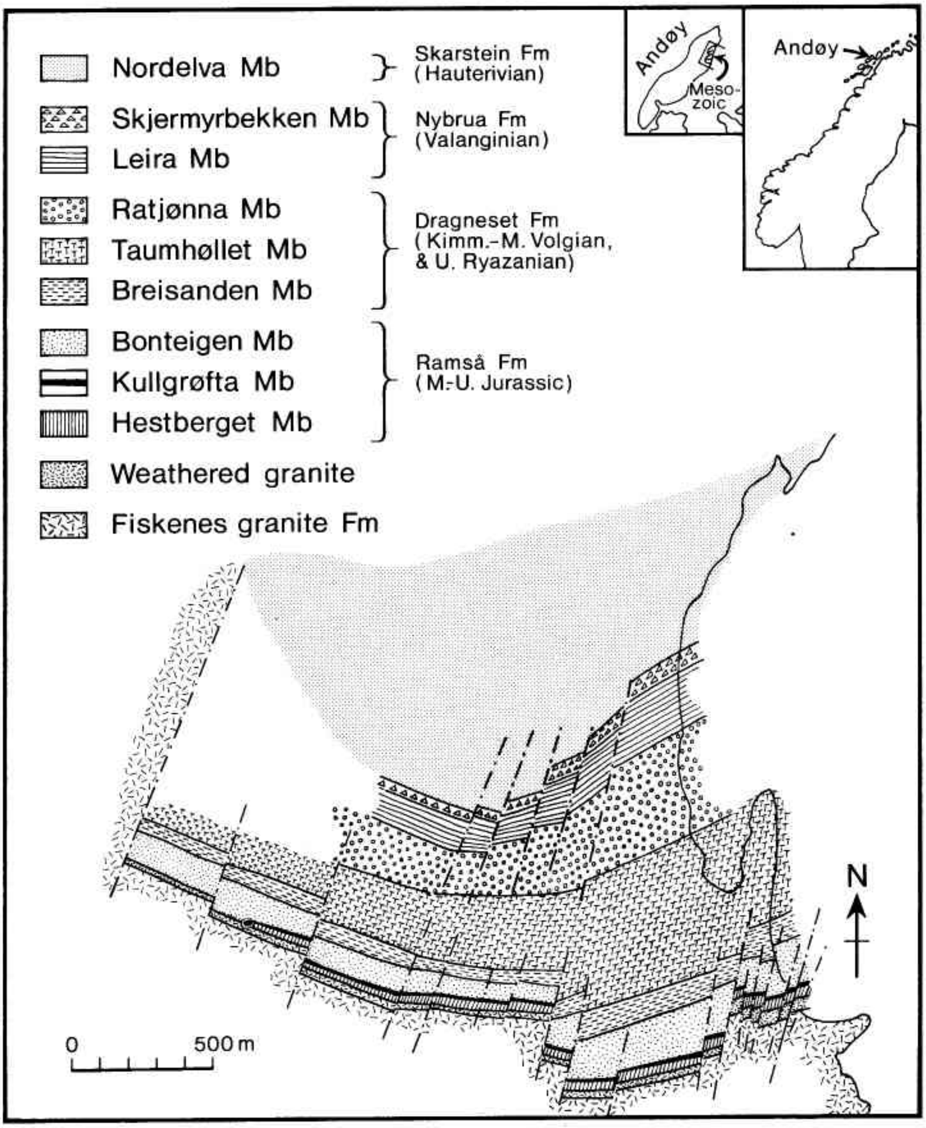


Fig. 1. Map showing location and geology of the down-faulted Mesozoic sequence on the east coast of Andøy (after Dalland 1980).

thus in some cases used as index for zones of different age in different regions (Fig. 3). This slightly confusing practice is, however, difficult to avoid because faunal composition varies between regions. The sample numbers of Dalland are indicated for each assemblage (D-147 to D-174, E-6 to E-12, and F-3 to F19). The positions of the samples are shown on Fig. 2 and the numbers are the same as those used by Birkelund et al. (1978).

The faunal succession and its correlation

1. *Buchia russiensis* Zone (D-147, D-149). The zone has been recognized on the basis of *B.* ex gr. *russiensis* (Pavlow) (Pl. 1, figs 1–3). This species occurs mainly in the Middle Volgian. At some localities in the Russian Plain it reaches into the basal Upper Volgian (*Kachpurites fulgens* Zone), in which it is usually associated with *B. fischeriana* and *B. terebratuloides*. The

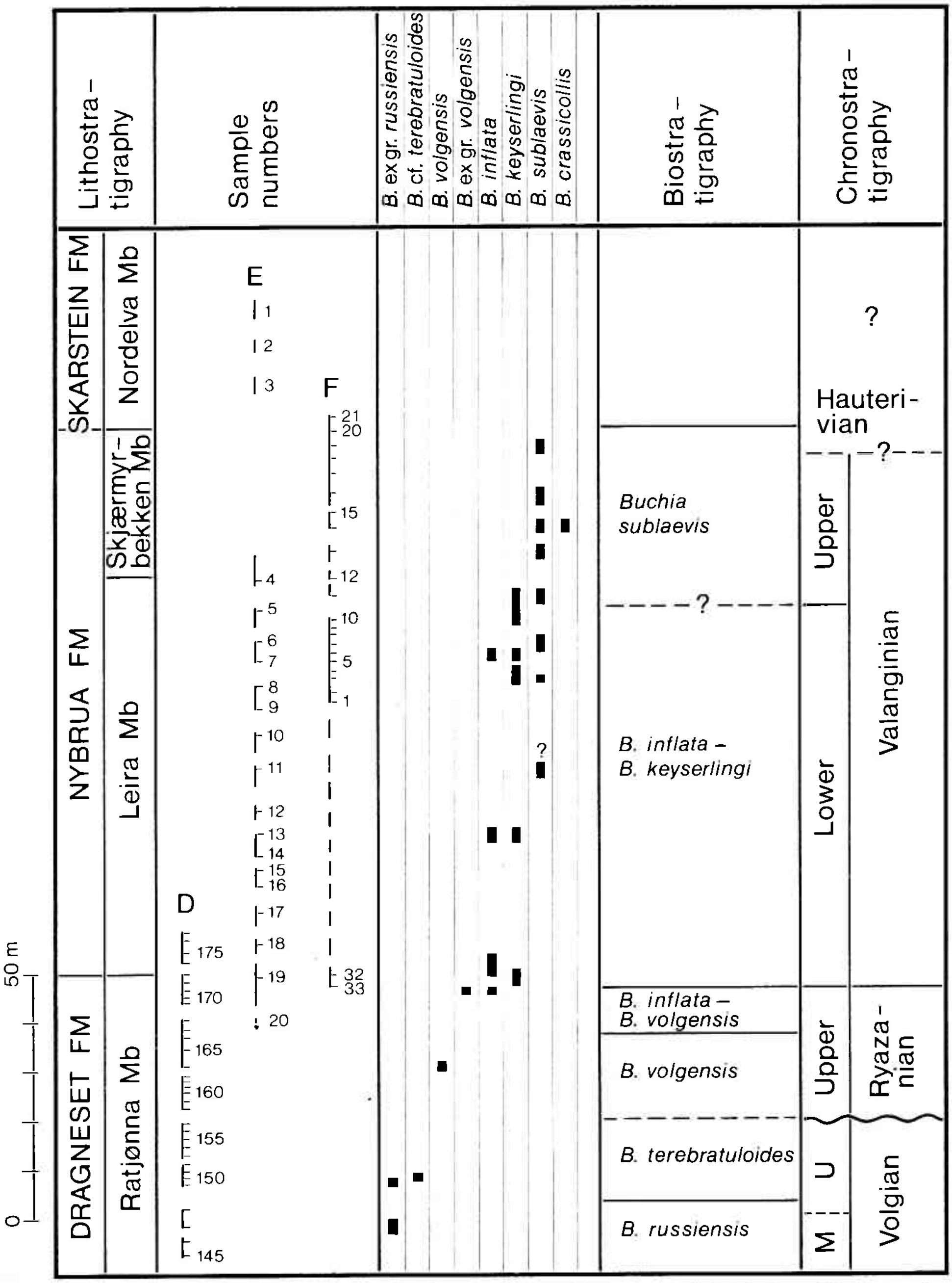


Fig. 2. The Jurassic – Cretaceous boundary sequence of Andøy showing sample numbers and distribution of *Buchia* species.

absence in Andøy of the two latter species, and of the mainly early Middle Volgian *B. mosquensis*, suggests that the fauna belongs to the transition between the Middle and Upper Volgian.

2. *Buchia terebratuloides* beds (?) (D-150). The identity of this level is questionable because only one poorly preserved specimen has been found, determined here as *B.* cf. *terebratuloides* (Lahusen) (Pl. 1, fig. 4). The beds probably belong to the Upper Volgian.

3. *Buchia volgensis* Zone (D-164). This zone is very clearly marked by the abundance of the very variable *B. volgensis* (Lahusen) (Pl. 1, fig. 5) (see also Birkelund et al. 1978, pl. 4, figs 1–4; pl. 5, figs 4–6). In most parts of the Boreal Realm the species has its first occurrence above the Jurassic-Cretaceous boundary in the *Hectoroceras kochi* Zone. It reaches its main abundance in the *Surites analogus* Zone and has its last appearance in the *Bojarkia mesezhnikowi* Zone. It has not been found together with Valanginian ammonites.

In Andøy *B. volgensis* s.s. is not associated with other species of *Buchia* such as *B. tolmatschowi, B. okensis* or *B. unschensis* that are characteristic of the Lower and lower Upper Ryazanian. This indirect evidence may suggest a slightly younger age for the strata in question. From the same level Birkelund et al. (1978) recorded an ammonite, which they determined as *Surites (Bojarkia)* cf. *mesezhnikowi* (Shulgina).

4. *Buchia inflata – Buchia volgensis* beds (D-171). These beds which contain *B. inflata* (Lahusen) (Pl. 1, fig. 8) and *B.* ex gr. *volgensis* (Lahusen) (Pl. 1, figs. 6–7) are probably of latest Ryazanian Age because in Northern Siberia (Petschora and Cheta River basins) these species have only been found together in the upper part of the *Bojarkia mesezhnikowi* Zone (Zakharov 1981).

5. *Buchia inflata – Buchia keyserlingi* beds (D-172, D-173, E-13, F-3, F-4, F-6, F-10, ?F-11). *B. inflata* (Pl. 1, figs 9–10, Pl. 2, figs 1–2) and *B. keyserlingi* (Trautschold) Pl. 2, figs 3–4) are found in association in Northern Siberia only in the Lower Valanginian. *B. inflata* is, however, most common in the lowermost Valanginian (*Neotollia klimovskiensis* Zone), while *B. keyserlingi* is characteristic of the uppermost Lower Valanginian (*Temnoptychites syzranicus – Polyptychites michalskii* Zones). In the top part of the Lower Valanginian *B. keyserlingi* sometimes occur together with *B. sublaevis*, but the latter is much more characteristic of the Upper Valanginian.

6. *Buchia sublaevis* beds (?E-11, E-6, F-11, F-13, F-14, F-16, F-19). These beds are characterized by the highly variable *B. sublaevis* (Keyserling) (Pl. 2, figs 5–8). One left valve is very close to *B. crassicollis* (Pl. 2, fig. 9). These two species are characteristic of the highest beds with *Buchia* in the Boreal Realm. They are not found together below the Lower-Upper Valanginian boundary. They may reach into the Lower Hauterivian because in northern Siberia their last occurrence is in the *Homolsomites bojarkensis* Zone (Saks & Shulgina 1974). Other authors prefer to place these highest beds still in the top Valanginian (Kemper 1978, Jeletzky 1979).

The study of the Buchia fauna from Andøy thus presents evidence for the presence of beds belonging to the upper Middle Volgian, probably most of the Upper Volgian, the uppermost Ryazanian, and all of the Valanginian. The lack of evidence for the successive *unschensis, okensis, jasikovi* and probably part of the *tolmatschowi* Zones is taken to suggest a major sedimentary break in the Early and early Late Ryazanian corresponding to the *Praetollia maynci*, *Hectoroceras kochi* and partly *Surites analogus* Zones.

Geologic implications

The Mesozoic sediments of Andøy occupy a position on a small down-faulted block on the east coast of the island (Fig. 1). The sequence, which is cut by numerous normal faults, is initiated by Middle Jurassic non-marine sandstones resting on weathered crystalline basement or on a thin sandy limestone (Holen Formation) of presumed late Devonian-early Carboniferous age (Dalland 1980). The lower part of the sandstone sequence has yielded pollen and spores of Bajocian-Bathonian age (Birkelund et al. 1978). It is followed by fluviatile and shallow marine finer grained sandstones of uncertain age relations. The whole basal sandstone sequence is included in the Ramså Formation.

System	Stage	Substage	NORTHERN SIBERIA – Ammonites	NORTHERN SIBERIA – Buchia	EAST GREENLAND – Buchia	ANDØY – Buchia
LOWER CRETACEOUS	Hauterivian	L	*Speetoniceras versicolor*	non-marine beds	hiatus	
			Homolsomites bojarkensis	*crassicollis*	*crassicollis*	?
	Valanginian	U	*Dichotomites* spp.	*sublaevis*	*sublaevis*	*sublaevis*
		L	*Polyptychites michalskii*	*keyserlingi*	*keyserlingi*	*keyserlingi - inflata*
			Temnoptychites syzranicus			
			Neotollia klimovskiensis	*inflata*	*inflata*	
	Ryazanian	U	*Bojarkia mesezhnikowi*	*volgensis*:	*volgensis*	*inflata-volgensis*
			Surites analogus	*volgensis*: *tolmatschowi*		*volgensis*
		L	*Hectoroceras kochi*	*volgensis*: *jasikovi* / *okensis*	*okensis*	? / ?
			Chetaites sibiricus	*unschensis*	*unschensis – terebratuloides*	?
UPPER JURASSIC	Volgian	U	*Chetaites chetae*			? *terebratuloides*
			Craspedites taimyrensis			
			Craspedites okensis (*C. originalis*, *C. okensis*, *V. exoticus*)	*obliqua*	*fischeriana*	*russiensis*
		M	*Epivirgatites variabilis*	*mosquensis*: *taimyrensis*	*russiensis*	
			Taimyrosphinctes exentricus			
			Dorsoplanites maximus	*mosquensis*: *russiensis*	*mosquensis*	
			Dorsoplanites ilovaiskii			
			Pavlovia iatriensis			
		L	*Pectinatites pectinatus*	*mosquensis*: *rugosa*	?	?
			Subdichotomoceras subcrassum			
			Eosphinctoceras magnum	*mosquensis*: *mosquensis*		
	Kimm.	U	*Streblites taimyrensis*	*tenuistriata*	*tenuistriata*	

Fig. 3. Stratigraphic scheme showing the correlation of the *Buchia* faunas of Andøy with the *Buchia* zonation of northern Siberia (Zakharov 1981) and East Greenland (Surlyk 1978a, Surlyk & Zakharov in press).

The major Late Jurassic eustatic sea-level rise is reflected by the incoming of highly fossiliferous fine-grained sandstones rapidly passing into dark offshore marine mudstones. This transgressive sequence, which is termed the Dragneset Formation, has yielded the ammonites *Rasenia evoluta* and *Amoeboceras (Amoebites)* sp. from the lower sandy Breisanden Member, indicative of an Early Kimmeridgian *R. cymodoce* Zone Age (Birkelund et al. 1978).

The middle position of the formation, the Taumhølet Member, is characterized by a fining upwards sequence of fine-grained sandstone, siltstone and mudstone which have not yielded any age-diagnostic fossils. They give way to dark mudstones of the Ratjønna Member, which is the highest member of the Dragneset Formation. *Dorsoplanites* cf. *subpanderi* and *Pavlovia (Epipallasiceras)* cf. *pseudoperta* of Middle Volgian Age have been obtained from the lower part of the member (Birkelund et al. 1978), and now also *Buchia* ex gr. *russiensis* from the Lower-Middle Volgian transition has been found. Lack of biostratigraphical evidence for the Upper Kimmeridgian-Lower Volgian may suggest a major hiatus between the Taumhølet and Ratjønna Members concealed by the general fine-grained nature of the sediments. This is a parallel to the situation in the Wollaston Forland area, East Greenland, where the fine-grained distal parts of the Middle Volgian Laugeites Ravine Member often rest directly on the lithologically reminiscent Bernbjerg Formation of Late Oxfordian-Early Kimmeridgian Age. In more proximal situations the two members are separated by thick Middle Volgian resedimented conglomerates and sandstones of the Rigi Member (Surlyk 1978a).

Another major hiatus within the Ratjønna Member is suggested by the lack of evidence for the Lower - lower Upper Ryazanian. No break can be detected at the Ryazanian-Valanginian boundary, contrary to the assumption of Dalland (1980). The supposed break was proposed partly on the basis of a marked facies change from the dark mudstone of the Ratjønna Member to the sandstone, siltstone and marl of the Valanginian Leira Member of the Nybrua Formation (Dalland 1980). The depositional environment of the Leira Member is not known, but by analogy with the highly reminiscent sequence in Wollaston Forland, East Greenland (Surlyk 1978a) a turbidity current or mass flow origin may be suggested for the coarser beds. If this is the case, the abrupt facies change can be considered to be of less significance as if representing a shift from deep-water mudstones to shallow marine sandstones. The Valanginian section is topped by red silt- and mudstones of the Skjærmyrbekken Member. This facies presents an exact analogue to the contemporaneous Rødryggen Member of East Greenland, and can likewise be interpreted as deposited in an oxidized environment on a submarine high formed over the crest of a tilted fault-block (Surlyk 1978a).

Acknowledgements. The manuscript was read critically by J. H. Callomon and F. T. Fürsich. A. Brantsen, J. Ågård, and S. L. Jakobsen contributed with technical assistance. V. A. Zakharov's stay in Copenhagen in 1979, during which the manuscript was completed, was supported by the Danish Natural Science Research Council. The paper is published with the permission of the Director of the Geological Survey of Greenland.

Received April 1981

PLATE 1. All figures in natural size. Specimens are deposited in the Paleontologisk museum, University of Oslo and have numbers prefixed by the letters PMO A.

Fig. 1. Buchia ex gr. *russiensis* (Pavlow). PMO A38840, D-149, Ratjønna Member, Middle–Upper Volgian transition.

Fig. 2. Buchia ex gr. *russiensis* (Pavlow). PMO A38841 D-147, Ratjønna Member, Middle–Upper Volgian transition.

Fig. 3. Buchia ex gr. *russiensis* (Pavlow). PMO A38842 D-149, Ratjønna Member, Middle–Upper Volgian transition.

Fig. 4. Buchia cf. *terebratuloides* (Lahusen). PMO A38843 D-150, Ratjønna Member, Upper (?) Volgian.

Fig. 5. Buchia volgensis (Lahusen). PMO 38844 D-164, Ratjønna Member, Upper Ryazanian.

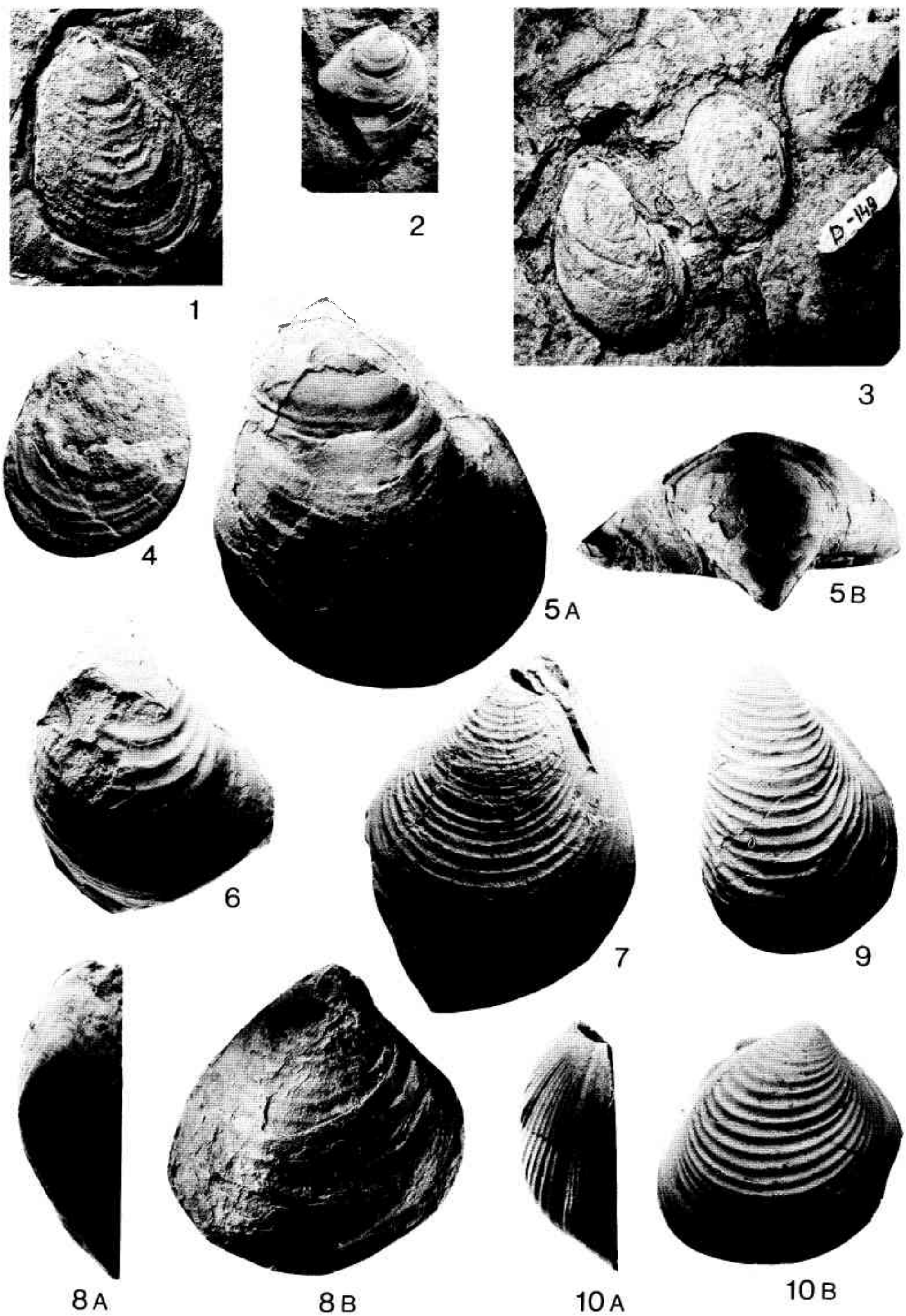
Fig. 6. Buchia ex gr. *volgensis* (Lahusen). PMO A38845 D-171, Ratjønna Member, uppermost Ryazanian.

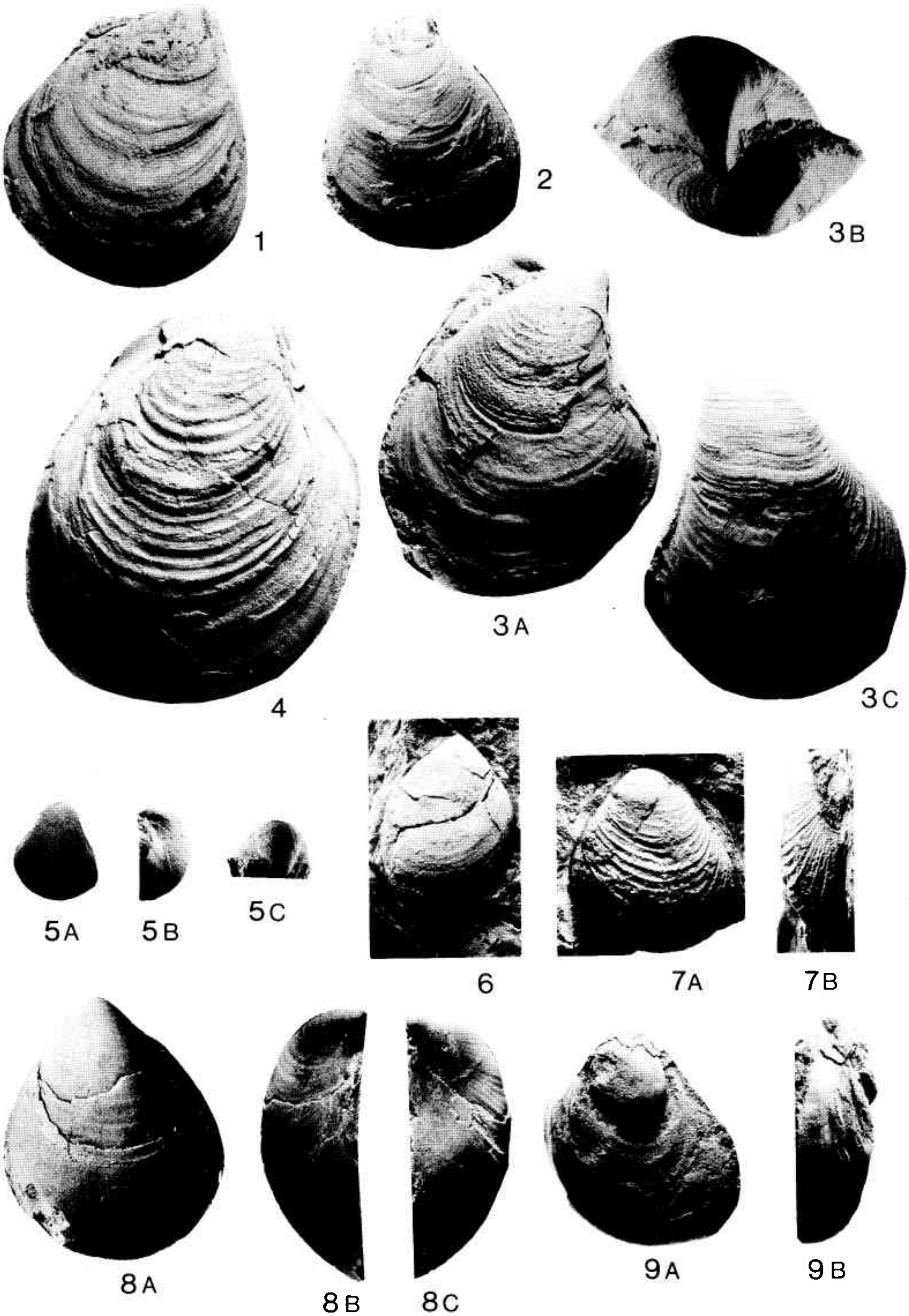
Fig. 7. Buchia ex gr. *volgensis* (Lahusen). PMO A38846 D-171, Ratjønna Member, uppermost Ryazanian.

Fig. 8. Buchia inflata (Lahusen). PMO A38847 D-171, Ratjønna Member, uppermost Ryazanian.

Fig. 9. Buchia inflata (Lahusen). PMO A388-48, Leira Member (loose blocks), Lower Valanginian.

Fig. 10. Buchia inflata (Lahusen). PMO A388-49, Leira Member (loose blocks), Lower Valanginian.


1
2
3
D-149
4
5A
5B
6
7
9
8A
8B
10A
10B


1
2
3B
3A
4
3C
5A
5B
5C
6
7A
7B
8A
8B
8C
9A
9B

References

Birkelund, T., Thusu, B. & Vigran, J. 1978: Jurassic and Cretaceous biostratigraphy of North Norway with comments on British ammonite *Rasenia evoluta*. *Palaeontology, 21*, 31–63.

Dalland, A. 1975: The Mesozoic rocks of Andøy, northern Norway. *Norg. geol. unders. 316*, 271–287.

Dalland, A. 1980: The sedimentary sequence of Andøy, northern Norway – depositional and structural history. *Mem. Can. Soc. Petrol. Geol. 7.*

Jeletzky, J. A. 1979: Eurasian craspeditid genera *Temnoptychites* and *Tollia* in the Lower Valanginian of Sverdrup Basin, District of Franklin with comments on taxonomy and nomenclature of Craspeditidae. *Geol. Surv. Can., Bull. 299*, 60 pp.

Kemper, E. 1977: Biostratigraphy of the Valanginian in Sverdrup Basin, District of Franklin. *Geol. Surv. Can., Paper 76–32*, 6 pp.

Løfaldli, M. & Thusu, B. 1979: Micropalaeontological studies of the Upper Jurassic and Lower Cretaceous of Andøya, northern Norway. *Palaeontology, 22*, 413–425.

Saks, V. N. & Shulgina, N. I. 1974: Valanginian Stage of the Boreal Realm. *Akad. Nauk SSSR, Sib. Otd., Inst. Geol. Geofiz., Tr., No. 136*, 142–149 (In Russian).

Sokolov, D. N. 1912: Fauna der mesozoischen Ablagerungen von Andö. *Videnskapsselskabets Skrifter. I. Mat.-Naturv. Klasse. N 6*, 3–14.

Surlyk, F. 1973: The Jurassic-Cretaceous boundary in Jameson Land, East Greenland. *In* Casey, R. and Rawson, P. F. (eds.) The Boreal Lower Cretaceous. *Geol. J. Spec. Iss. 5*, 81–100.

Surlyk, F. 1977: Stratigraphy, tectonics and palaeogeography of the Jurassic sediments of the area north of Kong Oscars Fjord, East Greenland. *Bull. Grønlands geol. Unders. 123*, 56 pp.

Surlyk, F. 1978a: Submarine fan sedimentation along fault scarps on tilted fault blocks (Jurassic-Cretaceous boundary, East Greenland). *Bull. Grønlands geol. Unders., 128*, 108 pp.

Surlyk, F. 1978b: Mesozoic geology and palaeogeography of Hochstetter Forland, East Greenland. *Bull. geol. Soc. Denmark, 27*, 73–87.

Surlyk, F., Callomon, J. H., Bromley, R. G. and Birkelund, T., 1973. Stratigraphy of the Jurassic-Lower Cretaceous sediments of Jameson Land and Scoresby Land, East Greenland. *Bull. Grønlands geol. Unders., 105*, 76 pp.

Zakharov, V. A. 1981: *Buchiidae (Bivalvia) and biostratigraphy of the boreal Upper Jurassic and Neocomian.* Moscow, 'Nauka', (In Russian).

Surlyk, F. & Zakharov, V. A. (in press): Buchiid bivalves from the Upper Jurassic–Lower Cretaceous of East Greenland Palaeontology.

PLATE 2.

Fig. 1. Buchia ex gr. *inflata*. PMO A38850 D-174, Leira Member, Lower Valanginian.

Fig. 2. Buchia ex gr. *inflata*. PMO A 38851 D-174, Leira Member, Lower Valanginian.

Fig. 3. Buchia keyserlingi (Trautschold). PMO A38852 F-3, Leira Member, Lower Valanginian.

Fig. 4. Buchia keyserlingi (Trautschold). PMO A38853 F-12, Leira Member, Lower Valanginian.

Fig. 5. Buchia sublaevis (Keyserling). PMO A38854 F-13, Skjærmyrbekken Member, Upper Valanginian.

Fig. 6. Buchia sublaevis (Keyserling). PMO A 38855 F-14, Skjærmyrbekken Member, Upper Valanginian or Lower Hauterivian.

Fig. 7. Buchia cf. *sublaevis* (Keyserling). PMO A38856 F-16, Skjærmyrbekken Member, Upper Valanginian or Lower Hauterivian.

Fig. 8. Buchia sublaevis (Keyserling). PMO A38857 E-6, Leira Member, uppermost Lower Valanginian.

Fig. 9. Buchia crassicollis (Keyserling). PMO A38858 F-14, Skjærmyrbekken Member, Upper Valanginian or Lower Hauterivian.