METHODS FOR THE STUDY OF MICROFACIES WITH AN EXAMPLE FROM THE OSLO REGION

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The value of microfacies analysis is demonstrated by an example from the Middle Ordovician of the Oslo Region. Limestones and shales were sampled systematically and studied in thin section by X-ray diffraction and by insoluble residue determination. The results indicate greater sedimentological and biological variation in this succession than previously thought.

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Few studies of the Cambro-Silurian of the Oslo Region combine both palaeontological and sedimentological approaches, and no microfacies investigations have been carried out before now.

Several publications deal with the recognition of fossil fragments in thin section (Majewske 1969, Horowitz & Potter 1971), but the use of point counting in quantifying their abundance is a relatively recent development. Although general agreement has not yet been reached on the practical applications of such an approach, Jaanusson (1972) has discussed many of the theoretical problems involved in such quantifications. Thus I hope in this paper to demonstrate the value of microfacies analysis in the study of palaeontological problems by taking a concrete example from the Middle Ordovician. The succession studied is exposed in a railway cutting in the vicinity of Lunner station, Hadeland, and consists of almost 40 metres of stages 4bδ and 4cα (Lauritzen 1973: 28). Stage 4bδ is dominated by nodular limestones, while 4cα consists of shales with isolated limestone beds.

Methodology

Samples of limestone and interbedded shales were collected systematically at approximately 0.5 m intervals in this section, the nearest limestone to each sample point being collected. 74 samples were taken, the sample numbers used refer to their height in the succession. Interbedded shales were also sampled for comparison. The limestones were point counted using the grain-solid method (Dunham 1962) on the skeletal grains, and the insoluble resi-

Table 1. Thin section analyses of 74 limestone samples. All contents in % (unsmoothed). + refers to counts of less than 1%.

Sample	Rock type	Textural components (%)											I.R. %
		Micritic matrix	Sparry calcite	Clay	Quartz	Pyrite	Skeletal grains					Tril.	
							Total.	Brach.	Echin.	Gastr.	Ostr.		
0.10	foss. micrite	90	6	14		+	4	+	+		+	3	14
0.50	foss. micrite	92	2	17		+	5	1	+		+	3	17
1.00	foss. micrite	97	2	11		+	1		+		+	+	11
1.60	foss. micrite	98		19		+	1		+			+	19
2.00	micrite	99		15	+	+	+		+		+	+	16
2.45	foss. micrite	97	+	18	+	+	3	+	2		+	1	19
3.00	foss. micrite	96	1	21		+	2		+			2	21
3.45	foss. micrite	96		21		+	4	+	1			2	21
4.00	biomicrite	82		24		+	17	+	3	6	+	6	24
4.50	foss. micrite	94	+	21		+	4		2			2	21
5.05	foss. micrite	93	+	25	+	1	5	+	2			3	26
5.40	foss. micrite	95	+	26		+	4		2		+	2	26
6.00	foss. micrite	97		21		+	3	+	+			2	21
6.40	foss. micrite	96		24	+	+	3		2			1	25
7.00	foss. micrite	97		27		+	3		2		+	1	27
7.60	biomicrite	89		23		+	11	+	6		+	4	23
8.00	foss. micrite	97		22		2	1	+			+	+	24
8:45	foss. micrite	95		33		+	4		2			2	33
8.90	foss. micrite	95		26		+	4	+	3		+	+	26
9.55	foss. micrite	96		21		+	3	+	2			1	21
10.00	foss. micrite	90	4	23		+	6	+	2		+	4	23
10.55	foss. micrite	98		22		+	2	+	+	+		+	22
11.00	foss. micrite	89	4	17		+	7	+	+		+	5	17
11.50	foss. micrite	93	2	21		2	3		+	+	+	2	23
12.05	biomicrite	87		23	+	+	13	+	4		+	8	24
12.50	micrite	99		23		+	+		+				23
13.00	foss. micrite	84	1	11		+	6		3	+		2	11
13.55	foss. micrite	94	+	16		+	5	+	3	+		2	16
14.15	foss. micrite	96		18		+	4		3			+	18
14.50	foss. micrite	97	+	12	+	+	2		+	+	+	+	13
15.05	foss. micrite	93	1	18	1	+	3		1	+		2	19
15.55	foss. micrite	84	6	17	3	+	7		4			3	20
16.00	foss. micrite	84	6	13	1	+	7		3	1	+	3	14
16.50	foss. micrite	87	3	16	2	+	7		2	1	+	3	18
17.50	foss. micrite	88	1	15	+	1	9	1	4		+	4	16
18.00	foss. micrite	97	+	16		+	2		+			1	16
18.45	foss. micrite	90		18	+	+	9	+	4		+	4	19
18.90	foss. micrite	97	+	29		+	1		1				29
19.50	foss. micrite	92	+	25	+	+	6	+	2		+	3	26
20.05	micrite	99	+	22			+		+			+	22
20.45	foss. micrite	96		21		+	4		+		+	2	21
21.10	foss. micrite	98	+	15	+	+	2	+	+		+	+	16
21.50	foss. micrite	96	+	28		+	3		1		+	2	28
22.00	foss. micrite	94	+	23			4		+	+	+	3	23
22.50	foss. micrite	95	+	25	+	+	4	+	+	+	+	2	26
23.10	foss. micrite	96		25	+	+	3		2	+		+	26
23.50	foss. micrite	96	+	29	+	1	2		+	+	+	+	31
24.00	foss. micrite	96	+	28	+	1	2	+	+		+	+	29
24.55	foss. micrite	96		25	+	+	3		+		+	2	26
25.00	foss. micrite	90	2	22	1	1	5	+	+	+	+	3	24
25.50	foss. micrite	89		27	3	+	8	+	2		+	5	30
26.00	biomicrite	69	1	9	3		24		13		+	10	12
26.50	foss. micrite	86		21	4	2	8		2		+	5	27
27.00	foss. micrite	97	+	26	1	+	1		+			+	27
27.45	foss. micrite	97	+	26	+	+	1		+		+	+	27
28.60	foss. micrite	96		18	2	+	1		+			+	20
29.05	micrite	98	+	26	+	+	+		+			+	27
29.50	micrite	98		25	+	+	+		+			+	26
30.00	micrite	98		26	+	+	+	+	+			+	27
30.50	micrite	98		20	+	+	+		+			+	21
30.90	micrite	98		18	+	+	+		+			+	19
31.60	micrite	99		22	+	+	+		+			+	23
32.10	foss. micrite	97		23	+	+	1	+	+			+	24
32.60	foss. micrite	98		19	+	+	1		+			+	20
33.00	micrite	97		14	+	2	+		+			+	16
33.60	micrite	98	+	26	+	+	+		+			+	27
34.00	micrite	99	+	26	+		+		+			+	26
34.55	micrite	98	+	19	+	+	+		+		+	+	20
35.00	micrite	98		23	+	+	+		+			+	24
35.70	micrite	98	+	11	+	+	+		+			+	12
36.20	micrite	99		20	+	+	+	+				+	21
37.05	micrite	99		21	+	+	+		+			+	22
37.60	foss. micrite	95		13	+	+	1		+	1		2	14
38.05	micrite	99		23	+	+	+		+			+	24

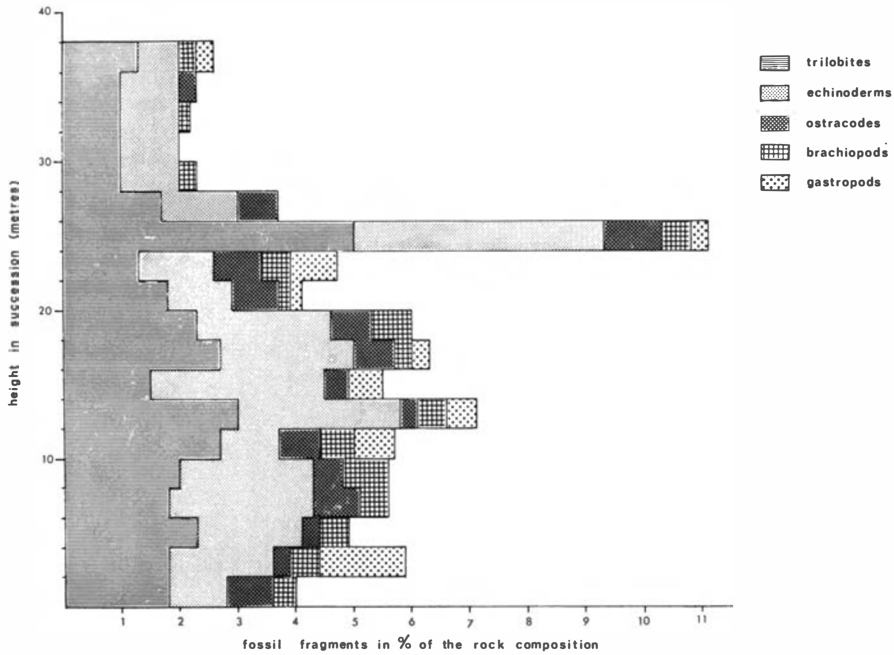

Fig. 1. Comparison of the bioclastic content in the limestones for 2 metre units through the section south of Lunner station, Hadeland. All results are smoothed.

dues of all samples (I.R.) were determined chemically (Ellingboe & Wilson 1964: 412). All samples were also examined by X-ray diffraction.

The following minerals were identified in all samples: calcite, quartz, illite, chlorite, feldspar and secondary pyrite; small amounts of dolomite are sometimes present in both shales and limestones. This mineralogical picture agrees well with that given by Bjørlykke (1974).

As suggested by Jaanusson (1952, 1972) and Martna (1955), all fossil fragments over a minimum size of 0.1 mm were counted. Even smaller fragments of some fossil groups are identifiable (Feray et al. 1962), but generally the minimum size used by Jaanusson is appropriate.

The results obtained are shown in Table 1; the 'clay' content in fact represents total insoluble matrix under 4μ in size. Rock types are classified according to the system of Folk (1959, 1962) as micrite (less than 1% fossil debris), fossiliferous micrite (1–10%), and biomicrite (more than 10% fossil debris). Fossil material occurs in all samples investigated; its abundance varies from less than 1% to 24%, (mean approximate somewhat less than 4%, Table 1). However, it is clear that references to 'biomicrites' in the literature on the Oslo Region are in fact insufficient. The analyses as presented in Fig. 1 have been smoothed by combining samples in 2 metre units. These smoothed results show a maximum bioclastic content of about 11%.

The same smoothing was also adapted for the insoluble residues of both the limestones and the shales (Fig. 2). The acid insoluble residue content of

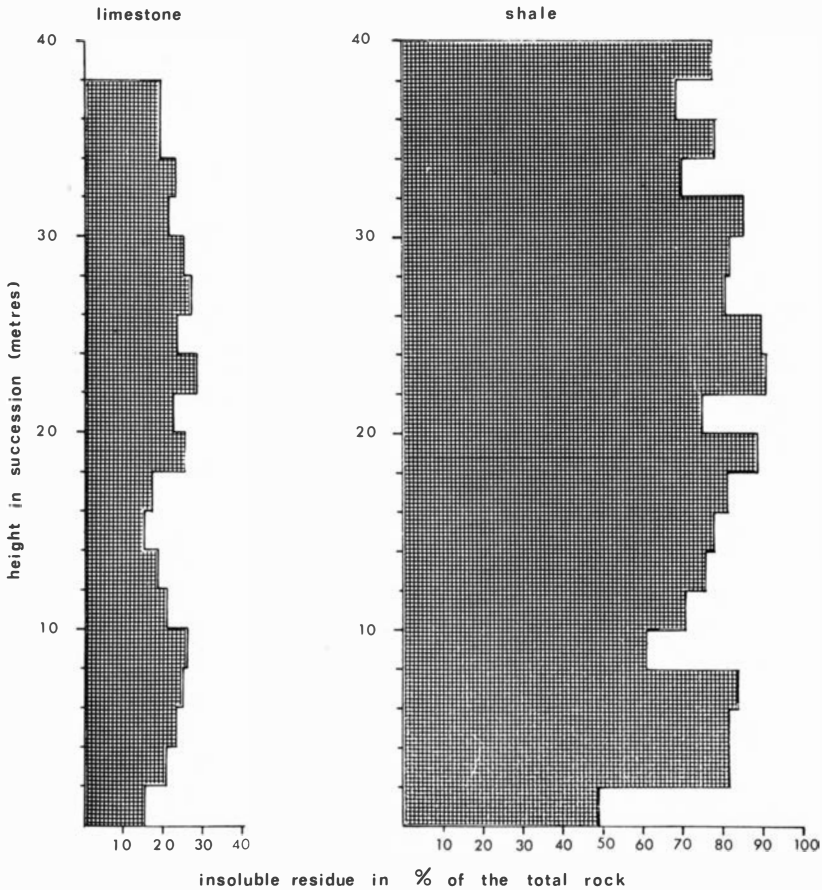

Fig. 2. Comparison of the insoluble residue content in the limestones and shales for 2 metre units through the section south of Lunner station, Hadeland. All results are smoothed.

the limestones varies more gradually than that of the shales, and the actual spread in insoluble residue content is larger in shales (50–90%) than in the limestones (15–30%). This is the reverse of that observed by Worsley (1969) in the Lower Silurian. However, the high carbonate content of both limestones and shales in the lowermost unit (0–2 m) probably results from tectonically emplaced microscopic calcite veins in the rock.

Comparison of the macrofaunal elements of this section (Størmer 1945, Lauritzen 1973) with the microfacies results shown in Fig. 1 shows a poor agreement. For example, the only macrofossil recorded in the basal smoothed unit (0–2 m) is *Lonchodomas* sp., while thin sections contain fragments of brachiopods, echinoderms, ostracodes and trilobites. The fossils *'Calymene'* sp., *Illaenus* sp., *Lonchodomas* sp., *Orthis* sp., *Strophomena* sp. and *Sinuites corpulentus* are listed from the next unit (2–4 m), whereas thin sections also contain echinoderms and ostracodes. Comparisons through the whole section show that one or more of the groups identified in thin section is invariably lacking in the list of macrofossils. Thus the bioclastic fragments in the rocks indicate much more varied organic activity than would be indicated by a purely macrofaunal study.

A striking feature in this respect is the abundance of echinoderm fragments in thin sections. This is apparently the most overlooked fossil group in the Oslo Region; echinoderms are not often mentioned in the fossil lists, but their fragments are extremely common, both in this section and throughout major parts of the Cambro-Silurian of the Oslo Region. This phenomenon is probably a result of the rapid post-mortem disintegration of echinoderms (Blyth Cain 1968).

Fossils and fossil fragments are important rock constituents of the sediments studied here, although the relative paucity of macrofossils is noteworthy. Fragmentation of the whole fossil may have been caused either by predepositional transportation or by postdepositional bioturbation of the enclosing sediment causing fragmentation. The bioclastic fragments seen are much larger than the silt-sized clastic content of the sediments, indicating that the former factor may not be relevant. However, coarser clastic grains may not have been available in the depositional basin, so this factor cannot be rejected with certainty.

Thus usually these fossil fragments tell us little about the individual organisms' life environment, although in some cases definitely in situ fossils occur, which are only seen in thin section and have a great ecological interest (Lauritzen & Worsley 1974). Any palaeoecological studies should therefore embrace both macrofaunal and microfacial analyses.

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REFERENCES

Bjørlykke, K. 1974: Depositional history and geochemical composition of Lower Palaeozoic epicontinental sediments from the Oslo Region. *Nor. Geol. Unders. 305.*

Blyth Cain, J. D. 1968: Aspects of the depositional environment and palaeoecology of crinoidal limestones. *Scott. J. Geol. 4,* 191–208.

Dunham, R. J. 1962: Classification of carbonate rocks according to depositional texture. *In* W. E. Ham *(ed.), Classification of Carbonate Rocks.* Am. Assoc. Pet. Geol., Memoir 1, 108–121.

Ellingboe, J. & Wilson, J. 1964: A quantitative separation of non-carbonate minerals from carbonate minerals. *J. Sediment. Petrol. 34,* 412–418.

Feray, D. E., Heuer, E. & Hewatt, W. G. 1962: Biological, genetic, and utilitarian aspects of limestone classification. *In* W. E. Ham *(ed.), Classification of Carbonate Rocks.* Am. Assoc. Pet. Geol., Memoir 1, 20–32.

Folk, R. L. 1959: Practical petrographic classification of limestones, *Bull. Am. Assoc. Pet. Geol. 43,* 1–38.

Folk, R. L. 1962: Spectral subdivision of limestone types. *In* W. E. Ham *(ed.), Classification of Carbonate Rocks.* Am. Assoc. Pet. Geol., Memoir 1, 62–84.

Horowitz, A. S. & Potter, E. P. 1971: *Introductory Petrology of Fossils*. Springer-Verlag, Berlin. 302 pp.
Jaanusson, V. 1952: Untersuchungen über die Korngrösse der ordovizischen Kalksteine. *Geol. Fören. Förhandl. 74,* 121–130. Stockholm.
Jaanusson, V. 1972: Constituent analysis of an Ordovician limestone from Sweden. *Lethaia 5,* 217–237.
Lauritzen, Ø. 1973: The Middle Ordovician of the Oslo Region, Norway. 24. Stage 4b at Lunner, Hadeland. *Nor. Geol. Tidsskr. 53,* 25–40.
Lauritzen, Ø. & Worsley, D. 1974: Algae as depth indicators in the Silurian of the Oslo region. *Lethaia 7,* 157–161.
Majewske, O. P. 1969: Recognition of invertebrate fossil fragments in rocks and thin sections: International sedimentary petrographical series, v. 13, 101 pp., 106 plates. *E. J. Brill.* Leiden.
Martna, J. 1955: Studies on the Macrourus and Slandrom Formations I. Shell fragment frequencies of the Macrourus Formation and adjacent strata of Fjäcka, Gräsgård, and File Haidar. *Geol. Fören. Förhandl. 77,* 229–256.
Størmer, L. 1945: Remarks on the Tretaspis (Trinucleus) shales of Hadeland. *Nor. Geol. Tidsskr. 25,* 379–426.
Worsley, D. 1969: Lower Llandovery brachiopod faunas and associated sediments from Malmøya and adjacent islands, Oslo Region, Norway. Unpublished Ph.D. thesis, University of Manchester.