Fusulinid zonation of the Upper Carboniferous Kap Jungersen and Foldedal Formations, southern Amdrup Land, eastern North Greenland

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New fusulinid data from the Kap Jungersen and Foldedal Formations in southern Amdrup Land, eastern North Greenland allow the establishment of a detailed fusulinid-based zonation of the Upper Carboniferous succession in the Wandel Sea Basin. The fusulinid fauna is quite similar to that of the Russian Platform, the Ural Mountains, Spitsbergen, Bjørnøya, and the offshore areas of the Barents Sea, and therefore the Greenland strata are confidently correlated to the these regions. The Kap Jungersen Formation and the lower part of the Foldedal Formation are dated as late early Moscovian to latest Moscovian in age. The locally more than 450 m thick Moscovian part of the succession comprises four fusulinid zones: the *Profusulinella prisca – Neostaffella subquadrata* Zone and the *Citrinoides paraozawai* Zone of early Moscovian age, and the *Fusulinella bocki – Pseduofusulinella pulchra* Zone and the *Protriticites ovatus* Zone of late Moscovian age. Lower and middle Kasimovian deposits, characterized by two fusulinid assemblages of the *Obsoletes obsoletus – Protriticites pseudomontiparus* Zone and the *Montiparus paramontiparus* Zone, are recognised for the first time in Amdrup Land. The thin lower Gzelian succession is represented by two fusulinid assemblages that definine the *Rugosofusulina flexuosa* Zone and the *Daixina crispa – Rauserites stuckenbergi* Zone. The youngest Carboniferous strata, belonging to the Orenburgian part of the Gzelian are characterised by an assemblage of the *Schellwienia ulukensis* Zone.

Keywords: Biostratigraphy, Fusulinid zonation, Upper Carboniferous, Wandel Sea Basin.

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Dating and correlation of the Upper Carboniferous successions in North Greenland, Spitsbergen, Bjørnøya, Arctic Canada and the offshore areas of the Barents Sea along the northern margin of Pangea are based primarily on fusulinids. The fusulinid assemblages recorded along the northern Pangean shelf correspond well to those used to establish the fusulinid zones in the stadial stratotype regions of Russia, thereby allowing a firm correlation to those Upper Carboniferous stages. Previous studies of the fusulinid fauna in the Upper Palaeozoic sediments of Holm Land and Amdrup Land in eastern North Greenland led to the establishment of three local fusulinid zones of Moscovian to possible earliest Asselian age (Dunbar et al. 1962; Ross & Dunbar 1962; Nilsson et al. 1991; Nilsson 1994) (Figs 1, 3). Biostratigraphic work in the time equivalent successions of Prinsesse Ingeborg Halvø and eastern Peary Land further to the north in Greenland led to a more refined zonation with distinction of additional upper Kasimovian and lower Gzelian zones (Nilsson 1994; Stemmerik et al. 1996).

The present paper is the first detailed study of the fusulinid fauna of the well exposed Upper Carboniferous succession in the coastal cliffs of southern Amdrup Land. Nine local fusulinid zones, spanning the early Moscovian (Tsninian) to the late Orenburgian (Melekhovian) part of the Gzelian *sensu lato* have been distinguished in the Kap Jungersen and Foldedal Formations of Amdrup Land based on the study of 38 productive fusulinid samples (Fig. 2).

Fig. 1A

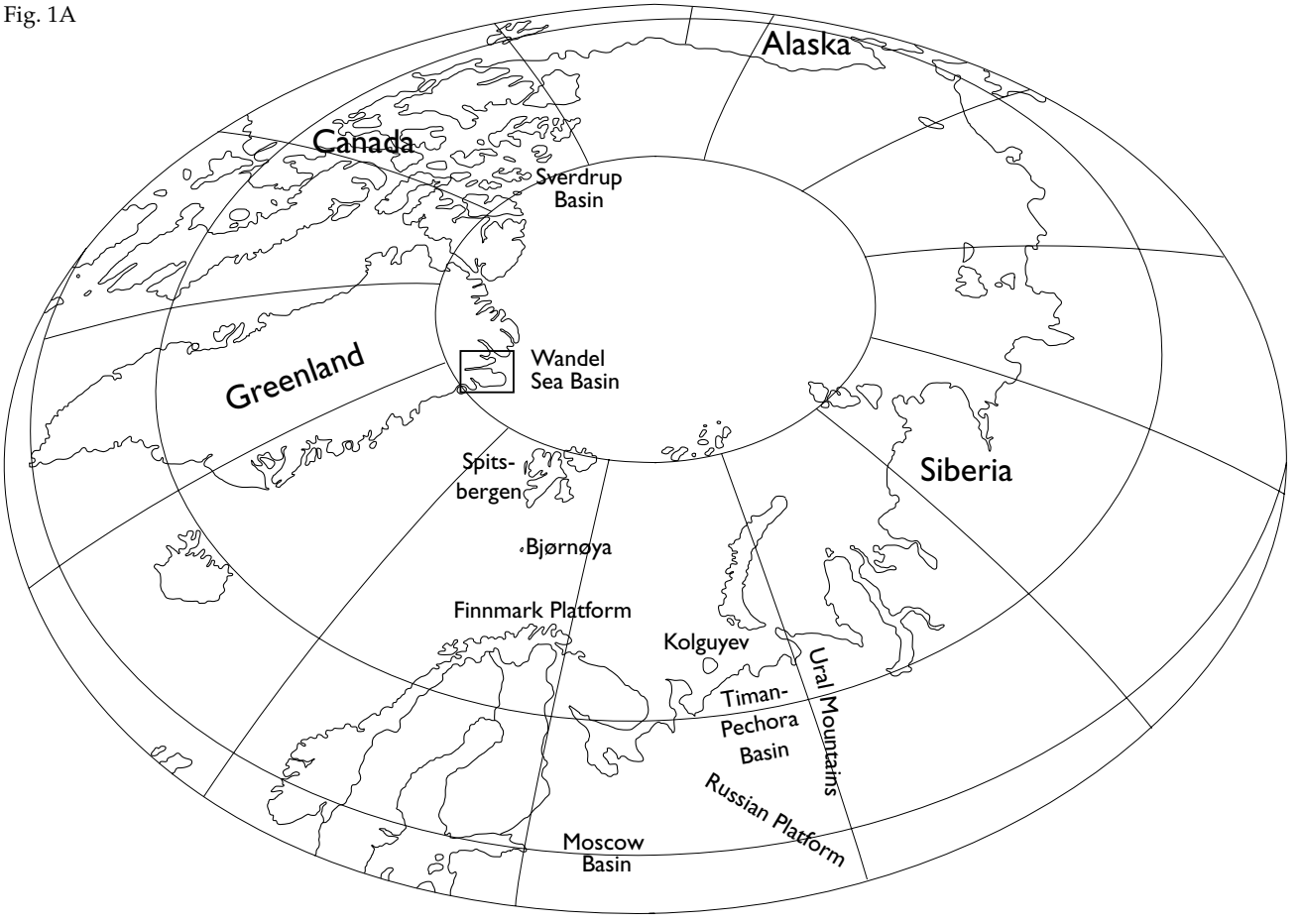
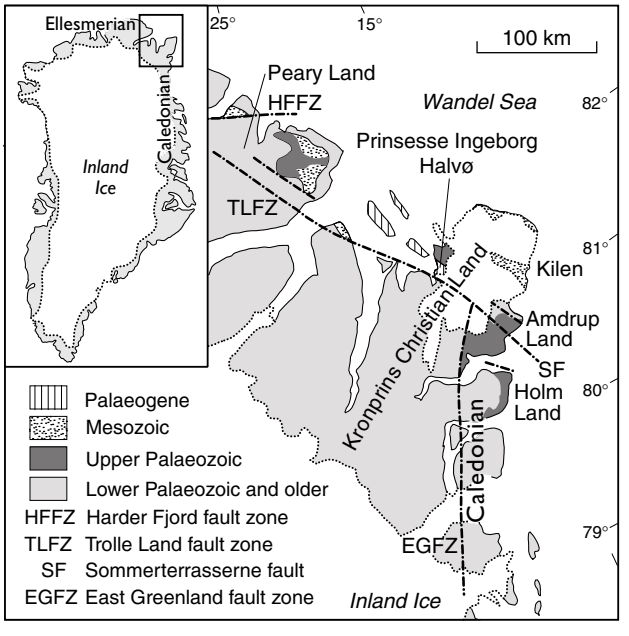


Fig. 1B



Lithostratigraphy and material

More than 400 thin sections with oriented fusulinids were prepared from the productive fusulinid samples collected in southern Amdrup Land. All collected samples are precisely located in sedimentological sections measured along the coastal cliffs from Kap Jungersen westward to Østelv and along the riverbanks east of the Østelv river (Fig. 3). Correlation of sedimentological sections within the outcrop area is based on the tracing of key surfaces on the outcrops and from helicopter supplemented with multi-model photogrammetric analysis of the cliff exposures. The undisturbed nature of the outcrops allow continuous correlation between individual sections.

The Upper Carboniferous succession at southern Amdrup Land is composed of several shelf carbonates, shallow marine to deeper shelf siliciclastics, and subordinate evaporites (gypsum and anhydrite). The sediments were originally included in the Upper and Lower Marine Groups of Grönwall (1916). Later, Stemmerik & Håkansson (1989) included the succession in the Kap Jungersen, Foldedal and lower Kim

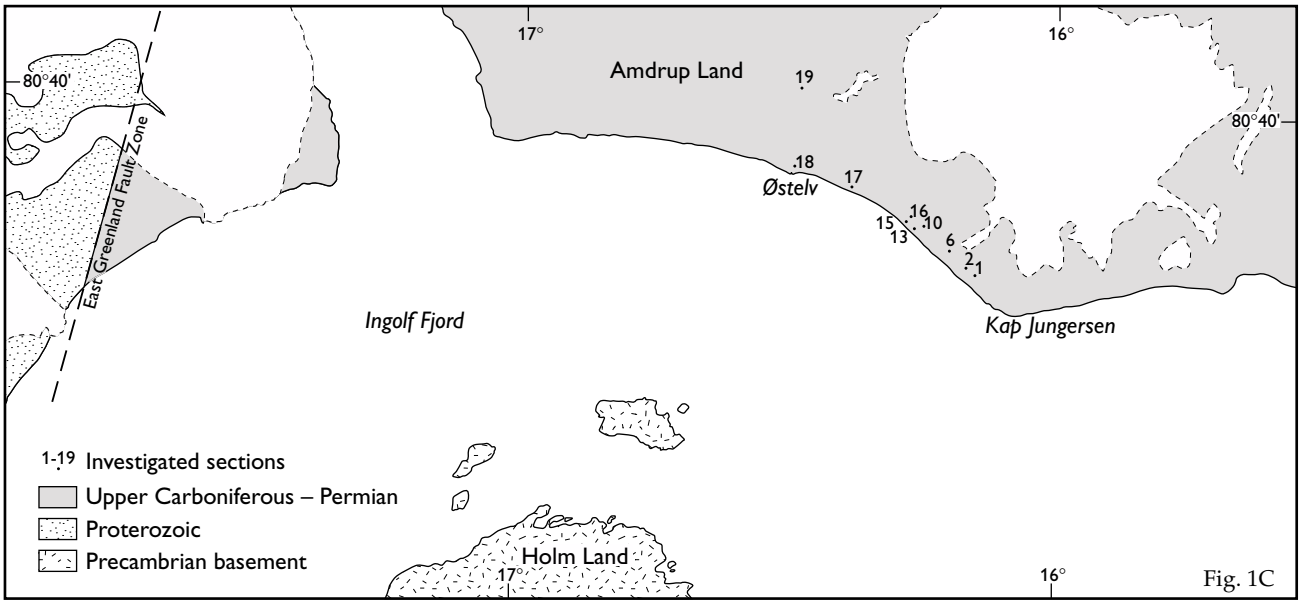


Fig. 1. A. North polar projection showing the present day position of localities mentioned in the text. Framed area indicates position of Fig. 1B. B. Map of eastern North Greenland showing distribution of marine Upper carboniferous sediments within the Wandel Sea Basin. C. Location of studied sections in southern Amdrup Land.

Fjelde Formations of the Mallemuk Mountain Group. During renewed field work in eastern Peary Land in 1991 it became clear that the lithostratigraphy was in need of further revision and the boundary between the Foldedal and Kim Fjelde Formation was redefined. The Kim Fjelde Formation is now regarded as entirely Permian in age based on conodonts, small foraminifers and palynomorfs (Stemmerik et al. 1996). Similarly, field work in Amdrup Land and Holm Land in 1993–1995 resulted in adjustments to the lithostratigraphy in the area. The lithostratigraphic nomenclature used in this paper follows the division of the Upper Carboniferous succession into the Kap Jungersen and Foldedal Formations separated from the Permian Kim Fjelde Formation by a well-developed subaerial exposure surface representing a break in sedimentation spanning most of the Lower Permian (Asselian – lower Artinskian). In southern Amdrup Land, the boundary between the Kap Jungersen and Foldedal Formations is placed somewhat higher in the section than originally proposed by Stemmerik & Håkansson (1989) at a major erosional surface.

The lower part of the Kap Jungersen Formation is exposed along the riverbanks of Østelv river in the western part of the study area (section 18, Fig. 3). Based on fusulinids these sediments are the oldest Carboniferous known on Amdrup Land. The upper part of the formation is well exposed in the western part of Kap Jungersen (sections 13, 15, 17, Figs 1, 3–4). The Foldedal Formation forms the main part of the exposed strata in the eastern part of the Kap Jungersen section; it thins westward and form the top of the exposures along the western half of the coastal cliffs (sections 1, 2, 6, 10, 16, Figs 1, 3). The upper part of the formation is present at the northernmost outcrops at Østelv where the formation is separated from the Kap Jungersen Formation by a major subaerial exposure surface representing a break in sedimentation spanning the Kasimovian and the earlier parts of the Gzelian (section 19, Fig. 1). The Foldedal Formation is disconformably overlain by Permian sediments of the Kim Fjelde Formation in northern Østelv and at eastern Kap Jungersen; elsewhere it forms the top of the outcrops.

Fusulinid zonation

A total of nine local fusulinid zones, spanning the early Moscovian to late Gzelian have been defined based on the 38 productive fusulinid samples from the south coast of Amdrup Land between Østelv and Kap Jungersen (Fig. 2; Table 1). The faunas have been compared with faunas in the stratotype areas of the Russian Platform and the Ural Mountains and to faunas elsewhere in the Arctic region.

The stratigraphic nomenclature used in Figure 2 and in the text uses the recently proposed subdivision of the Pennsylvanian Subsystem of the Carbon-

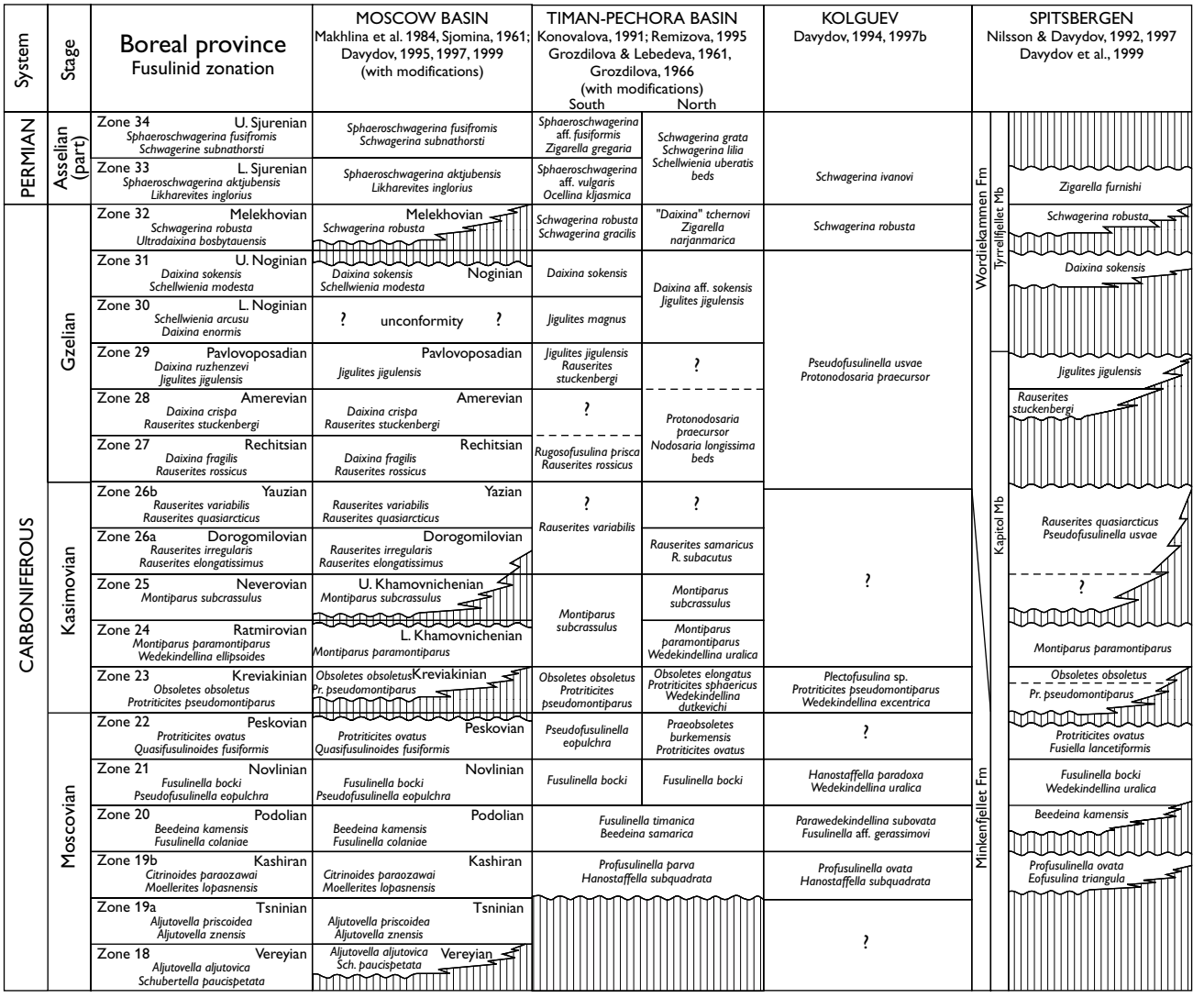
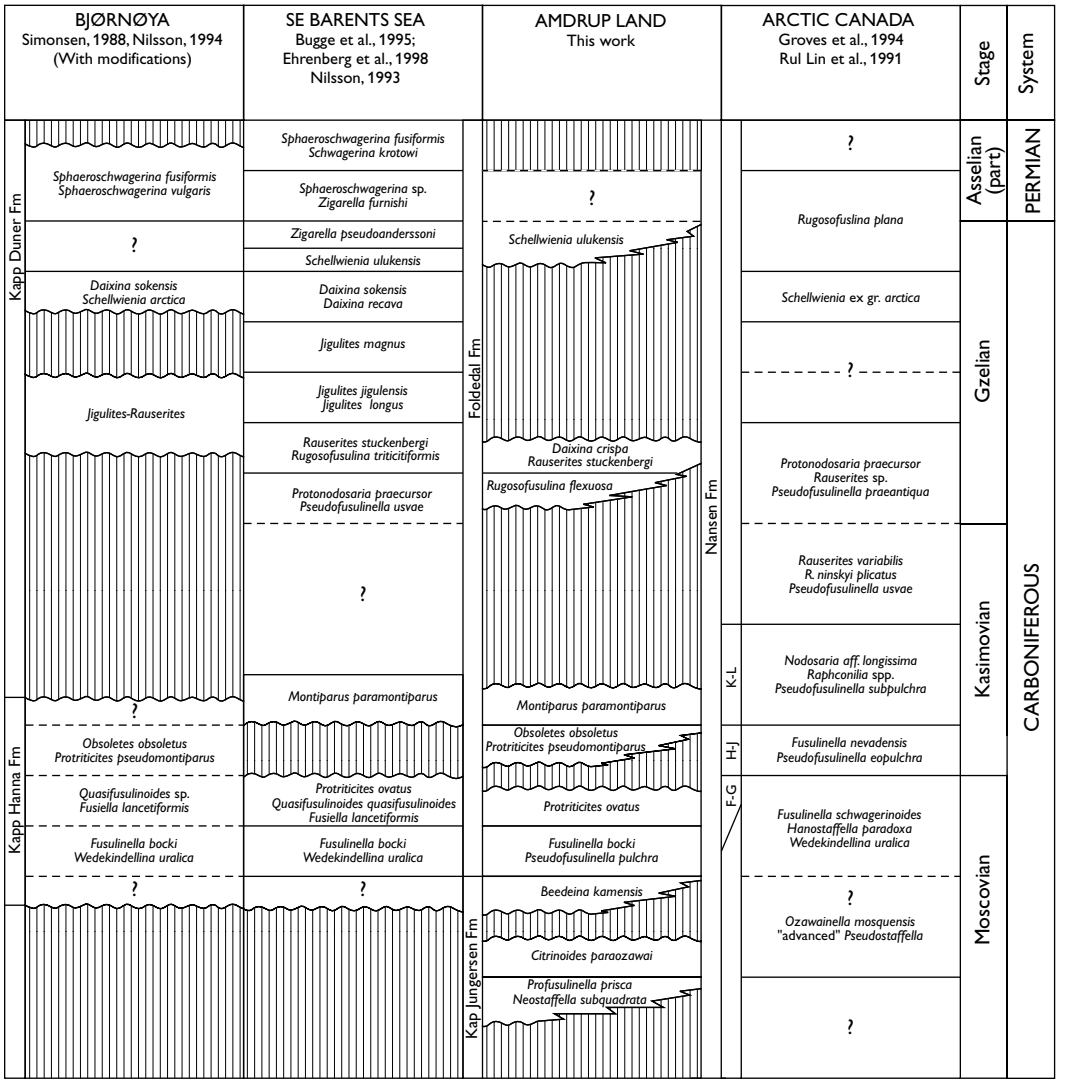


Fig. 2. Correlation of local Upper Carboniferous (Moscovian-Gzelian) fusulinid zonations along the northern margin of Pangea with the fusulinid zonation of the Russian Platform. For location see Fig. 1A.

iferous into the Russian stages Bashkirian, Moscovian, Kasimovian and Gzelian (Remane 2000). The substadial subdivision is based on work in the Russian Platform and the southern Ural Mountains (Ivanova & Khvorova 1955; Makhlina et al. 1984; Kagramanov & Donakova 1990; Alekseev et al. 1996; Davydov 1996, 1997a). The subdivision was established as Geological Horizons, meaning regional stages in the Russian Code of Stratigraphic Nomenclature (Zhamoida 1988), and recently several more regional stages (horizons), such as Tsninian, Peskovian, Ratmirovian, Neverovian and Melekhovian have been added to the original subdivision (Fig. 2; Solovieva 1986; Makhlina & Isakova 1997; Davydov 1996, 1999). The Lower Permian, Cisuralian stages were established in the southern Ural Mountains where the sedimentary succession is most complete and biostratigraphically well dated by ammonoids, fusulinids and conodonts (Rauser-Chernousova 1949; Ruzhenzev 1951; Rosovskaya 1950; Davydov 1986; Chernykh & Ritter 1997; Davydov et al. 1998).

The fusulinid zonation established in the North Greenland succession is generally applying the same fusulinid species and the same zonal criteria as used in the Russian Platform and the southern Ural Mountains by Rauser-Chernousova (1949), Rosovskaya (1950), Rauser-Chernousova & Reitlinger (1954), Solovieva (1977, 1986), Davydov & Popov (1991), and Davydov (1995, 1997a, 1999) (Fig . 2). The only two exceptions are the lower Gzelian *Rugosofusulina flexuosa* zone and the upper Gzelian *Schellwienia ulukensis* zone that both are established in the North



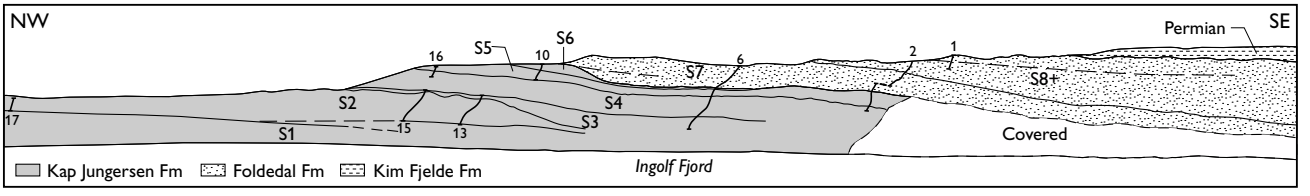
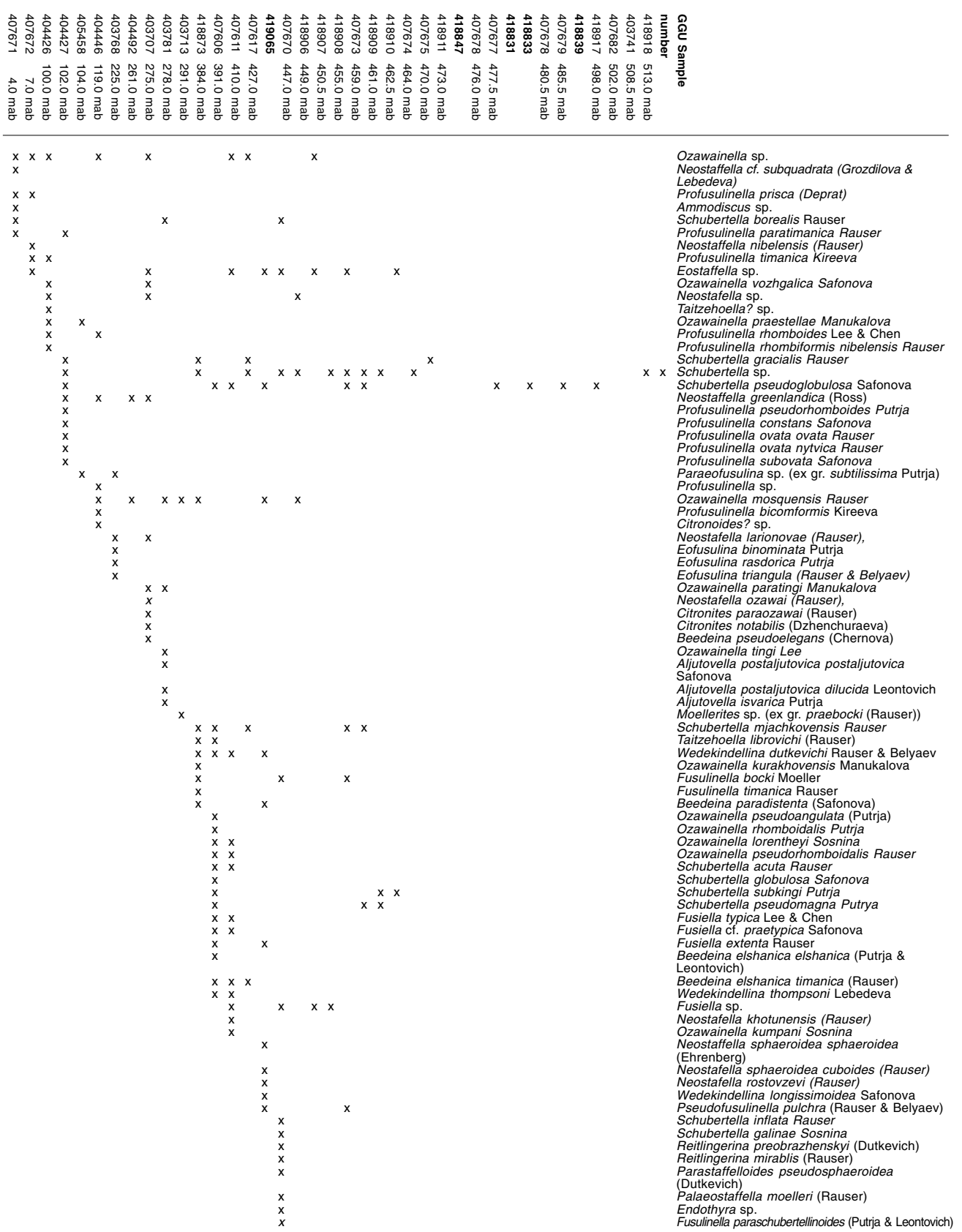


Fig. 3. Correlation of investigated sections at Kap Jungersen, southern Amdrup Land. Correlation is based on tracing of beds in the field and on photos. S1 – S7 are Moscovian depositional sequences. Note the eastward thickening of the Kasimovian-Gzelian sequences S8+. For location see Fig. 1C.

Table 1. Distribution chart of fusulinids in the composite section at the coastal cliffs of southern Amdrup Land. Heights are given as metres above base of Sequence 1 in Fig. 3. Samples marked by bold are not precisely located in the composite section.




GGU Sample number
418918 513.0 mab
403741 508.5 mab
407682 502.0 mab
418917 498.0 mab
418839
407679 485.5 mab
407678 480.5 mab
418833
418831
407677 477.5 mab
407678 476.0 mab
418847
407674 464.0 mab
418910 462.5 mab
418909 461.0 mab
407673 459.0 mab
418908 455.0 mab
418907 450.5 mab
418906 449.0 mab
407670 447.0 mab
419065
407617 427.0 mab
407611 410.0 mab
407606 391.0 mab
418873 384.0 mab
403713 291.0 mab
403781 278.0 mab
403707 275.0 mab
404492 261.0 mab
403768 225.0 mab
404446 119.0 mab
405458 104.0 mab
404427 102.0 mab
404426 100.0 mab
407672 7.0 mab
407671 4.0 mab
Fusulinella cf. vozhgalensis Safonova
Beedeina nytvica callosa (Safonova)
Beedeina siviniensis (Rauser)
Beedeina nytvica nytvica (Rauser)
Beedeina samarica (Rauser & Belyaev)
Beedeina cf. samarica (Rauser & Belyaev)
Fusulinella praebocki Rauser
Pseudofusulinella eopulchra (Rauser)
Protriticites aff. ovatus Putrja
Protriticites ovatus Putrja
Protriticites variabilis Bensh
Protriticites subschwagerinoides Rosovskaya
Praeobsoletes sp.
Protriticites pseudomontiparus Putrja
Protriticites manukalovae Kireeva
Quasifusulinoides sp.
Fusiella lancetiformis Putrja
Obsoletes grozdilovae (Miklukho-Maclay)
Plectofusulina sp.
Pseudofusulinella sp.
Pseudofusulinella usvae (Dutkevich)
Protriticites sphaericus Volozhanina
Quasifusulinoides intermedius (Rauser & Gryzlova)
Quasifusulinoides pulchellus (Gryzlova)
Quasifusulinoides quasifusulinoides (Rauser)
Protriticites globulus Putrja
Quasifusulinoides firmus (Rauser)
Schubertella polymorpha Safonova
Reitlingerina timanica (Rauser)
Parastaffelloides fraudulenta (Rauser)
Palaeostaffella sp.
Fusulinella pseudobocki Lee & Chen
Praeobsoletes pauper (Volozhanina)
Schubertella miranda Leontovich
Schubertella magna Lee and Chen
Praeobsoletes burkemensis (Volozhanina)
Praeobsoletes curtus (Volozhanina)
Obsoletes callosus Kireeva
Montiparus sp.
Montiparus paramontiparus Rosovskaya
Montiparus umbonoplicatus Rosovskaya
Schubertella paramelonica Suleimanov
Pseudofusulinella cf. annae (Grozdilova)
Rugosofusulina triticitiformis Volozhanina
Boultonia? sp.
Rugosofusulina elliptica Rosovskaya
Rugosofusulina ovoidea Bensh
Rugosofusulina exiqua Remizova
Rugosofusulina pleiomorpha Remizova
Rugosofusulina flexuosa Rosovskaya
Rauserites ex gr. stuckenbergi (Rauser)
Rauserites elongatissima (Rosovskaya)
Rauserites stuckenbergi (Rauser)
Rauserites variabilis (Rauser)
Rauserites communis (Rauser)
Rauserites postarcticus (Rauser)
Rauserites paraarcticus (Rauser)
Rauserites cf. rossicus (Schellwien)
Daixina fragilis Rosovskaya
Daixina nikolskiensis Davydov
Daixina enormis Scherbovich
Daixina naviculaeformis Alksne & Polozova
Jigulites magnus (Rosovskaya)
Schellwienia delicata (Alksne)
Schellwienia porrecta (Sjomina)
Schellwienia ulukensis (Bensh)
Schellwienia aff. glandiformis (Alksne)
Schellwienia postmodesta Davydov
Daixina ex gr. sokensis (Rauser)
Quasifusulina sp. 1
Quasifusulina cayeuxi (Deprat)
Schellwienia biformis (Bensh)
Schellwienia krushiensis (Alksne)
Schellwienia malkovskyi (Alksne)
Schellwienia lata (Alksne)
Schellwienia salebrosa (Konovalova)
Schellwienia subundulata (Konovalova)
Schellwienia emaciata (Konovalova)
Schellwienia aff. bornemani (Leven & Scherbovich)
Zigarella acuminulata (Echlakov)
Schellwienia iohchiensis (Davydov)
Schellwienia arctica (Schellwien)
Schellwienia visotchaensis (Konovalova)
Schellwienia modesta (Scherbovich)
Schellwienia grata (Konovalova)
Schellwienia kharjagaensis (Konovalova)
Zigarella praegregaria (Scherbakova)
Zigarella simplex (Konovalova)

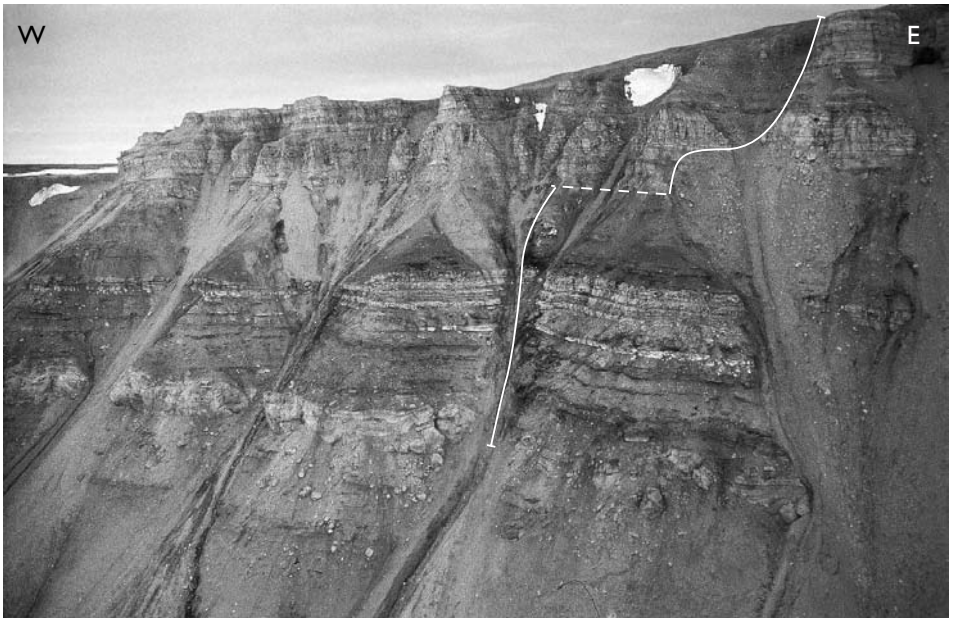


Fig. 4. The Upper Carboniferous succession in the coastal cliffs west of Kap Jungersen with position of section 2. Fusulinids are common in the upper cliff-forming carbonate unit. Cliff is 250 m high.

Greenland succession. The lower Gzelian *Rugosofusulina flexuosa* zone is characterised by a taxonomically poor and environmentally dependent assemblage of fusulinids that differs significantly from the lower Gzelian assemblage in the Russian Platform, and accordingly precise correlation can not be established. The uppermost Carboniferous *Schellwienia ulukensis* zone in North Greenland is characterised by an assemblage of advanced *Schellwienia* most of which range from the lower Orenburgian part of the Gzelian to the lower Asselian in the Russian Platform and the southern Ural Mountains. Several of the species characterising the North Greenland assemblage, including the index-species, have their lowermost appearance in the late Orenburgian part of the Gzelian, and most probably the *Schellwienia ulukensis* zone corresponds to the Melekhovian (upper Orenburgian part of the Gzelian) *Schwagerina robusta-Ultradaixina bosbytauensis* zone of the Russian Platform and the southern Ural Mountains. However, index-species of the Melekhovian in the Russian Platform and the southern Ural Mountains, such as *Schwagerina robusta* and *Ultradaixina bosbytauensis* are not present in North Greenland. The correlation of this zone to the standard zonation is based on the presence of some of more rare Russian species in the North Greenland assemblage as discussed in more details below.

Profusulinella prisca – Neostaffella subquadrata Zone (Plate 1)

Definition: The zone is defined as the body of strata characterised by the co-occurrence of *Profusulinella prisca* (Deprat), *Pr. paratimanica* Rauser, *Pr. timanica* Kireeva, *Neostaffella nibelensis* (Rauser) and *N.* cf. *subquadrata* (Grozdilova & Lebedeva).

Distribution: Assemblages belonging to this zone have been identified in samples GGU 407761 and 407762 from section 18, southern Østelv (Fig. 1).

Composition: The assemblage includes *Ammodiscus* sp., *Eostaffella* sp., *Ozawainella* sp., *Schubertella borealis* Rauser, *Neostaffella nibelensis* (Rauser), *N.* cf. *subquadrata* (Grozdilova & Lebedeva), *Profusulinella prisca* (Deprat), *Pr. paratimanica* Rauser and *Pr. timanica* Kireeva.

Age: Early Moscovian, Tsninian (Standard fusulinid zone 19a)

Comments: The fusulinid assemblage characterising this zone includes some of the common taxa found in the assemblages of the Vereyian and Kashirian (*sensu stricto)* Horizons in Russia, such as *Profusulinella*, *Neostaffella* and *Schubertella*. The assemblage is transitional between those characterising the Vereyian Horizon below and Kashirian Horizon above and is accordingly regarded as Tsininian in age. Tsninian fusulinid assemblages differ from the underlying Vereyian assemblages by the absence of *Verella*. *Citrinoides*, *Beedeina*, *Moellerites*, *Fusiella*, *Paraeofusulina* and some advanced species of *Profusulinella* and *Neostaffella*, all characteristic of the Kashirian Horizon, have not been recognised in Greenland assemblage suggesting it to be older than Kashirian.

The assemblage described from the *Profusulinella prisca – Neostaffella subquadrata* Zone is generally very poor and may be extended by future investigations.

Citrinoides paraozawai zone (Plates 2–3)

Definition: The zone is defined as the body of strata between the first appearance of *Fusiella*, *Citrinoides*, *Beedeina* and *Paraeofusulina* and the first appearance of *Fusulinella*, *Wedekindellina*, advanced *Beedeina*, *Taitzehoella* and *Neostaffella*, and numerous *Fusiella*.

Distribution: The assemblage has been identified in samples GGU 404458 (section 17, Fig. 3), GGU 404426 and 404427 (section 15, Fig. 3), GGU 404446 (section 13, Fig. 3) and GGU 403707 (section 10, Fig. 3).

Composition: The following species have been identified within the assemblage: *Ozawainella mosquensis* Rauser, *Oz. vozhgalica* Safonova, *Oz. praestellae* Manukalova, *Oz. paratingi* Manukalova, *Oz. tingi* Lee, *Schubertella gracilis* Rauser, *Sch. pseudoglobulus* Safonova, *Fusiella* sp., *Neostaffella greenlandica* (Ross), *N. larionovae* (Rauser), *N. ozawai* (Rauser), *Profusulinella rhomboides* Lee & Chen, *Pr. rhombiformis nibelensis* Rauser, *Pr. pseudorhomboides* Putrja, *Pr. constans* Safonova, *Pr. timanica* Kireeva, *Pr. paratimanica* Rauser, *Pr. ovata ovata* Rauser, *Pr. ovata nytvica* Rauser, *Pr. subovata* Safonova, *Pr.* aff. *prisca* (Deprat), *Aljutovella postaljutovica postaljutovica* Safonova, *Al. postaljutovica dilucida* Leontovich, *Al. isvarica* Putrja, *Taitzehoella*? sp., *Eofusulina binominata* Putrja, *E. rasdorica* Putrja, *E. triangula* (Rauser & Belyaev), *Paraeofusulina* sp. (ex gr. *subtilissima* Putrja), *Citrinoides paraozawai* (Rauser), *C. notabilis* (Dzhenchuraeva) and *Beedeina pseudoelegans* (Chernova).

Age: Early Moscovian, Kashirian (*sensu stricto*) (Standard fusulinid zone 19b).

Comments: The fusulinid assemblage of this zone differs from the underlying assemblage by the appearance of several distinct genera characteristic for the Kashirian Horizon in the Russian Platform, such as *Fusiella*, *Beedeina*, *Citrinoides*, and *Paraeofusulina*. Some advanced species of *Ozawainella*, *Neostaffella*, *Profusulinella*, and *Aljutovella*, characteristic for the Kashirian of the Russian Platform, also occur in this zone. The abundance and diversity of fusulinids in this zone indicate open marine conditions and good connection to adjacent shelf regions. Deposition most likely took place during a third order sea-level rise as in the Kashirian of the Russian Platforms, Spitsbergen and Central Asia (Makhlina, 1979; Leven, 1998; Anisimov et al. 1998).

Fusulinella bocki – Pseudofusulinella pulchra Zone (Plate 4)

Definition: This zone includes the strata between the basal appearance of *Fusulinella bocki*, *Wedekindellina longissima*, *Beedeina paradistenta* and *Pseudofusulinella eopulchra* and the basal appearance of primitive *Protriticites* and typical *Quasifusulinoides*.

Occurrence: The assemblage characterises sample GGU 407670 (setion 1, Fig. 3).

Composition: The following species have been recognised within the assemblage: *Reitlingerina preobrazhenskyi* (Dutkevich), *R. mirablis* (Rauser), *Parastaffelloides pseudosphaeroidea* (Dutkevich), *Palaeostaffella moelleri* (Rauser), *Neostaffella sphaeroidea cuboides* (Rauser), *N. rostovzevi* (Rauser), *Schubertella borealis* Rauser, *Sch. gracilis* Rauser, *Sch. inflata* Rauser, *Sch. pseudoglobulosa* Safonova, *Sch. galinae* Sosnina, *Fusulinella bocki* Moeller, *F. paraschubertellinoides* (Putrja & Leontovich), *F.* cf. *vozhgalensis* Safonova, *Wedekindellina longissimoidea* Safonova, *Beedeina paradistenta* (Safonova), *Pseudofusulinella pulchra* (Rauser & Belyaev).

Age: Late Moscovian, early Myachkovian, Novlinian (Standard fusulinid zone 21).

Comments: The genera *Fusulinella* and *Beedeina* are represented by typical advanced species such as *F. bocki*, *F. vozhgalensis* and *B. paradistenta*. Their primitive relatives *Citrinoides* and *Moellerites* have completely disappeared, while the first primitive *Pseudofusulinella* (*P. pulchra*) first appeared during this time. It is interesting to note that staffellids, such as *Reitlingerina*, *Palaeostaffella* and *Parastaffelloides* are abundant in this zone. Similarly, abundant staffellids occurs in Novlinian of the Barents Sea suggesting some regional event. Usually the abundance of staffellids is taken as evidence of a stressful environment in form of cooler water or higher salinity (Zolotova et al. 1975). At Kap Jungersen, the *Fusulinella bocki – Pseudofusulinella pulchra* Zone represents an overall transgressive, non-evaporitic interval suggesting that the environmental stress most likely relates to the presence of cooler water.

Protriticites ovatus Zone (Plate 5)

Definition: The zone defines the strata between the basal appearance of primitive *Protriticites* (*Protriticites* ex gr. *ovatus*), *Quasifusulinoides*, very rare *Praeobsoletes* and advanced elongate *Beedeina,* and the basal appearance of numerous *Praeobsoletes*, *Obsoletes* and advanced *Protriticites* (*Pr. pseudomontiparus* group).

Occurrence: The assemblage has been recognised in samples GGU 418820 (section 19, Fig. 1), GGU 418906 and 418907 (Section 1, Fig. 3).

Composition: The assemblage includes *Eostaffella* sp., *Millerella* sp., *Neostaffella*? sp., *Schubertella* sp., *Fusiella* sp., *Fusulinella* cf. *bocki* Moeller, *Fusulinella praebocki* Rauser, *Protriticites ovatus* Putrja, *Protriticites* aff. *ovatus*

Putrja, *Protriticites* aff. *subschwagerinoides* Rosovskaya, *Praeobsoletes* sp., *Pseudofusulinella eopulchra* (Rauser), *Pseudofusulinella pulchra* (Rauser & Belyaev), *Beedeina nytvica nytvica* (Rauser), *B. nytvica callosa* (Safonova), *B. siviniensis* (Rauser), *B. samarica* (Rauser & Belyaev), *B.* cf. *samarica* (Rauser & Belyaev) and *Quasifusulinoides* sp.

Age: Late Moscovian, Peskovian (Standard fusulinid zone 22).

Comments: The assemblage is characterised by the basal appearances of *Protriticites*, *Praeobsoletes* and *Quasifusulinoides,* and the presence of very advanced elongate *Beedeina* (e.g. *B. siviniensis*). Representatives of *Fusulinella* and particularly *Neostaffella* are very rare. The relatively poor taxonomic diversity of this assemblage as compared with age equivalent assemblages of Spitsbergen and the Barents Sea subsurface (Davydov & Nilsson 1999) most likely reflects the limited number of studied samples.

Obsoletes obsoletus – Protriticites pseudomontiparus Zone (Plates 6–7)

Definition: The zone includes the strata between the basal appearances of *Obsoletes* and advanced *Protriticites* of the *Pr. pseudomontiparus* group and the basal appearance of *Montiparus*.

Occurrence: The assemblage occurs in samples GGU 407673, 407674 and 418908-910 (section 1, Fig. 3).

Composition: The assemblage is characterised by *Reitlingerina timanica* (Rauser), *R. variabilis* (Rauser), *Parastaffelloides pseudosphaeroidea* (Dutkevich), *P. frandulenta* (Rauser), *Palaeostaffella* sp., *Eostaffella* sp., *Ozawainella mosquensis* Rauser, *Schubertella pseudoglobulosa* Safonova, *Sch. polymorpha* Safonova, *Sch. mjachkovensis Rauser*, *Sch. pseudomagna* Putrya, *Fusiella lancetiformis* Putrja, *Fusulinella bocki* Moeller, *F. pseudobocki* Lee & Chen, *Pseudofusulinella eopulchra* (Rauser), *Ps. pulchra* (Rauser & Belyaev), *Ps. usvae* (Dutkevich), *Protriticites pseudomontiparus* Putrja, *Pr.* aff. *ovatus* Putrja, *Pr. variabilis* Bensh, *Pr. manukalovae* Kireeva, *Pr. subschwagerinoides* Rosovskaya, *Pr. sphaericus* Volozhanina, *Pr. globulus* Putrja, *Praeobsoletes pauper* (Volozhanina), *Praeobsoletes* sp., *Obsoletes grozdilovae* (Miklukho-Maclay), *Quasifusulinoides intermedius* (Rauser & Gryzlova), *Q. pulchellus* (Gryzlova), *Q. quasifusulinoides* (Rauser), and *Q. firmus* (Rauser).

Age: Early Kasimovian, Krevyakinian (Standard fusulinid zone 23).

Comments: This assemblage is characterised by the presence of very rare *Obsoletes* and the abundance of advanced species of *Protriticites*. These taxa are also characteristic of the Krevyakinian of Spitsbergen, the Timan-Pechora Basin, the Russian Platform, Donets Basin, Carnic Alps and Cantabrian Mountains (Davydov 1990, 1997b; Davydov & Krainer 1999; Konovalova 1991; Rauser-Chernousova & Scherbovich 1974; van Ginkel & Villa 1999). Most of the other species ranged from underlying beds. Only *Pseudofusulinella usvae* (Dutkevich) has also its earliest appearance in this zone.

Montiparus paramontiparus Zone (Plates 8–9)

Definition: The zone includes the strata between the basal and top occurrences of *Montiparus*.

Occurrence: This assemblage has been recognised in only one sample from Kap Jungersen, GGU 407675 (section 1, Fig. 3).

Composition: The assemblage includes the alga *Beresella* sp., and the fusulinids *Schubertella pseudoglobulosa* Safonova, *Sch. miranda* Leontovich, *Sch. magna* Lee & Chen, *Sch. mjachkovensis* Rauser, *Fusulinella pseudobocki* Lee & Chen, *Protriticites sphaericus* Volozhanina, *Pr. pseudomontiparus* Putrja, *Pr. globulus* Putrja, *Pr. variabilis* Bensh, *Praeobsoletes burkemensis* (Volozhanina), *Pr. curtus* (Volozhanina), *Obsoletes callosus* Kireeva, *Quasifusulinoides* sp., *Montiparus* sp., *M. paramontiparus* Rosovskaya, *M. umbonoplicatus* Rosovskaya, and *M.* sp.

Age: Early Kasimovian, early Khamovnichenian (Ratmirovian) (Standard fusulinid zone 24).

Comments: The most common fusulinids of this assemblage are species of *Protriticites* and *Praeobsoletes*. *Montiparus,* which defines the zone, is rare, but clearly indicates a Khamovnichenian age. Like in Spitsbergen, typical Krevyakinian (early Kasimovian) taxa like *Praeobsoletes* and *Obsoletes* are present in the Greenland assemblage (Davydov & Nilsson 1999). The top of this zone is limited by a disconformity that is overlain by beds of the lower Gzelian *Rugosofusulina flexuosa* Zone (Standard fusulinid zone 27).

Rugosofusulina flexuosa Zone (Plate 10)

Definition: The zone is defined as the body of strata between the basal appearance of the small foraminifer *Raphconilia*, and the fusulinids *Rauserites* ex gr. *stuckenbergi*, *R. elongatissima* and *Rugosofusulina,* and the basal appearance of advanced *Rauserites* (*R. stuckenbergi*, *R. paraarcticus* and *R. postarcticus*) and *Rugosofusulina triticitiformis*.

Occurrence: The assemblage occurs in sample GGU 407675 (section 1, Fig. 3).

Composition: The assemblage is composed of the

alga *Beresella* sp., the small foraminifer *Raphconilia* sp., and the fusulinids *Schubertella miranda* Leontovich, *Sch. pseudoglobulosa* Safonova, *Pseudofusulinella* sp., *Rugosofusulina flexuosa* Rosovskaya, *R. elliptica* Rosovskaya, *R. ovoidea* Bensh, *R. exiqua* Remizova, *R. pleiomorpha* Remizova, *Rauserites* ex gr. *stuckenbergi* (Rauser) and *R. elongatissima* (Rosovskaya).

Age: Early Gzelian, Rechitsian (Standard fusulinid zone 27).

Comments: The assemblage defining this zone is relatively low in abundance and diversity. Most characteristic is the numerous, but primitive *Rugosofusulina* first appearing in this zone. Rare *Rauserites* are represented by poorly preserved specimens. Very important to note is the occurrence of the small foraminifer *Raphconilia* sp., which has its basal appearance in Gzelian strata in Central Asia, the Donets Basin, the Ural Mountains, Spitsbergen, Kolguev Island and the Barents Sea (Davydov 1991, 1997b; Brenckle & Wahlman, 1994, 1996; Groves & Wahlman 1997). The alga *Beresella*, which is reported mostly from Moscovian strata (Maslov 1956; Kulik 1964; Mamet et al. 1987) in Greenland, ranges into the early Gzelian *Rugosofusulina flexuosa* and *Daixina crispa - Rauserites stuckenbergi* Zones.

Daixina crispa – Rauserites stuckenbergi Zone (Plates 11–12)

Definition: The zone encompasses the strata between the basal and top appearance of advanced species of *Rauserites* (i.e., *R. stuckenbergi*, *R. paraarcticus* and *R. postarcticus*) and *Rugosofusulina triticitiformis*. The top of this zone is limited by a hiatus followed by strata belonging to the upper Orenburgian (Melekhovian) part of the Gzelian (*Schellwienia ulukensis* Zone, standard fusulinid zone 32).

Occurrence: This assemblage has been identified in samples GGU 418831 (section 19, Fig. 1), GGU 407674, 407677 and 418911 (section 1, Fig. 3).

Composition: The fauna includes the alga *Beresella* sp., the small foraminifer *Nodosaria* sp., and the fusulinids *Eostaffella* sp., *Millerella* sp., *Schubertella pseudoglobulosa* Safonova, *Sch. subkingi* Putrja, *Sch. miranda* Leontovich, *Sch. paramelonica* Suleimanov, *Boultonia*? sp., *Plectofusulina* sp., *Pseudofusulinella eopulchra* (Rauser), *Rauserites stuckenbergi* (Rauser), *R. variabilis* (Rauser), *R. postarcticus* (Rauser), *R. paraarcticus* (Rauser), *R.* cf. *rossicus* (Schellwien), *Daixina nikolskiensis* Davydov, *D. fragilis* Rosovskaya, *Rugosofusulina elliptica* Rosovskaya and *R. triticitiformis* Volozhanina.

Age: Early Gzelian, Amerevian (Standard fusulinid zone 28).

Comments: This zone is characterised by advanced species of *Rauserites*, such as *R. stuckenbergi* (Rauser), *R. postarcticus* (Rauser), *R. paraarcticus* (Rauser), and *R.* cf. *rossicus* (Schellwien), which in the Russian Platform characterise the lower Gzelian Amerevian Horizon. *Rugosofusulina* is represented by *R. triticitiformis*, a more advanced species of *Rugosofusulina* than in the underlying beds. The small foraminifer *Nodosaria* sp. has its basal occurrence in Amdrup Land in this zone, but in Spitsbergen it first occurs in the Kasimovian (Khamovnichenian) *Montiparus montiparus* Zone (Davydov & Nilsson 1999).

The abundant *Schubertella* present in this zone are dominated by large and well-developed species such as *Schubertella subkingi*, and *Sch. paramelonica*. The latter has been described from the lower Permian of the Ural Mountains (Suleimanov 1949), and in Central Asia it has been reported from the early-middle Gzelian (Davydov 1984). Also in this zone, one specimen of an elongate *Schubertella*-like fusulinid with fluted septa was identified as *Boultonia*(?). The occurrence of this form indicates that we can expect the appearance of *Boultonia* somewhere immediately above this zone in the Orenburgian part of the Gzelian.

Schellwienia ulukensis Zone (Plates 13–16)

Definition: The zone is defined as the strata between the basal and top occurrences of advanced *Schellwienia* (*Sch. ulukensis* and *Sch. modesta*), *Zigarella acuminulata* and *Z. simplex*. This zone represents the youngest Carboniferous strata in southern Amdrup Land and elsewhere in North Greenland.

Occurrence: The assemblage has been identified in samples GGU 418839 (section 19, Fig. 1), GGU 407679, 407682, 403741, 418917, and 418918 (section 1, Fig. 3).

Composition: The assemblage includes the problematic *Palaeoaplysina*, the small foraminifers *Asselodiscus* sp., *A. primitivus* Mamet & Pinard, *Syzrania* sp., *Nodosaria* sp., and the fusulinids *Millerella* sp., *Plectofusulina* sp., *Schubertella pseudoglobulosa* Safonova, *Pseudofusulinella* cf. *annae* (Grozdilova), *Quasifusulina cayeuxi* (Deprat), *Quasifusulina* sp.1, *Daixina* ex gr. *sokensis* (Rauser), *Daixina enormis* Scherbovich, *Daixina naviculaeformis* Alksne & Polozova, *Jigulites magnus* (Rosovskaya), *Schellwienia delicata* (Alksne), *Sch. biformis* (Bensh), *Sch. iohchiensis* (Davydov), *Sch. arctica* (Schellwien), *Sch. krushiensis* (Alksne), *Sch. malkovskyi* (Alksne), *Sch. lata* (Alksne), *Sch. porrecta* (Sjomina), *Sch. salebrosa* (Konovalova), *Sch. kharjagaensis* (Konovalova), *Sch. grata* (Konovalova), *Sch. subundulata* (Konovalova), *Sch. emaciata* (Konovalova), *Sch. visotchaensis* (Konovalova), *Sch. modesta* (Scherbovich), *Sch. postmodesta* Davydov, *Sch. ulukensis* (Bensh), *Sch.* aff. *bornemani* (Leven & Scherbovich), *Sch.* aff. *glandi-*

formis (Alksne), *Zigarella praegregaria* (Scherbakova), *Z. simplex* (Konovalova), and *Z. acuminulata* (Echlakov).

Age: Late Orenburgian part of the Gzelian, Melekhovian (Standard fusulinid zone 32).

Comments: This zone is represented by a very diverse fusulinid assemblage. The small foraminifer *Nodosaria* is also common in this zone. It is interesting to note the occurrence of *Asselodiscus primitivus*, which was first described from the Sakmarian of Arctic Canada (Mamet & Pinard 1990), but probably ranges from the Gzelian into the Artinskian. *Millerella* still occurs in this zone. The most characteristic taxa in the assemblage are the numerous *Schellwienia*, which first appear in the early Orenburgian part of the Gzelian (Standard fusulinid zone 31) and range into the Asselian. The presence of *Sch. postmodesta*, *Sch. ulukensis* and *Sch.* aff. *bornemani* clearly indicates that this zone is of Melekhovian (late Gzelian) age.

Correlation

Moscovian

The Lower Moscovian strata of Amdrup Land are dated as belonging to the *Profusulinella prisca-Neostaffella subquadrata* and *Citrinoides paraozawai* Zones, which correlate to the Tsninian and Kashirian of the stratotype areas of the Moscow Basin and the Ural Mountains (Fig. 2). Fusulinid assemblages of Tsninian age have not previously been reported from North Greenland suggesting that southern Amdrup Land was transgressed earlier than the adjacent areas. Based on graphic correlation data, Davydov et al. (1999) suggested that there is a break in sedimentation at the Lower-Upper Moscovian boundary between strata characterised by Kashirian and Podolian fusulinid assemblages, respectively. This is in accordance with lithostratigraphic data from the Moscow Basin (Makhlina et al. 1984).

Strata of the *Citrinoides paraozawai* Zone are overlain by younger Moscovian sediments of the *Fusulinella bocki – Pseudofusulinella pulchra* and *Protriticites ovatus* Zones, which can be correlated to the Novlinian and Peskovian of the stratotype areas of the Moscow Basin and the Ural Mountains. Similar fusulinid assemblages are also reported from the Timan-Pechora Basin, Spitsbergen, Bjørnøya, the Finnmark Platform, and the Sverdrup Basin of the Canadian Arctic (Fig. 2).

Kasimovian

Graphic correlation data (Davydov et al. 1999) suggest that there is a break in sedimentation at the base of the Kasimovian in North Greenland. A hiatus of this age has also been reported from the Moscow Basin, Spitsbergen, and the Finnmark Platform. The Kasimovian succession at Amdrup Land is characterised by two lower Kasimovian fusulinid assemblages of the *Obsoletes obsoletus – Protriticites pseudomontiparus* and *Montiparus paramontiparus* Zones. These zones correspond to similar assemblages of the Moscow Basin, the Timan-Pechora Basin, and Spitsbergen. The Lower Kasimovian succession on Bjørnøya is more condensed and only the *Obsoletes obsoletus-Protriticites pseudomontiparus* assemblage has been identified (Davydov & Nilsson, unpubl. data). Similarly, the Kasimovian succession on Finnmark Platform is less complete, represented only by the *Montiparus paramontiparus* zone (Fig. 2).

In the Sverdrup Basin of Arctic Canada, Kasimovian strata are represented by three fusulinid assemblages; the taxa of units H-J and units K-L of Rui Lin et al. (1991) tentatively correspond to the two Kasimovian fusulinid assemblages defined at Amdrup Land. Rui Lin and Nassichuk (1994) described two new fusulinid assemblages above unit L of the type section of the Nansen Formation, which they correlated to the Krevyakianian Horizon of the Lower Kasimovian of the Moscow Basin. However, in our opinion the assemblages are slightly younger because they include specimens with a true keriothecal wall structure. We believe such forms belong to the genus *Rauserites*, which has its first appearance in the Late Kasimovian in the Donets Basin, Central Asia, Moscow Basin, the Ural Mountains, Spitsbergen and North Greenland (Davydov & Nilsson 1999). The *"Protriticites"* (i.e. *Rauserites*) fauna of Rui Lin and Nassichuk (1994) seems to correlate to the *Rauserites quasiarcticus – R. variabilis* Zone of the stratotype area (i.e. Dorogomilavian Horizon) of the Moscow Basin. Assemblages of this age have not been recognized in Amdrup Land, but late Kasimovian fusulinids of the *Rauserites* ex.gr. *simplex* assemblage have been reported from the eastern Peary Land part of the Wandel Sea Basin (Nilsson 1994).

Gzelian

The lower Gzelian strata of Amdrup Land are characterized by the *Rugosofusulina flexuosa* and *Daixina crispa – Rauserites stuckenbergi* assemblages. Again, the graphic correlation data of Davydov et al. (1999) suggest that there is a break in sedimentation at the base.

A hiatus at the base of the Gzelian is also recognized on Bjørnøya, Spitsbergen and in the Timan-Pechora Basin (Fig. 2).

There is a prolonged Gzelian break in sedimentation in the Amdrup Land succession corresponding to standard fusulinid zones 29-31. Sedimentation did not resume until the late Orenburgian part of the Gzelian where fusulinids of the *Schellwienia ulukensis* zone are recognized. This assemblage corresponds to the *Schwagerina robusta* zone reported from the uppermost Orenburgian of the Gzelian in the Moscow Basin, the Timan-Pechora Basin, Kolguev and Spitsbergen. On the Finnmark Platform these strata include two assemblages, the *Schellwienia ulukensis*- and *Zigarella pseudoanderssoni* assemblage, respectively. The fusulinids of the *Daxina sokensis* zone of Bjørnøya are slightly older than the assemblage of the *Schellwienia ulukensis* zone of Amdrup Land. Similar fusulinids have not been reported from the Sverdrup Basin of Arctic Canada, but the *Rugosofusulina plana-Pseudofusulinella* zone of Nilsson (1993) may partly correlate to the fauna at Amdrup Land.

Summary and conclusions

The fusulinid assemblages recognised at southern Amdrup Land allow a more refined stratigraphic subdivision of the Upper Carboniferous succession in the Wandel Sea Basin. The assemblages show strong similarities with those described from Spitsbergen by Nilsson & Davydov (1997). The North Greenland - Spitsbergen fusulinid faunas form part of a relatively uniform fauna that occurs along the northern margin of Pangea from Arctic Canada in the west to the Timan-Pechora Basin in the east (e.g. Volozhanina 1962; Mikhailova 1966, 1974; Thornsteinsson 1974; Nassichuk & Wilde 1977; Konovalova 1991; Rui Lin et al. 1991; Davydov 1991, 1997b; Groves et al. 1994; Remizova 1995). The fusulinid fauna in the Timan-Pechora Basin is palaeobiogeographically divided into a northern fauna with strong affinity to the Barents Sea fauna and a southern fauna that includes many southern species from the Moscow Basin and the Ural Mountains. The Timan-Pechora Basin thus provides an import link for correlation of the northern Pangean fusulinid assemblages to the assemblages described from the stratotype areas of the Moscow Basin and the Ural Mountains by Rosovskaya (1950, 1958), Rauser-Chernousova et al. (1951), Rauser-Chernousova & Scherbovich (1974), Solovieva (1977, 1986) and more recently Davydov (1997a, b).

The fusulinid zonation established at southern Amdrup Land indicates two major breaks in sedimentation during the Late Carboniferous, spanning the late Kasimovian (standard fusulinid zones 25 and 26) and the mid-Gzelian (standard fusulinid zones 29–31), in addition to the numerous smaller breaks indicated by the repeated presence of subaerial exposure surfaces at sedimentary cycle tops (Stemmerik 1996). The late Kasimovian hiatus seems to be local because sediments of that age are well represented in Spitsbergen and elsewhere in the Barents Sea. The mid-Gzelian hiatus is of more regional significance and correlates to a prolonged break in sedimentation also recognised throughout Spitsbergen (Anisimov et al. 1998). Preliminary estimates of the duration of these hiati based on graphic correlation indicate a duration of 2.0–2.4 My (Davydov et al. 1999).

Dansk sammendrag

De Øvre Karbon aflejringer i det sydlige Amdrup Land, østlige Nordgrønland er dateret ved hjælp af fusulinider indsamlet i forbindelse med Danmarks og Grønlands Geologiske Undersøgelses kortlægning af området. Det er muligt at identificere ni fusulinid assemblages af tidlig Moscov til sen Gzhel alder. Fusulinid faunaen ligner den fundet i Øvre Karbon aflejringer på den Russiske Platform, i Uralbjergene, på Spitsbergen og Bjørnøya og i dybe boringer fra Barentshavet. Det er derfor muligt at korrelere den grønlandske lagserie temmelig præcist med sedimenterne i disse områder.

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Plate 1

Fusulinids from the assemblage characterising the early Moscovian *Profusulinella prisca - Neostafella subquadrata* Zone in southern Amdrup Land. All figured specimens, ×30.

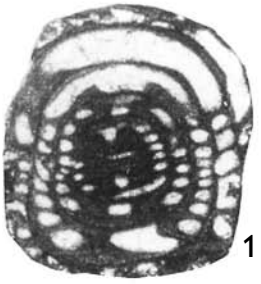
Fig. 1. *Neostaffella nibelensis* (Rauser), MGUH 25771 from GGU 407672-2.

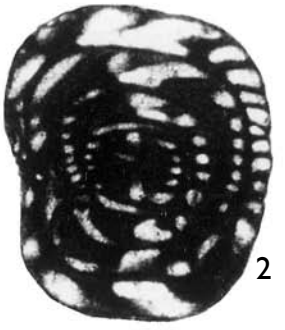
Fig. 2. *Neostaffella cf. subquadrata* (Grozdilova & Lebedeva), MGUH 25772 from GGU 407671-1.

Figs 3–4. *Profusulinella prisca* (Deprat), Fig. 3: MGUH 25773 from GGU 407672-2, Fig. 4: MGUH 25774 from GGU 407671-3.

Fig. 5. *Profusulinella prisca sphaeroidea* Rauser, MGUH 25775 from GGU 407672-3.

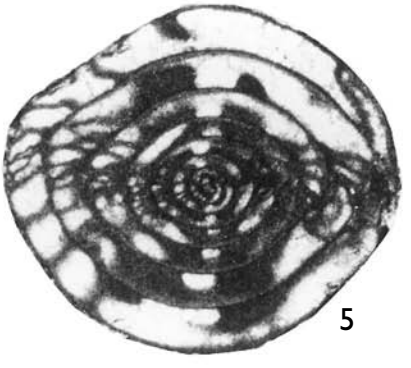
Figs 6–7. *Profusulinella timanica* Kireeva, Fig. 6: MGUH 25776 from GGU 407672-6, Fig. 7: MGUH 25777 from GGU 407672-1.

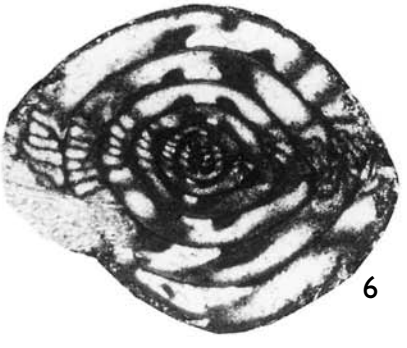

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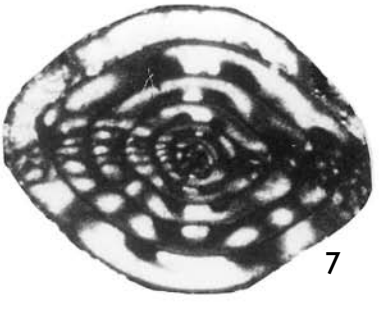

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Plate 2

Fusulinids from the assemblage characterising the early Moscovian *Citrinoides paraozawai* Zone in southern Amdrup Land. All figured specimens, ×30.

Figs 1–2. *Neostaffella ozawai* (Rauser), Fig. 1: MGUH 25778 from GGU 403707-6, Fig. 2: MGUH 25779 from GGU 403707-5.

Fig. 3. *Neostaffella larionovae* (Rauser & Safonova), MGUH 25780 from GGU 403781-4.

Figs 4–7. *Neostaffella greenlandica* (Ross), Fig. 4: MGUH 25781 from GGU 403781-8, Fig. 5: MGUH 25782 from GGU 403781-1, Fig.6: MGUH 25783 from GGU 403781-8, Fig. 7: MGUH 25784 from GGU 403781-1.

Figs 8–9. *Profusulinella ovata ovata* Rauser, Fig. 8: MGUH 25785 from GGU 404427-8, Fig. 9: MGUH 25786 from GGU 404427-2.

Fig. 10. *Profusulinella subovata* Safonova, MGUH 25787 from GGU 404427-1.

Figs 11–13. *Profusulinella constans* Safonova, Fig. 11: MGUH 25788 from GGU 404427-9, Fig. 12: MGUH 25789 from GGU 404427-7, Fig. 13: MGUH 25790 from GGU 404427-4.

Figs 14–15. *Profusulinella rhomboides* Lee & Chen, Fig. 14: MGUH 25791 from GGU 404426-1, Fig. 15: MGUH 25792 from GGU 404426-8.

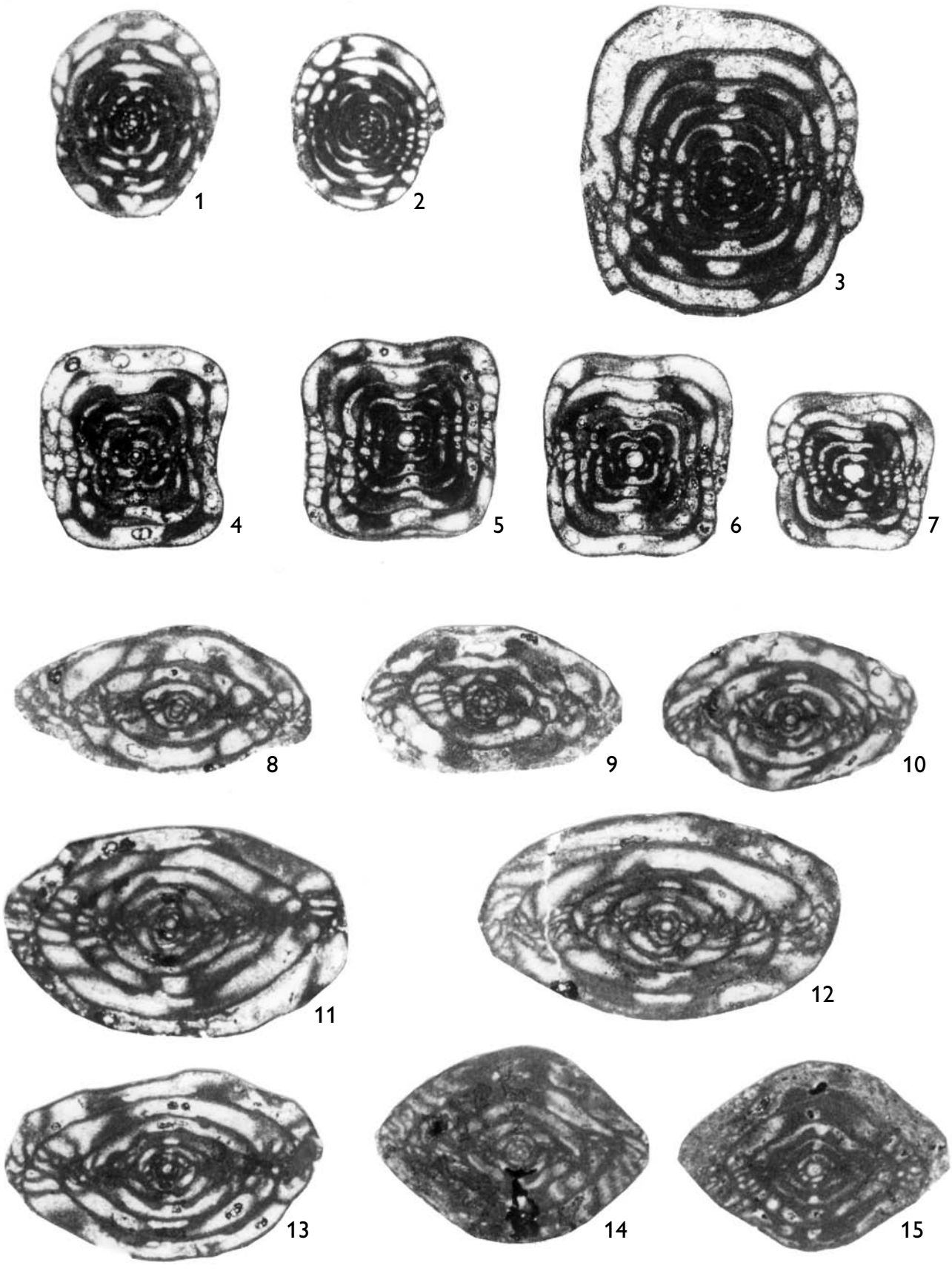

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Plate 3

Fusulinids from the assemblage characterising the early Moscovian *Citrinoides paraozawai* Zone in southern Amdrup Land.

Figs 1–2. *Profusulinella rhombiformis nibelensis* Rauser, Fig. 1: MGUH 25793 from GGU 404426-3, ×30, Fig. 2: MGUH 25794 from GGU 404426-9, ×30.

Fig. 3. *Aljutovella postaljutovica postaljutovica* Safonova, MGUH 25795 from GGU 403781-3, ×30.

Fig. 4. *Aljutovella postaljutovica dilucida* Leontovich, MGUH 25796 from GGU 403781- 5, ×30.

Fig. 5. *Profusulinella pseudorhomboides* Putrja, MGUH 25797 from GGU 404427- 2, ×30.

Fig. 6. *Paraeofusulina* sp. 1, MGUH 25798 from GGU 404458-2, ×20.

Fig. 7. *Citronoides notabilis* (Dzhenchuraeva), MGUH 25799 from GGU 403707-3, ×30.

Figs 8–9. *Beedeina pseudoelegans* (Chernova), Fig. 8: MGUH 25800 from GGU 403707-2, ×30, Fig. 9: MGUH 25801 from GGU 403707-6, ×30.

Fig. 10. *Citronoides paraozawai* (Rauser), MGUH 25802 from GGU 403707- 4, ×30.

Figs 11–12. *Eofusulina binominata* Putrja, Fig. 11: MGUH 25803 from GGU 403768-1, ×15. Fig. 12: MGUH 25804 from GGU 403768-2, ×15.

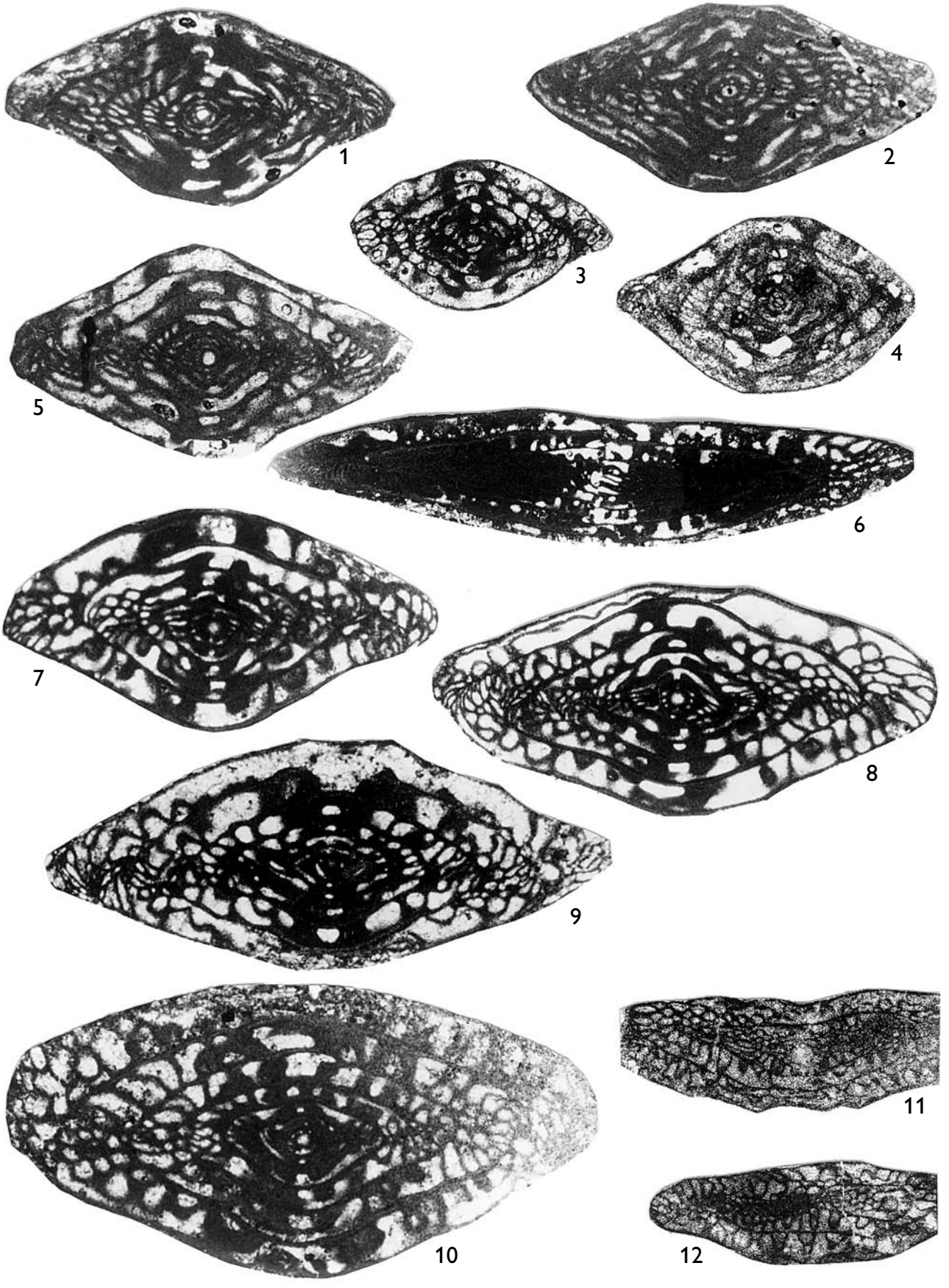

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Plate 4

The assemblage characterising the late Moscovian *Fusulinella bocki – Pseudofusulinella pulchra* Zone in southern Amdrup Land.

Fig. 1. *Reitlingerina preobrazhenskyi* (Dutkevich), MGUH 25805 from GGU 407670-1, ×80.

Fig. 2. *Schubertella* sp., MGUH 25806 from GGU 407670-5, ×80.

Fig. 3. *Schubertella pseudoglobulosa* Safonova, MGUH 25807 from GGU 407670-3, ×80.

Fig. 4. *Schubertella gracilis* (Rauser), MGUH 25808 from GGU 407670-8, ×80.

Figs 5–6. *Neostaffella sphaeroidea cuboides* (Rauser), Fig. 5: MGUH 25809 from GGU 419065-7, ×30, Fig. 6: MGUH 25810 from GGU 419065-10, ×30.

Fig. 7. *Neostaffella rostovzevi* (Rauser), MGUH 25811 from GGU 419065-3, ×30.

Fig. 8. *Fusulinella bocki* Moeller, MGUH 25812 from GGU 407670-5, ×30.

Fig. 9. *Fusulinella paraschubertellinoides* Putrja & Leontovich, MGUH 25813 from GGU 407670-3, ×30.

Figs 10–11. *Beedeina paradistenta* (Safonova), Fig. 10: MGUH 25814 from GGU 419065-1, ×30, Fig. 11: MGUH 25815 from GGU 419065-2, ×30.

Fig. 12. *Wedekindellina longissimoidea* Safonova, MGUH 25816 from GGU 419065-2, ×30.

Fig. 13. *Wedekindellina dutkevichi* Raueser & Belayev, MGUH 25817 from GGU 419065-5, ×30.

Fig. 14. *Pseudofusulinella pulchra* (Rauser & Belyaev), MGUH 25818 from 419065-10, ×30.

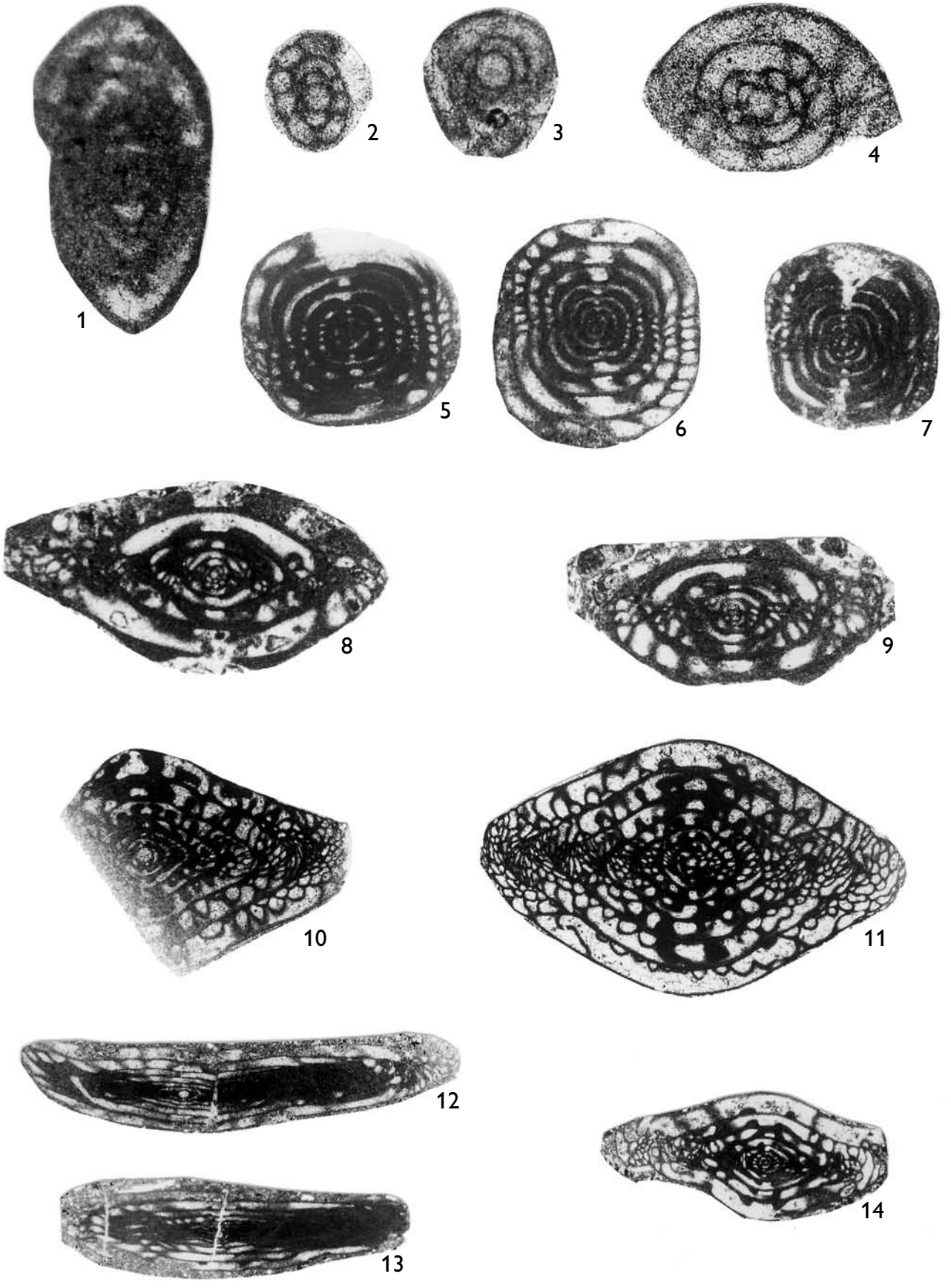

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Plate 5

The assemblage characterising the late Moscovian *Protriticites ovatus* Zone in southern Amdrup Land.

Figs 1–3. *Pseudofusulinella eopulchra* (Rauser), Fig. 1: MGUH 25819 from GGU 418907-5, ×30, Fig. 2: MGUH 25820 from GGU 418907-3, ×30, Fig. 3: MGUH 25821 from GGU 418907-9, ×10.

Fig. 4. *Beedeina siviniensis* (Rauser), MGUH 25822 from GGU 418906-3, ×15.

Figs 5–6. *Beedeina nytvica nytvica* (Rauser), Fig. 5: MGUH 25823 from GGU 418907-7, ×15, Fig. 6: MGUH 25824 from GGU 418907-9, ×15.

Fig. 7. *Beedeina nytvica callosa* (Rauser), MGUH 25825 from GGU 418906-1, ×15.

Fig. 8. *Protriticites subschwagerinoides* Rosovskaya, MGUH 25826 from GGU 418907-3, ×20.

Fig. 9. *Protritcites* aff. *ovatus* Putrja, MGUH 25827 from GGU 418907-10, ×20.

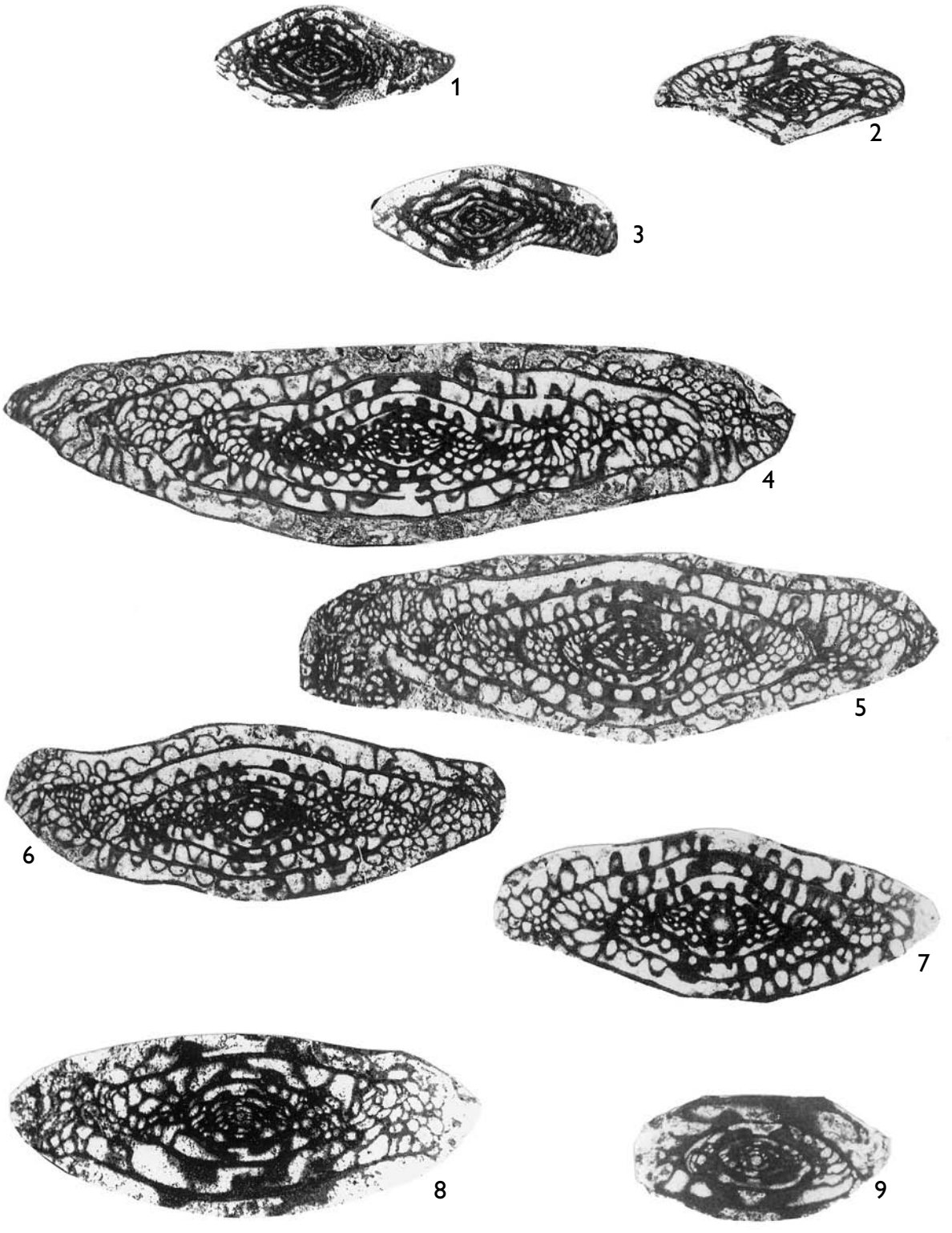

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Plate 6

The assemblage characterising the early Kasimovian *Obsoletes obsoletus – Protriticites pseudomontiparus* Zone in southern Amdrup Land.

Fig. 1. *Reitlingerina timanica* (Rauser), MGUH 25828 from GGU 407674-6, ×80.

Fig. 2. *Parastaffelloides fraudulenta* (Rauser), MGUH 25829 from GGU 407674-10, ×40.

Fig. 3. *Parastaffelloides pseudosphaeroidea* (Dutkevich), MGUH 25830 from GGU 407674-7, ×40.

Figs 4–6. *Ozawainella mosquensis* Rauser, Fig. 4: MGUH 25831 from GGU 418910-6, ×40, Fig. 5: MGUH 25832 from GGU 418910-6, ×40, Fig. 6: MGUH 25833 from GGU 418910-8, ×40.

Fig. 7. *Schubertella pseudoglobulosa* Safonova, MGUH 25834 from GGU 407674-10, ×80.

Figs 8–9. *Schubertella polymorpha* Safonova, Fig. 8: MGUH 25835 from GGU 407674-2, ×80, Fig. 9: MGUH 25836 from GGU 418908-4, ×80.

Figs 10–11. *Quasifusulinoides quasifusulinoides* (Rauser), Fig. 10: MGUH 25837 from GGU 418909-4, ×20, Fig. 11: MGUH 25838 from GGU 418909-6, ×20.

Fig. 12. *Fusiella lancetiformis* Putrja, MGUH 25839 from GGU 418910-4, ×40.

Fig. 13. *Quasifusulinoides intermedius* (Rauser & Gryzlova), MGUH 25840 from GGU 418909-1, ×20.

Figs 14–15. *Quasifusulinoides* sp., Fig. 14: MGUH 25841 from GGU 418910-4, ´15, Fig. 15: MGUH 25842 from GGU 418910-4, ×15.

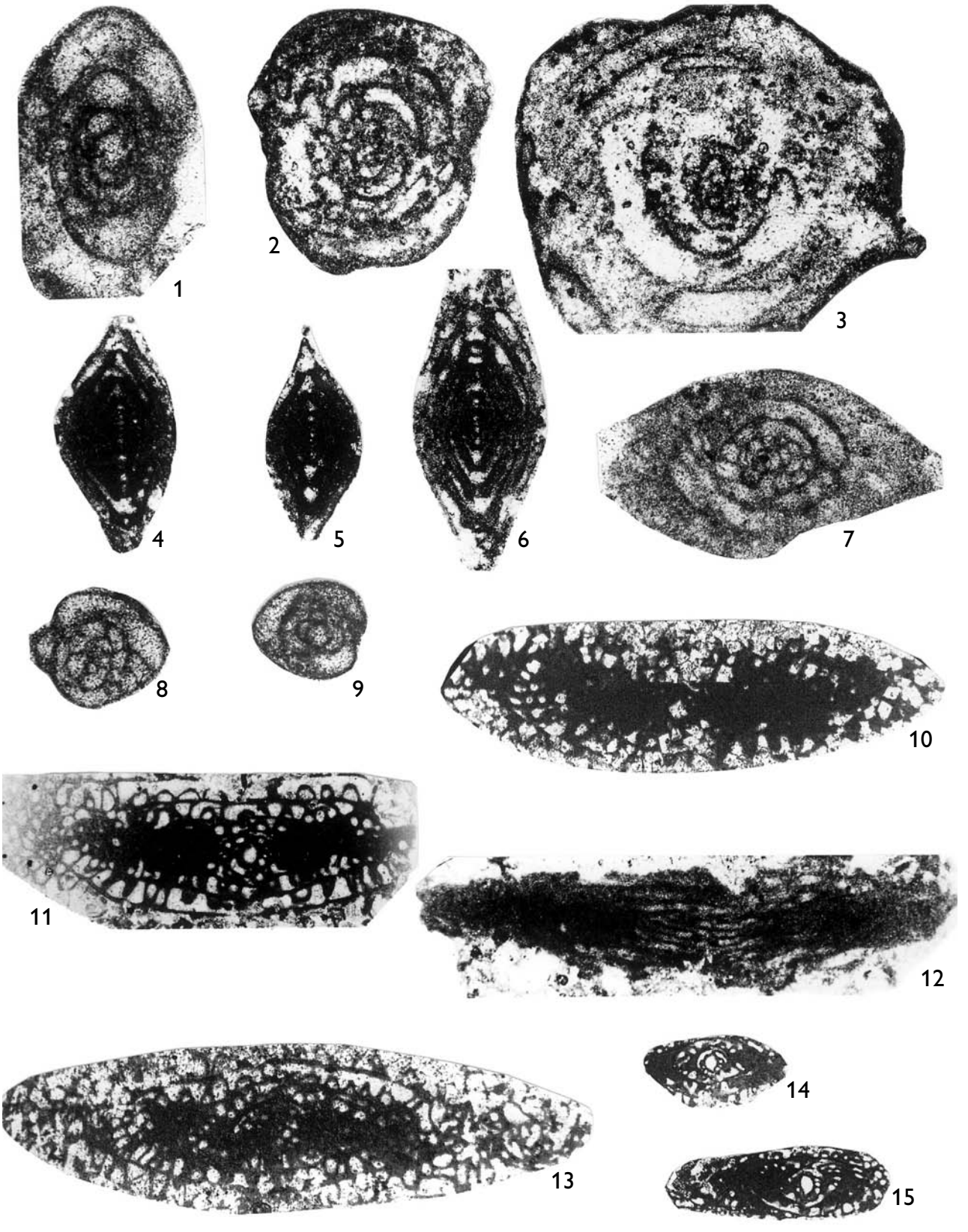

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Plate 7

Fusulinids from the assemblage characterising the early Kasimovian *Obsoletes obsoletus – Protriticites pseudomontiparus* Zone in southern Amdrup Land.

Fig. 1. *Pseudofusulinella usvae* (Dutkevich), MGUH 25843 from GGU 418909-3, ×40.

Figs 2–4. *Pseudofusulinella eopulchra* (Rauser), Fig. 2: MGUH 25844 from GGU 418910-6, ×15, Fig. 3: MGUH 25845 from GGU 418910-5, ×15, Fig. 4: MGUH 25846 from GGU 407673-2, ×15.

Fig. 5. *Fusulinella pseudobocki* Lee & Chen, MGUH 25847 from GGU 407674-7; ×30.

Fig. 6. *Fusulinella praebocki* Rauser, MGUH 25848 from GGU 407674-6, ×30.

Figs 7–8. *Praeobsoletes pauper* (Volozhanina), Fig. 7: MGUH 25849 from GGU 407674-2, ×40, Fig. 8: MGUH 25850 from GGU 407674-2, ×30.

Fig. 9. *Obsoletes grozdilovae* (Miklukho-Maklay), MGUH 25851 from GGU 407673-1, ×15.

Fig. 10. *Protriticites pseudomontiparus* Putrja, MGUH 25852 from GGU 407674-5, ×30.

Figs 11–12. *Protriticites variabilis* Bensh, Fig. 11: MGUH 25853 from GGU 418910-6, ×15, Fig. 12: MGUH 25854 from GGU 407674-5, ×15.

Fig. 13. *Protriticites ovatus* Putrja, MGUH 25855 from GGU 407674-3, ×30.

Figs 14–15. *Protriticites globulus* Putrja, Fig. 14: MGUH 25856 from GGU 418910-8, ×20, Fig. 15: MGUH 25857 from GGU 418910-1, ×20.

Figs 16–17. *Protriticites manukalovae* Kireeva, Fig. 16: MGUH 25858 from GGU 418908-2, ×20, Fig. 17: MGUH 25859 from GGU 407673-2, ×20.

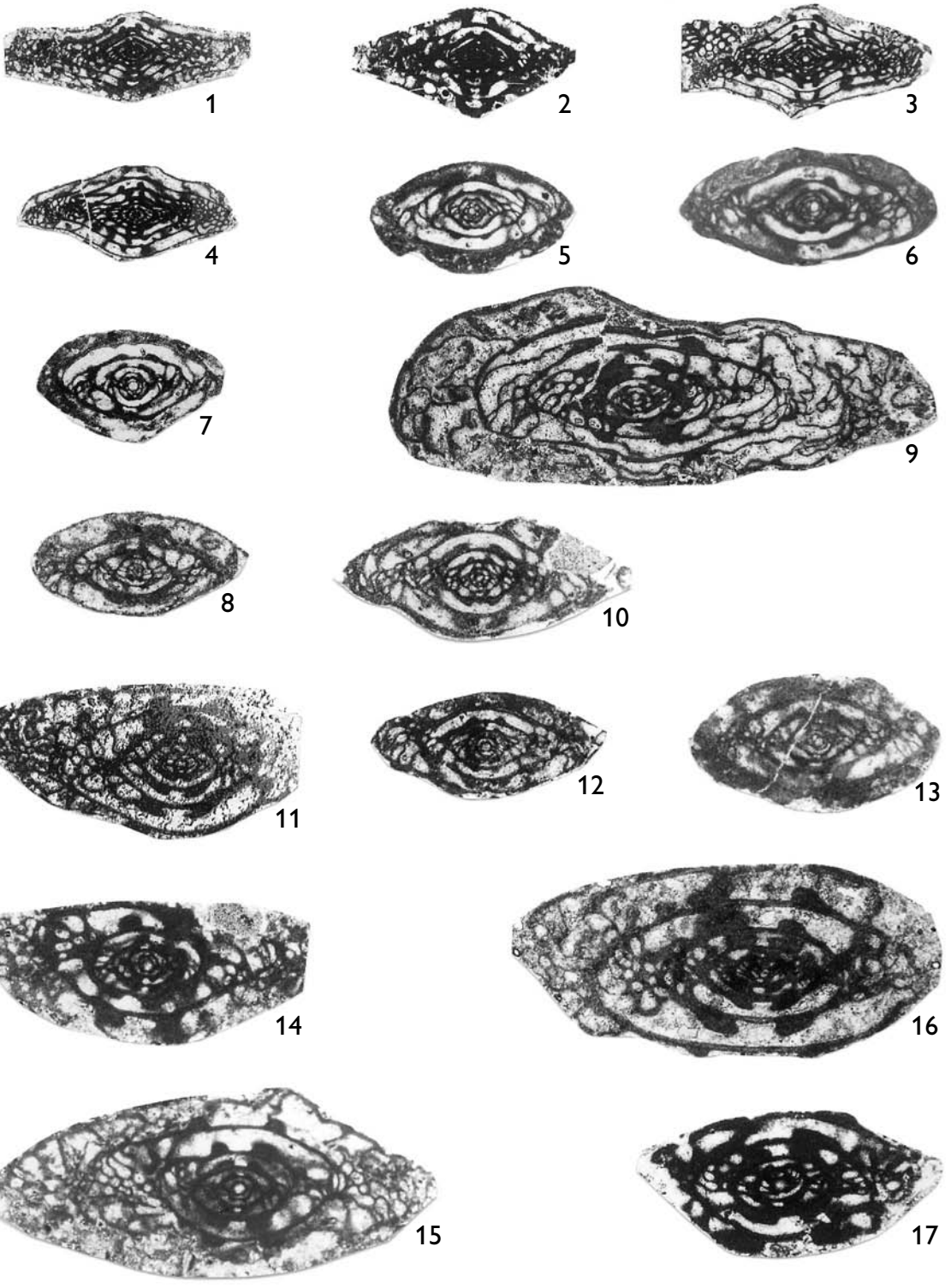

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Plate 8

Fusulinids from the assemblage characterising the early Kasimovian *Montiparus paramontiparus* Zone in southern Amdrup Land.

Fig. 1. *Schubertella pseudoglobulosa* Safonova, MGUH 25860 from GGU 407675-2, ×80.

Fig. 2. *Schubertella miranda* Leontovich, MGUH 25861 from GGU 407675-3, ×80.

Fig. 3. *Schubertella magna* Lee & Chen, MGUH 25862 from GGU 407675-3, ×80.

Figs 4–6. *Schubertella subkingi* Putrja, Fig. 4: MGUH 25863 from GGU 407675-5, ×80, Fig. 5: MGUH 25864 from GGU 407675-4, ×80, Fig. 6: MGUH 25865 from GGU 407675-5, ×80.

Fig. 7. *Obsoletes callosus* Kireeva, MGUH 25866 from GGU 407675-6, ×20.

Figs 8–10. *Praeobsoletes burkemensis* (Volozhanina), Fig. 8: MGUH 25867 from GGU 407675-1, ×20, Fig. 9: MGUH 25868 from GGU 407675-18, ×20, Fig. 10: MGUH 25869 from GGU 407675-11, ×20.

Figs 11–13. *Praeobsoletes curtus* (Volozhanina), Fig. 11: MGUH 25870 from GGU 407675-17, ×20, Fig. 12: MGUH 25871 from GGU 407675-16, ×20, Fig. 13: MGUH 25872 from GGU 407675-19, ×20.

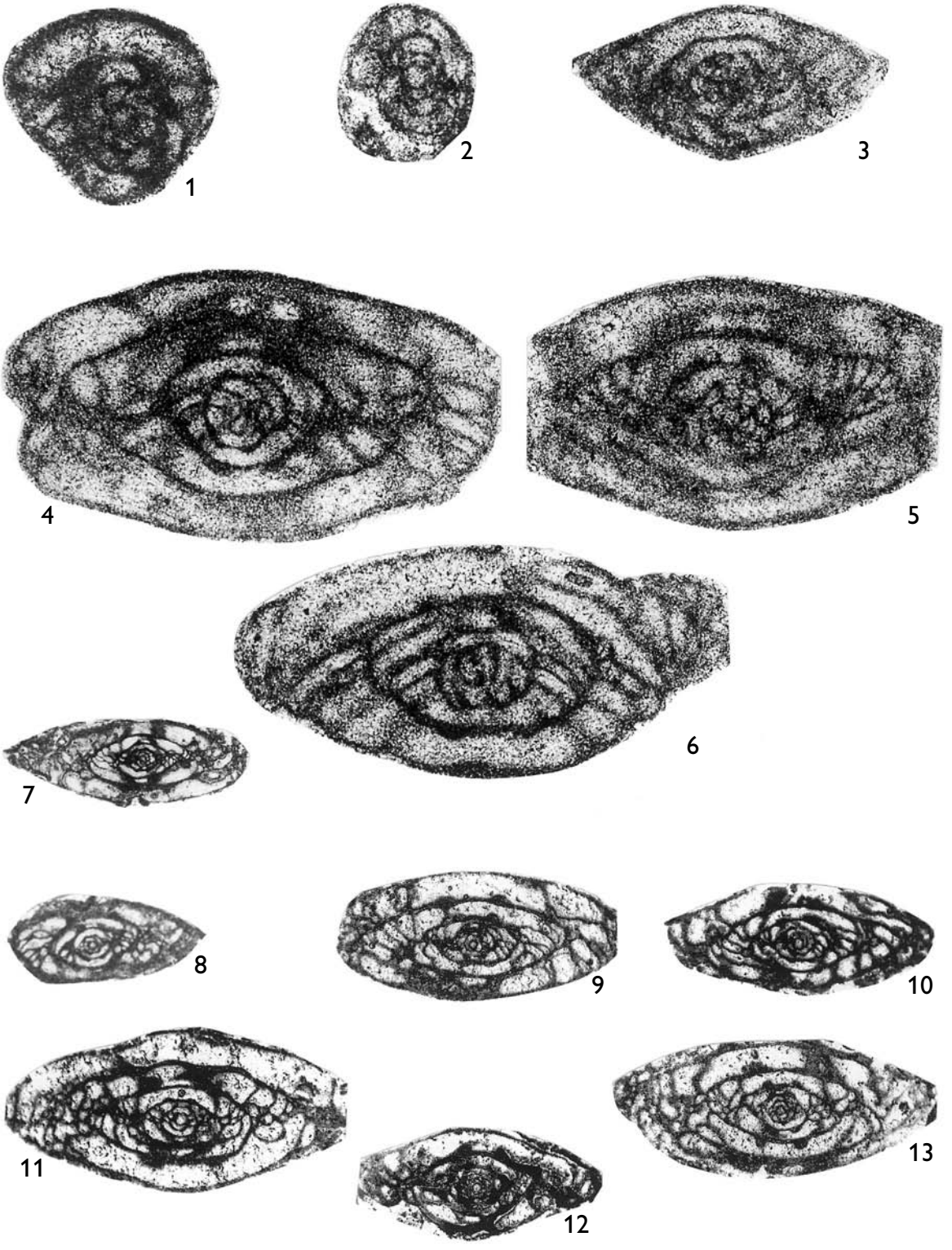

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Plate 9

Fusulinids from the assemblage characterising the early Kasimovian *Montiparus paramontiparus* Zone in southern Amdrup Land.

Fig. 1. *Protriticites pseudomontiparus* Putrja, MGUH 25873 from GGU 407675-5, ×30.

Fig. 2. *Protriticites variabilis* Bensh, MGUH 25874 from GGU 407675-13, ´20.

Figs 3–4. *Protriticites globulus* Putrja, Fig. 3: MGUH 25875 from GGU 407675-15, ×20, Fig. 4: MGUH 25876 from GGU 407675-14, ×20.

Figs 5–6. *Montiparus paramontiparus* Rosovskaya, Fig. 5: MGUH 25877 from GGU 407675-10, ×15, Fig. 6: MGUH 25878 from GGU 407675-9, ×15.

Figs 7–9. *Montiparus umbonoplicatus* (Rauser & Belyaev), Fig. 7: MGUH 25879 from GGU 407675-8, ×15, Fig. 8. MGUH 25880 from GGU 407675-7, ×15, Fig. 9: MGUH 25881 from GGU 407675-12, ×15.

Fig. 10. *Montiparus* sp., MGUH 25882 from GGU 407675-2, ×40.

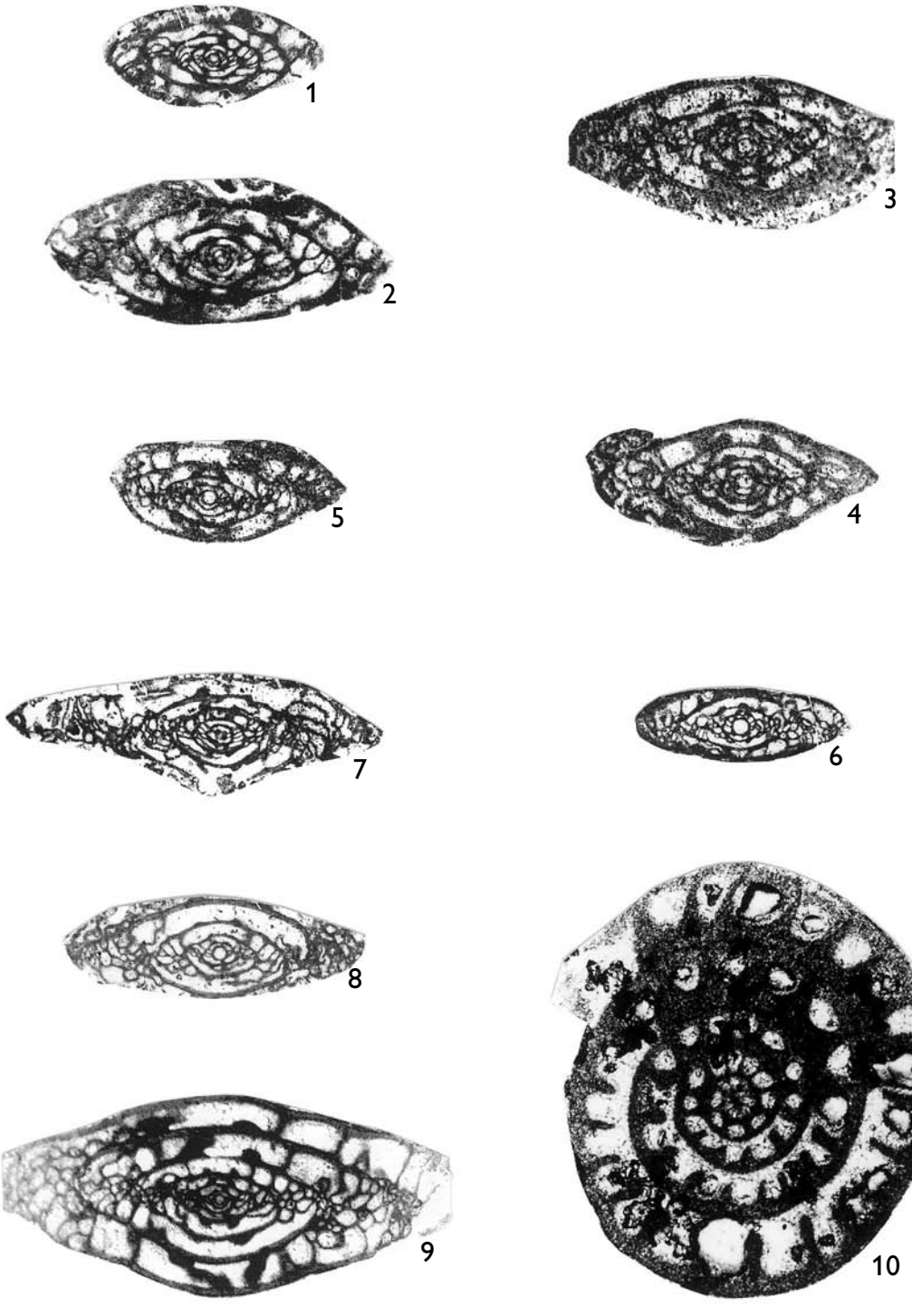

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Plate 10

The assemblage characterising the early Gzelian *Rugosofusulina flexuosa* Zone in southern Amdrup Land.

Fig. 1. *Raphconilia* sp., MGUH 25883 from GGU 422597-4, ×160.

Figs 2–4. *Schubertella miranda* Leontovich, Fig. 2: MGUH 25884 from GGU 422597-6, ×80, Fig. 3: MGUH 25885 from GGU 422597-5, ×80, Fig. 4: MGUH 25886 from GGU 422597-10, ×80.

Figs 5–7. *Rugosofusulina flexuosa* Rosovskaya, Fig. 5: MGUH 25887 from GGU 422597-4, ×10, Fig. 6: MGUH 25888 from GGU 422598- 4, ×10, Fig. 7: MGUH 25889 from GGU 418839-1, ×10.

Figs 8–9. *Rugosofusulina elliptica* Rosovskaya, Fig. 8: MGUH 25890 from GGU 407676-1, ×10, Fig. 9: MGUH 25891 from GGU 407676-2, ×10.

Figs 10–11. *Rugosofusulina exiqua* Remizova, Fig. 10: MGUH 25892 from GGU 422597-6, ×10, Fig. 11: MGUH 25893 from GGU 422597-5, ×10.

Figs 12–13. *Rugosofusulina pleiomorpha* Remizova, Fig. 12: MGUH 25894 from GGU 422597-6, ×10, Fig 13: MGUH 25895 from GGU 422597-6, ×10.

Figs 14–16. *Rugosofusulina ovoidea* Bensh, Fig. 14: MGUH 25896 from GGU 422597-10, ×10, Fig. 15: MGUH 25897 from GGU 422597-1, ×10, Fig. 16: MGUH 25898 from GGU 422598-3, ×10.

Fig. 17. *Rugosofusulina elliptica* Rosovskaya, MGUH 25899 from GGU 422598-4, ×10.

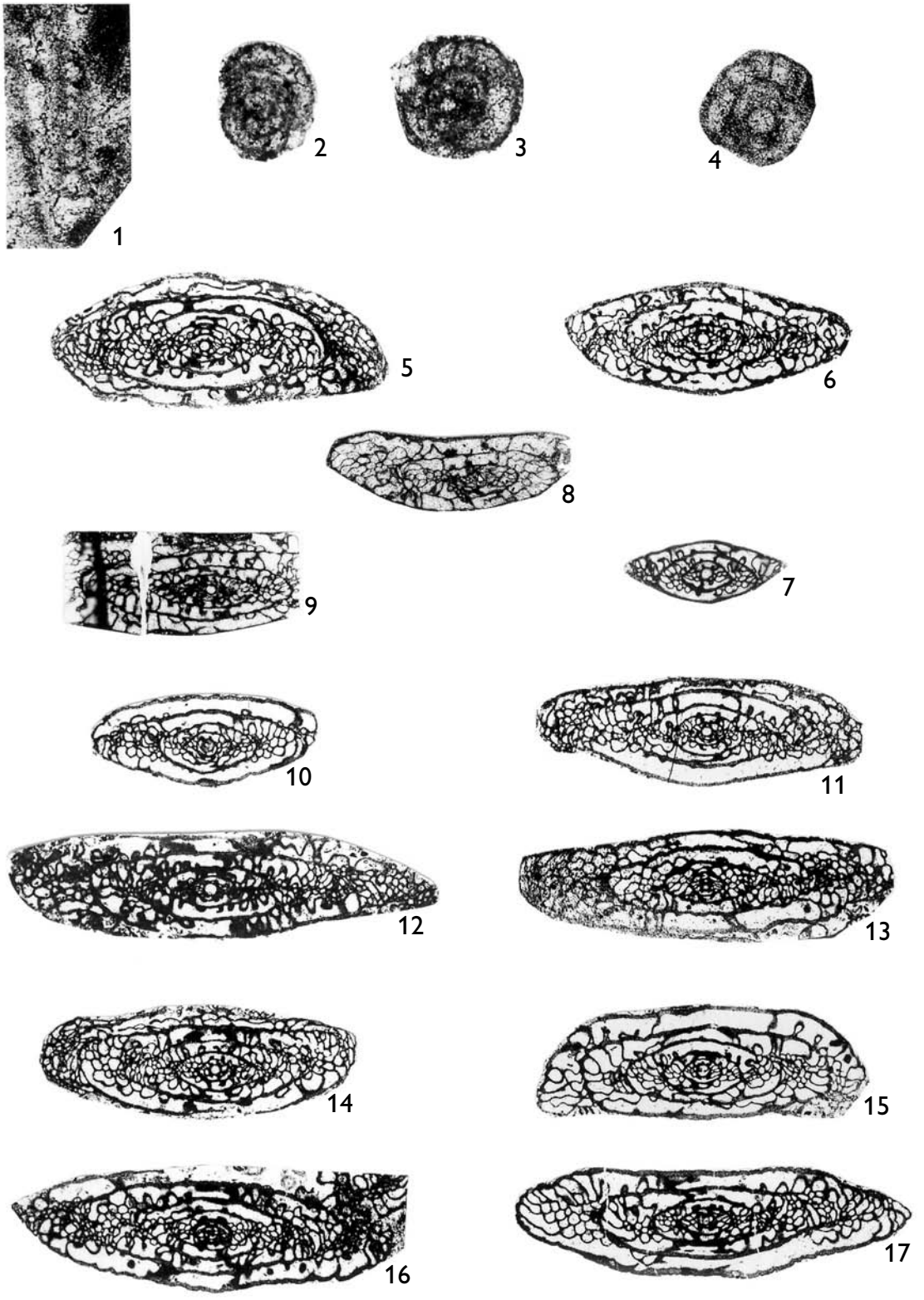

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Plate 11

The assemblage characterising the early Gzelian *Daixina crispa – Rauserites stuckenbergi* Zone in southern Amdrup Land.

Fig. 1. *Nodosaria* sp., MGUH 25987 from GGU 407677-5, ×80.

Figs 2–4. *Millerella* sp., Fig. 2: MGUH 25900 from GGU 418911-2, ×160, Fig. 3: MGUH 25901 from GGU 418911-5, ×80. Fig. 4: *Eostaffella* sp., MGUH 25902 from GGU 418911-3, ×80.

Figs 5–6. *Schubertella miranda* Leontovich, Fig. 5: MGUH 25903 from GGU 418911-3, ×80, Fig. 6: MGUH 25904 from GGU 418911-3, ×80.

Fig. 7. *Schubertella* sp., MGUH 25905 from GGU 418911-6, ×80.

Figs 8–10. *Schubertella subkingi* Putrja, Fig. 8: MGUH 25906 from GGU 418911-4, ×80, Fig. 9: MGUH 25907 from GGU 418911-4, ×80, Fig. 10: MGUH 25908 from GGU 418911-1, ×80.

Figs 11–12. *Boultonia?* sp., Fig 11: MGUH 25909 from GGU 418911-4, ×80, Fig. 12: MGUH 25910 from GGU 418911-5, ×80.

Fig. 13. *Plectofusulina* sp., MGUH 25911 from GGU 418911-3, ×80.

Fig. 14. *Pseudofusulinella annae* (Grozdilova), MGUH 25912 from GGU 418911-6, ×15.

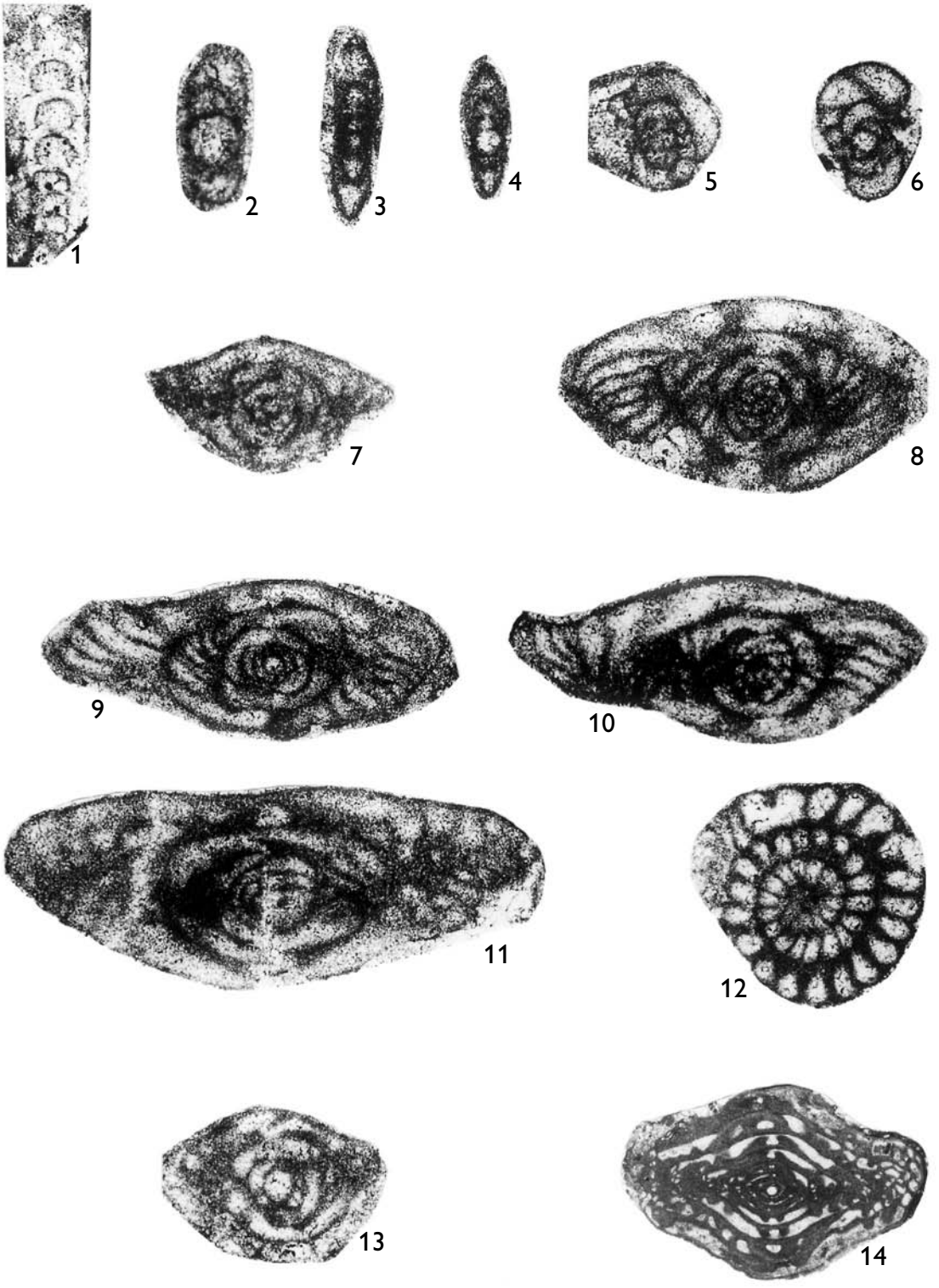

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Plate 12

The assemblage characterising the early Gzelian *Daixina crispa – Rauserites stuckenbergi* Zone in southern Amdrup Land.

Fig. 1. *Rauserites stuckenbergi* (Rauser), MGUH 25913 from GGU 418831-1, ×10.

Figs 2–4. *Rauserites communis* (Rauser), Fig. 2: MGUH 25914 from GGU 407677-1, ×10, Fig. 3: MGUH 25915 from GGU 407677-1, ×10, Fig. 4: MGUH 25916 from GGU 407677-8, ×10.

Figs 5–7. *Rauserites postarcticus* (Rauser), Fig. 5: MGUH 25917 from GGU 407674-5, ×10, Fig. 6: MGUH 25918 from GGU 407677-4, ×10, Fig. 7: MGUH 25919 from GGU 407677-6, ×10.

Fig. 8. *Rauserites paraarcticus* (Rauser), MGUH 25920 from GGU 407677-7, ×10.

Figs 9–11. *Rugosofusulina triticitiformis* (Rauser), Fig. 9: MGUH 25921 from GGU 418911-3, ×10, Fig. 10: MGUH 25922 from GGU 418911-1, ×10, Fig. 11: the same specimen as in fig. 10, wall with rugose tectum, ×80.

Figs 12–14. *Rugosofusulina elliptica* Rosovskaya, Fig. 12: MGUH 25923 from GGU 418911-5, ×10, Fig. 13: MGUH 25924 from GGU 418911-6, ×10, Fig. 14: MGUH 25925 from GGU 418911-2, ×10.

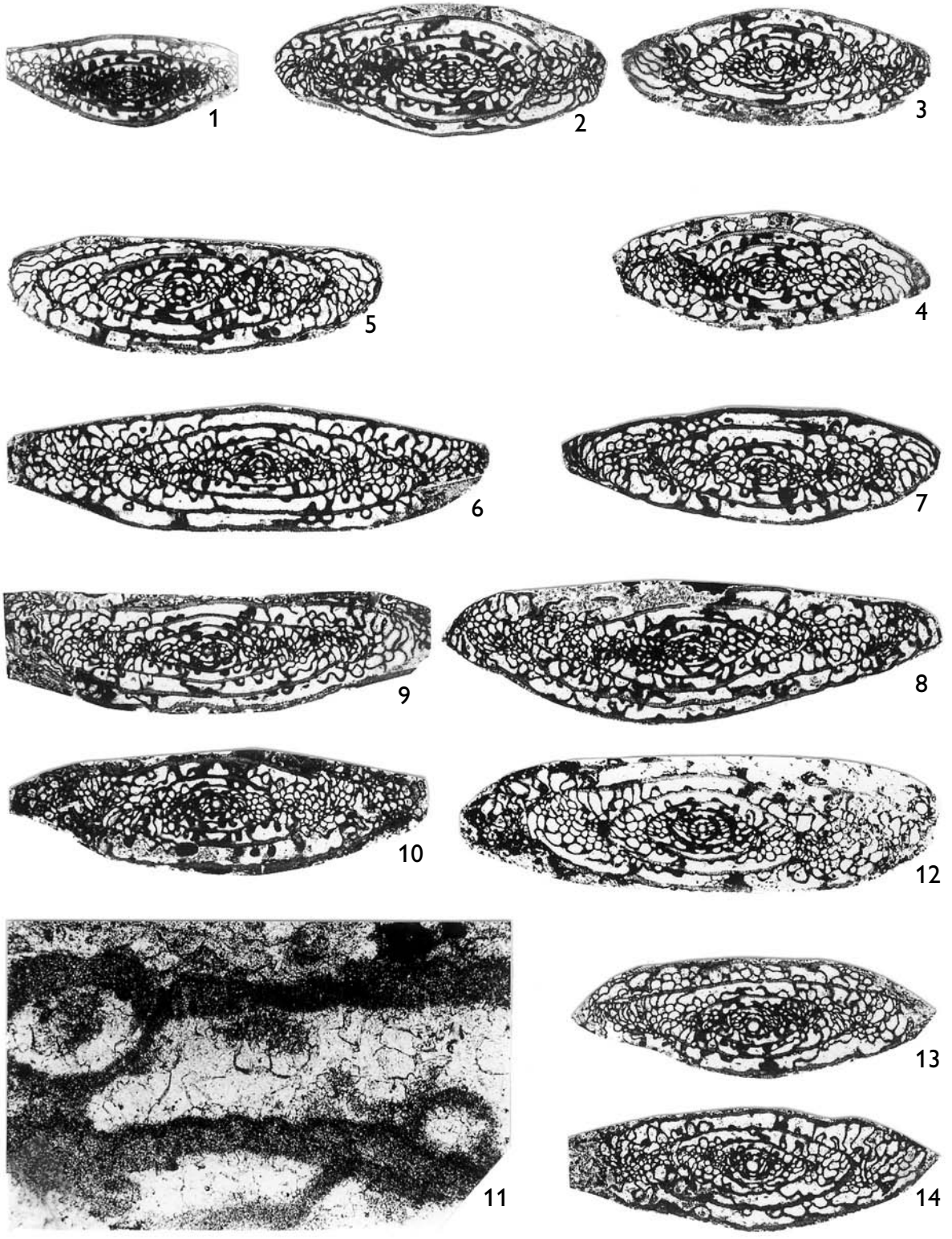

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Plate 13

The assemblage characterising the late Gzelian *Schellwienia ulukensis* Zone in southern Amdrup Land.

Figs 1–2. *Asselodiscus* sp., Fig. 1: MGUH 25926 from GGU 418917-8, ×160, Fig. 2: MGUH 25927 from GGU 418917-8, ×160.

Fig. 3. *Syzrania* sp., MGUH 25928 from GGU 418918-3, ×80.

Figs 4–5. *Millerella* sp., Fig. 4: MGUH 25929 from GGU 418918-1, ×80, Fig. 5: MGUH 25930 from GGU 418918-2, ×80.

Figs 6–9. *Nodosinelloides* sp., Fig. 6: MGUH 25931 from GGU 418918-6, ×80, Fig. 7: MGUH 25932 from GGU 418917-6, ×80, Fig. 8: MGUH 25933 from GGU 418917-10, ×160, Fig. 9: MGUH 25934 from GGU 418918-2, ×80.

Figs 10–12. *Schubertella miranda* Leontovich, Fig. 10: MGUH 25935 from GGU 418917-10, ×80, Fig. 11: MGUH 25936 from GGU 407679-1, ×80, Fig. 12: MGUH 25937 from GGU 418918-6, ×80.

Figs 13–17. *Schubertella pseudoglobulosa* Safonova, Fig. 13: MGUH 25938 from GGU 403741- 4, ×80, Fig. 14: MGUH 25939 from GGU 407679-1, ×80, Fig. 15: MGUH 25940 from GGU 418917-7, ×80, Fig. 16: MGUH 25941 from GGU 418839-6, ×80, Fig. 17: MGUH 25942 from GGU 418917-6, ×80.

Fig. 18. *Plectofusulina* sp., MGUH 25943 from GGU 418859-1, ×40.

Fig. 19. *Quasifusulina* sp., MGUH 25944 from GGU 418917-10, ×10.

Figs 20–23. *Quasifusulina cayeuxi* (Deprat), Fig. 20: MGUH 25945 from GGU 418917-5, ×10, Fig. 21: MGUH 25946 from GGU 418917-8, ×10, Fig. 22: MGUH 25947 from GGU 418918-10, ×10, Fig. 23: MGUH 25948 from GGU 418917-5, ×10.

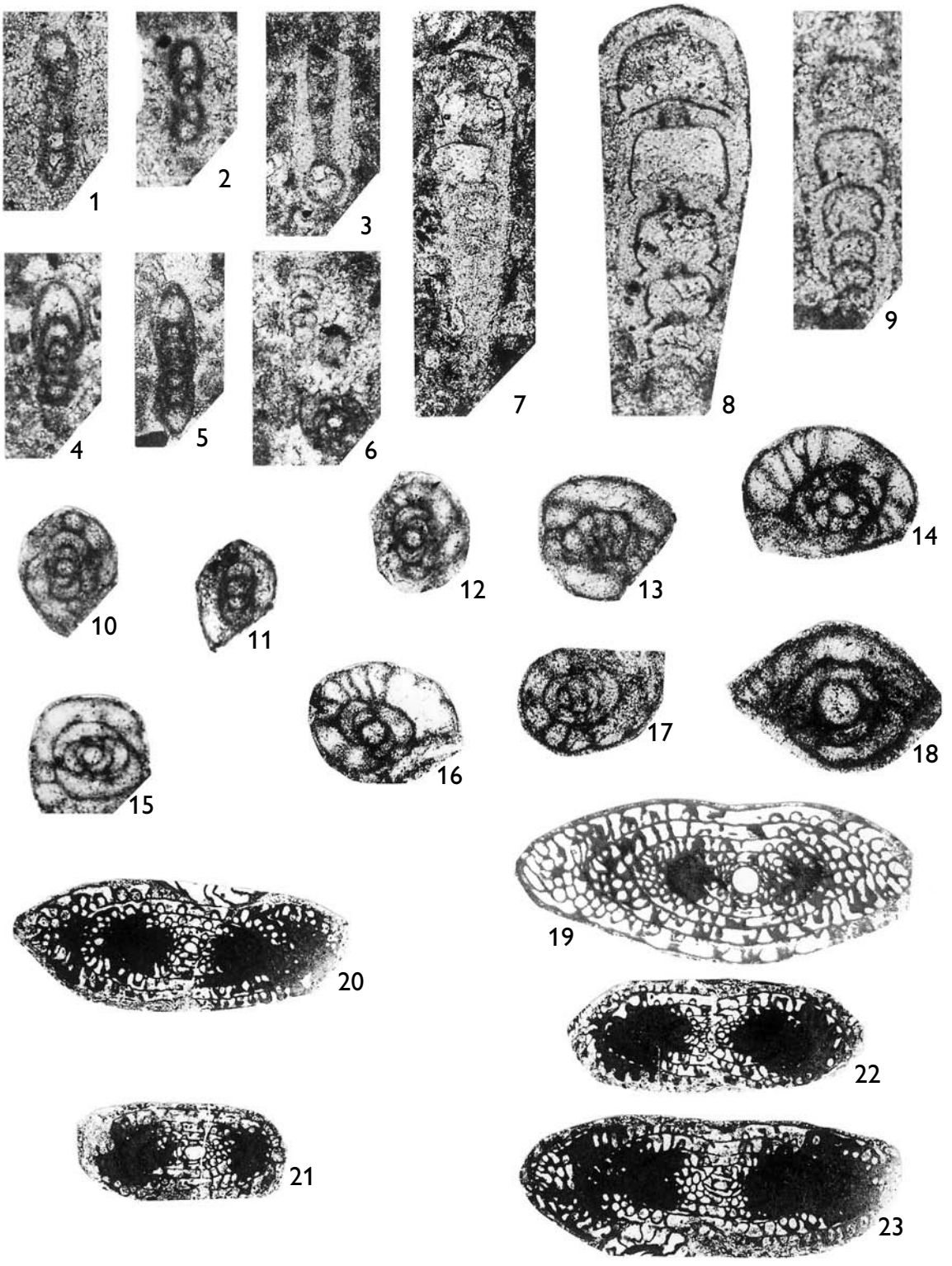

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Plate 14

The assemblage characterising the late Gzelian *Schellwienia ulukensis* Zone in southern Amdrup Land. All figured specimens ×10.

Fig. 1. *Jigulites magnus* (Rosovskaya), MGUH 25949 from GGU 407679-4.

Fig. 2. *Daixina enormis* Scherbovich, MGUH 25950 from GGU 407679-6.

Fig. 3. *Daixina vasylkovskyi* Bensh, MGUH 25951 from GGU 407679-1.

Fig. 4. *Daixina naviculaeformis* (Rosovskaya), MGUH 25952 from GGU 407679-2.

Figs 5–6. *Schellwienia delicata* (Alksne), Fig. 5: MGUH 25953 from GGU 418918-4, Fig. 6: MGUH 25954 from GGU 418918-10.

Fig. 7. *Schellwienia delicata* (Alksne), MGUH 25955 from GGU 418918-10.

Figs 8–11. *Schellwienia salebrosa* (Konovalova), Fig. 8: MGUH 25956 from GGU 418918-6, Fig. 9: MGUH 25957 from GGU 418917-4, Fig. 10: MGUH 25958 from GGU 418917-8, Fig. 11: MGUH 25959 from GGU 403741-1.

Fig. 12. *Schellwienia vozeiensis* (Konovalova), MGUH 25960 from GGU 407679-8.

Fig. 13. *Schellwienia visotchnayaensis* (Konovalova), MGUH 25961 from GGU 403741-4.

Fig. 14. *Schellwienia emaciata* (Konovalova), MGUH 25962 from GGU 418917-1.

Figs 15–16. *Schellwienia lata* (Alksne), Fig. 15: MGUH 25963 from GGU 418917-7, Fig. 16: MGUH 25964 from GGU 418917-10.

Fig. 17. *Schellwienia kharjagaensis* (Konovalova), MGUH 25965 from GGU 418918-8.

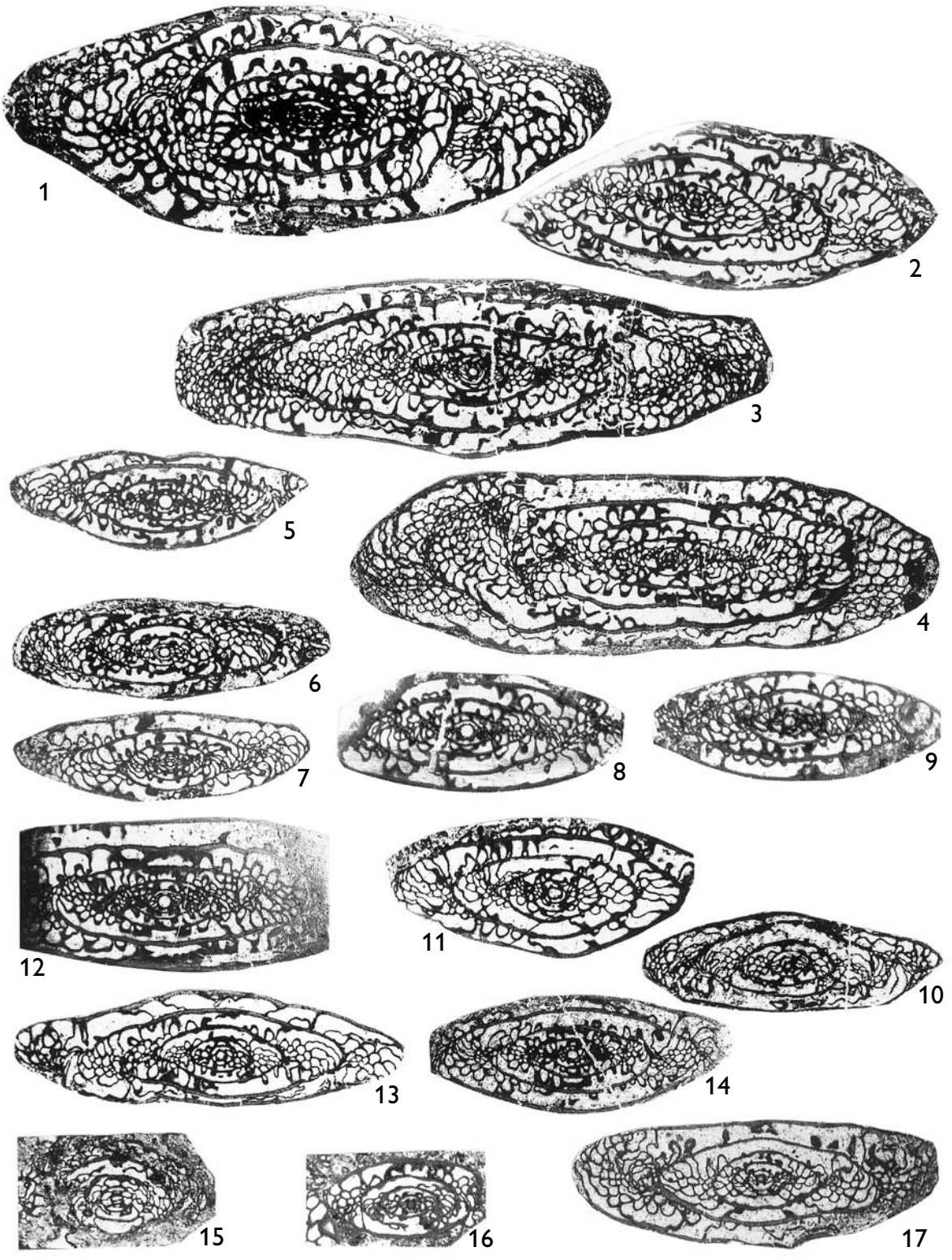

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Plate 15

The assemblage characterising the late Gzelian *Schellwienia ulukensis* Zone in southern Amdrup Land.

Figs 1–2. *Schellwienia krushiensis* (Alksne), Fig. 1: MGUH 25966 from GGU 407682-8, ×10, Fig. 2: the same specimen as in fig. 1, keriothecal wall with outer tectorium, ×80.

Figs 3–6. *Schellwienia malkovskyi* (Ketat), Fig. 3: MGUH 25967 from GGU 407682-10, ×10, Fig. 4: MGUH 25968 from GGU 418917-6, ×10, Fig. 5: MGUH 25969 from GGU 407682-11, ×10, Fig. 6: the same specimen as in fig. 5, keriothecal wall with outer tectorium, ×40.

Figs 7–9. *Schellwienia porrecta* (Sjomina), Fig. 7: MGUH 25970 from GGU 407682-2, ×10, Fig. 8: MGUH 25971 from GGU 418839-2, ×10, Fig. 9: MGUH 25972 from GGU 407682-7, ×10.

Figs 10–12. *Schellwienia subundulata* (Konovalova), Fig. 10: MGUH 25973 from GGU 418917-4, ×10, Fig. 11: MGUH 25974 from GGU 418918-3, ×10, Fig. 12: MGUH 25975 from GGU 418918-10, ×10.

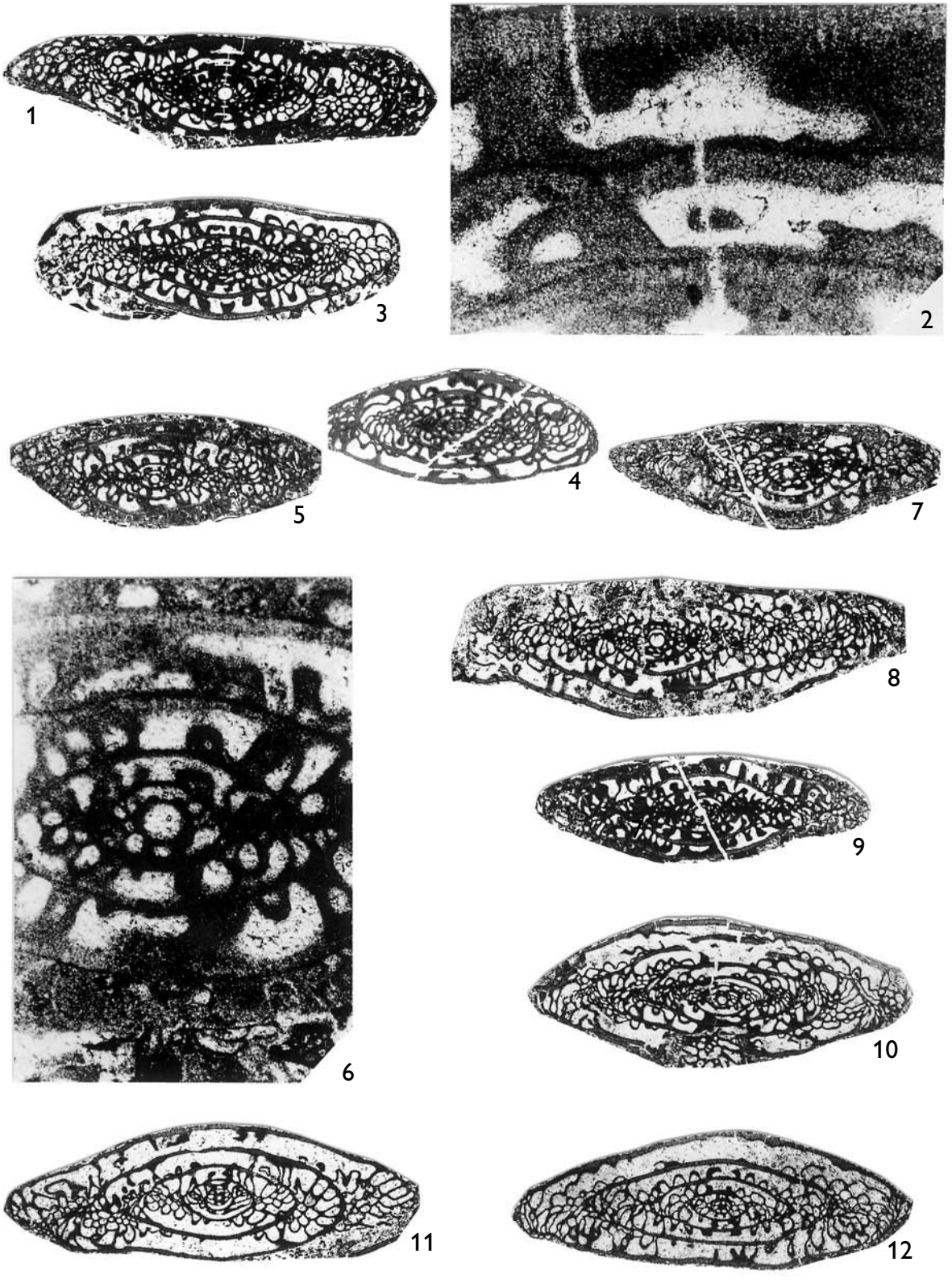

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Plate 16

The assemblage characterising the late Gzelian *Schellwienia ulukensis* Zone in southern Amdrup Land. All figured specimens ×10.

Fig. 1. *Schellwienia* aff. *modesta* (Scherbovich), MGUH 25976 from GGU 403741-3.

Figs 2–4. *Schellwienia modesta* (Scherbovich), Fig. 2: MGUH 25977 from GGU 418918-5, Fig. 3: MGUH 25978 from GGU 418918-9, Fig. 4: MGUH 25979 from GGU 418917-7.

Fig. 5. *Schellwienia postmodesta* Davydov, MGUH 25980 from GGU 418839-3.

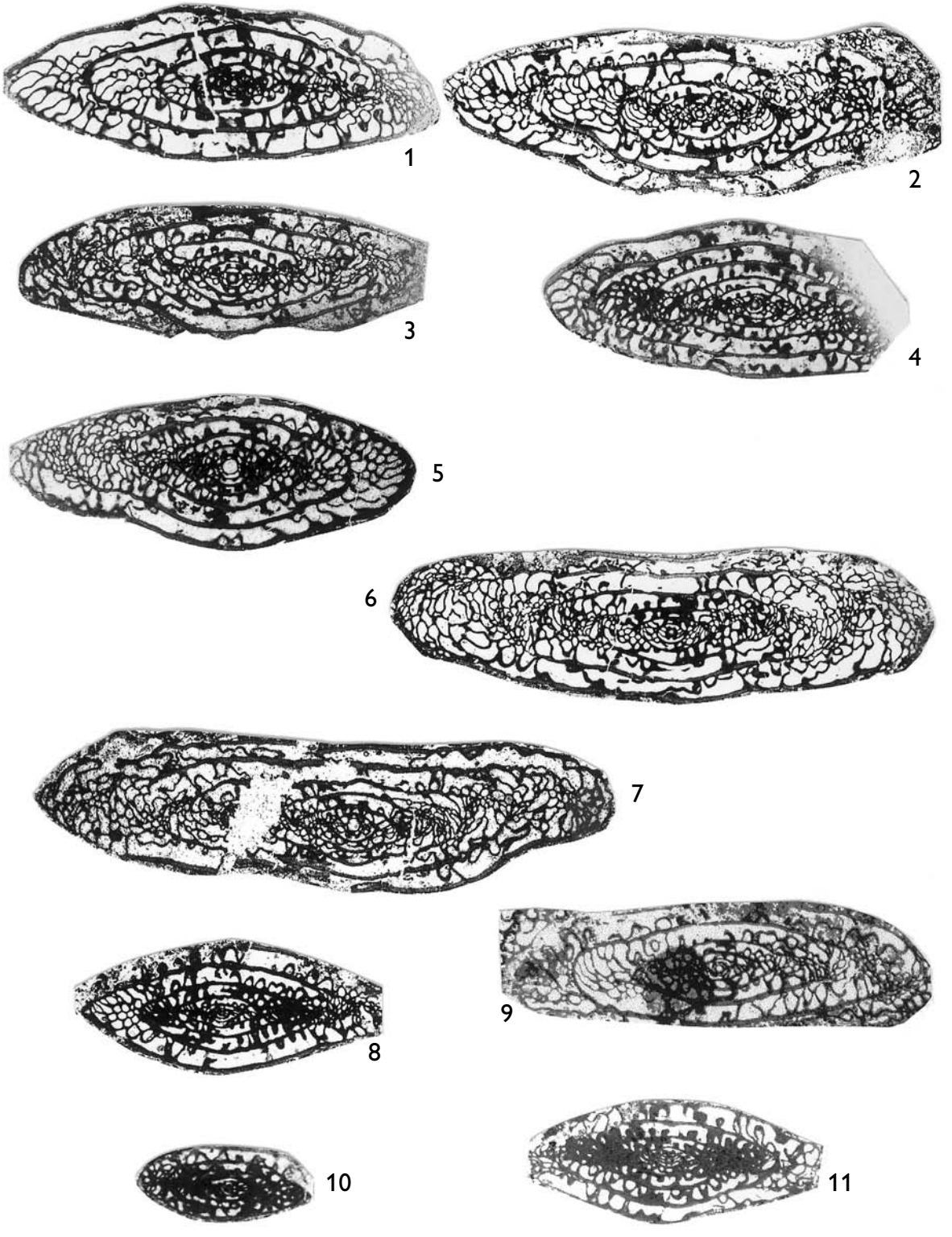
Figs 6–7. *Schellwienia ulukensis* (Bensh), Fig. 6: MGUH 25981 from GGU 407679-6, Fig. 7: MGUH 25982 from GGU 418879-4.

Fig. 8. *Zigarella acuminulata* (Echlakov), MGUH 25983 from GGU 418917-2.

Fig. 9. *Schellwienia aff. bornemani* (Leven & Scherbovich), MGUH 25984 from GGU 418917-11.

Fig. 10. *Zigarella praegregaria* (Scherbakova), MGUH 25985 from GGU 418918-3.

Fig. 11. *Zigarella simplex* (Konovalova), MGUH 25986 from GGU 418918-7.


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