Distribution of Late Silurian (?) and Early Devonian grey-green sandstones in the Liefdefjorden-Bockfjorden area, Spitsbergen

TORE GJELSVIK and ROBERT ILYES

Gjelsvik, T. & Ilyes, R.: Distribution of Late Silurian (?) and Early Devonian grey-green sandstones in the Liefdefjorden-Bockfjorden area, Spitsbergen. *Polar Research 9(1)*, 77–87.

Lithologic, petrographic and paleontologic data for the various areas of late Silurian (?) and early Devonian grey-green sandstones (greywackes) in the Liefdefjord area of northern Spitsbergen are evaluated. A number of new localities with fossil fauna have been detected in these sandstones, both to the north and south of Liefdefjorden. It is shown that vertebrate and invertebrate fossils occur at lower levels than hitherto believed. Differences in the amounts of plagioclase and potash feldspar in the sandstones north and south of the fjord, as well as the finds of fossils, suggest that the Siktefjellet Sandstone is restricted to the type area north of Liefdefjorden. The grey-green sandstones south of Liefdefjorden are correlated with the Andréebreen Sandstone Formation of the Red Bay Group.

T. Gjelsvik, Norsk Polarinstitutt, Rolfstangveien 12, Snarøya, P.O. Box 158, N-1330 Oslo Lufthavn, Norway; R. Ilyes, Department of Geology, Northern Arizona University, P.O. Box 6030 Flagstaff, Arizona 86011-6030, U.S.A.

Introduction

Old Red Sandstone (O.R.S.) occurs extensively in northern Spitsbergen, overlying the Caledonian metamorphic complexes. The oldest formations occur in the northwestern areas, where conglomerates and sandstones were observed by Nordenskiöld (1892) and Holtedahl (1914, 1926), (Fig. 1). Early work focused on the rich fish fauna in the sandstones (Kiær & Heintz 1935). Subsequent studies also comprised aspects of stratigraphy and sedimentology (Føyn & Heintz 1943; Friend 1961; Gee & Moody-Stuart 1966; Murašov & Mokin 1979). Table 1, extracted from Murašov & Mokin 1979, gives the presently most detailed concept of the stratigraphy of the lower O.R.S. in Spitsbergen.

Many of the sandstones are grey-green in colour and compose three units: the Siktefjellet Sandstone of the Siktefjellet Group, the Rabotdalen Member within the Red Bay Conglomerate, and the Andréebreen Formation of the Red Bay Group.

The rocks are extensively faulted, and tectonic juxtaposition of the different units has complicated the stratigraphic correlation.

The extensive surface covers of glaciers, water, and rock debris obscure many vital contacts and fault lines. In order to establish the stratigraphic relationships, comprehensive and detailed lithologic and structural analysis is needed. The present paper is only one step in this process.

In the area north of Liefdefjorden, Gee & Moody-Stuart (1966) reported the occurrence of an angular unconformity within the lower part of the O.R.S. The sequence below the unconformity, named the Siktefjellet Group after the type area on the mountain of the same name on the northern side of Liefdefjorden, is composed of Siktefjellet Sandstone and underlying Liljeborgfjellet Conglomerate. Two major north-northwest trending faults influence the Siktefjellet Group north of Liefdefjorden (Fig. 1). The Breibogen Fault defines the eastern margin, separating a horst (Gjelsvik 1979) of metamorphic rocks with overlying basal conglomerates and sandstones from the younger O.R.S. rocks (the Wood Bay Group of the main Devonian Graben). Further west the Hannabreen Fault, also downthrowing eastwards, brings the Red Bay Group and the Siktefjellet Group in contact with the metamorphic basement in Wulfberget on the northern shore of Liefdefjorden. The Hannabreen Fault apparently continues northwards, outcropping on the eastern side of Raudfjorden where it downthrows westwards. South of Liefdefjorden grey-green sandstones occur in a faultbounded area extending southwards along the eastern margin of the horst of metamorphic rocks (Fig. 1,

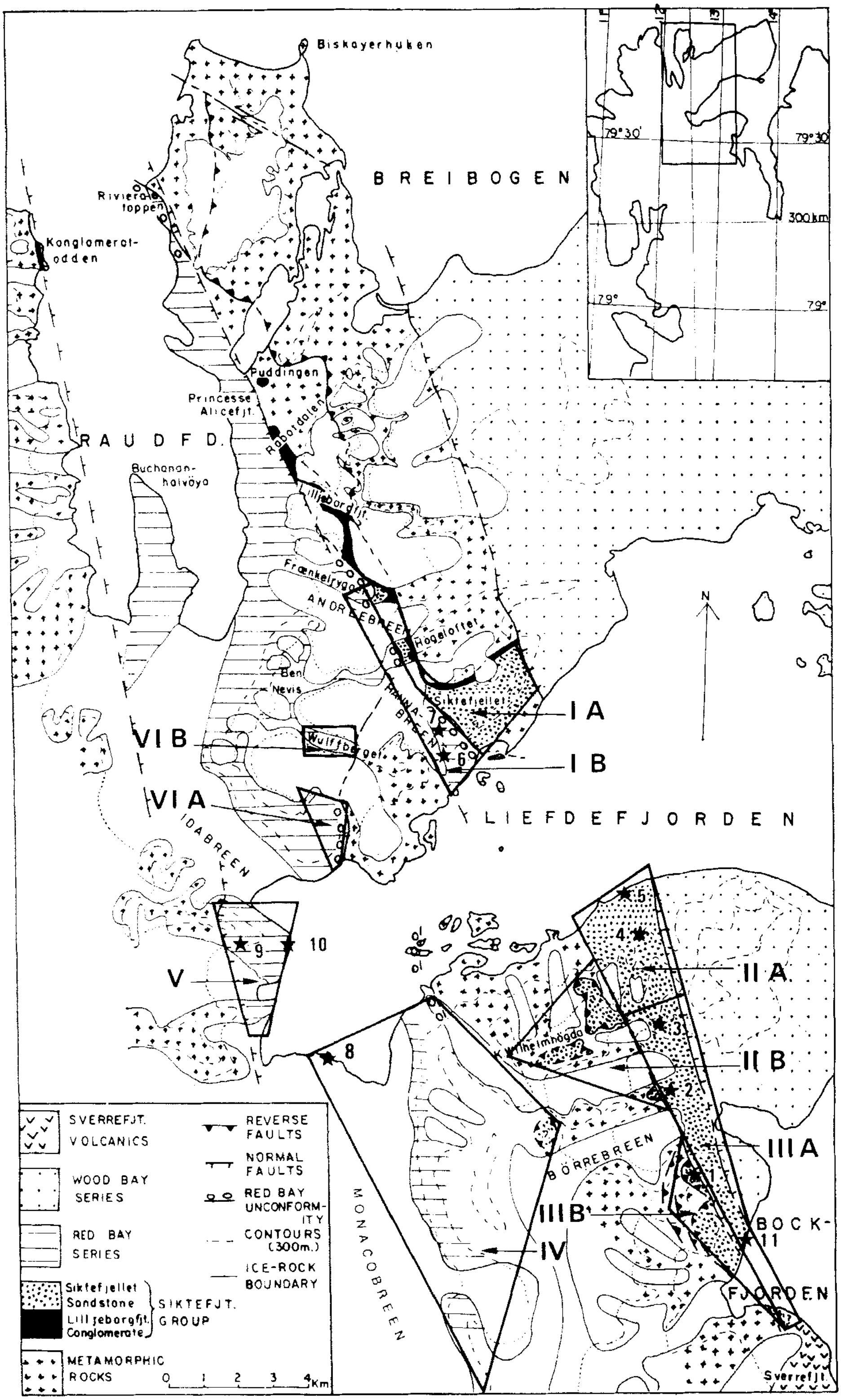


Fig. 1. Fossil locations 1–11 (marked with stars) within subareas I–VI. Map based on fig. 1 in Gee & Moody-Stuart (1966).

Table 1. Stratigraphy and lithology of the Red Bay Group and the Siktefjellet Group in northern Spitsbergen.

Group	Formation	Member	Lithology
RED BAY	Ben Nevis 900 m		grey, micaceous sandstone
	Frænkelryggen 600 m		alternating red and green sand/siltstone
	Andréebreen >200 m		grey-green, yellow-grey sand/siltstone, basal grit.
	Red Bay Conglomerate 700 m	Princesse Alicefjellet 300 m	matrix supported, quartz chip conglomerate
		Rabotdalen 200 m	grey-green, in lower part multicoloured sandstone
		Wulfberget 200 m	coarse, massive marble conglomerate
	Unconformity		
SIKTE-FJELLET	Siktefjellet Sandstone 350 m		grey-green sand/siltstone
	Lilljeborgfjellet Conglomerate 400 m		massive, polymict conglomerate

subareas IIA and IIIA). Gee & Moody-Stuart correlated these sandstones with the Siktefjellet Sandstone because of similarity in lithology, tectonic setting, and internal deformation. They also included some partly disrupted sandstone units on the western side of the Hannabreen Fault (Fig. 1, subareas IIB and IIIB). Previous workers (Føyn & Heintz 1943) favoured the inclusion of the grey-green sandstones south of Liefdefjorden in the Red Bay Group on the basis of 'scanty fossils' and the occurrence of a conglomerate 'common in the Red Bay Series'.

From the map in the paper by Gee & Moody-Stuart (1966, fig. 1) it is seen that rocks belonging to the Red Bay Group in subarea IB also are located between the same major faults, and that the formations of the Siktefjellet Group in subarea IA have been folded to strike ENE, making a southern continuation questionable. It should be noted that the tectonics of the Siktefjellet and Hannabreen areas are more complicated than shown on the map of Gee & Moody-Stuart (1966), as both the Siktefjellet Group and the Red Bay Group reappear in various places in the Hannabreen area, apparently due to a complex fault system hidden under the glacier and other overburden.

During several field seasons between 1963 and 1989, T. Gjelsvik (this study) mapped and sampled the grey-green sandstones on both sides of Liefdefjorden, southwards to Bockfjorden on the east side of the anticlinal ridge of metamorphic rocks, and along the glacier Monacobreen on the western side of the ridge. In some areas only reconnaissance surveys could be undertaken.

The objectives of this paper are to clarify the stratigraphic relationship of the sandstones and to investigate the question of the southward extension of the Siktefjellet Group. To accomplish this, a detailed petrographic and paleontologic examination of the sandstones has been performed.

Lithology, tectonics, and stratigraphy

For comparative purposes the sandstone areas are divided into ten subareas (delineated in Fig. 1), four of which are located on the north side of Liefdefjorden, one on the west side and five between Liefdefjorden and Bockfjorden.

IA Siktefjellet, between the Breibogen fault and the unconformity below the Red Bay Group, and a narrow strip northwards to Frænkelryggen.

IB West Siktefjellet, between the unconformity and the Hannabreen Fault and northwards to Frænkelryggen.

IIA From the south shore of Liefdefjorden, between the two converging Hannabreen and Breibogen faults and southwards to the watershed to Bockfjorden.

IIB Outliers in the K. Wilhelmshøgda to the west of IIA.

IIIA Between the two convergent faults from the water divide and southwards to Sverrefjellet in Bockfjorden.

IIIB An imbricated sandstone area to the west of IIIA.

IV South of the head of Liefdefjorden, between Monacobreen and the western border of the metamorphic rocks.

V Western side of Liefdefjorden between Monacobreen and Idabreen.

VIA The mountain Pteraspisfjellet west of Erikbreen.

VIB The northwest trending ridge of Wulfberget (Wulfkammen).

The general appearance of the sandstones in all subareas is rather similar: grey, grey-green, or occasionally yellow-green, tough and massive dm-m thick beds of fine-to-medium-grained sandstone, rhythmically interbedded with cm-dm thick layers of fine-grained, shale-like sandstone or siltstone. Up to one metre thick beds or lenses of quartz chip conglomerate are occasionally interspersed. Graded bedding and sole markings are rare, but cross-bedding is often seen and is very conspicuous in some areas. The directions of sediment dispersion deduced from these structures give a confusing picture, showing both longitudinal and transverse, sometimes opposing, directions in the basin. Since the observations are too few and too scattered, more detailed sedimentological studies are needed for a closer analysis of the dispersion pattern. The colour variations of the sandstones are nearly the same within all the subareas, although the yellow-green variety may be missing. At least locally, the grey-green sandstones in subareas IB to VIB may appear more stratified than those of subarea IA – the Siktefjellet Sandstone type area.

The sandstones are polymict and poorly sorted in all subareas, much like greywackes. The maximum size of quartz grains in the beds of massive sandstone mostly varies between 0.2 and 0.8 mm, that of scattered clasts in the conglomeratic varieties between 5 and 20 mm. In the fissile, thin and darker beds the grain size usually is less than 0.1 mm, approaching siltstone. In some places these beds are rich in carbonate.

In the subareas IB, IV, VIA and VIB, the sandstones rest concordantly on the Wulfberget conglomerate, often with a transition zone of quartz chip conglomerate similar to the Princess Alicefjellet Member. Although sometimes folded about SW and NNW axes, the beds generally dip to the west. They are thus equivalent to the Andréebreen Formation. In the subareas IIA, IIB, IIIA, IIIB and V, the Wulfberget conglomerate is not observed as the sandstones are contained by faults.

In the subareas IIA, IIIA, and V, quartz chip conglomerates similar to the Princess Alice Member occur, either intertonguing or alternating with the sandstones or separated by faults. The internal stratigraphic relationships are largely obscured by extensive overburden and perhaps disturbed by tectonic displacements along the adjacent faults. It is also possible that lateral transitions of grey-green sandstone and quartz chip conglomerate (Princess Alicefjellet type) are repeated in several places inside the subareas IIA and IIIA, making it difficult to distinguish between the Rabotdalen and Andréebreen sandstones.

Mineral composition of the sandstones

The thin sections selected for quantitative mineral analysis are mostly representative of the abundant massive sandstone beds, but also representative of the less common silty or gritty layers. They were chosen after inspection of a large number of samples. A few of the thin sections come from sandy intercalations in conglomerates. The samples of the Siktefjellet Sandstone come mostly from the eastern and western shoulders of the Siktefjellet mountain, but a few are also from the central part. From some of the subareas only a few thin sections could be obtained due to scarcity of samples. Microscopic examination of these poorly sorted and polymict sandstones is very time-consuming, largely due to difficulties in identifying the very fine-grained, often pigmented rock fragments occurring mostly in the matrix. The modal proportions of the fragments of quartz and quartzite (Q), plagioclase (Plag), potassium feldspar (Kf, stained with HF and cobaltnitrate), micas (including chlorite) and carbonate (mainly, if not solely calcite) have been estimated by a crude point-counting (Table 2). Small grains of quartz and mica (especially sericite), which

Table 2. Modal proportions of the most common minerals in the grey-green sandstones.

AREA 1 A

Sample No.	Q	Plag	Kf	Mica	Carb
75 - Gj. 191 A	43	5	5	37	4
78 - Gj. 108 A	47	5	9	25	2
89 - Gj. 113 C	35	12	2	19	28
89 - Gj. 113 M	44	13	0	9	15
89 - Gj. 113 N	40	5	0	19	3
89 - Gj. 270 A	45	9	6	14	13
89 - Gj. 227 C	50	6	8	11	8
89 - Gj. 229	39	14	13	10	0
78 - Gj. 42 A	42	10	9	12	7
78 - Gj. 46	43	12	7	16	11
78 - Gj. 138	53	3	1	16	11
Average of 11	44	9	5	17	9
Spread	35–50	3–14	0–13	9–37	0–28

AREA I B

75 - Gj. 187 B	66	1	tr	25	1
78 - Gj. 106	57	0	0	16	8
89 - Gj. 243 A	63	2	0	30	0
89 - Gj. 243 D	63	1	0	22	2
89 - Gj. 264 A	65	0	0	8	0
89 - Gj. 266 A	51	12	0	15	4
89 - Gj. 268 A	53	7	0	28	8
Average of 7	60	3	0	21	3
Spread	51–66	0–12	0–tr	8–30	0–8

AREA II A

89 - Gj. 294 A	41	2	0	19	7
89 - Gj. 294 B	70	1	0	6	3
89 - Gj. 295 B	50	2	tr	2	9
Average of 3	54	2	0	9	6
Spread	41–70	1–2	0–tr	2–19	3–9

AREA II B

75 - Gj. 86 A	50	1	0	14	10
78 - Gj. 127 D	64	0	0	2	tr
Average of 2	57	1	0	8	5
Spread	50–64	0–1	—	2–14	tr–10

AREA III A

75 - Gj. 183 B	52	0	0	5	1
78 - Gj. 69 A	45	4	4	8	18

AREA III A, cont.

Sample No.	Q	Plag	Kf	Mica	Carb
78 - Gj. 70 B	55	8	1	10	17
78 - Gj. 72	54	2	0	15	5
Average of 4	52	4	1	10	10
Spread	45–55	0–8	0–4	5–15	1–18

AREA III B

78 - Gj. 89 B	43	1	3	7	6
89 - Gj. 287	42	tr	0	6	1
89 - Gj. 289	50	1	0	8	7
Average of 3	45	1	1	7	5
Spread	42–50	tr–1	0–3	6–8	1–7

AREA IV

63 - Gj. 89	63	0	0	11	0
63 - Gj. 143	47	8	0	7	5
64 - Gj. 87	55	0	0	13	0
75 - Gj. 77 G	47	5	0	8	1
89 - Gj. 237 A	50	0	0	5	1
89 - Gj. 238 C	36	2	0	14	0
Average of 6	50	3	0	10	1
Spread	36–63	0–8	—	5–14	0–5

AREA V

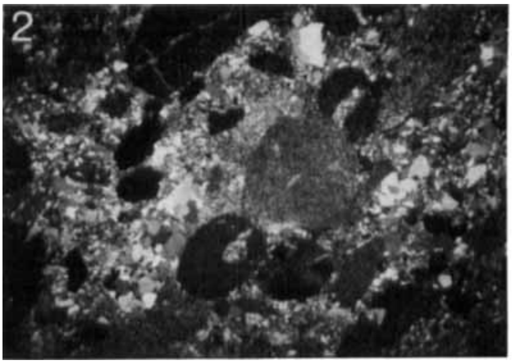
78 - Gj. 51 A	42	6	10	4	4
78 - Gj. 51 H	36	1	4	7	43
78 - Gj. 53 A	54	3	0	4	0
Average of 3	44	3	5	5	16
Spread	36–54	1–6	0–10	4–7	0–43

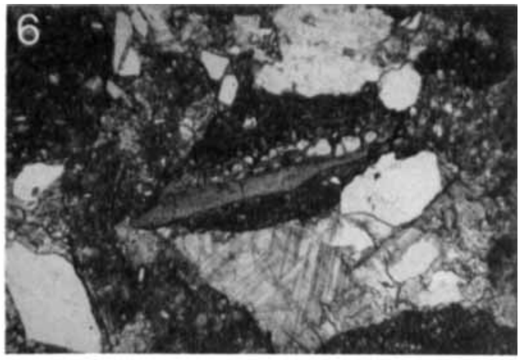
AREA VI A

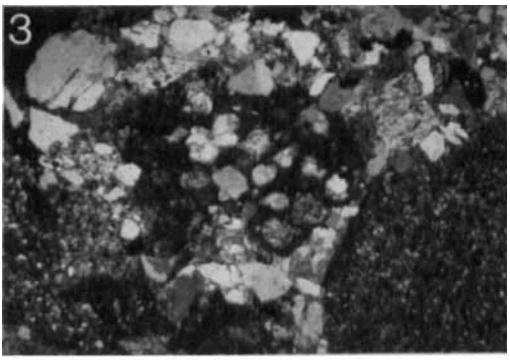
89 - Gj. 215 B	49	2	0	19	1
89 - Gj. 279 A	41	0	0	13	14
75 - Gj. 171 B	45	1	0	16	8
Average of 3	45	1	0	16	8
Spread	41–49	0–2	—	13–19	1–14

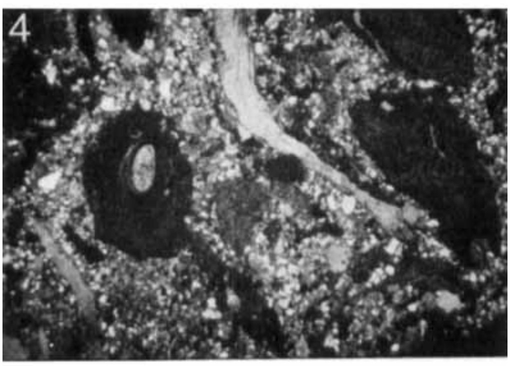
AREA VI B

89 - Gj. 162 H	50	0	0	12	0
89 - Gj. 163 G	45	0	0	8	1
Average of 2	48	0	0	10	1
Spread	45–50	—	—	8–12	0–1









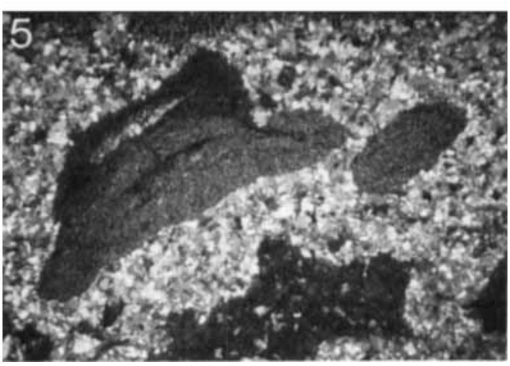


Fig. 2. Peloid conglomerate with a mixture of spheroidal and angular clasts. Location 2. 4×.

Fig. 3. Algal structure. Location 8. 13×.

Fig. 4. Two large monocrystalline echinoderm fragments in upper right of center and in lower left corner. In between is a subspherical, vaguely concentric, fine-grained clast with drusy calcite in the center. Location 1. 15×.

Fig. 5. Angular, laminated clast. Location 1. 4×.

Fig. 6. Cyathaspidid fragment in dark intraclast. Angular, white clasts are (extraneous) quartz and quartzite. Numerous stylolites. Location 8. 30×.

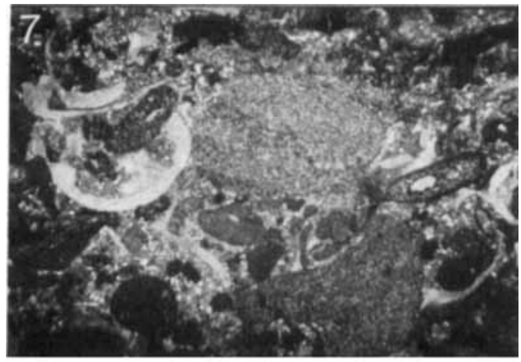
commonly occur in the matrix, have not been counted.

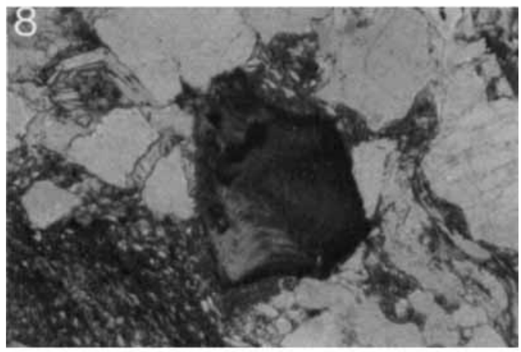
It is seen that the sandstones in subarea IA, the type area of the Siktefjellet Sandstone, are relatively low in quartz and high in both feldspars. The other subareas to the north and south are higher in silica, somewhat variable in plagioclase (though lower than in IA), and just about devoid of potassium feldspar. Subarea V, west of the head of the Liefdefjorden, has intermediate values of both feldspars. The internal variations of the content of carbonate and detrital mica in most subareas are higher than the variations between the areas, making these minerals less useful in classification. The feldspar relationships, in particular the absence of potassium feldspar, and the paucity of plagioclase in the sandstones to the south of Liefdefjorden are confirmed by examination of more than 60 other thin sections stained by cobaltnitrate. Thus there is a clear difference in the feldspar content between the Siktefjellet Sandstone and the sandstones located between the Hannabreen and Breibogen fault system south of Liefdefjorden.

Fossil horizons in the sandstone

During the field investigations vertebrate and invertebrate fossils were found at various places in the grey-green sandstone formations (Fig. 1). Most of these fossils are located in thin, apparently concordant beds or lenses of a peculiar conglomerate or breccia. The lithology of this conglomerate, which is dominated by small limestone clasts in a quartz/carbonate matrix, differs markedly from that of the quartz chip conglomerate occurring elsewhere in the sandstones. The clasts make up between 30 and 70 per cent of the rock. These conglomerate beds are usually only a few dm thick (in one case as much as one metre). As a rule, only one bed of conglomerate is usually found, but in a few exceptional locations two or three closely spaced beds have been observed. Spherical or ellipsoidal limestone clasts are common in the conglomerate (Fig. 2), but angular clasts are in the majority. A few of the spherical clasts are ooids or pisolites, and algal structures are inferred in some of the other cases (Fig. 3). But most of the round clasts show no internal pattern and should be called peloids only (Tucker 1981). The grain size in the clasts ranges from submicroscopic to 0.1 mm. Only a few of them, consisting solely of pigmented carbonate, are fine-grained enough to be called micritic. Most of the clasts are a little more coarse-grained and contain up to ten per cent quartz or quartzite and a small per cent of sericite. The most fine-grained clasts often contain clear, drusy calcite in the central parts (Fig. 4) which is interpreted as cavity fillings. Stylolites are common. These clasts are considered to be intraclasts.

Besides these presumably biochemically or chemically derived clasts, very fine-grained, often laminated, angular clasts of detrital sediments





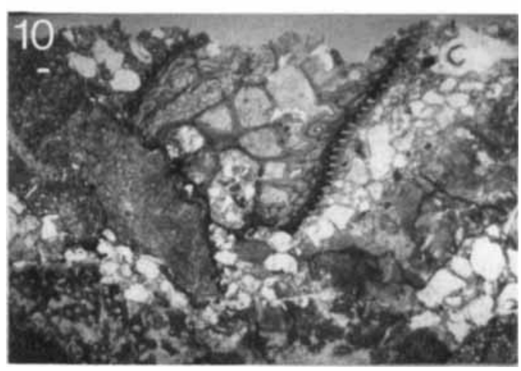


Fig. 7. Peloid conglomerate with well-rounded to angular, fine-grained clasts. Monocrystalline enchinoderm fragments, recrystallized bivalve shells, an arthrodire fragment and an articulated ostracod make up the fossil content. Location 5. 4×.

Fig. 8. Well-preserved acanthodian scale with growth lines. Location 8. 50×.

Fig. 9. Large psammosteid fragment with well-rounded corners in the matrix of a peloid conglomerate. Below, to the right, a monocrystalline echinoderm fragment. Location 5. 11×.

Fig. 10. A large fragment of a cyathaspidid shield in the matrix, upper part near the center. In lower left corner a psammosteid fragment. Stylolites common. Location 8. 12×.

Table 3. Distribution of fossil fauna in the grey-green sandstones.

		Localities	1	2	3	4	5	6[2]	7	8[3]	9	10	11
INVERTEBRATES	Heterostaci	Cyathaspidida	x			x			x	x	x	x	
		Pteraspidida									x		
		Cyathaspidida or Pteraspidida		x			x			x			
		Psammosteida					x			x			
		Unspecified					x	x	x	x	x		x
	Placodermi	Arthrodira		x	x		x		x		x		x
	Acanthodii						x		x	x	x		x
		Unidentified	x	x		x	x	x		x			
VERTEBRATES		Ostracoda	x	x			x			x			x
		Echinodermata	x				x					x	
		Bivalvia		x[1]									x[4]
		Gastropoda					x						

[1] Less probable: brachiopods. [2] In addition plant fossils.
[3] In addition one algae. [4] Questionable.

such as mudstone, shale and low grade schist also commonly occur (Fig. 5). Most of these are rich in carbonate, and some tabular shaped clasts are parallel oriented and up to 3 cm long. These clasts are also interpreted as intraclasts. In addition, a few extraneous angular clasts of quartz and quartzite are present (Fig. 6). In a few cases very thin slabs of shale, which resemble dessication flakes and measure up to 5 cm, are present, usually in the border zone. They are frequently also observed in the sandstone beds. The matrix consists of 40–60 per cent angular quartz fragments, 0.1–0.2 mm in size, a little detrital mica, some rock fragments, and 30–60 per cent of clear, interstitial calcite (sparite), often poikilotopic. For convenience, these units are hereafter called peloid conglomerates.

More than 70 rock samples, mainly from the peloid conglomerates, have been examined both macroscopically and in thin sections, and a number of vertebrate and invertebrate fossils have been identified at 11 localities (Fig. 1, nos. 1–11). The finds are presented in Table 3.

The vertebrate fossils occur both as larger fragments of the bony shields and as tiny fragmented units. They can be seen both macroscopically and in thin sections. Two large fragments of arthrodire trunk shields have been found, one from the pectoral area of the ventral part of the trunk shield and one from a spinal plate. The majority of the vertebrates studied macroscopically are cyathaspidids, probably poraspids. They are very similar to the well-known poraspids from the Red Bay Group, but preliminary studies indicate that they may belong to new and, so far, undescribed species. A large fragment of a dorsal or ventral plate from a heterostracan has been found. Its large size indicates that it probably belongs to a pteraspidid. Large cyathaspidids are known from the Lower Devonian of Spitsbergen (Blieck & Heintz 1983), but the measurements seem to indicate that the studied fragment is from a much larger specimen than the known cyathaspidids. It has not been possible to determine whether the fragmentation of the vertebrate fossils found in the matrix is due to transportation or abrasion in situ. The occurrence of some cyathaspidid and invertebrate fragments in some of the intraclasts indicates resedimentation and some transportation of at least some of the material (Fig. 6). Articulated ostracod valves found in the matrix in some of the samples (Fig. 7) indicate little or no transportation. The occurrence of echinoderms (Figs. 4, 7, and 9) and acanthodians (Fig. 8) in the matrix indicates deposition under normal marine conditions. Some of the fine-grained spherical clasts show concentrical lamination (Fig. 4). This is probably the result of biological activity. Algae, trapping fine sediment on a rolling particle, may be an explanation for the occurrence of these structures.

The fossil-bearing rock in locality 6 (Fig. 1) is an ordinary grey-green sandstone, devoid of carbonate minerals. In locality 10 it is a carbonate rich, grey-green sandstone containing a few, scattered peloids, probably clasts, of micrite and minor amounts of quartz and sericite. On the northwestern coast of Bockfjorden (locality 11) the fossils are found in grey-green sandstones and interbedded quartz chip conglomerates usually containing 5–20 per cent carbonate minerals in the matrix. In all the other localities the fossils are contained in the matrix or clasts of the peloid conglomerates.

In the present stage of investigation, it has not been ascertained whether the various exposures of the peloid conglomerates represent one or more horizons. In most cases they seem to be located in the middle or lower parts of the exposed sandstones. Vertebrate fossils are found in a number of horizons in the overlying Devonian formations (Blieck & Heintz 1979; Blieck et al. 1987), but the sedimentological environment is not described in much detail. According to Heintz (1929), Kiær & Heintz (1935), and Wängsjø (1952), most of the fossil horizons between Raudfjorden and Liefdefjorden are located in various carbonate-rich sandstones; only some of the horizons in the Ben Nevis Formation and the Wood Bay Group are hosted in 'nodular' or conglomerate-like sandstones. In order to check this relationship we examined a number of thin sections of samples from these localities which are in the custody of the Paleontologisk museum, University of Oslo. Many of these samples are similar to the peloid conglomerates reported in this study.

According to Friend (1961), Kiær & Heintz (1935), and Blieck et al. (1987), the lowest of the fossil bearing horizons is located at the base of the Frænkelryggen Formation, and the underlying Andréebreen Formation has been characterized as fossil-free (except for some plant fossils). This is a mistake. The lowest horizon, called the 'psammosteus' horizon, is located on the Frænkelryggen ridge, 550 m above sea level, in a yellow-green sandstone of the Andréebreen Formation, and well below the base of the Frænkelryggen Formation, (see Gee 1966, map IV). The sandstones under consideration have psammosteids (Fig. 9) and arthrodires (Fig. 7) in common with this horizon, which in addition contains osteostracans and thelodonts (Blieck et al. 1987). Representatives of these two groups have not yet been recorded in the sandstones of this study which on the other hand has numerous fragments of cyathaspidids (Fig. 10) and pteraspidids not reported from the 'psammosteus' horizon. It should be taken into consideration that our study is preliminary, and that the samples contain several unidentified vertebrate fragments.

The exact locations of the fossils are registered on vertical air photographs in the archives of the Norwegian Polar Research Institute. This information can be obtained upon request. The studied fossiliferous samples are kept at the Paleontological Museum, University of Oslo.

Discussion and conclusion

The mineral composition of the sandstones in all the subareas IB to VI, with the exception of subarea V, differs in the amount of feldspar fragments from that of the Siktefjellet Sandstone of subarea IA. Subarea V is located close to the western border fault of the Devonian graben (Fig. 1). All along this border the Devonian sediments contain clasts and detritus derived from the adjacent feldspar-rich gneiss-granite complex of northwest Spitsbergen. Thus, the great amount of feldspar fragments in subarea V can most likely be explained by its location adjacent to these crystalline rocks.

Of particular interest is the high proportion of feldspar of the sandstones in subarea 1A (the type area of Siktefjellet Sandstone) as compared with the subareas further south where the sandstones are similar to those of subareas IB, IV, VIA and VIB. From their stratigraphic relationship the latter subareas clearly belong to the Andréebreen Formation, indicating that the sandstones in subareas II and III also belong to this formation. This interpretation is supported by the occurrence of the unique peloid conglomerates in all subareas except IA. In all localities these conglomerates have nearly the same size and composition and they have been formed in a similar environment. The occurrence of echinoderms and acanthodians indicate marine conditions; it is suggested that the conglomerates originated in a tidal basin by a combination of detrital, biogenic, and biochemical activity, and were later broken up and reworked by waves, perhaps during storms. Some clasts and matrix minerals were supplied from distant sources. These conditions were repeated during deposition at higher levels in the Devonian formations, but they have not yet been reported from the undisputed Siktefjellet Sandstone in subarea IA.

The fossil fauna of the various peloid conglomerate localities exhibits significant similarities both in composition and fossil content, indicating contemporaneous deposition under similar environmental conditions. Differences in the content of fossils may be the result of vertical or lateral facies variations in the deposition environment or of insufficient sampling at some localities. The arthrodire fauna indicate an early Devonian age (Lochkovian) for the sandstones. The presence of cyathaspidids indicates an affinity to the Red Bay Group for all localities. From stratigraphic evidence, some of the sandstones clearly belong to the Andréebreen Formation, most likely they all do. In the Siktefjellet sandstone north of Liefdefjorden, only plant fossils and no fauna have been reported (Murašov & Mokin 1979). It can therefore be concluded that the Siktefjellet Group does not extend south of Liefdefjorden, and that the grey-green sandstones containing the peloid conglomerates belong to the Andréebreen Formation of the Red Bay Group.

Acknowledgements. – The authors thank the field assistants, in particular Halvor Jahre, for effective contribution to the project. Most of the fossils described in the paper were collected by Halvor Jahre. We sincerely express our gratitude for valuable assistance, advice, and evaluation of the paper offered by Natascha Heintz, and for critical reading and improvement of the manuscript draft by David G. Gee. The full responsibility for the content and the conclusions of this study, however, rests with the authors.

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